# 15.0 ACCIDENTAL EVENTS

## 15.1 ACCIDENT PREVENTION

To identify and manage potential accidental events that could occur during Project activities, BHP uses a systematic, risk-based approach. Accidental events for the Project may include malfunctions, upset conditions or other unplanned events. While the risk of an accidental event often cannot be reduced to a zero probability of occurrence, the Project will be designed to: prevent the occurrence of accidents; and avoid or reduce environmental effects. This chapter discusses potential accidental event scenarios related to Project activities, BHP's prevention and response measures, and potential environmental effects resulting from such events.

Potential accidental events that could arise during Project operations, are presented in this chapter, with a focus on those that could result in a release of hydrocarbons to the marine environment. This chapter also presents the results of oil spill fate and behaviour modelling (refer to Section 15.3 and Appendix F). BHP's approach to crisis and emergency management (including oil spill response and planning) and lessons learned following the 2010 Deepwater Horizon (DWH) incident and other industry incidents, are also considered in the assessment (Section15.5).

BHP's Environmental Protection Plan (EPP) will outline environmental management, while the Safety Plan and Emergency Response Plan (ERP) (and associated Oil Spill Response Plan [OSRP]) will provide detailed information about reasonably foreseeable events that could impact worker safety and the environment. BHP's Safety Plan, EPP, ERP, and OSRP will be submitted to the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) as part of the Operations Authorization (OA) process. The mobile offshore drilling unit (MODU) operator will also prepare a separate ERP for the MODU.

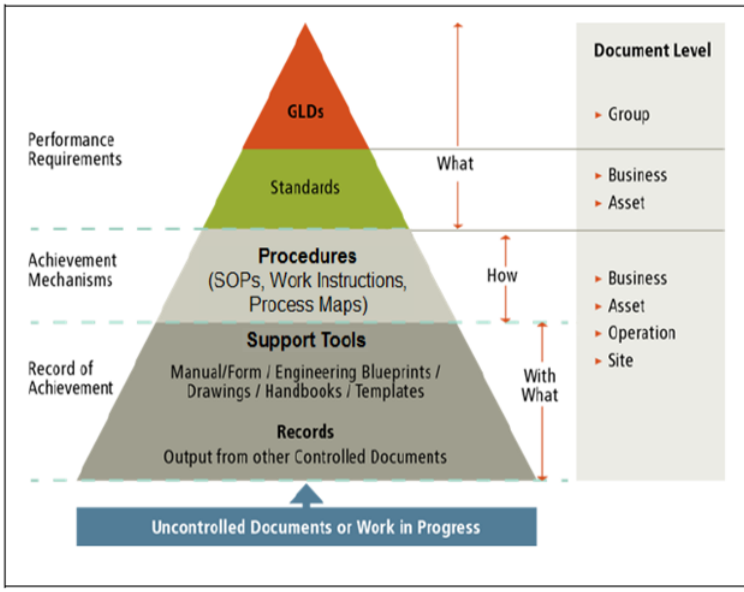
### 15.1.1 Leadership and Safety Culture

BHP has a company-wide Charter, Code of Conduct and sets Management Standards that clearly define the performance requirements for all operating businesses, including BHP Petroleum. Consistent within these documents is the requirement to make safety of personnel and the protection of the environment the highest priority.

For drilling and completion activities, the Wells and Seismic Delivery (WSD) department supplements the Company Charter (refer to Figure 1-2) with a statement outlining how operations will be undertaken, this is termed the WSD 'Stand'. BHP personnel and Contractors are required to adhere to this core value at all times including the design and operational phases of the project. Individuals are supported by a highly developed and detailed management system covering technical, safety and risk management standards and procedures; this is detailed further below.

## 15.1.2 Management System

The BHP Petroleum Management System (Figure 15-1), is a hierarchical management system where documents and systems must meet and support the requirements of those of higher levels (i.e., Group Level requirements set at a corporate level).




| Document types: | |
|---|---|
| | Requirements and guidance set by Corporate |
| | Petroleum D&C Standards |
| | Campaign Operations Management Plan (COMP)<br>Field Operating Manuals (FOM)<br>Drilling/Completion Programs |
| | Planning and Operational Checklists<br>Diagrams<br>Templates<br>Schematics / Drawings<br>Audit and Inspection Checksheets |

**Figure 15-1 BHP Management System**

A key component of the management system is risk management.

The Drilling & Completions (D&C) Controls Framework Standard describes how the requirements of the BHP Charter, Our Requirements (Group Level Documents), Petroleum Health, Safety and Environment (HSE) Standards, the Petroleum HSE Controls Framework, and Petroleum Leadership expectations will be met. Table 15.1 summarizes the content of the various levels of documentation within the management system.

As supplements to the global BHP management system, several campaign specific management system documents have been developed (e.g., well control bridging document, Safety Plan, EPP).

### Table 15.1 BHP's Management System Documentation Levels

| | BHP Definition | Petroleum D&C Applicability |
|---|---|---|
| **Our Requirements (GLDs)** | Requirements that we all need to follow, so that we can deliver on our strategy, meet our legal obligations, manage a defined risk or improve productivity. Supports long term requirements. | Requirements and guidance set for all of BHP by Corporate headquarters |
| **Standard** | Documents which primarily include performance requirements and controls to achieve uniformity of the specific activity or process and support long-term requirements. | Petroleum D&C Standards (including Policies) |
| **Procedure** | Documents which describe how to operate and control an activity or process to achieve functional excellence or the quality required. Includes Management Plans and Operating Procedures. Purpose is to improve the overall performance by achieving repeatability, continuity, effectiveness and efficiency. | Campaign Operations Management Plan (COMP), Rig SOPs, Drilling/Completion Programs, Standard Procedures |
| **Work Instruction** | Documents which describe how to perform a task. Includes Preventative Work Instructions and Standard Work Instructions. Purpose is to reduce mistakes in executing tasks to achieve safety, repeatability, continuity, effectiveness and efficiency. | Instructions to Contractors (ITC), Contractor Work Instructions |
| **Other controlled documents** | Documents which do not contain mandatory requirements but must be controlled to maintain version and currency. Includes forms and templates associated with the Standard and Procedure categories, engineering blueprint/drawing, communication documents, employee handbooks and training documents. | Planning and Operational Checklists, Diagrams, Templates, Schematics / Drawings and Audit and Inspection Checksheets |

## 15.1.3 Risk Management

Hazard identification, risk evaluation and control will be managed jointly by BHP and Contractors (BHP+Contractor).

Key elements of the integrated management system (BHP+Contractor) include the following:

- Systematic methods will be used to identify hazards and quantify risks
- Risks will be classified and control measures instigated appropriate to the classification
- Effectiveness of control measures will be assessed on a continuing basis
- It is a BHP requirement that all MODUs hold a Safety Case in an International Association of Drilling Contractors (IADC) format. Part of this document is a formal safety assessment undertaken with crew participation to establish the operating risks and associated controls in the manner described above. In addition, BHP has stringent technical and operational requirements contained within the management system to ensure equipment installed in the well is fit for purpose
- Marine vessels (including MODUs) are subject to an intensive auditing process (during pre-hire and ongoing throughout the drilling campaign) to ensure they are fit for purpose and well maintained
- Management of generic industry hazards such as pressure, lifting operations, are in line with accepted industry best practices

Prior to operations commencing, the requirements of the BHP management system and the MODU and Project supply vessel (PSV) Contractors are compared. Hence operations offshore are undertaken under a bridged version of the Contractor management system that meets or exceeds BHP requirements.

### 15.1.4 Well Control and Well Integrity

While an unlikely scenario, the event with the highest potential worst-case outcome in terms of personnel and environmental damage is an uncontrolled release of hydrocarbons from the well at seabed (i.e., a blowout). A large proportion of the BHP management system is dedicated to preventing this occurrence. Specific areas of focus include:

- Well Integrity: BHP has various standards relating to well design with the sole aim of ensuring that wells are designed to effectively within stand the forces imposed upon them, equipment is designed and manufactured to appropriate standards and sufficient barriers between hydrocarbons and the surface are always in place
- Well Control: BHP has various standards relating to well control with the sole aim of ensuring that personnel are trained and competent in well control principles, and procedures and that well control equipment is fit for purpose, maintained correctly, in good working order and within certification

These areas of high focus are subject to intensive verifications including:

- Well design peer reviews and independent verification
- BHP oversight in the manufacturing process of critical pieces of well equipment
- Each well has a list of critical elements that must be tested and verified prior to continuing with operations (e.g., casing pressure test and blowout preventor [BOP] equipment test prior to drilling)
- Well control equipment Hazard Identification (HAZID) session prior to commencing operations to ensure a common understanding of the system and identify weaknesses of project specific differences
- Well control audits to ensure personnel and not only qualified but competent in well control issues

### 15.1.5 C-NLOPB Special Oversight Measures

The C-NLOPB identified the need to establish special oversight measures for deep-water wells so that lessons learned from the DWH incident could be used to prevent similar events, and to accommodate heightened public concern over drilling operations in the NL Offshore Area. The C-NLOPB first announced this initiative in 2010, in relation to Chevron's Orphan Basin Lona O-55 exploration drilling program (C-NLOPB 2018a). Since then, any deep-water well, high pressure-high temperature well, or other well where there may be higher concerns of a well control incident, is considered a "critical well" and is included in C-NLOPB's special oversight role (C-NLOPB 2018a). The focus of special oversight measures is on well control protocols, equipment and contingencies, blowout prevention, and oil spill contingency plans. C-NLOPB (2016) outlines special oversight measures included in the program:

- Establishment of a dedicated Special Oversight Team
- Bi-weekly oversight meetings with the operator
- Increased monitoring, reporting, and frequency of offshore audits and inspections

- Program change reviews
- Lessons learned from review sessions

Operators are notified of the C-NLOPB's decision to exercise special regulatory oversight on a case-by-case basis (C-NLOPB 2018a).

## 15.2 POTENTIAL ACCIDENTAL EVENTS SCENARIOS

### 15.2.1 Potential Scenarios

Safety specialists and operational risk personnel within BHP have identified the accidental risk events for the Project, which are described here. Risk management is a dynamic process and it is possible that additional accidental risk scenarios other than those presented below could occur. BHP regularly evaluates the risk events, and continually seeks to improve its preventative and response barriers to ensure a robust risk management strategy.

This EIS focuses on credible worst-case accidents that could result from a subsurface blowout, batch spill or SBM spill. Further descriptions of the accidental events, such as potential causes and consequences, and the controls that are in place to help manage these risks, are provided in Section 15.2.2, 15.2.3, and 15.2.4. A Safety Plan is required to be submitted for regulatory approval as part of the OA process and will provide additional information about accidental risks that could occur during Project operations, including risks with health and safety consequences.

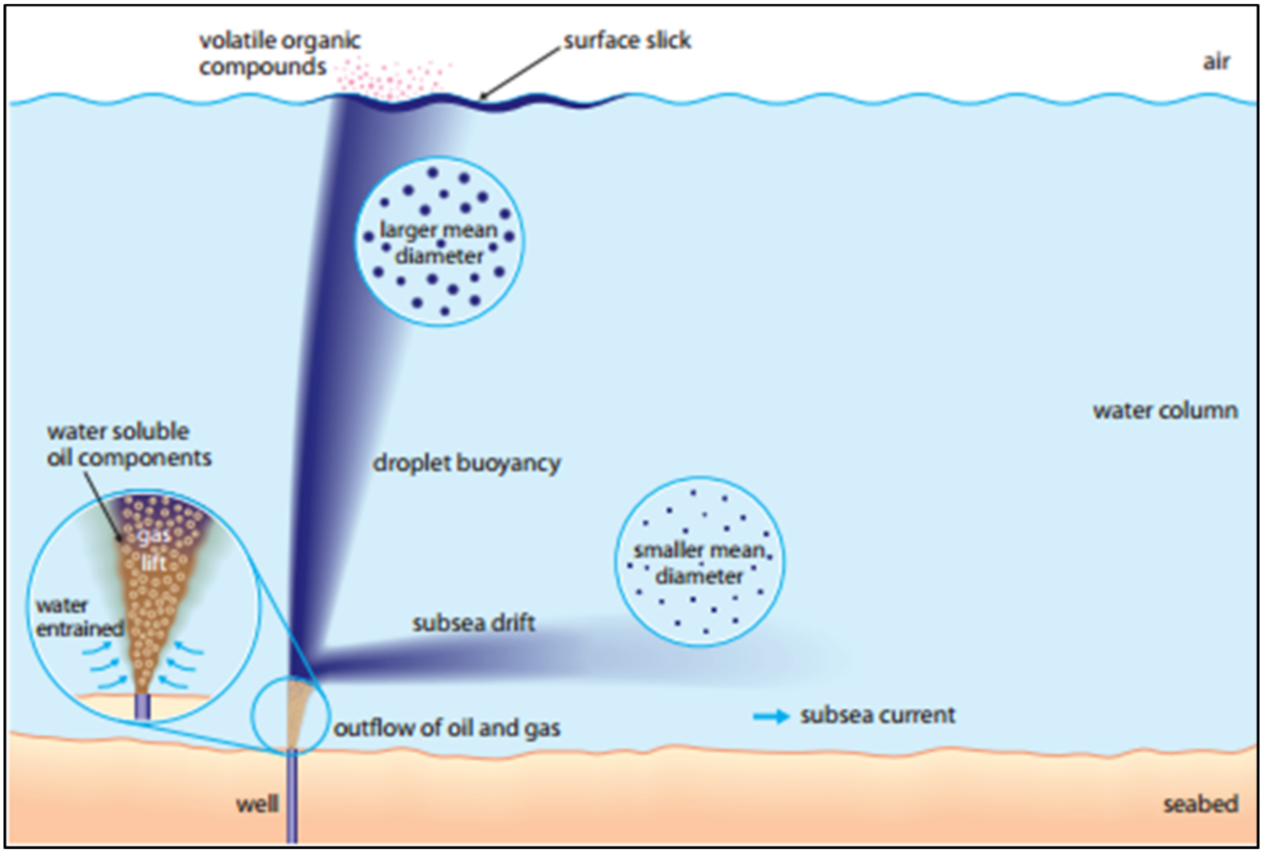
Section 15.5 provides detailed information on emergency preparedness and response.

Spill fate and behaviour modelling has been conducted for a well blowout incident at two potential locations within the ELs. A summary of modelling results and assumptions and background information about the modelling work including specific scenarios that were modelled are provided in Section 15.3; refer to Appendix F for a detailed account of the spill modelling. Section 15.6 presents the effects assessment for blowout events.

### 15.2.2 Well Blowout Incident

A blowout could occur if primary and secondary well control was lost. Potential causes of loss of primary well control could be unexpectedly high formation pressures, loss of drilling fluid hydrostatic overbalance due to human error, downhole losses, riser failure, MODU station keeping failure requiring emergency riser disconnect or poor cement job design, vessel collision requiring emergency riser disconnect, and accidental riser disconnect. Potential causes of loss of secondary well control could be equipment failure, human error, fire or explosion on the rig.

If there is a loss of well control, an uncontrolled release from the wellbore (a blowout incident; Figure 15-2), can occur. When the pressure encountered in the formation increases rapidly and becomes higher than the pressure exerted by the mud column, it is referred to as a 'kick'. Factors that determine the severity of the kick include the reaction time of the drill crew, the permeability of the formation (i.e., how it allows fluid to flow through it), and the difference between the formation pressure and the hydrostatic pressure of the drilling fluid. During a blowout, formation fluids that can be released including saltwater, gas, and oil. If formation pressure exceeds the pressure exerted from the drilling fluid and secondary well control measures fail, a blowout incident could occur. A blowout could occur at surface through the marine riser or at the seabed if the marine riser has been disconnected or failed.




Source: IPIECA-IOGP 2015

**Figure 15-2 Blowout Incident Schematic**

A subsurface well blowout incident includes (IPIECA-IOGP 2015):

- High-velocity jets of oil and gas released subsurface in deep water will be broken up by the intense turbulence of the release conditions into small oil droplets and gas bubbles. This is often referred to as "mechanically" dispersed oil to distinguish it from oil dispersed by chemical dispersant use
- The plume of small oil droplets, gas bubbles, and entrained water will initially rise rapidly in the form of a buoyant plume, with the gas providing the dominant source of lift and buoyancy. Close to the point of release, this plume will behave like a single-phase plume
- As the plume of oil droplets and gas bubbles rise through the deep water (where water depths are greater than 500 m), the methane gas will dissolve into the ocean (due to its solubility at high pressure); this reduces the buoyancy of the plume, thereby slowing its ascent through the water
- Stratification in the water column and currents will then separate the oil droplets and gas bubbles (if not already dissolved) from the plume of entrained water

- The larger oil droplets will then continue to rise slowly to the sea surface under their own buoyancy, which is a function of size, while the smaller oil droplets will be carried horizontally under the influence of ocean currents and remain suspended in the water column as they dilute and biodegrade

If secondary well control measures (the BOP) fail to shut the well in, then either the rig will be disconnected from the well to protect personnel onboard or in the worst case the rig may catch fire and sink (DWH). A subsurface blowout is therefore used as a credible worst-case scenario and so has been selected for assessment in this EIS.

Since the first well was drilled in 1966, there have been no loss of well control incidents offshore Newfoundland. However, in offshore Nova Scotia, there were two loss of well control incidents in the mid-1980s, with one unmitigated case that resulted in a blowout incident and release of hydrocarbons to the environment. On February 22, 1984, the Uniacke G-72 loss of well control incident resulted in a blowout. The incident occurred 150 nautical miles (278 km) from Halifax at a gas well that was being drilled by the semi-submersible drilling vessel, *Vinland*, under contract to Shell Canada Resources. The incident lasted 10 days, with an initial flow rate of gas and condensate at approximately 300 bbl per day, releasing a total of approximately 1,500 bbl of gas condensate and between 1.11 to 1.83 million $m^3$/day of natural gas. After 10 days, a team of specialists boarded the *Vinland* and pumped mud down the choke line, and the well was declared static (Gill et al. 1985).

The second incident occurred in 1985 at N-91, a Mobil exploratory gas well in West Venture at a water depth of 38 m. The loss of well control resulted in no fluids or hydrocarbons being released into the marine environment or atmosphere because the BOP was activated at the N-91 incident and hydrocarbons were contained within the subsurface formations. The cause was a casing failure in the wellbore that allowed natural gas to escape from one subsurface formation to another and resulted in the loss of well control. A relief well was drilled to kill the well (Angus and Mitchell 2010).

These incidents occurred prior to the implementation of additional controls and mitigation measures that will be used for well control. The following controls and mitigation measures are based on the lessons learned following the Macondo well blowout (DWH incident) and industry advancements:

- Enhanced industry and BHP training and competency assessment for individuals and crews with accountability for well control and other wells operations
- Secondary shear rams on the BOP - there are a minimum of two pipe rams and a minimum of a single annular preventer.
- Third-party verification of BOP testing and maintenance
- Onshore remote monitoring to support well operations
- Enhanced monitoring processes and procedures

Controls to prevent this type of spill include:

- Rigorous well delivery process using data from offset wells ensuring that well control and well integrity are the highest priority in the well design
- Pre-drill geohazards assessment

- Detailed suite of well design and operational standards and compliance with the CNLOPB Drilling and Production Guidelines and industry best practices (e.g., Well Control compliance with American Petroleum Institute (API) Standard 53)
- Independent well design verifications
- Well Control critical equipment (e.g., casing, wellheads) must be manufactured to industry standards (e.g., API 6A) and BHP agreed quality plan with BHP oversight during the manufacturing process
- Riser, wellhead, and conductor design analysis
- Visual inspection of riser when running, pressure test riser auxiliary lines prior to use
- Stringent DP requirements
- Auditing of MODU DP and power generation systems
- DP and power generation redundancy
- Weather monitoring and predefined procedures of well suspension and riser displacement to seawater prior to planned unlatch
- LMRP and wellhead connector unlatch function protected from accidental activation
- Controls to prevent accidental vessel collision
- Personnel competence and training requirements in line with Atlantic Canada Offshore Petroleum Standard Practice for the Training and Qualifications of Offshore Personnel
- All personnel involved with well control must hold valid well control certification (e.g., International Well Control Forum (IWCF))
- Well control drills prior to drilling into possible over-pressure
- Intensive well data monitoring program with independent sensors and personnel to catch early signs of loss of primary well control
- Well control bridging document to ensure that drilling contractor well control procedures meet or exceed BHP requirements
- Well control auditing program to ensure personnel not only qualified but competent in well control matters and to verify the effectiveness of well controls
- BHP and CNLOPB requirement for rig to hold an IADC Safety Case, this will contain a formal safety assessment identifying major accident events (MAEs) and associated controls which will be managed using the bow tie method.
- Detailed well control equipment assessment prior to operations commencing to ensure that all equipment is fit for purpose, within certification and in good condition
- BHP MAE risk assessments include a blowout, supplementary and complimentary controls to drilling contractor
- Regular pressure and function testing of secondary well control equipment in line with drilling and production regulations and API Standard 53 requirements
- Direct BHP and drilling contractor supervision during critical operations
- Well program will have a critical elements list of well integrity tests that must be passed prior to continuing to the next stage of operations
- Equipment redundancy (e.g., multiple closing elements within the BOP, back up control systems both from surface and subsurface)

### 15.2.3 Batch Spill

Batch spills are accidental releases of various hydrocarbons (e.g., marine diesel) that occur once and include a bulk release with a finite amount (e.g., contents of a fuel tank or transfer hose). As an example, batch spills can occur as a result of a vessel collision or during bunkering operations on a MODU or PSV. Because batch spills cover a range of spill events the measures employed to prevent and, in the case of a spill, respond a release are broad ranging.

Control measures include but are not limited to:

- Well maintained and well-designed equipment and processes
- Trained personnel on the MODU and PSVs
- Oil spill response kits on the MODU and PSVs
- Stringent DP requirements
- Bunkering transfer procedures (including control of work processes to conduct a risk assessment)
- Use of dry-break hose couplings
- Use of hose floats
- Regular inspection of transfer hoses

### 15.2.4 SBM Spill

Spills of SBM could occur when transferring SBM to or from the PSV due to hose failure, station keeping failure and incorrect valve alignments. Controls to prevent this type of spill include:

- Hydrocarbon hoses must be changed out annually
- Floats on hose and visibility requirements
- Dry break couplings must be used
- Detailed transfer procedure conducted under a PTW
- Stringent DP requirements
- Auditing of vessel and MODU DP and power generation systems
- DP and power generation redundancy
- 500 m checklist requiring PSV station keeping and power systems to be confirmed as fully operational prior to entry
- Oversight from BHP environmental specialist (drilling fluids compliance technician)
- Dump valves locked shut and controlled under a PTW

Spills of SBM could occur from the riser; these could be minor in nature (a few bbls) caused by failure of the slip joint packer, or a major spill (several thousand bbls) caused by riser failure or LMRP unlatch (due to metocean conditions or MODU DP failure or accidental activation). Controls to prevent this type of spill include:

- Riser design analysis
- Visual inspection of riser when running
- Riser planned maintenance and inspection program
- Pressure test riser auxiliary lines prior to using SBM
- Stringent DP requirements

- Auditing of MODU DP and power generation systems
- DP and power generation redundancy
- Weather monitoring and predefined procedures of well suspension and riser displacement to seawater prior to planned unlatch
- Rig design and selection criteria (e.g., variable deck load, surface capacity) for the appropriate water depth
- LMRP and wellhead connector unlatch function protected from accidental activation

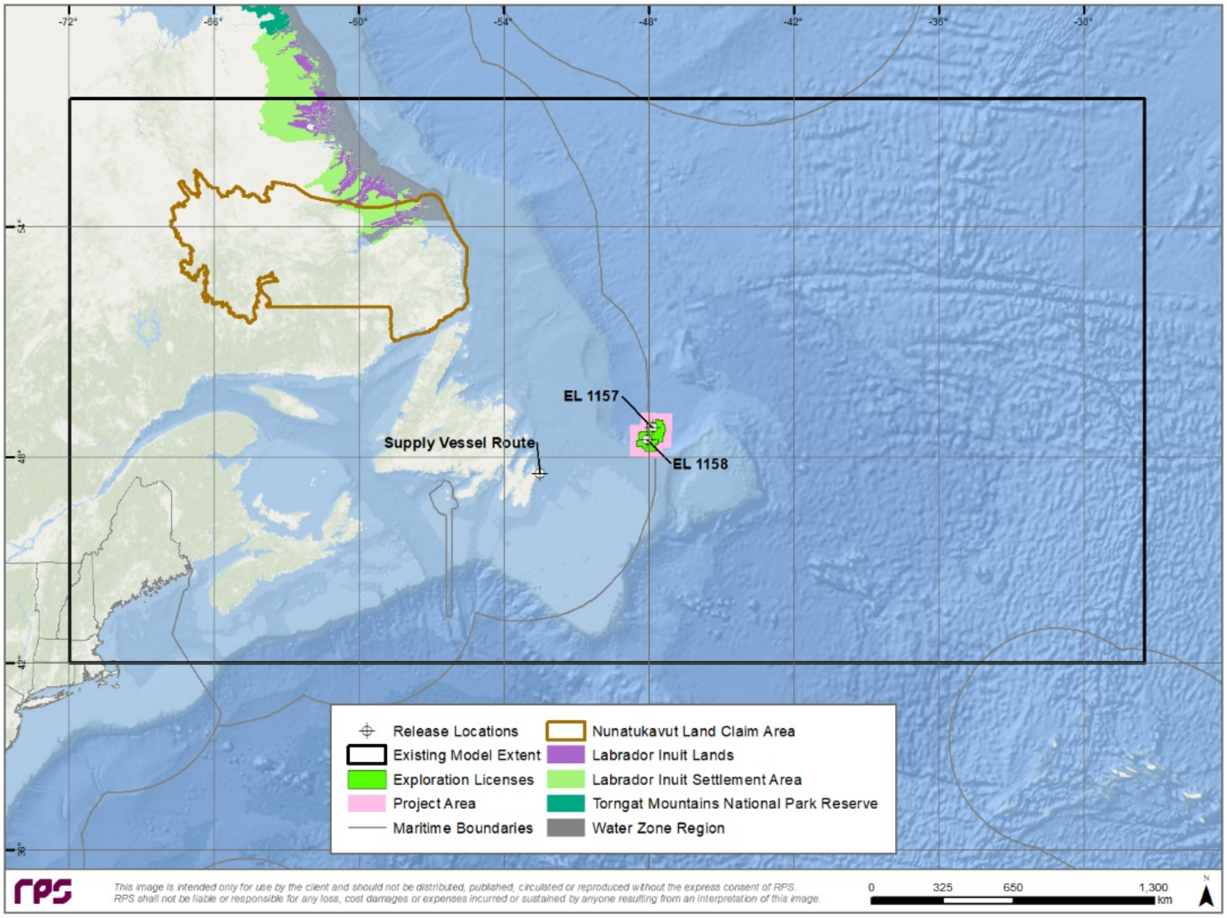
## 15.3 FATE AND BEHAVIOUR OF POTENTIAL SPILLS

Oil spill trajectory and fate modelling was performed to support an Environmental Assessment (EA) for the BHP Canada Exploration Drilling Project 2019-2028 in the Orphan Basin area. Hypothetical releases were modelled at two locations in the Orphan Basin located more than 350 km east-northeast of St. John's, Newfoundland (Figure 15-3). Releases were modelled as unmitigated subsurface blowouts of Bay du Nord crude oil (BdN) (Table 15.2). Two hypothetical subsurface blowout scenarios were developed within the Project Area in the blocks of interest (EL 1157 and EL 1158) (Table 15.3). The subsurface blowouts at each release site were simulated as continuous 30- and 120-day releases, with a total model run time of 160 days. The 30-day release represents the successful mobilization and implementation of a capping stack to contain the release while the 120-day releases represent the anticipated time to shut in a well by mobilizing a MODU and drilling a relief well.

The estimated release rates of hydrocarbons simulated in the subsurface blowout scenario were conservative (i.e., high) based on the current knowledge of the reservoir and other subsurface properties associated with the blowout scenario. An additional near-instantaneous, 3,200 L marine diesel batch spill was modelled for 30 days at a nearshore location, 12 km east of St. John's, along a potential PSV route. The modelled batch spill volume evaluated a potential discharge on the surface associated with marine diesel spills that could occur from a rupture of a diesel storage tank.

A stochastic assessment was used to provide an understanding of the probability and minimum time to exposure from unmitigated releases of oil. Highly conservative thresholds were each investigated separately for oil on the water surface, concentrations of hydrocarbons in the water column, and oil on shorelines (Table 15.4). The goal was to identify the areas that may be susceptible to contamination as well as the associated minimum time to exposure based upon variable environmental conditions. For example, seasonal and interannual variability in weather patterns and currents were assessed using >100 simulated releases.

To conservatively determine the approximate magnitude of potential contamination from a single credible "worst-case" scenario (i.e., with spatially- and temporally-varying concentrations, rather than simply the knowledge of a threshold exceedance), three individual deterministic scenarios were selected from each stochastic simulation to represent 95th percentile maximum potential effects within each environmental compartment. These highly conservative 95th percentile scenarios were identified from the modelled area of surface oil, volume of oil in the water column, and the length of shoreline oiled.




The black bounding box represents the modelled domain extent, while the pink shaded box represents the Project Area.

**Figure 15-3 Hypothetical Release Locations for the Subsurface Blowouts (EL 1157 and EL 1158) and Supply Route Vessel Location**

### Table 15.2 Physical Properties for the Oil Products Used in the Modelling

| Physical Property | BdN Crude Oil | Marine Diesel |
|---|---|---|
| Density (g/cm³) | 0.84553 @16°C<br>0.85800 @0°C | 0.83100 @25°C |
| Viscosity (cP) | 5.0 @20°C<br>53.0 @0°C | 2.76 @15° |
| API Gravity | 35.85 | 38.8 |
| Pour Point (°C) | -9 | -50 |
| Interface Tension (dyne/cm) | 15.5 | 27.5 |
| Emulsion Maximum Water Content (%) | 72 | 0 |

### Table 15.3 Hypothetical Subsurface Release Location, Parameters, and Stochastic Scenario Information

| Scenario Parameter | Release Locations of Stochastic Scenarios | | | | |
|---|---|---|---|---|---|
| Block / Release Location | EL 1157 | | EL 1158 | | Vessel Route |
| Latitude | 48.825889 N | | 48.491786 N | | 47.550842 N |
| Longitude | 47.851234 W | | 48.06617 W | | 52.522011 W |
| Water Depth of Release | 2,338 m | | 2,047 m | | Surface |
| Released Product | Bay du Nord (BdN) | | | | Marine Diesel |
| Gas to Oil Ratio | 400 scf/bbl | | | | - |
| Pipe Diameter | 31.12 cm (12.25 in.) | | | | - |
| Oil Discharge Temperature | 85°C | | | | - |
| Release Duration | 30 d | 120 d | 30 d | 120 d | Near-Instantaneous |
| Release Rate | 135,084 bpd | 129,141 bpd | 135,006 bpd | 129,137 bpd | - |
| Total Released Volume | 4,052,506 bbl | 15,496,924 bbl | 4,050,183 bbl | 15,496,430 bbl | 3,200 L |
| Model Duration | 160 d | | | | 30 d |
| Number of Simulations within Stochastic Analysis* | 172 annual (79 winter and 93 summer) for each scenario | | | | |

* A total of 688 individual subsurface releases were modelled within the stochastic analyses, another 172 for surface marine diesel, for a total of 860 individual simulations

## Table 15.4 Thresholds Used to Define Areas and Volumes Exposed Above Levels of Concern

| Threshold Type | Cutoff Threshold* | Rationale / Comments (Socio-economic, Response, Ecological) | Visual Appearance | References |
|---|---|---|---|---|
| Oil Floating on Water Surface | 0.04 g/m² (0.04 µm on average over grid cell) | Socio-economic: A conservative threshold used in several risk assessments to determine effects on socio-economic resources (e.g., fishing may be prohibited when sheens are visible on the sea surface). Socio-economic resources and uses that would be affected by floating oil include commercial, recreational and subsistence fishing; aquaculture; recreational boating, port concerns such as shipping, recreation, transportation, and military uses; energy production (e.g., power plant intakes, wind farms, offshore oil and gas); water supply intakes; and aesthetics. | Fresh oil at this minimum threshold corresponds to a slick being barely visible or scattered sheen (colorless or silvery / grey), scattered tarballs, or widely scattered patches of thicker oil. | French McCay et al. 2011, 2012; French McCay 2016; Lewis 2007, Bonn Agreement 2009, 2011 |
| | 10 g/m² (10 µm on average over grid cell) | Ecological: Mortality of birds on water has been observed at and above this threshold. Sublethal effects on marine mammals, sea turtles, and floating Sargassum communities are of concern. | Fresh oil at this threshold corresponds to a slick being a dark brown or metallic sheen. | French et al. 1996; French McCay 2009 (based on review of Engelhardt 1983, Clark 1984, Geraci and St. Aubin 1988, and Jenssen 1994 on oil effects on aquatic birds and marine mammals); French McCay et al. 2011, 2012; French McCay 2016 |
| Shoreline Oil | 1.0 g/m² (1 µm on average over grid cell) | Socio-economic / Response: A conservative threshold used in several risk assessments. This is a threshold for potential effects on socio-economic resource uses, as this amount of oil may trigger the need for shoreline cleanup on amenity beaches and affect shoreline recreation and tourism. Socio-economic resources and uses that would be affected by shoreline oil include recreational beach and shore use, wildlife viewing, nearshore recreational boating, tribal lands and subsistence uses, public parks and protected areas, tourism, coastal dependent businesses, and aesthetics. | May appear as a coat, patches or scattered tar balls, stain | French McCay et al. 2011, 2012; French McCay 2016 |

## Table 15.4 Thresholds Used to Define Areas and Volumes Exposed Above Levels of Concern

| Threshold Type | Cutoff Threshold* | Rationale / Comments (Socio-economic, Response, Ecological) | Visual Appearance | References |
|---|---|---|---|---|
| Shoreline Oil (cont'd) | 100 g/m² (100 µm on average over grid cell) | Ecological: This is a screening threshold for potential ecological effects on shoreline flora and fauna, based upon a synthesis of the literature showing that shoreline life has been affected by this degree of oiling. Sublethal effects on epifaunal intertidal invertebrates on hard substrates and on sediments have been observed where oiling exceeds this threshold. Assumed lethal effects threshold for birds on the shoreline. | The oil would appear as dark brown coat or opaque / black oil. | French et al. 1996; French McCay 2009, 2016; French McCay et al. 2011, 2012 |
| In Water Concentration | 1.0 ppb (µg/L) of dissolved PAHs; corresponds to ~100 ppb (µg/L) of whole oil (THC) in the water column (soluble PAHs are approximately 1% of the total mass of fresh oil) | Water column effects for both ecological and socio-economic (e.g., seafood) resources may occur at concentrations exceeding 1 ppb dissolved PAH or 100 ppb whole oil; this threshold is typically used as a screening threshold for potential effects on sensitive organisms. | N/A | Trudel et al. 1989; French McCay 2004, 2002; French McCay et al. 2012 |

### 15.3.1 Stochastic Modelling Results

A stochastic analysis was conducted for each hypothetical unmitigated subsurface blowout, consisting of 172 individual modelled simulations within each stochastic scenario. Stochastic simulations included continuous unmitigated 30- and 120-day BdN blowouts at both locations (EL 1157 and EL 1158) as well as a small volume release of marine diesel at a near-shore location (12 km) east of St. John's. Each simulation was initialized with a different start date / time between 2006-2012 to sample a range of environmental conditions. The dates and times were selected randomly from within each 14-day interval spanning the entire seven years of data. Results of the stochastic analysis included probability footprints above specified highly conservative socio-economic thresholds for surface, water column, and shoreline contact and minimum time to oil exposure as well as less conservative ecological thresholds that may result in potential effects (e.g., acute mortality).

Socio-economic Thresholds:

- Surface oil average thickness >0.04 µm
- Subsurface (within the water column) dissolved hydrocarbon concentrations >1.0 µg/L
- Shore oil average concentration >1.0 g/m²

Ecological Thresholds:

- Surface oil average thickness >10 µm
- Subsurface (within the water column) dissolved hydrocarbon concentrations >1.0 µg/L
- Shore oil average concentration >100 g/m²

Because each set of stochastic simulations spanned seven full years and included the associated seasonal variability, the complete set was referred to as annual summaries. To investigate seasonality, results from stochastic analyses were broken into two seasons depending on the majority of modelled days falling within either ice free conditions (i.e., summer) from May through October or periods with ice-cover (i.e., winter) from November through April.

It is important to note that although large footprints of oil are depicted for stochastic analyses, they do not represent the expected distribution of oil from any single release. These maps do not provide information on the quantity of oil in a given area. They simply denote the probability of oil exceeding the specific threshold passing through each grid cell location in the model domain at any point over the entire model duration (i.e., 160 days for the subsurface blowouts), based on the entire ensemble of simulations (172 individual releases). Only probabilities of 1% or greater were included in the map output, as lesser probabilities represent random variability in the set of 172 trajectories. Stochastic maps of water column exposure depict the likelihood that dissolved and total hydrocarbon concentrations (THCs) are predicted to exceed the identified threshold at any depth within the water column (i.e., vertical maximum). However, these figures do not specify the depth at which this threshold exceedance occurs and do not imply that the entire water column (i.e., from surface to bottom) will experience a concentration above the identified threshold.

Stochastic results are useful in planning for oil spill response as well as environmental assessments, as they characterize the probability that regions may experience oil exposure above specified thresholds, taking into account the environmental variability that is expected. Many release scenarios were simulated over multiple years to capture the different environmental forcing (e.g., variable wind and current speed and direction) that may be possible. For both release sites, EL 1157 and EL 1158, stochastic analyses were used to demonstrate that the highest potential likelihood (>90%) to exceed thresholds of potential surface oil exposure and water column contamination by dissolved hydrocarbons primarily occurred to the east, up to 1,400 km from the release site. Prevailing winds and currents were most likely to force released oil to the east, away from Canadian shorelines. Water column probability footprints were smaller than surface oil footprints, where the probability of threshold exceedance decreased as distance from the release site increased. In nearly all stochastic scenarios, lower probabilities of threshold exceedance are predicted for surface and water column oil contamination to the north and south, while generally <25% of releases have the potential to exceed thresholds >100 km to the west of the Project Area.

Due to the predominantly eastward transport of oil and the distance of EL 1157 and 1158 to Canadian shorelines, the average probability of shoreline oiling above the threshold was low (9%), with a maximum probability of 28% for a single shoreline grid cell. The currents in the region, due primarily to the bathymetric steering along the continental shelf, were predicted to further reduce the potential for Canadian shoreline exposure to oil. As the Labrador Current flows southward along the continental shelf, it transports entrained oil parallel to the coast. However, this trend is generally absent in the surface oil predictions, as wind forcing typically transported oil to the east, further out to sea. Oil that does make its way to Canadian shorelines would likely be patchy and discontinuous due to the considerable weathering that would take place over the span of weeks to months. Predicted minimum time to shoreline threshold exceedance is 7 to 27 days along southeastern Newfoundland. This range accounts for the non-linear nature of transport, which is the result of spatially and temporally variable wind and currents, between each of the modeled scenarios. All of the diesel batch spills modelled from a nearshore location (12 km east of St. John's) along a potential PSV route were predicted to result in less than 68 km² of surface oil exposure above the socio-economic threshold and no areas of exposure above the ecological threshold. Additionally, 53 km of shoreline was predicted to have exposure to oil above the socio-economic threshold. Due to the small release volume and size of the concentration gridding (150 m by 150 m), predicted concentrations of dissolved or THCs in the water column did not register above a recordable threshold. Therefore, no water column exposure above the modelled thresholds was predicted.

Figures depicting stochastic results are provided for surface oil thickness >0.04 µm and 10 µm, dissolved hydrocarbon contamination >1 µg/L, and shoreline contact >1 g/m² and 100 g/m² for annual scenarios for the two release sites (Figure 15-4 to Figure 15-23). Figures depicting stochastic results are provided for shoreline contact >1 g/m² and 100 g/m² for annual scenarios for nearshore batch spill (Figures 15-24 to 15-27) from the two release sites. They include both the probabilities and associated minimum times to threshold exceedance for the five hypothetical release scenarios (Table 15.5). Increased release duration also resulted in more predicted potential for shoreline oiling above the 1% probability of threshold exceedance at EL 1157 (2,782 km 30-day vs 4,100 km 120-day) and EL 1158 (2,637 km 30-day vs. 3,944 km 120-day) (Table 15.6). In addition, there were predicted increases in the overall probability of shoreline oiling for the 120-day releases (Table 15.7).

### 15.3.1.1 EL 1157

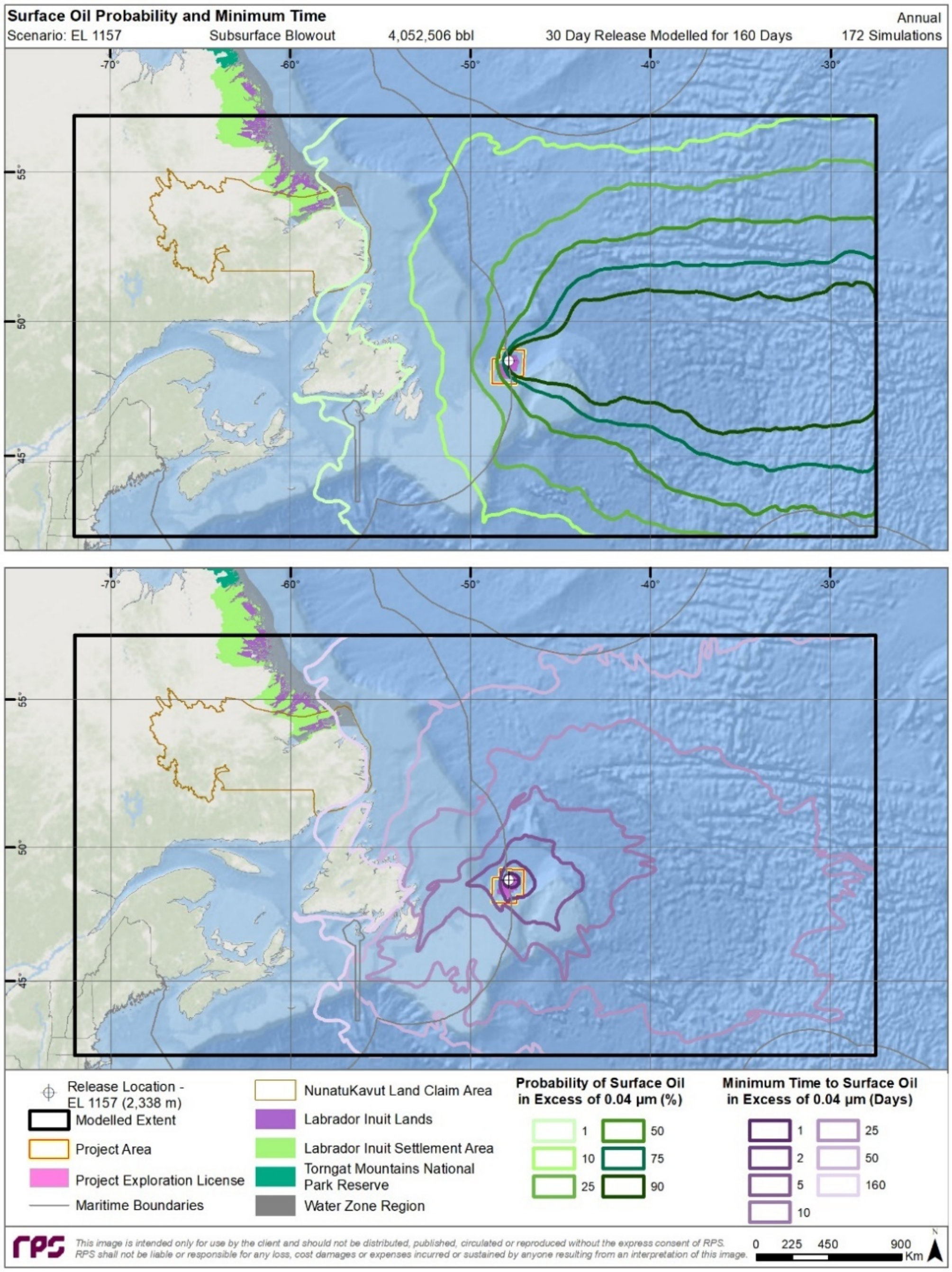



**Figure 15-4 Annual probability of surface oil thickness >0.04 µm (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1157**

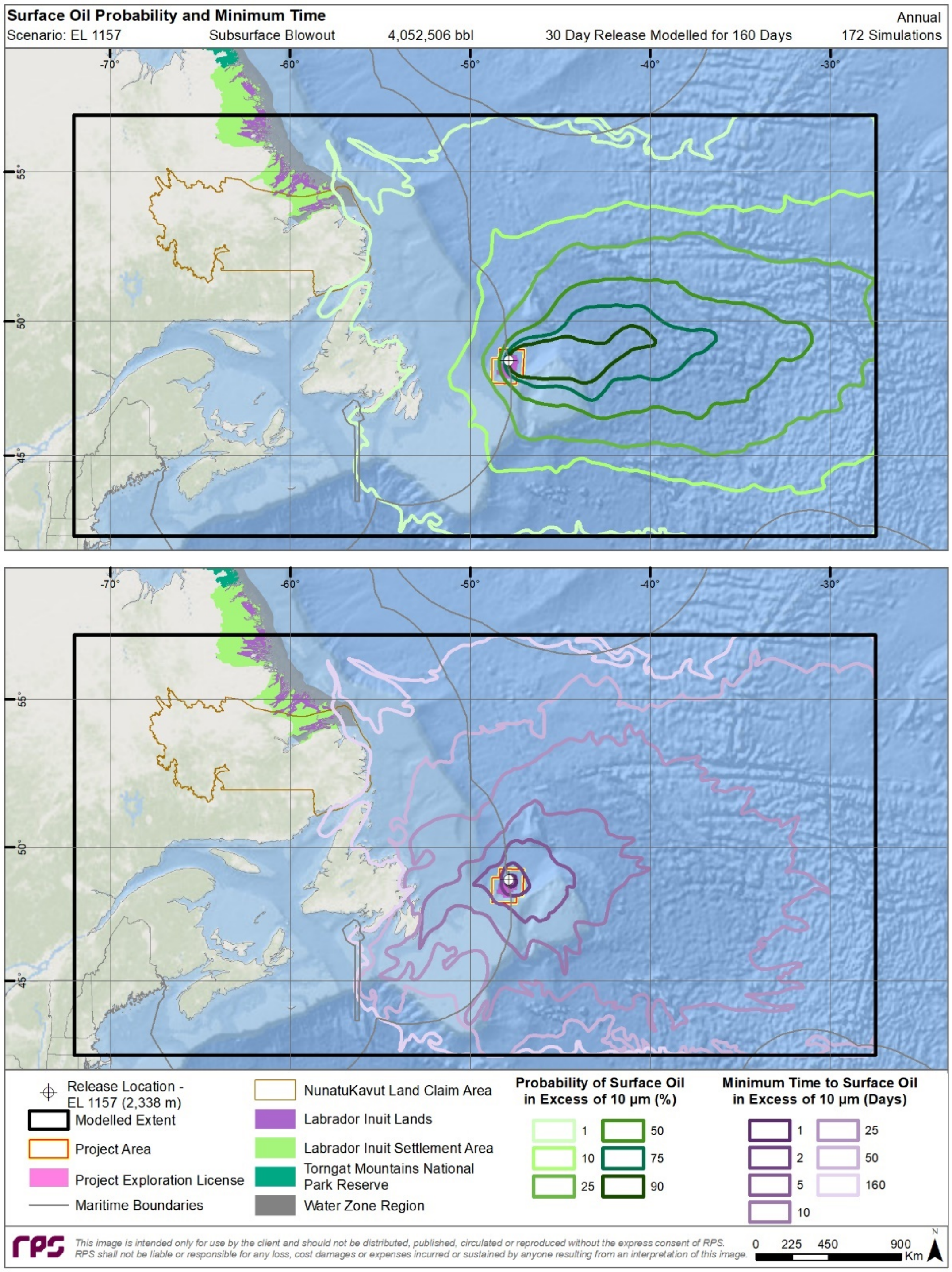



**Figure 15-5** **Annual probability of surface oil thickness >10 µm (top) and minimum time to ecological threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1157**

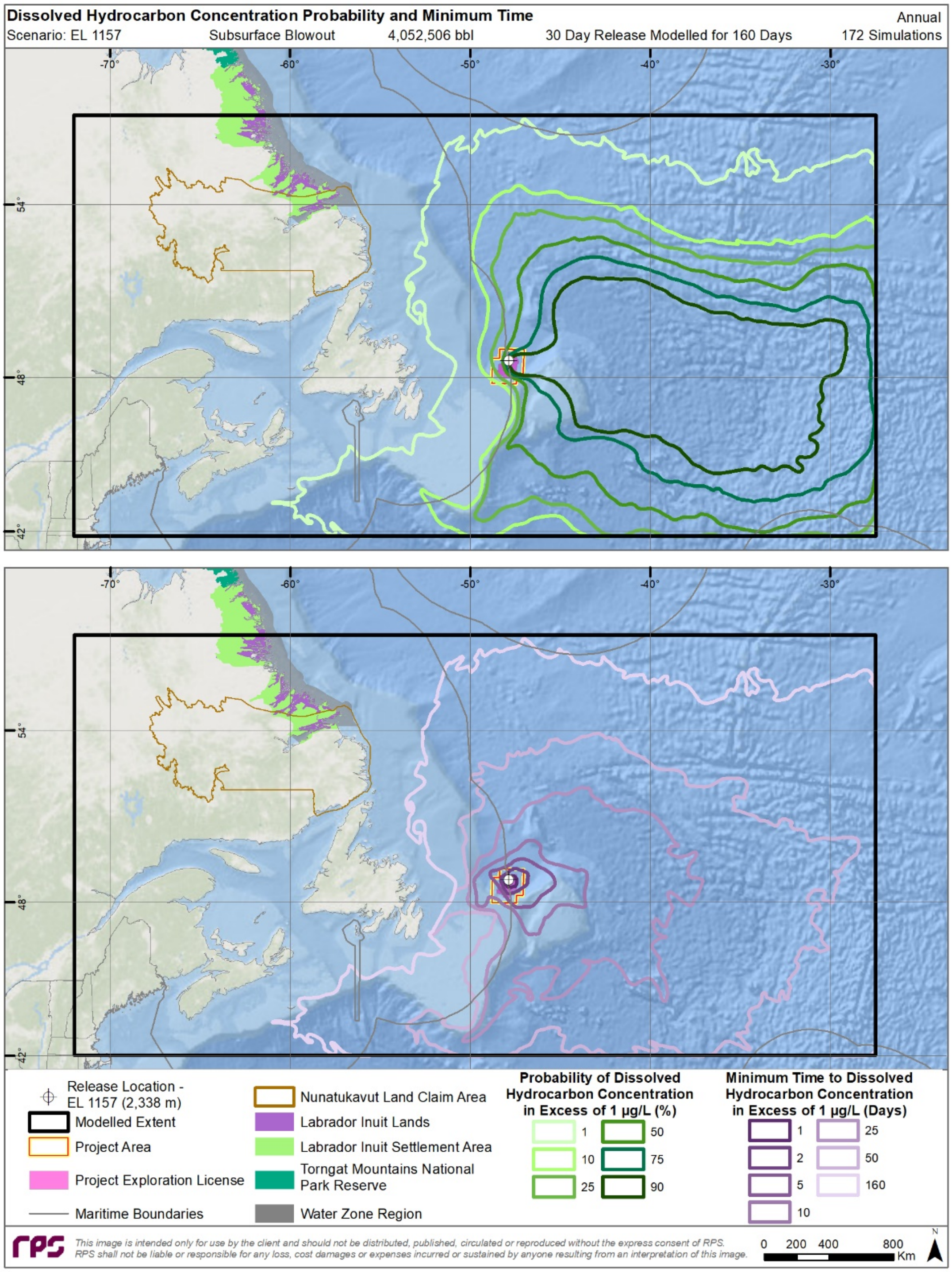



**Figure 15-6 Annual probability of dissolved hydrocarbon concentrations >1 µg/L at some depth in the water column (top) and minimum time to threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1157**

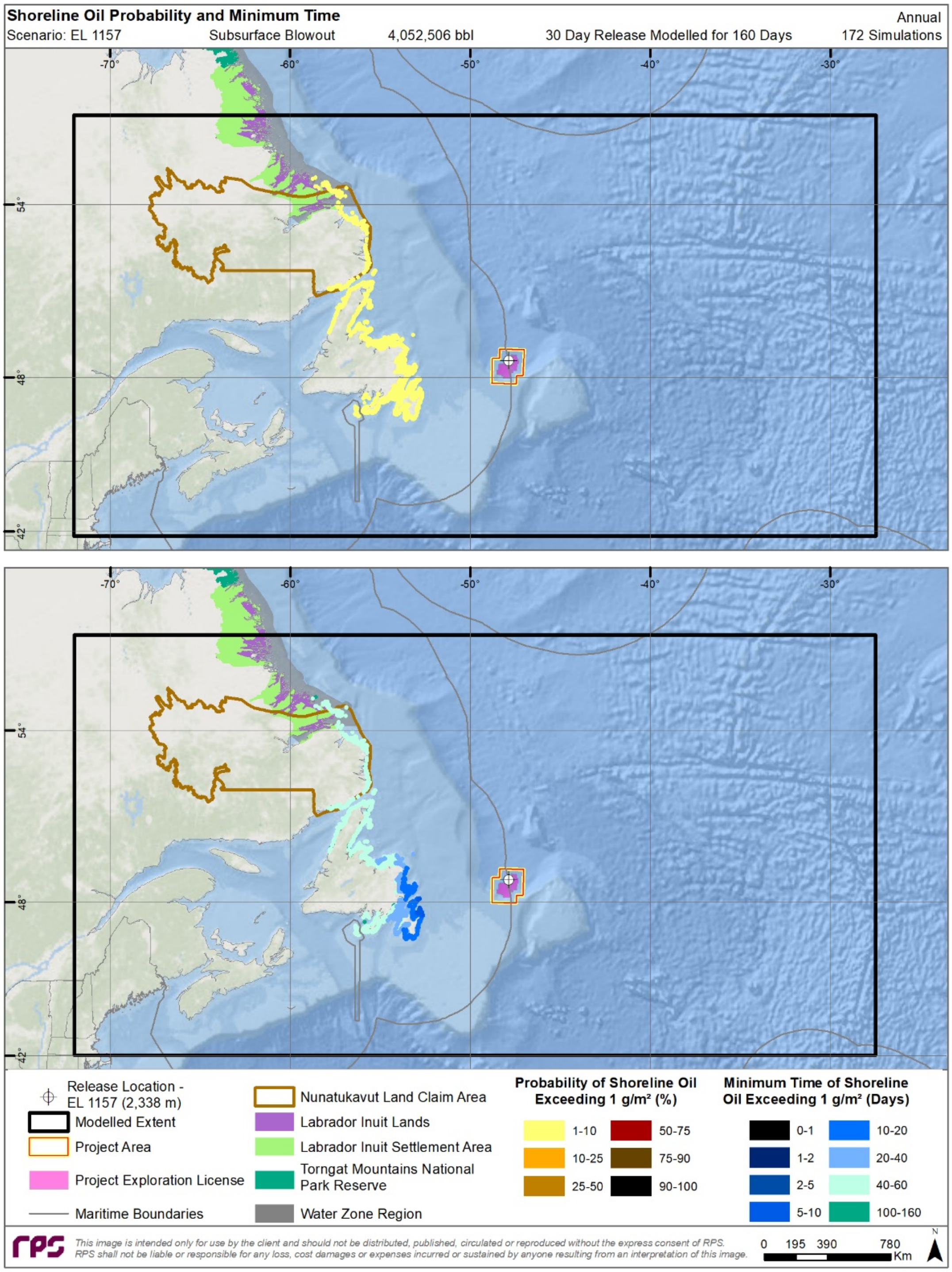



**Figure 15-7 Annual probability of shoreline contact >1 g/m² (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1157**

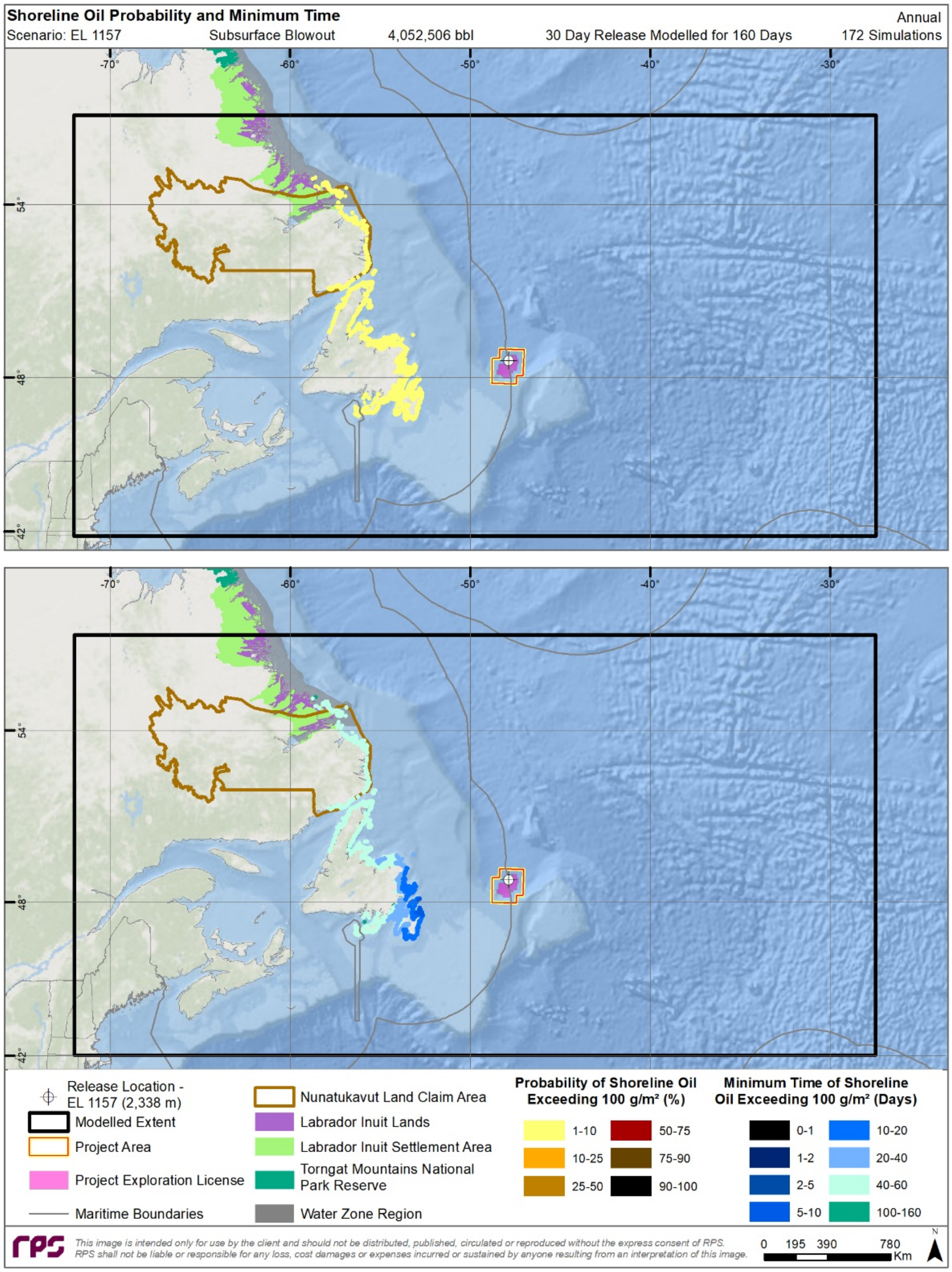



**Figure 15-8 Annual probability of shoreline contact >100 g/m² (top) and minimum time to ecological threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1157**

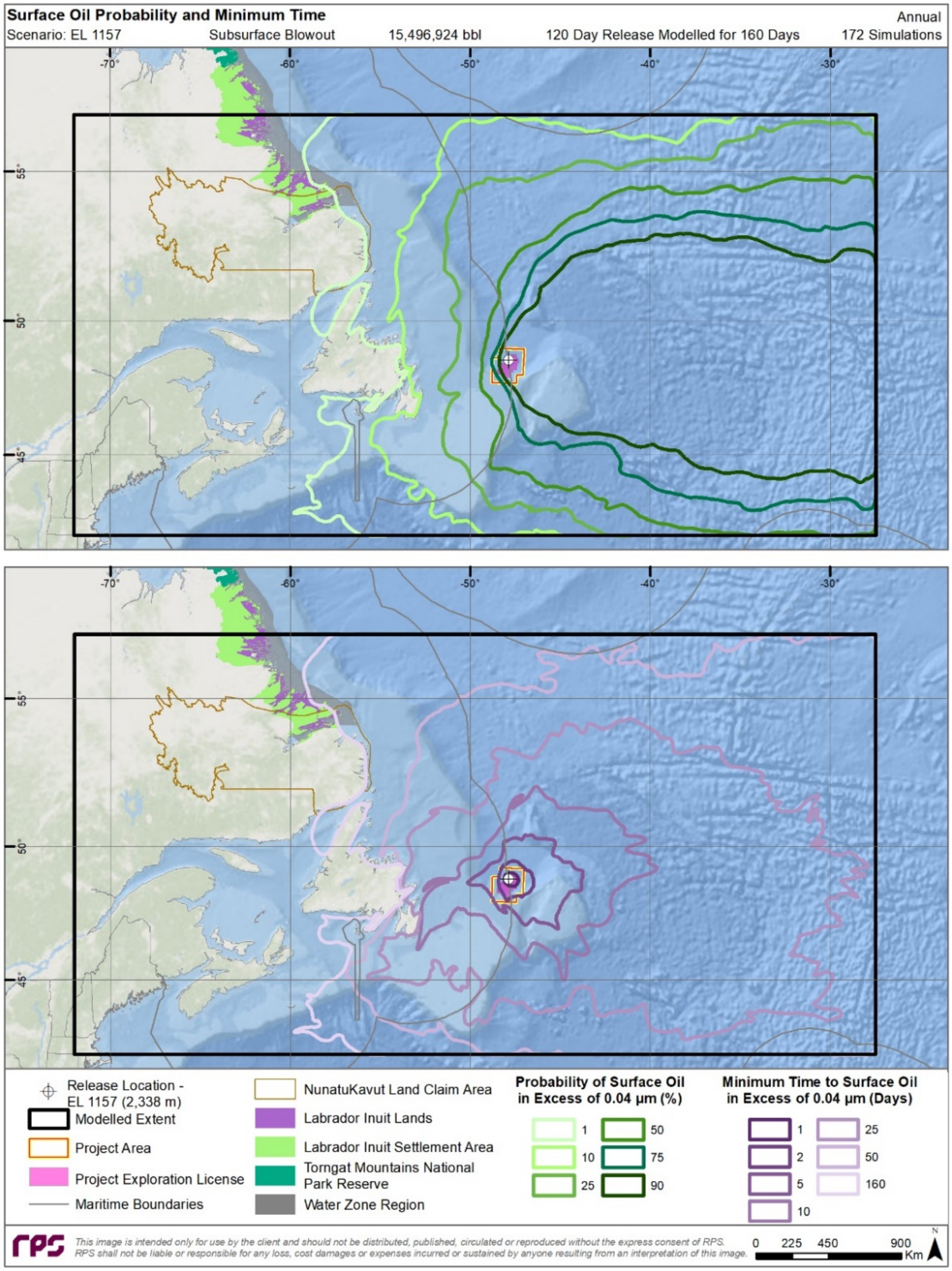



**Figure 15-9** **Annual probability of surface oil thickness >0.04 µm (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1157**

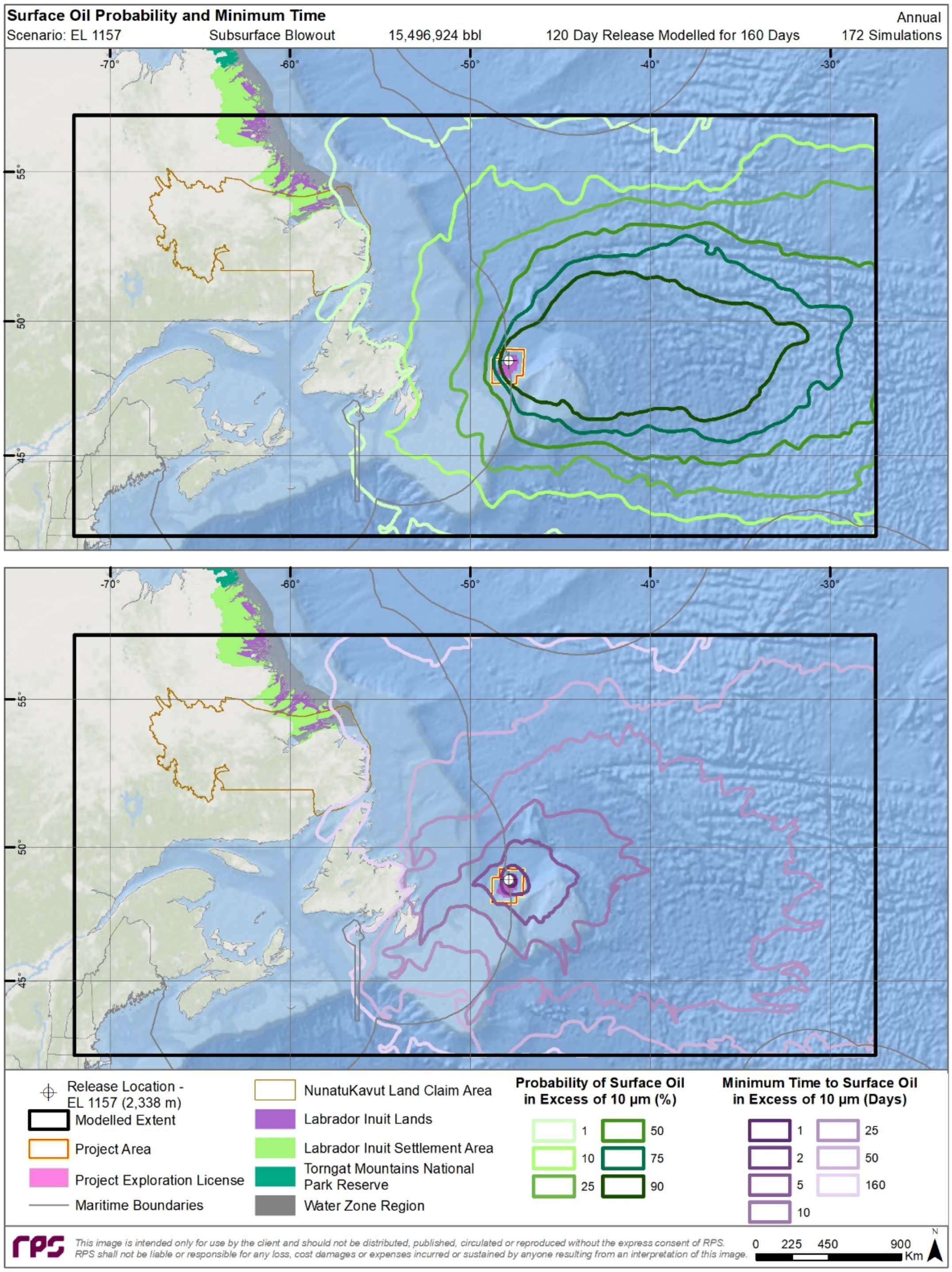



**Figure 15-10 Annual probability of surface oil thickness >10 µm (top) and minimum time to ecological threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1157**

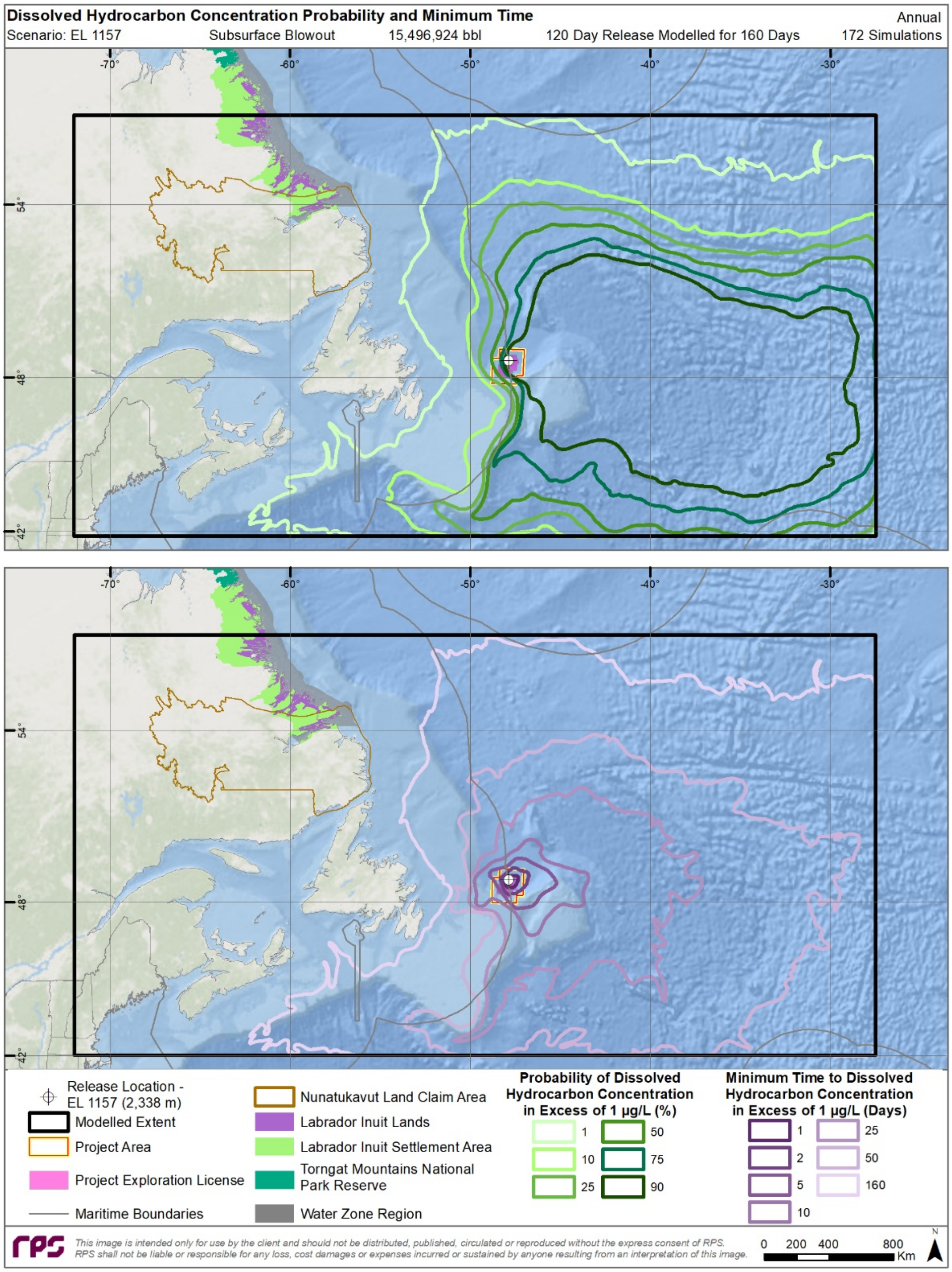



**Figure 15-11 Annual probability of dissolved hydrocarbon concentrations >1 µg/L at some depth in the water column (top) and minimum time to threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1157**

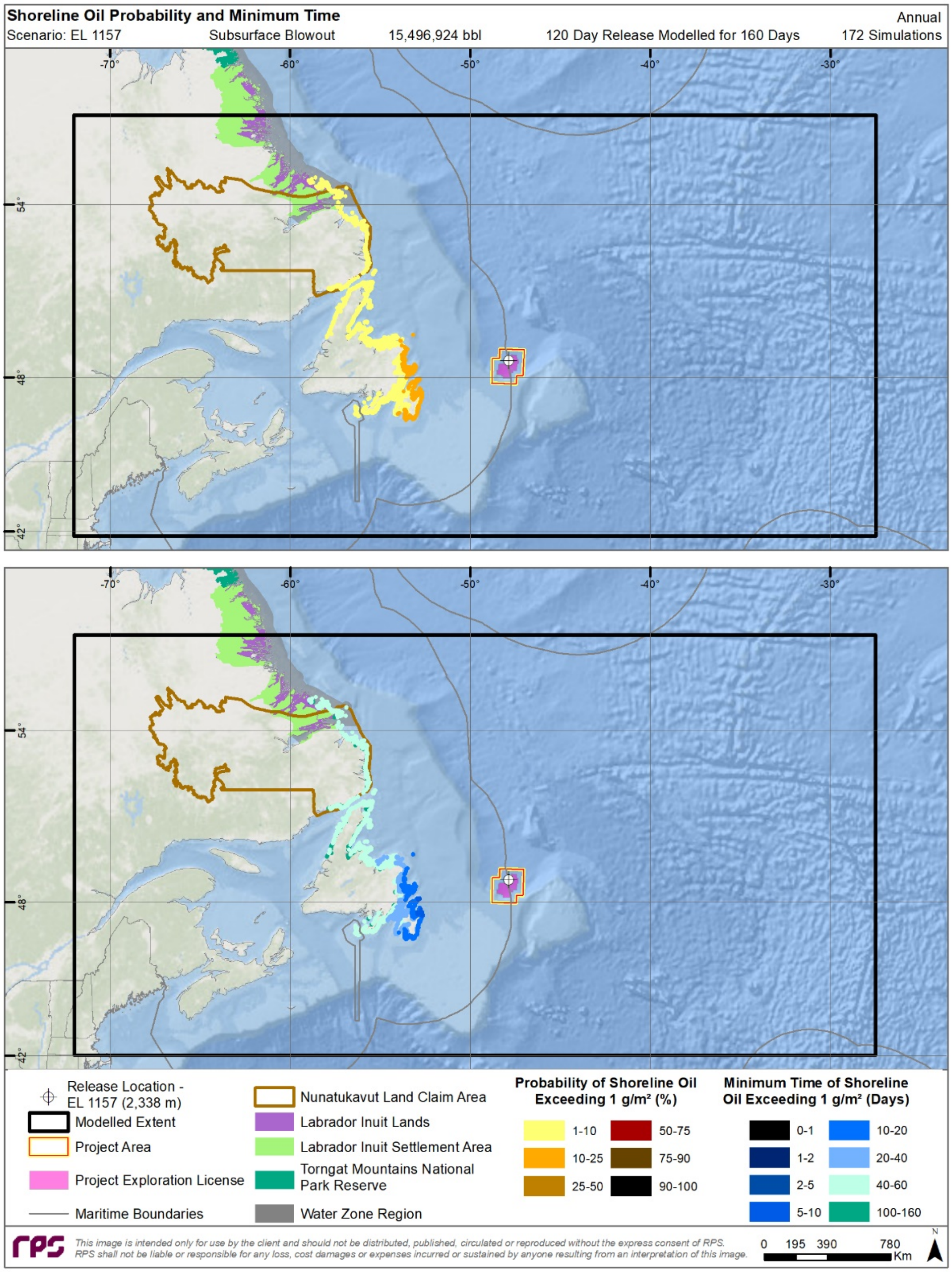



**Figure 15-12 Annual probability of shoreline contact >1 g/m² (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1157**

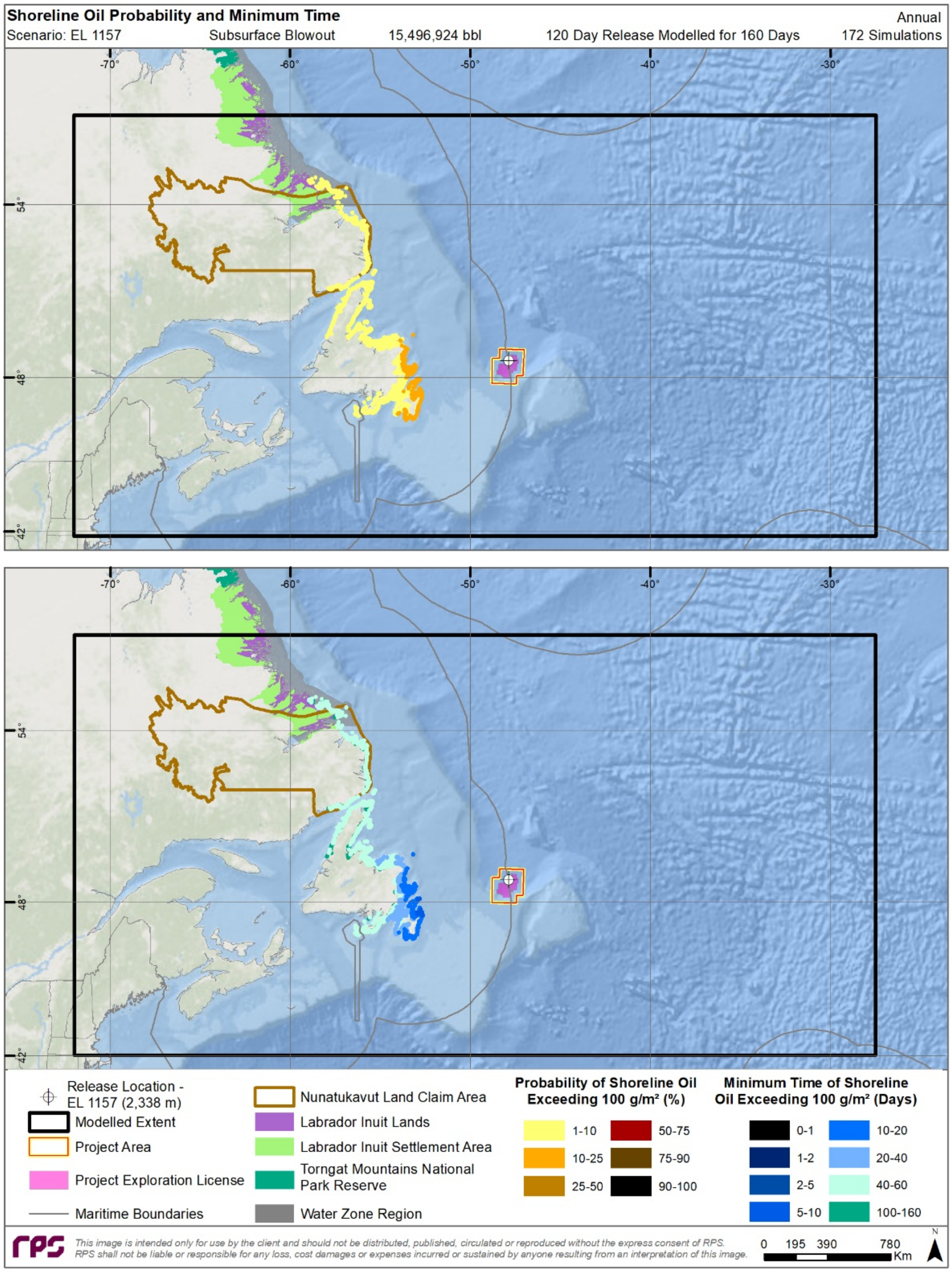



**Figure 15-13 Annual probability of shoreline contact >100 g/m² (top) and minimum time to ecological threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1157**

### 15.3.1.2 EL 1158

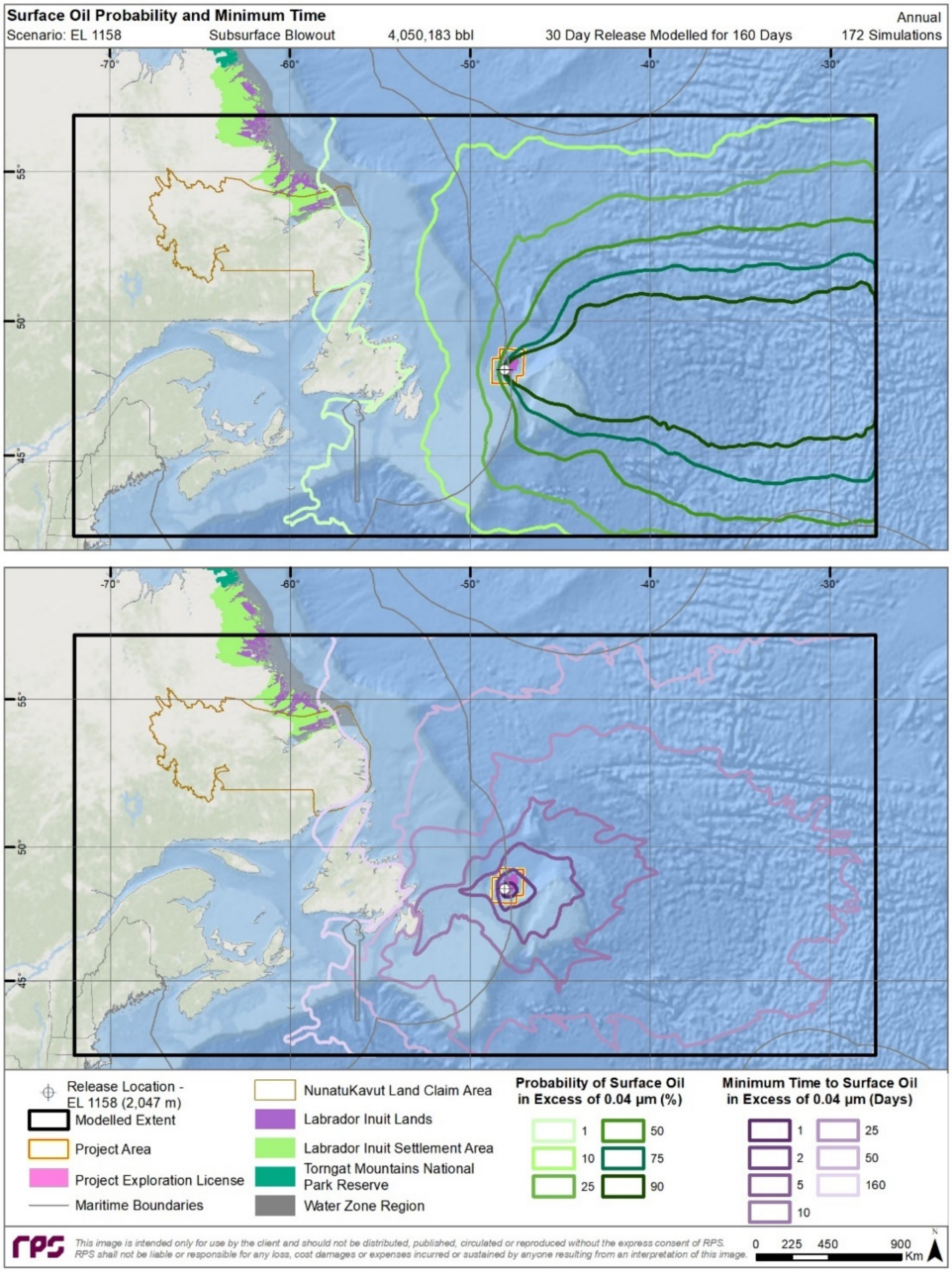



**Figure 15-14 Annual probability of surface oil thickness >0.04 µm (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1158**

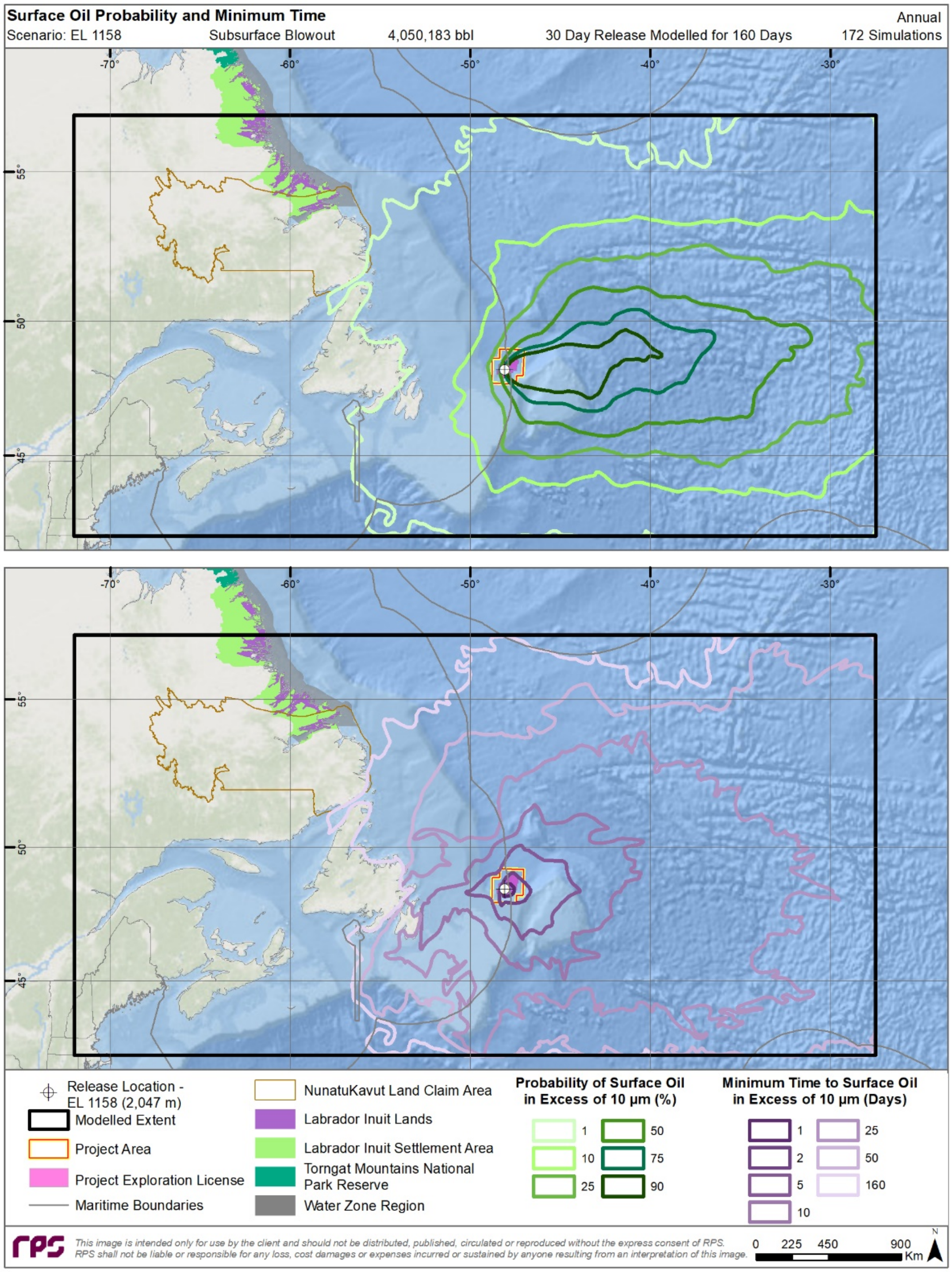



**Figure 15-15 Annual probability of surface oil thickness >10 µm (top) and minimum time to ecological threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1158**

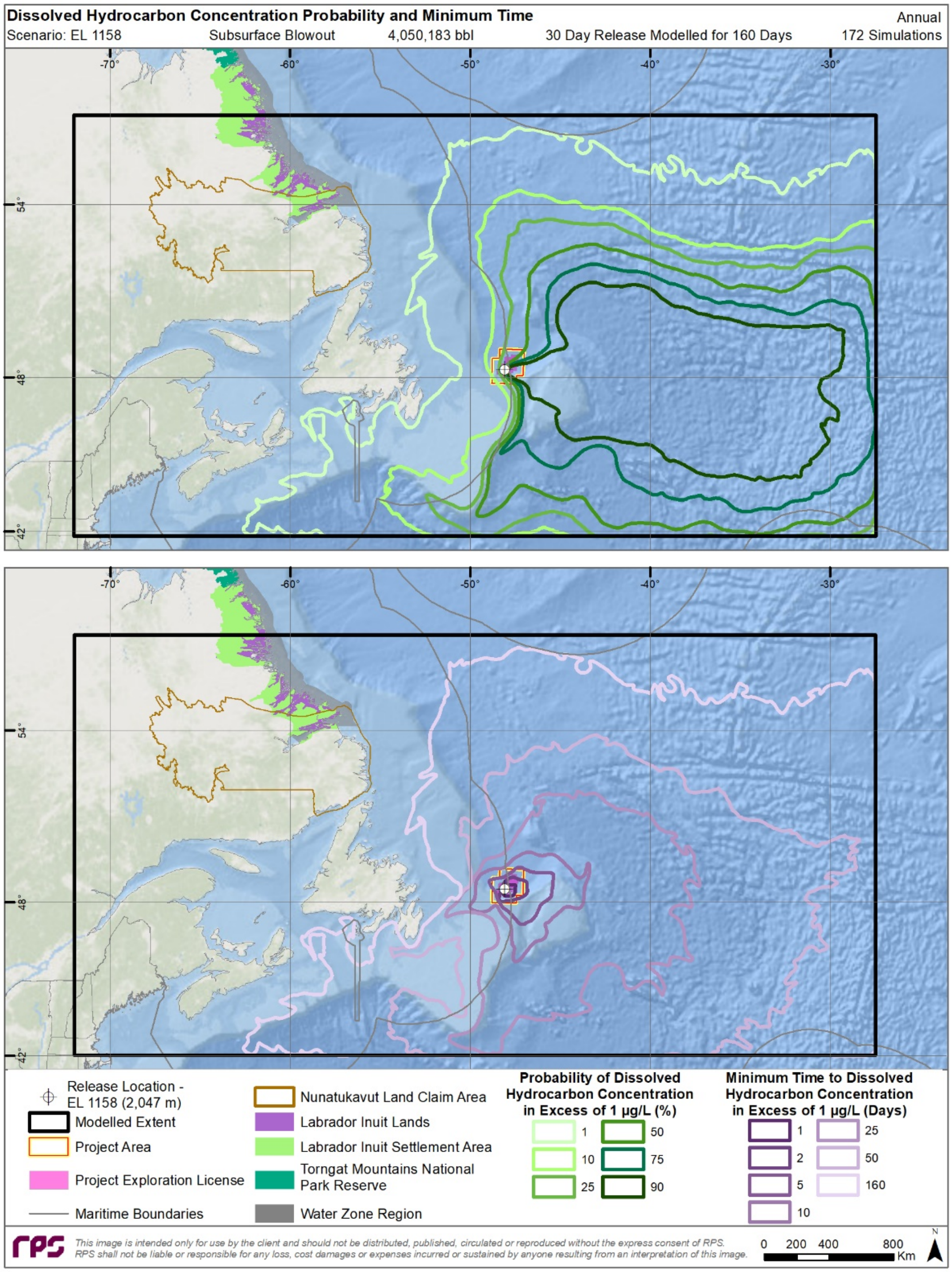



**Figure 15-16 Annual probability of dissolved hydrocarbon concentrations >1 µg/L at some depth in the water column (top) and minimum time to threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1158**

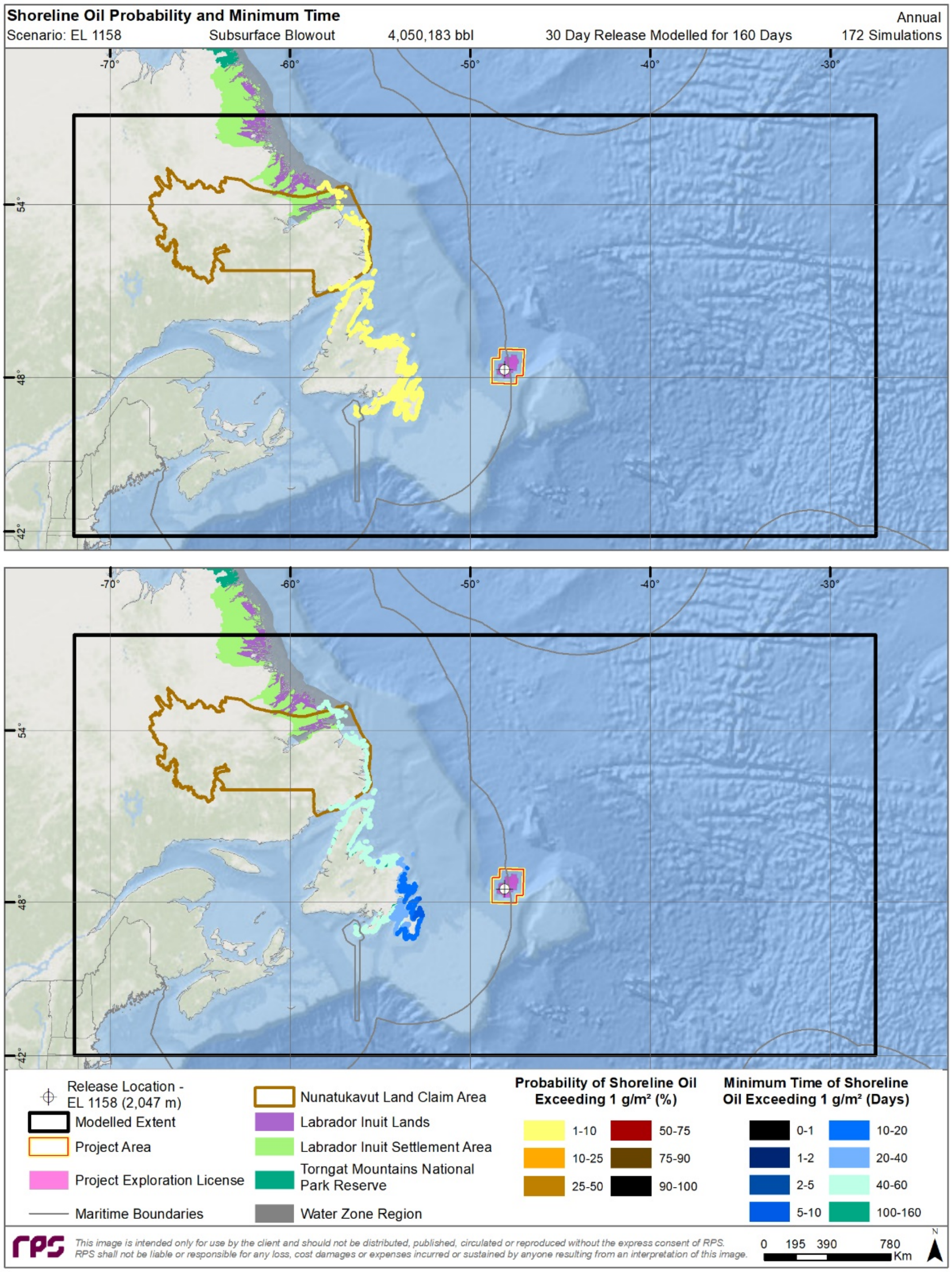



**Figure 15-17 Annual probability of shoreline contact >1 g/m² (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1158**

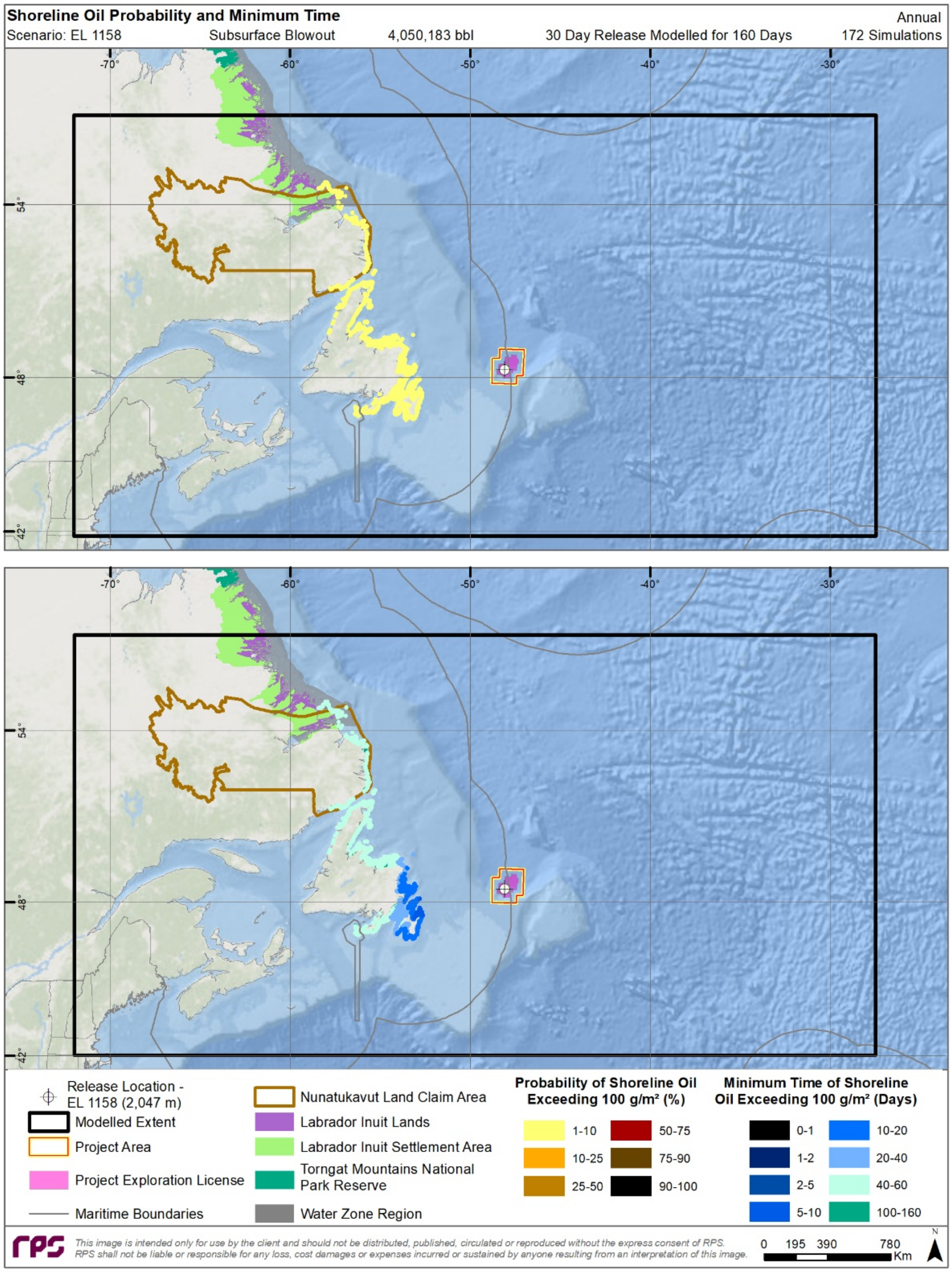



**Figure 15-18 Annual probability of shoreline contact >100 g/m² (top) and minimum time to ecological threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1158**

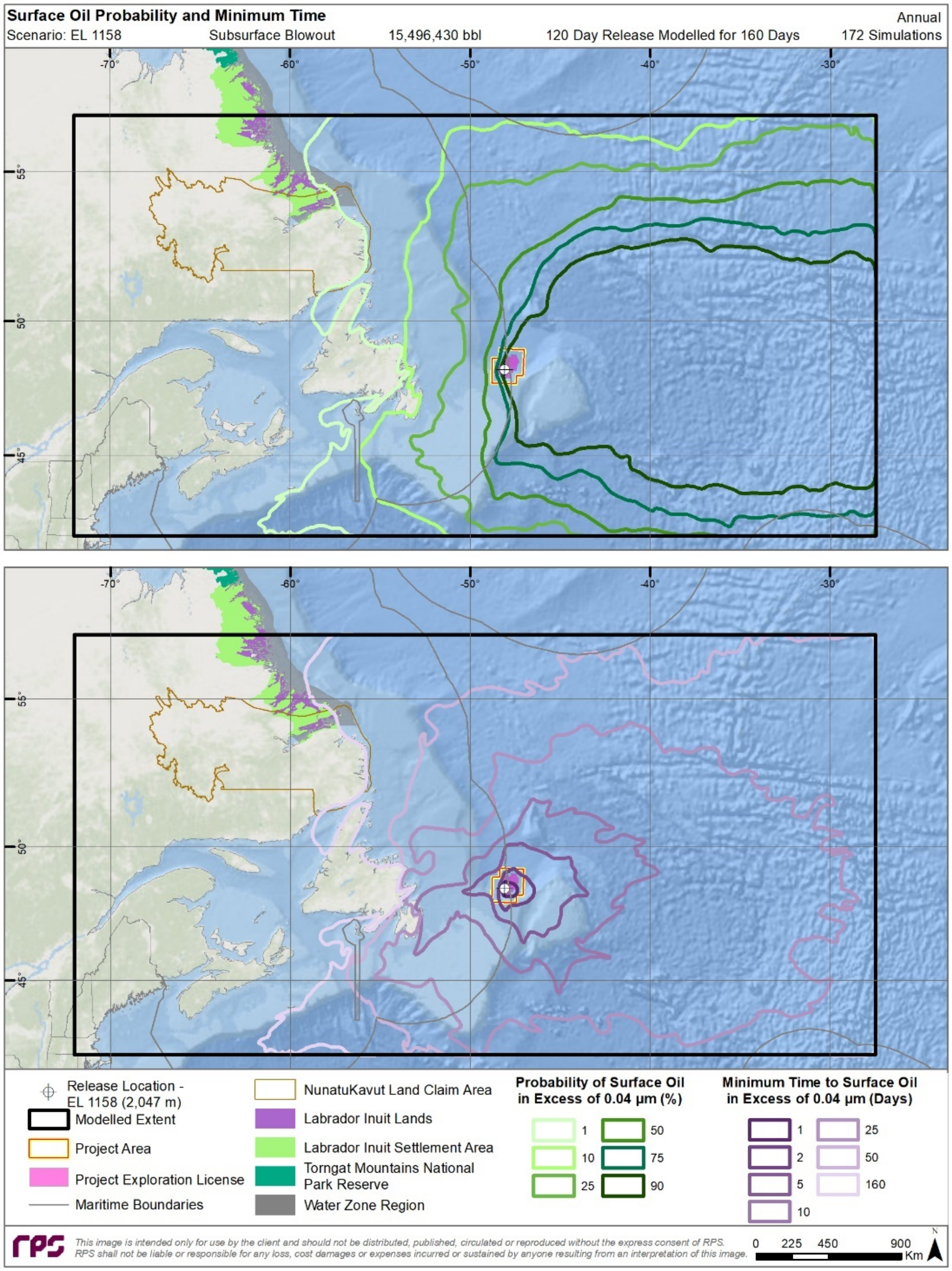



**Figure 15-19 Annual probability of surface oil thickness >0.04 µm (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1158**

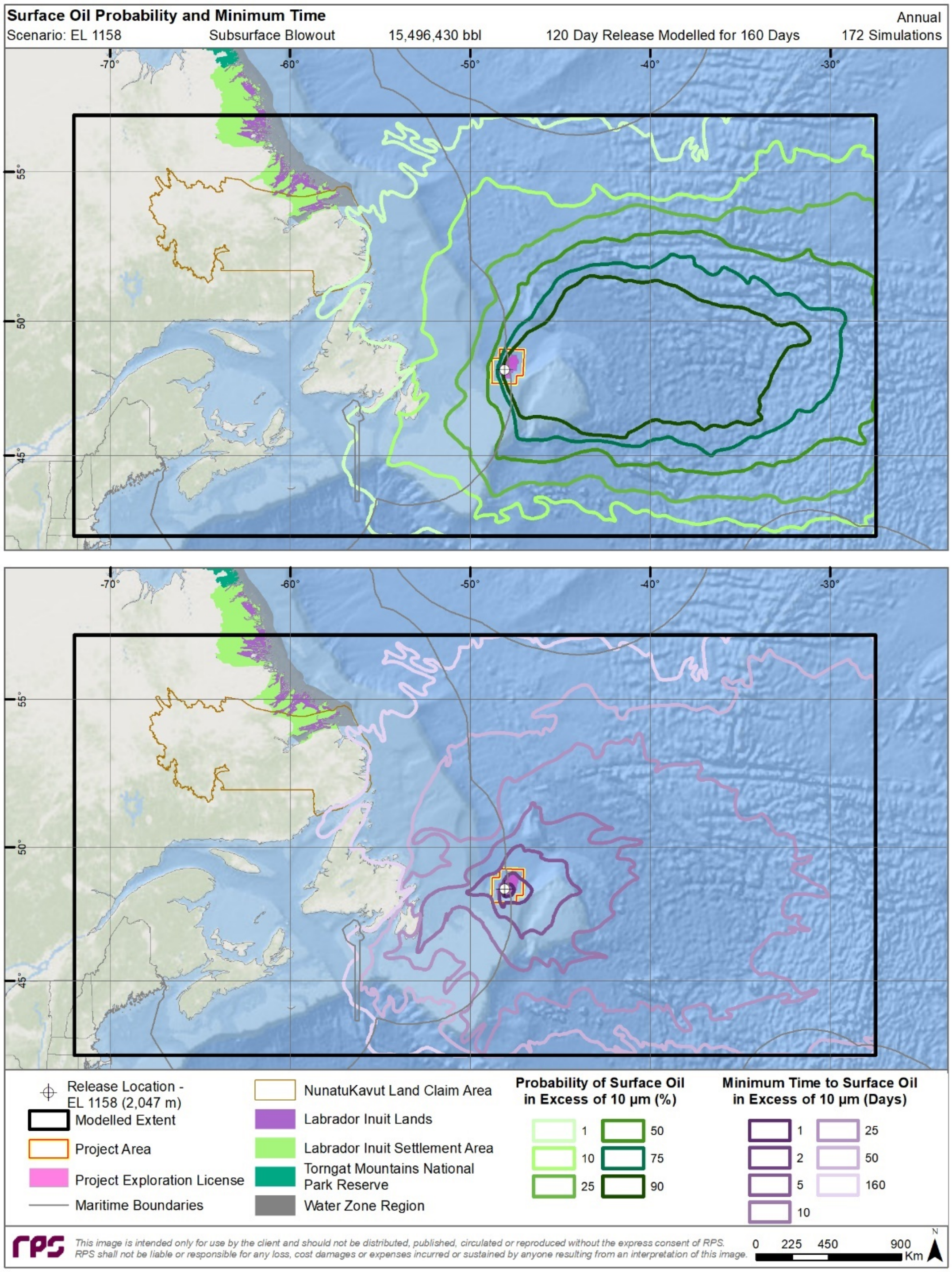



**Figure 15-20 Annual probability of surface oil thickness >10 µm (top) and minimum time to ecological threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1158**

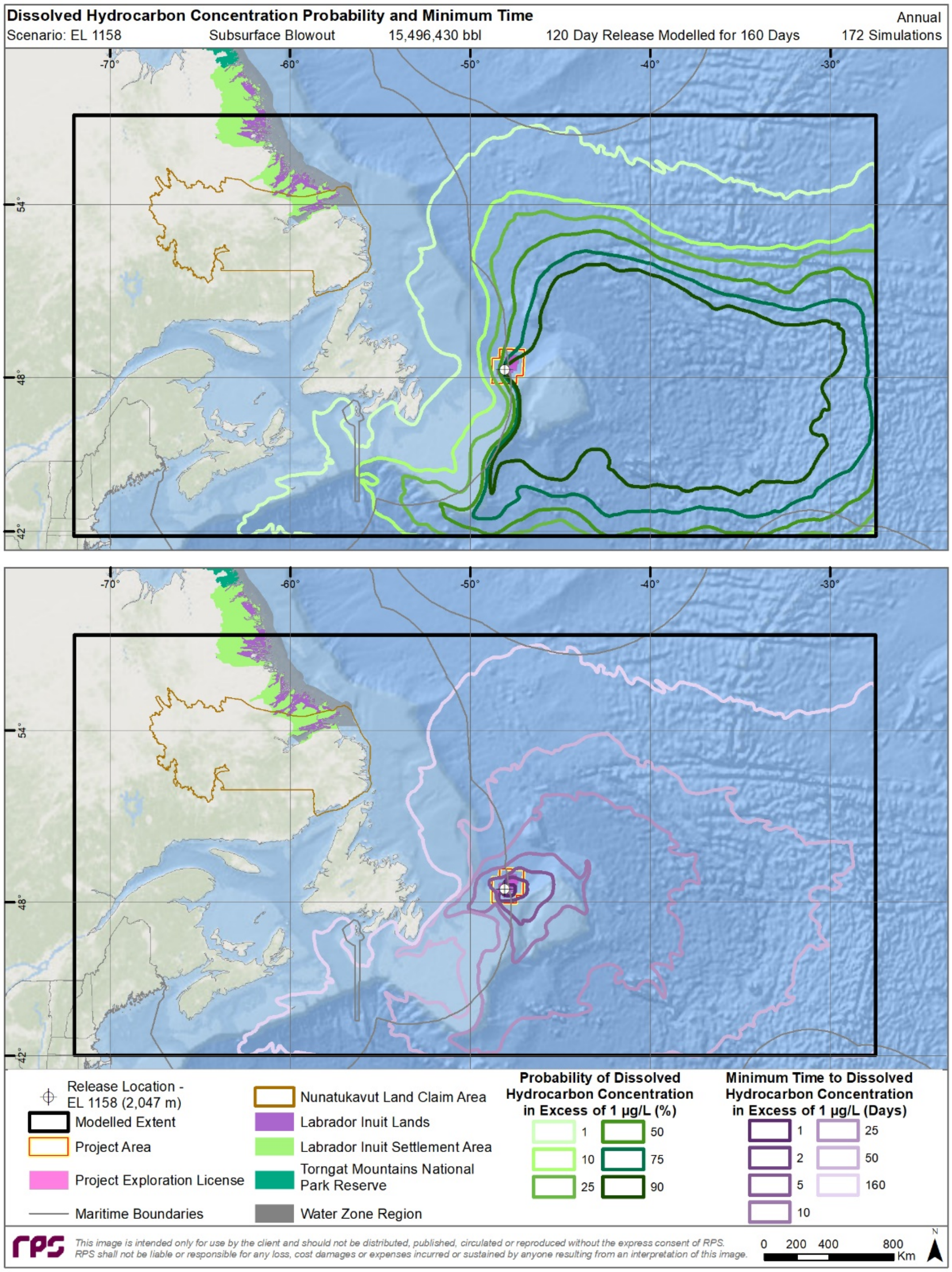



**Figure 15-21 Annual probability of dissolved hydrocarbon concentrations >1 µg/L at some depth in the water column (top) and minimum time to threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1158**

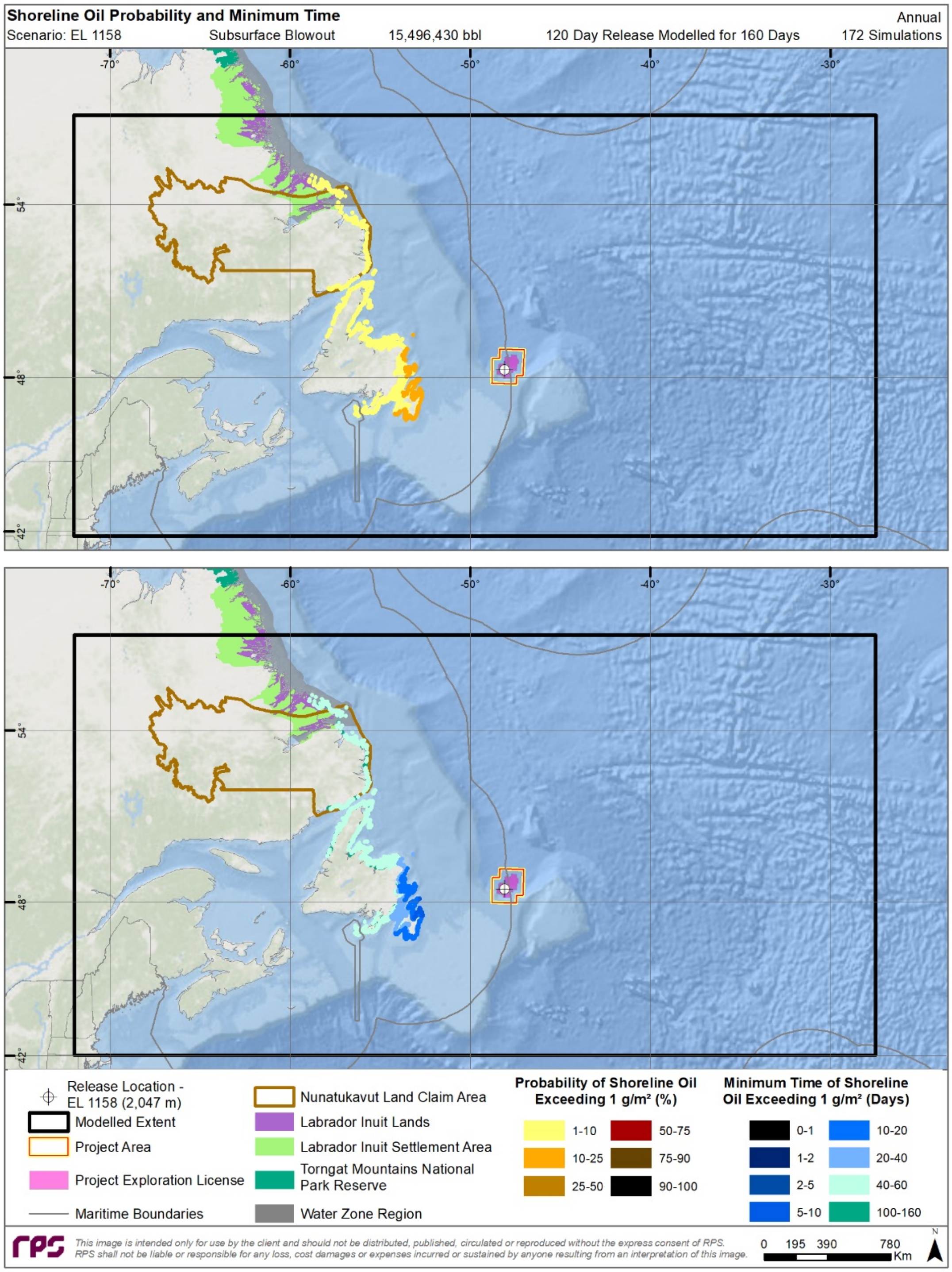



**Figure 15-22 Annual probability of shoreline contact >1 g/m² (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1158**

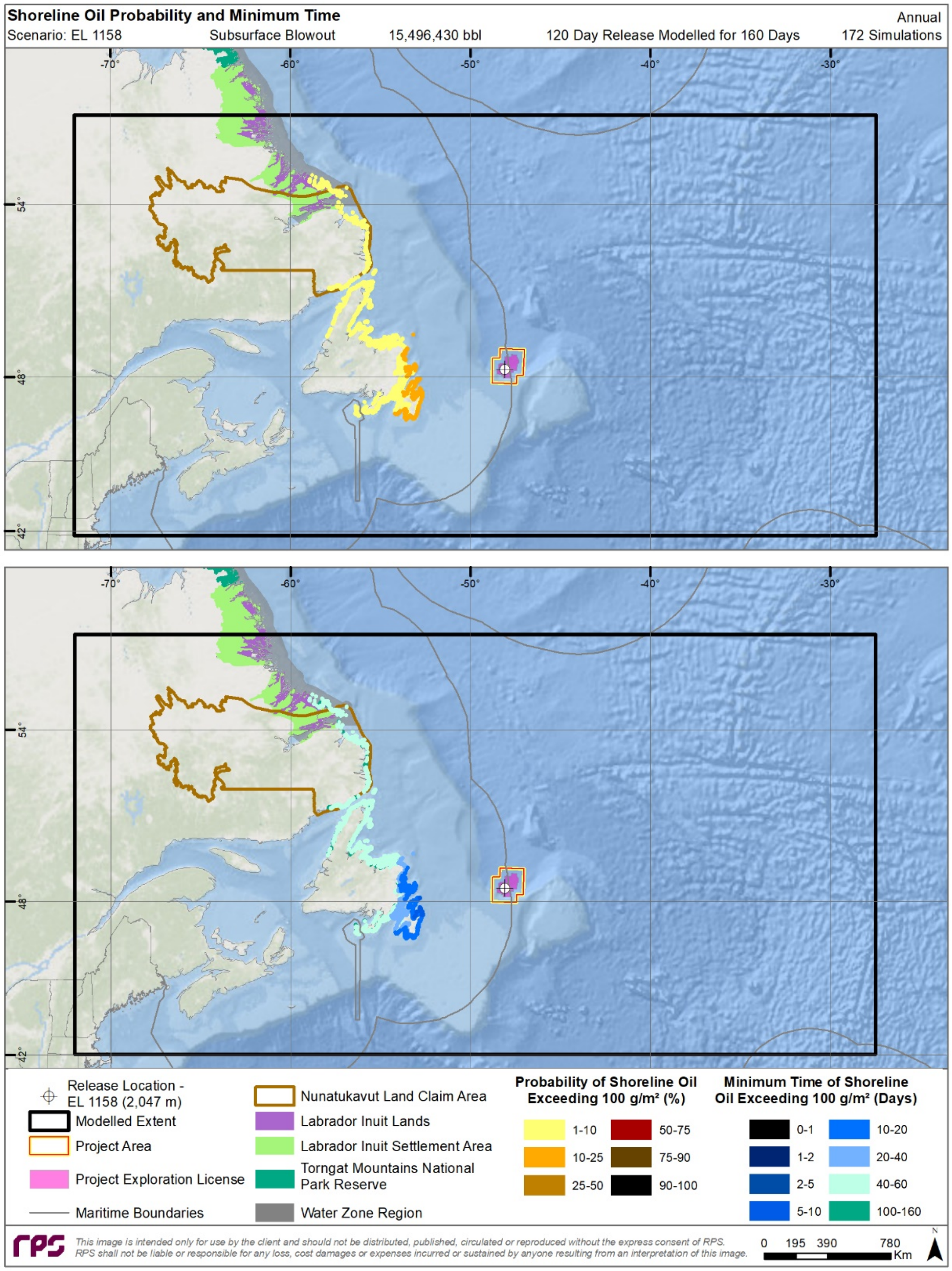



**Figure 15-23 Annual probability of shoreline contact >100 g/m² (top) and minimum time to ecological threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1158**

### 15.3.1.3 Surface Diesel Batch Spill Results

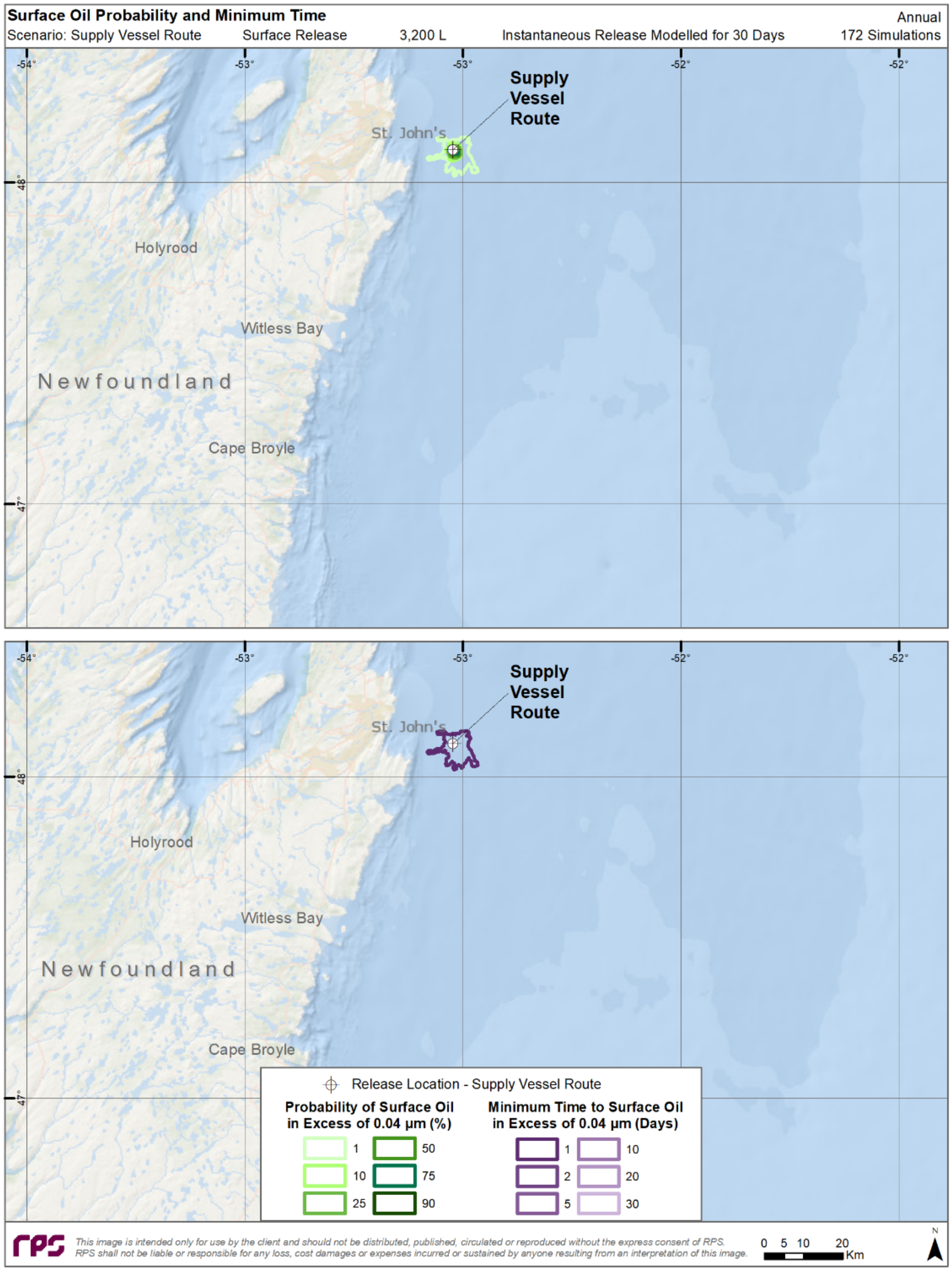



**Figure 15-24 Annual probability of surface oil thickness >0.04 µm (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a near-instantaneous surface diesel (batch spill) release**

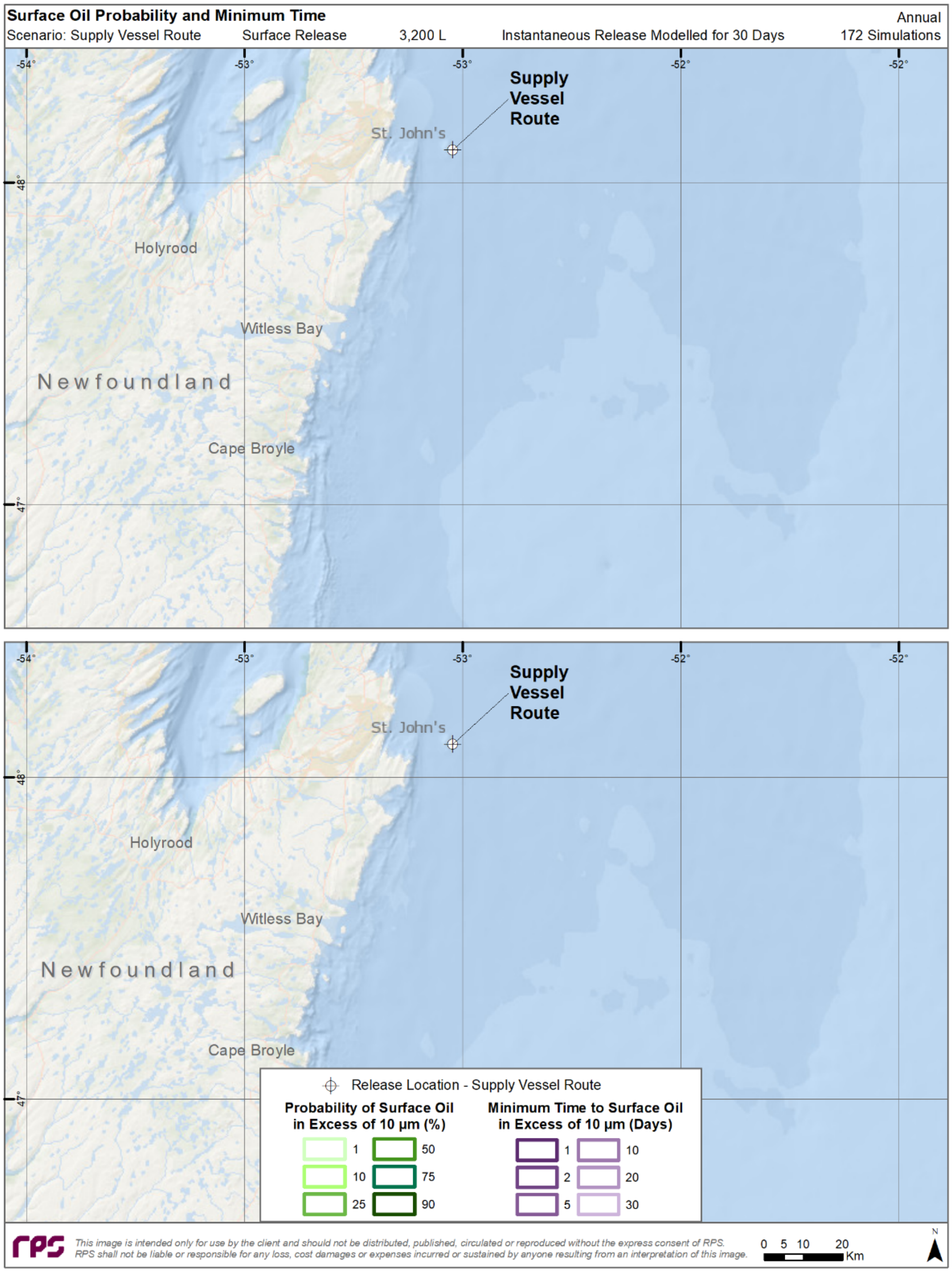



**Figure 15-25 Annual probability of surface oil thickness >10 µm (top) and minimum time to ecological threshold exceedance (bottom) predictions resulting from a near-instantaneous surface diesel (batch spill) release**

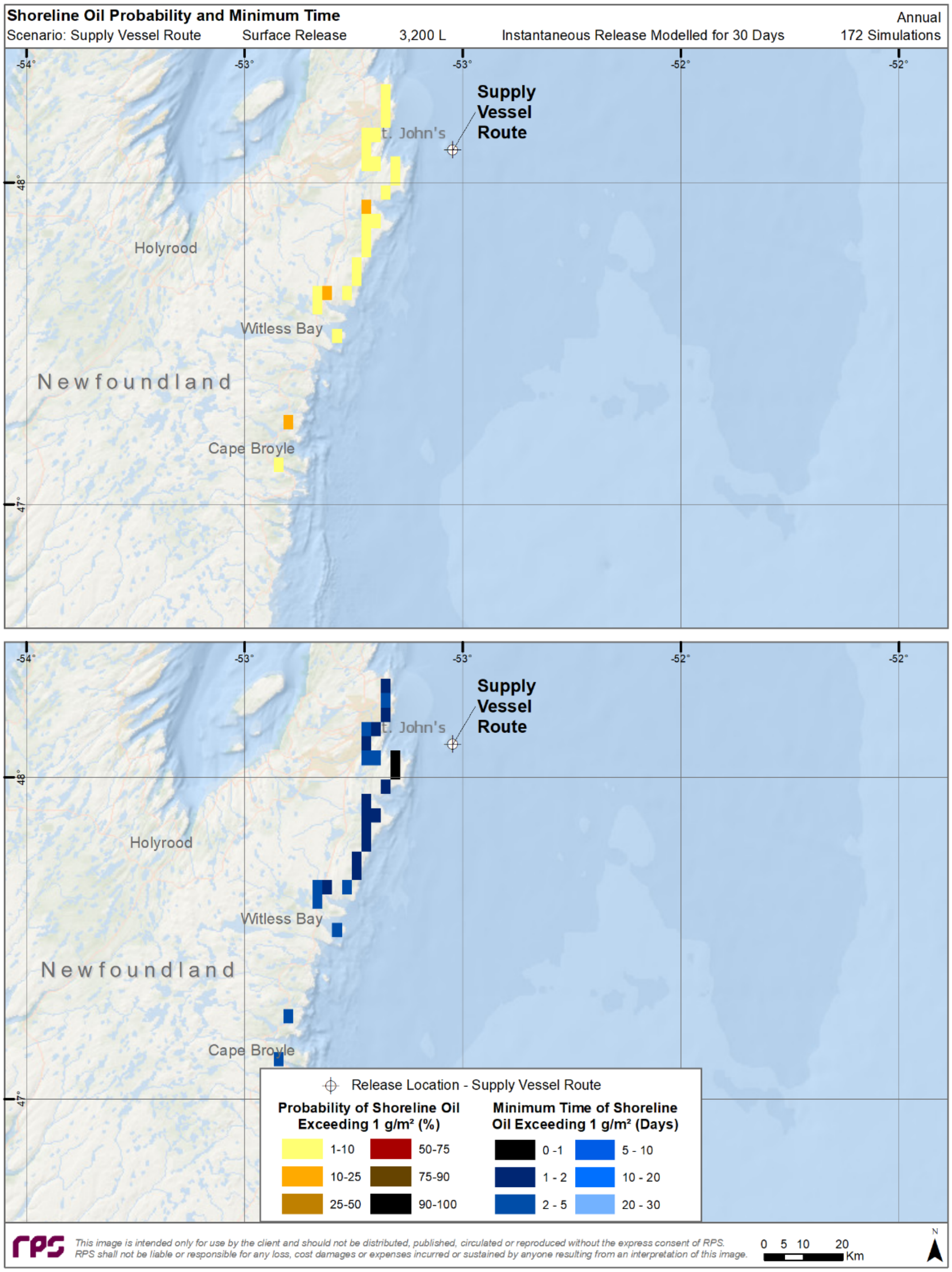



**Figure 15-26 Annual probability of shoreline contact >1 g/m² (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a near-instantaneous surface diesel (batch spill) release**


**Figure 15-27 Annual probability of shoreline contact >100 g/m² (top) and minimum time to ecological threshold exceedance (bottom) predictions resulting from a near-instantaneous surface diesel (batch spill) release**

**Table 15.5 Summary of Threshold Exceedances Predicted for Surface and Water Column Exposure within the Modelled Domain by Season (annual, winter, summer)**

| Stochastic Scenario Parameters | | | | Areas Exceeding Socio-Economic Threshold (km²) | | | Areas Exceeding Ecological Threshold (km²) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Component** | **Spill Location** | **Release Scenario** | **Probability Contour or Bin*** | **Annual** | **Winter (ice cover)** | **Summer (ice-free)** | **Annual** | **Winter (ice cover)** | **Summer (ice-free)** |
| Surface Oil | EL 1157 | 30-day release | 1% | 3,499,000 | 3,540,000 | 3,342,000 | 3,389,000 | 3,454,000 | 3,015,000 |
| | | | 10% | 2,733,000 | 2,895,000 | 2,603,000 | 1,709,000 | 1,832,000 | 1,553,000 |
| | | | 90% | 664,100 | 586,600 | 746,500 | 74,790 | 72,480 | 103,200 |
| | | 120-day release | 1% | 3,547,000 | 3,580,000 | 3,546,000 | 3,372,000 | 3,421,000 | 3,248,000 |
| | | | 10% | 3,048,000 | 3,148,000 | 2,895,000 | 2,433,000 | 2,578,000 | 2,219,000 |
| | | | 90% | 1,209,000 | 1,244,000 | 1,245,000 | 510,900 | 527,300 | 526,300 |
| | EL 1158 | 30-day release | 1% | 3,518,000 | 3,548,000 | 3,444,000 | 3,296,000 | 3,404,000 | 3,031,000 |
| | | | 10% | 2,782,000 | 2,930,000 | 2,650,000 | 1,711,000 | 1,834,000 | 1,626,000 |
| | | | 90% | 741,200 | 645,800 | 856,000 | 87,130 | 94,400 | 91,100 |
| | | 120-day release | 1% | 3,584,000 | 3,646,000 | 3,636,000 | 3,402,000 | 3,441,000 | 3,352,000 |
| | | | 10% | 3,053,000 | 3,155,000 | 2,949,000 | 2,439,000 | 2,637,000 | 2,235,000 |
| | | | 90% | 1,310,000 | 1,310,000 | 1,400,000 | 556,500 | 557,100 | 583,000 |
| | Vessel Route Location | Instantaneous release | 1% | 27 | 31 | 68 | - | - | - |
| | | | 10% | 6 | 6 | 5 | - | - | - |
| | | | 90% | <1 | <1 | <1 | - | - | - |
| Water Column Dissolved Hydrocarbons | EL 1157 | 30-day release | 1% | 2,903,000 | 3,060,000 | 2,741,000 | Ecological threshold is the same value as the socio-economic threshold for water column effects | | |
| | | | 10% | 2,091,000 | 2,075,000 | 1,984,000 | | | |
| | | | 90% | 697,200 | 495,700 | 595,000 | | | |
| | | 120-day release | 1% | 3,004,000 | 3,128,000 | 2,909,000 | | | |
| | | | 10% | 2,271,000 | 2,290,000 | 2,125,000 | | | |
| | | | 90% | 1,017,000 | 799,800 | 964,000 | | | |

## Table 15.5 Summary of Threshold Exceedances Predicted for Surface and Water Column Exposure within the Modelled Domain by Season (annual, winter, summer)

| Stochastic Scenario Parameters | | | | Areas Exceeding Socio-Economic Threshold (km²) | | | Areas Exceeding Ecological Threshold (km²) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Component** | **Spill Location** | **Release Scenario** | **Probability Contour or Bin*** | **Annual** | **Winter (ice cover)** | **Summer (ice-free)** | **Annual** | **Winter (ice cover)** | **Summer (ice-free)** |
| Water Column Dissolved Hydrocarbons | EL 1158 | 30-day release | 1% | 2,970,000 | 3,101,000 | 2,850,000 | Ecological threshold is the same value as the socio-economic threshold for water column effects | | |
| | | | 10% | 2,169,000 | 2,114,000 | 2,055,000 | | | |
| | | | 90% | 738,000 | 537,400 | 605,900 | | | |
| | | 120-day release | 1% | 2,958,000 | 3,136,000 | 3,000,000 | | | |
| | | | 10% | 2,227,000 | 2,333,000 | 2,174,000 | | | |
| | | | 90% | 978,700 | 895,700 | 1,085,000 | | | |
| | Vessel Route Location | Instantaneous release | 1% | - | - | - | - | - | - |
| | | | 10% | - | - | - | - | - | - |
| | | | 90% | - | - | - | - | - | - |

* Predicted areas (km²) are provided for the >1%, 10%, or 90% likelihood of exposure to oil contours

**Table 15.6 Summary of Threshold Exceedance Information Predicted for Shoreline Oil Exposure within the Modelled Domain by Season (annual, winter, summer)**

| Stochastic Scenario Parameters | | | | Lengths Exceeding Socio-Economic Threshold (km) | | | Lengths Exceeding Ecological Threshold (km) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Component** | **Spill Location** | **Release Scenario** | **Probability Contour or Bin*** | **Annual** | **Winter (ice cover)** | **Summer (ice-free)** | **Annual** | **Winter (ice cover)** | **Summer (ice-free)** |
| Shoreline Oil | EL 1157 | 30-day release | 1 - 5% | 2,629 | 1,943 | 466 | 2,626 | 1,941 | 463 |
| | | | 5 - 15% | 154 | 1,025 | 15 | 150 | 1,021 | 15 |
| | | | 15 - 30% | - | - | - | - | - | - |
| | | | All Probabilities | 2,782 | 2,968 | 480 | 2,776 | 2,962 | 478 |
| | | 120-day release | 1 - 5% | 2,556 | 1,574 | 1,330 | 2,255 | 1,546 | 1,337 |
| | | | 5 - 15% | 1,465 | 1,599 | 404 | 1,426 | 1,587 | 401 |
| | | | 15 - 30% | 79 | 771 | - | 81 | 794 | - |
| | | | All Probabilities | 4,100 | 3,933 | 1,734 | 3,762 | 3,927 | 1,738 |
| | EL 1158 | 30-day release | 1 - 5% | 2,494 | 1,915 | 498 | 1,937 | 1,424 | 498 |
| | | | 5 - 15% | 143 | 942 | 13 | 100 | 839 | 13 |
| | | | 15 - 30% | - | - | - | - | - | - |
| | | | All Probabilities | 2,637 | 2,857 | 510 | 2,037 | 2,263 | 510 |
| | | 120-day release | 1 - 5% | 2,537 | 1,533 | 1,200 | 2,244 | 1,053 | 562 |
| | | | 5 - 15% | 794 | 1,619 | 427 | 1,296 | 1,606 | 429 |
| | | | 15 - 30% | 68 | 653 | 15 | 66 | 641 | 15 |
| | | | All Probabilities | 3,944 | 3,805 | 1,642 | 3,606 | 3,300 | 1,006 |
| | Vessel Route Location | Instantaneous release | 1 - 5% | 34 | 23 | 21 | - | - | - |
| | | | 5 - 15% | 19 | 9 | 28 | - | - | - |
| | | | 15 - 30% | - | - | 4 | - | - | - |
| | | | All Probabilities | 53 | 32 | 53 | - | - | - |

*The predicted length (km) of shoreline susceptible to exposure by oil is provided at 1-5%, 5-15%, and 15-30% contoured intervals.

## Table 15.7 Shoreline Contamination Probabilities and Minimum Time for Oil Exposure for All Shorelines

| Threshold | Spill Location | Scenario | Scenario Timeframe | Probability of Shoreline Oil Contamination (%) | | Time to Shore (days) | |
|---|---|---|---|---|---|---|---|
| | | | | Average | Maximum | Minimum | Maximum |
| Oil exposure exceeding 1 g/m² for all shorelines | EL 1157 | 30-day release | Annual | 3 | 9 | 7 | 137 |
| | | | Winter | 5 | 15 | 7 | 158 |
| | | | Summer | 4 | 8 | 22 | 157 |
| | | 120-day release | Annual | 6 | 20 | 7 | 147 |
| | | | Winter | 9 | 28 | 7 | 160 |
| | | | Summer | 3 | 14 | 22 | 160 |
| | EL 1158 | 30-day release | Annual | 3 | 9 | 7 | 135 |
| | | | Winter | 5 | 15 | 7 | 156 |
| | | | Summer | 3 | 8 | 14 | 157 |
| | | 120-day release | Annual | 5 | 21 | 7 | 148 |
| | | | Winter | 8 | 27 | 7 | 159 |
| | | | Summer | 4 | 18 | 27 | 160 |
| | Vessel Route Location | Instantaneous release | Annual | 5 | 14 | 1 | 17 |
| | | | Winter | 4 | 11 | 1 | 29 |
| | | | Summer | 7 | 17 | 1 | 17 |
| Oil exposure exceeding 100 g/m² for all shorelines | EL 1157 | 30-day release | Annual | 3 | 9 | 7 | 137 |
| | | | Winter | 5 | 15 | 7 | 158 |
| | | | Summer | 4 | 8 | 22 | 157 |
| | | 120-day release | Annual | 6 | 20 | 7 | 147 |
| | | | Winter | 9 | 28 | 7 | 160 |
| | | | Summer | 3 | 14 | 22 | 160 |
| | EL 1158 | 30-day release | Annual | 3 | 9 | 7 | 135 |
| | | | Winter | 5 | 15 | 7 | 156 |
| | | | Summer | 3 | 8 | 14 | 157 |
| | | 120-day release | Annual | 5 | 21 | 7 | 148 |
| | | | Winter | 8 | 27 | 7 | 159 |
| | | | Summer | 4 | 18 | 27 | 160 |
| | Vessel Route Location | Instantaneous release | Annual | - | - | - | - |
| | | | Winter | - | - | - | - |
| | | | Summer | - | - | - | - |

As required in the EIS Guidelines, these results are predicted from worst-case open hole blowouts for up to 120 days, with no effort to stop the release, contain the spread or mitigate its effects. BHP's environmental policies and management system would not allow such an unmitigated scenario and will be actively employed to decrease the likelihood and consequence of a spill.

Figures depicting stochastic results for summer and winter scenarios for the two release sites are provided in Appendix F.

### 15.3.2 Deterministic Modelling

Representative deterministic scenarios (i.e., single trajectory) were identified from each set of stochastic results of subsurface blowouts (Table 15.8). Individual scenarios were selected based upon the size of the surface oil footprint, the concentration of dissolved hydrocarbons in the water column, and the length of shoreline contacted with oil, contingent upon the set of highly conservative socio-economic thresholds mentioned above.

The selected cases for deterministic analysis included the identified 95th percentile scenarios for surface oil footprint (by area), water column concentration (by volume), and shoreline oil length predicted to be affected by the subsurface releases at EL 1157 and EL 1158. Additionally, the mass balance information was provided for the 50th percentile scenario for surface oil footprint scenario and the 95th percentile scenarios for the batch releases of marine diesel.

For comparison purposes, Annex A of the RPS report (Appendix F) provides the result of modelling a subsurface release with mitigations. The effects assessment (Section 15.6) of the EIS does not consider the mitigated modelling results as the EIS guidelines require “modelling for worst-case large-scale spill scenarios,” and would not include mitigation.

The figures provided depict the cumulative footprint of all oil predicted to be within a region over the entire modelled duration. Therefore, the depicted footprints are much larger than the amount of oil that would be present in a region at any given time following the release of oil. This concept is illustrated in Figure 4-73, Appendix F, which portrays predicted surface oil thickness at five specific time steps or “snapshots” in time (days 2, 10, 50, 100, and 160) for the 95th percentile surface oil thickness case for the 120-day release at EL 1157. Note the patchy and discontinuous nature of the predicted footprint as the released oil dispersed and thinned over time. Figure 4-74, Appendix F portrays the cumulative footprint for the exact same simulation. The area covered is much larger, depicting the maximum surface oil thickness that was predicted to occur at each location over the entire modelled time period. The deterministic figures in the RPS report (Appendix F) depict cumulative footprints as opposed to “snapshots” at given time steps to provide conservative estimates of potentially affected areas.

## Table 15.8 Selected Representative Deterministic Scenarios

| Scenario Parameter | Release Parameters for Representative Deterministic Scenarios | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 d Subsurface Release | | | 120 d Subsurface | | | 30 d Subsurface Release | | | 120 d Subsurface | | | Surface Batch Spill | | | |
| Representative Scenario | Surface Oil Exposure Area | Water Column Oil Volume | Shoreline Contact Length | Surface Oil Exposure Area | Water Column Oil Volume | Shoreline Contact Length | Surface Oil Exposure Area | Water Column Oil Volume | Shoreline Contact Length | Surface Oil Exposure Area | Water Column Oil Volume | Shoreline Contact Length | 50th % Surface Oil Exposure Area | 95th % Surface Oil Exposure Area | 95th % Water Column Oil Volume | 95th Shoreline Contact Length |
| Block<br>Release Site | EL 1157 | | | | | | EL 1158 | | | | | | Vessel Route | | | |
| Release Type | Subsurface Blowout | | | | | | | | | | | | Surface Batch Spill | | | |
| Water Depth of Release | 2,338 m | | | | | | 2,047 m | | | | | | Surface | | | |
| Released Product | Bay du Nord | | | | | | | | | | | | Marine Diesel | | | |
| Release Duration | 30 d | | | 120 d | | | 30 d | | | 120 d | | | Near-Instantaneous | | | |
| Release Rate | 135,084 bpd | | | 129,141 bpd | | | 135,006 bpd | | | 129,137 bpd | | | - | | | |
| Total Released Volume | 4,052,506 bbl | | | 15,496,924 bbl | | | 4,050,183 bbl | | | 15,496,430 bbl | | | 3,200 L | | | |
| Model Duration | 160 d | | | | | | | | | | | | 30 d | | | |
| Modelled Start Date and Season | Nov. 8, 2009 Winter | Oct. 30, 2010 Winter | Mar. 31, 2008 Summer | Jan. 15, 2010 Winter | Jul. 22, 2010 Summer | Nov. 8, 2009 Winter | Apr. 7, 2008 Summer | Dec. 11, 2009 Winter | Apr. 7, 2008 Summer | Jan. 6, 2010 Winter | Sep. 7, 2010 Winter | Dec. 9, 2010 Winter | Apr. 20, 2007 Summer | Nov. 1, 2011 Winter | Oct. 10, 2007 Winter | Mar. 12, 2011 Summer |

For most representative credible “worst-case” deterministic scenarios at EL 1157 and EL 1158, natural degradation processes (evaporation and biological degradation) weathered most of the oil over the 160-day model simulations. The highly volatile nature and large proportion of lower molecular weight compounds in the BdN oil resulted in large percentages of evaporated (>41%) and degraded (31 to 43%) oil, accounting for up to 87% of each modelled release over each 160-day simulation. The amount of oil predicted to remain on the water surface or within the water column totaled 2 to 17%, understanding that entrainment and resurfacing can result in surface and entrained oil “see-sawing” between the two environmental compartments based upon wind / wave conditions on hourly time-scales. Between 3 to 22% of oil (predominantly persistent surface oil) was predicted to be transported by winds outside the model domain (to the east) over the 160-day simulation. Shoreline contact made up a very small proportion of released oil for these simulations with a maximum value of <3% of the released oil contacting shorelines. Oil transported to the sediment was not a major fate pathway for these completely unmitigated offshore subsurface blowouts with <0.01% predicted to settle on sediments. Note that all scenarios assume a completely unmitigated release, which is an unlikely situation, as emergency response tactics would typically be employed in the event of a spill within hours to days of the release.

The batch spill releases of 3,200 L marine diesel were predicted to result in silver or colorless sheens (<0.0001 mm) of oil floating on the water surface. Generally, oil was predicted to be transported south and, in some cases, wrap around the Avalon peninsula towards Saint Lawrence, Newfoundland. However, this small amount of oil was at thicknesses below the socio-economic threshold. The 95th percentile shoreline exposure case was predicted to lead to shoreline oil contamination exceeding the socio-economic threshold of 1 g/m² on over approximately 1,010 km of shoreline, with the biological threshold exceeded over 9 km.

The hypothetical releases modelled in this study are not intended to predict a specific future event, but rather are intended to be used as a tool in environmental assessments and spill contingency planning. The results presented in this document demonstrate that there are a range of potential trajectories and fates that could result if a release of crude oil or a batch spill of marine diesel were to occur at any point throughout the year. The specific trajectories and fates vary greatly for each release based upon the environmental conditions occurring at the time of the release. While each oil release is unique, and uncertainties exist, the results of this modelling study suggest that, if oil were to be released in the Project Area, it has a high likelihood of moving away from shore to the east with less likelihood of shoreline oil exposure. Furthermore, this modelling assumes completely unmitigated releases, which is an unlikely situation because emergency response measures would typically be employed in the event of a spill.

Surface oil thickness, water column THC, and shoreline and sediment THC are described in the following sections; mass balance plots are provided for each of the scenarios. The complete oil spill trajectory modelling report is provided in Appendix F.

#### 15.3.2.1 Surface Oil Thickness

Overall predicted surface area exposed to oil > 0.001 mm (dull brown sheens to heavy black oil) was similar between sites and release durations for the selected deterministic cases. Larger surface areas were predicted for the 120-day releases at both sites compared to the 30-day releases (Figures 4-81 and 4-76, Appendix F; Table 15.9). Heavy black oil (> 1 mm) was not predicted in any of the selected deterministic cases due to the natural dispersion as oil rose from the relatively deep release locations and the light and low viscosity BdN crude oil, which tended to spread rapidly. It is important to note that these scenarios were identified as some of the largest predicted cumulative surface oil footprints (95th percentile) out of all (172) of the 160-day simulations.

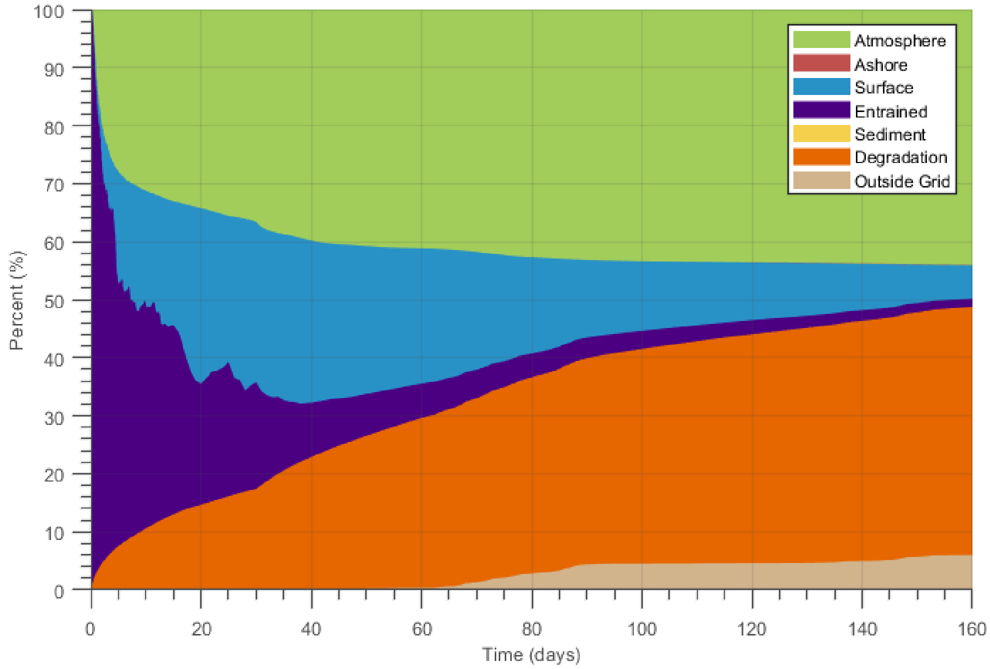
At the end of the 160-day simulations of the 95th percentile surface oil exposure for 30- and 120-day releases at the EL 1157 site, large percentages of the oil evaporated (approximately 42 to 46%) and degraded (33 to 43%), accounting for >77% of each modelled release (Figure 15-28). The amount of oil predicted to remain on the water surface was <15%, with 3% and less within the water column (Table 15.10). Up to 13% of oil (predominantly persistent surface oil) was predicted to be transported outside of the modelled domain. Shoreline contact made up a very small proportion of releases (<1%) and oil transported to the sediment was not a major fate pathway with <0.1% predicted to settle on sediments (Table 15.10). At the EL 1158 site, 42 to 46% of oil was predicted to evaporate and 31 to 42% degrade (Figure 15-29). Less than 15% was predicted to remain floating on the water surface, 3 to 22% was transported outside the modelled domain, <3% remained within the water column, and <0.1% settled on sediment. Similar to the cases at EL 1157, shoreline contact made up a small percentage of the released oil (<1%) (Table 15.10).

### Table 15.9 Representative Deterministic Cases and Associated Areas, Lengths, and Volumes Exceeding Specified Thresholds for Representative Trajectories at EL 1157, EL 1158, and a PSV Route Location

| 95th Percentile Scenario | Site | Released Volume | Approximate Surface Area exceeding thickness thresholds ($km^2$) | | Approximate Shore Length exceeding mass per unit area thresholds (km) | | Approximate Subsurface Volume exceeding THC threshold ($km^3$) |
|---|---|---|---|---|---|---|---|
| | | | Socio-economic (0.04 µm) | Ecologic (10 µm) | Socio-economic (1 g/m²) | Ecologic (100 g/m²) | Socio-economic (1 µg/L) |
| **Subsurface Blowout Releases** | | | | | | | |
| Surface oil exposure case- 30 d | EL 1157 | 4,052,506 bbl | 2,705,000 | 832,900 | 226 | 216 | 77,010 |
| Water column case- 30 d | | | 2,843,000 | 1,031,000 | 4,510 | 4,384 | 64,230 |
| Shoreline contact case- 30 d | | | 2,267,000 | 833,300 | 1,409 | 1,358 | 64,070 |
| Surface oil exposure case- 120 d | | 15,496,924 bbl | 3,037,000 | 1,616,000 | 1,668 | 1,608 | 78,860 |
| Water column case- 120 d | | | 2,446,000 | 1,406,000 | 756 | 735 | 86,370 |
| Shoreline contact case- 120 d | | | 2,953,000 | 1,645,000 | 1,597 | 1,547 | 82,010 |
| Surface oil exposure case- 30 d | EL 1158 | 4,050,183 bbl | 2,322,000 | 837,400 | 1,241 | 1,194 | 60,290 |
| Water column case- 30 d | | | 2,616,000 | 1,012,000 | 9 | 6 | 65,470 |
| Shoreline contact case- 30 d | | | 2,322,000 | 837,400 | 1,241 | 1,194 | 60,290 |
| Surface oil exposure case- 120 d | | 15,496,430 bbl | 3,050,000 | 1,573,000 | 1,006 | 965 | 76,150 |
| Water column case- 120 d | | | 3,185,000 | 1,816,000 | 4,264 | 4,258 | 99,090 |
| Shoreline contact case- 120 d | | | 2,311,000 | 1,433,000 | 1,478 | 1,401 | 79,950 |

### Table 15.9 Representative Deterministic Cases and Associated Areas, Lengths, and Volumes Exceeding Specified Thresholds for Representative Trajectories at EL 1157, EL 1158, and a PSV Route Location

| 95th Percentile Scenario | Site | Released Volume | Approximate Surface Area exceeding thickness thresholds (km²) | | Approximate Shore Length exceeding mass per unit area thresholds (km) | | Approximate Subsurface Volume exceeding THC threshold (km³) |
|---|---|---|---|---|---|---|---|
| | | | Socio-economic (0.04 µm) | Ecologic (10 µm) | Socio-economic (1 g/m²) | Ecologic (100 g/m²) | Socio-economic (1 µg/L) |
| **Batch Spill** | | | | | | | |
| Surface Batch Spill 50th % Surface Oil Exposure Area | Vessel Route Location | 3,200 L | - | - | - | - | - |
| Surface Batch Spill 95th % Surface Oil Exposure Area | | | - | - | - | - | - |
| Surface Batch Spill 95th % Water Column Oil Volume | | | - | - | - | - | - |
| Surface Batch Spill 95th Shoreline Contact Length | | | - | - | 1,010 | 9 | - |



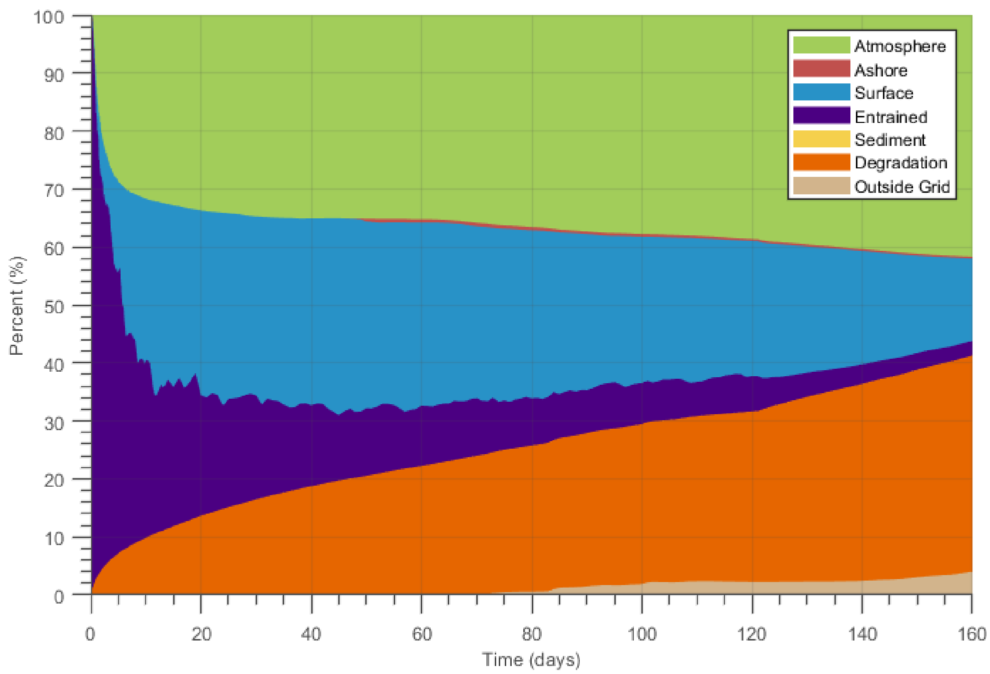
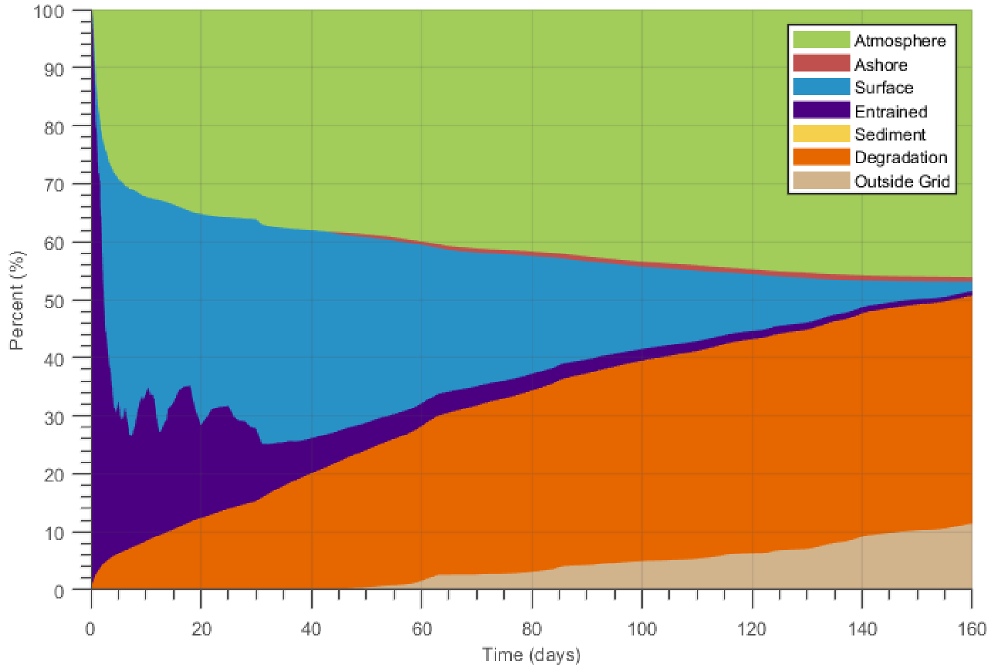




**Figure 15-28 Mass balance plots of the 95th percentile surface oil thickness cases resulting from 30- (top) and 120-day (bottom) blowouts at EL 1157**

## Table 15.10 Summary of the Mass Balance Information for All Representative Scenarios

| 95th Percentile Scenario | Site | Percent of Total Released Oil (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Surface | Evaporated | Water Column | Sediment | Ashore | Degraded | Outside Grid |
| **Subsurface Blowout Releases** | | | | | | | | |
| Surface oil exposure case- 30 d | EL 1157 | 5.8 | 44.0 | 1.4 | <0.1 | <0.1 | 42.8 | 6.0 |
| Water column case- 30 d | | 1.2 | 41.9 | 1.4 | <0.1 | 3.0 | 42.9 | 9.7 |
| Shoreline contact case- 30 d | | 1.7 | 44.4 | 1.0 | <0.1 | 1.2 | 39.1 | 12.6 |
| Surface oil exposure case- 120 d | | 14.3 | 41.7 | 2.5 | <0.1 | 0.3 | 37.3 | 4.0 |
| Water column case- 120 d | | 8.5 | 44.5 | 3.3 | <0.1 | 0.2 | 32.8 | 10.8 |
| Shoreline contact case- 120 d | | 14.2 | 41.8 | 2.7 | <0.1 | 0.4 | 37.8 | 3.2 |
| Surface oil exposure case- 30 d | EL 1158 | 1.6 | 46.1 | 0.7 | <0.1 | 0.8 | 39.3 | 11.4 |
| Water column case- 30 d | | 7.4 | 45.5 | 1.3 | <0.1 | <0.1 | 42.4 | 3.4 |
| Shoreline contact case- 30 d | | 1.6 | 46.1 | 0.7 | <0.1 | 0.8 | 39.3 | 11.4 |
| Surface oil exposure case- 120 d | | 14.3 | 42.5 | 2.2 | <0.1 | 0.1 | 36.1 | 4.8 |
| Water column case- 120 d | | 9.3 | 42.7 | 2.9 | <0.1 | 1.0 | 35.7 | 8.4 |
| Shoreline contact case- 120 d | | 2.9 | 42.1 | 2.2 | <0.1 | 0.2 | 30.6 | 22.1 |
| **Batch Spill** | | | | | | | | |
| Surface Batch Spill<br>50th % Surface Oil Exposure Area | Vessel Route Location | <0.1 | 67.2 | 11.9 | <0.1 | 0.0 | 20.9 | 0.0 |
| Surface Batch Spill<br>95th % Surface Oil Exposure Area | | <0.1 | 67.2 | 11.9 | <0.1 | 0.0 | 21.0 | 0.0 |
| Surface Batch Spill<br>95th % Water Column Oil Volume | | <0.1 | 64.2 | 12.6 | <0.1 | 0.0 | 23.1 | 0.0 |
| Surface Batch Spill<br>95th Shoreline Contact Length | | <0.1 | 80.4 | 6.2 | <0.1 | 1.1 | 12.3 | 0.0 |

Values represent a percentage (%) of the total amount of released oil at the end of the representative deterministic scenarios.



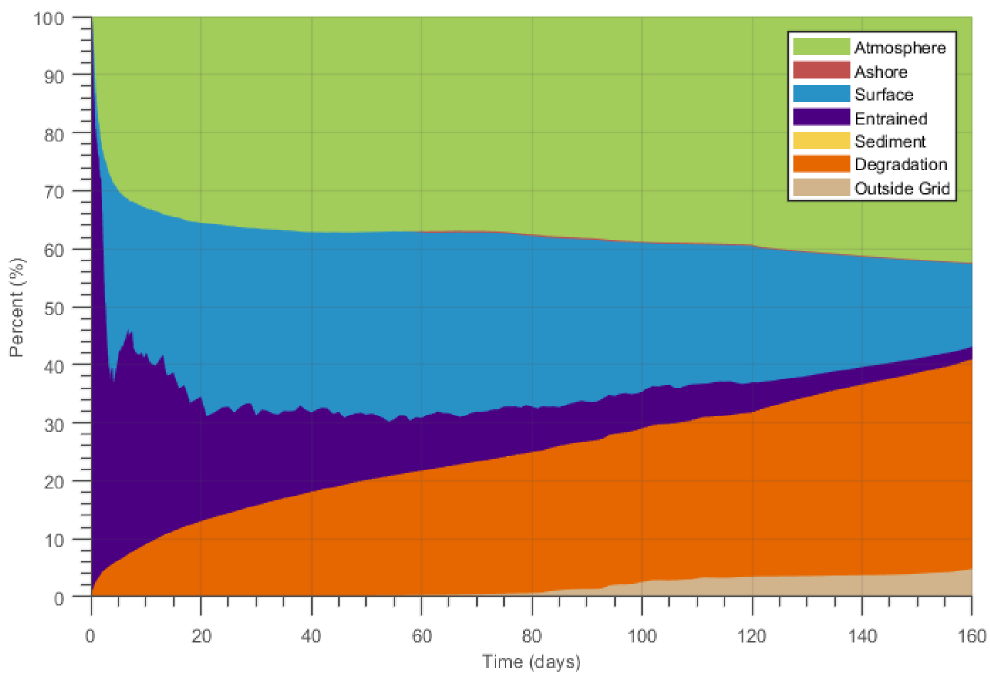
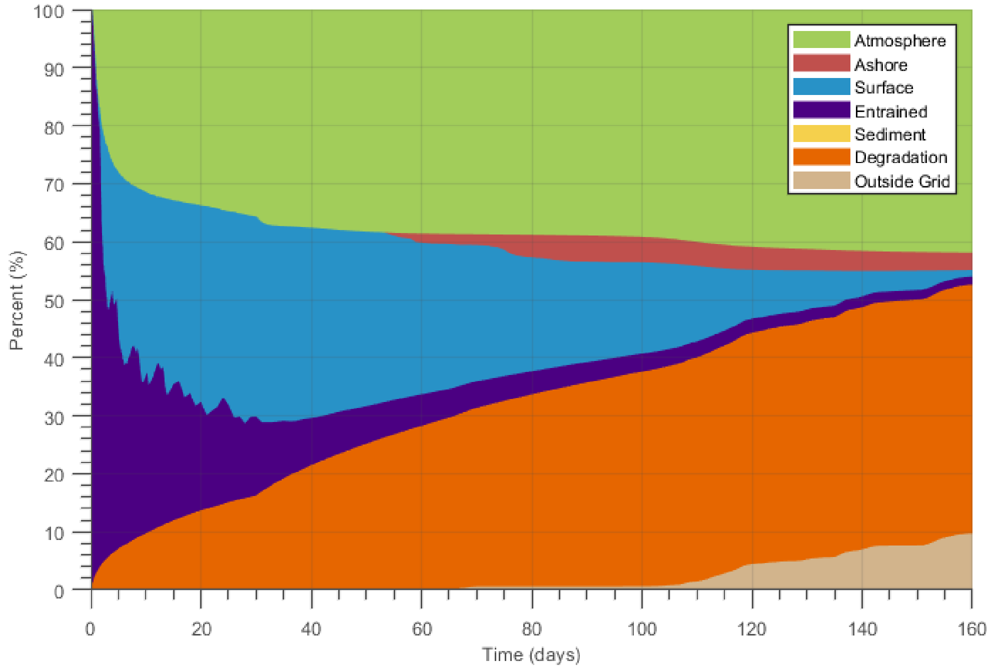




**Figure 15-29 Mass balance plots of the 95th percentile surface oil thickness cases resulting from 30- (top) and 120-day (bottom) blowouts at EL 1158**

### 15.3.2.2 Water Column THC

The high potential for surface oil entering into the water column in these four representative scenarios is the result of high wind speeds in the region, which resulted in surface breaking winds that entrained surface oil into the water column. The formation of persistent emulsions then increased the likelihood that oil would be see-sawing between the surface mixed layer and the surface of the water. Similar to the results from the representative surface oil exposure cases, water column concentrations of THC and total dissolved hydrocarbon (DHC) were very similar between sites, except for more extensive transport of dissolved hydrocarbons at EL 1158 to the south through the Flemish Pass (Figures 4-88 and 4-93, Appendix F). THCs were predicted to be more uniform (low level contamination) than dissolved concentrations. This was due to the rapid dispersion, degradation, and volatilization of soluble constituents, and the rapid transport of surface oil by winds and persistence of the whole oil after it formed emulsions. The highest predicted THCs (up to 5,000 µg/L for the 120-day releases) extended to the east-southeast (Table 15.9).

At the end of the 160-day simulations for the representative 30- and 120-day releases at the EL 1157 site, large percentages of the oil evaporated (42 to 45%) and degraded (33 to 43%), accounting for 77 to 85% of each modelled release (Figure 15-30). Up to 11% of oil (predominantly persistent surface oil) was predicted to be transported outside of the modelled domain. The amount of oil predicted to remain on the water surface was up to 9%, with up to 3% within the water column. Oil transported to the sediment was not a major fate pathway with <0.1% predicted to settle on sediments. Shoreline oil contamination of <3% of the released oil was predicted (Table 15.10). At the EL 1158 site, approximately 43 to 46% of oil was predicted to evaporate and 36 to 42% degrade, accounting for 78 to 88% of each modelled release (Figure 15-31). The amount of oil predicted to remain on the water surface was between 7% and 9%, <3% remained in the water column, and <0.1% settled on sediment. Shoreline contact was not a major fates pathway with <1% of oil contacting the shoreline. Although <3% of the oil was predicted to remain in the water column at the end of the identified scenarios, these cases were still predicted to experience the highest amount of water column exposure throughout the length of the simulation, and thus resulted in them being the 95th percentile worst-case scenarios (Table 15.10). Frequent cycling of wind and calm events were evident in all water column oil exposure cases, as indicated by “see-sawing” between oil on the surface and entrained oil in the water column.



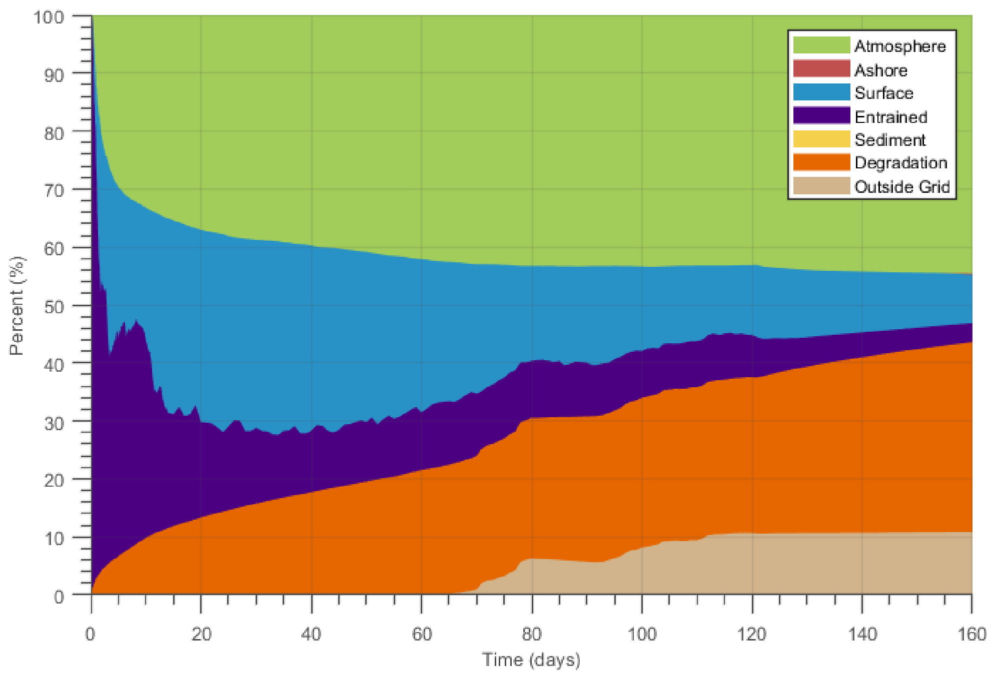
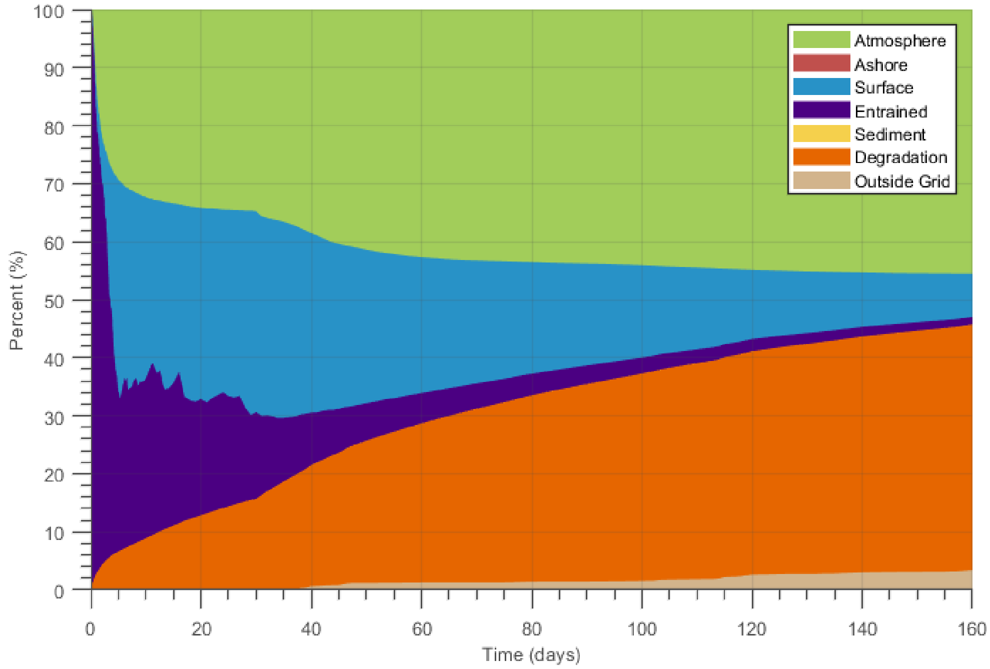




**Figure 15-30 Mass balance plots of the 95th percentile water column cases resulting from 30- (top) and 120-day (bottom) blowouts at EL 1157**



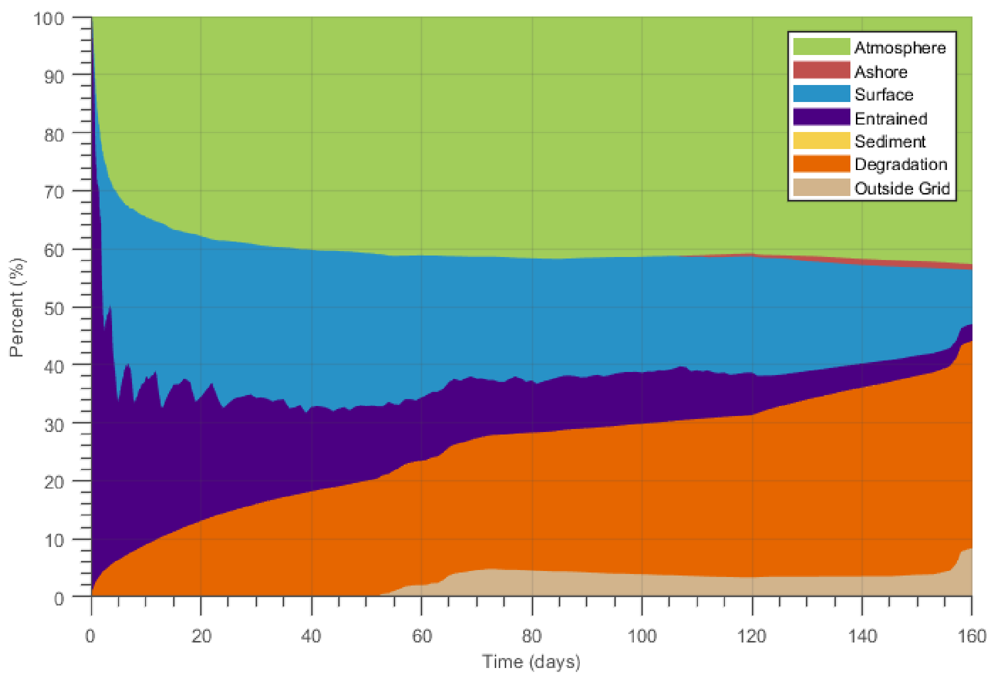




**Figure 15-31 Mass balance plots of the 95th percentile water column cases resulting from 30- (top) and 120-day (bottom) blowouts at EL 1158**

### 15.3.2.3 Shoreline and Sediment THC

The identified representative shoreline exposure cases were predicted to result in 1,241 to 1,597 km of contaminated shorelines. The releases at both sites resulted in similar lengths of shoreline oiling with the potential for contamination along the coasts of Newfoundland, mostly in excess of 500 g/m². The 30-day representative releases were predicted to contact the southern coasts of Newfoundland and the southern coast of the Avalon Peninsula (Figures 4-99 and 4-104, Appendix F). However, the 120-day representative releases were predicted to make contact with the northern coasts of Newfoundland and the eastern coasts of the Avalon Peninsula. In general, the oil that was predicted to reach shorelines was expected to be highly weathered, patchy, and discontinuous, as it would have degraded for well over a week (or more) before contacting shore. Limited sediment contamination of generally <0.1 g/m² was predicted to the east and south of the release sites. Additionally, there were localized patches of sediment oil up 0.5 g/m² predicted from the releases at EL 1157.

At the end of the 160-day simulations of the 95th percentile shoreline exposure for 30- and 120-day releases at the EL 1157 site, large percentages of the oil evaporated (42 to 44%) and degraded (38 to 39%), accounting for >79% of each modelled release (Figure 15-32). The amount of oil predicted to remain on the water surface was 2 to 14%, with <3% within the water column. Up to 13% of oil (predominantly persistent surface oil) was predicted to be transported outside of the modelled domain. Oil transported to the sediment and shoreline were not major fate pathways with <0.1% predicted to settle on sediments and up to 1.2% was predicted to remain on the shoreline (Table 15.10). At the EL 1158 site, approximately 42 to 46% of oil was predicted to evaporate and 31 to 39% degraded, accounting for >72% of each modelled release (Figure 15-33). The amount of oil predicted to remain on the water surface was 2 to 3%, 11 to 22% was transported outside the modelled domain, <2% remained in the water column, and <0.1% settled on sediment. Shoreline contact was not a major fates pathway with ≤1% of the total volume of released oil making contact with the shoreline (Table 15.10). Frequent cycling of wind and calm events were evident in all shoreline oil exposure cases, as indicated by “see-sawing” between oil on the surface and entrained oil in the water column.

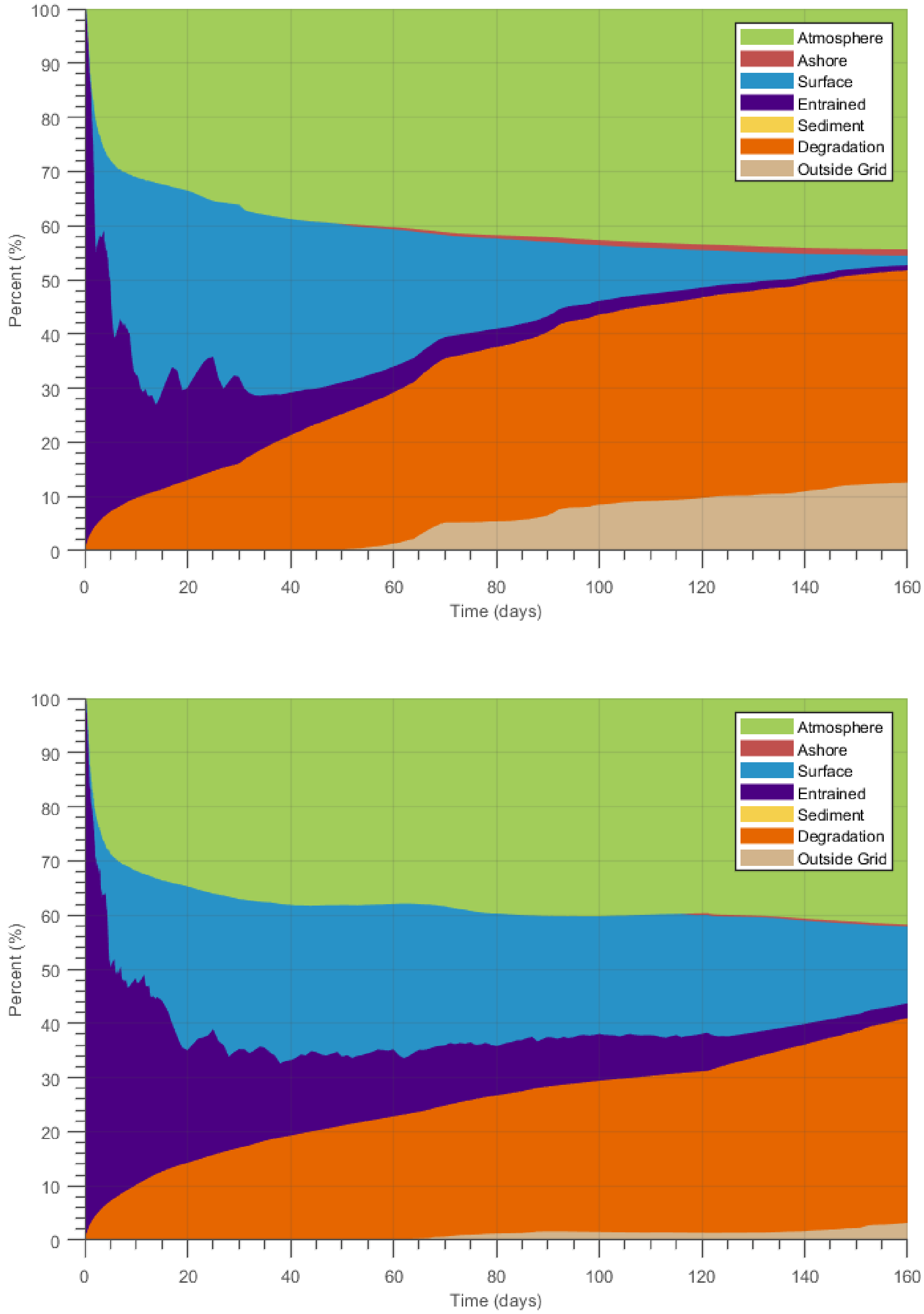



**Figure 15-32 Mass balance plots of the 95th percentile shoreline cases resulting from 30- (top) and 120-day (bottom) blowouts at EL 1157**

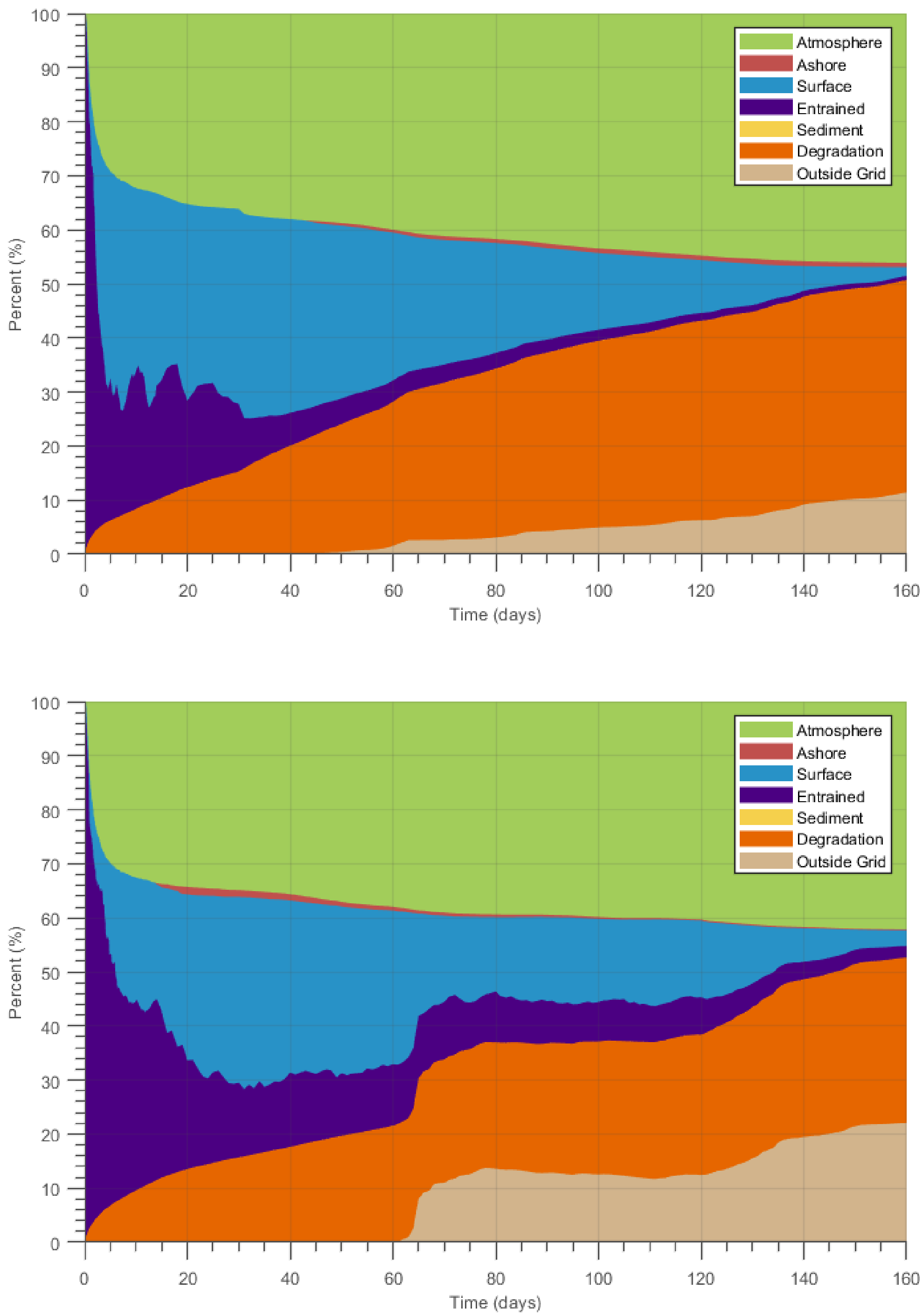



**Figure 15-33 Mass balance plots of the 95th percentile shoreline cases resulting from 30- (top) and 120-day (bottom) blowouts at EL 1158**

#### 15.3.2.4 Batch Spill of Marine Diesel Along Vessel Transit Route

The batch spill releases of 3,200 L marine diesel were predicted to result in silver or colorless sheens (<0.0001 mm) of oil floating on the water surface. Generally, oil within these representative scenarios was predicted to be transported to the south and in some cases wrap around the Avalon peninsula to the west, towards Saint Lawrence, Newfoundland. Note that THC and DHC concentrations in the water column were not predicted for the marine diesel batch spills modelled due to the relatively small volume of diesel oil released on the water surface. Thus, figures of THC and DHC are not presented in the RPS Report (Appendix F).

At the end of the 30-day marine diesel batch spill simulations, 64 to 80% was predicted to evaporated into the atmosphere, 12 to 23% degraded, 6 to 13% remained entrained in the water column, while 0.1% of the released volume was predicted to remain floating on the water surface. No marine diesel was predicted to strand on shorelines or settled on sediments in these representative scenarios other than the 95th percentile shoreline oiling case, which resulted in 1.1% of the release predicted on shore (Figure 15-34 and Table 15.10). The 95th percentile shoreline oiling case was predicted to result in 1,010 km of shoreline oiling above the socio-economic threshold and 9 km above the biological threshold.

#### 15.3.2.5 Summary of Deterministic Results

For the representative credible “worst-case” deterministic scenarios at EL 1157 and EL 1158, subsurface oil was predicted to rise through the water column where it surfaced and predominantly was transported to the east and south. In several simulations, oil was predicted to strand on shorelines. In each scenario, nearly half of the oil was predicted to evaporate, while a third was predicted to degrade by natural processes (Table 15.10). Of the remaining volume of released oil, 2 to 14% was predicted to remain on the surface, ≤3% remain in the water column, ≤3% stranded on shorelines, and <0.1% settled onto sediments over the course of the 160 day simulations. Because the simulations were so long, between 3 to 22% of the oil (predominantly surface oil as highly weathered emulsifications and tarballs) was predicted to leave the model domain to the east. Note that all scenarios assume a completely unmitigated release, which is an unlikely situation because various emergency response tactics would typically be employed immediately in the event of a spill.

The maximum subsurface water volumes exposed to THC concentrations for the 95th percentile water column cases were predicted to range between 64,070 $km^3$ and 99,090 $km^3$ (Table 15.9). Areas of relatively high THC concentration (500 to 5,000 µg/L) occurred in the Flemish Pass and Flemish Cap region in most scenarios. Regions of >500 µg/L dissolved hydrocarbons were predicted to be transported primarily east and southeast of the release site in the 95th percentile cases at EL 1157 and EL 1158.

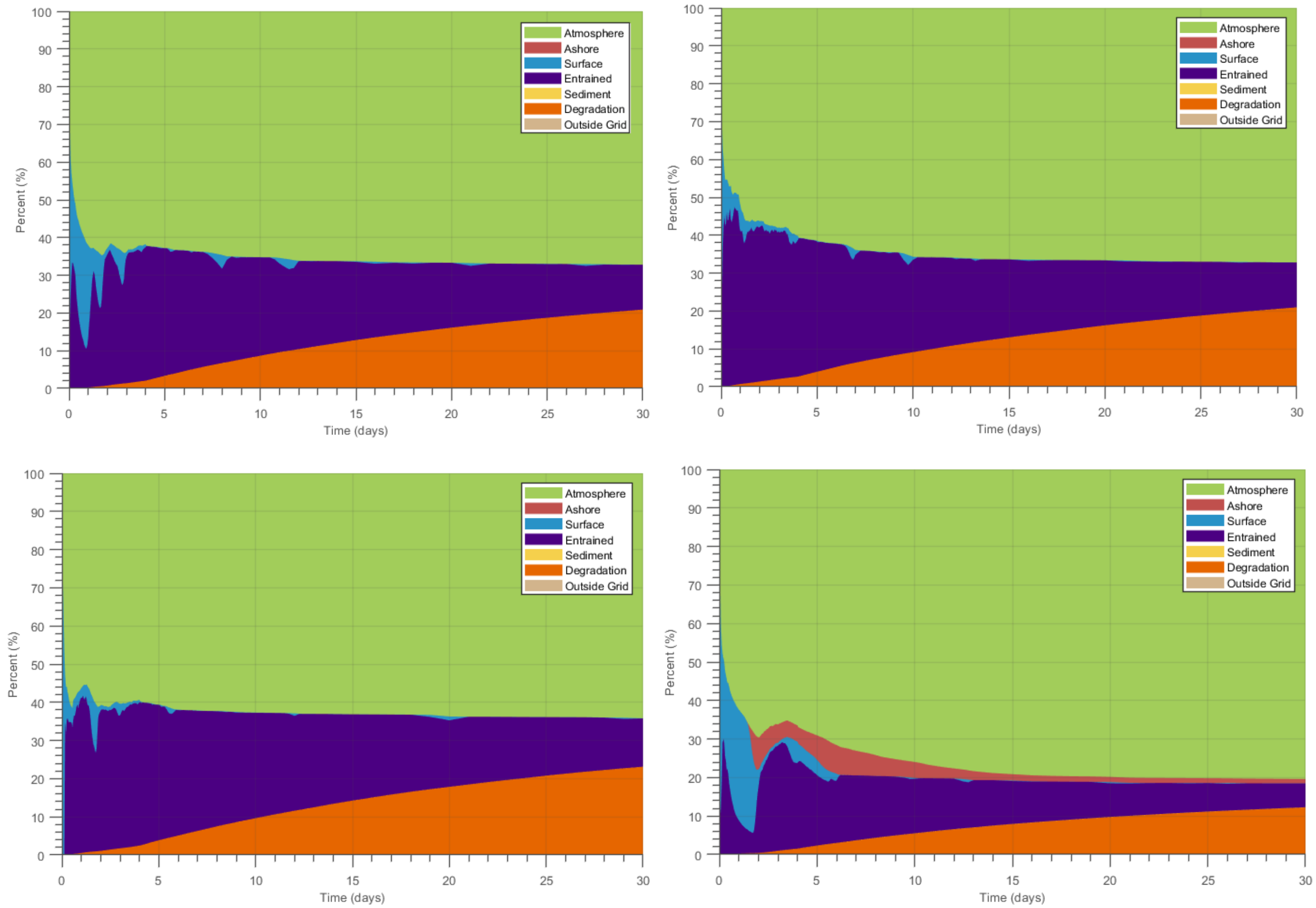



**Figure 15-34 Mass balance plots of the marine diesel batch spills of 3,200 L along a PSV route location corresponding to the 50th percentile surface exposure case (top left), 95th percentile surface exposure case (top right), 95th percentile water column exposure case (bottom left), and the 95th percentile shoreline exposure case (bottom right)**

For the shoreline oil exposure cases, shoreline oil contamination was predicted to range from approximately 9 to 4,264 km for socio-economic and ecological effects (Table 15.9). In general, most oiling in these scenarios was predicted along the eastern and southern shores of Newfoundland for these representative deterministic simulations, although stochastic results did result in the potential for shoreline oiling from southern Newfoundland up through Labrador. The oil that was predicted to strand along shorelines was generally in the 100 to >500 g/m² range (exceeding both the socio-economic and ecological thresholds), but would be patchy, discontinuous, and generally highly weathered by the time it reached shore. Offshore sediment contamination was much less prevalent and generally occurred at low levels (<0.01 g/m²) at locations near the release sites and to the south along the continental shelf break, although localized patches of concentrations up to 0.05 g/m² were also predicted.

The marine diesel used in the scenario was a standard diesel that had a low viscosity and a high aromatic content, which resulted in rapid predicted evaporation during the summertime releases. The marine diesel releases were also predicted to result in a patchy distribution of colorless or silver sheen of oil <0.0001 mm (0.1 µm). Due to the proximity of the modelled spill site to the coastline, the 95th percentile shoreline exposure case was predicted to lead to shoreline oil contamination exceeding the socio-economic threshold of 1 g/m² on over approximately 1,010 km of shoreline. The biological threshold was exceeded over 9 km of shoreline. The remaining representative scenarios were not predicted to contaminate shores.

## 15.4 SPILL RISK AND PROBABILITIES

The following was prepared to provide a probability analysis of offshore spills and blowouts to support the BHP Orphan Basin Region Exploration Drilling Project. It considers the probability of both continuous longer-term, larger scale blowouts, as well as smaller scale, shorter-term spill scenarios (batch spills) from offloading and production riser losses in association with the Project.

There are three important aspects to determining “spill risk” associated with offshore oil exploration activities:

- Determining the likelihood or probability that a well blowout or other well release will occur
- Determining the potential oil spillage volumes that might occur and the probabilities that the spill will be a large-scale spill
- Determining the potential impacts of hypothetical spills

The results of the analyses show that the probability of a well blowout or other release is very low (i.e., blowouts and other spills from offshore production wells are quite rare). The analyses also show that if a spill were to occur, the chances are great that it would be a small volume of spillage rather than a very large event with high consequences. The available data were reviewed and findings are based on historical research on offshore spills to determine the probabilities for spills and the potential spill volumes that might be involved.

In addition, this analysis complements the modelling and assessment of potential spill scenarios conducted as part of the EIS for the BHP Orphan Basin Project by providing a perspective on the probability of occurrence of the various scenarios as well as the probability distributions of spill volumes. The sites for the modelled spills are shown in Table 15.11. Properties of the discharged crude oil are in Table 15.12. The modelled scenarios of hypothetical spills analyzed in the probability analysis are summarized in Table 15.13.

### Table 15.11 BHP Orphan Basin Hypothetical Spill Sites

| Site | Block | Type | Latitude | Longitude | Water Depth |
|---|---|---|---|---|---|
| Site 1 | EL 1157 | Exploratory | 48.825889 | -47.851234 | 2,338 metres |
| Site 2 | EL 1158 | Exploratory | 48.491786 | -48.06617 | 2,047 metres |

### Table 15.12 Properties of Oils for BHP Orphan Basin Hypothetical Spill Modelling

| Oil | Spill Types | Density | Viscosity (cP at 25°C) | Surface Tension (dyne/cm) |
|---|---|---|---|---|
| Bay du Nord Crude (BdN) | Blowouts and well releases | 0.84553 @16°C<br>0.85800 @0°C | 5.0 @20°C<br>53.0 @0°C | 15.5 |
| Marine Diesel | Batch spills from vessels | 0.843 | 2.76 @ 15 C | 27.5 |

### Table 15.13 Modelled Hypothetical BHP Orphan Basin Spill Scenarios

| Scenario ID | Spill Event | Oil Type | Location | Spill Rate | Release Duration | Total Volume |
|---|---|---|---|---|---|---|
| SB-1 | Seafloor Blowout | BdN Crude | Site 1 (EL 1157) | 131,604 bbl/day decreasing linearly to 129,848 bbl/day | 30 days | 4,052,506 bbl |
| SB-2 | Seafloor Blowout | BdN Crude | Site 1 (EL 1157) | 131,604 bbl/day decreasing linearly to 124,541 bbl/day | 120 days | 15,496,924 bbl |
| SB-3 | Seafloor Blowout | BdN Crude | Site 2 (EL 1158) | 130,013 bbl/day decreasing linearly to 129,116 bbl/day | 30 days | 4,050,183 bbl |
| SB-4 | Seafloor Blowout | BdN Crude | Site 2 (EL 1158) | 130,013 bbl/day decreasing linearly to 126,370 bbl/day | 120 days | 15,496,430 bbl |
| SR-5 | Surface Release (Batch) | Marine Diesel | 12 km offshore | Near Instantaneous | N/A | 3,200 litres (20 bbl) |

The probabilities of the hypothetical subsurface blowout scenarios are based on the drilling of up to 10 wells at each of the two Orphan Basin ELs over the licence term (2021 through 2028) using either a semi-submersible rig or a drillship (MODU). The drilling of each exploration well may take from 35 to 115 days.

The hypothetical 30-day release durations are based on the maximum time for a successful capping and containment operation. The hypothetical 120-day release durations are based on the maximum time for the successful drilling of a relief well.

## 15.4.1 Historical Spill Data - Canada-NL Offshore Area

### 15.4.1.1 Sources of Oil Inputs in Newfoundland and Labrador Offshore

During the 1990s, total inputs of oil from anthropogenic sources in coastal areas of Eastern Canada have averaged 9,000 barrels (bbl) annually, and in offshore areas, 2,700 bbl annually, for a total of 11,700 bbl. Spill volumes off Eastern Canada have decreased significantly in the last decade to about 600 bbl. Occasional tanker spills have provided the greatest threat to the region in the past.

In addition to anthropogenic inputs from spills, urban runoff, and vessel and facility operations, natural seepage may also contribute to overall hydrocarbon inputs in the region. Several natural seeps have been identified in the region, though there are no quantifications of annual inputs from this source (Moir et al. 2013).

Offshore NL exploration and production facilities have spilled a total of 2,759 bbl of oil in 478 incidents over the last 22 years (based on C-NLOPB spill data for 1997–2018). One single event–the spill of 1,572 bbl of crude oil from the Husky Energy White Rose field (*SeaRose FPSO*) in November 2018 made up nearly 57% of the total volume of spillage. Another spill event involving 1,037.8 bbl from Petro-Canada's Terra Nova FPSO occurred in November 2004. Together, these two events caused 95% of the volume of oil spillage over 22 years (this does not include spills of SBM). About 86% of the total volume of oil spillage occurred during development and production activities. A total of 33 incidents totaling 33 bbl occurred during exploration activities. About 72% of these spills involved less than one bbl. Offshore exploration activities over the time period 1997 through 2018 also resulted in 11 SBM spills for a total of 776 bbl. Development and production activities resulted in the spillage of 1,314 bbl of SBM in 44 incidents (C-NLOPB 1997-2018 spill data).

Well-related spills occur relatively infrequently during offshore operations. Most well spills involve releases of less than 100 bbl, or 16 cubic metres ($m^3$), over the course of less than one day. Additionally, large-scale well blowouts are very rare events. The greatest concern about blowout scenarios is for the potential volume that may be released into the environment. This concern has become particularly heightened after the 2010 Macondo MC252 blowout in the US Gulf of Mexico. While this blowout released a large amount of oil, blowouts, in general, are infrequent and also are statistically shown to involve much smaller quantities of oil.

In current analysis, a blowout is defined as “a loss of well control or uncontrolled flow of formation or other fluids, including flow to an exposed formation (an underground blowout) or at the surface of the seabed (a subsurface blowout), flow through a diverter, or uncontrolled flow resulting from a failure of surface equipment or procedures” (US Bureau of Safety and Environmental Enforcement n.d.). This definition encompasses incidents in which fluids other than oil are released. Only 41% of blowouts involve the release of any oil, as opposed to brine, water, or gas. The majority of subsurface blowouts from production wells last less than five days.

#### 15.4.1.2 Canada-Newfoundland and Labrador Offshore Spill Data

The C-NLOPB spill data for 1997-2018 were analyzed. A detailed breakdown of spills of >1 litre was available in the C-NLOPB data. The annual numbers and volumes of spills by oil type are shown in Tables 15.14 and 15.15 for exploratory wells. The percentage of spills by oil type for spills of ≥1 litre are shown in Table 15.16. These data show that for some years there are no spills at all of a particular type of oil and in other years there may be one or more. The volumes of spillage are dominated by individual incidents. This is very apparent for the synthetic fluid spillage in particular (as seen in Table 15.15). There was a total of 11 incidents involving >1 litre over the course of 18 years. There was a single incident in 2007 in which 465.45 bbl spilled, and another incident in 2015 in which 92.93 bbl spilled. In 2011, there were five incidents totaling 180.78 bbl. When the volume of spillage is averaged over 21.5 years, the average is 37.6 bbl per year. This does not mean that 37.6 bbl spills each year consistently.

**Table 15.14 Newfoundland and Labrador Exploration Spill Numbers (1997 to 2018)**

| Year | Numbers of Spills (>1 litre) | | | | | |
|---|---|---|---|---|---|---|
| | Crude Condensate | Diesel / Jet Fuels | Hydraulic / Lube Oils | Other Types (Oil) | Synthetic Fluids | Total |
| 1997 | 0 | 0 | 0 | 1 | 0 | 1 |
| 1998 | 0 | 4 | 0 | 0 | 0 | 4 |
| 1999 | 4 | 5 | 1 | 1 | 0 | 11 |
| 2000 | 1 | 0 | 0 | 0 | 0 | 1 |
| 2001 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 0 | 1 | 0 | 0 | 1 | 2 |
| 2004 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 0 | 0 | 3 | 0 | 1 | 4 |
| 2007 | 0 | 0 | 0 | 0 | 1 | 1 |
| 2008 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 0 | 0 | 0 | 2 | 0 | 2 |
| 2010 | 0 | 0 | 1 | 0 | 0 | 1 |
| 2011 | 0 | 0 | 2 | 0 | 5 | 7 |
| 2012 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2013 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2014 | 0 | 0 | 0 | 0 | 1 | 1 |

### Table 15.14 Newfoundland and Labrador Exploration Spill Numbers (1997 to 2018)

| Year | Numbers of Spills (>1 litre) | | | | | |
|---|---|---|---|---|---|---|
| | Crude Condensate | Diesel / Jet Fuels | Hydraulic / Lube Oils | Other Types (Oil) | Synthetic Fluids | Total |
| 2015 | 0 | 0 | 0 | 0 | 1 | 1 |
| 2016 | 0 | 0 | 1 | 0 | 0 | 1 |
| 2017 | 0 | 0 | 0 | 0 | 1 | 1 |
| 2018 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 5 | 10 | 8 | 4 | 11 | 38 |
| Average/Year | 0.23 | 0.47 | 0.37 | 0.19 | 0.51 | 1.77 |

### Table 15.15 Newfoundland & Labrador Exploration Spill Volumes (1997 to 2018)

| Year | Volume Spilled (bbl) | | | | | |
|---|---|---|---|---|---|---|
| | Crude Condensate | Diesel / Jet Fuels | Hydraulic / Lube Oils | Other Types (Oil) | Synthetic Fluids | Total |
| 1997 | 0 | 0 | 0 | 0.25 | 0 | 0.25 |
| 1998 | 0 | 20.1 | 0 | 0 | 0 | 20.10 |
| 1999 | 4.79 | 5.72 | 0.03 | 0.19 | 0 | 10.73 |
| 2000 | 1.01 | 0 | 0 | 0 | 0 | 1.01 |
| 2001 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| 2002 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| 2003 | 0 | 0.63 | 0 | 0 | 27.68 | 28.31 |
| 2004 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| 2005 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| 2006 | 0 | 0 | 0.1 | 0 | 3.77 | 3.87 |
| 2007 | 0 | 0 | 0 | 0 | 465.45 | 465.45 |
| 2008 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| 2009 | 0 | 0 | 0 | 0.05 | 0 | 0.05 |
| 2010 | 0 | 0 | 0.02 | 0 | 0 | 0.02 |
| 2011 | 0 | 0 | 0.28 | 0 | 180.78 | 181.06 |
| 2012 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| 2013 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| 2014 | 0 | 0 | 0 | 0 | 5.41 | 5.41 |
| 2015 | 0 | 0 | 0 | 0 | 92.23 | 92.23 |
| 2016 | 0 | 0 | 0.01 | 0 | 0 | 0.01 |
| 2017 | 0 | 0 | 0 | 0 | 0.02 | 0.02 |
| 2018 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| Total | 5.8 | 26.45 | 0.44 | 0.49 | 775.34 | 808.52 |
| Average / Year | 0.27 | 1.23 | 0.02 | 0.02 | 36.06 | 37.61 |

### Table 15.16 Oil Types in Spills in Offshore Newfoundland and Labrador (spills >1 litre) (1997 to 2018)

| Oil Type | Exploration | | | | Development & Production | | | |
|---|---|---|---|---|---|---|---|---|
| | Incidents | | Volume | | Incidents | | Volume | |
| | # | % Total | Bbl | % Total | # | % Total | Bbl | % Total |
| Crude Oil / Condensate | 5 | 13.2% | 5.8 | 0.7% | 63 | 28.4% | 2,698.29 | 66.8% |
| Diesel and Jet Fuel | 10 | 26.3% | 26.45 | 3.3% | 19 | 8.6% | 4.09 | 0.1% |
| Hydraulic / Lubricating | 8 | 21.1% | 0.44 | 0.1% | 73 | 32.9% | 17.84 | 0.4% |
| Other Types (Oil) | 4 | 10.5% | 0.49 | 0.1% | 24 | 10.8% | 2.96 | 0.1% |
| Synthetic Oils / Fluids | 11 | 28.9% | 776.03 | 95.9% | 43 | 19.4% | 1,314.46 | 32.6% |
| Total | 38 | 100.0% | 809.21 | 100.0% | 222 | 100.0% | 4,037.64 | 100.0% |

Of the oil spilled in exploration drilling during 1997 through 2018, 95.9% of the total volume spilled was synthetic oils and fluids. Only 0.7% of the spilled oil was crude oil. The most frequent incidents were of synthetic oils and fluids, followed by diesel and jet fuel. The percentages of volumes and incident numbers are summarized in Table 15.16.

As is typical for spills, most spills are relatively small with only infrequent larger spills. The spill volumes by size category based on the C-NLOPB data are in Table 15.17 for exploration, with the addition of data on spills of ≤1 litre that were provided by C-NLOPB that were not classified with regard to oil type.

### Table 15.17 Spill Volumes for Exploration in Newfoundland and Labrador (1997 to 2018)

| Volume Category (bbl) | % Total Spills >1 Litre | | | | | % Total All Spills (w/<1 Litre) |
|---|---|---|---|---|---|---|
| | Crude Oil / Condensate | Diesel / Jet Fuel | Hydraulic / Lube Oil | Synthetic Oils / Fluids | Other Types (Oil) | |
| 0.00001-0.00009 | - | - | - | - | - | 2.3% |
| 0.0001-0.0009 | - | - | - | - | - | 4.5% |
| 0.001-0.009 | - | - | - | - | - | 6.8% |
| 0.01-0.09 | 40.0% | 10.0% | 87.5% | 27.3% | 50.0% | 34.1% |
| 0.1-0.9 | 0.0% | 30.0% | 12.5% | 0.0% | 50.0% | 13.6% |
| 1-9 | 60.0% | 50.0% | 0.0% | 27.3% | 0.0% | 25.0% |
| 10-99 | 0.0% | 10.0% | 0.0% | 27.3% | 0.0% | 9.1% |
| 100-999 | 0.0% | 0.0% | 0.0% | 18.2% | 0.0% | 4.5% |
| 1,000-9,999 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

## 15.4.2 Probabilities of Spills from the Project

### 15.4.2.1 Probability of Batch Spills

There are various types of "batch spills" that occur during offshore operations, including ones from offshore PSV operations, bunkering (fueling), and operations related to semisubmersible drilling units or drill ships. These types of spills are considered to be "batch spills" in that they are of a finite amount of oil released instantaneously or over a few hours at most. The spills are finite in that they come from storage tanks or pipes that have specified quantities of refined oil or may be shut off to prevent further flow. They differ from potential well blowouts and releases, which may involve large volumes of oil coming from crude oil reservoirs for longer periods of time. For this analysis, diesel spills were considered for modelling as agreed with the CEA Agency in the July 2019 oil spill modelling workshop.

Based on analyses of the C-NLOPB exploration data for 1997 through 2018 for batch spills the average per-well probability of batch spills for exploration activities was determined to be 0.42 per well-year. This equates to 0.00115 per day for each well. Based on this rate, the expected numbers of batch spills for the BHP Orphan Basin Project is shown in Table 15.18 by well number (up to 20) and by drilling time frame, which varies from 35 days to 115 days per well. Note that these are the expected batch spills regardless of volume. Most batch spills will be very small; 70% will involve less than 1 bbl. The expected frequencies are dependent on the number of exploratory wells drilled. There is no difference in expected frequencies based on location.

**Table 15.18 Expected Frequency of Batch Spills for BHP Orphan Basin Project**

| Number of Wells | Expected Frequency of Batch Spills over Exploration Drilling Time Frame | | Chances of Batch Spills over Exploration Drilling Time Frame | |
|---|---|---|---|---|
| | 35 Days per Well | 115 Days per Well | 35 Days per Well | 115 Days per Well |
| 1 | 0.040 | 0.13 | 1 in 25 | 1 in 8 |
| 2 | 0.081 | 0.26 | 1 in 12 | 1 in 4 |
| 3 | 0.12 | 0.40 | 1 in 8 | 1 in 3 |
| 4 | 0.16 | 0.53 | 1 in 6 | 1 in 2 |
| 5 | 0.20 | 0.66 | 1 in 5 | 1 in 2 |
| 6 | 0.24 | 0.79 | 1 in 4 | 1 in 1 |
| 7 | 0.28 | 0.93 | 1 in 4 | 1 in 1 |
| 8 | 0.32 | 1.1 | 1 in 3 | 1 in 1 |
| 9 | 0.36 | 1.2 | 1 in 3 | 1 in 1 |
| 10 | 0.40 | 1.3 | 1 in 2 | 1 in 1 |
| 11 | 0.44 | 1.5 | 1 in 2 | 1 in 1 |
| 12 | 0.48 | 1.6 | 1 in 2 | 1 in 1 |
| 13 | 0.52 | 1.7 | 1 in 2 | 1 in 1 |
| 14 | 0.56 | 1.9 | 1 in 2 | 1 in 1 |
| 15 | 0.60 | 2.0 | 1 in 2 | 1 in 1 |
| 16 | 0.64 | 2.1 | 1 in 2 | 1 in 0.5 |
| 17 | 0.68 | 2.2 | 1 in 1 | 1 in 0.4 |

## Table 15.18 Expected Frequency of Batch Spills for BHP Orphan Basin Project

| Number of Wells | Expected Frequency of Batch Spills over Exploration Drilling Time Frame | | Chances of Batch Spills over Exploration Drilling Time Frame | |
|---|---|---|---|---|
| | 35 Days per Well | 115 Days per Well | 35 Days per Well | 115 Days per Well |
| 18 | 0.72 | 2.4 | 1 in 1 | 1 in 0.4 |
| 19 | 0.76 | 2.5 | 1 in 1 | 1 in 0.4 |
| 20 | 0.81 | 2.6 | 1 in 1 | 1 in 0.4 |
| Source: Based on C-NLOPB data for 1997 to 2018. | | | | |

Note that these expected frequencies are for spills of any volume over the course of the exploration period. Most of the spills would be expected to be relatively small. The spill frequencies were combined with probability volume distribution to determine the probability of batch spills of different volumes, including the modelled scenario, as shown in Table 15.19 for a 35-day drilling period and in Table 15.20 for a 115-day drilling period.

## Table 15.19 Probabilities of Batch Spills by Size / Well Number for 35-Day Drilling

| Wells | Expected Frequency of Spills over Project Time Frame | | | | |
|---|---|---|---|---|---|
| | Small <1 bbl | Small / Moderate 1–10 bbl | Moderate / Large 100–1,000 bbl | Large 1,000–10,000 bbl | Scenario SR-5 20 bbl |
| 1 | 0.04 | 0.02 | 0.0004 | 0.00004 | 0.02 |
| 2 | 0.08 | 0.04 | 0.0008 | 0.00008 | 0.04 |
| 3 | 0.12 | 0.06 | 0.0012 | 0.00012 | 0.06 |
| 4 | 0.16 | 0.08 | 0.0016 | 0.00016 | 0.08 |
| 5 | 0.20 | 0.10 | 0.0020 | 0.00020 | 0.10 |
| 6 | 0.24 | 0.12 | 0.0024 | 0.00024 | 0.12 |
| 7 | 0.28 | 0.14 | 0.0028 | 0.00028 | 0.14 |
| 8 | 0.32 | 0.16 | 0.003 | 0.0003 | 0.16 |
| 9 | 0.36 | 0.18 | 0.004 | 0.0004 | 0.18 |
| 10 | 0.40 | 0.20 | 0.004 | 0.0004 | 0.20 |
| 11 | 0.44 | 0.22 | 0.004 | 0.0004 | 0.22 |
| 12 | 0.48 | 0.24 | 0.005 | 0.0005 | 0.24 |
| 13 | 0.51 | 0.26 | 0.005 | 0.0005 | 0.26 |
| 14 | 0.55 | 0.28 | 0.006 | 0.0006 | 0.28 |
| 15 | 0.59 | 0.30 | 0.006 | 0.0006 | 0.30 |
| 16 | 0.63 | 0.32 | 0.006 | 0.0006 | 0.32 |
| 17 | 0.67 | 0.34 | 0.007 | 0.0007 | 0.34 |
| 18 | 0.71 | 0.36 | 0.007 | 0.0007 | 0.36 |
| 19 | 0.75 | 0.38 | 0.008 | 0.0008 | 0.38 |
| 20 | 0.80 | 0.41 | 0.008 | 0.0008 | 0.41 |

### Table 15.20 Probabilities of Batch Spills by Size / Well Number for 115-Day Drilling

| Wells | Expected Frequency of Spills over Project Time Frame | | | | |
|---|---|---|---|---|---|
| | Small <1 bbl | Small / Moderate 1–10 bbl | Moderate / Large 100–1,000 bbl | Large 1,000–10,000 bbl | Scenario SR-5 20 bbl |
| 1 | 0.13 | 0.07 | 0.0013 | 0.00013 | 0.07 |
| 2 | 0.26 | 0.13 | 0.0026 | 0.00026 | 0.13 |
| 3 | 0.40 | 0.20 | 0.0040 | 0.00040 | 0.20 |
| 4 | 0.52 | 0.27 | 0.0053 | 0.00053 | 0.27 |
| 5 | 0.65 | 0.33 | 0.0066 | 0.00066 | 0.33 |
| 6 | 0.78 | 0.40 | 0.0079 | 0.00079 | 0.40 |
| 7 | 0.92 | 0.47 | 0.0093 | 0.00093 | 0.47 |
| 8 | 1.09 | 0.55 | 0.011 | 0.0011 | 0.55 |
| 9 | 1.19 | 0.60 | 0.012 | 0.0012 | 0.60 |
| 10 | 1.29 | 0.65 | 0.013 | 0.0013 | 0.65 |
| 11 | 1.49 | 0.75 | 0.015 | 0.0015 | 0.75 |
| 12 | 1.58 | 0.80 | 0.016 | 0.0016 | 0.80 |
| 13 | 1.68 | 0.85 | 0.017 | 0.0017 | 0.85 |
| 14 | 1.88 | 0.95 | 0.019 | 0.0019 | 0.95 |
| 15 | 1.98 | 1.00 | 0.020 | 0.0020 | 1.00 |
| 16 | 2.08 | 1.05 | 0.021 | 0.0021 | 1.05 |
| 17 | 2.18 | 1.10 | 0.022 | 0.0022 | 1.10 |
| 18 | 2.38 | 1.20 | 0.024 | 0.0024 | 1.20 |
| 19 | 2.48 | 1.25 | 0.025 | 0.0025 | 1.25 |
| 20 | 2.57 | 1.30 | 0.026 | 0.0026 | 1.30 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | | | | |

### 15.4.2.2 Probability of Blowouts

Analyses of international and national historical spill data, well blowouts (with spillage) and other well-related spills from offshore drilling activities verify that large blowouts can be considered relatively rare events. The calculated probability results, expressed as both expected frequencies and chances, are summarized in Table 15.21. The mean frequencies represent the expected number of blowouts over the course of the exploration period based on the site and the number of wells. For example, with 10 wells at the Site 1 (EL 1157), the mean expected frequency is 0.00035. This means that there is a one in 2,900 chance that with 10 wells there may be a blowout (of any size) over the exploration period. With fewer wells, the likelihood of a blowout decreases. With only one well at Site 1, there is a one in 29,000 chance that there would be a blowout over the exploration period. Across the two sites, the expected frequency increases, depending on the number of wells in each site. These probabilities and chances do not indicate release volume or imply a worst-case discharge, only that there would be a release of any size.

## Table 15.21 Mean Frequencies and Chances of Blowouts for Project during Exploration

| Well Number | Mean Frequency during Exploration Period | Mean Chance during Exploration Period |
|---|---|---|
| 1 | 0.000035 | 1 in 29,000 |
| 2 | 0.000070 | 1 in 14,000 |
| 3 | 0.00011 | 1 in 9,500 |
| 4 | 0.00014 | 1 in 7,100 |
| 5 | 0.00018 | 1 in 5,700 |
| 6 | 0.00021 | 1 in 4,600 |
| 7 | 0.00025 | 1 in 4,100 |
| 8 | 0.00028 | 1 in 3,600 |
| 9 | 0.00032 | 1 in 3,200 |
| 10 | 0.00035 | 1 in 2,900 |
| 11 | 0.00039 | 1 in 2,600 |
| 12 | 0.00042 | 1 in 2,400 |
| 13 | 0.00046 | 1 in 2,200 |
| 14 | 0.00049 | 1 in 2,000 |
| 15 | 0.00053 | 1 in 1,900 |
| 16 | 0.00056 | 1 in 1,800 |
| 17 | 0.00060 | 1 in 1,700 |
| 18 | 0.00063 | 1 in 1,600 |
| 19 | 0.00067 | 1 in 1,500 |
| 20 | 0.00070 | 1 in 1,400 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | |

The probabilities of blowouts during the exploration period and after abandonment by volume category and well number are in Table 15.22 and Table 15.23 for Site 1 and Site 2, respectively. The same data are presented as chances in Table 15.24 and Table 15.25. The probabilities for blowouts by volume differ somewhat between the two sites due to differences in flowrates. Probabilities and chances of well releases are shown in Table 15.26 and Table 15.27. The probabilities of well releases do not differ between the two sites and are presented based on the total number of wells between the two sites.

## Table 15.22 Expected Blowout Frequency by Volume Category / Well Number-Site 1

| Wells | Expected Frequency over Exploration and 20-Year Abandonment Period | | | | | | |
|---|---|---|---|---|---|---|---|
| | Any Volume | 1,000 bbl or Larger | 10,000 bbl or Larger | 100,000 bbl or Larger | 1,000,000 bbl or Larger | Site 1 Scenarios | |
| | | | | | | SB-1 4,052,506 bbl | SB-2 15,496,924 bbl |
| 1 | 0.00014 | 0.00014 | 0.00014 | 0.00014 | 0.000021 | 0.000014 | 0.00000014 |
| 2 | 0.00028 | 0.00028 | 0.00027 | 0.00027 | 0.000042 | 0.000028 | 0.00000028 |
| 3 | 0.00042 | 0.00042 | 0.00041 | 0.00041 | 0.000063 | 0.000042 | 0.00000042 |
| 4 | 0.00056 | 0.00056 | 0.00055 | 0.00054 | 0.000084 | 0.000056 | 0.00000056 |
| 5 | 0.00070 | 0.00070 | 0.00069 | 0.00068 | 0.00011 | 0.000070 | 0.00000070 |
| 6 | 0.00084 | 0.00084 | 0.00082 | 0.00082 | 0.00013 | 0.000084 | 0.00000084 |
| 7 | 0.00098 | 0.00098 | 0.00096 | 0.00095 | 0.00015 | 0.000098 | 0.00000098 |
| 8 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.00017 | 0.00011 | 0.0000011 |
| 9 | 0.0013 | 0.0013 | 0.0012 | 0.0012 | 0.00019 | 0.00013 | 0.0000013 |
| 10 | 0.0014 | 0.0014 | 0.0014 | 0.0014 | 0.00021 | 0.00014 | 0.0000014 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | | | | | | |

## Table 15.23 Expected Blowout Frequency by Volume Category / Well Number-Site 2

| Wells | Expected Frequency over Exploration and 20-Year Abandonment Period | | | | | | |
|---|---|---|---|---|---|---|---|
| | Any Volume | 1,000 bbl or Larger | 10,000 bbl or Larger | 100,000 bbl or Larger | 1,000,000 bbl or Larger | Site 2 Scenarios | |
| | | | | | | SB-3 4,050,183 bbl | SB-4 15,496,430 bbl |
| 1 | 0.00014 | 0.00014 | 0.00014 | 0.00012 | 0.000022 | 0.000014 | 0.00000014 |
| 2 | 0.00028 | 0.00028 | 0.00027 | 0.00024 | 0.000044 | 0.000028 | 0.00000028 |
| 3 | 0.00042 | 0.00042 | 0.00041 | 0.00036 | 0.000066 | 0.000042 | 0.00000042 |
| 4 | 0.00056 | 0.00056 | 0.00055 | 0.00048 | 0.000088 | 0.000056 | 0.00000056 |
| 5 | 0.00070 | 0.00070 | 0.00069 | 0.00060 | 0.00011 | 0.000070 | 0.00000070 |
| 6 | 0.00084 | 0.00084 | 0.00082 | 0.00072 | 0.00013 | 0.000084 | 0.00000084 |
| 7 | 0.00098 | 0.00098 | 0.00096 | 0.00084 | 0.00015 | 0.000098 | 0.00000098 |
| 8 | 0.0011 | 0.0011 | 0.0011 | 0.0010 | 0.00018 | 0.00011 | 0.0000011 |
| 9 | 0.0013 | 0.0013 | 0.0012 | 0.0011 | 0.00020 | 0.00013 | 0.0000013 |
| 10 | 0.0014 | 0.0014 | 0.0014 | 0.0012 | 0.00022 | 0.00014 | 0.0000014 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | | | | | | |

## Table 15.24 Chances of Blowouts by Volume Category by Well Number-Site 1

| Wells | Chance over Exploration and 20-Year Abandonment Period | | | | | | |
|---|---|---|---|---|---|---|---|
| | Any Volume | 1,000 bbl or Larger | 10,000 bbl or Larger | 100,000 bbl or Larger | 1,000,000 bbl or Larger | Site 1 Scenarios | |
| | | | | | | SB-1 4,052,506 bbl | SB-2 15,496,924 bbl |
| 1 | 1 in 7,100 | 1 in 7,100 | 1 in 7,300 | 1 in 7,400 | 1 in 48,000 | 1 in 71,000 | 1 in 7,100,000 |
| 2 | 1 in 3,600 | 1 in 3,600 | 1 in 3,700 | 1 in 3,700 | 1 in 24,000 | 1 in 36,000 | 1 in 3,600,000 |
| 3 | 1 in 2,400 | 1 in 2,400 | 1 in 2,400 | 1 in 2,500 | 1 in 16,000 | 1 in 24,000 | 1 in 2,400,000 |
| 4 | 1 in 1,800 | 1 in 1,800 | 1 in 1,800 | 1 in 1,800 | 1 in 12,000 | 1 in 18,000 | 1 in 1,800,000 |
| 5 | 1 in 1,400 | 1 in 1,400 | 1 in 1,500 | 1 in 1,500 | 1 in 9,500 | 1 in 14,000 | 1 in 1,400,000 |
| 6 | 1 in 1,200 | 1 in 1,200 | 1 in 1,200 | 1 in 1,200 | 1 in 7,900 | 1 in 12,000 | 1 in 1,200,000 |
| 7 | 1 in 1,000 | 1 in 1,000 | 1 in 1,000 | 1 in 1,100 | 1 in 6,800 | 1 in 10,000 | 1 in 1,000,000 |
| 8 | 1 in 890 | 1 in 890 | 1 in 910 | 1 in 920 | 1 in 6,000 | 1 in 8,900 | 1 in 890,000 |
| 9 | 1 in 790 | 1 in 790 | 1 in 810 | 1 in 820 | 1 in 5,300 | 1 in 7,900 | 1 in 790,000 |
| 10 | 1 in 710 | 1 in 710 | 1 in 730 | 1 in 740 | 1 in 4,800 | 1 in 7,100 | 1 in 710,000 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | | | | | | |

## Table 15.25 Chances of Blowouts by Volume Category by Well Number-Site 2

| Wells | Chance over Exploration and 20-Year Abandonment Period | | | | | | |
|---|---|---|---|---|---|---|---|
| | Any Volume | 1,000 bbl or Larger | 10,000 bbl or Larger | 100,000 bbl or Larger | 1,000,000 bbl or Larger | Site 2 Scenarios | |
| | | | | | | SB-3 4,050,183 bbl | SB-4 15,496,430 bbl |
| 1 | 1 in 7,100 | 1 in 7,100 | 1 in 7,300 | 1 in 8,300 | 1 in 45,000 | 1 in 71,000 | 1 in 7,100,000 |
| 2 | 1 in 3,600 | 1 in 3,600 | 1 in 3,700 | 1 in 4,200 | 1 in 23,000 | 1 in 36,000 | 1 in 3,600,000 |
| 3 | 1 in 2,400 | 1 in 2,400 | 1 in 2,400 | 1 in 2,800 | 1 in 15,000 | 1 in 24,000 | 1 in 2,400,000 |
| 4 | 1 in 1,800 | 1 in 1,800 | 1 in 1,800 | 1 in 2,100 | 1 in 11,000 | 1 in 18,000 | 1 in 1,800,000 |
| 5 | 1 in 1,400 | 1 in 1,400 | 1 in 1,500 | 1 in 1,700 | 1 in 9,100 | 1 in 14,000 | 1 in 1,400,000 |
| 6 | 1 in 1,200 | 1 in 1,200 | 1 in 1,200 | 1 in 1,400 | 1 in 7,600 | 1 in 12,000 | 1 in 1,200,000 |
| 7 | 1 in 1,000 | 1 in 1,000 | 1 in 1,000 | 1 in 1,200 | 1 in 6,500 | 1 in 10,000 | 1 in 1,000,000 |
| 8 | 1 in 890 | 1 in 890 | 1 in 910 | 1 in 1,000 | 1 in 5,700 | 1 in 8,900 | 1 in 890,000 |
| 9 | 1 in 790 | 1 in 790 | 1 in 810 | 1 in 930 | 1 in 5,100 | 1 in 7,900 | 1 in 790,000 |
| 10 | 1 in 710 | 1 in 710 | 1 in 730 | 1 in 830 | 1 in 4,500 | 1 in 7,100 | 1 in 710,000 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | | | | | | |

## Table 15.26 Probability of Release by Volume Category by Well Number

| Wells | Expected Frequency over Exploration and 20-Year Abandonment Period | | | | |
|---|---|---|---|---|---|
| | Any Volume | 1 bbl or Larger | 10 bbl or Larger | 100 bbl or Larger | 1,000 bbl or Larger |
| 1 | 0.000022 | 0.000020 | 0.000015 | 0.0000044 | 0.00000022 |
| 2 | 0.000044 | 0.000040 | 0.000030 | 0.0000088 | 0.00000044 |
| 3 | 0.000066 | 0.000060 | 0.000045 | 0.000013 | 0.00000066 |
| 4 | 0.000088 | 0.000080 | 0.000060 | 0.000018 | 0.00000088 |
| 5 | 0.00011 | 0.00010 | 0.000075 | 0.000022 | 0.0000011 |
| 6 | 0.00013 | 0.00012 | 0.000090 | 0.000026 | 0.0000013 |
| 7 | 0.00015 | 0.00014 | 0.00011 | 0.000031 | 0.0000015 |
| 8 | 0.00018 | 0.00016 | 0.00012 | 0.000035 | 0.0000018 |
| 9 | 0.00020 | 0.00018 | 0.00014 | 0.000040 | 0.0000020 |
| 10 | 0.00022 | 0.00020 | 0.00015 | 0.000044 | 0.0000022 |
| 11 | 0.00024 | 0.00022 | 0.00017 | 0.000048 | 0.0000024 |
| 12 | 0.00026 | 0.00024 | 0.00018 | 0.000053 | 0.0000026 |
| 13 | 0.00029 | 0.00026 | 0.00020 | 0.000057 | 0.0000029 |
| 14 | 0.00031 | 0.00028 | 0.00021 | 0.000062 | 0.0000031 |
| 15 | 0.00033 | 0.00030 | 0.00023 | 0.000066 | 0.0000033 |
| 16 | 0.00035 | 0.00032 | 0.00024 | 0.000070 | 0.0000035 |
| 17 | 0.00037 | 0.00034 | 0.00026 | 0.000075 | 0.0000037 |
| 18 | 0.00040 | 0.00036 | 0.00027 | 0.000079 | 0.0000040 |
| 19 | 0.00042 | 0.00038 | 0.00029 | 0.000084 | 0.0000042 |
| 20 | 0.00044 | 0.00040 | 0.00030 | 0.000088 | 0.0000044 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | | | | |

## Table 15.27 Chances of Well Releases by Volume Category by Well Number

| Wells | Expected Chances over Exploration and 20-Year Abandonment Period | | | | |
|---|---|---|---|---|---|
| | Any Volume | 1 bbl or Larger | 10 bbl or Larger | 100 bbl or Larger | 1,000 bbl or Larger |
| 1 | 1 in 45,000 | 1 in 50,000 | 1 in 67,000 | 1 in 227,000 | 1 in 4,500,000 |
| 2 | 1 in 23,000 | 1 in 25,000 | 1 in 33,000 | 1 in 110,000 | 1 in 2,300,000 |
| 3 | 1 in 15,000 | 1 in 16,700 | 1 in 22,000 | 1 in 76,000 | 1 in 1,500,000 |
| 4 | 1 in 11,000 | 1 in 12,500 | 1 in 17,000 | 1 in 57,000 | 1 in 1,100,000 |
| 5 | 1 in 9,100 | 1 in 10,000 | 1 in 13,000 | 1 in 45,000 | 1 in 910,000 |
| 6 | 1 in 7,600 | 1 in 8,300 | 1 in 11,000 | 1 in 38,000 | 1 in 760,000 |
| 7 | 1 in 6,500 | 1 in 7,100 | 1 in 9,500 | 1 in 32,000 | 1 in 650,000 |

### Table 15.27 Chances of Well Releases by Volume Category by Well Number

| Wells | Expected Chances over Exploration and 20-Year Abandonment Period | | | | |
|---|---|---|---|---|---|
| | Any Volume | 1 bbl or Larger | 10 bbl or Larger | 100 bbl or Larger | 1,000 bbl or Larger |
| 8 | 1 in 5,700 | 1 in 6,300 | 1 in 8,300 | 1 in 28,000 | 1 in 570,000 |
| 9 | 1 in 5,100 | 1 in 5,600 | 1 in 7,400 | 1 in 25,000 | 1 in 510,000 |
| 10 | 1 in 4,500 | 1 in 5,000 | 1 in 6,700 | 1 in 23,000 | 1 in 450,000 |
| 11 | 1 in 4,100 | 1 in 4,500 | 1 in 6,100 | 1 in 21,000 | 1 in 410,000 |
| 12 | 1 in 3,800 | 1 in 4,200 | 1 in 5,600 | 1 in 19,000 | 1 in 380,000 |
| 13 | 1 in 3,500 | 1 in 3,800 | 1 in 5,100 | 1 in 17,000 | 1 in 350,000 |
| 14 | 1 in 3,200 | 1 in 3,600 | 1 in 4,800 | 1 in 16,000 | 1 in 320,000 |
| 15 | 1 in 3,000 | 1 in 3,300 | 1 in 4,400 | 1 in 15,000 | 1 in 300,000 |
| 16 | 1 in 2,800 | 1 in 3,100 | 1 in 4,200 | 1 in 14,000 | 1 in 280,000 |
| 17 | 1 in 2,700 | 1 in 2,900 | 1 in 3,900 | 1 in 13,000 | 1 in 270,000 |
| 18 | 1 in 2,500 | 1 in 2,800 | 1 in 3,700 | 1 in 13,000 | 1 in 250,000 |
| 19 | 1 in 2,400 | 1 in 2,600 | 1 in 3,500 | 1 in 12,000 | 1 in 240,000 |
| 20 | 1 in 2,300 | 1 in 2,500 | 1 in 3,300 | 1 in 11,000 | 1 in 230,000 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | | | | |

Probabilities of well blowouts and releases are based on historical data. It is anticipated that future blowouts will be less frequent and involve smaller volumes due to technological advances. One research team conducted a fault-tree analysis of blowouts including newer intervention technologies developed after the Macondo MC252 incident. They concluded that the interventions would reduce flow duration and reduce the total blowout volume, by 30% to 60% (Caia et al. 2018). Their analysis predicted much smaller volumes of release.

### 15.4.3 Summary

The estimated probabilities (and return periods) of modelled scenarios are shown in Table 15.28. Overall, the probabilities of spillage are very low and if spillage does occur, the spill volumes are likely to be relatively small. The same data are presented as chances in Table 15.29.

## Table 15.28 Probabilities of BHP Orphan Basin Hypothetical Scenario Spillage

| Well Number | Expected Frequency over BHP Orphan Basin Project Exploration and Abandonment | | | | | |
|---|---|---|---|---|---|---|
| | Site 1 Blowout | | Site 2 Blowout | | SR-5 Batch Spill 20 bbl | |
| | SB-1 4,052,506 bbl | SB-2 15,496,924 bbl | SB-3 4,050,183 bbl | SB-4 15,496,430 bbl | 35-day Drilling | 115-day Drilling |
| 1 | 0.000014 | 0.00000014 | 0.000014 | 0.00000014 | 0.02 | 0.07 |
| 2 | 0.000028 | 0.00000028 | 0.000028 | 0.00000028 | 0.04 | 0.13 |
| 3 | 0.000042 | 0.00000042 | 0.000042 | 0.00000042 | 0.06 | 0.20 |
| 4 | 0.000056 | 0.00000056 | 0.000056 | 0.00000056 | 0.08 | 0.27 |
| 5 | 0.000070 | 0.00000070 | 0.000070 | 0.00000070 | 0.10 | 0.33 |
| 6 | 0.000084 | 0.00000084 | 0.000084 | 0.00000084 | 0.12 | 0.40 |
| 7 | 0.000098 | 0.00000098 | 0.000098 | 0.00000098 | 0.14 | 0.47 |
| 8 | 0.00011 | 0.0000011 | 0.00011 | 0.0000011 | 0.16 | 0.55 |
| 9 | 0.00013 | 0.0000013 | 0.00013 | 0.0000013 | 0.18 | 0.60 |
| 10 | 0.00014 | 0.0000014 | 0.00014 | 0.0000014 | 0.20 | 0.65 |
| 11 | n/a | n/a | n/a | n/a | 0.22 | 0.75 |
| 12 | n/a | n/a | n/a | n/a | 0.24 | 0.80 |
| 13 | n/a | n/a | n/a | n/a | 0.26 | 0.85 |
| 14 | n/a | n/a | n/a | n/a | 0.28 | 0.95 |
| 15 | n/a | n/a | n/a | n/a | 0.30 | 1.00 |
| 16 | n/a | n/a | n/a | n/a | 0.32 | 1.05 |
| 17 | n/a | n/a | n/a | n/a | 0.34 | 1.10 |
| 18 | n/a | n/a | n/a | n/a | 0.36 | 1.20 |
| 19 | n/a | n/a | n/a | n/a | 0.38 | 1.25 |
| 20 | n/a | n/a | n/a | n/a | 0.41 | 1.30 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | | | | | |

### Table 15.29 Chances of BHP Orphan Basin Hypothetical Scenario Spillage

| Well Number | Chances over BHP Orphan Basin Project Exploration and Abandonment | | | | | |
|---|---|---|---|---|---|---|
| | Site 1 Blowout | | Site 2 Blowout | | SR-5 Batch Spill 20 bbl | |
| | SB-1 4,052,506 bbl | SB-2 15,496,924 bbl | SB-3 4,050,183 bbl | SB-4 15,496,430 bbl | 35-day Drilling | 115-day Drilling |
| 1 | 1 in 71,000 | 1 in 7,100,000 | 1 in 71,000 | 1 in 7,100,000 | 1 in 50 | 1 in 15 |
| 2 | 1 in 36,000 | 1 in 3,600,000 | 1 in 36,000 | 1 in 3,600,000 | 1 in 25 | 1 in 8 |
| 3 | 1 in 24,000 | 1 in 2,400,000 | 1 in 24,000 | 1 in 2,400,000 | 1 in 17 | 1 in 5 |
| 4 | 1 in 18,000 | 1 in 1,800,000 | 1 in 18,000 | 1 in 1,800,000 | 1 in 13 | 1 in 4 |
| 5 | 1 in 14,000 | 1 in 1,400,000 | 1 in 14,000 | 1 in 1,400,000 | 1 in 10 | 1 in 3 |
| 6 | 1 in 12,000 | 1 in 1,200,000 | 1 in 12,000 | 1 in 1,200,000 | 1 in 8.3 | 1 in 2.5 |
| 7 | 1 in 10,000 | 1 in 1,000,000 | 1 in 10,000 | 1 in 1,000,000 | 1 in 7.1 | 1 in 2.2 |
| 8 | 1 in 8,900 | 1 in 890,000 | 1 in 8,900 | 1 in 890,000 | 1 in 6.3 | 1 in 1.8 |
| 9 | 1 in 7,900 | 1 in 790,000 | 1 in 7,900 | 1 in 790,000 | 1 in 5.6 | 1 in 1.7 |
| 10 | 1 in 7,100 | 1 in 710,000 | 1 in 7,100 | 1 in 710,000 | 1 in 5.0 | 1 in 1.5 |
| 11 | n/a | n/a | n/a | n/a | 1 in 4.5 | 1 in 1.3 |
| 12 | n/a | n/a | n/a | n/a | 1 in 4.2 | 1 in 1.3 |
| 13 | n/a | n/a | n/a | n/a | 1 in 3.8 | 1 in 1.2 |
| 14 | n/a | n/a | n/a | n/a | 1 in 3.6 | 1 in 1.1 |
| 15 | n/a | n/a | n/a | n/a | 1 in 3.3 | 1 in 1.0 |
| 16 | n/a | n/a | n/a | n/a | 1 in 3.1 | 1 in 1.0 |
| 17 | n/a | n/a | n/a | n/a | 1 in 2.9 | 1 in 0.9 |
| 18 | n/a | n/a | n/a | n/a | 1 in 2.8 | 1 in 0.8 |
| 19 | n/a | n/a | n/a | n/a | 1 in 2.6 | 1 in 0.8 |
| 20 | n/a | n/a | n/a | n/a | 1 in 2.5 | 1 in 0.8 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | | | | | |

There are two types of oil releases that could potentially occur directly from exploration wells and their associated infrastructure–subsurface blowouts, well releases, Batch spills of fuel oils and other oils used in operations, as well as SBM, may also occur from PSVs and drilling rigs. The likelihood of incidents occurring depends on the number of wells and the duration of the exploration period. With more wells there are greater chances of having a spill. The two sites within the BHP Orphan Basin do not differ with respect to the probability of blowouts. They do differ with respect to potential blowout volumes due to a 1.2% difference in flowrates.

For each, there is a 1 in 7,100 chance that there will be a blowout during exploration if there is one well. With 10 wells, the chance increases to 1 in 710. Across both sites with up to 20 wells, there is a 1 in 360 chance of a blowout.

It is important to remember that when a blowout occurs, it is more likely to involve a relatively smaller volume than a very large volume. The vast majority (84%) of blowouts bridge over naturally within a few hours to days even in the absence of any intervention or before an intervention can be implemented. However, it should be noted that the high flowrates for the two wells–5,484 bbl per hour and 5,420 bbl per hour during the first day for Site 1 and Site 2, respectively–means that even with a few hours of flow, there would be a spill in the tens of thousands of barrels. The chances of a blowout involving 100,000 bbl or more are 1 in 7,400 for Site 1, and 1 in 8,300 for Site 2 per well. Larger blowout volumes are less likely. The chances of a blowout of 1,000,000 bbl are 1 in 48,000 and 1 in 45,000, respectively.

The chances for the four hypothetical blowout scenarios modelled are as shown in Table 15.30. These scenarios were identified as potential "worst-case" discharges and assume that intervention measures could not be properly implemented until 30 days (capping) or 120 days (relief well).

### Table 15.30 Chances of BHP Orphan Basin Modelled Hypothetical Blowout Scenarios

| Site | Scenario | Flow Duration | Total Volume | Chances over Exploration | |
|---|---|---|---|---|---|
| | | | | 1 Well at Site | 10 Wells at Site |
| Site 1 | SB-1 | 30 days | 4,052,506 bbl | 1 in 71,000 | 1 in 7,100 |
| Site 1 | SB-2 | 120 days | 15,496,924 bbl | 1 in 7,100,000 | 1 in 710,000 |
| Site 2 | SB-3 | 30 days | 4,050,183 bbl | 1 in 71,000 | 1 in 7,100 |
| Site 2 | SB-4 | 120 days | 15,496,430 bbl | 1 in 7,100,000 | 1 in 710,000 |
| Probability results calculated by ERC based on analysis of international and national oil spill data. | | | | | |

For well releases, the chances are 1 in 45,000 per well for both sites. With 10 wells, the chances increase to 1 in 4,500. With 20 wells across both sites, the chances increase to 1 in 2,300. Well releases tend to be small, with a maximum that is much smaller than a potential worst-case blowout.

There is a 1 in 5 chance of a batch spill for each well. This means that with five or more wells, it can be expected that there is at least one batch spill, although this is not "guaranteed." There is no difference between the sites. Batch spills also are generally relatively small as there is a limited amount of oil that is contained in the fuel tanks or other storage capacity.

The analyses on probabilities of blowouts, well releases, and batch spills are based on historical data, which include incidents that occurred under conditions that did not include many of the safety measures that are now in place or will be implemented in years to come. There are continuing developments in blowout prevention and mitigation, as well as improved safety practices in offshore operations, that will continue to reduce the likelihood and severity of these incidents in the future.

The probability and frequency of potential blowout and batch spills that may result from the various activities that comprise this Project were calculated based on a review of national and international records of historical offshore spill events. This analysis found that the highest potential frequencies are for the smaller, operational spills. Spills less than one barrel in size (less than 159 L) may occur one to two times per well, based on recent petroleum development experience off NL. Although these smaller spills may occur more often, the median volume is 4 L. Historical spill records for very small spills do not differentiate between production and exploration activities, and so the probability of very small spills during exploration activities may be overestimated.

# 15.5 CONTINGENCY PLANNING AND SPILL RESPONSE

As detailed in previous sections of this chapter, BHP prioritizes actions to prevent accidents occurring. However, in the unlikely event of a spill occurring a comprehensive set of emergency management procedures and equipment will be available to minimize harm to the environment.

## 15.5.1 Emergency Response Plans

BHP has a tiered emergency response structure dependent on the severity of the emergency, as shown in Figure 15-35.

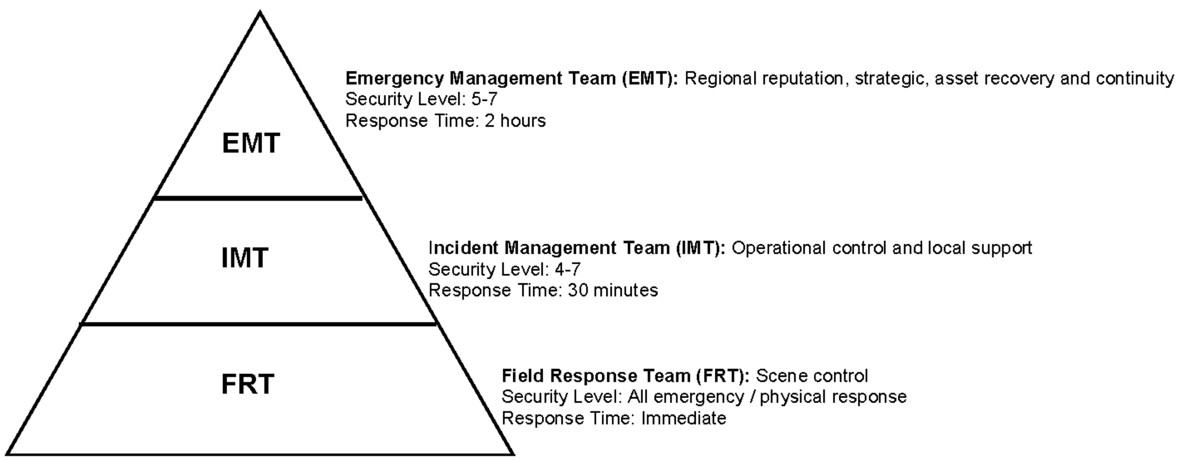



**Figure 15-35 BHP Emergency Response Structure**

The Field Response Team will be based onboard the MODU, the Incident Management Team in St John's and the Emergency Management Team in Houston. These teams will use the Incident Command System structure.

Project specific ERP have been written to supplement and compliment Contractor ERPs. These documents provide:

- Guidance, flowcharts and checklists for key members of the Field Response Team and the Incident Management Team
- Integration into Contractor ERPs
- A comprehensive list of contact details for key campaign personnel and outside agencies that may provide support in an emergency scenario.

The BHP HSE Standard sets out minimum requirements of ERPs and training exercises.

Prior to commencing operations, an emergency response drill will be undertaken with the purpose of testing the effectiveness of ERPs and confirming lines of communication. A report will be produced and any deficiencies rectified.

BHP will ensure that sufficient support is available for the contractor emergency response requirements as outlined below.

BHP will have a suite of ERPs including:

- ERP, this document will be supplementary and complimentary to MODU and PSV Contractor ERPs.
- OSRP
- Oiled Wildlife Response Plan (OWRP)
- Blowout Contingency Plan (Source Control Plan)

The Project will adopt a tiered approach for the OSRP, as per IPIECA guidelines, for planning the response to oil spills. The tiered response definitions are provided in Table 15.31.

### Table 15.31 Tiered Level Response Description

| | |
|---|---|
| **Tier 1** | **Resources necessary to handle a local spill and/or provide an initial response**<br>Tier 1 has been conventionally defined by the response capability required to deal immediately with operational spills. However, it is important to recognize that all spills, regardless of cause or consequence, have a Tier 1 component. Tier 1 is therefore the foundation of preparedness and response for all spills, which may or may not ultimately escalate beyond the scope of Tier 1 initial actions and capabilities. |
| **Tier 2** | **Global resources necessary for spills that require a substantial external response due to incident scale, complexity and/or consequence potential**<br>Tier 2 capability includes a wider selection of equipment suited to a range of strategic response options. More importantly, Tier 2 delivers more people, and a greater range of specialism. While Tier 1 responders may be appropriately trained and knowledgeable, their response duties are invariably subordinate to their operational role. Tier 2 service providers come with appropriate professional training and have knowledge of national legislation and domestic practices in the countries / regions in which they work. In the context of the wider incident, Tier 2 contractors can also provide access to expertise for specific elements of spill response (e.g., aircraft, communication systems, marine logistics and other emergency-related services), the absence of which may delay or hinder a response. |
| **Tier 3** | **Global resources necessary for spills that require a substantial external response due to incident scale, complexity and/or consequence potential**<br>Tier 3 capability tends to be predetermined, with well-established industry-controlled equipment stockpiles and response personnel at key strategic locations and with defined geographical remits. It is through contracts and agreements that industry and governments can have access to the cooperatively held resources therein. Physical response times to any given risk location can be ascertained, and agreements are in place which guarantee specified response services and time frames to provide added security |
| Source: IPIECA-IOGP 2015 | |

A full range of response tools and strategies are provided in the tiered response approach and it can be mobilized, demobilized and implemented efficiently and appropriately. The tiered response approach will be adhered to in BHP's ERP, OSRP, and the well control plan.

Response resources include:

- Regional resources such as ECRC
- International resources such as Oil Spill Response Limited (OSRL)
- Specialized well control contractors
- Regional mutual aid agreements with other operators

BHP's OSRP will include an OWRP and will be submitted to the C-NLOPB during the OA application process. In consultation with Environment and Climate Change Canada (ECCC), BHP will develop the OWRP in conjunction with professionals with expertise in wildlife response offshore NL that reflects the requirements for mounting an effective wildlife response for risks, species, and facilities specific to NL.

The primary headings of the Wildlife ERP OWRP will include

- Scope and application
- Initial wildlife response actions: 0 to 48 hours
- Wildlife Branch structure and function
- Resources at risk
- Field operations
- Rehabilitation operations
- Demobilization
- Record keeping and information management
- Personnel
- Facilities

NL-specific information will be appended to the OWRP as required and could include

- Contact list(s)
- Roles and responsibilities
- Task checklist
- Oiled wildlife sightings tracking
- Roles of agencies and permits
- Human health and Safety
- Personnel guidelines
- Facility requirements

### 15.5.2 Blowout Contingency (Source Control) Planning

A multi-faceted approach will be taken in response to an uncontrolled hydrocarbon flow from the well. Many of these measures will be deployed simultaneously to provide a comprehensive response and ensure redundancy in control measures, as shown in Figure 15-36. This approach also provides a level of contingency so that additional measures will be available to be deployed as back-up if initial response measures are unsuccessful.

Efforts for well control response and well intervention (i.e., source control) strategies include:

- Direct BOP intervention
- Mobilization and installation of a capping stack
- Drilling of a relief well if required

Containment and recovery of oil and *in situ* burning, may also be implemented, as appropriate. Depending on the outcome of the Project and incident-specific SIMAs, and pending regulatory approval, dispersant application may be considered to help reduce surface or shoreline oiling. If dispersant use was determined to be appropriate, approved, and shown to be feasible, BHP would deploy surface dispersant (from boats and or planes) and subsurface dispersant injected into the flow stream from the well.

Throughout the response effort process the IMT will assess each situation as it evolves to adjust the response strategy so that it is appropriate for the specific and/or changing conditions.

In the event of a loss of well control and subsequent blowout incident there will be a general sequence of response for source control, which is illustrated in Figure 15-36, showing the relative timing of BOP intervention and capping and containment measures that would be implemented to stop the flow of hydrocarbons. Note that additional spill response efforts would be ongoing to manage, contain, and recover spilled hydrocarbons.

BHP will have a source control plan that conforms to IOGP 594 Guidelines (industry best practice for these documents) and will be signed on to Atlantic Canada mutual aid agreements that facilitate the sharing of equipment, resources and personnel in the event of a blowout.

BHP will conduct a Spill Impact Mitigation Assessment (SIMA), which is an evaluation applied to an oil spill to assist in the selection of the appropriate response options that will maintain responder safety and result in the best overall recovery resources of concern (either ecological, socio-economic and/or cultural). Multiple response options are often required to reduce environmental impacts in most spill scenarios. A SIMA:

- Compiles and evaluates data for relevant oil spill scenarios
- Predicts outcomes / impacts for the relevant spill scenarios (including a "No Intervention" [or "natural attenuation" option)
- Balance trade-offs of the benefits and drawbacks of each feasible response scenario, including No Intervention
- Selects the best response option(s) to develop the strategy for each scenario,

BHP will develop their SIMA as per the Guidelines on Implementing Spill Impact Mitigation Assessment (SIMA) (IPIECA-API-IOGP 2017) and will consider all feasible response options that would be potentially effective in the Project Area.

### 15.5.3 Well Intervention Response

#### 15.5.3.1 BOP Intervention

A BOP intervention response is estimated to take between two and five days. BHP's first response to primary BOP procedures failure (see Section 2.3.4 of the EIS) would be to attempt direct intervention measures intended to close in the original BOP. The BOP will be equipped with multiple shear rams as noted previously to provide additional options to close the BOP.

External intervention on the BOP may be required and equipment and capacity will be maintained to do so. This will include specialist equipment and ROVs that can be deployed from a PSV or the MODU to provide hydraulic power to the BOP in order to close the rams directly.

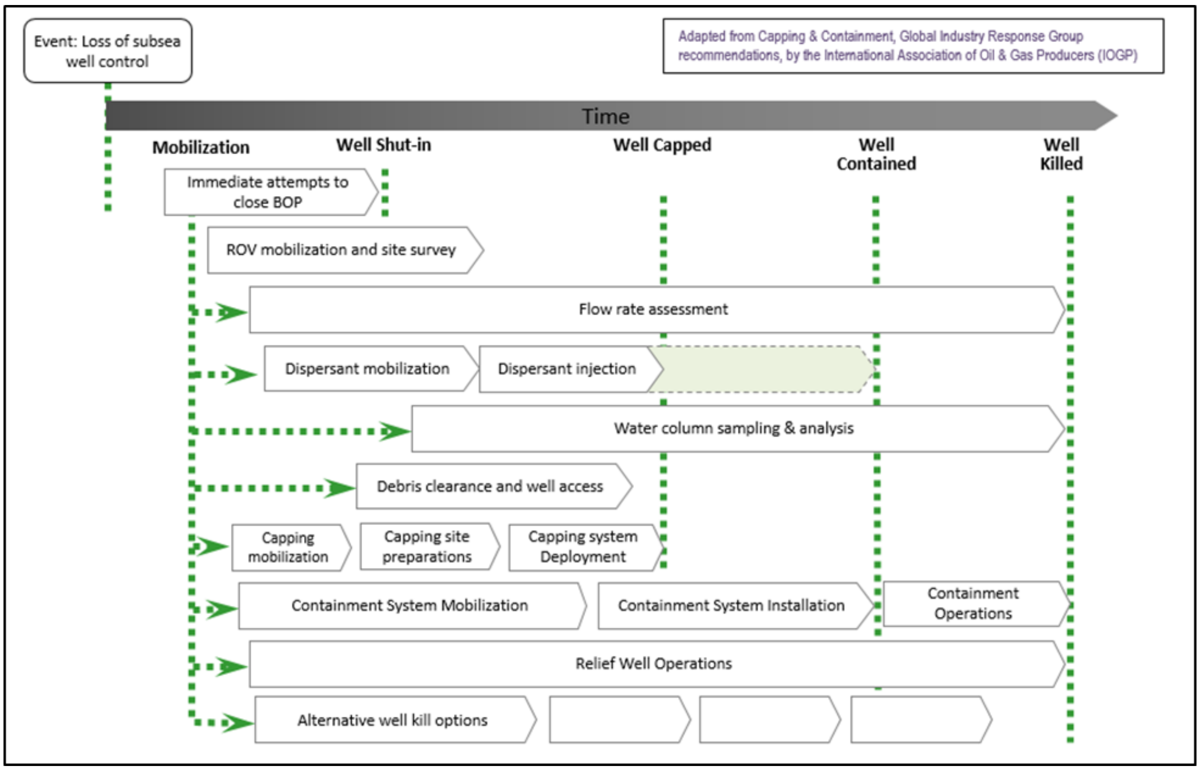



**Figure 15-36 Generic Sequence of Response for Source Control**

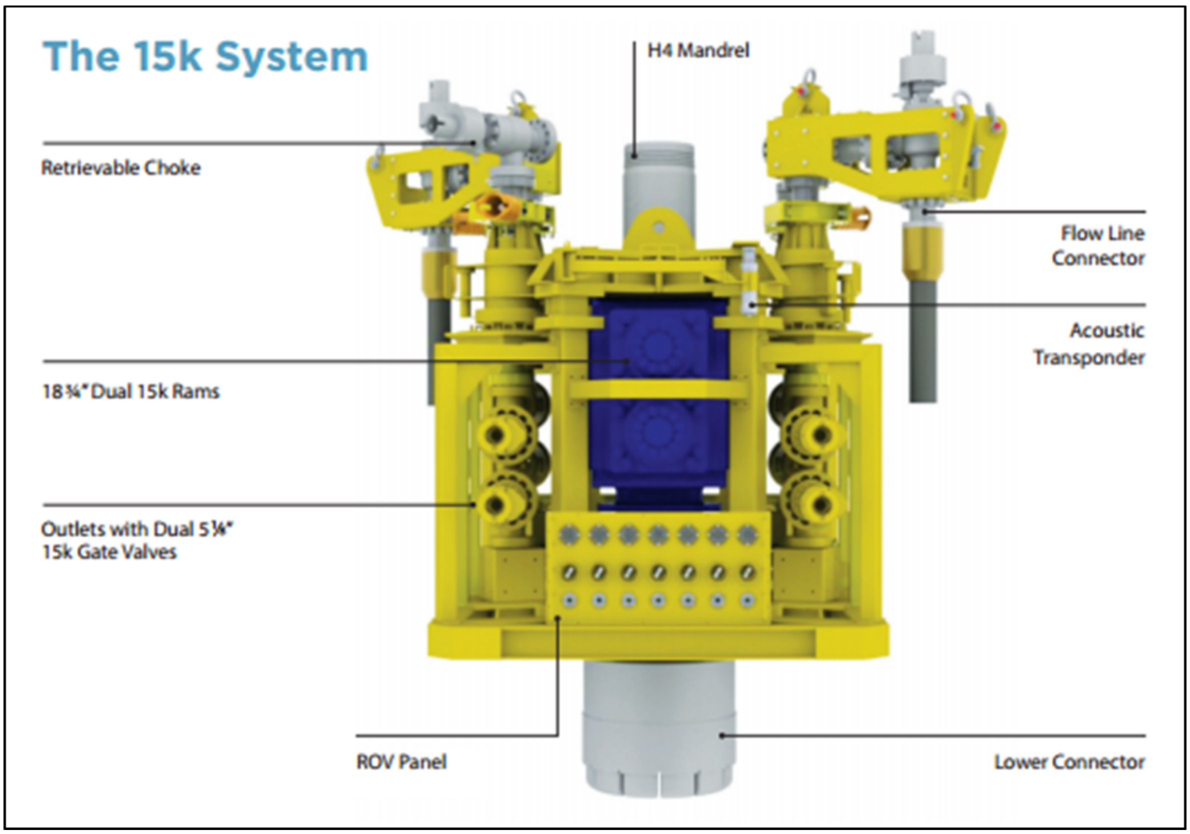
#### 15.5.3.2 ROV Mobilization, Site Survey and Debris Clearance

Additional response efforts can be impeded by debris on the seafloor, potentially including marine riser debris, and limiting access for response equipment. An ROV-based site survey will be carried out to assess the extent of debris on the seafloor following the blowout incident. Subsurface cranes and ROVs with debris removal tools will be used to clear the area around the wellsite if large debris is detected.

### 15.5.3.3 Well Capping

A specialized piece of equipment, referred to as a subsurface well capping stack, can be used to “cap” (i.e., stop or redirect) the well flow while work to permanently kill the well is undertaken. Well capping stacks are designed to withstand the maximum anticipated wellhead pressure generated by the well. Operators within the industry, including BHP, are continually refining and enhancing the deployment of capping stacks.

In the event of an incident, BHP’s current primary plan is to use the OSRL capping stack stored in Stavanger, Norway, and will maintain a list of suitable deployment vessels in both the Atlantic Canada region (e.g., the Skandi Constructor, the Maersk Nexus or several of the Atlantic towing fleet) and in the northwest European region (e.g., from the North Sea or Norway).The capping stack stored in Stavanger, Norway, is rated to 15,000 psi working pressure. A diagram of the 15,000-psi capping stack that would be used is shown in Figure 15-37. This capping stack, established by OSRL (in response to industry demand for improved response times), in collaboration with its members, is a single unit air-freightable capping stack which is capable of being transported, fully assembled in one single unit, by air, in an Antonov AN-124.




Source: OSRL 2014

**Figure 15-37 15,000 psi Capping Device**

If a blowout incident were to occur, BHP would immediately assess the most expedient route for capping the well. This could involve securing a deployment vessel in North West Europe and mobilizing the capping stack direct from Stavanger via marine transport to the incident site or transporting it by air to the St. John’s or Gander international airports using an Antonov AN-124 aircraft and mobilizing it from there to offshore in a suitable PSV. The most likely timing for mobilization and installation by sea on a subsurface construction vessel from Stavanger is calculated to be 13 days (summer) to 17 days (winter) (P50, median value), while likely timing for mobilization and installation by air is calculated to be nine days (P50, median value). Metocean conditions will affect cruising speeds, and therefore sailing times, from Stavanger to the Project Area, which are likely to differ between summer and winter.

During the cap transit, the necessary engineering analysis, technical review, debris clearance, and site preparations will have been underway such that cap installation can begin upon arrival of the cap at the wellsite.

A straightforward installation and closure under good conditions would take approximately 24 hours, however, precise durations would be highly dependent on local conditions specific to the incident and longer times may be required for a more complicated installation, with potential weather-related downtime. Allowing for these uncertainties, BHP estimates that the earliest a well could be capped would be 17 days after an incident based on P50 timings.

#### 15.5.3.4 Relief Well Drilling

Prior to drilling BHP will calculate a worst-case discharge (flowrate) using conservative parameters and model a dynamic kill (kill from a relief well) to ensure that the well is practical to kill. Casing and wellhead inventories will be maintained to ensure there is always equipment on hand to drill a relief well.

Once secondary well control has been re-established via the capping stack, primary well control would be regained by the drilling of a relief well. Depending on the nature of the blowout it may not be possible to re-establish secondary well control with the capping stack. If secondary well control is re-established, then a relief well may not be required, depending on the scenario. BHP has master service agreements in place for specialist assistance to help with engineering and operational support for a relief well.

Execution plans for a relief well will be similar to a standard well. A relief well is typically drilled as a vertical hole down to a planned deviation ("kick-off") point, where it is turned toward the target well using directional drilling technology and tools. Dynamic kill well control commences after the target well is intersected, by pumping drilling fluid down the relief well into the incident well to kill the flow. Concrete may follow to seal the original well bore.

Should a relief well be required, a suitable MODU will be sourced (which may include mobilization to Newfoundland offshore waters), and wellheads, running tools, and tubulars will be transported by air and sea as appropriate such that equipment required in the top-hole sections of the relief well construction would be available prior to spud. It is estimated that it would take up to 120 days to kill the well based on a conservative (P90) time forecast and a 50% non-productive time assumption.

### 15.5.4 Oil Spill Response

Oil spill response at an offshore facility falls under the jurisdiction of the C-NLOPB pursuant to Section 161 of the *Atlantic Accord Act*. The regulatory mandate of the C-NLOPB is to ensure the operator is taking all reasonable measures to prevent further spillage and to mitigate the effect and impacts of the spill. The

Chief Conservation Officer (CCO) has the authority to direct the operator or to take over management of the response effort directly, if reasonable measures are not being taken.

C-NLOPB is the designated lead agency in offshore spill incidents at the drilling site under memoranda of understanding. A variety of other federal and provincial agencies that may act in supporting roles include:

- Fisheries and Oceans Canada (DFO)
- Canadian Coast Guard (CCG)
- ECCC
- Transport Canada
- Provincial government departments

The C-NLOPB is also named as the lead agency in offshore spill incidents under the CCG National Emergency Response Plan. BHP is expected by the C-NLOPB to have a credible response capability including:

- Designated response personnel
- A training program for BHP personnel and BHP contractors
- Spill tracking and clean-up equipment at the offshore site

The C-NLOPB has expressed a series of ‘expectations’ or policies that pertain to drilling operations, in addition to specific requirements under formal guidelines, these include:

- An on-site oil spill response capability
- Access to third party oil spill personnel and equipment
- Mutual aid agreements with other Grand Banks operators

BHP’s OSRP for the BHP Canada Exploration Drilling Project will cover the management, countermeasures, strategies, and training that will be used in the response to potential spills originating inside the safety zone of the Project.

BHP’s OSRP will contain specific details of response methods that can be used in the event of an oil spill, including different tactical response methods that will be available to be used depending on the specific conditions of a spill event. The OSRP will address how some of the methods will be affected by specific environmental conditions (e.g., wave height and visibility), and provide a description of how different tactics will be selected for different scenarios and locations.

The following list is a comprehensive review of what the OSRP will provide:

- BHP’s philosophy and policies concerning oil spill response
- The organization of BHP’s response efforts and the evolution of those efforts with the increasing scale of the spill response
- Arrangements for assistance from contractors, other operators and corporate resources
- Environmental issues resulting from an offshore oil spill
- BHP’s policies concerning safety, oil spill waste management, and training

Detailed information within the following areas will be included in the plan:

- Actions - Personnel checklists and the forms to be used both in the field and by the onshore Emergency Response Team (ERT) during oil spill response
- Resources - Details of the personnel, equipment and vessel resources available to BHP for use in an oil spill response
- Oil Spill Fate - Anticipated fate and characteristics of spilled crude
- Procedures - Stand-alone detailed procedures which describe specific actions that may be undertaken during oil spill response. Some of these procedures will be used directly as training materials
- Glossary - A dictionary of oil spill terms and acronyms
- Contacts - Contact information for:
  - BHP emergency personnel
  - Key BHP contractors
  - Oil spill consultants and contractors
  - Government agencies
  - Other offshore Operators' emergency personnel
  - Grand Banks offshore platforms and vessels

For response to small fuel, hydraulic, or testing spills, BHP's vessels will be equipped with sorbent materials. BHP will contract Eastern Canada Response Corporation (ECRC) as their spill response contractor, thereby providing a pool of equipment and consistency with all Grand Banks Operators. BHP will be a signatory to the multi-operator mutual aid which includes oil spill response and oiled wildlife rehab. Additionally, BHP has a contract with OSRL, which is an international, industry-owned organization that provides resources and expertise for oil spill response and clean-up. This gives BHP access to and use of specialist equipment and call on and deploy specialist incident management experts and technical advisors. OSRL's expertise and resources are strategically located across the world to facilitate effective and efficient response to oil spill incidents.

BHP's OSRP has been structured to support any of BHP's operations offshore Newfoundland. An operational component meets or exceeds standards established by the *Canada Shipping Act*. A response management component is linked to BHP's ERP and the ECRC Spill Management System, which is certified under the *Canada Shipping Act*.

BHP has established an operational capability to respond to offshore oil spills. Equipment has been staged, with resources at site, to allow prompt response to small spills, and a contract will be established with ECRC to use their services equipment stored at ECRC's facility in Mount Pearl, to allow an efficient response to larger spills.

Oil spill response resources include:

- Surveillance and monitoring
- Oil and oiled wildlife sampling
- Wildlife monitoring and handling
- Physical and chemical dispersion
- Containment and recovery (Sorbent boom or other systems stored onshore)

- *In situ* burning
- Natural degradation
- Shoreline protection and clean up

The management of BHP's response to an offshore oil spill will follow the process established for the response to other emergencies (Section 15.5.1), described in BHP's ERP and will be an integrated and coordinated approach to a spill incident that includes:

- Immediate reaction to the incident controlled by the Person In Charge in the Emergency Command Centre or bridge of the offshore facility
- Prompt and direct support for the offshore FRT by BHP's onshore IMT and EMT, located in St. John's and Houston, respectively
- Activation of ECRC in all spill events requiring mobilization of BHP's IMT and EMT, either as advisors to the BHP FRT or through the mobilization of the ECRC Spill Management Team
- Activation of OSRL

Three levels, or tiers, are used for response planning purposes based on the severity of the response to potential oil spills (Section 15.5.1, Table 15.31). This scheme is not just dependent on the volume of oil released, but also the level of the response. It allows for an appropriate initial response to each level of spill and subsequent escalation of the response should the potential impact of the spill increase. Each tier will require a successively higher level of operational effort and response management. The parameters to be considered in selecting the appropriate level of response include:

- Size and nature of the oil spill
- Environmental and operational conditions at the time of the spill
- Vessel and equipment availability
- Numbers and qualifications of personnel available at site
- On-site waste oil storage

BHP will employ a structured, systematic, and proportional management process, in the response to any uncontrolled release of hydrocarbons at any offshore site, in the unlikely event of a spill. Priorities in managing the response will be:

- Protection of personnel
- Protection of property (as it may affect human or environmental safety)
- Protection of the environment

The management process of any oil spill response involves two levels, regardless of the magnitude of the incident or the number of participants:

- Incident Management - the management of field activities to contain, recover, and clean up the spill based on an escalating scale of required response. This level is often referred to the "down and in" perspective
- Issues Management - the management of the community, business and communications aspects of the response at a corporate level. This level is often referred to the "up and out" perspective

Safely mitigating the effects of a spill in a way that results in the highest Net Environmental Benefit will be BHP's response priority in response to a spill. The measures implemented will be taken after consultation with regulators and will be safe, have little or no environmental impact, practical, and cost-effective. The Incident Command Systems planning process, implemented by ECRC and OSRL for an oil spill, will determine the response strategies, including cost. BHP may consult with and seek input from C- NLOPB with supporting federal and provincial government agencies. Relief well planning will be managed by BHP using other specialist contractors.

# 15.6 ENVIRONMENTAL EFFECTS ASSESSMENT

## 15.6.1 Marine Fish and Fish Habitat

The Northeast Grand Bank shelf and slope and the abyssal plain of the Orphan Basin are areas of biodiversity and marine productivity for a variety of pelagic fish, groundfish, and invertebrate species. An accidental spill could affect the risk of mortality or physical injury of fish and/or change the quality or use of fish habitat. The following sections give a brief background of the fish and fish habitat present, and the potential effects of an accidental release of oil or synthetic-based mud (SBM) within the Regional Assessment Area (RAA) from Project-related activities. An in-depth description of the existing fish and fish habitat in the RAA is presented in Section 6.1 and an associated assessment of routine activities is presented in Chapter 8.

The RAA consists of inshore, coastal, nearshore, and offshore habitat for fish. Habitat use by fish species observed in the RAA differs depending on the species and life stage. Some species exhibit life-stage or behavioral specific habitat use while other species could go through their whole life cycle in one habitat type. This EIS considers the effects of accidental oil spills on fish and fish habitat found within the RAA. Nearshore habitats including coastal and estuarine areas found in the RAA are used by fish species as feeding grounds, seasonal migrations, spawning, and nursery grounds. Other species found in nearshore habitats include invertebrates such as cephalopods (e.g., squid and octopus), crustaceans (e.g., lobster and crabs), cnidarians (e.g., corals and jellyfish), and molluscs (e.g., bivalves and gastropods). Many of these species are either commercially harvested or potentially support commercially important species. Other organisms important in the offshore environment that may be affected by an accidental oil spill include invertebrates, specifically corals and sponges. While data availability within the Project Area is limited, several species of corals and sponges may occur within the area (see Section 6.1.6.1) including soft corals, sea pens, gorgonians, and various sponges. Portions of the Newfoundland shelf edge and slope within the LAA and Project Area are designated as Significant Benthic Areas (SBA) for coral species. Of the fish species known to occur at various times of the year within the RAA and/or the Project Area, 30 species have conservation designations (identified in Section 6.1.8). Three of these species have Schedule 1 *Species at Risk Act* (SARA) protection (spotted and northern wolffish, and white shark) and one species is listed and protected under the NL ESA (American eel).

### 15.6.1.1 Project Pathways for Effects

Accidental releases of oil or SBM in the marine environment will have the potential to affect marine fish and fish habitat. The overall implications for marine fish and fish habitat depend on the nature, scale, and duration of an offshore spill. Hydrocarbon exposure to marine fish may result in change in risk of mortality or physical injury from direct and indirect effects. Hydrocarbon releases may also result in changes to fish habitat availability, quality, and use through potential effects on water and sediment quality, biogenic habitats (e.g., eelgrass beds, corals, and sponges), and associated avoidance of these areas by marine fish. As noted in Chapter 8, potential effects to marine fish and fish habitat may have associated effects on higher trophic levels (e.g., marine and migratory birds, marine mammals and sea turtles) and various fisheries (e.g., commercial, Indigenous).

### Potential Effects of an Oil Spill on Marine Fish and Fish Habitat

#### *Change in Risk of Mortality or Physical Injury*

The potential effects of an oil spill on marine fish and invertebrates depends on the type and volume of oil released, life history characteristics, habitats occupied, behavioural and avoidance responses, and time of year. Hydrocarbons may have effects on species occurring in both pelagic and benthic areas. It is generally accepted that the early life history stages of fish and invertebrates (e.g., eggs and larvae) have greater sensitivity to oil relative to adult stages (Lee et al. 2015, Sørensen et al. 2017, Laurel et al. 2019).

Planktonic species may be affected from oil on the water surface and in the water column through reduction of air-water gas exchange and light penetration. Plankton and microorganisms do not generally exhibit an avoidance response to contaminants as their movements are mainly driven by oceanographic conditions. As responses of hydrocarbon exposure on phytoplankton and zooplankton varies by species and are dependent on the nature of exposure, effects ultimately result in a change in community composition (Teal and Howarth 1984, Abbriano et al. 2011, Gilde and Pinckney 2012 in BP 2018). Oil exposure to phytoplankton typically results in altered productivity and growth (Buskey et al. 2016, Almeda et al. 2018). In laboratory studies with Gulf of Mexico plankton assemblages, crude oil exposures (e.g., 1, 5, and 25 µl/L) modified the phytoplankton community (Almeda et al. 2018). Exposures reduced the abundance of phytoplankton grazers, disrupted predator-prey controls, and resulted in increased concentration of blooming dinoflagellates (Almeda et al. 2018). Laboratory experiments with DWH oil spill crude oil or Texas crude oil samples resulted in decreasing phytoplankton abundance with increasing concentration of oil and change in phytoplankton community (Gilde and Pinckney 2012 in BP 2018). Within the saltmarsh estuarine phytoplankton community studied, some phytoplankton (diatoms, cyanobacteria, euglenophytes, and chlorophytes) were found to be relatively resistant to contamination, while others (cryptophytes) were found to be vulnerable in the community (Gilde and Pinckney 2012 in BP 2018).

Zooplankton are considered sensitive to hydrocarbon exposure, resulting in lethal and sublethal (e.g., effects on growth, development, feeding, and reproduction) effects (Almeda et al. 2013, Utne 2017, Toxværd et al. 2018). Utne (2017) did not observe any effects on hatching success rates in adult *Calanus* copepods exposed to hydrocarbons; however, exposed early life history stages showed increased oxygen consumption and metabolism effects with potential negative implications for development. *Calanus* are important zooplankton species in the Northwest Atlantic whose population dynamics have implications for higher trophic levels (see Section 6.1.4). As with other plankton, zooplankton have limited avoidance to oil spills, however certain taxa of coastal and estuarine copepods have been observed to detect and avoid small patches (1-7 cm) of hydrocarbon contaminated water (Seuront 2010). Oil components may be accumulated in zooplankton through ingestion of hydrocarbon exposed phytoplankton, or through direct ingestion of crude oil droplets (Almeda et al. 2014, 2016). Zooplankton have oil-degrading bacteria in their gut that facilitates hydrocarbon detoxification through excretion as fecal pellets (Toxværd et al. 2018). Zooplankton exposed to sublethal levels of hydrocarbons have been shown to depurate accumulated hydrocarbons within days of being moved to clean water (Trudel et al. 1985, in BP 2018). Due to short generation times and high fecundity, recovery of zooplankton communities are likely to occur soon after a spill (BP 2018).

The local microbe community in an area is adapted to background levels of hydrocarbons (ASM 2011). Hydrocarbons are a source of organic matter that serve as a food source for microbes where they are able to metabolize the compounds for energy and growth (ASM 2011).Therefore, bacteria capable of degrading hydrocarbons proliferate and multiply quickly in the presence of a spill of crude oil or hydrocarbons (ASM 2011). As microbial communities do with other sources of organic matter, hydrocarbons are degraded into marine 'snow' and shuttled to the deep-sea, where it will continue to degrade (Passow et al. 2012, Daly et al. 2016, Passow 2016). The volume of oil released into the environment during a spill initially outpaces the ability of bacteria to degrade the substance until the community replicates and increase their population in response to the increased availability of a hydrocarbon source (ASM 2011). In coordination with other physical processes (e.g., evaporation, dissolution, dispersion, and photo-oxidation), bacteria will eventually clean up the spill by consuming the hydrocarbon compounds which are biodegradable (ASM 2011). The end products of hydrocarbon degradation under aerobic conditions are typically carbon dioxide and water (ASM 2011). Some remaining partially degraded hydrocarbon compounds may be toxic to marine organisms; however, they are not likely to result in adverse effects greater than original oil components (ASM 2011). Bacterial respiration, through biodegradation of hydrocarbons in association with oxidation of methane, has the potential to cause oxygen depletion, eventually leading to hypoxia in areas near oil spills based on modelling scenarios in the Gulf of Mexico (Adcroft et al. 2010 in BP 2018).These hypoxic conditions tend to form in deeper waters as the oil is broken down, with the hypoxic area smaller than the overall oil spill plume (Adcroft et al. 2010 in BP 2019).

Hydrocarbon exposure to adult fish has been observed to lead to reduced swimming performance (Stieglitz et al. 2016), reduced immune defences (Bayha et al. 2017, Suzuki et al. 2018), higher susceptibility to parasite loading (Khan 1990), and increased physiological stress (Klinger et al. 2015). However, these effects are reflective of long-term exposures to hydrocarbons or single laboratory studies with farm-raised fish or caged fish that are unable to avoid oil exposure (e.g., Barnett and Toews 1978, Thomas and Rice 1987, Vignier et al. 1992, Alvarez Piñeiro et al. 1996, Zhou et al. 1997, Stagg et al. 1998, Meador et al. 2006, Stieglitz et al. 2016 in Nexen 2018). Adult stages of pelagic and benthic fish and invertebrates generally have lower exposure risk because of their mobile nature and ability to avoid oiled areas (Irwin et al. 1997, Law et al. 1997 in BP 2018). Experiments indicate that salmon species have some capability for detection of hydrocarbon concentrations shown to cause mortality, and subsequently avoid the contaminated water (Barnett and Toews 1978, Weber et al. 1981, Alvarez Piñeiro et al. 1996, Stagg et al. 1998). Exposure of Atlantic bluefin tuna to hydrocarbons may result in reproductive alterations; however, adults may be able to avoid prolonged exposure to oil as they are capable of long-distance travel (approximately 100 km per week) (Hazen et al. 2016). Species that spawn or occur in nearshore areas are at higher risk of repeated exposure in instances of shoreline oiling or contamination of sediments (Yender et al. 2002, Lee et al. 2015 in BP 2018). Depending on their motility and use of contaminated sediments, benthic invertebrates have a moderate to high risk of exposure (Yender et al. 2002, Lee et al. 2015 in BP 2018). Deep-sea fishes and invertebrates are generally characterized as having lower metabolisms, slower growth rates, and longer life spans, therefore recovery from anthropogenic disturbances such as oil spills would be slower than shallow water counterparts (Clark et al. 2015, Cordes et al. 2016).

Early life stages are generally at a greater risk of exposure as they are less motile than adults with limited avoidance capability (Yender et al. 2002 in BP 2018). These life stages are also typically more sensitive to lower concentrations of hydrocarbons because they may not have yet developed detoxification systems for metabolizing hydrocarbons (Rice 1985, Carls et al. 1999, Incardona et al. 2013, Lee et al. 2015 in BP 2018). Experimental exposure studies to hydrocarbons have shown lethal and sublethal toxic effects on sensitive early life stages of marine fish and invertebrates (Marty et al. 1997, Petersen and Kristensen 1998, Carls et al. 1999, Heintz et al. 1999, Couillard 2002, Pollino and Holdway 2002, Colavecchia et al. 2004, Incardona et al. 2004, 2014, Hendon et al. 2008 in BP 2018). Increased mortalities and deformities and reduced growth have been observed in Atlantic herring and capelin larvae exposed to polyaromatic hydrocarbon (PAH) in laboratory studies (Paine et al. 1992, Ingvarsdóttir et al. 2012). Similarly, Atlantic cod, Atlantic haddock, and polar cod embryos exposed to dispersed oil resulted in heart and skull deformities (Sørensen et al. 2017, Laurel et al. 2019). Laboratory exposure of larval echinoderm and bivalve invertebrate species to oil collected from DWH spill indicated no effect on survival and development from weathered oil and adverse effects from fresh oil (Stefansson et al. 2016). There is potentially more risk during the seasonal phytoplankton plume when there is increased concentration of eggs, larvae, and juveniles in the water column and are typically associated with elevated food levels (Stige et al. 2018, Samuelsen et al. 2019). Although potential effects on larval stages are adverse, some modelling studies on cod species indicate that it may not necessarily result in population-level negative effects on adult populations (Gallaway et al. 2017, Carroll et al. 2018).

As noted in Section 6.1.6.1, corals and sponges are sensitive benthic invertebrates in the region and have limited capacity for avoidance as sessile species. The effects of hydrocarbons on corals using visual indicators of stress have been observed *in situ* in the vicinity of the DWH spill area (White et al. 2012a). After the DWH spill, several coral colonies were found to be impacted by the spill (Fisher et al. 2014a). Signs of impact and stress observed on adult corals included tissue loss, retracted polyps, sclerite enlargement, excess mucous production, bleached commensal ophiuroids, the presence of a brown flocculent substance (floc), and death for up to 6 to 22 km from the release site (White et al. 2012b, Buskey et al. 2016, Etnoyer et al. 2016, Silva et al. 2016, Prouty et al. 2016, Hourigan et al. 2017). Follow-up surveys observed sporadic distribution of stress on corals within the vicinity of the DWH (Fisher et al. 2014b) and patchy distribution of stress on the coral colonies themselves possibly due to the nature of oil released at depth (Hsing et al. 2013). Hydroids were observed colonizing the stressed corals on sections that had been damaged (Hsing et al. 2013, Fisher et al. 2014b) and some corals lost several branches resulting in a reduction of total biomass at impacted sites (Girard et al. 2018). Subsequent benthic surveys have found indications of recovery within 16 months of the spill (Fisher et al. 2014b) with projected recoveries (remaining branches appear healthy) to take 10 to 30 years for pre-established adult corals (Girard et al. 2018). Recovery on some coral colonies may have been aided by the presences of symbiotic ophiuroids (Girard et al. 2016). Coral reproductive processes and coral larvae could also be impacted in the presence of oil including smaller number of breeding colonies, fewer planulae per coral head, premature planulae shedding, lower life expectancy of planulae, and fewer settlement and survival following exposure (Loya and Rinkevich 1980, Goodbody-Gringley et al. 2013, Fisher et al. 2014b). Laboratory studies have found coral larvae metamorphosis was inhibited when exposure to concentrations as low as 103 µg/L, which is similar oil concentrations found in seawater following large spills; however, sponges exhibited different sensitivities to oil exposure (Negri et al. 2016).

Similar to cold-water corals, deep-sea sponges are long-lived sessile organisms which cannot actively avoid exposure to an accidental spill in their vicinity. When exposed to hydrocarbons sponges have exhibited both impacts and adaptive behaviours. Studies have found adult sponges are impacted by exposure to oil and bioaccumulate hydrocarbons which can potential damage sponge DNA (Zahn et al. 1983, Batista et al. 2013, Gentric et al. 2016, Stévenne 2018). Relatively high capabilities for PAH bioaccumulation have been found in some species of sponges (Batista et al. 2013, Gentric et al. 2016) including the carcinogenic PAH benzo(a)pyrene (Gentric et al. 2016) which could damage sponge DNA (Zahn et al 1983). However, accumulations within individuals were highly variable as adult sponges have adapted their filtering behaviours and altered feeding behaviours in the presence of oil (Vad and Duran 2017). Sponge larvae could also be impacted by oil exposure. Experimental studies have found that in the presence of hydrocarbons larval settlement decreased when exposed to 100 and 500 ng/L PAH and the metal copper (Cebrian and Uriz 2007). Other studies have found that in the presence of condensate water accommodated fractions (WAF) containing total petroleum aromatic hydrocarbon, sponge larvae were less sensitive than coral larvae with 24-hr exposure and able to successfully attach and undergo metamorphosis (Negri et al. 2016). It was only when concentrations exceeded 11,000 µg/L total petroleum aromatic hydrocarbon that sponge larvae appeared misshaped (Negri et al. 2016). *Geodia barretti* sponges experimentally exposed to oil over eight days did not demonstrate strong sublethal stress effects and no significant effects on respiration rates (Stévenne 2018). While initial exposures resulted in cellular effects with destabilization of lysosomal membranes, sponges recovered to control levels after a 30-day recovery period (Stévenne 2018). Microbial communities associated with *G. barretti* were stable across treatments and days of oil exposure (Stévenne 2018). Stévenne (2018) suggests that naturally hosted microorganisms may play a role in oil degradation / detoxification for this species and provide some resistance to acute oil exposures.

### *Change in Fish Habitat Availability, Quality, and Use*

A hydrocarbon release has the potential to interact with the benthic, pelagic and coastal habitats and associated biogenic habitats (e.g., seagrasses, corals, sponges) depending on the nature, scale, and duration of an offshore spill. Changes to fish habitat depend on the overall extent of hydrocarbon release along with the oil state (e.g., fresh oil, weathered oil, tar balls). Water and sediment quality for fishes and invertebrates living in benthic and pelagic environments may be diminished through oil exposure. Habitat use may also decrease with avoidance of these areas by some mobile fish and invertebrates. Oil exposure in coastal environments may potentially have effects on nursery and rearing habitats for various species. Therefore, Project-specific modelling of oil spill releases has been conducted as described in Section 15.3 to provide further information on the potential fate of oil on marine environments (RPS Group 2019b; Appendix F). This is further described in Section 15.6.1.3 as it relates to marine fish and fish habitats.

Seagrass and macroalgae form important ecosystems, creating complex habitats that are used as rearing grounds, spawning areas, and feeding areas for a wide variety of fish and invertebrates in coastal and shelf areas (Gurney and Lawton 1996). The response of macroalgae and marine plants to oiling is species-specific, variable, and dependent on factors such as the degree of exposure, the presence of chemical dispersants, and length of exposure. Macroalgae exposed to low concentrations of oil appear to have little to no response, and in some cases may have a positive response. Experimental releases of oil in the Canadian Arctic on the order of 3 to 30 mg/L had either no visible effect on macroalgae, or resulted in a mild stimulation of growth in some species (Cross et al. 1987). After the *Prestige* oil spill off the coast of northern Spain, similar results were found for macroalgae in that no difference was noted between years for algal richness, cover, or diversity (Díez et al. 2008). Both studies conclude that low levels of oiling due to dispersion resulted in the lack of observed effects. After the *Exxon Valdez* oil spill, an upper intertidal species of brown algae was heavily impacted. These macroalgae were removed and juveniles were unable to recolonize due to the lack of canopy cover to protect from desiccation and wave action (Stekoll and Deysher 1996). The use of artificial turf mats was successful in re-introducing *Fucus gardneri* to the upper intertidal. After the DWH spill, macroalgae at a site west of the well had a reduction in richness of 83% that subsequently impacted the assemblage of crustaceans and other organisms living within the macroalgae (Felder et al. 2014). Crustose coralline algae acted as a seed bank in this area for the re-recruitment of other macroalgal species.

Much like macroalgae, seagrasses have varied responses to exposure to oil. Following the DWH spill, Kenworthy et al. (2017) examined seagrass cover on an island north of the spill site, and found reductions in areas with confirmed oiling but an overall increase in seagrass cover in the back barrier shelf. Laboratory exposures of seagrass to oil found low amounts sufficient to result in mortality (Thorhaug et al. 1986), and sub-lethal effects at 0.53 ml/L of oil in seawater and above. Martin et al. (2015) found shorter and wider roots and fewer inflorescences in a seagrass species exposed to 0.53 ml/L and 1.05 ml/L of oil, indicating lower reproductive output and easier dislodgement of seagrass. Dean et al. (1998) investigated the effects of spilled oil from *Exxon Valdez* on *Zostera marina*, the species of seagrass present in most of Atlantic Canada. They compared eelgrass in a heavily oiled bay and a reference site and found little difference in biomass, germination, and no signs of elimination of beds. Some reductions were noted in shoot density and inflorescences, but less than a year after the spill these differences were not seen. Overall, oiling does appear to impact seagrasses in the short-term, but recovery is possible if grasses are not extirpated from a given area.

Corals and sponges are sessile, long-lived marine fauna that may provide biogenic habitat to slope and deep-sea areas. Corals have been found associated with local higher biodiversity and may provide fish habitat (Ross and Quattrini 2007, Ballion et al. 2012, Dean et al. 2016). Sponges have also been observed to provide biogenic habitat (Beazley et al. 2013). In the RAA and surrounding areas, these species inhabit deep, cold-water environments and some species can reach water depths >2,000 m (Wareham and Edinger 2007, Kenchington et al. 2016a, 2016b, Meredyk 2017). The effects of an accidental hydrocarbon release on corals and sponges is discussed above with respect to change in risk of mortality and physical injury. Although many of these studies are derived from laboratory experiments, modelling studies, and species from other regions, recovery of these biogenic habitats is likely on the order of decades for slow-growing, deep-sea organisms (Cordes et al. 2016, Ragnarsson et al. 2017, Girard et al. 2018, Vad et al. 2018).

### Potential Effects of Dispersants on Marine Fish and Fish Habitat

Oil dispersants are a mix of emulsifiers and solvents designed to break oil into small droplets and allow these to disperse into the water column. While this does not remove oil from the environment, it creates a larger surface area for accelerated degradation of spilled oil by specialized microbes (Lee et al. 2013;

AOSRT-JIP 2014; Coelho et al. 2017). Debate is ongoing regarding the effectiveness of varying dispersant ratios on oil degradation rate, but all act on surficial oil and increase its overall surface area and disperse it throughout the water column (Brakstad et al. 2014, 2015; Kleindienst et al. 2015; Seidal et al. 2016). This has the potential effect of increasing oil exposure within the water column and at the seabed, which may affect pelagic and demersal fish and invertebrates that may not have been exposed to (or will be exposed to a greater degree of) surface oil (Ramachandran et al. 2004).

The majority of toxicological concern regarding the use of dispersants result from the increased exposure potential of pelagic and demersal fish and fish habitat to increased concentrations of the toxic components of oil (e.g., PAHs), or potentially the interaction of both oil and dispersant together (Pace et al. 1995; DeLeo et al. 2016). Many studies have found increased sensitivity to oil or dispersed oil in early life stages of fish and invertebrates compared to adults, specifically on eggs and larvae (Cordes et al. 2016, DeLeo et al. 2016). Greer et al. (2012) found that Atlantic herring eggs had increased deformities and mortality when exposed to dispersed oil. For invertebrates, dispersed oil has been found to reduce larval settlement, and cause tissue degradation and abnormal development in sessile invertebrates (Cordes et al. 2016). Laboratory studies on capelin exposed to dispersed oil have found decreased fertilization activity, hatching success, survival, and heart rate, as well as upregulation of genes used in oil biotransformation (Beirão et al. 2018; 2019). Studies on Gulf of Mexico deep-sea coral found that dispersed oil was more toxic than untreated oil solutions, and that early life history (settlement and post-settlement survival) stages were the most heavily impacted (DeLeo et al. 2016).

While dispersants may affect early life history of marine fish and fish habitat, population level effects are difficult to study and are likely species-specific. Gallaway et al. (2017) modelled the effects of dispersed oil on Arctic cod populations and found that lethal and sub-lethal effects on juveniles and eggs may be insignificant to the regional population overall. As Arctic cod produce enormous amounts of small eggs, even the worst-case dispersed oil spill model was found to be insignificant on the regional population (Gallaway et al. 2017). However, the effects of such an oil spill and dispersant use are likely to be highly species-specific, as a variety of life histories exist in the Northwest Atlantic (e.g., pelagic or demersal eggs, brooding, semelparity or iteroparity), all of which are likely to be impacted differently depending on sensitivity and exposure. However, there is evidence that relative sensitivity to dispersed oil is similar among fish and invertebrate species from the Arctic, temperate, and tropical waters (Olsen et al. 2011; Bejarano et al. 2017).

### Potential Effects of in situ Burning on Marine Fish and Fish Habitat

*In situ* burning is the collecting and concentrating of oil using fireproof booms, which is then ignited to reduce the overall mass of oil. Oil is then continuously collected using the booms to maintain a combustible thickness of 2 to 5 mm (IPIECA 2016). This creates thick black plumes of smoke in the atmosphere, and leaves behind a thinner layer of oil that may be far denser than the original source. Depending on the oil source, burn time, and temperature, this remaining oil may then continue to float or sink as it cools (Allen 1990; Buist and Trudel 1995). Field and laboratory tests using *in situ* burning in Newfoundland found that samples collected below the burning oil had increased toxicity but was within the range of toxicity found below unburned oil (Daykin et al. 1994). Fingas et al. (1995) found that a test burn in Newfoundland did not result in elevated sea surface temperatures due to the continual replacement of unburned oil and seawater using the boom.

As fish and fish habitat are unlikely to be impacted by the atmospheric release of burned oil, the main potential impact is the burning oil itself and the remaining residue. The residual slick after an *in situ* burning contains uncombusted oil, and so the effects would be similar to those described above for the effects of oil on marine fish and fish habitat. Studies that have investigated residual oil remaining from *in situ* burning found that efficiency of the burn and oil type changed the composition of the slick (Fritt-Rasmussen et al. 2015). *In situ* burning residues may have increased metal concentrations, and a reduction in light (three-ring or less) PAHs but an increase in heavier (four or more ring) PAHs (Wang et al. 1999; Faksness et al. 2012). Additional research on local conditions and oil composition is required in relation to *in situ* burning.

The surface microlayer (upper 1 mm of the water column) is important habitat for a variety of phytoplankton, zooplankton, and ichthyoplankton such as fish eggs and larvae (Kocan et al. 1987). Many important fish species in NL (e.g., Atlantic cod, American plaice) have eggs and/or larvae that occupy surface water for a portion of their life cycle, typically during the spring or fall plankton blooms. *In situ* burning is likely to result in mortality at the surface of the water column, though the overall surface area would be small in scale as oil is concentrated in order to sustain combustion. As *in situ* burning is a rare event and restricted to a confined area, associated mortality is unlikely to have long-term population effects, and the microlayer would be replenished from adjacent areas post-*in situ* burning (Shigenaka and Barnea 1993). Mobile and adult life stages of pelagic species would likely avoid the area of *in situ* burning and are unlikely to be impacted.

### Potential Effects of an SBM Spill on Marine Fish and Fish Habitat

Potential effect pathways for an accidental SBM batch spill on marine fish and fish habitat would be similar to those assessed for routine drilling discharges (see Sections 8.3.1.3 and 8.3.2.3). Potential changes to habitat availability, quality and use from accidental SBM fluid release may result from increased turbidity and suspended solids in the water column (Cordes et al. 2016, IOGP 2016). Drilling mud and cuttings discharges that settle on the seafloor may change habitat quality and availability from sediment alteration, and degradation of organic components that lead to oxygen depletion (Kjeilen-Eilertsen et al. 2004, Smit et al. 2008, Neff 2010, Ellis et al. 2012, DeBlois et al. 2014, Tait et al. 2016, DFO 2019). Potential changes in risk of mortality or physical injury may occur from direct exposure to drill cuttings (e.g., suspended sediments, burial) or from the indirect effects resulting from environmental alterations (e.g., anoxic environments).

SBM sinks rapidly in the water column when released as it is a heavy, dense fluid (see Section 2.8.2 for information on SBM constituents) indicating suspended solid and turbidity effects are non-persistent and temporary (BP 2018). SBM fluids were developed specifically to have low toxicity and fast degradation (Neff et al. 2000, Jagwani et al. 2011, Paine et al. 2014, Tait et al. 2016) and have properties that reduce potential effects on marine fish (IOGP 2016). For example, lobsters injected with SBM fluids in laboratory exposure studies did not show signs of adverse health effects (e.g., changes in lipid and protein metabolism) after 20 days (Hamoutene et al. 2004).Drilling fluids will be screened and selected in accordance with the Offshore Chemical Selection Guideline (OCSG) (NEB et al. 2009), such that lower toxicity drilling muds that are biodegradable and have environmentally friendly properties within the muds will be used where feasible. A thin surface sheen may also result from an accidental spill of SBM (e.g., in the event of a surface SMB spill) with effects similar to those discussed above for hydrocarbon spills, but more limited in nature. Sessile or low mobility benthic invertebrates have higher potential for effects from accidental drill mud releases relative to mobile fish and invertebrates that can avoid suspended sediments and deposition areas. Therefore, environmental effects are mainly restricted to smothering of sessile or slow-moving individuals and sedimentation (see Sections 8.3.1.3 and 8.3.2.3).

Initial recovery from SBMs spills are predicted to occur within weeks to months, with full recovery within years. In laboratory studies, total petroleum hydrocarbon levels were observed to decrease by 31% and 14% in fresh and recycled SBM fluid respectively on marine sediments after incubation at 5°C for four weeks (Centre for Offshore Oil, Gas and Energy Research [COOGER] and Lee 2009). COOGER and Lee (2009) suggest that degradation at seafloor temperatures would likely be slower; however native bacteria that are adapted to functioning in cold-water environments may facilitate hydrocarbon degradation in synthetic-based fluids. SBM spills have previously occurred in deep water environments including in the Gulf of Mexico and offshore Nova Scotia, Canada. Approximately 390 $m^3$ of SBM was released in 2003 in the Gulf of Mexico from two locations where the riser parted during drilling activities at a water depth of 1,841 m (USDOI MMS 2004). The USDOI MMS (2004) indicated that benthic species were likely affected by smothering and resulting anoxic environments; however, mobile species would be able to avoid burial. While an area of effect was not reported, it was determined that partial recovery of the benthic community would occur within weeks or months of the release and generally a full recovery within one to two years, and effects on the environment were not significant considering the dispersion of the SBM fluid and the fluid's non-toxic nature (USDOI MMS 2004). Approximately 354 $m^3$ of SBM was released from a riser flex joint in 2004 south of Sable Island, NS in approximately 2,067 m water depth (CNSOPB 2005). Follow-up remotely operated vehicle (ROV) surveys indicated that the SBM settled on the seafloor in narrow ribbons from the wellhead with a total estimated area of 35,000 $m^2$ (CNSOPB 2005). CNSOPB (2005) concluded that the environmental effects from the spill were minor with no remediation recommended due to the low toxicity of SBM fluids and that recovery of the benthic environment was estimated to occur in approximately five years. In 2018, approximately 136 $m^3$ of SBM was released from piping that forms part of the mud system during drilling activities in approximately 2,800 m water depth offshore Nova Scotia (CNSOPB 2018a). Information released to date on this spill do not indicate the spatial extent of spill effects. CNSOPB have indicated that the SBM may have resulted in physical smothering to the seabed affecting benthic species but are not expected to have an impact on fish or other marine species due to the low toxicity of SBMs (CNSOPB 2018b). Recovery would likely occur within years based on larger spills described above.

### 15.6.1.2 Mitigation of Project-Related Environmental Effects

Spill prevention measures are the most effective way to mitigate against potential effects from accidental events. BHP's strategy for contingency planning and spill response is described in Section 15.5. Mitigation of potential accidental events is incorporated as part of the regulatory processes (e.g., Operations Authorization [OA], Approval to Drill a Well), project-specific safety and response plans (e.g., safety plan, oil spill response plan, EPP), and well design (e.g., BOP).

The Project will operate under safety and contingency plans, including an oil spill response plan (OSRP) that will be submitted to the C-NLOPB before the start of any drilling activity as part of the OA process. The OSRP will outline response methods and procedures, and response strategies based on severity of hydrocarbon spills. Potential responses considered in the event of an accidental release may include, but not be limited to, offshore containment and recovery, dispersants (surface application and/or subsurface injection), *in situ* burning, shoreline protection and clean-up, and OWRP. Further details on spill responses are provided in Section 15.5. A SIMA/ Net Environment Benefit Assessment (NEBA) will be conducted as part of the OA Process as well. These assessments will be used to qualitatively evaluate the risks and trade-offs of feasible and effective response options, when compared to no action. An overall spill response strategy will be selected for the Project based on the SIMA process. If identified as a response option, chemical dispersant application would not occur without authorization from C-NLOPB.

Mechanical measures and barriers that are implemented as part of well design, and drilling and monitoring procedures for prevention of blow-outs are described in Section 2.3.4. This includes use of steel casings, drilling fluids, and BOPs for controlling formation pressures. The BOP includes a series of rams that are designed to seal off the wellbore at the wellhead on the seafloor when required. Furthermore, the BOP and other pressure control equipment are tested regularly and recorded in accordance with the Drilling and Production Guidelines (C-NLOPB and CNSOPB 2017a) and to BHP standards.

Specific environmental effects monitoring and follow-up programs may be required in the unlikely event of a spill. These monitoring programs will be developed in consultation with applicable regulatory agencies.

### 15.6.1.3 Characterization of Residual Project-Related Environmental Effects

#### Subsurface Blowout

Accidental event scenarios with a subsurface blowout would have the greatest potential for causing environmental effects due to the potential quantities and spatial extents. The extent of the effects from a subsurface blowout would largely depend on the duration and volume of the spill, and environmental conditions. To describe the potential spatial extent and associated effects of subsurface blowouts on the environment, Project-specific modelling was conducted as described in Section 15.3 and Appendix F (RPS Group 2019b). Stochastic oil release modelling was conducted for continuous 30-day (capping stack scenario) and 120-day (relief well scenario) subsurface releases over a 160-day period for representative locations in EL 1157 (2,337 m water depth) and EL 1158 (2,047 m water depth). The modelling results were assessed against conservative ecological thresholds for oil surface thickness (10 μm), water column concentration (1.0 μg/L dissolved PAH or 100 μg/L THC), and shoreline oiling (100 g/m$^2$).

In the event of a blowout scenario, there could be effects to the water column, surface waters, and sediments with changes to water and sediment quality from dissolved oil fractions, resulting in effects on fish and invertebrate species (e.g., injury, mortality, avoidance). Although spilled oil is not predicted to interact with sediments based on Project-specific modelling, there may be interactions with benthic areas through flocculation and sinking associated with plankton and microbial pathways. Spilled oil interactions in coastal areas may have effects on seagrasses, macroalgae and associated nursery and rearing areas.

There is a risk of mortality to phytoplankton and zooplankton present in the mixed surface layer of the water column from hydrocarbon exposure during a blowout scenario. There will be a temporary decline in the abundance of zooplankton and phytoplankton in the immediate area of the spill with changes to community composition (e.g., increase in some species, decline in other species). Due to short generation times zooplankton and phytoplankton are estimated to recover after the spill has subsided due to response actions (e.g., containment, recovery) and natural weathering.

The effects on fish and invertebrates from a subsurface blowout would vary depending on the timing of the event as species may exhibit seasonal migrations or have seasonally timed life stages. Generally, many fish and invertebrate species have early life stages occurring in the water column in association with seasonal phytoplankton blooms. Fish and invertebrate eggs, larvae, and juveniles in the water column or in spawning and rearing areas within the spill area also experience lethal and sub-lethal effects. Fish and invertebrate species in the RAA typically spawn over large spatial scales, and a spill is unlikely to encompass the full geographic extent these spawning areas for any single species. Therefore, the effects of an accidental release are not predicted to affect species such that natural recruitment of juvenile organisms may not re-establish the population(s) to their original level. It is anticipated that through temporary migration, mobile adult fish and invertebrates would be able to avoid hydrocarbon exposure. Oil transported away from the release site would also be highly weathered, patchy and discontinuous with natural degradation processes occurring over a week or more. Effects on slow-moving or sedentary species would be similar to those on phytoplankton, zooplankton, and larval and juvenile fish species. Coastal seagrasses and macroalgae that support spawning and rearing areas are predicted to initially decline with exposure to spilled oil, potentially including southern, eastern, and northern areas of Newfoundland. These marine plant areas are estimated to recover within years after the spill has subsided. Recovery of cold-water corals and sponges is dependent on the nature and extent of initial oil exposure with recoveries potentially on the scale of decades. However, in unmitigated scenarios, oil reaching the seafloor is typically low (<0.1 g/m²) or localized for higher concentrations (0.5 g/m²). As described in Section 6.1.8, there are various fish species at risk that are known to occur in the RAA. These species would also have the potential to be adversely affected through pathways described above in the unlikely event of a subsurface blowout. It is expected that potential effects would be similar to those described above for species not of conservation concern, nor result in permanent alteration or irreversible loss of critical habitat as defined in a recovery plan or an action strategy.

Model scenarios are based on unmitigated subsurface blowout scenarios. Emergency response and mitigations measures as detailed in Section 15.5 would be implemented in an actual event to limit the magnitude, duration, and extent of a spill. Shoreline protection measures would also reduce the potential effects on shorelines and coastal fish and fish habitat.

The residual environmental effects from an unmitigated subsurface blowout on marine fish and fish habitat are predicted to be adverse and moderate to high magnitude based on the range of effects from potential hydrocarbon exposure effects on fish and invertebrates and associated habitats across modelling scenarios. The geographic extent of potential effects is beyond the RAA based on subsurface blowout modelling; however, oil transported at that distance would be highly weathered, patchy and discontinuous. This effect is considered reversible with a moderate to long-term duration and is predicted to occur as a single event.

### Marine Diesel Spill

Surface batch spills releases (3,200 L) of marine diesel from a vessel were predicted to result in patchy distributions of silver or colourless sheens (<0.0001 mm) of oil on the water surface (RPS Group 2019b; Appendix F). Oil was not predicted in stochastic modelling to exceed the ecological threshold or in worst case deterministic scenarios for surface oil and water column. In 95th percentile worst case scenarios for shoreline oiling, approximately 9 km of shoreline exceeded the ecological threshold. Oil was predicted to be transported south and wrap around the Avalon peninsula in some model runs (RPS Group 2019b; Appendix F).

Based on modelling of surface batch spills from a PSV, effects on marine fish and fish habitat would likely be limited. There may be temporary and reversible degradation in habitat quality at the water surface with localized and patchy distributions of oil. Marine diesel is known to have immediate toxic effects on intertidal and benthic organisms (Stirling 1977; Simpson et al. 1995; Cripps and Shears 1997, in BP 2018), however toxicity quickly declines as volatiles evaporate. As with other accidental hydrocarbon releases, early life stages (e.g., eggs, larvae, juveniles) are mainly at risk due to their low capacity for active avoidance. Fish and invertebrate eggs, larvae, and juveniles in the water column or in spawning and rearing areas within the spill area also experience lethal and sub-lethal effects. However, predicted effects of surface batch spills on species in the water column would be low considering the low spatial extent. These potential effects would be similar for species at risk and secure species.

Oil is predicted to reach the shoreline in worst case scenarios with potential for coastal spawning and rearing areas including seagrass and macroalgae areas, to be potentially affected. These coastal areas are estimated to recover within months to years after the spill has subsided. Overall, given the small-scale and short-term nature of the spill, the effects on nearshore areas are predicted to be limited. Emergency response and mitigations measures as detailed in Section 15.5 would be implemented in an actual event to limit the magnitude, duration, and extent of a spill and further limit effects on marine fish and fish habitat.

The residual environmental effects from a marine diesel spill on marine fish and fish habitat are predicted to be adverse and low in magnitude considering the small scale of the spill. As potential spills may occur along vessel traffic routes, the geographic extent is localized to the LAA. This short-term effect is considered reversible and is predicted to occur as a single event.

### SBM Spill from the MODU and the Marine Riser

Modelling results for SBM spills in EL 1144 (1,137 m water depth) for Nexen Energy's Flemish Pass Exploration Drilling Project (Nexen 2018, Amec Foster Wheeler 2018) were used to inform potential effects of SBM spills for the Orphan Basin. Accidental surface releases of SBM (64 m³) would reach the seafloor within 1 km from the release site with the lowest maximum horizontal spill distance occurring in the summer at 264 m and highest maximum horizontal spill distance occurring in fall at 982 m (Nexen 2018, Amec Foster Wheeler 2018). Maximum spatial footprints ranged from 7,200 m² to 9,000 m² across seasonal scenarios and drilling stages (Nexen 2018, Amec Foster Wheeler 2018). Maximum (7.1 cm) and average (1.7-2.2 cm) modelled deposition thicknesses exceed the 6.5 mm predicted no-effect threshold (PNET) and conservative 1.5 mm PNET for burial effects (refer to Section 8.3.1.3 for discussion of PNET) indicating there would be potential burial and deposition effects on benthic organisms. These deposition areas were not continuous but a localized deposition area within the maximum horizontal spill distance (Amec Foster Wheeler 2018). The depth of the Orphan Basin is deeper, and currents are approximately two to four times higher at modelled SBM release site in EL 1144 (Amec Foster Wheeler 2018, RPS Group 2019a). Therefore, the accidental surface SBM release is predicted to be dispersed further before settling on the seabed resulting in a thinner layer of solids spread over a larger area relative to modelling results for EL 1144. This suggests that burial and smothering effects to benthic areas will likely be reduced. Furthermore, environmental monitoring of the effects of a June 2018 spill of 136 m³ of SBM from a drilling riser on the

Scotian Slope found no indications of SBM constituents 500 m from the well site (depth 2,800 m), and the CNSOPB concluded that the spill resulted in no significant adverse environmental effects (CNSOPB 2019).

Modelled subsurface release of SBM (255 m³) for EL 1144 from the marine riser and transport lines during an emergency BOP disconnect event contacts the seafloor closer to the drilling site relative to accidental surface releases, resulting in a smaller maximum spill distance of <60 m across seasonal scenarios (Nexen 2018, Amec Foster Wheeler 2018). Maximum spatial footprints ranged from 1,800 m² to 3,600 m² across seasonal scenarios and drilling stages (Nexen 2018, Amec Foster Wheeler 2018). Maximum (28.3 cm) and average (23.6-27.2 cm) modelled deposition thicknesses exceed the 6.5 mm PNET indicating there would be potential burial and deposition effects on benthic organisms (Nexen 2018, Amec Foster Wheeler 2018). As a similar release in the Orphan Basin would still be near the seabed, the extent of SBM deposition would likely remain localized to around the wellhead.

In consideration of the modelling results and local oceanographic processes, it is conservatively estimated that there may be potential effects to marine fish and fish habitat from a localized deposition area within a few kilometres from site. Potential changes to risk of mortality, injury, and health on fish and invertebrates would be limited to sessile benthic species within this area. Similarly, there may be changes to temporary and reversible degradation in water and benthic habitats within this area. As discussed in Sections 8.3.1.3 and 15.6.1.1, SBMs biodegrade rapidly and the acute toxicity of SBMs is considered relatively low and below environmental guidelines. SBM spills are therefore predicted to result in adverse effects that are low, temporary and reversible. As described in Section 15.6.1.1, partial recovery of the benthic community would occur within weeks or months of the release and generally a full recovery within years. These potential effects would be similar for species at risk and secure species.

## Summary

Table 15.32 provides a summary of predicted residual environmental effects of accidental events on marine fish and fish habitat. The residual environmental effects from an SBM spill (surface or subsurface) on marine fish and fish habitat are predicted to be adverse and low in magnitude considering the localized nature of the spill and lack of acute toxicity of SBM. The geographic extent of potential effects would likely be localized to the Project Area. This potential effect is predicted to occur as a single event and is considered reversible with short to long-term duration considering that recovery would likely occur within years.

### Table 15.32 Summary of Residual Project-Related Environmental Effects on Marine Fish and Fish Habitat – Accidental Events

| Residual Effect | Residual Environmental Effects Characterization | | | | | | |
|---|---|---|---|---|---|---|---|
| | Direction | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | Ecological and Socio-economic Context |
| **Change in Risk of Mortality or Physical Injury/Change in Habitat Quality and Use** | | | | | | | |
| Well Blowout Incident | A | M-H | RAA* | LT | S | R | D |
| Marine Diesel Spill | A | L | LAA | ST | S | R | D |

### Table 15.32 Summary of Residual Project-Related Environmental Effects on Marine Fish and Fish Habitat – Accidental Events

| Residual Effect | Residual Environmental Effects Characterization | | | | | | |
|---|---|---|---|---|---|---|---|
| | Direction | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | Ecological and Socio-economic Context |
| Marine Diesel Spill | A | L | LAA | ST | S | R | D |
| SBM Spill | A | L | PA | ST-LT | S | R | D |

KEY:
N/A: Not Applicable

Direction:
P: Positive
A: Adverse

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"

Duration:
ST: Short-term
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

### 15.6.1.4 Determination of Significance

In consideration of the characterization of potential effects and significance criteria identified in Section 8.1, the predicted residual adverse effects from accidental events scenarios on marine fish and fish is predicted to be not significant. This determination takes into account the potential adverse effects as described above, modelled spatial extents of predicted effects, the conservative nature of the spill modelling and assumptions, and the use of mitigation measures to prevent and reduce effects from a spill. Although hydrocarbon spills could result in adverse effects on marine fish and fish habitat, these residual effects are predicted to be reversible at the population level. The majority of fish species in the Orphan Basin spawn across a variety of large areas and over long time-scales, and therefore a spill is not predicted to encompass all of these areas or time scales within the RAA to such a degree that natural recruitment of juvenile organisms may not re-establish to affected areas. Population level effects from accidental events are considered unlikely given the low probabilities for large spill events to occur and the associated response measures that would be implemented to reduce the consequences of such an event. These potential effects would be similar for species at risk and secure species.

Significance determinations are made with a high level of confidence for SBM spill scenarios in consideration of the low magnitude and geographic extent of likely effects. While modelling scenarios are based upon a credible worst case scenario, a medium level of confidence is assigned to the marine diesel spill and subsurface blowout scenarios given the uncertainties associated with an actual spill event with volume spilled, durations, locations, time of year, and regional species responses and recoveries. Spill scenarios are not expected to result in permanent alteration or irreversible loss of critical habitat as defined in a recovery plan or an action strategy.

### 15.6.2 Marine and Migratory Birds

As detailed in Section 6.2.2 a variety of marine and migratory bird species occur in large numbers within the marine and coastal environments off eastern NL at various times of the year, including seabirds and other avifauna that inhabit the region for breeding, summering, staging, wintering, migration, or other activities according to their individual life histories and habitat requirements, and could be present in the RAA at the time of an accidental event.

Seabirds, waterfowl, loons, grebes, and shorebirds (plovers, sandpipers) are the most vulnerable to perturbation as they spend much of their life in the marine environment. Some land bird species may also be affected, especially those associated with coastal habitats and those that undertake nocturnal migration over offshore waters. The time of year that a marine and migratory bird species are present depends on the species, with some abundant year-round (such as large gull species and kittiwake, some alcid species, and northern fulmar) while others are more likely to be present in the winter (dovekie, thick-billed murre, ivory gull, coastal waterfowl) or the nesting and migration seasons (Leach's storm-petrel). Several important habitats for birds have also been identified at locations along the coastline of NL. Although not in the Project Area itself but within the RAA, there are several Important Bird Areas (IBAs), Migratory Bird Sanctuaries (MBSs), Seabird Ecological Reserves (SERs), nesting sites around coastal NL, and Ecologically or Biologically Significant Areas (EBSAs) in the Northwest Atlantic designated in part due to their importance to seabirds (see Figure 6-37).

There are 15 marine and migratory bird species at risk that are likely to occur within the marine areas RSA and or coastal regions of RAA (Section 6.2.4). Species designated as having low conservation status (i.e., Least Concern) are not included in this assessment of effects on SAR. As discussed in Chapters 6 and 9, there is a low potential for these SAR (listed in Table 9.4 in Section 9.3.3) to interact with the routine Project-related activities due to their low densities in the Project Area, LAA and overall RAA, and because there are no critical habitats or nesting sites of SAR or SOCC in the RAA. However, as with secure bird species, at risk marine and migratory birds are at risk from oil spills.

#### 15.6.2.1 Project Pathways for Effects

Accidental spill scenarios have potential to result in a change in risk of mortality or physical injury and/or a change in habitat quality and use for marine and migratory birds. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in space and time. The assessment is conservative (i.e., geographic and temporal overlap are assumed to occur, and modelling results assume no implementation of mitigation measures).

**Potential Effects of an Oil Spill on Marine and Migratory Birds**

An accidental release of hydrocarbons can result in the physical exposure of birds to oil in the affected area. Such discharges, and even routine operational discharges from vessels and platforms may lead to sheens of crude oil and other substances on the water's surface, to which avifauna (especially pelagic seabirds) may be exposed (Wiese and Robertson 2004; O'Hara and Morandin 2010; Morandin and O'Hara 2016). There would be an increased risk of mortality for individual birds that encountered the sheen (particularly for diving birds and those that spend large amounts of time on the water), as well as potential sublethal toxicity effects (metabolic rate and chick growth) to species such as Leach's storm-petrel. Chicks and eggs are more susceptible to negative effects of exposure to oil (even at very low levels). The possible physical effects of oil exposure on birds include changes in thermoregulatory capability (hypothermia) and buoyancy (drowning) due to feather matting (Clark 1984; Montevecchi et al. 1999), as well as physiological effects of oil ingestion from excessive preening (Hartung 1995).

Even small amounts of oil from sheens have been shown to affect the structure and function of seabird feathers (O'Hara and Morandin 2010; Matcott et al. 2019), which has the potential to result in water penetrating plumage and displacing the layer of insulating air, resulting in loss of buoyancy and hypothermia. This can cause a heightened metabolic rate (increased energy expenditure) and potential starvation due to increased energy needs to compensate for heat loss resulting from oiling and loss of insulation (Peakall et al. 1980, 1982; MMS 2001). Greater heat loss accompanied by an increase in food consumption has been documented in a species of marine bird, (Cunningham et al. 2017; Mathewson et al. 2018). A decrease in body temperature from plumage oiling has been documented in another marine bird species (Maggini et al. 2017c). External oiling (applied experimentally to homing pigeons released to fly 50, 80, or 100 miles) also alters birds' flight paths, increases flight duration, and increases flight distance, and reduces the ability to regain body weight between flights (Perez et al. 2017a,b,c).

Plumage oiling can also lead to behavioural changes such as increased time spent preening at the expense of foraging and breeding, and potentially death (Morandin and O'Hara 2016). Birds whose plumage is lightly oiled may not suffer hypothermia or drowning, but the effects on their flight feathers may cause inefficient flight, requiring increased energy demand during flight. Evidence for this comes from experimentally applying a light oiling to the plumage of a marine bird, which reduces takeoff speed by 30% and increases flight energy cost by 20-45% (Maggini et al. 2017a,b,c).

The potential for toxic effects from ingesting small amounts of oil are becoming better understood due to recent research and may have greater effects on bird populations than acute mortality (Bursian et al. 2017b). While acute toxic effects from exposure to sheens are considered unlikely (Morandin and O'Hara 2016), some studies have shown effects from exposure to low levels of oil on adult birds (Miller et al. 1980; Trivelpiece et al. 1984; Butler et al. 1986, 1988; Alonso-Alvarez et al. 2007). Ingested oil can cause lethal and sublethal effects (McEwan and Whitehead 1980), including damage to the liver (Khan and Ryan 1991), pneumonia (Hartung and Hunt 1966), brain damage (Lawler et al. 1978), and immunotoxic effects (Barron 2011). Oxidative injury to cytoplasmic hemoglobin (anemia) causing fatigue and reduction in energy available for metabolic energy due to oil ingested through diet and through preening has been documented in six species of marine birds, and in a seventh species results consistent with hemolytic anemia were found (Bursian et al. 2017a; Dean et al. 2017; Harr et al. 2017c; Horak et al. 2017; Maggini et al. 2017c; Pritsos et al. 2017; Fallon et al. 2018). These effects have the potential to reduce survival and lifetime reproductive success. Species-specific differences were found in this effect, potentially due to physiology, foraging strategies, habitat preferences, and behaviour (Fallon et al. 2018). This hemolytic anemia can have its greatest effects during migration, when metabolic oxygen requirements are very high (Bursian et al. 2017b). Increases in liver and kidney weights have been found in two species (Harr et al. 2017b; Horak et al. 2017). Lesions in kidney, liver, heart, and thyroid gland were found in one species (Harr et al. 2017a). Damage to the thyroid gland can cause endocrine disruption, which affects metabolism, weight gain, thermoregulation, reproduction, and development, e.g., common murres oiled by the M/V *Tricolour* spill (Troisi et al. 2016). Impaired heart function has also been noted in one species of marine bird (Harr et al. 2017a). Birds that feed on organisms from affected areas are also at heightened risk of contamination from their food sources (Engelhardt 1982). Residual oil can result in chronic exposure long after a spill. For example, biomarkers in harlequin ducks showed that individuals of this species continued to be exposed to oil at least 22 years after the *Exxon Valdez* spill in Prince William Sound, Alaska (Esler et al. 2017). Other studies have, however, found little or no effects from exposure to low doses of oil on adult seabirds (Ainley et al. 1981; Stubblefield et al. 1995; Alonso-Alvarez et al. 2007; Camphuysen 2011).

Morandin and O'Hara (2016) reviewed several short- and long-term studies of marine oil spills and reinforced that these effects can result in increased mortality rates, physiological impairment, reduced reproductive success and, in severe cases, possible long-term population declines. Bird species at greatest risk are those that spend a considerable time resting or foraging on the water surface, i.e., alcids, waterfowl, loons, and grebes (Wiese and Robertson 2004; Boertmann and Mosbech 2011). However, in the breeding season following the DWH blowout, brown pelicans, great egrets and tricolored herons in oiled colonies showed no significant difference in the number and size of chicks compared with unoiled colonies (Burger 2018). Piping plovers (SARA and NL ESA endangered) wintering on coastlines oiled by the DWH blowout did not have different demographic rates than those on unoiled coastlines (Gibson et al. 2017). The long lifespan of marine bird species, delayed sexual maturation, and small clutch size (one egg in most species) also suggests that these species are vulnerable to long-term population effects from oil exposure (Esler et al. 2002; Wiese and Robertson 2004). While the primary potential for exposure and thus for direct effects on seabirds occurs within the spatial extent of the spill itself, the ecological effects of oiled areas may also be transferred away from the affected site due to the migratory nature of some marine-associated avifauna (Henkel et al. 2012).

The possible effects of oil exposure on birds vary between species, as well as with different types of oil (Gorsline et al. 1981), weather conditions, times of year, variation in distribution and abundance of prey, migratory patterns, and other activities (Wiese et al. 2001; Montevecchi et al. 2012), making the effects on population difficult to predict. Mortality rates and potential changes in bird populations due to accidental releases of oil are poorly known, but this is often cited as the main risk to marine birds from the offshore oil and gas industry (Fraser et al. 2008; Ellis et al. 2013). As noted above, seabirds have a life history strategy that depends on low annual adult mortality to compensate for very low annual reproductive rates. Consequently, a significant increase in mortality of adults of reproductive age results in a significant decrease in the number of juveniles recruited into a population, resulting in long-term effects on population size (Esler et al. 2002; Wiese and Robertson 2004). In years of poor food availability, nesting birds may abandon reproductive attempts, resulting in massive die-offs of chicks but preserving fitness of adult birds to reproduce in subsequent years. Although the volume of oil spilled and number of seabirds oiled is weakly correlated (Burger 1993), it is clear that the timing, location of a given spill (and not just its size) has an important influence on avifauna mortality and injury rates resulting from that spill due to the influence of variation in seabird abundance at a given location and of the effect of weather at the time on the dissipation of the slick (Wiese et al. 2001). As a result, the effects of a spill on seabird populations cannot be predicted with a high degree of confidence.

The use of dispersants, which is intended to enhance the natural microbial degradation, may be beneficial for marine and migratory birds within a spill area by reducing the exposure to floating oil on the sea surface. As a result, application of chemical dispersants reduces the risk of adverse effects on marine and migratory birds at the water's surface, and potentially results in a far greater rate of biodegradation of oil to a matter of weeks rather than of years (Baelum et al. 2012). Such a relatively rapid rate of degradation greatly reduces the chance of accidentally released oil reaching shorelines, where it could potentially cause great harm to shorebirds and adversely affect seabird nesting colonies (Prince 2015). However, a recent review of studies of the effects of dispersants on biodegradation showed the majority of studies found that dispersants inhibit microbial degradation of oil (Fingas 2017). The effect of dispersants and surfactants on biodegradation was most dependent on the characteristics of the dispersant itself, perhaps due to toxicity of specific components to microbial degraders (Fingas 2017). In addition, the use of dispersants results in increased oil in the water column, potentially resulting in exposure of food sources (fish and water column invertebrates) to oil, and exposure of diving birds near the dispersed oil (Fingas 2017). A study of the effect of dispersant use on feather structure, waterproofing, and buoyancy of common murres showed no significant difference between the effects of oil alone and the effects of a mixture of dispersant and oil (Whitmer et al. 2018). In both cases the effect was dose-dependent and resolved over two days. A high concentration of dispersant alone caused an immediate, life-threatening loss of waterproofing and buoyancy, which resolved within two days. The measured toxicity of dispersants themselves to birds varies among studies. Prince (2015) found very low toxicity. Fiorello et al. (2016) found that common murre, a species that forages underwater, exposed to Corexit EC9500a, crude oil, develops conjunctivitis and is at higher risk of corneal ulcers. Preliminary studies of dispersant use during the DWH blowout show that dispersants enhance oil's toxicity to early life stages of coastal waterbirds (Beyer et al. 2016). The dispersed oil has similar effects to that of oil, as presented earlier, but the size of the slick and exposure concentrations would be lower than untreated oil. Hence, dispersant mitigates the potential adverse effects of oil on birds compared to untreated oil.

Hydrocarbon spills can also result in a change in habitat quality and use for marine and migratory birds. Day et al. (1997) examined the effects of the *Exxon Valdez* oil spill on marine bird habitat use, determining that while initial effects were severe, most of the habitat use for most bird species recovered within 2.5 years of the spill. While initial effects to bird habitat were severe, this rate of recovery was attributed to high-latitude seabird populations, which appear to be fairly resilient to environmental perturbations, as well as Prince William Sound being a high wave energy and a largely rocky substrate environment where oil does not persist as long as other settings (Day et al. 1997). In shorebird staging areas in coastal Louisiana oiled by crude oil from the DWH blowout, sanderlings had lower fuelling rates than in unaffected areas in the first spring migration following the blowout, but red knots showed no difference (Bianchini and Morrissey 2018). Both sanderlings and red knots departed oiled staging areas to resume northward migration later than the study average.

### Potential Effects of an SBM Spill on Marine and Migratory Birds

SBM is considered to be of low toxicity (IOGP 2016) and environmental effects are mostly restricted to physical smothering effects on the sea floor. A release of SBM would result in elevated levels of TSS in the water column and possibly a small thin sheen on the surface, with effects potentially similar to those discussed above for hydrocarbon spills, but more limited in magnitude given the comparative volume and physical property of the SBM. O'Hara and Morandin (2010) investigated the effects of thin oil sheens associated with both crude oil and synthetic-based drilling fluids on the feathers of pelagic seabirds (common murre and dovekie) and found that feather weight and microstructure changed substantially for both species after exposure to thin sheens of both hydrocarbons, concluding a plausible link even between operational discharges of hydrocarbons and increased seabird mortality.

### 15.6.2.2 Mitigation of Project-Related Environmental Effects

Spill prevention measures are the most effective way to mitigate against potential effects from accidental events. BHP's strategy for contingency planning and spill response is described in Section 15.5. Mitigation of potential accidental events is incorporated as part of the regulatory processes (e.g., Operations Authorization [OA], Approval to Drill a Well), project-specific safety and response plans (e.g., safety plan, oil spill response plan, EPP), and well design (e.g., blowout preventer [BOP]).

The Project will operate under safety and contingency plans, including an OSRP that will be submitted to the C-NLOPB before the start of drilling activity as part of the OA process. The OSRP will outline response methods and procedures, and response strategies based on severity of hydrocarbon spills. Potential responses considered in the event of an accidental release may include, but not be limited to, offshore containment and recovery, dispersants (surface application and/or subsurface injection), *in situ* burning, shoreline protection and clean-up, and oiled wildlife response. Further details on spill responses are provided in Section 15.5. A SIMA / NEBA will be conducted as part of the OA Process as well. These assessments will be used to qualitatively evaluate the risks and trade-offs of feasible and effective response options, when compared to no action. An overall spill response strategy will be selected for the Project based on the SIMA process. If identified as a response option, chemical dispersant application would not occur without authorization from C-NLOPB.

Mechanical measures and barriers that are implemented as part of well design, and drilling and monitoring procedures for prevention of blow-outs are described in Section 2.3.4. This includes use of steel casings, drilling fluids, and BOPs for controlling formation pressures. The BOP includes a series of rams that are designed to seal off the wellbore at the wellhead on the seafloor when required. Furthermore, the BOP and other pressure control equipment are tested regularly and recorded in accordance with the Drilling and Production Guidelines (C-NLOPB and CNSOPB 2017a) and BHP company standards.

Of particular relevance to marine and migratory birds are the commitments related to shoreline protection and clean-up, and oiled wildlife response (see Section 15.5.4). In the event that oil threatens or reaches the shoreline, shoreline protection measures, including deflection from sensitive areas, will be implemented as practical. SCAT teams will be mobilized to the affected areas to conduct shoreline surveys to document the type and degree of shoreline oiling and inform shoreline clean-up and remediation as applicable. SCAT teams will also be used to monitor and evaluate the effectiveness of the clean-up operations.

BHP will develop an OWRP and, for incidents where wildlife is threatened, engage specialized expertise to implement the Plan, including the recovery and rehabilitation of wildlife species as needed (see Section 15.5.4 for BHP's oiled wildlife response approach).

Specific environmental effects monitoring and follow-up programs may be required in the unlikely event of a spill. These monitoring programs will be developed in consultation with applicable regulatory agencies.

### 15.6.2.3 Characterization of Residual Project-Related Environmental Effects

#### Subsurface Blowout

The potential effects of a subsurface well blowout will depend on the nature of the spill and its trajectory and how the spill trajectory overlaps in space and time with marine and migratory birds. Although unlikely to occur, such a blowout has potential to change both the risk of mortality or physical injury and the habitat quality and use for marine and migratory birds. Two oil exposure thresholds were used to assess the effects on marine and migratory birds. These thresholds are based on the habitats of seabirds (open water) and shorebirds (shorelines). There is potential for direct effects from oil from a blowout on the nesting habitat of a subset of marine-associated species, but there is greater potential for direct effects on habitat at sea (i.e., those used for foraging, loafing, and roosting). For seabirds at-sea, the greatest potential risk of mortality or injury is from exposure to oil on the sea surface. The threshold thickness of surface oil causing lethal effects to seabirds is greater than 10 μm thick (>10 g/m²) (French et al. 1996; French McCay and Rowe 2004; French McCay 2009). For shorebirds (and other wildlife) on or along the shore, and for nesting seabirds resting on the water near their coastal nesting colonies, an oil exposure index consisting of the length of shoreline oiled by a threshold for the potential ecological effects on shoreline fauna and flora of 100 g/m² (100 μm thick) was used.

As discussed in 15.6.2.1, change in risk of mortality or physical injury to marine birds from exposure to hydrocarbons is manifested as hypothermia and drowning leading to death, and sub-lethal effects of lower reproductive rates or premature death. Sub-lethal effects may persist for a number of years, depending upon generation times of affected species and the persistence of spilled hydrocarbons. Most marine birds are relatively long-lived. Survival rate for oiled birds were traditionally considered to be very low even with rescue and cleaning attempts (French McCay 2009). In recent years, however, the percent of African penguins successfully released after de-oiling has often been over 90% (Wolfaardt et al. 2009). Survival rate of cleaned little blue penguins following their release back into the wild did not differ from control birds (Sievwright et al. 2019a). Post-release breeding success in this species differed from control birds only in reduced hatching success in the first season in rehabilitated pairs of penguins (Sievwright et al. 2019b). However, oiled birds are generally assumed to have a very low survival rate (approximately 0 to 5%). The probability of lethal effects to birds is therefore primarily dependent on the probability of exposure, which is influenced by behavior (i.e., the percentage of the time an animal spends on the water or shoreline as well as oil avoidance behavior) (French McCay 2009). French McCay (2009) calculated vulnerability scores (i.e., the combined probabilities of a) encountering oil and b) mortality once oiled) which are, in effect, the mortality rate of a bird in the area of an oil slick. These scores were calculated for various wildlife groups which were then applied to species: surface-diving seabirds and waterfowl) (99% combined probability of oil encounter and mortality once oiled); nearshore aerial (plunge) divers (35% combined probability); and aerial seabirds (5% combined probability). In Newfoundland waters during summer large numbers of sooty shearwaters moult their flight feathers and, as a result, spend a great deal of time on the sea surface (Hedd et al. 2012). Great shearwaters are also moulting their flight feathers at this time of year and probably also spend a larger proportion of their time on the surface. Sub-adult northern fulmars also moult their flight feathers in offshore Newfoundland waters during summer (Huettmann and Diamond 2000). The vulnerability score of moulting shearwaters and fulmars, therefore, may be more like that of surface-diving seabirds than that of aerial seabirds. Table 15.33 indicates the combined probabilities of oiling and mortality once oiled for various generic behaviour categories.

### Table 15.33 Combined Probability of Encounter with Oil and Mortality Once Oiled for Generic Behaviour Categories (If Present in the Habitats Listed and Area Swept by Oil Exceeding Threshold Thickness)[1]

| Bird Group | Probability | Habitats[2] |
|---|---|---|
| Surface-divers[3] | 99% | Coastal and pelagic waters |
| Aerial divers (plunge-divers), shorebirds[4] | 35% | Intertidal, coastal and pelagic waters |
| Aerial seabirds[5] | 5% | Coastal and pelagic waters |

Source: Modified from French McCay (2009)
Note:
[1] A thickness of 10 µm is assumed as threshold thickness for oiling mortality of wildlife.
[2] Intertidal includes all between-tide or terrestrial areas flooded by tides or by storm surges.
[3] Cormorants, waterfowl, loons, grebes, both murre species, dovekie, puffin, razorbill, black guillemot, both phalarope species, moulting shearwaters and fulmars.
[4] Northern gannet, arctic and common terns, plovers, sandpipers, bald eagle, osprey.
[5] Leach's storm-petrel, non-moulting shearwaters and fulmars, gadfly petrels, gulls, jaegers and skuas.

As part of this assessment, the ecological risk to marine birds was assessed by using these metrics in combination with the threshold concentrations for marine birds for the oil floating on the surface (10 µm thickness, 10 g/m²), and shoreline oil (100 g/m²).

Hydrocarbon spills are not likely to cause a permanent change in habitat quality and use for marine and migratory birds. Prey availability may be reduced, or birds may avoid affected habitat. However, spill cleanup and natural weathering processes are likely to result in the eventual recovery of such habitat. Recovery of marine bird abundance and use of oiled shorelines sites in Prince William Sound, Alaska, following the 1989 *Exxon Valdez* oil spill, back to estimated (naturally variable) baseline levels, was reported for all surveyed species within 12 years (Wiens et al. 2004). The recovery of sessile, mobile, and infaunal invertebrate species on oiled rocky and open coast soft-sediment shorelines, which provide an important food source for marine birds, is expected to occur within five to ten years following oiling (Moore 2006). The recovery time of sand beaches is variable, depending on conditions and initial disturbance during spill response, but is estimated at a maximum of three years (French McCay 2009).

The risk of marine birds interacting with oil would take place in the various habitats used by those birds in their annual cycle (see Section 6.2.2). Interactions could occur in foraging habitat whether inshore, where nesting birds feed on pelagic fish that have come inshore to spawn, or the continental shelf slope used by nesting, summering, staging, or wintering birds. Inshore waters are also used by nesting birds that rest and preen in large numbers close to nesting colonies. Although stochastic modelling shows the probability of oil from a blowout coming into contact with the Avalon Peninsula is 9%, and the representative 95th percentile shoreline exposure case predicted a 3% (see Appendix F) or less of the total volume of oil released would contact shore, contact during the breeding season has the potential to affect species' populations because of the large concentrations of birds nesting in colonies. However, the greatest risk of adverse seabird interactions with an oil spill generally occurs in the winter months when water and air temperatures are colder and consequently thermoregulation is most difficult, increasing the likelihood of mortality for affected birds (Morandin and O'Hara 2016). The species at greatest risk of interactions with an oil spill vary with the species' abundance in the area, which depends on the season, weather, and on prey distribution, which at short time scales is dependent on weather and currents.

Adult common murre, Atlantic puffin, razorbill, and black guillemot are vulnerable to interactions with oil in inshore waters during the nesting season while foraging and while resting near their nesting colonies (Section 6.2.2). Fledglings of these species are also vulnerable following colony abandonment, as chicks are flightless for a period of one to two months while they are accompanied by their male parent to foraging areas on the continental shelf slope. Although the core wintering range of the common murre is south of the Project Area, this species winters in relatively large numbers in the continental shelf slope waters. Dovekie and thick-billed murre are vulnerable in those shelf slope waters because of the globally significant numbers of birds overwintering there. In recognition of these globally significant bird concentrations portions of these waters are designated as Northeast Shelf and Slope EBSA (Table 6.3) and Seabird Foraging Zone in the Southern Labrador Sea (United Nations) Convention on Biological Diversity Ecologically or Biologically Significant Area (CBD EBSA; Figure 6-11).

Among the species of gulls, black-legged kittiwake concentrates inshore while foraging and attending nesting colonies. Following colony abandonment kittiwakes are most vulnerable in shelf slope and deeper waters where the globally significant concentrations overwinter. Great black-backed gull is at risk in the fall in both inshore and offshore waters. This and other species of gulls are at risk on inshore foraging grounds and near the colonies during the nesting season. Iceland's nesting population of great skua is vulnerable to interactions with oil in the waters off Atlantic Canada because these waters are the core wintering area for this population.

Northern gannet is most vulnerable to interactions with oil during the nesting season in coastal areas, where it feeds on spawning fish and attend nesting colonies, and during the fall when fledglings depart the colony (Garthe et al. 2007).

Leach's storm-petrel is at greatest risk during the nesting season in the shelf slope and deep waters of the RAA, when adults nesting in globally significant numbers at Baccalieu Island and at Great Island commute to foraging areas in the deep waters off the Grand Banks including the Project Area (Hedd et al. 2018). Breeding adults may be exposed to hydrocarbons while foraging within the affected area and transfer oil from their breast plumage to eggs or nestlings. This species is also at risk of exposure during the fall when fledglings depart the colonies for those feeding grounds. Great shearwater and large numbers of sooty shearwater are vulnerable to oiling during the summer months in coastal and offshore waters because most of the world's great shearwaters and large numbers of sooty shearwaters summer in the Northwest Atlantic. Fulmars are most vulnerable in winter due to the relatively large numbers wintering in the shelf slope and deeper waters of the RAA.

Stochastic modelling results for unmitigated subsurface blowouts for both release sites, EL 1157 and EL 1158, demonstrated that the highest potential likelihood (>90%) to exceed thresholds of potential surface oil exposure primarily occurred to the east, up to 1,400 km from the release site due to prevailing winds and currents (Section 15.3.1).

Oil was predicted to strand on shorelines in several simulations. The maximum probability of shoreline oiling above the ecological threshold from a blowout in EL 1157 lasting 30 days was 15% during winter and 8%

in summer (Table 15.7). The minimum time to shore was seven days in winter and 22 days in summer. For a 120-day release the probability was 28% in winter and 14% in summer. The minimum times to shore were the same as for the 30-day release. In EL 1158 the maximum probability of shoreline oiling during a 30-day release was 15% in winter and 8% in summer (Table 15.7). The minimum time to shore was seven days in winter and 14 days in summer. For a 120-day release the maximum probability was 27% in winter and 18% in summer. The minimum time to shore was seven days in winter and 27 days in summer.

Representative credible “worst-case” deterministic scenarios of a subsurface blowout at EL 1157 and EL 1158 are characterized by surface oil transported predominantly to the east and south. The proportion of oil leaving the model domain to the east (as weathered emulsifications and tar balls) ranged from 3 to 22%. The footprints of the representative “worst-case” scenarios were centered to the east of the release sites. The area affected by surface oil thickness over the ecological threshold in the simulations ranged from 832,900 km² (modelled release: EL 1157, 4,052,506 bbl, 30 days) to 1,616,000 km² (EL 1157, 15,496,924 bbl, 120 days) (95th percentile) (Table 15.9).

The length of shoreline affected by oil concentrations above the ecological threshold in the representative credible “worst-case” scenario simulations ranged from 1,194 km (30 days, EL 1158) to 1,597 km (120 days, EL 1157). The specific coastlines affected in the EL 1157 release were similar to those for the EL 1158 release but differed between those in the 30-day release and those in the 120-day release (Figures 4-99 and 4-104 in Appendix F). For the 30 day-release the coastlines affected by oil concentrations above the ecological threshold included much of the east coast of the Avalon Peninsula and the island’s southern coast to the Burin Peninsula, and part of the coastline of Fortune Bay. In the 120-day release the affected coastlines were the east coast of the Avalon Peninsula and the north coast of the island to the eastern half of Notre Dame Bay and the north coast of the Baie Verte Peninsula. However, the EL 1158 release did differ slightly from the EL 1157 release in that the former only affected the north coast as far west as the west coast of Trinity Bay. Shoreline oil would be highly weathered, patchy and discontinuous. Major nesting colonies of marine bird in eastern Newfoundland are listed in Section 6.2, Table 6.13, and locations of IBAs (including MBSs), SERs, and Seabird EBSAs in eastern Newfoundland potentially affected by oil from subsurface blowout reaching shore are illustrated in Figure 6-37.

The modelling results suggest that the areas most likely to be affected by an unmitigated, subsurface, well blowout is Orphan Basin, Flemish Pass and the areas to the east. As a result, a blowout during summer would have the potential to interact primarily with the relatively high concentration of great shearwaters, Leach’s storm-petrels foraging for their nestlings, and smaller concentrations of northern fulmars and sooty shearwaters. Of these species, the shearwaters and fulmars would be most vulnerable to interaction with oil due to their moulting of flight feathers and the resulting greater amount of time on the sea surface. A blowout during winter would have the potential to interact with large concentrations of thick-billed murres, dovekies, kittiwakes, and fulmars, and smaller concentrations common murres. Of these species, the murres and dovekies would be most vulnerable due to the large proportion of time that alcids spend on the sea surface. A blowout during spring or fall has the potential to interact with all of the above species, with murres and dovekies as the most vulnerable species. However, higher average wind speeds and sea states during winter and fall would decrease the length of time that contiguous areas of oil would persist on the surface. The magnitude and extent of potential effects would be reduced with the application of spill response measures, therefore the risk of adverse effects on secure and at-risk to marine and migratory birds would be reduced.

In the even less likely event of shoreline oiling, particularly at or near the seabird colonies of the Avalon Peninsula and for coastal SERs on the Avalon, such as Cape St. Mary's and Witless Bay Islands, there is potential for marine and migratory birds present and nesting in these areas to interact with surface oil. As stated above, by the time oil made contact with the shoreline, it would be patchy, discontinuous and weathered. As with surface oil, the potential effects would be reduced with mitigation measures, therefore the risk of adverse effects on shoreline and coastal marine and migratory birds would be reduced.

As discussed above, there is a low potential for SAR (see Section 9.3.3) to interact with accidental hydrocarbon releases.

With spill prevention plans and response procedures in place, the residual effects of a subsurface blowout on Marine and Migratory Birds are predicted to be adverse, potentially high in magnitude, short- to medium-term in duration, within the RAA, a single event and reversible in nature.

### Marine Diesel Spill

A batch diesel spill or vessel spill has the potential to result in a change in risk of mortality or physical injury and change in habitat quality and use for marine and migratory birds. A threshold concentration for lethal effects to seabirds is the open water area covered by an oil plume greater than 10 μm thick (>10 g/m²). For shorebirds (and other wildlife) on or along the shore, an exposure index is length of shoreline oiled by a slick >100 g/m² in thickness.

The batch spill releases of 3,200 L marine diesel from a nearshore location (12 km east of St. John's) along a potential PSV route were predicted to result in silver or colorless sheens (<0.0001 mm, 0.1 μm) of oil floating on the water surface (Figure 4-106 in Appendix F) over a much smaller than a well blowout scenario. Generally, marine diesel within these representative scenarios was predicted to be transported to the south, potentially bringing it within the boundaries of the Witless Bay Islands SER. In some modelled cases, the slick wrapped westward around the south shore of the Avalon peninsula, towards Saint Lawrence, Newfoundland (Figure 4-106 in Appendix F). At the end of the 30-day marine diesel batch spill simulations, 64 to 80% was predicted to evaporated into the atmosphere, 12 to 23% degraded, 6 to 13% remained entrained in the water column, while 0.1% of the released volume was predicted to remain floating on the water surface. Modelling predicted zero probability of surface oil above the ecological threshold for thickness and zero probability of shoreline contact of oil above the ecological threshold (Figure 15-25 and 15-27). As a result, none of the worst-case scenarios of surface batch spills exhibited surface area affected by oil thicknesses greater than the either the socio-economic or ecological thresholds (Table 15.9).

Based on the modelling results, a batch spill could result in a temporary and reversible degradation in habitat quality. Depending on the location and extent of the spill, it could directly and indirectly reduce the amount of habitat available to marine and migratory birds at sea. In the event of a vessel spill in the nearshore area, there is the potential for shoreline to be affected by a diesel spill. When diesel spills interact with the shoreline, it tends to penetrate porous sediments quickly and washes off quickly by waves and tidal flushing (NOAA 2016). These effects would be short-term in duration until the slick disperses and the diesel content in the area reaches background levels (Appendix F). A batch spill of diesel is therefore not expected to create permanent or irreversible changes to habitat quality and use, including habitat quality and use within the Witless Bay Islands SER. A marine diesel batch spill of similar size along a potential PSV route from Bay Bulls could initially occur much closer the Witless Bay Islands SER than the modelled spill scenarios. Given the modelling predictions of a low probability of the diesel on the water's surface or on the shorelines on the nesting islands approaching the thickness of the respective ecological thresholds, and given the rapid evaporation, degradation and entrainment of the slick, the effects on habitat quality and use in the SER would be short-term and reversible.

A batch spill of hydrocarbons has the potential to cause a change in risk of mortality or physical injury for marine and migratory birds through direct contact. However, since the modelled sheen's predicted thickness is below the ecological threshold it is predicted that birds coming into contact with the sheen would not suffer mortality or sublethal effects. The number of birds affected would also be limited due to the short time and small area where the diesel would be on the water's surface. If the spill occurred during the breeding season near St. John's and drifted to the Witless Bay Islands SER, or occurred near the SER along a PSV route from Bay Bulls, a potentially larger number of birds could be affected than if the spill remained in the St. John's area. Species nesting in the SER that would be most vulnerable would be those species spending the greatest amount of time on the water (i.e., common murre and Atlantic puffin, which nest in the SER in large numbers with smaller numbers of thick-billed murre and razorbill). However, the surface thickness would still be below the ecological threshold and the diesel would rapidly evaporate and degrade. As a result, birds nesting on the islands in the SER would not suffer mortality or sublethal effects.

With spill prevention response procedures in place, potential effects of a batch spill on marine and migratory birds are predicted to be adverse, low in magnitude, short-term in duration, within the LAA, a single event and reversible.

### SBM Spill from the MODU and the Marine Riser

An SBM spill has the potential to result in a surface sheen which in turn could cause a change in risk of mortality or physical injury or change in habitat quality and use for seabirds present in the immediate vicinity of the MODU (Morandin and O'Hara 2016). A sheen would be limited in size, temporary, and moderate wind and wave conditions would quickly break it up. Given the low surface oil thickness required to result in a sheen (0.04 μm), it is expected that effects would be minor and unlikely to result in seabird mortality. Potential effects of a drill mud spill on marine and migratory birds are therefore predicted to be adverse, low in magnitude, within the LAA, short-term in duration, a single event, and reversible.

### Summary

Table 15.34 provides a summary of predicted residual environmental effects of accidental events on migratory birds.

### Table 15.34 Summary of Residual Project-Related Environmental Effects on Marine and Migratory Birds – Accidental Events

| Residual Effect | Residual Environmental Effects Characterization | | | | | | |
|---|---|---|---|---|---|---|---|
| | Direction | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | Ecological and Socio-economic Context |
| **Change in Risk of Mortality or Physical Injury/Change in Habitat Quality and Use** | | | | | | | |
| Well Blowout Incident | A | H | RAA* | ST-MT | S | R | D |
| Marine Diesel Spill | A | L | LAA | ST | S | R | D |
| SBM Spill | A | L | LAA | ST | S | R | D |

KEY:
N/A: Not Applicable

Direction:
P: Positive
A: Adverse

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"

Duration:
ST: Short-term
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

## 15.6.2.4 Determination of Significance

Based on the characterization of residual effects described above, a precautionary conclusion is drawn that the residual adverse environmental effect of an unmitigated blowout incident, large batch spill, or vessel spill is predicted to be significant for marine and migratory birds, but not likely to occur. Infrequent small spills, as well as a SBM release, would be not significant for marine and migratory birds.

Although hydrocarbon spills could result in some mortality at the individual level, these residual adverse environmental effects are predicted to be reversible at the population level. However, these environmental effects could be significant if the consequences carried over more than one generation according to the significance threshold used in this environmental assessment or self-sustaining population objectives or recovery goals for listed species are jeopardized. Again, this is considered unlikely given the low probability of a large spill event to occur and the response that would be in place to reduce the consequences of such an event.

A medium level of confidence is assigned to the significance determination for all accident scenarios, with the exception of a blowout incident (which is made with high confidence), as the significance is based on a worst-case credible scenario, with the actual significance influenced by a number of factors such as volume spilled, duration, location, season, and presence of birds.

## 15.6.3 Marine Mammals and Sea Turtles

There are 32 marine mammal species that could potentially occur in the Project Area and Regional Assessment Area (RAA), including 26 cetacean species (whales, dolphins, and porpoises) and six seal species; however, seven of the cetacean species are considered to be extralimital (i.e., outside their normal ranges). Four species of sea turtle could also occur within or near the Project Area and/or RAA. Of these marine mammal and sea turtle species, there are five marine mammal SAR (North Atlantic right whale, blue whale [Atlantic population], northern bottlenose whale [Scotian Shelf population], fin whale, and Sowerby's beaked whale), two sea turtle SAR (leatherback and loggerhead sea turtles), and two marine mammal SOCC (killer whale and harbour porpoise) (see Tables 6.20 and 6.21). Most of these SAR are expected to be rare or uncommon in the Project Area, although fin and northern bottlenose whales could occur there regularly. Nonetheless, an accidental release of oil or SBM could extend outside of the Project Area and affect SAR, SOCC, and other species in the larger RAA.

Many marine mammal and sea turtle species that could occur in the RAA have the potential to be present year-round but are most likely to occur from late spring or summer through fall; this is also the period when most migratory marine mammals and sea turtles frequent the area. Exceptions are harp and hooded seals, which may occur year-round but mostly from winter to spring; ringed seals, which are seasonally present from winter to spring; and leatherback sea turtles, which are seasonally present from April to December.

The species of marine mammals potentially found in coastal areas within the RAA include the North Atlantic right whale, fin whale, humpback whale, minke whale, blue whale, Atlantic white-sided dolphin, common bottlenose dolphin, killer whale, harbour porpoise, grey seal, ringed seal, and bearded seal.

Sections 6.3.2 and 6.3.8 describe several areas of importance to marine mammals and sea turtles that are found within the RAA, including nearshore and offshore areas. Additional details regarding existing conditions for marine mammal and sea turtle species are provided in Section 6.3.

### 15.6.3.1 Project Pathways for Effects

Accidental spill scenarios have potential to result in a change in risk of mortality or physical injury and/or a change in habitat quality and use for marine mammals and sea turtles. The extent of potential effects will depend on how the spill trajectory and the VC overlap in both time and space (Frasier et al. 2020). Although the effects of dispersants on marine mammals and sea turtles is not well known (Frasier et al. 2020), they can be toxic or change the characteristics of the oil spill thereby exposing certain biota to oil longer (Dupuis and Ucan-Marin 2015; Beyer et al. 2016). However, according to Prince (2015), the positive effects of its use on a spill likely outweigh the environmental consequences; however, the use of dispersants remains controversial (Beyer et al. 2016). Spill modelling for this assessment is conservative in its analysis of potential effects of oil spills on marine mammals and sea turtles, and assumes that geographic and temporal overlap occur; in addition, the modelling results assume no implementation of mitigation measures.

## Potential Effects of an Oil Spill on Marine Mammals and Sea Turtles

### *Marine Mammals*

The effects of oil on marine mammals depend on the extent of exposure to toxic components of oil. Exposure may occur due to external coatings of oil (e.g., interaction with surface slicks when animals surface for air, clogging of baleen plates), inhalation of aerosols of particulate oil and hydrocarbons, and ingestion of contaminated prey (Helm et al. 2015; Lee et al. 2015; NRDA 2016). Animals that move through an area covered by floating oil (e.g., emulsions, slicks, or other floating forms such as tar balls) are assumed to be oiled based on the probability of encounter; those individuals that are oiled above a threshold dose are assumed to die (French McCay 2009). A combined probability of oil encounter and mortality once oiled for marine mammals present in the area swept by oil exceeding a threshold thickness of 10 μm (for spills larger than 230 m in diameter) was 0.1% for cetaceans and 75% for fur-bearing marine mammals such as seals (French McCay 2009).

Studies to date have shown variable results regarding the ability of marine mammals to detect and/or avoid oil-contaminated waters (Engelhardt 1983; St. Aubin et al. 1985; Smultea and Würsig 1995; Ackleh et al. 2012; Wilkin et al. 2017). Several cetacean and seal species were reported to behave normally in the presence of oil (St. Aubin 1990; Harvey and Dahlheim 1994; Matkin et al. 1994). During the 1989 *Exxon Valdez* spill in Prince William Sound, killer whales were seen swimming through surface oil within 24 hours of the spill (Matkin et al. 2008). It is possible that cetaceans swim through oil because of strong behavioural motivation, such as the need to feed. Following the *Exxon Valdez* spill, harbour seals were seen swimming through and surfacing in floating oil while foraging and moving to and from haul-out sites (Lowry et al. 1994).

However, other studies have documented that cetaceans avoid surface slicks. Aerial surveys conducted between 1979 and 1982 in Atlantic Canada monitored the presence of cetaceans near small oil slicks, reporting that some individuals were seen swimming near surface oil but rarely within surface slicks (Sorensen et al. 1984). During the 1989 *Exxon Valdez* spill, humpback whales may have shown temporary avoidance of the oiled area (von Ziegesar et al. 1994). Some data indicates that dolphins attempt to minimize contact with surface oil by decreasing their respiration rate and increasing the dive duration (Smultea and Würsig 1995). In some cases, marine mammals may avoid the area beyond the detected slick. Based on a comparison of sperm whale acoustic activity from pre-spill (2007) and post-spill (2010) conditions associated with the DWH oil spill, Ackleh et al. (2012) reported that sperm whales may have relocated out of areas that had high concentrations of oil and pollutants, possibly because of food shortages, and increased boat traffic, which likely had increased levels of anthropogenic noise.

According to Geraci and St. Aubin (1980, 1982), whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage. Marine mammal species feed in restricted areas or within restricted ranges may be at greater risk of ingesting oil (Würsig 1990; Helm et al. 2015). However, when returning to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982). Hydrocarbons consumed via contaminated prey can be metabolized and excreted, but some is stored in blubber and other fat deposits (Lee et al. 2015). Absorbed oil can cause toxic effects such as liver, kidney, and brain lesions (Geraci and Smith 1976; Geraci 1990; Spraker et al. 1994). Examination of deceased common bottlenose dolphins that had been exposed to oil during and after the DWH spill indicated that elevated petroleum compounds in coastal waters had caused adrenal and lung disease and contributed to increased numbers of dolphin mortalities (Venn-Watson et al. 2015). Lung disease, as well as adrenal toxicity, were evident during examination of live dolphins in 2011 that inhabited an area of the Gulf of Mexico that received heavy oiling from the spill (Schwacke et al. 2014). A health assessment of dolphins from the same area conducted four years after the spill showed some improvement in dolphin health, although impaired stress response and lung disease were still evident (Smith et al. 2017).

Crude oil could coat the baleen plates of mysticetes and reduce filtration efficiency, but these effects are considered reversible (Geraci 1990). Geraci (1990) noted that adverse effects on cetaceans, such as sickness, stranding, or mortality tended to be associated with crude or bunker C oil. Nonetheless, most marine mammals can tolerate some oiling without toxic or hypothermic effects. Direct contact with oil can cause fouling in fur-bearing marine mammals such as seals, reducing their ability to thermoregulate (Kooyman et al. 1977) and potentially causing effects similar to those associated with thermoregulatory failure in birds (Lee et al. 2015) (see Section 15.6.2). Whales and seals use blubber to maintain core body temperature, which is not affected by a covering of oil (Helm et al. 2015). However, hypothermia is possible if marine mammals that rely on fur for insulation (e.g., polar bears, fur seals, otters) are oiled (Helm et al. 2015). Contact with oil decreases the insulative value of hair, but for healthy seals, this is unlikely a major problem as they rely primarily on blubber for insulation; thus, the risk of hypothermia may be offset by thick layers of blubber (Lee et al. 2015). However, young seal pups, if oiled, are susceptible to hypothermia, as it takes several months to build up a blubber layer sufficient to maintain body heat. Oil fouling could affect seal locomotion, by causing flippers to stick to the body with heavy oiling. Seals became cleaner over time if they are not repeatedly exposed to oil. Various types of skin lesions likely caused by crude oil have also occurred in harbour seals. Examination of dead, oiled seals suggested lesions may have been related to inhalation of toxic fumes and mortality could have resulted from behavioural disorientation, lethargy, and stress response (Ott et al. 2001). Stimmelmayr et al. (2018) reported that oiled arctic seals showed hepatic, pulmonary, and cardiac lesions likely associated with increased levels of polycyclic aromatic hydrocarbon (PAH) in their tissues.

Monitoring studies of marine mammals following oil spills have shown evidence implicating oil exposure with the mortality. Sea otters, harbour seals, Stellar sea lions, killer whales, and humpback whales were most affected by the *Exxon Valdez* oil spill (Lee et al. 2015). Monitoring over a 16-year period after the spill showed a measurable decrease and lack of recovery in the population of a resident fish-eating killer whale pod using the area affected by the spill (Dahlheim and Matkin 1994; Matkin et al. 2008). Fraker (2013) challenged Matkin's conclusion that the killer whale deaths could be attributed to the *Exxon Valdez* spill, as there does not appear to be a clear and plausible connection given other factors, such as bullet wounds, that might have contributed to the documented mortalities. Nonetheless, neither the resident pod nor the transient population of killer whales in Prince William Sound has recovered, even though it has been 28 years since the spill (Esler et al. 2018). Although Esler et al. (2018) noted that chronic direct effects after this many years is unlikely, they suggest that demographic factors such as a small population size and life history characteristics are constraining the recovery.

Five harbour porpoises were also found dead in Prince William Sound following the *Exxon Valdez* spill. Although three autopsied individuals showed elevated levels of hydrocarbons in liver and blubber tissues, the levels of assimilated oil were not high enough to conclude with certainty that the animals succumbed from exposure to crude oil (Dalheim and Matkin 1994). The deaths could have resulted from a combination of factors, including acute toxicity of crude oil, starvation due to chronic respiratory damage, reduced prey abundance, increased energy expenditure from epidermal fouling, and increased susceptibility to parasitism or disease (Albers and Loughlin 2003; Lee et al. 2015).

Following the DWH oil spill in the Gulf of Mexico, over 150 dolphins and whales were found dead of which nine were visibly oiled; 90% of mortalities consisted of bottlenose dolphins (NOAA 2018). The low estimated carcass recovery rates of cetaceans (as low as 2%) after the DWH oil spill (Williams et al. 2011) limits the statistical validity of proposed cause-effect relationships. The low carcass recovery after a spill is one reason why it is challenging to link oil exposure to acute and chronic effects in marine mammals (Lee et al. 2015). Nonetheless, some studies of dolphin populations inhabiting areas of the Gulf of Mexico that were affected by the oil spill have indicated that elevated petroleum compounds contributed to increased numbers of dolphin mortalities (Schwacke et al. 2014; Venn-Watson et al. 2015). Pregnancy success rates of dolphins inhabiting the exposed area were also depressed (Lane et al. 2015). Poor reproductive success may have been caused by increased concentrations of genotoxic metals in these animals (Wise et al. 2018). Although chronic effects are uncertain, long-term acoustic monitoring in the Gulf of Mexico suggests local declines in marine mammal presence (e.g., sperm whale, beaked whales, *Kogia* spp.), possibly due to reduced reproductive success as a result of oil exposure (Frasier et al. 2020).

### *Sea Turtles*

The effects of oil on sea turtles depend on the extent of exposure to toxic components of oil. Exposure pathways for effects on sea turtles are similar to those of marine mammals: external coatings of oil (e.g., interaction with surface slicks when animals surface for air); inhalation of aerosols of particulate oil and hydrocarbons; and ingestion of contaminated prey (Shigenaka et al. 2003; Lee et al. 2015; NRDA 2016). Sea turtles are likely unable to detect oil during a spill (e.g., Vargo et al. 1986; Gramentz 1988; Milton et al. 2003). Loggerhead and Kemp's ridley turtles continued to forage in oil-exposed areas even after the DWH oil spill (Vander-Zanden et al. 2016; Reich et al. 2017).

French McCay (2009) suggested a combined probability of oil encounter and mortality once oiled of 5% for juvenile and adult sea turtles and 50% for hatchling sea turtles. This is based on a moderate to high short-term survival rate if oiling occurs as indicated by the literature (Vargo et al. 1986), but also takes into consideration that there are few data on the long-term effects of oil on reptiles. Hatchlings are especially vulnerable as they spend most of their time at the surface of the water, and their size and anatomy (e.g., weaker mobility) increases their susceptibility to passing through oil and suffocating as a result of exposure. Hatchlings may not be able to swim as well once oiled, thereby increasing their predation risk. French McCay (2009) acknowledged that the probability for oiling and dying of hatchlings ranges from 10 to 100%, but used 50% as a best estimate. Compared to hatchlings, juveniles and adult sea turtles spend less time at the surface of the water, which likely reduces their exposure to smaller oil slicks. The data on hatchlings is provided for context, as there is an absence of sea turtle hatchlings in Atlantic Canada waters. Sea turtles are especially susceptible to prolonged exposure to petroleum vapours as a consequence of their diving behaviour, which requires rapidly inhaling large volumes of air before diving and continually resurfacing (Milton et al. 2003).

Even if sea turtles avoid direct contact with oil slicks, they can be directly affected through ingestion of oil or contaminated prey. As turtles consume anything that is the same size as their preferred prey (e.g., jellyfish), ingestion of tar balls is an issue for turtles of all ages (e.g., Witherington 2002, 2012).

Ingested oil can be retained within a turtle's digestive tract for several days thereby increasing the likelihood of absorption of toxic compounds and the risk of gut impaction (Milton et al. 2003). Sea turtle exposure to oil has also been shown to cause histologic lesions, as well as damage to nasal and eyelid tissue, a reduction in lung diffusion capacity, and a decrease in oxygen consumption or digestion efficiency (Lutz et al. 1989; Bossart et al. 1995; Lutcavage et al. 1995; Camacho et al. 2013). Hall et al. (1983) observed seven live and three dead sea turtles following the Ixtoc 1 oil well blowout incident in 1979. Two of the carcasses had oil in the gut but no lesions; there was no evidence of aspirated oil in the lungs. However, hydrocarbon residues were found in liver, kidney, and muscle tissues of the three dead turtles; prolonged exposure to oil may have disrupted foraging behaviour and weakened the turtles.

Following the DWH oil spill, there was an increase in sea turtle strandings rates in the Gulf of Mexico (Beyer et al. 2016). Although on average, 240 sea turtles strand in the northern Gulf of Mexico each year, 1700 standings were reported between May 2010 and November 2012 (Beyer et al. 2016). More than one thousand turtles were collected, including at least 450 living but oiled turtles (McDonald et al. 2017; Stacy et al. 2017; NOAA 2018) that were cleaned and released back into the wild (NOAA 2018), and 600 dead turtles of which 18 were visibly oiled (NOAA 2018). Most (95%) of the live released turtles were loggerheads, and most (75%) of the dead turtles were Kemp's ridley turtles (NOAA 2018). It is likely that 100% of heavily oiled turtles died from the effects of oiling, and 30% of oceanic turtles that were not heavily oil succumbed to the effects from oil ingestion (Mitchelmore et al. 2017). In total, it was estimated that up to 7600 adult turtles and large juveniles and as many as 160,000 small juveniles were killed by the spill (NRDA 2016).

The most acute adverse effect on turtles from the DWH oil spill was coating by oil and becoming entrained in the oil slick; turtles stuck in the oil had decreased mobility, and suffered from exhaustion, dehydration, and overheating leading to death (NRDA 2016; Stacy et al. 2017). Stacy et al. (2017) reported that turtles exposed to the spill showed metabolic and osmoregulatory derangements, while Ylitalo et al. (2017) showed that oiled sea turtles had increased levels of PAH in their tissues. Reich et al. (2017) reported that 51.5% of Kemp's ridley turtles that were sampled in the Gulf of Mexico after the DWH oil spill showed isotopic evidence of oil exposure in their scutes. However, the long-term health effects of oil exposure on turtles in the Gulf of Mexico are unknown (Vaner Zanden et al. 2016). A total of 2360 non-oiled sea turtles stranded in Alabama, Louisiana, and Mississippi from 2010 through 2014 (Stacy 2015). Necropsies found that most of these turtles succumbed as bycatch in the fishery, not because of exposure to oil; however, general decline in nutritional condition was also apparent for stranded turtles since the oil spill (Stacy 2015).

It is assumed that any sea turtles occurring within the zone of influence of an accidental event have the potential to be exposed to oil and experience related health effects, as described above. As the sea turtles occurring in the RAA would be juveniles and adults, the potential for mortality from oil exposure would be lower than for hatchlings. Sea turtles would also experience a short-term reduction in habitat quality, during which they have the potential to ingest oil or oiled prey.

### *Effects of Dispersants on Marine Mammals and Sea Turtles*

In general, dispersed oil is predicted to reduce potential adverse environmental effects on marine mammals and sea turtles. Marine mammals are susceptible to floating oil because they need to surface at regular intervals to breathe. The use of dispersants may be beneficial for marine mammals within a spill area by reducing the exposure to floating oil on the sea surface. The dispersion of oil, however, may expose swimming or feeding marine mammals to the consumption of contaminated plankton, skin/fur contamination, and potentially the clogging of baleen (Lee et al. 2015). Hydrocarbons consumed by marine mammals through contaminated prey can be metabolized and excreted. Some hydrocarbons, however, may be stored in blubber and other fat deposits which may be released into circulation during periods of physiological stress (low prey availability, migration, lactation) and may be bioavailable and toxic to a fetus or newborns (Lee et al. 2015).

### Potential Effects of an SBM Spill on Marine Mammals and Sea Turtles

SBM is a heavy, dense fluid which sinks rapidly in the water column when released. SBM constituent selection is controlled by the OCSG so that low toxicity chemicals are used wherever practicable. Therefore, SBMs are of low toxicity, and environmental effects are mostly restricted to physical smothering effects on the sea floor (C-NLOPB 2011). Interaction between an SBM whole mud spill and marine mammals and sea turtles would be limited given the scale of effects in the water column and low toxicity of the material, resulting in a temporary reduction in habitat quality. Risk of physical injury would be limited to individuals in the immediate vicinity of the spill. A subsurface release of SBM at the wellsite would have no expected effects on sea turtles given the water depth.

## 15.6.3.2 Mitigation of Project-Related Environmental Effects

Spill prevention measures are the most effective way to mitigate against potential effects from accidental events. BHP's strategy for contingency planning and spill response is described in Section 15.5. Mitigation of potential accidental events is incorporated as part of the regulatory processes (e.g., Operations Authorization [OA], Approval to Drill a Well), project-specific safety and response plans (e.g., safety plan, oil spill response plan, EPP), and well design (e.g., BOP).

The Project will operate under safety and contingency plans, including an oil spill response plan (OSRP) that will be submitted to the C-NLOPB before the start of any drilling activity as part of the OA process. The OSRP will outline response methods and procedures, and response strategies based on severity of hydrocarbon spills. Potential responses considered in the event of an accidental release may include, but not be limited to, offshore containment and recovery, dispersants (surface application and/or subsurface injection), *in situ* burning, shoreline protection and clean-up, and oiled wildlife response. Further details on spill responses are provided in Section 15.5. A SIMA / NEBA will be conducted as part of the OA Process as well. These assessments will be used to qualitatively evaluate the risks and trade-offs of feasible and effective response options, when compared to no action. An overall spill response strategy will be selected for the Project based on the SIMA process. If identified as a response option, chemical dispersant application would not occur without authorization from C-NLOPB.

Mechanical measures and barriers that are implemented as part of well design, and drilling and monitoring procedures for prevention of blow-outs are described in Section 2.3.4. This includes use of steel casings, drilling fluids, and BOPs for controlling formation pressures. The BOP includes a series of rams that are designed to seal off the wellbore at the wellhead on the seafloor when required. Furthermore, the BOP and other pressure control equipment are tested regularly and recorded in accordance with the Drilling and Production Guidelines (C-NLOPB and CNSOPB 2017a) and to BHP standards.

BHP will develop a OWRP and, for incidents where wildlife is threatened, engage specialized expertise to implement the Plan, including the recovery and rehabilitation of wildlife species as needed (see Section 15.5.4 for BHP's oiled wildlife response approach).

Specific environmental effects monitoring and follow-up programs may be required in the unlikely event of a spill. These monitoring programs will be developed in consultation with applicable regulatory agencies.

### 15.6.3.3 Characterization of Residual Project-Related Environmental Effects

The residual effects of an oil spill, that is the effects remaining after the implementation of emergency response measures (see Section 15.5), should it occur, are assessed in the following sections.

#### Subsurface Blowout

A well blowout may result in a change in risk of mortality or physical injury and a change in habitat quality and use for marine mammals and sea turtles. The likelihood, magnitude, geographic extent and duration of potential effects of a subsurface blowout will depend in large part on the occurrence and distribution of marine mammals and sea turtles at the time of the blowout, as well as the duration and spatial extent of oil release (i.e., potential severity of effects will be dependent on the potential for exposure). Given that marine mammals and sea turtles are known or expected to occur throughout most, if not all of the RAA, the magnitude of effects may be higher for subsurface releases of larger scale and extended duration, as was observed during the DWH spill in the Gulf of Mexico (e.g., Takeshita et al. 2017). Marine mammals and sea turtles may be exposed to oil via a combination of pathways (inhalation, ingestion, aspiration, and adsorption). Marine mammals and sea turtles that are closer to the site of the blowout are most likely to be exposed to a more constant flow and higher concentrations of recently released oil, as compared to species that are more prevalent in the nearshore.

For the purposes of this assessment, a surface oil thickness of 10 μm is the threshold at which it is assumed that a change in risk of mortality or physical injury may occur for marine mammals and sea turtles. A 10 μm thick layer of oil on-water has been identified with sub-lethal effects to marine mammals and sea turtles (French et al. 1996; French McCay and Rowe 2004; French McCay 2009). Note that fresh oil at this thickness corresponds to a dark brown or metallic sheen. A surface oil thickness of 0.04 μm is used in this assessment as a conservative threshold for a change in habitat quality and use for marine mammals and sea turtles. For wildlife (e.g., seals) on or along the shore, an oil exposure index consisting of the length of shoreline oiled by a threshold for the potential ecological effects on shoreline fauna and flora of 100 g/m² (100 μm thick) was used.

Stochastic modelling results for unmitigated subsurface blowouts for both release sites, EL 1157 and EL 1158, demonstrated that the highest potential likelihood (>90%) to exceed thresholds of potential surface oil exposure primarily occurred to the east, up to 1,400 km from the release site due to prevailing winds and currents (Section 15.3.1).

Representative credible "worst-case" deterministic scenarios of a subsurface blowout at EL 1157 and EL 1158 are characterized by surface oil transported predominantly to the east and south. The proportion of oil leaving the model domain to the east (as weathered emulsifications and tar balls) ranged from 3-22%. The footprints of the representative "worst-case" scenarios were centered to the east of the release sites.

The area affected by surface oil thickness over the ecological threshold (10 μm) in the simulations ranged from 832,900 km² (modelled release: EL 1157, 4,052,506 bbl, 30 days) to 1,616,000 km² (EL 1157, 15,496,924 bbl, 120 days) (95th percentile) (Table 15.9).

The modelling results suggest that areas most likely to be affected by an unmitigated, subsurface, well blowout are Orphan Basin, Flemish Pass and the areas to the east. As a result, a blowout would have a greater potential to interact with marine mammals that inhabit these deeper waters including species like sperm whales, beaked whales, and delphinids. Fin whales also occur regularly in the Flemish Pass area. Harp and hooded seals are considered in the Project Area and adjacent deep-water basins. Sea turtles are expected to be rare in Orphan Basin, Flemish Pass and the areas to the east. It is possible that marine mammals and sea turtles that do occur in offshore areas where predicted concentrations of hydrocarbons occurs above the ecological threshold levels from an unmitigated subsurface blowout could experience adverse changes in habitat quality and use, health, and in extreme cases increases in injury and mortality levels. As reviewed above, while some marine mammals seem to avoid oil spills, other marine mammals have been observed swimming through, and feeding in, large slicks (see Helm et al. 2015; Wilkin et al. 2017). Sea turtles may be more susceptible to the effects of exposure to hydrocarbons than marine mammals because they do not respond with avoidance behaviour, exhibit indiscriminate feeding, and take large pre-dive inhalations (see Milton et al. 2003; Vander Zanden et al. 2016). The magnitude and extent of potential effects would be reduced with the application of spill response measures; therefore, the risk of adverse effects on secure and at-risk marine mammals and sea turtles would be reduced.

As detailed in Section 15.3, oil was predicted to strand on shorelines in several simulations. The length of shoreline affected by oil concentrations above the ecological threshold in the representative credible “worst-case” scenario simulations ranged from 1,194 km (release: 4,050,183 bbl, 30 days, EL 1158) to 1, 597 km (15,996,924 bbl, 120 days, EL 1157). The specific coastlines affected in the EL 1157 release were similar to those for the EL 1158 release but differed between those in the 30-day release and those in the 120-day release (Figures 4-99 and 4-104 in Appendix F). For the 30-day release the coastlines affected by oil concentrations above the ecological threshold included much of the east coast of the Avalon Peninsula and the island’s southern coast to the Burin Peninsula, and part of the coastline of Fortune Bay. In the 120- day release, the affected coastlines were the east coast of the Avalon Peninsula and the north coast of the island to the eastern half of Notre Dame Bay and the north coast of the Baie Verte Peninsula. However, the EL 1158 release did differ slightly from the EL 1157 release in that the former only affected the north coast as far west as the west coast of Trinity Bay. Shoreline oil would be highly weathered, patchy and discontinuous particularly at longer ranges from the release site. There is potential for harbour and grey seals that are known to haul-out in small numbers and use coastal areas, particularly on the Avalon and Burin peninsulas, to interact with oiled shoreline. As with surface oil, the potential effects would be reduced with mitigation measures, therefore the risk of adverse effects on shoreline and coastal marine mammals would be reduced. Small numbers of seals which may interact with hydrocarbons (albeit highly weathered oil that is patchy and discontinuous), could conceivably experience a change in mortality or injury or a change in health; however, it is probable that only a small proportion of local populations would be affected. The magnitude and extent of potential effects would be reduced with the application of spill response measures, therefore the risk of adverse effects to coastal marine mammals would be reduced.

As described in Section 6.3, there are nine marine mammal and two sea turtle Species at Risk that are known or expected to occur in the in the LAA and/or RAA. In the extremely unlikely event of a subsurface blowout to the marine environment, these species have the potential to be adversely affected, if the spill occurs when the Species at Risk is in the area. The likelihood, however, of a subsurface blowout occurring is extremely low. In an actual event, emergency response measures would likely reduce the magnitude, duration and geographic extent of the spill, and therefore reduce the potential impacts on marine mammals and sea turtles.

With spill prevention plans and response procedures in place, potential effects of a subsurface blowout on marine mammals and sea turtles are predicted to be adverse, medium in magnitude, medium to long-term in duration, within the RAA, a single event and reversible.

### Marine Diesel Spill

Depending on the location and extent of the batch diesel spill, it could directly and indirectly reduce the amount and quality of habitat available to marine mammals and sea turtles. If the vessel spill of diesel occurred in the nearshore area, there is the potential for shoreline to be affected. When diesel spills interact with the shoreline, it tends to penetrate porous sediments quickly and washes off quickly by waves and tidal flushing (NOAA 2016). These effects would be short-term in duration until the slick disperses and the diesel content in the area reaches background levels. A batch spill of diesel is therefore not expected to create permanent or irreversible changes to habitat quality and use. Likewise, there is limited potential for a batch spill of diesel to change the risk in mortality or physical injury for marine mammals and sea turtles.

The batch spill scenario release of 3,200 L marine diesel from a nearshore location (12 km east of St. John's) along a potential PSV route was predicted to result in silver or colorless sheens (<0.0001 mm) of oil floating on the water surface (Figure 4-106 in Appendix F) over a substantially smaller area than a well blowout scenario. Generally, marine diesel spill scenarios were predicted to be transported to the south and in some cases wrap around the Avalon Peninsula to the west, towards Saint Lawrence, Newfoundland (Figure 4-106 in Appendix F). At the end of the 30-day marine diesel batch spill simulations, 64-80% of the marine diesel was predicted to evaporated into the atmosphere, 12-23% degraded, 6-13% remained entrained in the water column, while 0.1% of the released volume was predicted to remain floating on the water surface. The ecological thresholds for oiling were not exceeded.

With spill prevention response procedures in place, potential effects of a batch spill on marine mammals and sea turtles are predicted to be adverse, low in magnitude, short-term in duration, within the LAA, a single event and reversible.

### SBM Spill from the MODU and the Marine Riser

There is potential for an SBM spill to result in a surface sheen, which in turn could potentially cause a change in habitat quality and use and possibly a change in the risk of mortality or physical injury for marine mammals and sea turtles present in the immediate area. If the wind and wave conditions were such that a sheen formed, it would be temporary and limited in size, such that only individuals in the immediate area of the spill would likely be affected. Furthermore, given the low surface oil thickness required to result in a sheen (0.04 μm), it is expected that effects would be minor and unlikely to result in marine mammal or sea turtle mortality or injury. Likewise, reduction in habitat quality and use would be temporary, reversible, and localized.

Potential effects of a drill mud spill on marine mammals and sea turtles are therefore predicted to be adverse, low in magnitude, within the LAA, short-term in duration, a single event, and reversible.

## Summary

Table 15.35 provides a summary of predicted residual environmental effects of accidental events on marine mammals and sea turtles.

**Table 15.35 Summary of Residual Project-Related Environmental Effects on Marine Mammals and Sea Turtles – Accidental Events**

| Residual Effect | Residual Environmental Effects Characterization | | | | | | |
|---|---|---|---|---|---|---|---|
| | Direction | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | Ecological and Socio-economic Context |
| **Change in Risk of Mortality or Physical Injury/Change in Habitat Quality and Use** | | | | | | | |
| Well Blowout Incident | A | M | RAA | MT-LT | S | R | D |
| Marine Diesel Spill | A | L | LAA | ST | S | R | D |
| SBM Spill | A | L | LAA | ST | S | R | D |

KEY:
N/A: Not Applicable

Direction:
P: Positive
A: Adverse

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"

Duration:
ST: Short-term
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

### 15.6.3.4 Determination of Significance

Based on consideration of the information presented above, the predicted residual adverse environmental effects from the accidental event scenarios on marine mammals and sea turtles is predicted to be not significant. This determination is made in consideration of the precautionary approach of the spill modelling (results show an unmitigated release), the use of mitigation measures to prevent and reduce effects from a spill, and the nature of the adverse effects as described in the literature summarized above. This conclusion is made with a high level of confidence for the diesel and SBM spill scenarios based on the low magnitude and geographic extent of likely effects. A medium level of confidence is assigned to the well blowout scenarios given the larger geographic extent of affected area as well as the potential for marine mammal species at risk to occur in the affected area.

## 15.6.4 Special Areas

Special areas within the RAA have been designated as protected or otherwise special due to their biological or ecological characteristics. Special areas may have associated provincial, federal or other regulatory mandates to protect ecological features, cultural or historical sites, or areas used for scientific research, education or recreation. These areas and their important characteristics may be vulnerable to an accidental event, as degradation of their conditions may affect their habitat quality.

The potential effects of accidental events on the biological VCs are discussed above in Sections 15.6.1 to 15.6.3 for marine fish and fish habitat, marine and migratory birds, and marine mammals and sea turtles, respectively, and are summarized in this section, as relevant. The potential environmental effects on special areas used in the assessment of effects of routine activities (Chapter 11) were:

- Change in habitat quality

A change in habitat quality in special areas is also relevant to the assessment of accidental events although the mechanisms or pathways of effects may be different. The extent of the potential effects on special areas and their defining features and processes will depend on how the spill trajectory and the VC overlap in both space and time. Potential effects on special areas, in the unlikely event of an accidental release of hydrocarbons, includes potential degradation of the integrity of the special area so that it is not capable of providing the same biological or ecological function for which it is designated. The special areas VC is therefore closely linked to other VCs considered in this assessment, particularly the biological VCs.

### 15.6.4.1 Project Pathways for Effects

Accidental spill scenarios have the potential to result in a change in habitat quality for special areas. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in both space and in time. The assessment is conservative (i.e., geographic and temporal overlap are assumed to occur, and modelling results assume no implementation of mitigation measures).

Special areas provide important habitat and may be comparatively more vulnerable to environmental effects, including effects from accidental events, than other areas. Adverse effects on special areas could degrade the ecological integrity of the special area so it is not capable of providing the same ecological function for which it was designated (e.g., protection of sensitive or commercially important species). Potential effects from routine Project activities are discussed in Sections 15.6.1 to 15.6.3 for marine fish and fish habitat, marine and migratory birds, and marine mammals and sea turtles, and are not repeated at length in this section.

### 15.6.4.2 Mitigation of Project-Related Environmental Effects

Spill prevention measures are the most effective way to mitigate against potential effects from accidental events. BHP’s strategy for contingency planning and spill response is described in Section 15.5. Mitigation of potential accidental events is governed by regulatory processes (e.g., Operations Authorization [OA], Approval to Drill a Well), project-specific safety and response plans (e.g., safety plan, oil spill response plan, EPP), and well design (e.g., BOP).

The Project will operate under safety and contingency plans, including an oil spill response plan (OSRP) that will be submitted to the C-NLOPB prior to commencement of drilling activity as part of the OA process. The OSRP will outline response methods, procedures, and strategies based on severity of spills. Potential responses considered in the event of an accidental release may include, but not be limited to, offshore containment and recovery, dispersants (surface application and / or subsurface injection), *in situ* burning, shoreline protection and clean-up, and oiled wildlife response. Further details on spill responses are provided in Section 15.5. A SIMA / NEBA will be conducted as part of the OA Process. These assessments are used to qualitatively evaluate the risks and trade-offs of feasible and effective response options, when compared to no action. An overall spill response strategy will be selected for the Project based on the SIMA process. If identified as a response option, chemical dispersant application would not occur without authorization from C-NLOPB.

Mechanical measures and barriers implemented as part of well design and drilling and monitoring procedures for prevention of blow-outs are described in Section 2.3.4. This includes steel casings, drilling fluids, and BOPs for control of formation pressures. The BOP includes a series of rams designed to seal the wellbore at the wellhead on the seafloor as required. Furthermore, the BOP and other pressure control equipment are tested regularly and recorded in accordance with the Drilling and Production Guidelines (C-NLOPB and CNSOPB 2017a) and BHP company standard procedures.

Specific environmental effects monitoring, and follow-up programs may be required in the unlikely event of a spill. These monitoring programs will be developed in consultation with applicable regulatory agencies.

### 15.6.4.3 Characterization of Residual Project-Related Environmental Effects

Accidental releases of oil or SBM have the potential to affect marine habitats in special areas. The overall implications are dependent on the nature, scale, and duration of a spill and the types of special areas that occur in affected areas. Hydrocarbon releases may result in changes to habitat quality through potential effects on water and sediment quality in special areas.

#### Subsurface Blowout

Given the potentially large amount of oil that could be associated with an unmitigated blowout event, and the possibility for a spill to extend to adjacent areas and resources, it represents the accidental event of greatest environmental concern. The extremely unlikely scenario of such a subsurface blowout has the potential to result in a change in habitat quality of special areas in the RAA. The magnitude, geographic extent and duration of potential effects of a blowout will depend on the nature of the spill and its trajectory and the spatial and temporal overlap with special areas.

As described in Section 15.3.2, deterministic oil spill modelling was conducted for the Project. It is important to note that resultant figures depict the cumulative footprint of all oil predicted to be within a region over the entire modelled duration. Therefore, the depicted footprints are much larger than the amount of oil that would be present in a region at any given time following the release of oil. This concept is illustrated in Figure 4-73 of Appendix F which portrays predicted surface oil thickness at five specific time steps or "snapshots" in time (days 2, 10, 50, 100, and 160) for the 95th percentile surface oil thickness case for the 120-day release at EL 1157. The nature of the predicted footprint is patchy and discontinuous as the released oil dispersed and thinned over time. Figure 4-74 of Appendix F portrays the cumulative footprint for the same simulation. The area covered is much larger, depicting the maximum surface oil thickness predicted to occur at each location over the entire modelled period. The remaining figures in Appendix F depict cumulative footprints as opposed to “snapshots” at any given time to provide conservative estimates of potentially affected areas.

For releases in EL 1157 and EL 1158, stochastic analyses (Section 15.3.1) indicated that the highest potential likelihood (>90%) for exceeding surface oil exposure and water column ecological thresholds occurred primarily to the east towards the Flemish Cap, up to 1,400 m from the release site (Section 15.3.2; see also Appendix F). Oil spill trajectories were similar across spill scenarios with larger spatial extents in the 120-day subsurface oil release scenarios (Figures 15-10, 15-11, 15-20, and 15-21) relative to the 30-day scenarios (Figures 15-5, 15-6, 15-15, and 15-16). Lower probabilities of surface oil and water column threshold exceedance occurred north and south of the release site and generally less than 25% of release potentially exceeded thresholds west of the Project Area (Section 15.3.1). The probability of shoreline oiling from release scenarios was generally low with maximum annual probabilities of 9% for 30-day scenarios and 20 to 21% for 120-day scenarios. Predicted annual minimum time to shoreline threshold exceedance was 7 days, occurring along southeastern Newfoundland (Figures 15-8 and 15-13). Oil potentially reaching shorelines would likely be highly weathered oil that was discontinuous and patchy.

Table 15.36 summarizes the predicted overlap of special areas in the RAA with the 95th percentile deterministic results as the worst case scenario for conservative ecological thresholds for surface oil thickness (0.01 mm), THCs (100 µg/L) and shoreline contact (100 g/m²) along with the primary reason for designation of the special area (e.g., marine fish and fish habitat, marine and migratory birds, and marine mammals and sea turtles). Results are presented for the modelled 30-day release (time required to implement a capping stack) and 120-day release (time required to drill a relief well) unmitigated oil spill scenarios. Detailed information and descriptions of the special areas are presented in Section 6.4.

**Table 15.36 Potential (95th Percentile) Unmitigated Subsurface Blowout "Credible Worst Case" Interactions with Special Areas in the RAA Based on Deterministic Modelling**

| Special Area | Predominant Reason for Designation | Surface Oil | | Water Column THC | | Shoreline Oil Contact | |
|---|---|---|---|---|---|---|---|
| | | Spill Release Duration (days) | | | | | |
| | | 30 | 120 | 30 | 120 | 30 | 120 |
| **Marine Protected Areas (MPAs)** | | | | | | | |
| Eastport – Round Island | Marine fish and fish habitat | | | | | | |
| Eastport – Duck Islands | | | | | | | |
| Gilbert Bay | | | | | | | |
| **Candidate National Marine Conservation Areas (NMCAs)** | | | | | | | |
| South Burin / St. Pierre Bank | Marine and migratory birds<br>Marine mammals and sea turtles | X | X | | | | |
| West Avalon / Green Bank | | X | X | | | | X |
| East Avalon / Grand Banks | | X | X | | | | X |
| **Proposed Critical Habitat** | | | | | | | |
| Northern Wolffish | Marine fish and fish habitat | X | X | X | X | | |
| Spotted Wolffish | | X | X | X | X | | |
| **Marine Refuges** | | | | | | | |
| Northeast Newfoundland Slope Closure | Marine fish and fish habitat | X | X | X | X | | |
| Gooseberry Island Lobster Area Closure | | | X | | | | |
| Glovers Harbour Lobster Area Closure | | | | | | | |
| Mouse Island Lobster Area Closure | | | | | | | X |
| Gander Bay Lobster Area Closure | | | | | | | |
| Funk Island Deep Closure | | | | | | | |
| Hawke Channel Closure | | | X | | | | X |
| Hopedale Saddle Closure | | | X | | | | |
| Division 3O Coral Closure | Marine fish and fish habitat | | | | | | |

**Table 15.36 Potential (95th Percentile) Unmitigated Subsurface Blowout "Credible Worst Case" Interactions with Special Areas in the RAA Based on Deterministic Modelling**

| Special Area | Predominant Reason for Designation | Surface Oil | | Water Column THC | | Shoreline Oil Contact | |
|---|---|---|---|---|---|---|---|
| | | Spill Release Duration (days) | | | | | |
| | | 30 | 120 | 30 | 120 | 30 | 120 |
| | Marine mammals and sea turtles | | | | | | |
| **Migratory Bird Sanctuaries (MBSs)** | | | | | | | |
| Terra Nova | Marine and migratory birds | | | | | | |
| Shepherd Island | | | | | | | |
| Île aux Canes | | | | | | | |
| **Significant Benthic Areas (SiBA)** | | | | | | | |
| Sea Pens | Marine fish and fish habitat | X | X | X | X | | |
| Sponges | | X | X | | | | |
| Large Gorgonian Corals | | X | X | X | X | | |
| Small Gorgonian Corals | | X | X | | | | |
| **Ecologically and Biologically Significant Areas (EBSAs)** | | | | | | | |
| Haddock Channel Sponges | Marine fish and fish habitat | | X | | | | |
| Gilbert Bay | Marine fish and fish habitat<br>Marine and migratory birds | | | | | | |
| Grey Islands | | | X | | | | |
| Northeast Slope | Marine fish and fish habitat<br>Marine mammals and sea turtles | X | X | X | X | | |
| Lilly Canyon-Carson Canyon | | X | X | | | | |
| Laurentian Channel | | | X | | | | |
| Eastern Avalon | Marine and migratory birds<br>Marine mammals and sea turtles | X | X | | | | X |
| Southwest Slope | | | X | | | | |
| Placentia Bay | | X | | | | | |

## Table 15.36 Potential (95th Percentile) Unmitigated Subsurface Blowout "Credible Worst Case" Interactions with Special Areas in the RAA Based on Deterministic Modelling

| Special Area | Predominant Reason for Designation | Surface Oil | | Water Column THC | | Shoreline Oil Contact | |
|---|---|---|---|---|---|---|---|
| | | Spill Release Duration (days) | | | | | |
| | | 30 | 120 | 30 | 120 | 30 | 120 |
| Bonavista Bay | Marine fish and fish habitat<br>Marine and migratory birds<br>Marine mammals and sea turtles | | X | | | | X |
| Smith Sound | | | X | | | | X |
| Baccalieu Island | | | X | | | | X |
| St. Mary's Bay | | X | | | | | X |
| Virgin Rocks | | X | X | | | | |
| Southeast Shoal | | X | X | | | | |
| Fogo Shelf | | | X | | | | X |
| Hamilton Inlet | | | | | | | |
| Labrador Marginal Trough | | | X | | | | |
| Labrador Slope | | X | X | | | | |
| Notre Dame Channel | | | X | | | | |
| Orphan Spur | | X | X | | | | |
| **Canadian Fisheries Closures** | | | | | | | |
| Eastport Peninsula Lobster Management Area | Marine fish and fish habitat | | X | | | | X |
| Crab Fishing Area 5A | | | X | | | | X |
| Crab Fishing Area 6A | | | X | | | | X |
| Crab Fishing Area 6B | | | X | | | | |
| Crab Fishing Area – 8BX | | X | X | | | | |
| Crab Fishing Area – 9A | | X | X | | | | |
| Near Shore | | X | X | | | | |

**Table 15.36 Potential (95th Percentile) Unmitigated Subsurface Blowout "Credible Worst Case" Interactions with Special Areas in the RAA Based on Deterministic Modelling**

| Special Area | Predominant Reason for Designation | Surface Oil | | Water Column THC | | Shoreline Oil Contact | |
|---|---|---|---|---|---|---|---|
| | | Spill Release Duration (days) | | | | | |
| | | 30 | 120 | 30 | 120 | 30 | 120 |
| **National Parks and National Historic Sites (NHSs)** | | | | | | | |
| Cape Spear NHS | Cultural history | | X | | | | |
| Signal Hill NHS | | | X | | | | |
| Ryan Premises NHS | | | | | | | X |
| Caste Hill NHS | | X | | | | | |
| Terra Nova National Park | Coastal natural history | | X | | | | X |
| **Provincial Ecological Reserves** | | | | | | | |
| Baccalieu Island | Marine and migratory birds | | X | | | | X |
| Cape St. Mary's | | X | | | | | |
| Funk Island | | | | | | | |
| Hare Bay Islands | | | | | | | |
| Lawn Bay | | | | | | | |
| Witless Bay | | X | X | | | | |
| Mistaken Point | | | | | | | X |
| **Vulnerable Marine Ecosystems** | | | | | | | |
| Sponge | Marine fish and fish habitat | X | X | X | X | | |
| Sea Pen | | X | X | X | X | | |
| Large Gorgonian Coral | | X | X | X | X | | |

**Table 15.36 Potential (95th Percentile) Unmitigated Subsurface Blowout "Credible Worst Case" Interactions with Special Areas in the RAA Based on Deterministic Modelling**

| Special Area | Predominant Reason for Designation | Surface Oil | | Water Column THC | | Shoreline Oil Contact | |
|---|---|---|---|---|---|---|---|
| | | Spill Release Duration (days) | | | | | |
| | | 30 | 120 | 30 | 120 | 30 | 120 |
| **NAFO Fisheries Closures** | | | | | | | |
| Tail of the Bank (1) | Marine fish and fish habitat | X | X | | | | |
| Flemish Pass/Eastern Canyon (2) | | X | X | X | X | | |
| Beothuk Knoll (3) | | X | X | | | | |
| Eastern Flemish Cap (4) | | X | X | X | X | | |
| Northeast Flemish Cap (5) | | X | X | X | X | | |
| Sackville Spur (6) | | X | X | X | X | | |
| Northern Flemish Cap (7) | | X | X | X | X | | |
| Northern Flemish Cap (8) | | X | X | | X | | |
| Northern Flemish Cap (9) | | X | X | X | X | | |
| Northwest Flemish Cap (10) | | X | X | X | X | | |
| Northwest Flemish Cap (11) | | X | X | X | X | | |
| Northwest Flemish Cap (12) | | X | X | X | X | | |
| Beothuk Knoll (13) | | X | X | | | | |
| 30 Coral Area Closure | | | X | | | | |
| Fogo Seamounts (1) | | | X | | | | |
| Newfoundland Seamounts | | X | X | | | | |
| Orphan Knoll | | X | X | X | X | | |

### Table 15.36 Potential (95th Percentile) Unmitigated Subsurface Blowout "Credible Worst Case" Interactions with Special Areas in the RAA Based on Deterministic Modelling

| Special Area | Predominant Reason for Designation | Surface Oil | | Water Column THC | | Shoreline Oil Contact | |
|---|---|---|---|---|---|---|---|
| | | Spill Release Duration (days) | | | | | |
| | | 30 | 120 | 30 | 120 | 30 | 120 |
| **UN Convention on Biological Diversity (CBD) EBSAs** | | | | | | | |
| Orphan Knoll | Marine fish and fish habitat | X | X | X | X | | |
| Slopes of the Flemish Cap and Grand Bank | | X | X | X | X | | |
| Seabird Foraging Zone in the Southern Labrador Sea | Marine and migratory birds | X | X | X | X | | |
| Southeast Shoal and Adjacent Areas on the Tail of the Grand Bank | Marine fish and fish habitat<br>Marine and migratory birds<br>Marine mammals and sea turtles | X | X | | | | |
| **UNESCO World Heritage Sites** | | | | | | | |
| Mistaken Point | Natural history | X | | | | | |
| **Important Bird Areas** | | | | | | | |
| Cape St. Mary's | Marine and migratory birds | X | | | | | X |
| Witless Bay Islands | | X | X | | | | X |
| Baccalieu Island | | | X | | | | X |
| Funk Island | | | X | | | | X |
| Fischot Islands | | | | | | | |
| Northern Groais Island | | | | | | | |
| Bell Island South Coast | | | | | | | |
| Wadham Islands and adjacent Marine Area | | | X | | | | X |
| Cape Pine and St. Shotts Barren | | X | | | | | X |
| Terra Nova National Park | | | X | | | | X |
| Grates Point | | | X | | | | X |
| Cape St. Francis | | | X | | | | X |

**Table 15.36 Potential (95th Percentile) Unmitigated Subsurface Blowout "Credible Worst Case" Interactions with Special Areas in the RAA Based on Deterministic Modelling**

| Special Area | Predominant Reason for Designation | Surface Oil | | Water Column THC | | Shoreline Oil Contact | |
|---|---|---|---|---|---|---|---|
| | | Spill Release Duration (days) | | | | | |
| | | 30 | 120 | 30 | 120 | 30 | 120 |
| Quidi Vidi Lake | Marine and migratory birds | | X | | | | X |
| Mistaken Point | | X | X | | | | X |
| Cape Freels Coastline and Cabot Island | | | X | | | | X |
| Placentia Bay | | X | | | | | |
| Corbin Island | | X | | | | | |
| Middle Lawn Island | | | | | | | |
| St. Peter Bay | | | | | | | |

Note: X indicates the predicted overlap of special areas in the RAA with the 95th percentile deterministic results as the credible worst-case scenario for conservative ecological thresholds for surface oil thickness (0.01 mm), THCs (100 µg/L), and shoreline contact (100 g/m²)

In addition, some of the special areas, which overlap based on surface oil, in-water hydrocarbon or shoreline exposure, may be designated for seabed features (i.e., corals and sponges) rather than special habitats in the water column, at sea surface or on the shoreline. As the modelling showed that oil transported to bottom sediment was not a major fate pathway for the completely unmitigated subsurface blowouts with <0.01% predicted to settle on sediments, sediment concentration is not included in Table 15.36.

Deterministic modelling results for an unmitigated subsurface blowout predicted surface oiling on waters that overlap with special areas where hydrocarbons at the surface exceed the conservative ecological thresholds for surface oil thickness (0.01 mm) under a credible worst-case scenery. In the selected 95th percentile scenario for surface oil exposure releases, surface oil was predicted to be thickest closest to the release location. Maximum thickness corresponded with a visual appearance of black oil within a few kilometres of the release site with the majority of footprints predicted to have a maximum thickness closer in appearance to dark brown to dull brown sheens (0.01 to 0.1 mm). Based on modelling, surface oil was predicted to potentially exceed the ecological threshold (0.01 mm) in special areas identified for the presence of marine and migratory birds (Table 15.36). These include Canadian EBSAs, Provincial ecological reserves, UNCBD EBSAs, and IBAs and candidate NMCAs. While oil on the surface, as predicted by spill modelling, will not reach Quidi Vidi Lake itself, oil could overlap with a portion of the Quidi Vidi Lake IBA, which includes coastal areas. The effects of an unmitigated subsurface blowout on marine and migratory birds were assessed in Section 15.6.2.4, which concluded that these effects would be significant, but unlikely. With spill prevention plans and response procedures in place, residual effects on marine and migratory birds are predicted to be adverse, potentially high in magnitude, short- to medium-term in duration, within the RAA, a single event and reversible in nature.

Modelling also predicted that surface oil in exceedance of the ecological threshold (0.01 mm) could reach special areas identified for the presence of marine mammals and sea turtles (Table 15.36). These include EBSAs, the Southeast Shoal and Adjacent Areas on the Tail of the Grand Bank CBD EBSA and candidate NMCAs. The effects of an unmitigated subsurface blowout on marine mammals and sea turtles were assessed in Section 15.6.3, which concluded that these effects would be not significant. With spill prevention plans and response procedures in place, residual effects on marine mammals and sea turtles are predicted to be adverse, medium in magnitude, medium to long-term in duration, within the RAA, a single event and reversible.

The 95th percentile scenario for in-water exposure indicates that areas reaching or exceeding the ecological threshold, which could change water quality and therefore could affect fish habitat availability and quality in special areas include Northeast Newfoundland Slope Closure Marine Refuge, SiBAs, Northeast Slope EBSA, Vulnerable Marine Ecosystems, Northwest Atlantic Fisheries Organization (NAFO) Closures to protect benthic habitat, Slopes of the Flemish Cap and Grand Bank CBD EBSA and proposed critical habitat for northern and spotted wolffish (Table 15.36). These special areas have been identified primarily for the presence of sensitive benthic habitats and to a lesser extent for the presence of fish species. With spill prevention plans and response procedures in place, residual effects on marine fish and fish habitat are predicted to be adverse, moderate to high magnitude, beyond the RAA, medium to long-term duration, a single event, and reversible. The effects of an unmitigated subsurface blowout on marine fish and fish habitat and marine mammals and sea turtles were assessed in Sections 15.6.1 and 15.6.3, which both concluded that effects would be not significant.

The 95th percentile scenario for in-water THC exposure indicates that areas reaching or exceeding the ecological threshold (100 µg/L) could change water quality and therefore could affect marine mammal and sea turtle habitat availability and quality in the Northeast Slope EBSA. This special area is identified for the presence of concentrations of cetaceans. The effects of a subsurface blowout on marine mammals and sea turtles were assessed in Section 15.6.3, which concluded that residual effects on these species would be not significant.

The 95th percentile deterministic modelling for shoreline contact predicted no hydrocarbons above ecological threshold (100 g/m²) would reach the shoreline (including special areas) within the 30-day unmitigated scenario (Table 15.9). For the 120-day scenario, less than 0.1% of the total oil released making contact with coastal areas from the Baie Verte Peninsula to southwest coast of Newfoundland. Given the time for oil to make contact, it would be highly weathered, patchy, and discontinuous. Any oil reaching the shoreline would be highly weathered (i.e., lighter fractions would have evaporated, dissolved, and degraded thereby reducing the toxicity of the residual oil).

The modelling indicates a very low potential for oil exceeding ecological threshold to reach special areas on the coast of NL, which have been identified for the presence of marine and migratory birds. These special areas include Canadian EBSAs, provincial ecological reserves and IBAs and candidate NMCAs (Table 15.36). The effects of an unmitigated subsurface blowout on marine and migratory birds are described in Section 15.6.2, which concluded that effects would be significant but unlikely.

Special areas identified and / or protected for fish or marine mammals and sea turtles could be affected by oil contacting shorelines. These include marine refuges, EBSAs, fisheries closure areas and candidate NMCAs (Table 15.36). The effects of an unmitigated subsurface blowout on marine fish and fish habitat and marine mammals and sea turtles were assessed in Sections 15.6.1 and 15.6.3, which both concluded that effects would be not significant.

In summary, with spill prevention plans and response procedures in place, potential effects of a subsurface blowout on habitat quality in special areas identified for ecological and biological characteristics are predicted to be adverse, medium to high in magnitude within the RAA, short-term to long-term in duration, a single event and reversible, depending on the types of special areas affected.

### Marine Diesel Spill

Modelling results of a 3,200 L release of marine diesel from a PSV predicted silver or colourless sheens (<0.0001 mm) of oil floating on the surface in a much smaller area than for subsurface blowouts. Stochastic modelling showed that no areas, and thus no special areas, would be exposed to surface oil (Figure 4-62 in Appendix F) or shoreline (Figure 4-68 in Appendix F) concentrations above ecological thresholds from such a diesel spill. In addition, predicted concentrations of dissolved or total hydrocarbons in the water column did not register above recordable threshold levels. Thus, a marine diesel spill is not applicable to special areas for this Project.

### SBM Spill from the MODU and the Marine Riser

SBM modelling was not conducted specifically for BHP's exploration Project. As this Project is in the general vicinity of CNOOC ELs, conclusions from SBM modelling conducted for CNOOC's Flemish Pass

Exploration Drilling Project (2018-2028) (described in Section 15.6.1) were used to understand the potential effects of an SBM release from this Project. The results of modelling for the CNOOC Project suggest that if SBM were to be released within BHP ELs, there is the potential for measurable seabed deposition exceeding the ecological threshold (1.5 mm to 6.5 mm PNET) to extend to between 1,800 m² and 3,600 m² from the spill site depending on location and season. However, the predicted footprint for the BHP Project is anticipated to be smaller based on increased water depth and stronger currents in BHP ELs. Section 15.6.1 indicates that potential effects on fish and fish habitat could occur within a few kilometres from the deposition site. Portions of a marine refuge, SiBAs, an EBSA, proposed critical habitat and a CBD EBSA overlap the Project Area (Table 15.36) and thus could potentially be exposed to released drilling muds from such a spill. These special areas have been identified and / or protected due to the presence of high densities or corals, sponges or sea pens and due to the presence of fish species, including species at risk. The footprint is expected to be less than Flemish pass because of increased water depth and stronger currents. The effects of an SBM spill on fish and fish habitat was assessed in Section 15.6.1, which concluded that residual effects would be not significant.

In summary, with spill prevention plans and response procedures in place, potential effects of an SBM spill on habitat quality in special areas identified for ecological and biological characteristics are predicted to be adverse, low in magnitude, within the LAA, short-term to long-term in duration, a single event and reversible.

### Summary

Table 15.37 provides a summary of predicted residual environmental effects of credible worst-case accidental event scenarios on habitat quality in special areas. This summary for special areas is based on the determinations for the biological VCs depending on the types of special areas that may be affected. Subsurface blowouts could potentially affect habitat quality in special areas identified for marine fish and fish habitat, marine and migratory birds, and marine mammals and sea turtles. Conclusions regarding the effects of an SBM spill on habitat quality in special areas is based on residual effects on marine fish and fish habitat only as no special areas identified for marine and migratory birds or marine mammals and sea turtles overlap with the Project Area (i.e., zone of influence for an SBM spill).

**Table 15.37 Summary of Residual Project-Related Environmental Effects on Special Areas – Accidental Events**

| Residual Effect | Residual Environmental Effects Characterization | | | | | | |
|---|---|---|---|---|---|---|---|
| | Direction | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | Ecological and Socio-economic Context |
| **Change in Habitat Quality and Use** | | | | | | | |
| Well Blowout Incident | A | M-H | RAA | ST-MT | S | R | D |
| Marine Diesel Spill | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| SBM Spill | A | L | PA | ST-LT | S | R | D |

**Table 15.37 Summary of Residual Project-Related Environmental Effects on Special Areas – Accidental Events**

| Residual Effect | Residual Environmental Effects Characterization | | | | | | |
|---|---|---|---|---|---|---|---|
| | Direction | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | Ecological and Socio-economic Context |

KEY:
N/A: Not Applicable

Direction:
P: Positive
A: Adverse

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"

Duration:
ST: Short-term
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

### 15.6.4.4 Determination of Significance

It is predicted that accidental events associated with the Project will not result in significant residual adverse effects on habitat quality in special areas. For the purposes of this effects assessment, a significant adverse residual effect on special areas is defined as a Project-related environmental effect that:

- Alters the valued habitat physically, chemically or biologically, in quality or extent, to such a degree that there is a decline in abundance lasting more than one generation of key species (for which the special area was designated) or a change in community structure, beyond which natural recruitment (reproduction and immigration from unaffected areas) would not sustain the population or community in the special area and would not return to its original level within one generation; or
- Results in permanent and irreversible loss of critical habitat (if present) as defined in a recovery plan or an action strategy.

Residual adverse effects from accidental events scenarios on special areas are predicted to be not significant. This determination considers potential adverse effects as described above, modelled spatial extents of predicted effects, the conservative nature of the spill modelling and assumptions, and the use of mitigation measures to prevent and reduce effects from a spill. Although hydrocarbon spills could result in adverse effects on special areas, these residual effects would not be permanent or result in a change in habitat that would not be reversible at the population level for marine fish and fish habitat, marine and migratory birds and marine mammals and sea turtles.

Significance determinations are made with a high level of confidence for SBM spill scenarios in consideration of the low magnitude and geographic extent of likely effects and the types of special areas present. While modelling for a marine diesel spill and subsurface blowout incidents are based upon credible worst-case scenarios, a medium level of confidence is assigned given uncertainties (e.g., volume, duration, location, time of year) of an actual event and overlap with special areas. Accidental events are unlikely to occur, and spill prevention techniques and response strategies will be incorporated into the design and operations of Project activities, which will help to reduce effects that occur.

## 15.6.5 Commercial Fisheries and Other Ocean Uses

As described in Section 7.2, there has been little commercial fish harvesting recorded within the Project Area and less within the two BHP ELs, in recent history. This is, in part, because of the current ban on bottom-gear harvesting in the Northeast Newfoundland Slope Refuge which occupies much of the Project Area and the ELs (Figure 7.8).

The fisheries that do take place in adjacent waters are primarily for demersal species, harvested by both domestic Canadian enterprises (mainly within the Exclusive Economic Zone [EEZ], Figures 7-7 and 7-8) and by foreign vessels operating in the NRA (Figure 7-17). Harvesting locations in relation to the RAA, which encompasses the area of potential effects from accidental events for this EIS, are also indicated in the maps in Section 7.2. As these maps show, beyond the continental shelf, there has been little or no recorded fishing within a large portion of the RAA.

The RAA fisheries on and near the Grand Banks, the Northeast Newfoundland Shelf, and the Labrador Shelf are diverse, widespread, and intensive in many locations. The key species in most areas are groundfish (harvested mainly with bottom trawls and gillnets) and shellfish – principally snow crab (bottom pots), northern shrimp (bottom trawls), and deep-sea clams (dredges). Adjacent to the shelf margins large pelagic species such as swordfish and sharks are harvested (surface longlines). Near the shore, in coastal waters and bays, several smaller pelagic species are harvested including capelin, herring, and mackerel (seines), as are lobster (bottom pots). Seal harvesting takes place near coastal areas at “the Front” (Figure 7-47). Several aquaculture operations are also associated with RAA shorelines (Section 7.2.5). Recreational fisheries take place in the region, primarily near the coasts. Most domestic effort is focused spring to autumn, while international harvesting is more evenly distributed through all months, in waters to the southeast of the Project Area.

The RAA is also the location of many other human activities, described in Section 7.3. International and Canada-bound marine traffic makes up much of the other human activity throughout the RAA, operating year-round. Other petroleum industry operations (exploration and production-related) occur in the region, as do fisheries research and other types of studies, military exercises, and marine tourism. Submarine infrastructure and artifacts, including petroleum industry equipment, communications cables, shipwrecks, and UXO, are also present within RAA.

### 15.6.5.1 Project Pathways for Effects

Accidental releases or spills of hydrocarbons (crude oil or marine diesel fuel) or synthetic fluids (SBMs) have a potential to impact the availability of commercial fisheries resources by affecting the health of commercial fish or their habitat, by making preferred fishing grounds inaccessible, by damaging or fouling fishing gear or other equipment, or through negative effects on product markets (i.e., on sales). Other ocean uses could also be adversely affected by the closure of marine areas because of hydrocarbon slicks or clean-up operations. Closures might require marine operators to divert around an affected area, or to delay or relocate other activities and uses. Science studies might be similarly affected.

For this VC, the severity of effects would depend largely on the geographic extent of the spill and its duration; specifically, the extent to which the spilled hydrocarbons overlap with fishing and other activities in location and time. The assessment that follows is deliberately conservative since it assumes both a geographic and temporal overlap with important activities. In addition, the modelling results presented (Section 15.3 and Appendix F) assume that no mitigation measures have been implemented, which maximizes both the extent and the duration that hydrocarbons would be present.

### Potential Effects of an Oil Spill on Commercial Fisheries and Other Ocean Uses

Although the BHP ELs do not overlap areas where high levels of commercial fish harvesting are likely to occur, in some circumstances spilled hydrocarbons could reach beyond the ELs and the Project Area. Section 15.3. presents modelled scenarios for accidental releases that might occur during a drilling project, ranging from a diesel batch spill from a PSV along the traffic route, to crude oil blowouts lasting 30 days (blowout, then capped) or 120 days (blowout, relief well completed).

As described in Section 15.3, under the scenarios modelled and assuming no mitigation, hydrocarbons could reach areas on the continental shelf and margin, including the Sackville Spur, the Flemish Cap, and parts of the Grand Banks where domestic and/or foreign harvesting activities are concentrated. In some circumstances, hydrocarbons might reach coastal locations, potentially interacting with nearshore fisheries, aquaculture facilities, and other marine uses that occur there.

#### *Biological Effects on Commercial Fish Species*

Section 15.6.1.1 discusses potential pathways for effects on marine fish and their habitat from accidental spills, including from clean-up procedures, such as the use of dispersants. As described in that section, hydrocarbon exposure can result in increased mortality or physical injury, changes to fish habitat availability, quality, and use through potential effects on water and sediment quality and biogenic habitats. However, Section 15.6.1.4 concludes that associated residual effects on fish and fish habitat resulting from an accidental oil spill and spill effects mitigation, will be not significant. Consequently, this section focuses more specifically on potential effects on fishing opportunities and the implications for economic returns from harvesting, including lost catch, increased expenses, and price impacts.

#### *Loss of Access to Fishing Areas*

Depending on the geographic extent and condition of the spilled oil and the type of fishery targeted, closures may be implemented (by regulation or voluntarily) to prevent gear from being fouled, to prevent tainted products from entering the marketplace, and/or to prevent interference with cleanup operations. Fishery closures, and potentially closures for other uses, are usually established for areas where there is a visible sheen on the ocean surface or where surface oil is predicted to occur based on trajectory modelling. A visible sheen occurs if there is a surface oil thickness of 0.04 μm or more. Areas where there are detectable levels of subsurface hydrocarbons might also be closed to commercial fishing to avoid harvesting tainted fish (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011). Even benthic species (groundfish, shellfish) not affected by surface hydrocarbons could be harmed if catches were hauled through oily waters. Seal harvesting and recreational fishing might be similarly restricted, if timing overlaps in areas nearer shore, until sufficiently cleared of hydrocarbons.

Closures typically remain in place until the area is free of oil and/or surface sheen and there is low risk of future exposure based on the modelling. Commercial species from these areas might also be tested for the presence of hydrocarbons using chemical analysis and sensory sampling (smell and taste tests) for oil tainting before area are judged to be safe for harvesting (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011).

If closed areas are located on or near commercial fishing grounds and are present during usual fishing seasons, some level of economic impact is likely because access to the resource would be affected. Depending on times and locations, this might result in the loss of a fishing season for a species, or increase costs (fuel and time) if harvesters need to divert around a closed area to reach other fishing grounds. While closures might interfere with the normal pattern of fish harvesting, they would help to prevent the fouling of fishing gear and boats and to lessen concerns about tainted product reaching buyers and consumers (discussed below).

Marine research could be compromised because of the closure of planned survey areas. Other marine uses, such as transportation, tourism, petroleum exploration, access to subsurface infrastructure, and military training exercises, could also be affected if areas are closed, requiring the use of alternative locations, changing transit routes / detours, or delaying infrastructure operations.

*Damaging or Fouling of Gear, Ships or Marine Infrastructure*

Surface oil can cause physical fouling (contamination) of fishing gear and marine shipping (including fishing boats) that passes through an affected area. In some cases, fouling of gear can result in oil being transferred to the fish (IPIECA 1997; ITOPF 2011a). If a spill reaches shorelines, aquaculture, heritage structures and artifacts, and other shore associated infrastructure and uses (docks and wharfs) might also be affected. Fouling or contamination could result in lost opportunities and associated loss of income, and/or increased expenses (ITOPF 2011b). For instance, if a swordfish longline were to be affected, harvesting time would be lost and expense would be incurred while cleaning or replacing the gear.

*Effects on Marketability (Market Value) of Resources*

If a commercial species was found to be tainted because of the ingestion or absorption of hydrocarbons, the product could not be sold. This would have an immediate and potentially longer-term economic impact on affected harvesters, resulting a loss of income from being unable to sell the tainted catch.

ITOPF (2011a) notes that in addition to the mobility of the species, other factors that influence tainting include “the type of oil, the species affected, the extent and duration of exposure, the hydrographical conditions and the water temperature. Tainting of living tissue is reversible but, whereas the uptake of oil taint is frequently rapid (minutes or hours), the depuration process, whereby contaminants are metabolized and eliminated from the organism, is much slower (weeks).”

In addition to lost sales because of actual tainting, it is possible that buyer perceptions might harm the marketability of fish and affect consumer behaviour, because of a fear that products from a large area might be unfit, even if not affected, thereby widening and/or prolonging effects on fishing incomes (Yender et al 2002; IPIECA-IOGP 2015). After the Gulf of Mexico DWH spill, for instance, consumer confidence in the quality of seafood remained depressed even after government testing indicated that products were safe and untainted (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011). These types of effects are difficult to predict and may only be measured after an event occurs.

### Potential Effects of an SBM Spill on Commercial Fisheries and Other Ocean Uses

If a spill of SBMs occurred (e.g., from the riser or the MODU), the material would sink rapidly to the bottom, and effects on the sea surface would be minimal. Such a spill would occur within the Project Safety Zone where fish harvesting and other vessels are not allowed; consequently, an SBM spill would not reduce access to usual fishing grounds or areas where other marine activities occur, and would not result in the fouling of gear or other equipment.

Studies have shown little or no risk of SBMs bioaccumulating in harmful concentrations in the tissues of benthic animals or of being transferred through marine food webs to fishery species (Neff et al. 2000; CNSOPB 2019). Section 15.6.1.3 discusses and assesses the potential effects of SBMs on fish and their habitat, finding biological effects to be not significant, noting that “SBMs biodegrade rapidly and the acute toxicity of SBMs is considered relatively low and below environmental guidelines. SBM spills are therefore predicted to result in adverse effects that are low, temporary and reversible”.

### 15.6.5.2 Mitigation of Project-Related Environmental Effects

The primary means for reducing the likelihood of effects on all VCs that might result from an accidental event is prevention. Sections 2.9 and 15.1 describe BHP’s safety culture, its approach to risk management, and information about well control and blowout prevention measures that will be in place throughout the Project (Section 15.1). If an accident were to occur, BHP’s contingency planning and emergency response measures would be implemented as appropriate (Section 15.5). BHP’s SIMA will evaluate the risks and benefits of each available response option to guide the application of specific mitigations during an actual event.

In addition to the measures described in Section 15.5 and 15.6.1.2 (for Marine Fish and Fish Habitat) other mitigation measures would be implemented that are more specific to this VC:

- Implementation of a Fisheries Communication Plan, which would include procedures for informing fishers of an accidental event, appropriate responses, and the locations of closed areas. Emphasis would be on timely communication, thereby providing fishers with the opportunity to haul gear from affected areas, reducing the potential for gear fouling or bringing tainted fish to the marketplace.
- Communications to other ocean users through the media, direct industry-to-industry contacts, and the issuance of Notices to Fish Harvesters, NAVWARNS, and NOTMARs, which would include the locations of affected and/or restricted areas.
- 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.

Specific environmental effects monitoring and follow-up programs may be required in the unlikely event of a spill. These monitoring programs will be developed in consultation with applicable regulatory agencies, Indigenous communities, and fisheries stakeholder, as applicable.

### 15.6.5.3 Characterization of Residual Project-Related Environmental Effects

For each of the hydrocarbon spill scenarios considered below, the following conservative socio-economic thresholds are used to identify areas potentially affected by a spill for this VC, as discussed in Section 15.3 (and Table 15.4).

- For surface oil: a surface average thickness > 0.04 µm (.00004 mm)
- For hydrocarbons within the water column: dissolved hydrocarbon concentrations >1.0 µg/L (1 part per billion)
- For shoreline oiling: an average concentration of oil >1.0 g/m²

### Subsurface Well Blowout

A well blowout has the potential to result in a change in availability of, or access to, resources (including fishing income) for commercial harvesters and other ocean operators, with the extent of that change depending in large part on how the spill trajectory overlaps with those uses, both geographically and temporally. The level of residual effects will depend on these factors and the success of the mitigation measures that will be applied.

A surface oil thickness of >0.04 µm is the minimum concentration that would produce a barely visible sheen and is adopted in the trajectory modelling as a threshold for the possible closure of an area to fishing and possibly to other uses (Section 15.3, Table 15.4). For hydrocarbon concentrations in the water column, no absolute thresholds have been established for the level at which contamination or perceived tainting of fish flesh might occur. For the purpose of this assessment, a level of >1.0 µg/L (1.0 ppb) of dissolved hydrocarbons is applied, though perceived taint and consequent effects on the marketability of fish products could occur at higher or lower concentrations depending on the species and other factors, such as length of exposure and location in the water column (e.g., a pelagic swimming through, vs. a shellfish remaining in an exposed area). As noted above, for effects resulting from oil reaching shorelines, a threshold >1.0/gm² is used. Above this level, shoreline clean-up might be needed to rehabilitate wharf and dock areas and slipways, recreational use areas, indigenous lands, and coastal-dependent businesses, including aquaculture sites. The presence of oil could also diminish the aesthetic value of areas affected, with effects on tourism.

The stochastic modelling results for a continuous 120-day unmitigated blowout from theoretical well sites in EL 1157 and EL 1158 indicate that there is a probability that surface oil exceeding the threshold could be present in some areas throughout much of the RAA, and therefore over some fishing grounds in those areas. As the modelling suggests, the greatest predicted potential range occurs during winter months for most scenarios (see Table 15.5, and/or Appendix F for seasonal plots) for both 30-day and 120-day releases from either modelled site. In each case, the modelling also indicates that the greatest probability is for surface oil to move generally eastward, away from Canadian EEZ waters and towards the Flemish Cap, Orphan Basin, and beyond. Because of the extent of the modelled area where surface oil might occur, it would only be possible to determine which parts (and which specific fishing grounds) should be closed by monitoring the actual transport and fate of the oil at the time. Although fish species hauled through a surface oil slick (e.g., in snow crab pots) would be at risk of tainting, other types of harvesting (e.g., bottom otter trawling), might not, so long as the catch was brought on board outside an affected area (ITOPF 2011a).

The situation would be similar for dissolved hydrocarbons in the water column (Section 15.3.1), which might cause fish tainting and could result in market effects. As indicated in Figures 15-6, 15-11, 15-16, and 15- 21, there is a probability of dissolved hydrocarbons exceeding the socio-economic threshold in some areas within substantial parts of the RAA, though to a lesser geographic extent than for surface oil (Table 5.5). As with the surface oil modelling, most of the hydrocarbons are predicted to be transported eastward from the ELs and the modelling indicates a very low probably that threshold exceedances would occur in coastal waters and bays of the province, where several nearshore fisheries – such as those for capelin, herring and lobster – are most common. As with surface oil during an actual spill, monitoring, identification of affected areas and communication would be key to limiting socio-economic effects.

As detailed in Section 15.3, shoreline contact modelling predicts that oiling probabilities are low (1-10%) at threshold amounts in most RAA areas, but that some affected areas might occur between the central coast of Labrador, on either side of the Great Northern Peninsula, to the Connaigre Peninsula on the Island of Newfoundland. Affected shore-based aquaculture operations, if any, might take such measures as the temporary suspension of water intakes for shore tanks, ponds or hatcheries to isolate stocks (ITOPF 2004). The SIMA prepared by BHP will consider the proximity of aquaculture operations to areas that might be affected, as it will other requirements and contingencies for the cleanup and rehabilitation of other shore facilities, artifacts, beaches, and other areas.

As discussed in Section 15.3.1, the various probability contours presented (for surface oil, dissolved hydrocarbons, and shoreline contact) do not imply that all of the areas indicated within an isopleth will have hydrocarbons present, but rather, that there is a probability (% indicated in the maps) that some hydrocarbons will occur somewhere within the areas delineated. Mitigation measures to contain and clean up the spill would further reduce these probabilities. For this VC, a key part of the response to a spill would be monitoring and communicating the location of affected areas to all marine interests as quickly as possible through fisheries communications plans, NAVWARNS, and other mechanisms. This information would allow harvesters to avoid those areas, prevent gear fouling, and help reduce the risk of tainted product entering the marketplace. With good communications other marine users would also be able to plan routes and activities to avoid affected areas.

Although avoidance would help to limit effects on commercial fisheries, these actions would have a negative effect on fishing income if closures affected available fishing grounds during fishing seasons, and if no alternative grounds were available, and/or if harvesting expenses increased. In shoreline areas, if contact occurred, and depending on the best practice for the situation, shoreline cleanup and rehabilitation operations would be implemented. If a spill resulted in an actual loss of income from commercial fishing, compensation would be accessible in compliance with the requirements of the Accord Acts as described in the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity (C-NLOPB and CNSOPB 2017).

With prevention plans, response procedures, good monitoring, and effective communications protocols, for residual fisheries losses, potential effects of a subsurface release from the either EL (30 days or 120 days) on fisheries and other ocean uses are predicted to be adverse, moderate to high in magnitude, potentially affecting the RAA and waters eastward, medium-term in duration, single occurrence, and reversible.

## Marine Diesel Spill

The modelling results presented in Section 15.3.1.3 (see also Section 4.1.3 in Appendix F) for a batch spill of 3,200 L of marine diesel oil from a PSV (i.e., the rupture of PSV fuel storage tank) along the potential Project traffic route 12 km east of St. John's indicates that only a silver to colourless sheen would appear on the surface (0.1 μm oil thickness). It would likely be transported to the south and southwest, but no amounts exceeding socio-economic thresholds in the water column are predicted. In all cases modelled, a maximum area of <68 km² of surface oil exposure (summer release) above the socio-economic threshold is predicted, as well as a maximum of 53 km of oil shoreline contact above the socio-economic threshold, most likely on the near shores of Avalon Peninsula. The scenarios also predicted that 64% to 80% of the oil would evaporate within 30 days (the length of the simulation), and that less than 0.1% of the diesel would remain on the surface in any area by that time.

Depending on the location of a spill along the traffic route, the fishing grounds potentially affected include those for groundfish (in the east), snow crab (most of the distance across the Grand Banks), some small pelagic fisheries nearer to the coast, and lobster close to shore, particularly if it occurred in Conception Bay (Section 7.2). Marine diesel fuel is considered to present a moderate to high risk of seafood contamination because of its relatively high content of water-soluble aromatic hydrocarbons, which are semi-volatile and evaporate slowly (Yender et al. 2002), though this modelling does not predict threshold exceedances in the water column. As with a blowout, areas where hydrocarbons are present would need to be tracked, communicated and avoided, likely with some short-term closures for fishers and/or other users.

With spill prevention plans, response procedures (e.g., implementing the ship's SOPEP), good monitoring, and effective communications protocols, potential effects of a 3,200 L batch spill along a potential traffic route on fisheries and other ocean uses are predicted to be adverse, low in magnitude, potentially affecting the LAA and limited parts of the NAFO RAA, medium-term in duration, single occurrence, and reversible.

## SBM Spill

The constituents of synthetic muds are chosen for their low toxicity compared to oil-based materials, and selection will follow the OCSG (NEB et al. 2009). Studies have suggested little or no risk of drilling base chemicals bioaccumulating to the extent that the marine food web or commercial species would be affected (Neff et al. 2000). As detailed in Section 15.6.1.3, recent modelling of 64 m³ and 255 m³ SBM spills in the Flemish Pass area predicted that SBM materials would likely be contained within 982 m and <60 m, respectively, from the well site (Amec Foster Wheeler 2018). Environmental monitoring of the effects of a June 2018 spill of 136 m³ of SBM from a drilling riser on the Scotian Slope found no indications of SBM constituents 500 m from the well site (depth 2,800 m), and the CNSOPB concluded that the spill resulted in no significant adverse environmental effects (CNSOPB 2019). Given the rapid sinking of these dense materials, the likely localized nature of the spill footprint, mainly within the safety exclusion zone, the lack of fish harvesting in most of the ELs and the Project Area, and the small potential of the mud to affect species, additional closed areas beyond the established safety zone would not be likely. Therefore, effects on harvesting opportunities and on other marine activities would not be expected.

With spill prevention plans and response procedures in place, potential effects of an SBM spill on fisheries and other ocean uses are predicted to be adverse, negligible in magnitude, short-term in duration, localized within the Project Area, and reversible.

### Summary

Table 15.38 summarizes predicted residual environmental effects on commercial fisheries and other ocean uses from the accidental event scenarios considered (see Table 12-2 for the characterization of the residual effects on Commercial Fisheries and Other Ocean Uses identified in Table 15.38).

**Table 15.38 Summary of Residual Project-Related Environmental Effects on Commercial Fisheries and Other Ocean Uses – Accidental Events**

| Residual Effect | Residual Environmental Effects Characterization | | | | | | |
|---|---|---|---|---|---|---|---|
| | Direction | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | Ecological and Socio-economic Context |
| **Change in Availability of Resources or Operating Environment** | | | | | | | |
| Well Blowout Incident | A | M-H | RAA | MT | S | R | D |
| Marine Diesel Spill | A | L | LAA | ST | S | R | D |
| SBM Spill | A | N | PA | ST | S | R | D |

KEY:
N/A: Not Applicable

Direction:
P: Positive
A: Adverse

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"

Duration:
ST: Short-term
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

### 15.6.5.4 Determination of Significance

The significance of spill-related adverse effects depends on the type, size, location, and timing of the spill in relation to the activities of fish harvesters and other ocean operators. The definition of a significant residual effect for this VC is the same as the definition applied to assess any effects of routine Project activities (Section 12.1.6). It is an effect that causes

- An adverse change in commercial fishing activity, including overall timing and intensity, resulting in a measurable reduction in overall activity levels of commercial harvesting and/or in the net economic returns from commercial fishing because of a reduction in the quantity or quality of fish landings or increased operating expenses, for one or more fishing seasons
- An adverse change in other ocean uses such as marine research, shipping, military exercises, other petroleum exploration or production, or in-sea infrastructure or artifacts, including changes in the location and timing of these activities resulting in a measurable reduction in their quality, value or integrity over more than a year

Although the worst-case, unmitigated scenarios presented in the spill modelling report indicate a potential for adverse effects on fish harvesting areas (resulting temporary closures), transportation corridors, and places where other marine activities situate in offshore or coastal areas, these effects will be mitigated through the various response measures described in this chapter.

While spills are unlikely with rigorous precautions and the planned prevention measures in place, if a spill were to occur, the mitigation measures implemented would address adverse consequences for this VC. This includes compensation, if required, as identified in the Accord Acts and the Compensation Guidelines. Considering this, it is predicted that accidental events associated with Project will not result in significant residual adverse effects on commercial fisheries and other ocean uses.

## 15.6.6 Indigenous People and Communities

The EIS Guidelines identified 41 Indigenous groups with the potential to be affected by Project activities and therefore to be included within the scope of the environmental assessment: five groups in Newfoundland and Labrador, 13 groups in Nova Scotia, 16 groups in New Brunswick, two groups in Prince Edward Island, and five groups in Quebec. Many of these groups have asserted and/or established Aboriginal and/or Treaty rights including the right to hunt, fish or gather resources which could potentially be affected by the Project under certain circumstances as a result of an accidental event. Of the 41 identified Indigenous groups, several hold commercial communal and/or food, social, ceremonial (FSC) licenses for species in areas that overlap the Regional Assessment Area (RAA). There are no documented FSC licences within the Project Area, however some species targeted in FSC fisheries in other parts of the RAA can potentially migrate through the Project Area. Further information on these Indigenous groups is provided in Section 7.4.

### 15.6.6.1 Project Pathways for Effects

As discussed in Section 15.6.5 (Commercial Fisheries and Other Ocean Uses), an accidental spill has the potential to affect fisheries resources through direct and indirect effects on fished species therefore affecting fisheries success. Fishing activity may also be affected through displacement from traditional fishing areas, gear loss or damage, as well as reducing the marketability of commercial fish products and associated economic losses. These effects to fisheries resources and fishing activity have potential to result in changes to commercial communal fisheries and/or current use of lands and resources for traditional purposes, as well as associated effects on socio-economic conditions, well-being, and quality of life for the Indigenous communities. While the assessment is conservative (i.e., geographic and temporal overlap with resources of concern are assumed to occur in the case of an accidental event), the extent of potential effects depends on spill types and volumes, oceanographic conditions and how the spill trajectory and the VC overlap in both space and in time.

The biophysical effects in the event of an accidental spill are discussed in Section 15.6.1 for potential effects to marine fish and fish habitat, Section 15.6.2 for marine and migratory birds, and Section 15.6.3 for marine mammals and sea turtles. Discussion on potential effects to harvested species is not repeated in this section. This section instead focuses on effects related to commercial communal fisheries and the current use of these resources for traditional purposes, and in turn, the overall quality of life and well-being of an Indigenous community.

### Potential Effects of an Oil Spill on Commercial Communal Fisheries

An oil spill has the potential to interact with commercial communal fisheries by impeding the ability of Indigenous fishers to harvest fish, affecting the biological health of the commercial communal fish species, and reducing the marketability of the commercial communal fish products. While the Project is not located in an area of high harvesting activity, in the event of an oil spill, hydrocarbons could reach an area where harvesting activity is more concentrated. Fishing gear may be lost or damaged as a result of an accidental event. Physical contamination of fishing gear can also result in transfer of oil to the catch (ITOPF 2011a). Fishery closures are intended to reduce risk of contamination of gear and protect consumers from consumption of potentially contaminated resources. However, the restriction of access to commercial communal fisheries can also result in adverse socio-economic effects on Indigenous communities.

As discussed in Section 15.6.5, the uptake of oil and PAHs by exposed fish pose a potential threat to human consumers and affects the marketability of catches. Market perceptions of poor product quality (i.e., tainting) can persist following demonstrated results of safe exposure levels for consumption, resulting in prolonged effects to Indigenous fishers, including adverse socio-economic effects on Indigenous communities.

As discussed in Section 13.3, swordfish and tuna are noted through Indigenous engagement activities as being of primary commercial communal importance and are known to occur in the RAA. Potential effects of a hydrocarbon spill are, therefore, discussed for each of these species below.

#### *Swordfish*

Many Indigenous groups hold commercial communal fishing licences for swordfish, a large, highly migratory pelagic species, distributed widely throughout the Atlantic Ocean and known to forage in Canadian waters from June to October (DFO 2015). The species has a wide range and can be found along the edge of the continental shelf and most of the North Atlantic Basin (Dewar et al. 2011; Trenkel et al. 2014). Commercial communal licences are held in NAFO Areas that overlap with the RAA.

Adult finfish, such as swordfish, can likely avoid crude oil spills through temporary migration from affected areas. The species' seasonal distribution in Canadian waters, along with their non-schooling behavior, reduces potential population effects in the event of a Project-related spill (Arocha 2017). It is, therefore, unlikely that swordfish would be present within a spill area in large concentrations during an accidental event, and the highly mobile nature of the species would allow individuals to avoid affected areas. If swordfish are exposed to hydrocarbons via respiration, direct contact, or through diet, these hydrocarbons will be metabolized and generally will not pose a risk through bioaccumulation. Larvae are likely more vulnerable; however, spawning and nursery habitats are distant from the RAA (e.g., Gulf of Mexico, eastern continental shelf of the United States) (Arocha 2007), so larvae and juveniles would not come into contact with hydrocarbons from the Project in the unlikely event of an accidental spill.

### *Bluefin Tuna*

Tuna are a highly migratory species and have been found in the offshore waters of NL. There is potential for tuna to migrate through the Project Area in search of prey species; however, there are no known spawning or rearing habitats for larval and juvenile stages in Canadian waters (COSEWIC 2011). Adult bluefin are capable of moving at a scale of approximately 100 km per week and therefore it is likely they could move to avoid direct exposure to oil for prolonged periods (Hazen et al. 2016). Given their overall ranges and migration patterns, it is unlikely that bluefin tuna would be present within a spill affected area in large concentrations during an accidental event, and the highly mobile nature of the species would likely allow individuals to avoid affected areas.

## Potential Effects of an Oil Spill on Current use of Lands and Resources for Traditional Purposes

Harvesting activities that collect resources to provide nourishment, or for use in traditional ceremonies and social events are considered current use of lands and resources for traditional purposes. While there are no documented FSC licences within the Project Area, some species targeted in FSC fisheries in other parts of the RAA are anadromous and can potentially migrate through the Project Area. In the event of a spill, an effect on FSC species could affect health and/or socio-economic conditions of Indigenous communities through change in cultural practices and heritage, and/or direct (e.g., direct contact) or indirect exposure (e.g., ingestion of contaminated food) to contaminants. Current use of lands and resources for traditional purposes could also be adversely affected as a result of a change in quantity, quality or availability of traditional lands and resources as the result of an accidental event leading to a spill.

Indigenous communities are known to hunt migratory bird species that are present within the RAA; in particular, the murre is known to be present in the RAA and potentially affected by an accidental event. Exposure to hydrocarbons can occur through three key pathways for marine and migratory birds: external exposure to oil (resulting in coating of oil on feathers); inhalation of particulate oil and volatile hydrocarbons; and ingestion of oil. Diving species, including murres, are the most susceptible to the immediate effects of surface slicks (Leighton et al. 1985; Chardine 1995; Wiese and Ryan 1999; Irons et al. 2000). Further details on the potential effects to marine and migratory birds is provided in Section 15.6.2. Adverse effects to marine and migratory bird species harvested by Indigenous communities could result in a change of current use of lands and resources for traditional purposes, thereby decreasing the quality of life of a community.

Indigenous groups harvest seals for FSC purposes. Six seal species occur in the Project Area: harp, hooded, grey, ringed, harbor, and bearded seals. In the event of an oil spill, there is potential to result in a change in risk of mortality or physical injury and/or change in habitat quality and use. Further details on the potential effects to marine mammals and sea turtles is provided in Section 15.6.3. Adverse effects to marine mammals (e.g., seals) harvested by Indigenous communities could result in a change of current use of lands and resources for traditional purposes, thereby decreasing the quality of life of a community.

American eel and Atlantic salmon are two migratory fish species harvested in proximity to Indigenous communities and highlighted during Indigenous engagement as being of specific concern due to potential interaction with Project activities. Potential effects of a hydrocarbon spill are discussed for each of these species below. In the event a fish species harvest by Indigenous communities becomes exposed to oil, the uptake of oil and PAHs by exposed fish poses a potential threat to human consumers. In particular, consumers of seafood for subsistence use (e.g., members in Indigenous communities) may have higher seafood consumption rates, compared to the general population, relying more heavily on local seafood resources as sources of protein (Yender et al. 2002). The potential effects on health and well-being of Indigenous communities from an oil spill, therefore, may be higher in magnitude than for the general population of seafood consumers.

### *Atlantic Salmon*

Atlantic salmon populations breed and spend the early part of their life cycle in freshwater systems throughout Atlantic Canada, eastern Québec, and the northeastern seaboard of the United States. Research vessel surveys from 1965 to 1985 have caught salmon within the Project Area in the spring (Reddin and Shearer 1987; Section 6.1.9.2), however, even at much higher population levels, catch data indicate low abundances, particularly during their migration. There is no information with regards to salmon overwintering in relation to the LAA. Given that salmon egg and larval stages are restricted to freshwater, the potential effects to salmon are limited to potential changes in food availability and direct effects on highly mobile marine life history stages. Adult fish, including salmon, occurring in relatively deep waters have lower exposure risk because they are highly mobile and able to avoid oiled areas (Irwin et al. 1997; Law et al. 1997).

A behavioural study on adult Pacific salmon (*Oncorhynchus sp*.) was conducted where hydrocarbons that closely approximated the water-soluble fraction of Prudhoe Bay crude oil were added in one of two fishways as salmon were migrating upriver (Weber et al. 1981). Results found that migrating salmon substantially avoided hydrocarbons in the water at concentrations of 3,200 µg/L (i.e., 50% of fish, which were expected to ascend a fishway, avoided it). Furthermore, experiments indicate that salmon species have some capability for detection of hydrocarbon concentrations shown to cause mortality, and subsequently avoid the contaminated water (Barnett and Toews 1978, Weber et al. 1981, Alvarez Piñeiro et al. 1996, Stagg et al. 1998). Given the potential transitory presence of Atlantic salmon through the RAA, and potential ability to avoid contaminated waters, it is unlikely that Atlantic salmon would experience population level effects from an accidental spill.

### *American Eel*

The American eel lives primarily in freshwater and estuarine environments and has a broad distribution throughout the northwest Atlantic Ocean, stretching from Venezuela to Greenland and Iceland (Section 6.1.9; COSEWIC 2012). Specific migration patterns of American eel are not well known due to large data gaps, but if American eel were to occur within the Project Area, it is likely that they would be transported by currents on their way either to Greenland, Iceland, or to NL. Unlike other fish, American eel have been shown to be less sensitive to oil and when exposed to oil have been shown to induce oil degrading enzymes with a 5 mg/kg dose. It has been speculated that this is because of the species' life history, where they spend a portion of their life in estuaries with increased chance of exposure to contaminants and therefore less sensitivity (Schlezinger and Stegeman 2000).The potential for occurrence of American eel in a spill affected area within the RAA is low, however, if they are exposed to hydrocarbons as a result of an accidental spill from the Project, it is highly unlikely that American eel would experience effects that could result in a decrease of availability of resources for Indigenous fisheries.

### Potential Effects of an SBM Spill on Indigenous People and Communities

Given SBM is a dense low toxicity fluid, if released accidentally as a bulk spill, it would sink rapidly through the water column (Neff et al. 2000; CNSOPB 2005, 2018a). While a surface sheen could occur from the spill, most of the SBM would sink to the seafloor, affecting marine benthos within a localized area around the wellsite. Currently, FSC harvesting does not occur within the Project Area, including harvesting for benthic species. Therefore, potential interactions with marine resources harvested for commercial communal or FSC purposes, including but not limited to those species identified above, are not anticipated to occur. Associated socio-economic and health effects to Indigenous communities are also therefore not anticipated to occur.

### 15.6.6.2 Mitigation of Project-Related Environmental Effects

The primary means for reducing the likelihood of effects on all VCs that might result from an accidental event is prevention. Sections 2.9 and 15.1 describe BHP's safety culture, its approach to risk management, and information about well control and blowout prevention measures that will be in place throughout the Project (Section 15.1). If an accident were to occur, BHP's contingency planning and emergency response measures would be implemented as appropriate (Section 15.5). BHP's SIMA will evaluate the risks and benefits of each available response option to guide the application of specific mitigations during an actual event.

In addition to the measures described in Section 15.5 and 15.6.1.2 (for Marine Fish and Fish Habitat) other mitigation measures would be implemented that are more specific to this VC:

- An Indigenous Fisheries Communication Plan will be used to facilitate coordinated communication with fishers, including procedures for informing Indigenous groups of an accidental event. Timely communication will be important, thereby providing fishers with the opportunity to haul out gear from the affected areas and reducing the potential for fouling of fishing gear.
- 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.

Specific environmental effects monitoring and follow-up programs may be required in the unlikely event of a spill. These monitoring programs will be developed in consultation with applicable regulatory agencies, Indigenous communities, and fisheries stakeholder, as applicable.

### 15.6.6.3 Characterization of Residual Project-Related Environmental Effects

#### Subsurface Blowout

Given the larger spatial and temporal scale associated with a subsurface blowout, there is potential for effects on the availability of fisheries resources (e.g., effects on fisheries species), access to fisheries resources (e.g., fisheries closure), and/or fouling of fishing gear. These effects have the potential to result in a change in commercial communal and/or FSC fisheries, including FSC species harvested elsewhere that may migrate through the area. Adverse effects to commercial communal and/or FSC fisheries may also result in adverse effects on socio-economic conditions for the Indigenous communities from economic loss and/or reduction of food security, thereby potentially affecting quality of life within communities, with effects lasting longer than the physical effects of the spill itself. In the event of a subsurface blowout, the affected areas would be closed to fishing to prevent human contact with spilled oil as well as the consumption of potentially contaminated food sources. Effects can also occur from reduced consumer confidence and marketability of seafood following a spill (ITOPF 2011a). Tainting of seafood (when a fish absorbs oil-derived substances into its tissues, causing petroleum tastes and odours) can occur at exposures to low hydrocarbon concentrations (ITOPF 2011a). While tainting is reversible through depuration, perceived contamination concerns may linger after seafood has been determined safe for consumption, leading to potential continued economic losses (Yender et al. 2002; ITOPF 2011a) that can have adverse health and socio-economic effects for affected Indigenous communities.

The Project is not located in an area of high harvesting activity by Indigenous fishers, and in the event of a subsurface blowout, trajectory modelling (see Section 15.3) shows released oil moving towards the east, away from Canadian shorelines due to the prevailing winds and currents. For both release sites, EL 1157 and EL 1158, stochastic analyses were used to demonstrate that the highest potential likelihood (>90%) to exceed thresholds of potential surface oil exposure and water column contamination by dissolved hydrocarbons primarily occurred to the east, up to 1,400 km from the release site. Lower probabilities of surface oil and water column threshold exceedance occurred north and south of the release site and generally less than 25% of release potentially exceeded thresholds west of the Project Area. The probability of shoreline oiling from release scenarios was generally low with maximum annual probabilities of 9% for 30-day scenarios and 20 to 21% for 120-day scenarios. Predicted annual minimum time to shoreline threshold exceedance was 7 days, occurring along southeastern Newfoundland. Oil potentially reaching shorelines would likely be highly weathered, discontinuous and patchy.

It is therefore unlikely that in the event of a subsurface blowout, oil will intersect with areas traditionally harvested for commercial communal and/or FSC fisheries. There is, however, potential for interaction with species of interest to Indigenous communities, as harvested species for FSC purposes may migrate through a spill affected area before being harvested in a non-affected area, including marine fish, marine and migratory birds (e.g., murres), and marine mammals (e.g., seals). Effects on marine fish are assessed in Section 15.6.1, effects on marine and migratory birds are assessed in Section 15.6.2, and effects on marine mammals are assessed in Section 15.6.3. The magnitude of effects is dependent on the timing of the spill and the extent to which the spill trajectory may intersect with areas inhabited by marine species. As noted in Section 15.6.2.4, the environmental effects could be significant for migratory birds if the consequences carried over more than one generation according to the significance threshold used in this environmental assessment or self-sustaining population objectives or recovery goals for listed species are jeopardized;

however, this is considered unlikely given the low probability of a large spill event to occur and the response that would be in place to reduce the consequences of such an event.

The importance of FSC species has been emphasized by the communities as being culturally important and effects to FSC species may affect Indigenous groups, such that there are associated, detectable, and sustained decreases in the quality of life of a community. It is important to note, however, that the model scenarios are based on unmitigated subsurface blowout scenarios. Emergency response and mitigations measures, as detailed in Section 15.5, would be implemented in an actual event to reduce the magnitude, duration, and extent of a spill. Shoreline protection measures would also reduce the potential effects on shorelines and coastal habitat for harvested species.

Residual environmental effects from an unmitigated subsurface blowout on Indigenous people and communities are predicted to be adverse and moderate (given the highly migratory nature of species of interest and low likelihood of nearshore interaction) to high (given the cultural importance of the FSC fisheries) in magnitude. The geographic extent of potential effects is beyond the RAA based on subsurface blowout modelling, however, modelling shows released oil moving towards the east, away from harvesting locations, and oil transported at that distance would be highly weathered, patchy and discontinuous. This effect is considered reversible with a medium to long-term duration and is predicted to occur as a single event.

### Marine Diesel Spill

As discussed in Section 15.6.1, effects of a marine diesel spill on marine fish and fish habitat would likely be limited, with temporary and reversible degradation in habitat quality at the water surface and localized and patchy distributions of oil. Similarly, effects on marine and migratory birds (Section 15.6.2) and marine mammals (Section 15.6.3) are not likely to occur over a large area.

Surface batch spills (3,200 L) of marine diesel from a vessel were predicted to result in patchy distributions of silver or colourless sheens (<0.0001 mm) of oil on the water surface. A batch spill is predicted to evaporate quickly. The 95th percentile shoreline oiling case was predicted to result in 1,010 km of shoreline oiling above the socio-economic threshold and 9 km above the biological threshold. Therefore, there is limited potential for the biophysical effects of a diesel spill to have an adverse effect on the presence, abundance, distribution, quality or overall availability of resources for harvesting activities by Indigenous groups within their traditional harvesting areas. There are, therefore, limited effects on the quality or cultural value of these traditional activities by Indigenous group. Similarly, such effects are unlikely to extend to or affect the physical (through, for example, ingestion of toxic materials) or social health and well-being of Indigenous persons or communities.

Residual environmental effects from a marine diesel spill on Indigenous people and communities are predicted to be adverse and low magnitude considering the small scale of the spill. As potential spills may occur along vessel traffic routes, the geographic extent is localized to the LAA. This short-term effect is considered reversible and is predicted to occur as a single event.

### SBM Spill from the MODU and the Marine Riser

In the event of an SBM spill from the MODU and the marine riser, SBM is anticipated to rapidly sink to the seafloor and be localized to the area around the MODU, resulting in a temporary degradation of benthic habitat and potential smothering of benthic fauna. As discussed in Section 15.6.1, it is conservatively estimated that there may be potential effects to marine fish and fish habitat from a localized deposition area within a few kilometres from site. Substances that comprise drilling muds are, however, screened through a chemical management system in consideration of the OCSG (NEB et al. 2009), and studies have shown little or no risk of drilling base chemicals to bioaccumulate to potentially harmful concentrations in tissues of benthic animals or to be transferred through marine food webs to fishery species (Neff et al. 2000). Effects on commercial communal and FSC fisheries are expected to be negligible given the localized extent of benthic interaction. Although unlikely to occur, an SBM spill may result in a surface sheen which could result in mortality or physical injury of marine birds in the immediate area of the spill. However, as noted in Section 15.6.2, this is not predicted to result in population effects such that Indigenous harvesting of marine birds would be affected. No adverse effects are predicted on seals as a result of an SBM spill.

Residual environmental effects from an SBM spill on Indigenous people and communities are predicted to be adverse and negligible to low in magnitude considering the localized nature of the spill and lack of acute toxicity of SBM. The geographic extent of potential effects would likely be localized to the Project Area. This potential effect is predicted to occur as a single event and is considered reversible with short-term duration.

### Summary

Table 15.39 summarizes predicted residual environmental effects on Indigenous people and communities from various accidental event scenarios.

**Table 15.39 Summary of Residual Project-Related Environmental Effects on Indigenous People and Communities – Accidental Events**

| Residual Effect | Residual Environmental Effects Characterization | | | | | | |
|---|---|---|---|---|---|---|---|
| | Direction | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | Ecological and Socio-economic Context |
| **Change in Commercial Communal Fishers / Change in Current Use of Lands and Resources for Traditional Purposes** | | | | | | | |
| Well Blowout Incident | A | M-H | RAA | MT-LT | S | R | D |
| Marine Diesel Spill | A | L | LAA | ST | S | R | D |
| SBM Spill | A | N-L | PA | ST | S | R | D |

**Table 15.39 Summary of Residual Project-Related Environmental Effects on Indigenous People and Communities – Accidental Events**

| Residual Effect | Residual Environmental Effects Characterization | | | | | | |
|---|---|---|---|---|---|---|---|
| | Direction | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | Ecological and Socio-economic Context |

| | | |
|---|---|---|
| KEY:<br>N/A: Not Applicable<br><br>Direction:<br>P: Positive<br>A: Adverse<br><br>Magnitude:<br>N: Negligible<br>L: Low<br>M: Moderate<br>H: High | Geographic Extent:<br>PA: Project Area<br>LAA: Local Assessment Area<br>RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"<br><br>Duration:<br>ST: Short-term<br>MT: Medium-term<br>LT: Long-term | Frequency:<br>S: Single event<br>IR: Irregular event<br>R: Regular event<br>C: Continuous<br><br>Reversibility:<br>R: Reversible<br>I: Irreversible<br>Ecological / Socio-Economic Context:<br>D: Disturbed<br>U: Undisturbed |

### 15.6.6.4 Determination of Significance

The significance of a spill-related event depends on the magnitude, timing, and location of a spill. The significance definition defined in Section 13.1.6 is also applicable to the assessment of accidental events, and includes an environmental effect that involves:

- Loss of access to areas or resources relied on for traditional use practices or the loss of traditional use areas within a large portion of the LAA and RAA for a season
- Adverse effects on socio-economic conditions of affected Indigenous groups, such that there are associated, detectable, and sustained decreases in the quality of life of a community
- A decrease in established employment and business activity in commercial communal fisheries (e.g., due to fish mortality and/or dispersion of stocks) such that there is a detectable adverse effect upon the economy of the affected Indigenous community
- Unmitigated damage to fishing gear

A subsurface blowout could affect Indigenous people and communities on a larger spatial and temporal scale, with potential effects on FSC fisheries lasting longer than the physical effects of the spill itself. Socio-economic conditions could be adversely affected such that there is a detectable and sustained decrease in the quality of life of a community should Indigenous communities lose access to traditional use areas and/or experience a reduced supply of resources resulting in food insecurity for community members. Because of the widespread nature of the worst-case, unmitigated blowout incident, a significant effect (due to adverse effects on socio-economic conditions of affected Indigenous groups, such that there are associated, detectable, and sustained decreases in the quality of life of a community) is conservatively predicted for Indigenous people and communities in the event of a subsurface blowout. The likelihood of this significant

In the event of a marine diesel spill, adverse effects are predicted to be not significant for Indigenous people and communities given the limited spatial and temporal exposure of spilled diesel to Indigenous fisheries and resources use in the RAA. This prediction is made with a medium level of confidence recognizing potential concerns by Indigenous communities and perception of adverse effects on quality of life and concerns about tainting of resources.

Given the predicted affected area, temporary period of measurable effect on water quality, and the low toxicity of the product, effects of a SBM spill are predicted to be not significant on Indigenous people and communities. A fisheries closure is not anticipated, and fouling of gear would be unlikely given the relatively small spatial and temporal footprint of the spill event. This determination is made with a high level of confidence.

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# 16.0 EFFECTS OF ENVIRONMENT ON THE PROJECT

As required under section 19(1)(h) of the *Canadian Environmental Assessment Act 2012* (CEAA 2012) and as specified in the Environmental Impact Statement (EIS) Guidelines (Part 2, Section 7.6.2; Appendix A), this chapter provides a discussion of the expected and potential effects of the environment on the Project.

Careful consideration of the environment (e.g., winds, waves, currents, ice, precipitation, and seismicity) is required when planning, reviewing, and conducting offshore oil and gas production activities. Understanding these environmental characteristics enables offshore operations that are safe for workers, while also protecting the environment, equipment, and infrastructure.

Physical environment information presented herein is summarized from the more detailed description of the existing physical environment presented in Chapter 5 of this EIS.

## 16.1 KEY ENVIRONMENTAL CONSIDERATIONS

This section provides an overview of the key environmental conditions and phenomena relevant to potential effects of the environment on the Project, including:

- Seismicity and geohazards
- Climatology, weather and oceanographic conditions
- Sea ice and icebergs
- Climate change

### 16.1.1 Seismicity and Geohazards

The geology of the eastern Newfoundland Offshore Area is complex and dynamic. 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 (MTDs) comprised of both glaciogenic debris flow and blocky MTD (Campbell 2005). The MTDs in the southern Orphan Basin range in thickness from 2 m to 75 m (Campbell 2005). The western slope is classified as low gradient (1° to 2°) while the southern slope has a relatively higher gradient (4° to 6°). Seismic and piston cores taken in the West Orphan Basin, near the Project Area, indicate 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 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).

Potential offshore geohazards in and around the Project Area include, but are not necessarily limited to, submarine slides, shallow gas and dissociation of gas hydrates, and seismic events.

Canada's eastern continental margin is tectonically passive, and seismic events are relatively rare throughout much of the region. Based on the probability of earthquake occurrences across Canada, the Project Area and surrounding areas have been classified as having a low to moderate seismic hazard

(Natural Resources Canada (NRCan) 2018a; 2018b). According to the National Earthquake Database, 33 earthquakes occurred in the Regional Assessment Area (RAA) between 1985 and 2019, and no seismic events were recorded in Exploration Licences (ELs) 1157 and 1158 during the same time period (NRCan 2019).

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). 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 (NRCan 2010). It is likely that most landslide failures are earthquake triggered, with some seismicity induced by glacio-isostasy (Piper 2005). The recurrence of large-scale seabed failures in the basin is on the order of 75,000 to 100,000 years (Campbell 2005).

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). Generally, if a large natural slope failure did occur, it would likely be preconditioned by high pore pressure and triggered by earthquakes. In the Orphan Basin, the expected recurrence interval of landslides with an extent of over 50 km is approximately 10,000 years.

The tsunami hazard along Canada's Atlantic Coast is relatively low, with few tsunamis on record. A tsunami generated by the displacement of the seafloor from active plate boundaries is unlikely as there are no such plates nearby. Tsunamis along the Atlantic Coast could be generated by submarine landslides triggered by earthquakes. The probabilities of potentially damaging (≥1.5 m) tsunami wave runup resulting from an earthquake is estimated to be approximately every 300 to 1,700 years (Leonard et al. 2012).

#### 16.1.1.1 Potential Effects of Seismicity and Geohazards on the Project

The Project Area has been classified as having a relatively low to extremely low seismic hazard. A seismic event could disrupt Project activities, increase the risk of potential accidental events, and may also contribute to sediment and seafloor instability. Submarine landslides or tsunamis are estimated to be triggered by earthquakes of magnitude six or greater. The closest earthquake of such significance to the Project Area occurred in 1998 (magnitude of 6.2) at a location approximately 1,000 km east from ELs 1157 and 1158.

### 16.1.2 Climatology, Weather and Oceanographic Conditions

#### 16.1.2.1 Air Temperature, Fog and Precipitation

According to the International Comprehensive Ocean-Atmospheric Data Set, air temperature in the Project Area exhibits strong seasonal variations, with mean temperatures ranging from -1.4°C in January to 12.9°C in August (Research Data Archive et al. 2019). The coldest observed air temperature on record (-13.0°C) was in February with minimum summer 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.

Rain occurs approximately 8 to 17% of the time for all months of the year. Snow is most likely to occur in January (21% of the time) and is an annual occurrence 7% of the time. Freezing rain is relatively infrequent in this area, occurring less than 1% of the time during any given month. Thunderstorms, which can generate hail and lightning, have not been observed in the Project Area.

The Project Area and surrounding areas have some of the highest occurrence rates of marine fog in North America, and fog can persist for days or weeks. Annually, visibility is very poor 13% of the 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. Visibility is poorest in July, with very poor visibility (<500 m) occurring 39% of the time.

#### 16.1.2.2 Winds

Based on Meteorological Service of Canada, Wind and Wave Hindcast (MSC50) hindcast data (Swail et al. 2006), monthly mean hourly wind speed (1-hour average wind speeds for a height of 10 m above sea level) ranged 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. Exceedance values for wind speeds for various return periods are listed in Table 16.1. 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.

**Table 16.1 Extreme Wind 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 |
| Source: based on DFO 2019 | | | | |

#### 16.1.2.3 Waves

Based on MSC50 hindcast data (Swail et al. 2006), monthly mean significant wave heights in the Project Area range from approximately 1.8 m in July to 4.6 m in January, with an annual mean of 3 m. The most severe sea states occur in December through February (maximum significant wave heights of up to 15.0 m in February and 14.9 m in December). The largest waves are from the southwest through northwest directions with associated peak periods in the 16 to 17 s range. The maximum significant wave height at 6.5 m is lowest in July, with an associated peak period of 11 to 12 s. Exceedance values for significant wave heights for various return periods are listed below in Table 16.2.

**Table 16.2 Extreme Wave Estimates, MSC50 Node M6014847, 1962-2015**

| Return Period (years) | 1 | 10 | 50 | 100 |
|---|---|---|---|---|
| Significant Wave Height (m) | 11.3 +/- 0.2 | 13.3 +/- 0.4 | 14.7 +/- 0.5 | 15.3 +/- 0.5 |
| Source: based on DFO (2019) | | | | |

#### 16.1.2.4 Currents

The Labrador Current 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.

The dataset currently best suited for describing and understanding current and hydrodynamic variability in the Project Area is a multi-year moored current measurement program of the Orphan Basin completed by the Ocean Sciences Division of Fisheries and Oceans Canada (DFO) at the Bedford Institute of Oceanography from June 2004 to May 2010 (BIO 2015; Geshelin et al. 2006; Geshelin and Loder 2007; Loder et al. 2011). Key measurements from the program include annual mean current velocities and mean and maximum current speeds at select instrument depths at each location along this Orphan Basin line. Annual mean current speeds in the upper water column (40 and 180 m) are between 7 and 17 cm/s. Maximum current speeds at site OB-A (from the 2004-2005 deployment of the Orphan Basin Program), located in the Project Area at a water depth of 1,545 m, 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. At site OB-C, also in the Project Area but at a water depth of 2,261 m, maximum current speeds range from 70 to 80 cm/s near the surface, to generally approximately 50 cm/s at 360 m, and between 28 to 41 cm/s near-bottom. The program also detected isolated occurrences of tall eddies extending over the water column, but these were not readily apparent in water depths less than 2,100 m. These enhance the current speeds over much of the water column, up to 50 cm/s, with strongest currents at mid-depth.

### 16.1.2.5 Water Levels and Storm Surge

Water level variation due to tides in the Project Area are generally quite predictable. 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. Tidal water levels computed for the Project Area indicate the largest contribution to the observed tidal range is the principal lunar semidiurnal constituent with a constituent amplitude of 17.2 cm, followed by the solar semidiurnal constituent with a constituent amplitude of 8.7 cm (Dupont et al. 2002; DFO 2015). Storm surge, or the abnormal rise of seawater level generated by a storm, can pose a threat to infrastructure in coastal areas. The predicted 100-year return period storm surge in the northwest Atlantic at MSC50 Node M601487 is 0.9 m (Bernier and Thompson 2006).

### 16.1.2.6 Marine Icing

Marine icing can result from freezing precipitation or a combination of low ambient air temperature, low sea surface temperatures, and wind-induced sea spray. Marine icing is an important design consideration as it can cause a substantial increase in the weight of a vessel and alter its center of gravity, which in turn can impact vessel speed, maneuverability and cause problems with cargo-handling equipment (DFO 2012). Icing potential for vessels in the Project Area is most likely to occur between November and May. The frequency of occurrence for moderate, heavy, or extreme icing potential is greatest in January at 17.4%. No icing potential is reported for June through October (based on Research Data Archive et al. 2019).

#### 16.1.2.7 Potential Effects of Climatology, Weather and Oceanographic Conditions on the Project

Adverse weather and oceanographic conditions (e.g., high winds, large waves, low visibility or freezing precipitation) may affect Project activities (e.g., the movement and positioning of the mobile offshore drilling unit (MODU), transportation and receipt of personnel, equipment and other materials, and drilling operations).

Ocean current loads, in addition to surface wave conditions, have the potential to exert stress on the MODU and its associated subsurface components. Severe and/or extreme weather conditions (e.g., high wind and wave conditions) can potentially delay cargo or personnel transit over the temporal duration of the Project.

Ice and snow build-up on the MODU and Project support vessels (PSVs) are primarily a safety issue for personnel, with the risk of falling ice and snow from overhead. Heavy icing can also result in a higher center of gravity, thereby compromising the stability of the MODU or PSV, potentially resulting in potential equipment damage. Delays from vessel icing can occur if operations are slowed (or suspended) to remove ice accumulations.

Fog is a common occurrence in the region, and can be dangerous for offshore operations, particularly when ice or other hazards and human activities are present. Poor visibility resulting from fog, heavy rain, or snow conditions can hinder helicopter transits and delay supply and personnel movement to and from the Project. Poor visibility could also increase the potential for accidental events (e.g., a vessel or helicopter collision). Thunderstorms, which have not been observed in the Project Area, could affect aircraft movements, due to the potential for lightning strikes, strong downbursts of wind, and hail.

### 16.1.3 Sea Ice and Icebergs

Large variations in sea extent in the Project Area are common from year to year, as well as in any given year, on time scales of days to weeks and over comparatively small geographic scales. For this part of the North Atlantic Ocean, for any given week in the ice season, sea ice is more likely of greater concentration and thickness in the western portion and less severe farther offshore to the east (Canadian Ice Service [CIS] 2011). With each passing week, 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 to form nearshore and extend from a few metres to several hundred kilometres offshore. This may pose a potential risk for potential vessel traffic routes near the coastline of eastern NL but is unlikely to be a factor in the Project Area itself.

Sea ice is most prevalent along the southwestern quadrant of the Project Area, as the region receives the greatest influx of ice drifting south from Labrador and the northeast coast of Newfoundland and east over the Newfoundland Shelf, Orphan Basin and Flemish Pass. 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 first-year ice and in concentrations of 1 to 3/10 and 4 to 6/10 (CIS 2011). Further information on regional ice conditions in this area is provided in the Eastern Newfoundland Strategic Environmental Assessment (AMEC Environment & Infrastructure 2014).

A query of both the National Research Council (NRC) Program of Energy Research and Development (NRC-PERD) iceberg database (Sudom et al. 2014; NRC 2019) and the International Ice Patrol database yields a total of 2,591 iceberg sightings in the Project Area and icebergs have been sighted in the Project Area in all months except November. Of the icebergs in the Project Area, approximately 10.5% are growlers or bergy bits, 74% are small or medium, 13.9% are large, and 1.3% are very large. 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.

#### 16.1.3.1 Potential Effects of Sea Ice and Icebergs on the Project

The Project Area is subject to seasonal intrusions of sea ice and icebergs. PSV navigation and delivery of personnel and supplies can be hindered by the presence of sea ice and icebergs. The primary risk from sea ice is at the ocean surface (e.g., vessel collision). The MODU will not operate in the presence of sea ice, unless the MODU is classed to do so. Given that the water depths in the ELs are in the range of approximately 1,175 m to 2,575 m, there is no risk of iceberg scour to deep-water equipment in the Project Area.

### 16.1.4 Climate Change

Climate change considerations relevant to the Orphan Basin and offshore NL (organized according to atmospheric, oceanographic, and cryospheric variables) were provided in Chapter 5 (Section 5.8). Given that the temporal scope of the Project extends to 2028, it is unlikely that the physical environment in the Project Area will experience substantial climate change impacts beyond what is presently found in recent trends and interannual variability. Climate change is therefore unlikely to have a direct and significant effect on the Project beyond the overall design and planning measures being undertaken to address the physical environmental parameters discussed above.

## 16.2 MITIGATION

Mitigation measures and compliance with regulatory requirements planned by BHP to manage effects of the environment on the Project to acceptable levels are presented below.

### 16.2.1 Seismicity and Geohazards

- 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*.
- 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.
- 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.

### 16.2.2 Climatology, Weather and Oceanographic Conditions

- 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).
- 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 MODU will be supported by a fleet of PSVs to re-supply fuel, equipment, and other supplies during the drilling program. A stand-by vessel, which has a Canadian Standby Certificate, will be in attendance at all times. The selection criteria for vessels engaged in Project activities will include year-round operation for the environmental conditions prevalent in the Project Area and larger RAA.
- 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.
- Adequate food and potable water stores and water makers will necessarily be maintained on the MODU to accommodate weather-related delays in the transportation of supplies.
- 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).

### 16.2.3 Sea Ice and Icebergs

- 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 Operations Authorization (OA) process.

## 16.3 RESIDUAL EFFECTS SUMMARY

Significant adverse residual effects of the environment on the Project are defined as those where physical environmental conditions have an unplanned effect on Project components or activities that result in adverse effects to human health and safety, environment risks or the damage of key equipment or infrastructure resulting in effects on overall Project costs or schedule.

Key environmental factors, as described above, that may affect the Project include severe and/or extreme weather conditions, sea ice, icebergs, superstructure icing, and oceanographic conditions.

MODUs, PSVs, aircraft, and other equipment used for this Project will have the capacity to function within the environmental conditions that are known or likely to be encountered in the Project Area and will adhere to the applicable regulatory requirements for safety and environmental protection. Proper operational planning as well as Project compliance with applicable international standards and Canadian regulations for equipment design and use with respect to extreme weather and oceanographic conditions will help mitigate these risks. Given the relatively short time period associated with the drilling of each well, the probability of a major seismic event (and resulting landslides or tsunamis) occurring during the life of the Project is very low.

Engineering design, operational procedures, and mitigation measures discussed in Section 16.2 will reduce potential adverse effects to the Project. Based on the significance criteria defined above, and application of risk mitigation including adherence to the *Newfoundland Offshore Certificate of Fitness Regulations*, *Newfoundland Offshore Petroleum Installations Regulations,* and the Offshore Physical Environmental Guidelines, significant adverse residual effects of the environment on the Project are not likely to occur.

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# 17.0 SUMMARY AND CONCLUSIONS

BHP proposes to undertake an exploration drilling program within the areas of its existing offshore exploration licences (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 in the Orphan Basin, approximately 350 km northeast of St. John's, NL, in the Northwest Atlantic Ocean. Portions of the ELs are both inside and outside Canada's 200 nautical mile Exclusive Economic Zone (EEZ). Water depths in the ELs range from approximately 1,175 to 2,575 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.

This chapter provides a summary of the following:

- Summary of potential Project-related effects on selected valued components (VCs) (Section 17.1)
- Summary of mitigation, monitoring, and follow-up proposed for the Project (Section 17.2)
- Summary of Residual environmental effects, after mitigation has been applied, for the selected VCs (Section 17.3)
- Summary of predicted environmental changes and effects and their relationship to Federal jurisdiction and decisions (Section 17.4)
- Conclusions, including significance determinations for the selected VCs (Section 17.6)

## 17.1 SUMMARY OF POTENTIAL EFFECTS

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 Chapter 4 and have been developed in consideration the requirements of the *Canadian Environmental Assessment Act 2012* (CEAA 2012), guidance issued by the Canadian Environmental Assessment Agency (CEA Agency) and Project -specific requirements set out in *Guidelines for the Preparation of an Environmental Impact Statement pursuant to the Canadian Environmental Assessment Act, 2012* BHP Exploration Drilling Project (Environmental Impact Statement (EIS) Guidelines), issued by the CEA Agency on 28 June 2019. BHP will also meet the requirements for an authorization from the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) under the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Act* for the Project to proceed. 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 for the EIS. 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.

The assessment methods used in this EIS included an evaluation of the potential environmental effects for each VC that may arise during routine Project activities and potential accidental events examining the degree and nature of change to, and resulting effects on, the existing environment. The assessment methods also included an evaluation of potential cumulative effects to consider whether there is potential for the residual environmental effects of the Project to interact cumulatively with the residual environmental effects of other past, present, or future (i.e., certain or reasonably foreseeable) physical activities in the vicinity of the Project.

The VCs selected for the EIS include:

- 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 Communities
- Commercial Fisheries and Other Ocean Uses

Routine Project activities with the potential to affect the environment which are considered in this assessment includes drilling within EL 1157 and EL 1158 through the presence and operation of the mobile offshore drilling unit (MODU); vertical seismic profiling (VSP); well testing and flaring; well abandonment and decommissioning (including suspension); and supply and service activities. A summary of potential interactions between the VCs and routine Project activities included in the scope of the EIS, which formed the basis for the effects analysis, are presented in Table 17.1.

Potential accidental events (non-routine events) which may occur as a result of the Project, and the associated environmental effects, are assessed in Chapter 15. Non-routine events considered within the scope of the Project include blowouts (uncontrolled release of hydrocarbons during drilling), and MODU and vessel batch spills and releases (e.g., hydraulic fluid, drilling mud, diesel). A summary of potential interactions between the VCs and non-routine events included in the scope of the EIS are also included in Table 17.1.

Chapter 16 assesses the effects of the environment on the Project and considers how local environmental conditions and natural hazards (e.g., extreme weather) could adversely affect the Project and thus result in potential effects on the environment (e.g., accidental events). Potential adverse effects of the environment on a project are typically a function of project design and environmental conditions (e.g., geohazards, ice conditions) that could affect the project. The implementation of mitigation measures, such as engineering and environmental design criteria, industry standards, and environmental monitoring, will reduce the potential adverse effects on the Project.

The implementation of mitigation measures to reduce or eliminate potential adverse effects are fully integrated into the effects assessment and summarized in Section 17.2 and an overview of the effects analysis is presented in Section 17.3.

**Table 17.1 Potential Project-VC Interactions and Effects**

| Planned Activity | Valued Component | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 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 | Commercial Fisheries and Other Ocean Uses | Indigenous Peoples and Communities | |
| | Change in Risk of Mortality or Physical Injury | Change in Habitat Availability, Quality and Use | Change in Risk of Mortality or Physical Injury | Change in Habitat Quality and Use | Change in Risk of Mortality or Physical Injury | Change in Habitat Quality and Use | Change in Habitat Quality | Change in Availability of Resources or Operating Environment | Change in Commercial Communal Fisheries | Change in Current Use of Lands and Resources for Traditional Purposes |
| **Routine Activities** | | | | | | | | | | |
| Presence and operation of a MODU (including drilling, associated safety zone, lights, and sound) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Vertical Seismic Profiling (VSP) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Discharges (e.g., drill muds / cuttings, liquid discharges) | ✓ | ✓ | ✓ | ✓ | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Well Testing and Flaring (including air emissions) | – | – | ✓ | ✓ | – | – | – | – | – | ✓ |
| Well Decommissioning and Abandonment or Suspension | – | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Supply and Servicing Operations (including helicopter transportation and Project support vessel (PSV) operations) | – | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Accidental Events** | | | | | | | | | | |
| Well Blowout Incident | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Marine Diesel Spill | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Synthetic-based mud (SBM) Spill | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Notes:
✓ = Potential interaction
– = No interaction

# 17.2 SUMMARY OF MITIGATION, MONITORING AND FOLLOW-UP

## 17.2.1 Summary of Mitigation Measures

The implementation of mitigation measures is proposed to reduce or eliminate potential adverse effects. Many potential adverse environmental effects identified in this EIS can be managed effectively with standard operating procedures and standard mitigation measures. These mitigation measures have been routinely and successfully applied to similar oil and gas exploration programs off Newfoundland and Labrador (NL) and elsewhere in eastern Canada. In some cases (e.g., fishing gear loss) compensation measures may be warranted. Each VC assessment describes how the mitigation measures will reduce or eliminate potential adverse effects on the VC. 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. Table 17.2 provides a summary of standard mitigation and Project-specific commitments to be implemented.

**Table 17.2 Summary of BHP Canada Exploration Drilling Program (2019-2028) EIS - Mitigation Measures**

| No. | Proponent Commitments | EIS Reference |
|---|---|---|
| **General Mitigation Measures** | | |
| 1 | Contractors and subcontractors shall be required to demonstrate conformance with the Health, Safety and Environment standard and performance requirements that have been established, by BHP. | Section 2.9.4 |
| 2 | 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*. | Section 2.9.4<br>Section 16.2 |
| 3 | The observation, forecasting and reporting of physical environment data will be conducted in accordance with the Offshore Physical Environment Guidelines (NEB et al. 2008). | Section 2.9.4<br>Section 16.2 |
| 4 | 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. | Section 2.9.4<br>Section 16.2 |
| 5 | 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 (Fisheries and Oceans Canada (DFO) 2012). | Section 2.9.4 |
| 6 | 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. | Section 2.9.4<br>Section 16.2 |

## Table 17.2 Summary of BHP Canada Exploration Drilling Program (2019-2028) EIS - Mitigation Measures

| No. | Proponent Commitments | EIS Reference |
|---|---|---|
| 7 | 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. | Section 2.9.4<br>Section 16.2 |
| 8 | 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). | Section 2.9.4<br>Section 16.2 |
| 9 | 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). | Section 2.9.4 |
| 10 | 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. | Section 2.9.4<br>Section 12.3<br>Section 13.3 |
| 11 | 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 2017a), which apply when gear loss or damage occurs because of a spill or authorized discharge, emission or escape of petroleum. | Section 2.9.4<br>Section 12.3<br>Section 13.3 |
| 12 | 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. | Section 12.3 |
| 13 | BHP will continue to engage Indigenous communities to share Project details as applicable and facilitate coordination of information sharing. An Indigenous Fisheries Communication Plan will be used to facilitate coordinated communication with Indigenous fishers. | Section 13.3 |
| 14 | BHP will maintain ongoing communications with the Northwest Atlantic Fisheries Organization (NAFO) Secretariat, through DFO as the Canadian representative, regarding planned Project activities, including timely communication of drilling locations, safety zone, and decommissioned well sites. | Section 12.3 |
| 15 | BHP will contact DFO about timing and locations of planned DFO research surveys. | Section 12.3 |
| 16 | BHP will contact and inform the Department of National Defence (DND) of planned marine Project Activities and identify a specific individual or office to serve as a Point of Contact for Maritime Forces Atlantic queries and concerns. | Section 12.3 |
| 17 | If other petroleum exploration activities (e.g., another operator's seismic survey) are planned within the Project Area, or associated vessels are required to pass through the Project Area, communication protocols will be maintained with operators. | Section 12.3 |

## Table 17.2 Summary of BHP Canada Exploration Drilling Program (2019-2028) EIS - Mitigation Measures

| No. | Proponent Commitments | EIS Reference |
|---|---|---|
| 18 | In accordance with the Offshore Physical Environmental Guidelines (NEB et al. 2008), BHP will develop a Project-specific Ice Management Plan 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. | Section 16.2 |
| **Presence and Operation of the MODU** | | |
| 19 | 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. | Section 2.9.4<br>Section 12.3<br>Section 16.2 |
| 20 | 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. | Section 2.9.4 |
| 21 | The MODU will be supported by a fleet of PSVs to re-supply fuel, equipment, and other supplies during the drilling program. A stand-by vessel, which has a Canadian Standby Certificate, will be in attendance at all times. The selection criteria for vessels engaged in Project activities will include year-round operation for the environmental conditions prevalent in the Project Area and larger RAA. | Section 16.2 |
| 22 | 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. | Section 2.9.4<br>Section 12.3<br>Section 13.3 |
| 23 | 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. | Section 2.9.4<br>Section 11.3<br>Section 12.3<br>Section 16.2 |
| 24 | 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. | Section 2.9.4<br>Section 8.3<br>Section 11.3<br>Section 12.3 |
| 25 | 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. | Section 2.9.4<br>Section 8.3<br>Section 9.3<br>Section 11.3 |
| 26 | 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. | Section 2.9.4 |

### Table 17.2 Summary of BHP Canada Exploration Drilling Program (2019-2028) EIS - Mitigation Measures

| No. | Proponent Commitments | EIS Reference |
|---|---|---|
| 27 | BHP, in consultation with Environment and Climate Change Canada (ECCC) Canadian Wildlife Service (CWS), will develop a protocol for systematic, daily searches for seabirds stranded on the MODU and PSVs, which will include the documentation of search effort. Seabirds found will be recovered, rehabilitated, released and documented in accordance with the methods in Procedures for Handling and Documenting Stranded Birds Encountered on Infrastructure Offshore Atlantic Canada (ECCC 2017a). BHP will provide training in these protocols and procedures. A Seabird Handling Permit will be obtained from ECCC-CWS annually. In accordance with ECCC requirements, an annual report and all occurrence data that summarizes stranded and/or seabird handling occurrences will be submitted to ECCC. | Section 9.3 |
| 28 | BHP will monitor daily for the presence of marine birds from the drilling installation using a trained observer following Environment and Climate Change Canada's *Eastern Canada Seabirds at Sea Standardized Protocol for Pelagic Seabird Surveys from Moving and Stationary Platforms* and monitor for the presence of stranded birds and follow Environment and Climate Change Canada's *Procedures for Handling and Documenting Stranded Birds Encountered on Infrastructure Offshore Atlantic Canada.* | Section 9.3 |
| 29 | Adequate food and potable water stores and water makers will necessarily be maintained on the MODU to accommodate weather-related delays in the transportation of supplies. | Section 16.2 |
| **Discharges** | | |
| 30 | 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 the International Convention for the Prevention of Pollution from Ships (MARPOL) and the intent of the Global Gas Flaring Reduction Partnership. | Section 2.7<br>Section 2.9.4 |
| 31 | 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 Offshore Waste Treatment Guidelines [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 environmental protection plan (EPP) and waste management plan (WMP) will be designed to prevent unauthorized waste discharges. | Section 2.7<br>Section 2.9.4<br>Section 8.3<br>Section 11.3 |
| 32 | Selection of drilling chemicals will be in accordance with the Offshore Chemical Selection Guidelines (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 Offshore Chemical Notification System scheme and Pose little or no risk to the environment by the Convention for the Protection of the Marine Environment of the North-East Atlantic. | Section 2.7<br>Section 2.9.4<br>Section 8.3<br>Section 11.3 |

## Table 17.2 Summary of BHP Canada Exploration Drilling Program (2019-2028) EIS - Mitigation Measures

| No. | Proponent Commitments | EIS Reference |
|---|---|---|
| 33 | Discharges of SBM 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. | Section 2.7<br>Section 2.9.4<br>Section 8.3<br>Section 11.3 |
| 34 | 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. | Section 2.7<br>Section 2.9.4 |
| 35 | 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. | Section 2.7<br>Section 2.9.4 |
| 36 | Ballast water will be discharged according to the International Maritime Organization *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. | Section 2.7<br>Section 2.9.4<br>Section 8.3 |
| 37 | 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. | Section 2.7<br>Section 2.9.4<br>Section 8.3<br>Section 11.3 |
| 38 | 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. | Section 2.7<br>Section 2.9.4 |
| 39 | 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. | Section 2.7<br>Section 2.9.4 |
| 40 | Blowout preventer (BOP) fluids and other discharges from the subsea control equipment will be discharged according to OWTG and OCSG. | Section 2.7<br>Section 2.9.4 |
| 41 | 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. | Section 2.7<br>Section 2.9.4 |
| 42 | 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. | Section 2.7<br>Section 2.9.4 |
| 43 | Biomedical waste will be collected onboard by the medical professional and stored in special containers before being sent to land for incineration. | Section 2.7<br>Section 2.9.4 |
| 44 | 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. | Section 2.7<br>Section 2.9.4<br>Section 8.3<br>Section 11.3 |
| 45 | 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. | Section 2.7<br>Section 2.9.4 |

## Table 17.2 Summary of BHP Canada Exploration Drilling Program (2019-2028) EIS - Mitigation Measures

| No. | Proponent Commitments | EIS Reference |
|---|---|---|
| 46 | As part of the OA application process with the C-NLOPB, a Waste Management Plan will be prepared before drilling operations. | Section 2.7 |
| **VSP Surveys** | | |
| 47 | 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. | Section 2.9.4<br>Section 8.3<br>Section 9.3<br>Section 10.3<br>Section 11.3 |
| **Well Evaluation and Testing** | | |
| 48 | If flaring is required, BHP will discuss flaring plans with the C-NLOPB including steps to reduce adverse effects on migratory birds. This may involve restricting flaring to the minimum required to characterize the wells' hydrocarbon potential and as necessary for the safety of the operation, minimizing flaring during periods of migratory bird vulnerability, and the use of a water curtain to deter birds from the general vicinity of the flare. | Section 9.3 |
| 49 | If flaring is required, BHP will limit flaring to the length of time required to characterize the wells' hydrocarbon potential and as necessary for the safety of the operation. | Section 9.3 |
| 50 | If flaring is required, flaring will be conducted as early as practicable during daylight hours to limit flaring that occurs during nighttime. | Section 9.3 |
| 51 | C-NLOPB will be notified at least 30 days in advance of planned flaring to determine whether the flaring would occur during a period of migratory bird vulnerability and to determine how the Proponent plans to avoid adverse environmental effects on migratory birds. | Section 9.3 |
| **Supply and Servicing Operations** | | |
| 52 | PSVs will follow established shipping routes where they exist (i.e., in proximity to shore). | Section 2.9.4<br>Section 12.3<br>Section 13.3 |
| 53 | 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. | Section 2.9.4<br>Section 10.3 |
| 54 | 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. | Section 2.9.4<br>Section 10.3 |
| 55 | 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. | Section 2.9.4<br>Section 9.3<br>Section 11.3 |
| 56 | 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):<br>• Reducing vessel speed in heavy seas<br>• Placing gear below deck and covering deck machinery, if possible<br>• Moving objects that may prevent water drainage from the deck | Section 2.9.4 |

## Table 17.2 Summary of BHP Canada Exploration Drilling Program (2019-2028) EIS - Mitigation Measures

| No. | Proponent Commitments | EIS Reference |
|---|---|---|
| | • Making the ship as watertight as possible<br>• Manual removal of ice if required under severe icing conditions | |
| 57 | 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. | Section 2.9.4<br>Section 12.3 |
| 58 | 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. | Section 2.9.4 |
| 59 | The regional CWS office will be contacted for separation distances and altitudes between helicopters transiting to and from the MODU and migratory bird nesting colonies, as per CWS guidelines (Government of Canada 2018) and routes will comply with provincial Seabird Ecological Reserve Regulations, 2015 (no closer than 300 m). Specific details will be provided in the EPP. | Section 9.3<br>Section 11.3 |
| 60 | PSV routes transiting to and from the MODU will be planned to avoid passing within 100 m of migratory bird nesting colonies during the nesting period and will comply with provincial Seabird Ecological Reserve Regulations, 2015 and federal guidelines to reduce disturbance to colonies (ECCC 2017b). Specific details will be provided in the EPP. | Section 9.3<br>Section 11.3 |
| 61 | Searches for stranded birds and recovery, rehabilitation, release and documentation of birds will be conducted on PSVs as outlined above for the MODU. | Section 9.3<br>Section 11.3 |
| **Well Abandonment** | | |
| 62 | 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. | Section 2.9.4<br>Section 8.3<br>Section 11.3<br>Section 12.3 |
| 63 | Once wells have been drilled to True Vertical Depth 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. | Section 2.9.4<br>Section 8.3<br>Section 11.3<br>Section 12.3 |
| **Accidental Events** | | |
| 64 | Spill prevention measures are the most effective way to mitigate against potential effects from accidental events. BHP's strategy for contingency planning and spill response is described in Section 15.5. Mitigation of potential accidental events is incorporated as part of the regulatory processes (e.g., Operations Authorization [OA], Approval to Drill a Well), project-specific safety and response plans (e.g., safety plan, oil spill response plan, EPP), and well design (e.g., BOP). | Section 15.6.1<br>Section 15.6.2<br>Section 15.6.3<br>Section 15.6.4<br>Section 15.6.5<br>Section 15.6.6 |
| 65 | The Project will operate under safety and contingency plans, including an oil spill response plan that will be submitted to the C-NLOPB before the start of any drilling activity as part of the OA process. The oil spill response plan will outline response methods and procedures, and response strategies based on severity of hydrocarbon spills. Potential responses considered in the event of an accidental release may include, but not be limited to, offshore containment and recovery, dispersants (surface application and/or subsurface injection), *in situ* burning, shoreline protection and clean-up, and oiled wildlife response. Further details on spill responses are provided in Section 15.5. | Section 15.6.1<br>Section 15.6.2<br>Section 15.6.3<br>Section 15.6.4<br>Section 15.6.5<br>Section 15.6.6 |

## Table 17.2 Summary of BHP Canada Exploration Drilling Program (2019-2028) EIS - Mitigation Measures

| No. | Proponent Commitments | EIS Reference |
|---|---|---|
| 66 | A Spill Impact Mitigation Assessment (SIMA) / Net Environment Benefit Assessment will be conducted as part of the OA Process as well. These assessments will be used to qualitatively evaluate the risks and trade-offs of feasible and effective response options, when compared to no action. An overall spill response strategy will be selected for the Project based on the SIMA process. If identified as a response option, chemical dispersant application would not occur without authorization from C-NLOPB. | Section 15.6.1<br>Section 15.6.2<br>Section 15.6.3<br>Section 15.6.4<br>Section 15.6.5<br>Section 15.6.6 |
| 67 | Mechanical measures and barriers that are implemented as part of well design, and drilling and monitoring procedures for prevention of blow-outs are described in Section 2.3.4. This includes use of steel casings, drilling fluids, and BOPs for controlling formation pressures. The BOP includes a series of rams that are designed to seal off the wellbore at the wellhead on the seafloor when required. Furthermore, the BOP and other pressure control equipment are tested regularly and recorded in accordance with the Drilling and Production Guidelines (C-NLOPB and CNSOPB 2017b) and to BHP company standards. | Section 15.6.1<br>Section 15.6.2<br>Section 15.6.3<br>Section 15.6.4<br>Section 15.6.5<br>Section 15.6.6 |
| 68 | Specific environmental effects monitoring and follow-up programs may be required in the unlikely event of a spill. These monitoring programs will be developed in consultation with applicable regulatory agencies. | Section 15.6.1<br>Section 15.6.2<br>Section 15.6.3<br>Section 15.6.4<br>Section 15.6.5<br>Section 15.6.6 |
| 69 | Of particular relevance to marine and migratory birds are the commitments related to shoreline protection and clean-up, and oiled wildlife response (see Section 15.5.4). In the event that oil threatens or reaches the shoreline, shoreline protection measures, including deflection from sensitive areas, will be implemented as practical. SCAT teams will be mobilized to the affected areas to conduct shoreline surveys to document the type and degree of shoreline oiling and inform shoreline clean-up and remediation as applicable. SCAT teams will also be used to monitor and evaluate the effectiveness of the clean-up operations. | Section 15.6.2 |
| 70 | BHP will develop an Oiled Wildlife Response Plan (OWRP) and, for incidents where wildlife is threatened, engage specialized expertise to implement the Plan, including the recovery and rehabilitation of wildlife species as needed (see Section 15.5.4 for BHP's oiled wildlife response approach). | Section 15.6.2<br>Section 15.6.3<br>Section 15.6.4 |
| 71 | Implementation of a Fisheries Communication Plan, which would include procedures for informing fishers of an accidental event, appropriate responses, and the locations of closed areas. Emphasis would be on timely communication, thereby providing fishers with the opportunity to haul gear from affected areas, reducing the potential for gear fouling or bringing tainted fish to the marketplace. | Section 15.6.5 |
| 72 | Communications to other ocean users through the media, direct industry-to-industry contacts, and the issuance of Notices to Fish Harvesters, NAVWARNS, and NOTMARs, which would include the locations of affected and/or restricted areas. | Section 15.6.5 |
| 73 | 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 | Section 15.6.5 |

**Table 17.2 Summary of BHP Canada Exploration Drilling Program (2019-2028) EIS - Mitigation Measures**

| No. | Proponent Commitments | EIS Reference |
|---|---|---|
| | Activities (C-NLOPB and CNSOPB 2017a) which apply when gear loss or damage occurs because of a spill or authorized discharge, emission or escape of petroleum. | |
| 74 | An Indigenous Fisheries Communication Plan will be used to facilitate coordinated communication with fishers, including procedures for informing Indigenous groups of an accidental event. Timely communication will be important, thereby providing fishers with the opportunity to haul out gear from the affected areas and reducing the potential for fouling of fishing gear. In the event of Project-related damage to fishing gear, fishers will be compensated in accordance with the *Compensation Guidelines with Respect to Damages Relating to Offshore Petroleum Activity* (C-NLOPB and CNSOPB 2017a). | Section 15.6.6 |

## 17.2.2 Summary of Monitoring and Follow-up Requirements

As per CEAA 2012, a follow-up program is a program for "verifying the accuracy of the environmental assessment (EA) of a designated project" and "determining the effectiveness of any mitigation measures." Given offshore NL has a long history of oil and gas exploration and well-established oil production operations, most potential environmental interactions are well understood, and standard mitigation is well known. Proposed monitoring and follow-up programs are described below.

### 17.2.2.1 Marine Fish and Fish Habitat

BHP proposes to implement an imagery-based monitoring program to address the predicted residual effects of drilling mud and cuttings discharges on marine benthic environments in consideration of proximity to coral Significant Benthic Areas. As discussed in mitigation #24, BHP will conduct a pre-drilling seabed survey at proposed drilling locations. Furthermore, as discussed in mitigation #62, 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. The specific details of the follow-up program will be determined in consultation with the C-NLOPB and DFO and in consideration of pre-drill seabed survey results.

### 17.2.2.2 Marine and Migratory Birds

For the duration of the drilling program for each well:

- Systematic searches for stranded birds will be carried out daily on the MODU and PSVs, and this effort documented, by trained personnel according to search protocols designed specifically for each facility (refer to mitigation #27)
- BHP will monitor daily for the presence of marine birds from the drilling installation using a trained observer following Environment and Climate Change Canada's *Eastern Canada Seabirds at Sea Standardized Protocol for Pelagic Seabird Surveys from Moving and Stationary Platforms* and monitor for the presence of stranded birds and follow Environment and Climate Change Canada's *Procedures for Handling and Documenting Stranded Birds Encountered on Infrastructure Offshore Atlantic Canada* (refer to mitigation #28)

- Retrieval, rehabilitation, release and documentation of stranded birds will be conducted according to Procedures for Handling and Documenting Stranded Birds Encountered on Infrastructure Offshore Atlantic Canada (ECCC 2017a) and associated permit conditions under the *Migratory Birds Convention Act* authorizing the capture and handling of migratory birds
- Results of the monitoring program will be shared with regulators to help further improve the understanding of bird strandings and mortality in the NL offshore area

#### 17.2.2.3 Marine Mammals and Sea Turtles

BHP will develop a marine mammal and sea turtle monitoring plan to be implemented during VSP surveys as outlined in Section 10.3.1.2. The Plan will include Marine Mammal Observer requirements, shutdown, and ramp-up procedures and reporting requirements. A report of the observational program will be submitted annually to the C-NLOPB and DFO, including documentation of marine mammal and sea turtle sightings.

In the unlikely event of a Project vessel collision with a marine mammal or sea turtle, BHP will contact DFO through their 24-hour emergency contact number (1-888-895-3003).

#### 17.2.2.4 Special Areas

BHP is proposing to implement a follow-up program to address uncertainty regarding residual effects of drill waste discharges on the marine benthic environment in consideration of the proximity of sensitive benthic areas to BHP's Project Area and concerns raised about potential effects on cold-water corals. BHP plans to conduct a post-drilling visual survey of the seafloor using an ROV after drilling activities to assess the visual extent of sediment dispersion and validate the modelling for the discharges of drill mud and cuttings. The specific details of the follow-up program will be determined in consultation with the C-NLOPB and DFO in consideration of the pre-drill survey results.

#### 17.2.2.5 Commercial Fisheries and Other Ocean Uses

The implementation of the Project's Fisheries Communication Plan (refer to mitigation #12) will allow for ongoing feedback from fishing interests about the implementation and effectiveness of related mitigation measures, and about changes in fishing activities or science research relevant to the Project Area. Instances of suspected gear damage will be communicated to BHP and will be followed up through the operator gear compensation program as initiated by a claimant (refer to mitigation #11). Other follow-up communications described in the mitigation measures (e.g., contact with DFO, NAFO, DND) will be undertaken regularly, as will the issuance of NAVWARNs and NOTMARs (refer to mitigation #10, #14, #15, and #16). Depending on on-going Project activity, updates and reports on past activities, as required, will provide additional opportunities for consultation and evaluation of effects predictions.

#### 17.2.2.6 Indigenous Peoples and Communities

The implementation of the Project's Indigenous Fisheries Communication Plan (refer to mitigation #13) will allow for ongoing feedback from Indigenous fishing interests about the implementation and effectiveness of related mitigation measures, and about changes in fishing activities or science research relevant to the

Project Area. Instances of suspected gear damage will be communicated to BHP and will be followed up through the operator gear compensation program as initiated by a claimant (refer to mitigation #11).

## 17.3 RESIDUAL ENVIRONMENTAL EFFECTS

The residual environmental effects for routine operations for each VC is presented in Chapters 8 to13. Table 17.3 summarizes the residual effect findings for each VC and indicates the significance of these effects. Chapter 15 of this EIS presents the residual environmental effects for accidental events for each VC. Table 17.4 summarizes the residual effect findings for each VC and indicates the significance of these effects. Where an effect is predicted to be significant (refer to Chapters 8 to 13 for significance criteria for each VC), the likelihood of that effect occurring is also presented.

**Table 17.3 Summary of Residual Effects for Routine Operations**

| Valued Components | Area of Federal Jurisdiction (CEAA, 2012 s.5 "environmental effect") | Potential Effect | Project Activity | Mitigation Reference (refer to Table 17.2) | Residual Effect Characterization | | | | | Ecological/Socio-Economic Context | Significance of Residual Effect | Likelihood of Significant Effect |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | | | |
| Marine Fish and Fish Habitat | s. 5(1)(a)(i) | Change in Risk of Mortality or Physical Injury | Presence and Operation of a MODU | Refer to Section 8.3 | L | PA | MT | IR | R | D | N | N/A |
| | | | VSP | | L | PA | ST | IR | R | D | N | N/A |
| | | | Discharges | | L | PA | ST-LT | IR | R | D | N | N/A |
| | | Change in Habitat Availability, Quality, and Use | Presence and Operation of a MODU | | L | PA-LAA | MT | IR | R | D | N | N/A |
| | | | VSP | | L | PA-LAA | ST | IR | R | D | N | N/A |
| | | | Discharges | | L | PA | MT-LT | IR | R | D | N | N/A |
| | | | Well Decommissioning and Abandonment or Suspension | | L | PA | ST-LT | IR | R | D | N | N/A |
| | | | Supply and Servicing Operations | | L | LAA | MT | IR | R | D | N | N/A |
| Marine and Migratory Birds | s. 5(1)(a)(iii) | Change in Risk of Mortality or Physical Injury | Presence and Operation of a MODU | Refer to Section 9.3 | L | LAA | ST | IR | R | D | N | N/A |
| | | | VSP | | L | PA | ST | IR | R | D | N | N/A |
| | | | Discharges | | L | PA | ST | IR | R | D | N | N/A |
| | | | Well Testing and Flaring | | L | PA | ST | IR | R | D | N | N/A |
| | | | Well Decommissioning and Abandonment or Suspension | | L | LAA | ST | IR | R | D | N | N/A |
| | | | Supply and Servicing Operations | | L | LAA | ST | IR | R | D | N | N/A |
| | | Change in Habitat Quality and Use | Presence and Operation of a MODU | | L | LAA | ST | IR | R | D | N | N/A |
| | | | VSP | | N | PA | ST | UL | R | D | N | N/A |
| | | | Discharges | | L | PA | ST | IR | R | D | N | N/A |
| | | | Well Testing and Flaring | | L | PA | ST | IR | R | D | N | N/A |
| | | | Well Decommissioning and Abandonment or Suspension | | L | LAA | ST | IR | R | D | N | N/A |
| | | | Supply and Servicing Operations | | L | LAA | ST | IR | R | D | N | N/A |
| Marine Mammals and Sea Turtles | s. 5(1)(a)(ii) | Change in Risk of Mortality or Physical Injury | Presence and Operation of a MODU | Refer to Section 10.3 | N | PA | ST-MT | IR | R | D | N | N/A |
| | | | VSP | | N-L | PA | ST-MT | IR | R | D | N | N/A |
| | | | Well Decommissioning and Abandonment or Suspension | | N-L | PA | ST | IR | R | D | N | N/A |
| | | | Supply and Servicing Operations | | N-L | LAA | ST-MT | IR | R | D | N | N/A |
| | | Change in Habitat Quality and Use | Presence and Operation of a MODU | | L | PA-LAA | ST-MT | IR | R | D | N | N/A |
| | | | VSP | | L | PA | ST-MT | IR | R | D | N | N/A |
| | | | Discharges | | N | PA | ST | IR | R | D | N | N/A |
| | | | Well Decommissioning and Abandonment or Suspension | | N | PA | ST | IR | R | D | N | N/A |
| | | | Supply and Servicing Operations | | L | LAA | ST-MT | IR | R | D | N | N/A |

### Table 17.3 Summary of Residual Effects for Routine Operations

| Valued Components | Area of Federal Jurisdiction (CEAA, 2012 s.5 "environmental effect") | Potential Effect | Project Activity | Mitigation Reference (refer to Table 17.2) | Residual Effect Characterization | | | | | Ecological/Socio-Economic Context | Significance of Residual Effect | Likelihood of Significant Effect |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | | | |
| Special Areas | s. 5(1)(b)(i) | Change in Habitat Quality | Presence and Operation of a MODU | Refer to Section 11.3 | L | PA-LAA | ST-MT | IR | R | D | N | N/A |
| Special Areas | s. 5(1)(b)(i) | Change in Habitat Quality | VSP | Refer to Section 11.3 | L | PA-LAA | ST-MT | IR | R | D | N | N/A |
| Special Areas | s. 5(1)(b)(i) | Change in Habitat Quality | Discharges | Refer to Section 11.3 | M | PA | MT-LT | IR | R | D | N | N/A |
| Special Areas | s. 5(1)(b)(i) | Change in Habitat Quality | Well Decommissioning and Abandonment or Suspension | Refer to Section 11.3 | L | PA | ST | IR | R | D | N | N/A |
| Special Areas | s. 5(1)(b)(i) | Change in Habitat Quality | Supply and Servicing Operations | Refer to Section 11.3 | L | LAA | ST-MT | IR | R | D | N | N/A |
| Commercial Fisheries and Other Ocean Uses | s. 5(2)(b)(i) | Change in Availability of Resources or Operating Environment | Presence and Operation of a MODU | Refer to Section 12.3 | L | PA | ST | IR | R | D | N | N/A |
| Commercial Fisheries and Other Ocean Uses | s. 5(2)(b)(i) | Change in Availability of Resources or Operating Environment | VSP | Refer to Section 12.3 | L | PA | ST | IR | R | D | N | N/A |
| Commercial Fisheries and Other Ocean Uses | s. 5(2)(b)(i) | Change in Availability of Resources or Operating Environment | Discharges | Refer to Section 12.3 | L | PA | ST | IR | R | D | N | N/A |
| Commercial Fisheries and Other Ocean Uses | s. 5(2)(b)(i) | Change in Availability of Resources or Operating Environment | Well Decommissioning and Abandonment or Suspension | Refer to Section 12.3 | L | PA | ST-P | IR-C | R-I | D | N | N/A |
| Commercial Fisheries and Other Ocean Uses | s. 5(2)(b)(i) | Change in Availability of Resources or Operating Environment | Supply and Servicing Operations | Refer to Section 12.3 | L | LAA | ST | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change Commercial Communal Fisheries | Presence and Operation of a MODU | Refer to Section 13.3 | L | PA | ST | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change Commercial Communal Fisheries | VSP | Refer to Section 13.3 | N-L | PA | ST | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change Commercial Communal Fisheries | Discharges | Refer to Section 13.3 | L | PA | MT | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change Commercial Communal Fisheries | Well Decommissioning and Abandonment or Suspension | Refer to Section 13.3 | N-L | PA | ST-P | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change Commercial Communal Fisheries | Supply and Servicing Operations | Refer to Section 13.3 | L | LAA | ST | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change in Current Use of Lands and Resources for Traditional Purposes | Presence and Operation of a MODU | Refer to Section 13.3 | L | PA | ST | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change in Current Use of Lands and Resources for Traditional Purposes | VSP | Refer to Section 13.3 | L | PA | ST | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change in Current Use of Lands and Resources for Traditional Purposes | Discharges | Refer to Section 13.3 | L | PA | MT | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change in Current Use of Lands and Resources for Traditional Purposes | Well Testing and Flaring | Refer to Section 13.3 | L | PA | ST | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change in Current Use of Lands and Resources for Traditional Purposes | Well Decommissioning and Abandonment or Suspension | Refer to Section 13.3 | N-L | PA | ST-LT | IR | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i) s.5(1)(c)(iii) | Change in Current Use of Lands and Resources for Traditional Purposes | Supply and Servicing Operations | Refer to Section 13.3 | L | LAA | ST | IR | R | D | N | N/A |
| | | | | | **Magnitude:**<br>N: Negligible<br>L: Low<br>M: Moderate<br>H: High | **Geographic Extent:**<br>PA: Project Area<br>LAA: Local Assessment Area<br>RAA: Regional Assessment Area | **Duration:**<br>ST: Short-term<br>MT: Medium-term<br>LT: Long-term<br>P: Permanent | **Frequency:**<br>UL: Unlikely<br>S: Single event<br>IR: Irregular event<br>R: Regular event<br>C: Continuous | **Reversibility:**<br>R: Reversible<br>I: Irreversible | **Ecological/Socio-Economic Context:**<br>D: Disturbed<br>U: Undisturbed | **Significance:**<br>S: Significant<br>N: Not Significant | **Likelihood:**<br>U: Unlikely<br>L: Likely<br>N/A: Not applicable |

## Table 17.3 Summary of Residual Effects for Routine Operations

| Valued Components | Area of Federal Jurisdiction (CEAA, 2012 s.5 "environmental effect") | Potential Effect | Project Activity | Mitigation Reference (refer to Table 17.2) | Residual Effect Characterization | | | | | Ecological/Socio-Economic Context | Significance of Residual Effect | Likelihood of Significant Effect |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | | | |

**Key/Note:**
VC specific definitions included for each VC in Chapters 8-13.

**Environmental Effects under CEAA 2012:**
5(1)
(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*,
- (ii) aquatic species as defined in subsection 2(1) of the *Species at Risk Act*,
- (iii) migratory birds as defined in subsection 2(1) of the *Migratory Birds Convention Act*, 1994, and
- (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, or
- (iii) outside Canada; and

(c) with respect to Aboriginal 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, or
- (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 where the carrying out of the physical activity, the designated project, or the project requires a federal authority to exercise a power or perform a duty or function conferred on it under any Act of Parliament other than CEAA 2012.

5(2)
(a) a change, other than those referred to in paragraphs (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 (1)(c), of any change referred to in paragraph (a) on
- (i) health and socio-economic conditions,
- (ii) physical and cultural heritage, or any structure, site or thing that is of historical, archaeological, paleontological or architectural significance.

**Table 17.4 Summary of Residual Effects for Accidental Events**

| Valued Components | Area of Federal Jurisdiction (CEAA, 2012 s.5 "environmental effect") | Potential Effect | Accidental Event Scenario | Mitigation Reference (refer to Table 17.2) | Residual Effect Characterization | | | | | Ecological/Socio-Economic Context | Significance of Residual Effect | Likelihood of Significant Effect |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Magnitude | Geographic Extent | Duration | Frequency | Reversibility | | | |
| Marine Fish and Fish Habitat | s. 5(1)(a)(i) | Change in Risk of Mortality or Physical Injury / Change in Habitat Availability, Quality and Use | Well Blowout Incident | Refer to Section 15.5.1 | M-H | RAA* | LT | S | R | D | N | N/A |
| | | | Marine Diesel Spill | | L | LAA | ST | S | R | D | N | N/A |
| | | | SBM Spill | | L | PA | ST-LT | S | R | D | N | N/A |
| Marine and Migratory Birds | s. 5(1)(a)(iii) | Change in Risk of Mortality or Physical Injury / Change in Habitat Quality and Use | Well Blowout Incident | Refer to Section 15.5.2 | H | RAA* | ST-MT | S | R | D | S | U |
| | | | Marine Diesel Spill | | L | LAA | ST | S | R | D | S | U |
| | | | SBM Spill | | L | LAA | ST | S | R | D | N | N/A |
| Marine Mammals and Sea Turtles | s. 5(1)(a)(ii) | Change in Risk of Mortality or Physical Injury / Change in Habitat Quality and Use | Well Blowout Incident | Refer to Section 15.5.3 | M | RAA | MT-LT | S | R | D | N | N/A |
| | | | Marine Diesel Spill | | L | LAA | ST | S | R | D | N | N/A |
| | | | SBM Spill | | L | LAA | ST | S | R | D | N | N/A |
| Special Areas | s. 5(1)(b)(i) | Change in Habitat Quality | Well Blowout Incident | Refer to Section 15.5.4 | M-H | RAA | ST-MT | S | R | D | N | N/A |
| | | | Marine Diesel Spill | | N/A | N/A | N/A | N/A | N/A | N/A | N | N/A |
| | | | SBM Spill | | L | PA | ST-LT | S | R | D | N | N/A |
| Commercial Fisheries and Other Ocean Uses | s. 5(2)(b)(i) | Change in Availability of Resources or Operating Environment | Well Blowout Incident | Refer to Section 15.5.5 | M-H | RAA | MT | S | R | D | N | N/A |
| | | | Marine Diesel Spill | | L | LAA | ST | S | R | D | N | N/A |
| | | | SBM Spill | | N | PA | ST | S | R | D | N | N/A |
| Indigenous Peoples and Communities | s.5(1)(c)(i)<br>s.5(1)(c)(iii) | Change in Commercial Communal Fisheries / Change in Current Use of Lands and Resources for Traditional Purposes | Well Blowout Incident | Refer to Section 15.5.6 | M-H | RAA | MT-LT | S | R | D | S | U |
| | | | Marine Diesel Spill | | L | LAA | ST | S | R | D | N | N/A |
| | | | SBM Spill | | N-L | PA | ST | S | R | D | N | N/A |

Notes:
* In certain scenarios, effects may extend beyond the RAA.
See Table 17.3 for key.

# 17.4 SUMMARY OF PREDICTED ENVIRONMENTAL CHANGES AND EFFECTS AND THEIR RELATIONSHIP TO FEDERAL JURISDICTION AND DECISIONS

To satisfy sections 5(1) and 5(2) of CEAA 2012, the EIS assesses and evaluates the potential environmental changes and resulting environmental effects that may result from the Project. Table 17.3 summarizes residual environmental effects from routine Project-related activities and Table 17.4 summarizes residual environment effects from accidental events. Table 17.5 summarizes the changes that may be caused by the Project on the components of the environment listed in sections 5(1)(a) and (b) of CEAA 2012, including those that are directly linked or necessarily incidental to federal decisions that would allow the Project to proceed. The changes noted in Table 17.5 are detailed below in Sections 17.4.1 through 17.4.3. Conclusions in this section are summarized from the detailed analyses in Chapters 8 through 16 and are categorized as follows:

- Changes to components of the environment within federal jurisdiction
- Changes to the environment that would occur on federal lands, in another province, or outside Canada
- Changes to the environment that are directly linked or necessarily incidental to federal decisions

**Table 17.5 Summary of Changes to the Environment from Routine Activities and Unplanned (Accidental) Events**

| Topic | Changes |
|---|---|
| **Changes to Components of the Environment within Federal Jurisdiction** | |
| Marine Fish and Fish Habitat (including species at risk) | • Change in Risk of Mortality or Physical Injury<br>• Change in Habitat Availability, Quality, and Use |
| Marine and Migratory Birds (including species at risk) | • Change in Risk of Mortality or Physical Injury<br>• Change in Habitat Quality and Use |
| Marine Mammals and Sea Turtles (including species at risk) | • Change in Risk of Mortality or Physical Injury<br>• Change in Habitat Quality and Use |
| **Changes to the Environment that Would Occur on Federal or Transboundary Lands** | |
| Special Areas | • Change in Habitat Quality |
| Commercial Fisheries and Other Ocean Uses | • Change in Availability of Resources or Operating Environment |
| Indigenous Peoples and Communities | • Change in Commercial Communal Fisheries<br>• Change in Current Use of Lands and Resources for Traditional Purposes |
| **Changes to the Environment that are Directly Linked or Necessarily Incidental to Federal Decisions** | |
| Accord Acts Authorizations (Operations Authorization and Well Approval under the Accord Acts and *Newfoundland and Labrador Offshore Petroleum Drilling and Production Regulations*) | • Operations Authorizations and Well Approvals under the Accord Acts sanction offshore exploration drilling projects in their entirety. Therefore, the changes to the environment associated with Project activities and components are directly linked or necessarily incidental to these authorizations. |

**Table 17.5 Summary of Changes to the Environment from Routine Activities and Unplanned (Accidental) Events**

| Topic | Changes |
|---|---|
| Authorization under section 35(2)(d) of the *Fisheries Act* (if applicable) | • Change in risk of mortality or physical injury and/or change in habitat availability, quality, and use that constitutes serious harm to fish that are part of or support a commercial, recreational, or Indigenous fishery, or to fish that support such a fishery. |

## 17.4.1 Changes to Components of the Environment within Federal Jurisdiction

Under section 5(1)(a) of CEAA 2012, an EA is required to consider changes that may be caused to the following components of the environment that are within federal jurisdiction (i.e., within the legislative authority of Parliament): fish, as defined in section 2 of the *Fisheries Act;* aquatic species, as defined in section 2(1) of *Species at Risk Act*; and migratory birds, as defined in section 2(1) of the *Migratory Birds Convention Act*. An assessment for these components is provided in Chapter 8 (Marine Fish and Fish Habitat), Chapter 9 (Marine and Migratory Birds), and Chapter 10 (Marine Mammals and Sea Turtles) and is summarized below.

As discussed in Chapter 8, Project activities and components occurring in the marine environment may influence the biological and physical components of the marine ecosystem, including the marine fish, marine plants, and the associated habitats on which they depend. Marine plants include algae, marine flowering plants, and phytoplankton. The Project Area depths are generally beyond the range for marine flowering plants and macroalgae; however, phytoplankton is the base for many marine food webs and is an important biotic component of marine fish and fish habitat. Potential interactions include injury, mortality, or behavioral effects from underwater sound or other disturbances in the marine environment, effects to benthic communities through the alteration of marine habitats and change in habitat quality from discharges. Project activities are predicted to result in residual adverse environmental effects to marine fish and fish habitat from underwater sound and lighting emissions and discharges to the marine environment. The low magnitude and localized or short-term nature of predicted effects will result in interactions with marine fish and fish habitat that are spatially and temporally limited. Corals and sponges may provide biogenic habitat to fish and other invertebrates and their estimated recovery rates from injury and health effects are generally slow. However, overall effects are predicted to be low considering implementation of pre-drilling seabed surveys which will be conducted to determine if sensitive environmental features are present (and can therefore be avoided) and limited spatial extent of drill cuttings discharge (refer to Section 8.3.1.3 for details on drill cutting discharge). The potential for interactions between marine fish SAR and Project activities is limited through adherence to mitigation and environmental protection measures as used for fish species that are not of conservation concern (refer to Section 8.3.1.2 for mitigation). Although there is overlap between the LAA and critical habitat for northern and spotted wolffish, the area of overlap is small and potential interactions between these species and Project activities is limited. Project activities are not predicted to have implications on the overall abundance, distribution, or health of marine fish SAR or their eventual recovery. With implementation of mitigation and environmental protection measures, the residual environmental effects on marine fish and fish habitat (including SAR) are predicted to be not significant.

Accidental releases of oil or synthetic-based mud (SBM) in the marine environment will have the potential to affect marine fish and fish habitat. The overall implications for marine fish and fish habitat depend on the nature, scale, and duration of an offshore spill. Hydrocarbon exposure to marine fish may result in change in risk of mortality or physical injury from direct and indirect effects. Hydrocarbon releases may also result in changes to fish habitat availability, quality, and use through potential effects on water and sediment quality, biogenic habitats (e.g., eelgrass beds, corals, and sponges), and associated avoidance of these areas by marine fish. Accidental event scenarios with a subsea blowout would have the greatest potential for causing environmental effects due to the potential quantities and spatial extents. The extent of the effects from a subsea blowout would largely depend on the duration and volume of the spill, and environmental conditions. Fish and invertebrate species in the RAA typically spawn over large spatial scales, and a spill is unlikely to encompass the full geographic extent these spawning areas for any single species. Therefore, the effects of an accidental release are not predicted to affect species such that natural recruitment of juvenile organisms may not re-establish the population(s) to their original level. It is anticipated that through temporary migration, mobile adult fish and invertebrates would be able to avoid hydrocarbon exposure. Oil transported away from the release site would also be highly weathered, patchy and discontinuous with natural degradation processes occurring over a week or more. With the implementation of emergency response and mitigation measures, the predicted residual adverse effects from accidental events scenarios on marine fish and fish is predicted to be not significant.

As discussed in Chapter 9, Project activities and components have potential to interact with migratory birds and their associated habitat as a result of the attraction of nocturnally-active birds to artificial lighting, operational discharges during well drilling and testing operations, underwater sound emissions, and interactions with PSVs and helicopter activities during supply and servicing. The greatest potential for environmental effects on marine and migratory birds is related to artificial lighting associated with presence and operation of a MODU which may result in nocturnal attraction to and stranding of birds (including Leach's storm-petrels) on the MODU. This will be mitigated through the development and implementation of protocols and training for systematic, daily searches, and for recovery, rehabilitation, and release of birds adhering to protocols detailed in ECCC's *Procedures for Handling and Documenting Stranded Birds Encountered on Infrastructure Offshore Atlantic Canada* (ECCC 2017a). BHP will also monitor daily for the presence of marine birds from the drilling installation using a trained observer following Environment and Climate Change Canada's *Eastern Canada Seabirds at Sea Standardized Protocol for Pelagic Seabird Surveys from Moving and Stationary Platforms* and monitor for the presence of stranded birds and follow Environment and Climate Change Canada's *Procedures for Handling and Documenting Stranded Birds Encountered on Infrastructure Offshore Atlantic Canada.* Project-related components, activities and emissions may result in some localized, short-term effects with marine and migratory birds in parts of the Project Area and LAA primarily as a result of bird attraction to offshore lighting and other components, however, the Project is not predicted to result in a detectable decline in overall bird abundance or changes in the spatial and temporal distributions of bird populations within this area. The potential for interactions between individuals of SAR bird species and the Project is limited, and no identified critical habitat is present in the RAA. The Project is therefore not predicted to jeopardize the overall abundance, distribution, or health of SAR. With mitigation and environmental protection measures, the residual adverse environmental effects on marine and migratory birds (including SAR) are predicted to be not significant.

Accidental spill scenarios have potential to result in a change in risk of mortality or physical injury and/or a change in habitat quality and use for marine and migratory birds. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in space and time. There is potential for direct effects from oil from a blowout on the nesting habitat of a subset of marine-associated species, but there is greater potential for direct effects on habitat at sea (i.e., those used for foraging, loafing, and roosting). Although hydrocarbon spills could result in some mortality at the individual level, these residual adverse environmental effects are predicted to be reversible at the population level. However, these environmental effects could be significant if the consequences carried over more than one generation according to the significance threshold used in this EA or self-sustaining population objectives or recovery goals for listed species are jeopardized. A precautionary conclusion is drawn that the residual adverse environmental effect of a blowout incident, large batch spill, or vessel spill is predicted to be significant for marine and migratory birds, but not likely to occur.

As discussed in Chapter 10, routine Project activities and components have the potential to interact with marine mammal and sea turtle species due to underwater sound produced by operation of the MODU, VSP survey, PSVs, and helicopter overflights. These potential sources of disturbance, as well as operational discharges, could result in direct or indirect (e.g., changes in habitat quality) effects on marine mammals and sea turtles. There are two primary pathways from Project activities that may result in change in the risk of mortality or physical injury for marine mammals and sea turtles: ship strikes and underwater sound generated by Project activities. The PSVs transiting to and from the Project Area have the potential to collide with marine mammals or sea turtles, resulting in injury or mortality. The pathway of effect in the case of a ship strike is the physical contact with the vessel. Underwater sound generated by VSP operations and other Project activities has the potential to cause temporary hearing changes in marine mammals or sea turtles (temporary threshold shift) and there is the possibility of permanent hearing damage (permanent threshold shift). Auditory injury from MODU operations is deemed unlikely. There have been no reported cases of marine mammal or sea turtle mortalities that have been causally linked to sounds generated during oil and gas exploration activities. Although Project-related activities may result in localized, short-term effects on some marine mammals and possibly sea turtles in the Project Area extending to the LAA, the number of individuals that may be affected, and the temporary and reversible nature of these effects, indicates that the Project will not result in a detectable decline in overall marine mammal and sea turtle abundance or long-term changes in the spatial and temporal distributions of marine mammal and sea turtle populations. With mitigation and environmental protection measures, the residual environmental effects on marine mammals and sea turtles (including SAR) are predicted to be not significant.

Accidental spill scenarios have potential to result in a change in risk of mortality or physical injury and/or a change in habitat quality and use for marine mammals and sea turtles. The extent of potential effects will depend on how the spill trajectory and the VC overlap in both time and space (Frasier et al. 2020). Marine mammals and sea turtles may be exposed to oil via a combination of pathways (inhalation, ingestion, aspiration, and adsorption). Marine mammals and sea turtles that are closer to the site of the blowout are most likely to be exposed to a more constant flow and higher concentrations of recently released oil, as compared to species that are more prevalent in the nearshore. With the implementation of emergency response and mitigation measures, the predicted residual adverse environmental effects from the accidental event scenarios on marine mammals and sea turtles is predicted to be not significant.

### 17.4.2 Changes to the Environment that would Occur in Federal Lands, in Another Province, or Outside Canada

Under section 5(1)(b) of CEAA 2012, an EA is required to consider changes that may be caused to the environment that would occur on federal lands, in another province, or outside of Canada. Project activities and components described within the scope of this EIS have the potential to result in changes to the environment that would occur on federal lands, including federal submerged lands (i.e., the seabed) and the federal waters and airspace above those lands.

The ELs are located offshore eastern Newfoundland in the Orphan Basin area, with part of the ELs both inside and outside Canada's 200 nautical mile EEZ. The Government of Canada manages fish stocks within the 200 nautical mile EEZ from the Canadian coastline. Within these areas, the Canadian federal *Fisheries Act* provides protection to fisheries by managing the fish resources and habitats that support these activities. NAFO is an intergovernmental fisheries science and management body for fisheries resources in the Northwest Atlantic, including outside the Canadian EEZ.

Environmental effects from routine Project activities, therefore, have the potential to occur both inside and outside Canada's 200 nautical mile EEZ. In addition to the direct environmental effects of the Project components and activities occurring within the area of Canada's jurisdiction and extending to other jurisdictions, the Project may also affect environmental components (such as migratory fish, aquatic species, or birds) that extend to and/or move outside the areas under the jurisdiction of Canada, as described in Chapters 6 and 8 through 11.

For all VCs, an accidental event such as a large-scale oil spill (i.e., well blowout) could possibly result in transboundary effects by extending to other provinces of Canada or outside an area of Canada's jurisdiction, affecting environmental components (such as migratory fish, marine and migratory birds, or marine mammals and sea turtles) that extend across or move within and outside the areas under the jurisdiction of Canada (refer to Chapter 15 and Appendix F). However, with the implementation of proposed well control, spill response, contingency, and emergency response plans (refer to Section 15.5), a major accidental event is unlikely to occur and would not be left unmitigated.

Changes to marine fish and fish habitat, marine and migratory birds, and marine mammals and sea turtles will also occur on federal submerged lands and in federal waters; these components have been addressed in Section 17.4.1. Therefore, this section focuses on special areas, commercial fisheries and other ocean uses, and Indigenous peoples and communities, with greater detail provided in Chapter 11 (Special Areas), Chapter 12 (Commercial Fisheries and Other Ocean Uses), and Chapter 13 (Indigenous Peoples and Communities).

As discussed in Chapter 11, the primary pathways for Project-related activities to affect the physical quality of special areas is artificial lighting, operational discharges during well drilling and testing operations, underwater sound emissions, and interactions with PSVs and helicopter activities during supply and servicing. The Project Area, EL 1157 and/or EL 1158 intersect the Northeast Newfoundland Slope Closure marine refuge, Significant Benthic Areas identified for corals and sea pens, the Northeast Slope Ecologically or Biologically Significant Area (EBSA), and the Slopes of the Flemish Cap and Grand Bank EBSAs. The LAA also intersects with the Slopes of the Flemish Cap and Grand Bank EBSA, Vulnerable Marine

Ecosystems, and the NAFO Fisheries Closure Areas identified mainly for corals and sponges. Project-related activities have the potential to affect the ability of special areas to provide and maintain important ecological and biological functions for related species. With the implementation of applicable mitigation measures (Section 11.3), such as pre-drill seabed surveys and adherence to industry standards for offshore oil and gas activities in Newfoundland and Labrador, the residual adverse environmental effects are predicted to be low in magnitude for most Project components and activities. The residual environmental effects of a change in habitat quality within special areas are considered reversible because although the recovery rate of corals is slow, the benthic ecosystems are expected to recover. Drill cuttings sedimentation is estimated to be relatively low for this Project. This combined with mitigation to reduce potential effects on corals / sponges indicates that effects will not likely result in permanent habitat loss. With mitigation and environmental protection measures in place and implemented, residual adverse environmental effects on special areas are predicted to be not significant.

Accidental spill scenarios have the potential to result in a change in habitat quality for special areas. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in both space and in time. Special areas provide important habitat and may be comparatively more vulnerable to environmental effects, including effects from accidental events, than other areas. Adverse effects on special areas could degrade the ecological integrity of the special area so it is not capable of providing the same ecological function for which it was designated (e.g., protection of sensitive or commercially important species). Given the potentially large amount of oil that could be associated with an unmitigated blowout event, and the possibility for a spill to extend to adjacent areas and resources, it represents the accidental event of greatest environmental concern. The extremely unlikely scenario of such a subsurface blowout has the potential to result in a change in habitat quality of special areas in the RAA. Although hydrocarbon spills could result in adverse effects on special areas, these residual effects were predicted to be reversible at the population level for marine fish and fish habitat, marine and migratory birds and marine mammals and sea turtles. With the implementation of emergency response and mitigation measures, residual adverse effects from accidental events scenarios on special areas are predicted to be not significant.

As discussed in Chapter 12, planned activities associated with the Project have a potential to interact with commercial fisheries either directly through effects on fishing activity itself (e.g., through temporary displacement from preferred fishing grounds, interference and reduced efficiency, or physical interactions, such as fishing gear damage), and/or indirectly from physical or behavioural effects on fish species (e.g., changes in commercial fish or prey health or quality, fish avoiding areas because of underwater sound, or changes in water quality). Many commercial fish species are harvested from RAA waters throughout the year, primarily by Canadian vessels within Canada's EEZ, and by both Canadian and non-Canadian vessels outside of the EEZ. Commercial fisheries in the RAA include a variety of groundfish species such as redfish, Greenland halibut, and Atlantic cod in directed and/or by-catch fisheries. Other important fisheries include shellfish, particularly snow crab (fixed gear pots) over much of the Grand Banks, and shrimp (mobile trawls) in northern parts of the RAA. Harvesting large pelagic species, such as sharks and swordfish, and small pelagics, such as capelin and mackerel also occurs in some parts of the RAA but have not occurred in the Project Area. Given the type and location of planned Project activities, the anticipated level of domestic and foreign commercial fishing where Project activities may take place, and after the implementation of the mitigation measures (Section 12.3), residual effects from routine Project activities are not predicted to result in a measurable reduction in overall levels of commercial harvesting, and/or a loss of net economic returns because of a reduction in the quantity or quality of landings or increased operating expenses, for one or more fishing seasons. 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. With mitigation and environmental protection measures in place and implemented, residual adverse environmental effects on commercial fisheries and other ocean uses are predicted to be not significant.

Project interactions might also affect fisheries research, most of which involves fishing with commercial or modified gear, restrict access to marine areas, and/or require route or timing modifications by other marine operators (including freighters, military operations, cruise liners, or other petroleum exploration ships). Submarine infrastructure or artifacts (e.g., communications cables, shipwrecks, unexploded ordnance) may be affected if they are in areas where Project sub-sea installations occur. Residual effects are not predicted to result in an adverse change in other ocean uses, such as marine research, shipping, military exercises, other petroleum exploration or production, and in-sea infrastructure or artifacts, including changes in the location and timing of these activities resulting in a measurable reduction in their quality, value or integrity over more than a year.

Accidental releases or spills of hydrocarbons (crude oil or marine diesel fuel) or synthetic fluids (SBMs) have a potential to impact the availability of commercial fisheries resources by affecting the health of commercial fish or their habitat, by making preferred fishing grounds inaccessible, by damaging or fouling fishing gear or other equipment, or through negative effects on product markets (i.e., on sales). Other ocean uses could also be adversely affected by the closure of marine areas because of hydrocarbon slicks or clean-up operations. Closures might require marine operators to divert around an affected area, or to delay or relocate other activities and uses. Science studies might be similarly affected. Although the worst-case, unmitigated scenarios presented in the spill modelling report indicate a potential for adverse effects on fish harvesting areas (resulting temporary closures), transportation corridors, and places where other marine activities situate in offshore or coastal areas, these effects will be mitigated through the various response measures described in Section 15.5. With prevention plans, response procedures, good monitoring, and effective communications protocols, it is predicted that accidental events associated with Project will not result in significant residual adverse effects on commercial fisheries and other ocean uses.

As discussed in Chapter 13, the EIS Guidelines identified 41 Indigenous groups with the potential to be affected by Project activities and therefore to be included within the scope of the EA: five groups in NL, 13 groups in Nova Scotia, 16 groups in New Brunswick, two groups in Prince Edward Island, and five groups in Quebec. It is unlikely that effects from routine Project-activities will directly affect the physical or social health and well-being of Indigenous peoples or communities because the Project is in the marine environment and the nearest Indigenous community on the Island of Newfoundland is approximately 450 km away. Physical and cultural sites, including structures, sites, or things of historical, archaeological, paleontological, or architectural significance are not known to exist within the Project Area or LAA. Given the offshore location of the Project and localized extent of Project interactions, routine Project activities are unlikely to adversely affect any structure, site or thing that is of historical, archaeological, paleontological, or architectural significance.

Similar to commercial fisheries (Chapter 12), potential pathways of effects as a result of the Project on commercial communal fisheries associated with Indigenous groups include direct or indirect effects on fished species and/or effects on fishing activity from displacement from fishing areas, gear loss or damage, and/or availability of fisheries resources. Food, social, and ceremonial fishing and/or harvesting activities do not occur in the Project Area or LAA; however, routine Project activities could interact with fish, bird or mammal species that migrate through the Project area and are subsequently harvested or have the potential to be harvested by Indigenous groups from onshore / nearshore harvesting sites. Residual effects on Indigenous fisheries resources would be comparable to effects on marine fish and fish habitat, including species harvested for commercial communal and food, social, and ceremonial purposes, which are determined to likely be temporary and of low magnitude. Routine Project activities are not expected to result in a loss of access to areas or resources relied on for traditional use practices or the loss of traditional use areas within a large portion of the LAA and RAA for a season or adverse effects on socio-economic conditions of affected Indigenous groups, such that there are associated, detectable, and sustained decreases in the quality of life of a community. A decrease in established employment and business activity in commercial communal fisheries (e.g., due to fish mortality and/or dispersion of stocks) is not predicted to the extent that there is a detectable adverse effect upon the economy of the affected Indigenous community. With mitigation and environmental protection measures in place, the residual environmental effects on Indigenous peoples and communities are predicted to be not significant.

An accidental spill has the potential to affect fisheries resources through direct and indirect effects on fished species therefore affecting fisheries success. Fishing activity may also be affected through displacement from traditional fishing areas, gear loss or damage, as well as reducing the marketability of commercial fish products and associated economic losses. These effects to fisheries resources and fishing activity have potential to result in changes to commercial communal fisheries and/or current use of lands and resources for traditional purposes, as well as associated effects on socio-economic conditions, well-being, and quality of life for the Indigenous communities. Given the larger spatial and temporal scale associated with a subsea blowout, there is potential for effects on the availability of fisheries resources (e.g., effects on fisheries species), access to fisheries resources (e.g., fisheries closure), and/or fouling of fishing gear. The Project; however, is not located in an area of high harvesting activity by Indigenous fishers, and in the event of a subsea blowout, trajectory modelling (refer to Section 15.3) shows released oil moving towards the east, away from Canadian shorelines due to the prevailing winds and currents. Because of the widespread nature of the worst-case, unmitigated blowout incident, a significant effect (due to loss of access to areas or resources relied on for traditional use practices or the loss of traditional use areas within a large portion of the LAA and RAA for a season or adverse effects on socio-economic conditions of affected Indigenous groups, such that there are associated, detectable, and sustained decreases in the quality of life of a community) is conservatively predicted for Indigenous peoples and communities in the event of a subsea blowout. The likelihood of this significant effect occurring is considered low, given the potential for a blowout incident to occur and the response measures that would be in place to mitigate potential effects.

### 17.4.3 Changes to the Environment that are Directly Linked or Necessarily Incidental to Federal Decisions

Under section 5(2)(a) of CEAA 2012, an EA is required to consider additional changes that may be caused to the environment and that are 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 designated project. The primary regulatory approvals necessary to conduct an offshore drilling program are an Operations Authorization (Drilling) and a Well Approval (Approval to Drill a Well) pursuant to the Accord Acts and their regulations. A *Fisheries Act* authorization is not expected to be required in support of the Project, as Project activities and components are not predicted to result in harmful alteration, disruption or destruction (HADD) of fish habitat or cause the "death of fish" (other than fishing activities). Drill cuttings dispersion modelling was performed for the Project to assess the footprint, spatial extent, and thickness of discharged drill cuttings. Dispersion sediment thicknesses of 1.5 mm or greater predicted to reach a maximum extent up to 450-580 m from the discharge point cover an area less than 0.12 km² at EL 1157 and EL 1158. Although drilling discharges will result in localized alteration of benthic habitat, these effects will not be permanent and are not anticipated to affect commercial, recreational, or Indigenous fishery species. In advance of drilling, BHP will conduct seabed surveys at the proposed well sites to confirm the absence of sensitive environmental features (e.g., habitat-forming coral or species at risk) at the chosen drilling locations.

This section focuses on changes to the environment other than those referred to under section 5(1)(a) and (b) of CEAA 2012, which are considered in Sections 17.4.1 and 17.4.2, respectively, of this EIS.

Although atmospheric environment is not considered to be a stand-alone VC for this EA, Project activities and components could result in a change to the atmospheric environment through the release of air emissions and generation of sound emissions associated with operation of the MODU, PSVs, and helicopters. Atmospheric environment (i.e., air quality, light and noise and greenhouse gas (GHG)); however, is 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 5.5). GHGs are discussed in Section 2.7.1. Light is discussed in Section 2.7.6. Underwater noise is discussed in Section 2.7.5.1 and Appendix E, with atmospheric noise discussed in Section 2.7.5.3.

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 carbon dioxide equivalent ($CO_2e$) per year. This is approximately 0.71% of Newfoundland and Labrador's average annual emissions for 2017 and 0.01% of the 2017 national inventory. 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. 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.

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 nature of travelling aircraft and PSVs, and distance to human or other receptors.

Under section 5(2)(b) of CEAA 2012, an EA is also required to consider the effects of changes to the environment that are 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 designated project, if any of the following are affected:

- Health and socio-economic conditions
- Physical and cultural heritage and any structure, site or thing that is of historical, archaeological, paleontological or architectural significance

The changes to the environment that are linked to federal decisions on the Project that are required under the Accord Acts and the *Fisheries Act* are summarized in Table 17.6. Operations Authorizations and Well Approvals under the Accord Acts sanction offshore exploration drilling projects in their entirety. Therefore, Project activities and components are directly linked or necessarily incidental to these authorizations.

**Table 17.6 Summary of Changes to the Environment that are Potentially Contingent on Federal Decisions**

| Federal Decision | Changes (Potential Environmental Effects) | Affected VCs |
|---|---|---|
| Accord Acts Authorizations (Operations Authorization and Well Approval under the Accord Acts and *Newfoundland and Labrador Offshore Petroleum Drilling and Production Regulations*) | Change in Risk of Mortality or Physical Injury | • Marine Fish and Fish Habitat<br>• Marine and Migratory Birds<br>• Marine Mammals and Sea Turtles |
| | Change in Habitat Availability, Quality and Use | • Marine Fish and Fish Habitat |
| | Change in Habitat Quality and Use | • Marine and Migratory Birds<br>• Marine Mammals and Sea Turtles |
| | Change in Habitat Quality | • Special Areas |
| | Change in Availability of Resources or Operating Environment | • Commercial Fisheries and Other Ocean Uses |
| | Change in Commercial Communal Fishing or Change in Current Use of Lands and Resources for Traditional Purposes | • Indigenous Peoples and Communities |
| *Fisheries Act* Authorization (Authorization for Serious Harm to Fish under section 35(2)(d) of the *Fisheries Act*) | Change in Risk of Mortality or Physical Injury | • Marine Fish and Fish Habitat |
| | Change in Habitat Availability, Quality and Use | • Marine Fish and Fish Habitat |

Given the distance offshore, Project activities and components are not expected to result in changes to the environment that would have an effect on health conditions; physical and cultural heritage; or any structure, site or thing that is of historical, archaeological, paleontological or architectural significance for Indigenous or non-Indigenous people. Effects on socio-economic conditions, however, may occur from the following potential changes to the environment:

- Change in risk of mortality or physical injury for fish
- Change in habitat quality and use for fish
- Change in availability of resources (for commercial and Indigenous fisheries)
- Change in traditional use for Indigenous people

Potential changes to the environment are, however, anticipated to be temporary and localized around the MODU and PSVs, and that other suitable fish habitat and fishing areas are readily available throughout the RAA. Therefore, these potential changes to the environment are not anticipated to substantially affect socio-economic conditions for commercial or Indigenous fishers (refer to Chapters 12 and 13).

## 17.5 CONCLUSIONS

Table 17.7 summarizes the significance of residual effects identified in Tables 17.3 and 17.4 for each VC for routine operations, accidental events, and cumulative effects, and, where applicable, the likelihood of significant residual adverse environmental effects occurring.

**Table 17.7 Summary of Residual Environmental Effects for Routine Operations, Accidental Events and Cumulative Effects**

| VC | Routine Operations | Accidental Effects | | Cumulative Effects |
|---|---|---|---|---|
| | Significance of Residual Environmental Effect | Significance of Residual Environmental Effect | Likelihood of Significant Effect | Significance of Residual Environmental Effect |
| Marine Fish and Fish Habitat | N | N | N/A | N |
| Marine and Migratory Birds | N | S | U | N |
| Marine Mammals and Sea Turtles | N | N | N/A | N |
| Special Areas | N | N | N/A | N |
| Commercial Fisheries and Other Ocean Uses | N | N | N/A | N |
| Indigenous Peoples and Communities | N | S | U | N |

Key:
N = Not significant residual environmental effect (adverse)
S = Significant residual environmental effect (adverse)
U = Unlikely
N/A = Not Applicable

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 (range of 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 (Table 17.2). They include both general Project 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.

In summary, 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, adverse residual effects from routine Project activities is predicted to be not significant.

## 17.6 REFERENCES

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