Tilt Cove Exploration Drilling Program

Chapter 16: Accidental Events

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16.0 ACCIDENTAL EVENTS

Accidental events for the Project may include malfunctions, upset conditions or other unplanned events. Suncor recognizes that the most effective way to avoid damage to the environment from oil spills is to prevent the occurrence of releases. Suncor has a “zero tolerance” policy towards spills and has emphasized spill prevention in the design, operation and maintenance of the facilities and procedures to be employed offshore. Suncor has in place the personnel, policies, procedures, equipment, and training necessary to reduce the probability of incidents from occurring and to reduce the effects of spills, should they happen.

Suncor will ensure a spill prevention program is in place in consultation with the rig contractor(s) that is intended to limit the amount of petroleum products released to the marine environment. Any volume of oil accidentally released to the marine environment will be considered an oil spill event. Suncor is committed to continual improvement in terms of processes, equipment, systems, and training. In the event that a spill does happen, Suncor has in place the capability for an immediate and tiered response to an oil spill incident occurring during drilling operations.

The C-NLOPB Operations Authorization (OA) requires submission of an Environmental Protection Plan, a Safety Plan and Contingency Plans, including an Emergency Response Plan [ERP] and an Oil Spill Response Plan (OSRP), to provide additional information about response to accidental risks that could occur during Project operations. Suncor has an existing OSRP for its East Coast operations and will develop a Project-specific OSRP, which will be submitted to the C-NLOPB as part of the OA process.

In the wake of the Deepwater Horizon (DWH) spill, the C-NLOPB established special oversight measures for deep-water wells in the NL Offshore Area. The C-NLOPB’s special oversight role applies to any “critical well” (C-NLOPB 2018). Any deep-water well is considered a “critical well”, as is any high pressure-high temperature well or other well where there may be higher concerns of a well control incident. The C-NLOPB’s special oversight measures are focused on well control protocols, equipment and contingencies, blowout prevention, and oil spill contingency plans. The C-NLOPB determines the requirement to exercise special regulatory oversight on a case-by-case basis (C-NLOPB 2018). The water depth of EL 1161 is limited to less than 100 m, and is not considered a deep-water “critical well” site.

16.1 Potential Accidental Events Scenario

This EIS focuses on credible worst-case accidents that could result during exploration drilling, including a subsurface blowout, a batch spill or an SBM spill. Spill trajectory modelling for a worst case scenario has been conducted for a subsurface well blowout incident and a batch spill at a potential well location within EL 1161. A summary of modelling results and assumptions and background information about the modelling work including specific scenarios that were modelled are provided in Section 16.3, and a detailed report on the spill modelling is provided as Appendix E. The effects assessment for these scenarios is provided in Section 16.6.

16.1.1 Loss of Well Control / Subsurface Well Blowout Incident

Suncor's drilling and completions operations place an emphasis on well control and blowout prevention, incorporating well control into the design of the well at the planning phase. Well control protocol is based on the maximum anticipated well pressures expected to be encountered during drilling.

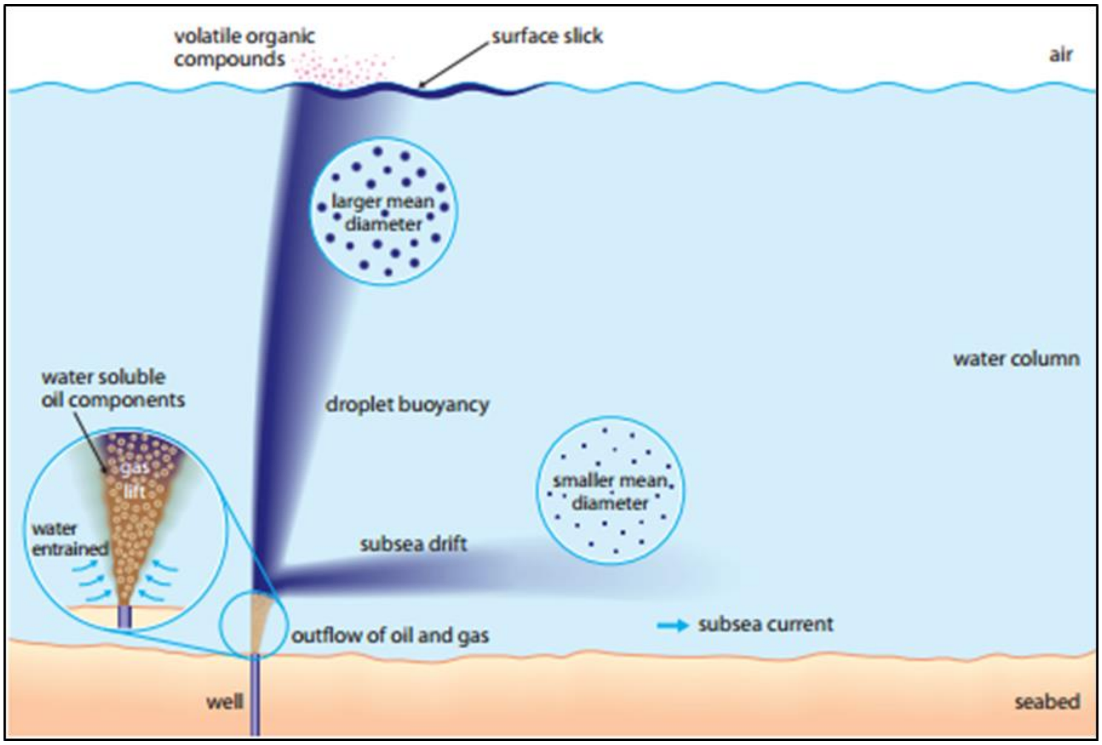
Loss of primary and secondary well control can result in a blowout. Loss of primary well control could result from unexpected contact with high formation pressures, , downhole losses, emergency riser disconnect due to loss of MODU station-keeping or vessel collision with MODU, accidental riser failure, or loss of drilling fluid hydrostatic overbalance. Secondary well loss could result from a rig fire (or explosion), human error or equipment failure.

A blowout, or uncontrolled release from the wellbore, can result from a loss of well control. Drilling through an area of rapidly increasing pressure in the formation can result in a 'kick' if that pressure is higher than the pressure exerted by the mud column. If the kick cannot be contained or the well cannot be returned to a static condition, then well control is lost and a blowout may occur. A blowout preventer (BOP) failure can also result in loss of well control and a subsurface blowout, although the multiple components or built-in redundancies on a BOP make this highly unlikely. The capability of a BOP to shut in a well is periodically pressure- and function-tested as per C-NLOPB regulation.

A deep-water (depths >500 m) subsurface well blowout incident includes (International Petroleum Industry Environmental Conservation Association-International Association of Oil and Gas Producers [IPIECA-IOGP] 2015) the following characteristics as shown in Figure 16-1:

- High-velocity jets of oil and gas: the intense turbulence created by the deep-water subsurface release will break these into small oil droplets and gas bubbles.
- Fast-rising buoyant plume: initial rapid ascent of small oil droplets due to the methane gas content, gas bubbles, and entrained water.
- Slower-rising plume: slower ascent as the plume loses buoyancy due to dissolution of the methane gas.
- Water column stratification: separation of oil droplets and remaining gas bubbles from the plume of entrained water by ocean currents.
- Separation of large and small oil droplets: larger oil droplets continue to rise slowly under their own buoyancy to the surface, while smaller oil droplets remain suspended within the water column and carried horizontally by ocean currents, where they will dilute and biodegrade by petroleum consuming microorganisms (mainly bacteria) in the water column.

A blowout does not necessarily involve a large oil release. It is more likely to involve a relatively small volume than the worst case contemplated for the purposes of the EIS. 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, in this worst case scenario, given the high flowrate of 5,242 barrels (bbl) per hour during the first day for the Project wells, even with a few hours of flow, there could be a spill in the tens of thousands of barrels (assuming no intervention).



Source: IPIECA-IOGP 2015

Figure 16-1 Fate of Oil during a Blowout Incident

16.1.2 Batch Spills

Batch spills are accidental one-time, bulk releases of finite amounts of hydrocarbons such as marine diesel. Batch spills can be characterized by a range of variables (size, location, weather conditions) and response measures to a release can be broad ranging. Batch spills can occur during bunkering operations or as a result of a vessel collision. Vessel collision scenarios can involve supply vessels, non-Project vessels (domestic or international), and/or the MODU. However, strict adherence to marine navigation standards and protocols, including the designation of a 500-m safety (exclusion) zone around the MODU, reduces the risk of vessel collisions. In the unlikely event of a vessel collision, the risk of a loss of hydrocarbon containment remains low.

16.1.3 SBM Spills

An accidental release of SBM could occur at the surface during transfer between the MODU and a supply vessel (via hose failure, incorrect valve alignment, or station-keeping failure) or subsurface, from the riser (via failure of the slip joint packer, riser failure or unlatching of the lower marine riser package). An accidental SBM release could also occur on the deck of the MODU, ending up in the marine environment via MODU drains.

16.2 Oil Spill Prevention

Credible accidents that could result during exploration drilling are a subsurface blowout, batch spill or SBM spill. Suncor will emphasize spill prevention in the selection, operation and maintenance of the semi-submersible and the procedures to be employed offshore. Suncor will review and provide oversight the design, operations and maintenance procedures and practices of the rig contractor(s) that will conduct drilling activities on behalf of Suncor.

Spills have occurred during transfer operations of SBM or diesel fuel from supply vessels to installations previously in the Newfoundland and Labrador offshore. Operators have applied corrective actions and lessons learned from investigations into these incidents that have been incorporated into operational practices and hose management procedures to reduce the probability of recurrence.

Prevention of well control events, including well kicks and blowouts, are based on well control management practices and procedures. There are mechanical measures and barriers that are implemented as part of well design, and drilling and monitoring procedures for well control and prevention of blowouts are described in Section 2.5. Suncor has implemented both best practices in well control and lessons learned from previous events into their well control practices.

16.3 Fate and Behaviour of Potential Spills

16.3.1 Overall Modelling Approach

Oil spill trajectory and fate modelling was conducted to support the evaluation of environmental effects from accidental spills. Two models developed and maintained by RPS were used to conduct modelling for this Project. The full modelling report by RPS can be found in Appendix E. A meeting was held with regulators to discuss all 3 models, including oil spill modelling parameters for this EIS . Hypothetical releases were modelled at one location approximately 325 km east-southeast of St. John’s, Newfoundland and Labrador, immediately west of the Terra Nova oil and gas field. The site selected for the modelling is near the eastern boundary for the EL, which was identified as a potential site for MODU drilling operations within the EL. There are no sensitive areas within EL 1161. Two hypothetical subsurface blowout scenarios were developed within the boundary of the EL 1161. Hypothetical releases were modelled as unmitigated subsurface blowouts of Terra Nova crude oil. The subsurface blowouts were simulated as continuous 30- and 120-day releases, with a total simulation duration 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 release scenario conservatively represents the anticipated time to mobilize a MODU to drill a relief well to kill the well (effectively stopping the subsurface release). The estimated release rates of hydrocarbons simulated in the subsurface blowout scenarios were deliberately 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, 1,000 L release of marine diesel was modelled as a batch spill for 30 days at EL 1161.

There were several goals of the modelling study. A stochastic assessment was used to provide an understanding of the probability and minimum time of exposure from unmitigated releases of oil. Separate highly conservative thresholds were investigated for oil on the water surface, concentrations of hydrocarbons in the water column, and oil on shorelines. 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 (seasonal and interannual variability was assessed using >100 simulated releases). To conservatively determine the approximate magnitude of potential contamination from a single credible “worst-case” scenario (with spatially- and temporally-varying concentrations, rather than simply a threshold exceedance), three individual deterministic scenarios were selected from each stochastic simulation to represent 95th percentile maximum potential effects. These highly conservative 95th percentile scenarios were identified from the area of surface oil, volume of oil in the water column, and the length of shoreline oiled. The modelling provides Suncor with a worst-case scenario for response preparedness purposes.

In a stochastic analysis, multiple model simulations (over one hundred releases) are overlaid upon one another to create a cumulative footprint of the potential trajectories. When combined with one another, the many individual deterministic footprints can be used to generate an area of probability that describes the potential areas that may be exposed to oil from the entire suite of modelled conditions. To determine the probability or likelihood of potential exposure, specific thresholds for surface oil thickness, in-water concentrations, and oil on shorelines and sediments were required (Table 16.1). Above these conservative thresholds, previous studies identified that there is the potential for negative effects to occur.

Floating surface oil is expressed as mass per unit area, averaged over a defined (grid cell) area. If the oil is evenly distributed in that area, it would be equivalent to a mean thickness, where 1 micron (µm) corresponds to a layer of oil that has a mass concentration of approximately 1 g/m². Surface oil thickness is typically associated with visual appearance by aerial observation for responders (National Research Council [NRC] 1985; Bonn Agreement, 2009, 2011; National Oceanic and Atmospheric Administration [NOAA] 2016). As an example, barely visible sheens may be observed above 0.04 µm and silver sheens correspond with surface oil thickness of approximately 0.3 µm. Crude and heavy fuel oils greater than 1 mm thick typically appear as black oil, while light fuels and diesels that are greater than 1 mm thick may appear brown or reddish. Because of the differences between oils and their degree of weathering, as well as the weather conditions and sea state at the time of observations, floating oil will not always have the same appearance. As oil weathers, it may be observed in the form of scattered floating tar balls and tar mats where currents converge. Typically, oil slicks in the environment would be observed as patchy and discontinuous with a range of visual appearances including silver sheen, rainbow sheen, and metallic areas simultaneously, as a combination of thicknesses may be present. Thus, a model result presented as average oil mass per unit area or “thickness” is actually a region with patches of oil of varying thickness, which when distributed evenly in the area of interest, would be on average a certain thickness.

Table 16.1 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, 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, 2016
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 2002, 2004; French McCay et al. 2012
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, 2016
	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.	May appear as black opaque oil.	French et al. 1996; French McCay 2009; French McCay et al. 2011, 2012, 2016

*Thresholds used in supporting stochastic results figures. For comparison, a bacterium is 1 to 10 µm in size, a strand of spider web silk is 3 to 8 µm, and paper is 70 to 80 µm thick. Oil averaging 1 g/m² is approximately equivalent to 1 µm

16.3.2 Modelled Scenarios

16.3.2.1 Stochastic Analysis

A stochastic analysis was conducted for each hypothetical unmitigated subsurface blowout, consisting of 171 individual modelled simulations within each stochastic scenario. Stochastic simulations included continuous unmitigated 30- and 120-day blowouts at EL 1161 using a Terra Nova light crude. Each simulation was initialized with a different start date/time between 2006 and 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 that may result in potential effects. The thresholds used for the stochastic modelling were socio-economic (see Table 16.1):

- 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/m^2

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.

Although large footprints of oil are depicted for stochastic analyses, they are not the expected distribution of oil from any single release, if a spill event occurred. These maps do not provide any 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 (171 individual releases). Only probabilities of 1% or greater were included in the map output, as lesser probabilities represent random variability in the set of 171 trajectories. Stochastic maps of water column exposure depict the likelihood that dissolved and total hydrocarbon concentrations 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.

Hypothetical subsurface release location, parameters, and stochastic scenario information used in the analysis is presented in Table 16.2.

Table 16.2 Hypothetical Subsurface Release Location, Parameters, and Stochastic Scenario Information

Scenario Parameter	Release Locations of Stochastic Scenarios	
Block/Release Location	EL 1161	
Latitude	46.546252 N	
Longitude	48.618508 W	
Water Depth of Release	100 m	
Released Product	Terra Nova Crude (34.58 API, see Table 16.3)	
Gas to Oil Ratio	153 m^3/m^3	
Pipe Diameter	27.31 cm (10.75 in.)	
Oil Discharge Temperature	118°C	
Release Duration	30 Days	120 days
Release Rate	Day 1: 20,000 m^3/day Day 30: 17,000 m^3/day	Day 1: 20,000 m^3/day Day 120: 7,693 m^3/day
Total Released Volume	555,012 m^3	1,661,574 m^3
Model Duration	160 Days	
Number of Simulations within Stochastic Analysis*	171 annual (82 winter and 89 summer) for each scenario	
*A total of 342 individual subsurface releases were modelled within the stochastic analyses.		

16.3.2.2 Deterministic Analysis

Representative deterministic scenarios (i.e., single trajectory) were identified from each set of stochastic results of subsurface blowouts. 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 noted 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. Additionally, the mass balance and surface oil footprint for the batch release of marine diesel are provided.

16.3.3 Model Input Data

In order to reproduce the dynamic and complex processes associated with deep subsea blowout releases, two models developed and maintained by RPS were used. The near-field model OILMAPDeep was used to characterize the dynamics of the jet and buoyant-plume phases of a subsurface blowout. It contains two sub-models, a plume model and a droplet size model. The plume model predicts the evolution of plume position, geometry, centerline velocity, and oil and gas concentrations until the plume either surfaces or reaches a terminal height, at which point the plume is “trapped.” The droplet size model within OILMAPDeep was used to characterize the size and distribution of oil droplets, including the associated mass of oil being released at specific water depths, where the oil jet and buoyant plume traps as an intrusion and the droplets rise by buoyancy alone. The output data from OILMAPDeep were then used to initialize the SIMAP model, which simulated the far-field trajectory, fate, and potential exposure of various environmental compartments within the marine environment following a release.

Geographical data, including habitat mapping and shoreline identification and classification, were obtained from multiple data sources. For Canadian areas, province-specific data from the New Brunswick Department of Natural Resources and Nova Scotia Department of Natural Resources were used, as well as high-resolution data covering Canadian shorelines from ECCC. For the U.S. shoreline, the NOAA's Environmental Sensitivity Index and Maine Department of Environmental Protection's Environmental Vulnerability Index were used. Bathymetry was characterized using databases provided by NOAA National Geophysical Data Center and GEBCO (General Bathymetric Chart of the Oceans).

Wind data for this study were obtained from the U.S. National Centers for Environmental Prediction Climate Forecast System Reanalysis and Climate Forecast System Version 2 models. Currents for the North Atlantic region were acquired from the U.S. Navy Global HYCOM (HYbrid Coordinate Ocean Model) circulation model. All data were acquired and used for the period between January 2006 and December 2012. This corresponded with the most recent long-term (7-year) re-analysis period, meaning the same code-base (which is updated regularly) was used to drive a hind-cast of the coupled hydrodynamic and wind model. Variability within this dataset would be associated with natural environmental variability and not any changes to the way the metocean modelling was conducted.

Terra Nova crude oil and marine diesel composition and properties used in the models are provided in Table 16.3.

Table 16.3 Physical Properties of the Oil Products Used in the Modelling

Physical Property	Terra Nova Crude Oil	Marine Diesel
Density (g/cm^3)	0.852 @25°C	0.83100 @25°C
Viscosity (cP)	2.04 @25°C	2.76 @15°
API Gravity	34.58	38.8
Pour Point (°C)	10	-50
Interface Tension (dyne/cm)	25.45	27.5
Emulsion Maximum Water Content (%)	10	0

Selected parameters for representative for the deterministic analysis are presented in Table 16.4.

Table 16.4 Selected Representative Deterministic Scenarios

Scenario Parameter	Release Parameters for Representative Deterministic Scenarios						
	30-day Subsurface Release			120-day Subsurface Release			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 Batch Spill
Block / Release Site	EL 1161						
Release Type	Subsurface Blowout						Surface Batch Spill
Water Depth of Release	100 m						Surface
Released Product	Terra Nova Crude						Marine Diesel
Release Duration	30 Days			120 Days			Near Instantaneous
Release Rate	Day 1: 20,000 m^3/day Day 30: 17,000 m^3/day			Day 1: 20,000 m^3/day Day 120: 7,693 m^3/day			-
Total Released Volume	555,012 m^3			1,661,574 m^3			1,000 L
Model Duration	160 Days						30 Days
Modelled Start Date and Season	10/7/2010 Winter	3/11/2008 Summer	4/24/2011 Summer	7/14/2007 Summer	4/4/2007 Summer	4/24/2011 Summer	6/15/2009 Summer

The water depth selected for the model was 100 m, which is slightly deeper than the range of 67-90m in EL 1161. In the OILMAPDeep simulations of subsurface blowouts, the water depth was too shallow for the plume trapping height to ever be reached. Therefore, oil from the simulated releases at 100 m was predicted to be transported to the surface rapidly (in a matter of minutes) through the jet and the buoyant plume phases of the release. Small differences in hypothetical release depths that range from 67 to 120 m may result in subtle differences in droplet size distributions. This may result in oil remaining in the water column for seconds or minutes longer, which would result in only extremely small differences in dissolved oil in the water column. Additionally, based upon the underlying hydrodynamics in the region, the longer period of time in the water column would result in only a negligible amount of lateral transport (on the order of metres) prior to surfacing, which would not affect the far-field modelling, nor any conclusions that were developed from the results.

Therefore, while it is known that release depth can affect modelling results, the very small changes that are expected for this Project would not result in any differences that would substantively change the predicted trajectory, fate, or predicted effects of any of the simulated release.

16.3.4 Subsurface Model Blowout Results

16.3.4.1 Stochastic Results

A total of 171 unique model simulations were conducted for each stochastic analysis at the EL 1161 hypothetical release site (Figure 16-2), representing subsurface blowouts in waters offshore of NL. Two blowout release scenarios were modelled for 160-day periods to simulate short (30-day) and long (120-day) duration blowouts. The 120-day release represents the conservative anticipated time to kill the well (effectively stopping the subsurface release) by mobilizing a drilling platform and drilling a relief well, while the 30-day release represents the successful mobilization and implementation of a capping stack to contain the release. The total model duration of 160 days was used to track the trajectory and fate of spilled product as it continued to weather after the release had stopped.

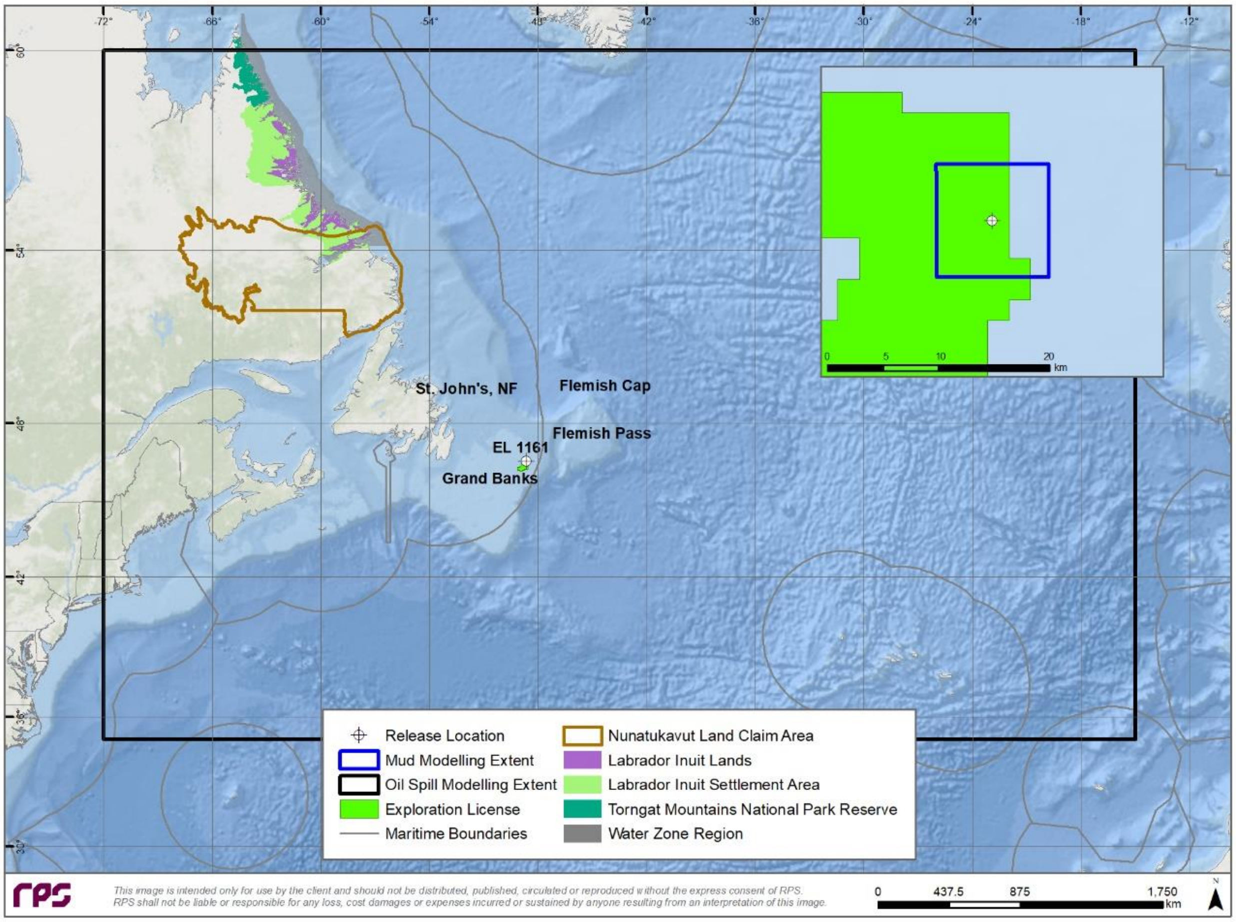


Figure 16-2 Hypothetical Release Location for the Subsurface Blowout on EL 1161

Summaries of the stochastic analyses of potential surface oil and water column exposure by dissolved hydrocarbons depict areas to the east of the release site as having the highest potential likelihood (>90%) to exceed socio-economic thresholds (annual probabilities depicted in Figures 16-3 to 16-8; see full RPS report in Appendix E for seasonal figures). The >90% likelihood area typically extended up to 1,500 km to the east to the edge of the model domain for the surface and water column oil. This is the result of persistent fractions of the Terra Nova crude being on the surface (emulsified, tarballs, and when environmental conditions are below the pour point). Notably, the high probability contours for surface oil thickness were much greater during winter months, when the temperature was lower than the pour point and surface oil remained thick, as it did not spread. As a result of this "freezing" behavior, it is also noted that the water column exceedance footprints for winter were typically slightly smaller than that of summer, the result of the less entrainment and dissolution from surface oil because the oil was below the pour point during winter months. Predicted water column probability footprints were typically smaller than surface oil footprints, with the probability of threshold exceedance predicted to decrease more rapidly for water column results as distance from the release site increased (Table 16.5; Figures 16-4 and 16-7).

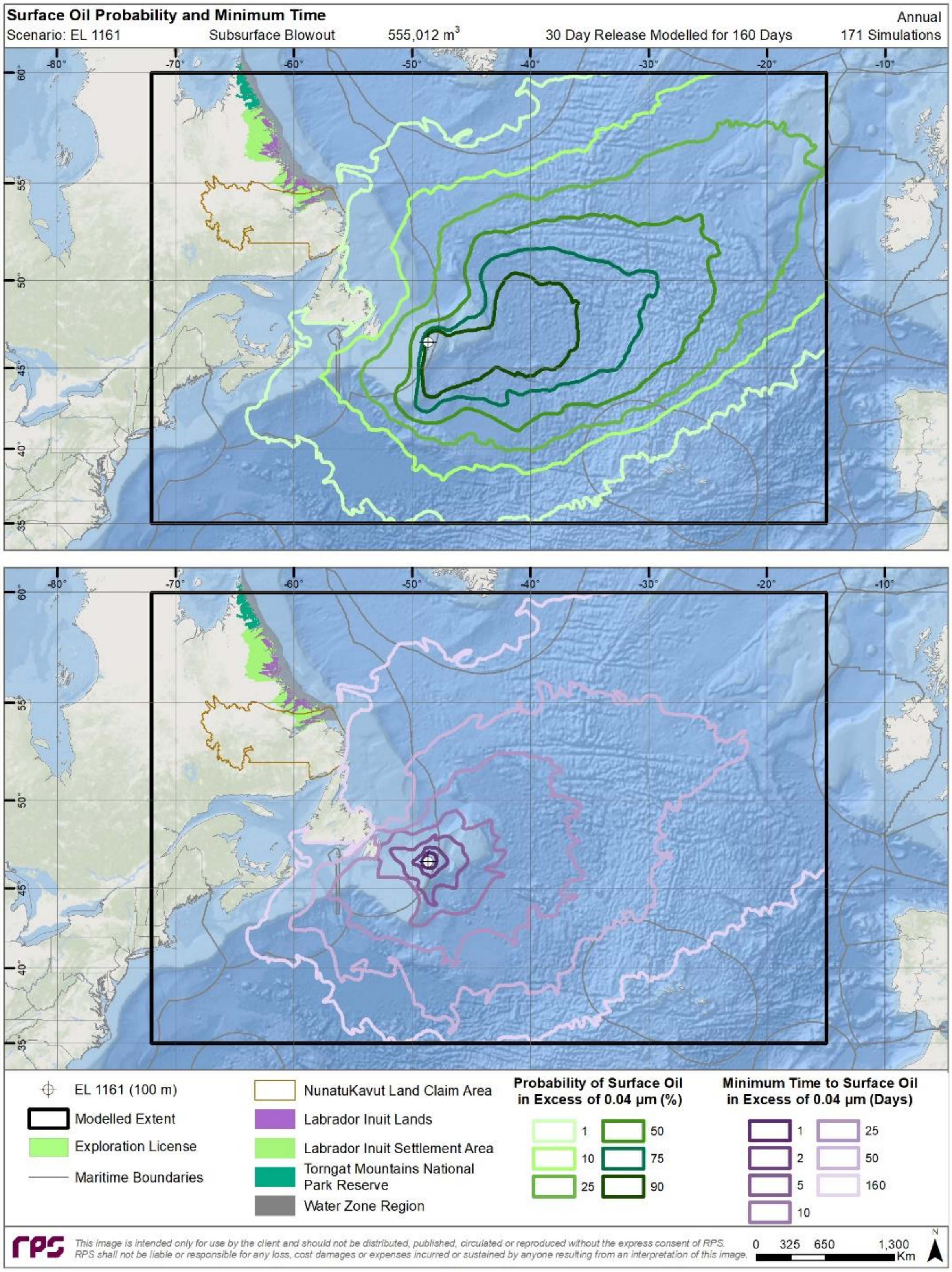


Figure 16-3 **Annual probability of surface oil thickness >0.04 µm (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1161**

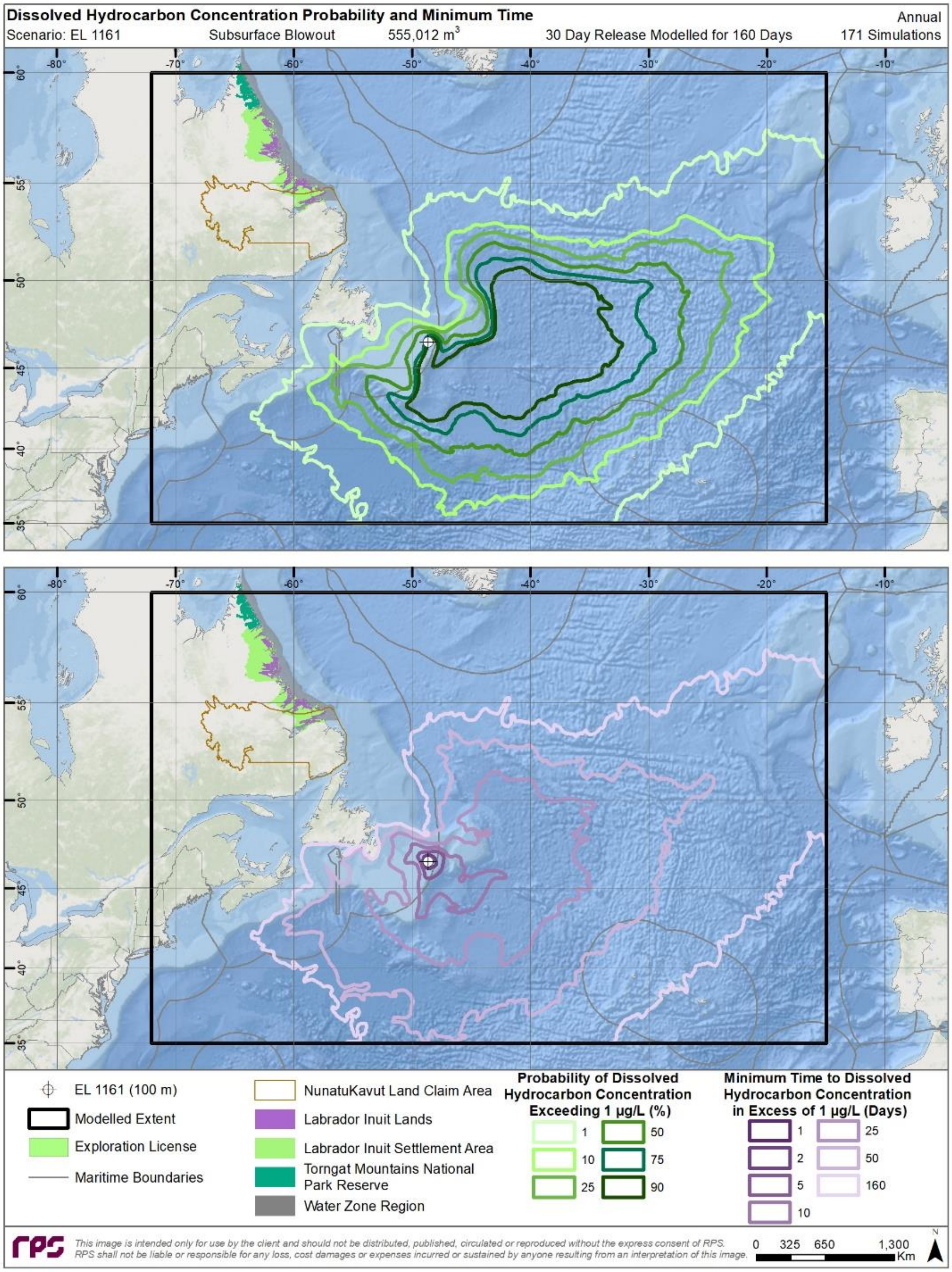


Figure 16-4 Annual probability of dissolved hydrocarbon concentrations >1 µg/L at some depth in the water column (top) and minimum time to threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1161

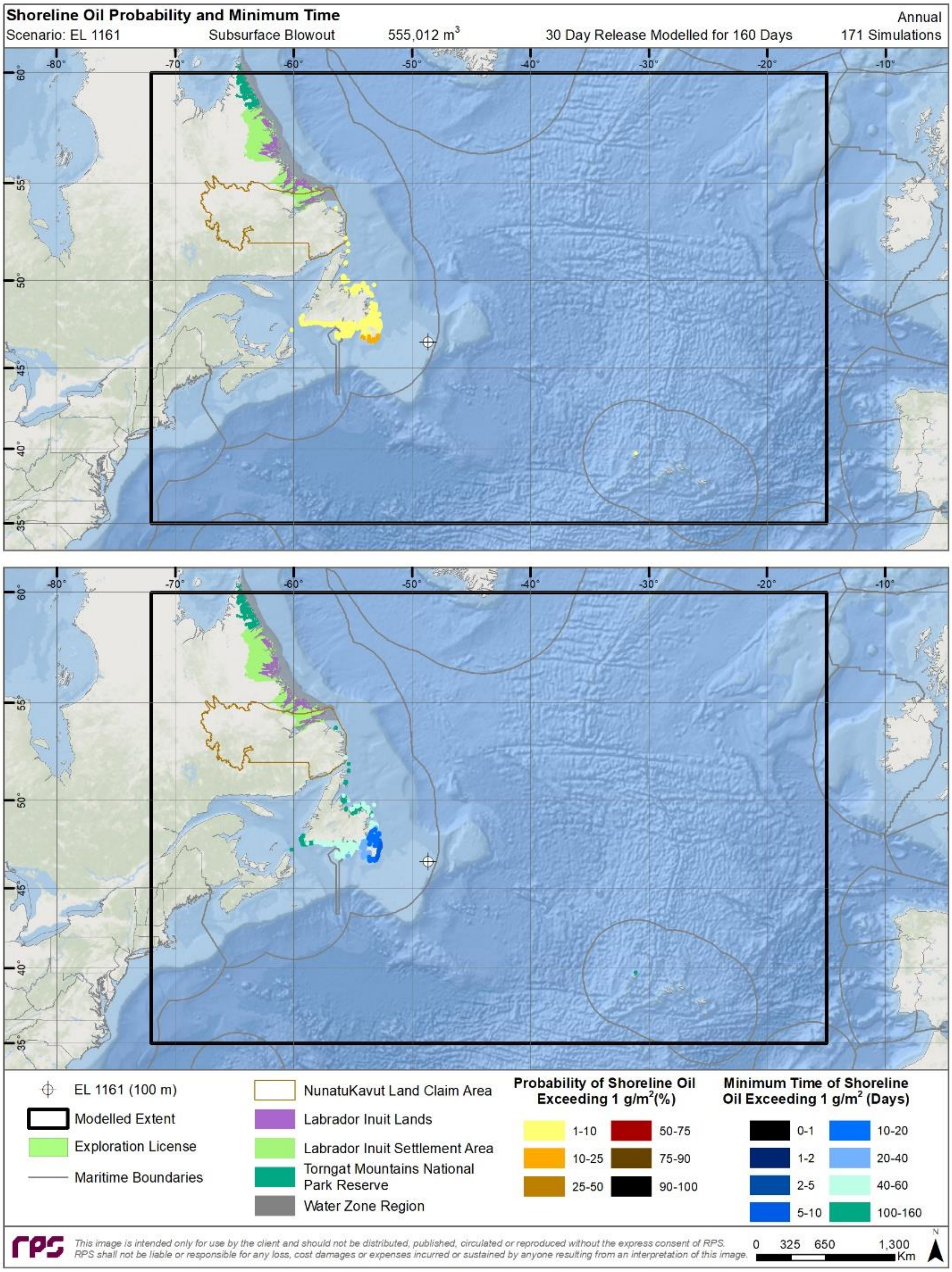


Figure 16-5 Annual probability of shoreline contact >1 g/m² (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 30-day subsurface blowout at EL 1161

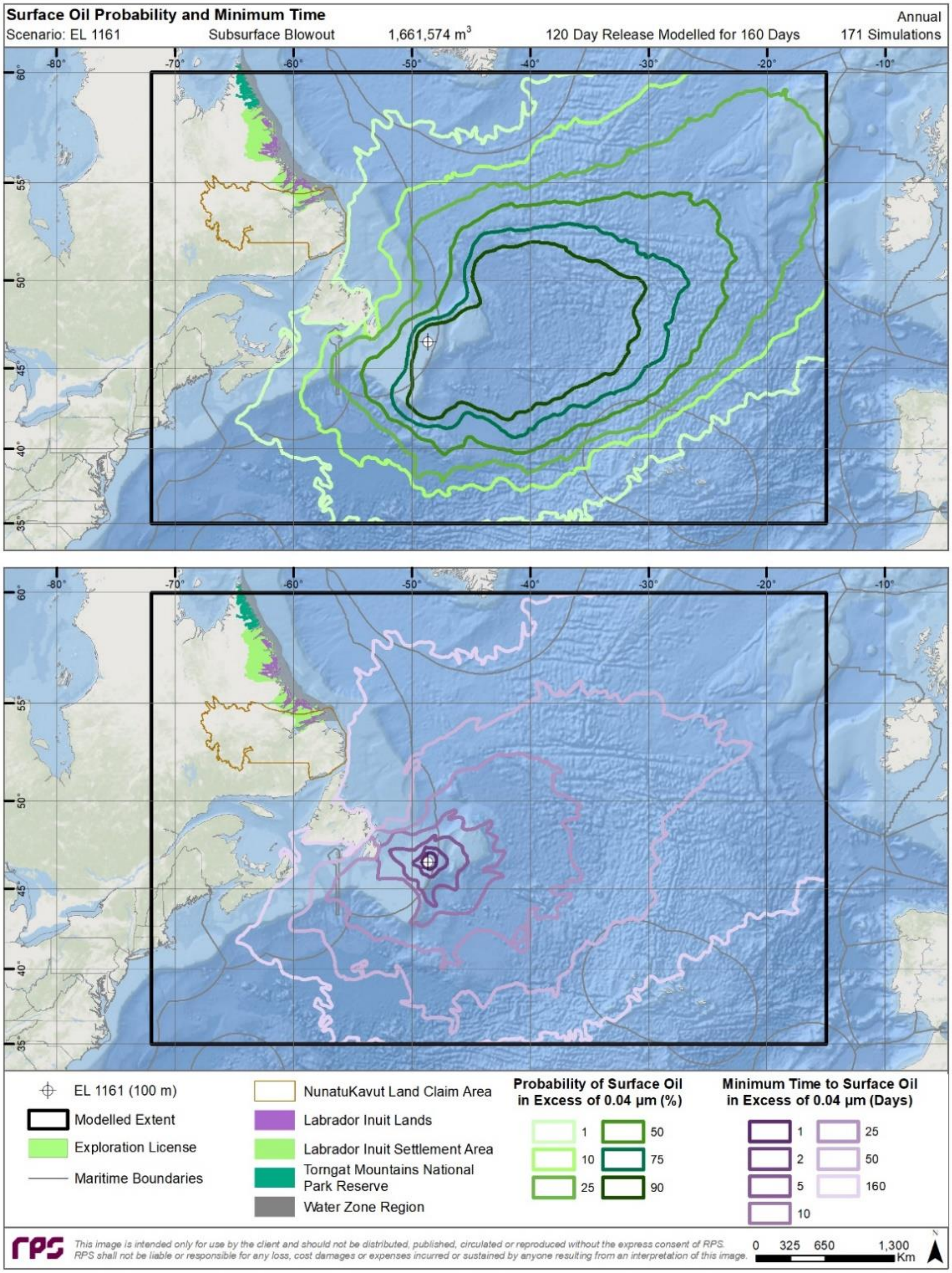


Figure 16-6 **Annual probability of surface oil thickness >0.04 µm (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1161**

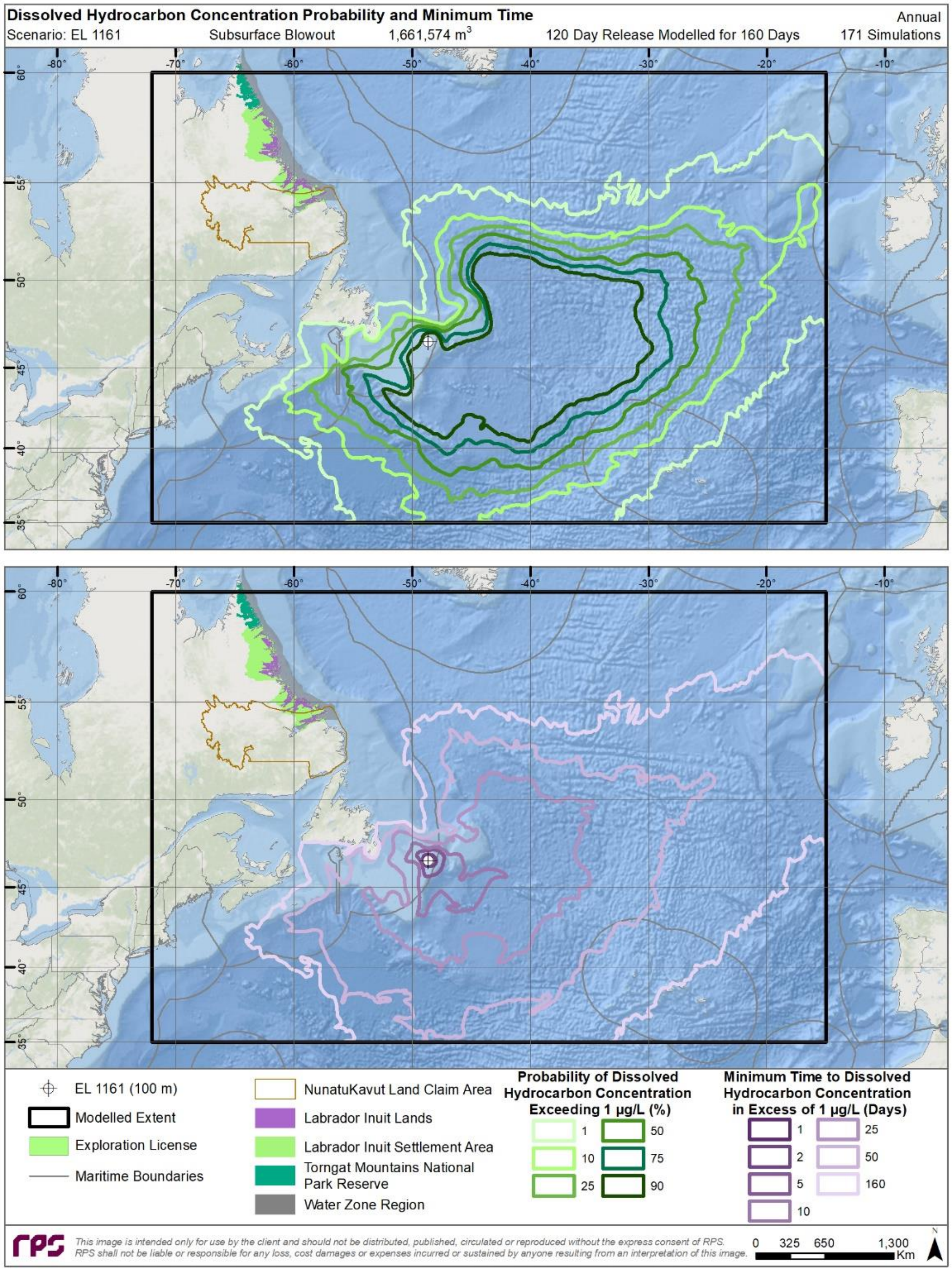


Figure 16-7 **Annual probability of dissolved hydrocarbon concentrations >1 µg/L at some depth in the water column (top) and minimum time to threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1161**

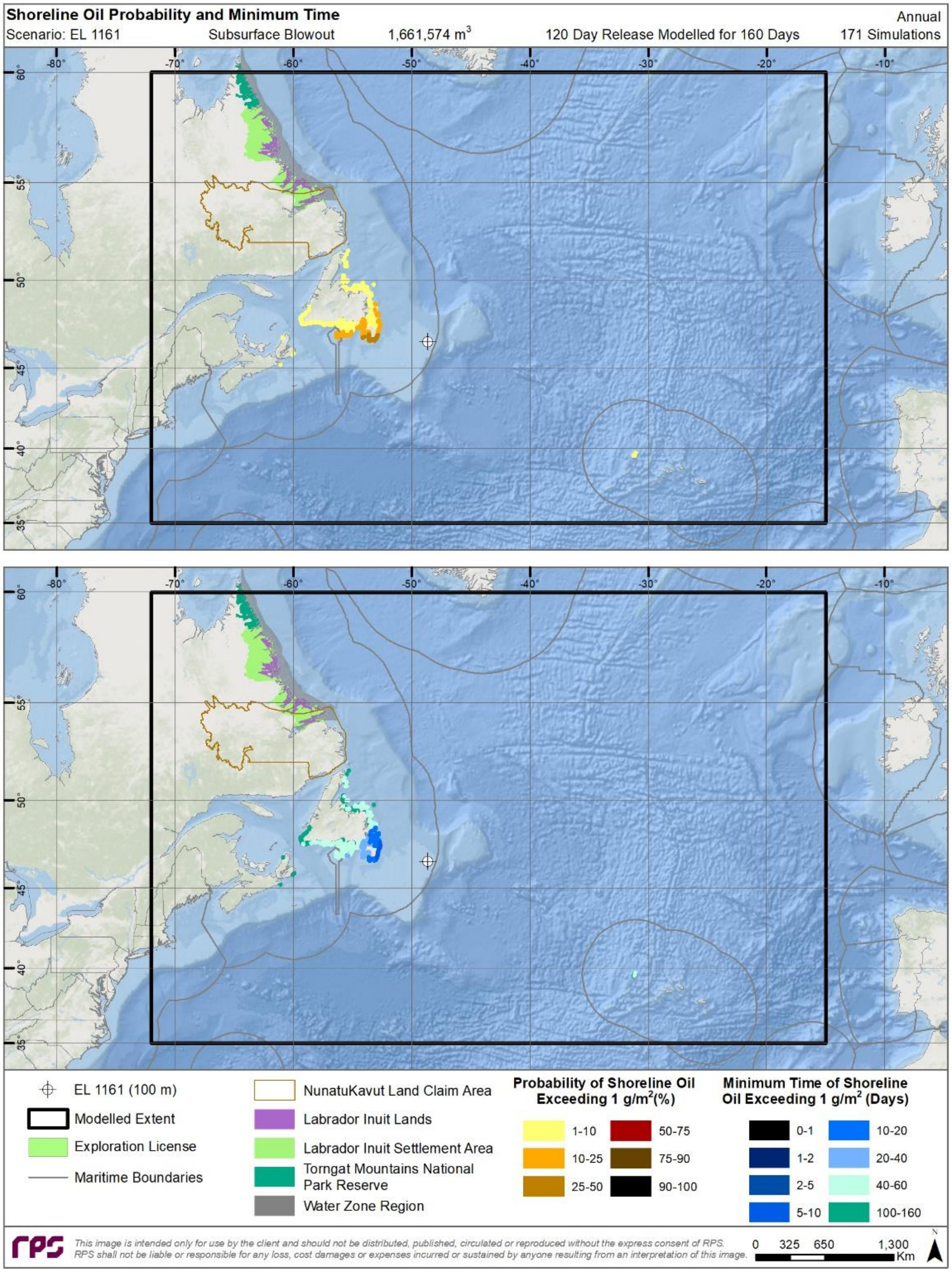


Figure 16-8 **Annual probability of shoreline contact >1 g/m² (top) and minimum time to socio-economic threshold exceedance (bottom) predictions resulting from a 120-day subsurface blowout at EL 1161**

Table 16.5 Summary of Socio-economic Threshold Exceedances Predicted for Surface, Water Column, and Shoreline Exposure within the Modelled Domain are Provided by Season

Stochastic Scenario Parameters			Areas Exceeding Threshold (km^2)		
Component	**Release Scenario**	**Probability Contour or Bin***	**Annual**	**Winter (ice cover)**	**Summer (ice-free)**
Surface Oil	30-day release	1%	7,167,000	7,601,000	7,037,000
		10%	4,797,000	5,295,000	3,370,000
		90%	450,400	816,600	421,700
	120-day release	1%	7,443,000	7,895,000	7,369,000
		10%	5,438,000	5,840,000	4,516,000
		90%	1,155,000	1,537,000	1,031,000
Water Column Dissolved Hydrocarbons	30-day release	1%	5,992,000	6,146,000	5,930,000
		10%	3,512,000	3,630,000	3,423,000
		90%	775,400	770,400	786,000
	120-day release	1%	6,058,000	6,246,000	6,192,000
		10%	4,064,000	4,143,000	3,894,000
		90%	1,258,000	1,279,000	1,272,000
Shoreline Oil	Lengths Exceeding Threshold (km)				
	30-day release	1 to 5%	1,241	864	754
		5 to 15%	648	432	721
		15 to 45%	23	23	32
		All Probabilities	1,911	1,319	1,507
	120-day release	1 to 5%	1,052	809	754
		5 to 15%	1,144	937	804
		15 to 45%	368	423	496
		All Probabilities	2,564	2,169	2,054

Predicted areas (km^2) are provided for the >1%, 10%, or 90% likelihood of exposure to oil contours. Predicted shoreline lengths (km) are provided for probability bins of 1 to 5%, 5 to 15%, and 15 to 45%.

*Bins are based on stochastic probabilities; for example, 450,400 km^2 of the ocean surface is predicted to exceed the 0.04 µm surface oil threshold in 90% of the 171 modelled simulations from the 30-day release at EL 1161 over the entire 160-day modelled duration.

In nearly all stochastic scenarios, lower probabilities of threshold exceedance are generally predicted for surface and/or water column oil contamination north of 60°N. However, higher probabilities of threshold exceedance (90% or above) are predicted for surface and/or water column oil contamination primarily to the east and in many cases to the south (Figures 16-3 and 16-4 and Figures 16-6 and 16-7). In addition, <50% of the simulated 30-day releases were predicted to result in surface threshold exceedance >200 km to the west of the release location, while <50% of the 120-day releases were predicted to result in surface threshold exceedance >500 km west of the release location (Figures 16-3 and 16-6). Due to the weathering of the oil (i.e., evaporation, dissolution, biodegradation, emulsification, and formation of tarballs) that took place over the week or more required for oil to reach shorelines, the viscosity of the oil increased, resulting in greater predicted thicknesses of surface oil, and typically resulted in stranding oil on shorelines greater than the threshold of 1 g/m² (Figures 16-5 and 16-8).

Due to the primarily eastward transport of oil from wind and currents, and the distance of the release location to the shoreline of Newfoundland, the maximum average annual probability of Canadian shoreline exposure above the 1 g/m² threshold was approximately 4% and 8% for the two subsurface blowouts, when one considers probabilities of all shorelines susceptible of oiling (Table 16.6). However, maximum probabilities of shoreline oil contamination at specific points ranged from 18 to 45% depending on the release scenario and season, focused on the Avalon Peninsula (Figures 16-5 and 16-8).

Table 16.6 Shoreline Contamination Probabilities and Minimum Time Predicted for Oil Exposure for All Shorelines

Threshold	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	30-day release	Annual	4.2	19.0	9.2	142.0
		Winter	3.7	21.0	3.7	158.3
		Summer	5.9	18.0	28.0	159.8
	120-day release	Annual	8.3	43.0	9.2	156.1
		Winter	9.0	45.0	9.2	159.9
		Summer	9.4	40.0	28.0	159.6

As the Labrador Current flowed southward along the continental shelf, it was predicted to transport subsurface oil to the south, parallel to the coast (Figures 16-4 and 16-7). This oil was predominantly the small droplet sizes that remained underwater for long periods of time (see Table 3.5 in Appendix E). However, this trend is generally absent in the surface oil projections, as wind forcing was more likely to transport oil to the east (Figures 16-4 and 16-6). Oil that was predicted to make its way to the shorelines of Canada would be patchy and discontinuous due to the considerable amount of weathering and natural dispersion that would take place over the weeks or months that were required for oil to reach shore. The minimum time to shorelines for threshold exceedance was 3.7 days in one winter scenario (but typically greater than a week for other scenarios), along the Avalon Peninsula and southeastern Newfoundland, >40 days along the northern shores of Newfoundland, southeastern Labrador, and the Azores (Table 16.6; Figures 16-5 and 16-8).

Seasonal variability in predicted spill behavior was present in the stochastic results. Regardless of the release duration, the average stochastic probability of shoreline oiling was consistently higher for summer releases than for winter releases (Table 16.6). Similarly, the minimum time to socio-economic shoreline threshold exceedance was approximately three to four times longer in the summer (28 days) than the winter (four to nine days) (Table 16.6). The probability footprints exceeding the threshold for surface oil contamination were larger in the summer compared to winter footprints (Table 16.5). This is due to the potential for greater westward transport of surface oil during the winter, associated with dynamic transitional periods, low pressure systems, and tropical and extra-tropical storms, when compared to the summer. As surface oil was transported to the east, it was predicted to reach the model domain boundaries in each modelled scenario due to the prevailing westerly winds and Gulf Stream current (see Sections 3.4 and 3.5 in Appendix E). However, the minimum time for oil to leave the boundary was nearly always >50 days and in many cases well in excess of 100 days for oil exceeding the highly conservative socio-economic threshold, implying that the oil that left the domain was highly weathered, patchy, and discontinuous.

Intuitively, the longer release durations correlate to larger spill volumes. The 30-day spill simulations released 555,012 m^3, while 120-day simulations released 1,661,574 m^3, respectively (Table 16.2). Despite the larger spill volume for the 120-day releases (almost three times more), the size of the predicted stochastic footprints did not increase proportionally. This is due to the same underlying forcing (i.e., winds and currents) transporting different volumes of oil with the same speed and direction. While the overall footprint (down to the 1% contour) did not change markedly, the higher probability contours (e.g., 90%) extended much further for the 120-day releases (Table 16.5). The annual stochastic 90% probability footprints of threshold exceedance for surface and water column oil increased by 156% and 62%, respectively, from the 30-day to the 120-day release. Nearly all expansion of footprints for long releases occurred to the east, northeast, and southeast of the release locations with very little expansion of lower probability footprints to the west. In other words, the longer spill duration mainly expanded probability footprints meridionally within the high probability areas east of the release site. Increased release duration also resulted in more predicted potential for shoreline oiling above the 1% probability of threshold exceedance (1,911 km 30-day vs 2,564 km 120-day) (Table 16.5). In addition, there were predicted increases (near doubling) in the overall probability of shoreline oiling for the 120-day releases (Table 16.6).

The model results in the stochastic figures do not imply that the entire contoured area would be covered with oil in the event of a single release, nor do they provide any information on the quantity of oil in each area. Furthermore, the largest-area threshold exceedance footprints from the annual results are not the expected exposure from any single release of oil, but rather areas where there is >1% probability that exposure above the threshold could occur, based on the combination of either 171 (annual), 89 (summer), or 82 (winter) individual releases analyzed together.

16.3.4.2 Deterministic Results

Individual trajectories of interest were selected from the stochastic ensemble of results for the deterministic analysis. The deterministic trajectory and fate simulations provided an estimate of the transport of oil through the environment as well as its physical and chemical behavior for the specific set of modelled environmental conditions. Representative 95th percentile credible “worst-case” trajectories for surface oil exposure, water column contamination, and contact with shoreline were identified from the stochastic subsurface scenarios and release duration (i.e., 30 vs. 120 days). These highly conservative individual cases were selected based upon the size of the surface oil footprint, volume of oil in the water column, and the length of shoreline contacted with oil. Three individual trajectories representative of the 95th percentile for surface, water column, and shoreline exposure for each release, as well as the 1,000 L marine diesel batch spill are presented below. This resulted in a total of seven individual trajectories (six associated with subsurface blowouts and one associated with the marine diesel batch spill) (Table 16-4).

During modelling, components of oil were tracked as floating surface oil, entrained droplets of whole oil, dissolved hydrocarbon constituents, stranded oil on shorelines and sediments, evaporated, degraded, and left the model domain. 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 16-9, 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 30-day release at EL 1161. Note the patchy and discontinuous nature of the predicted footprint as the released oil dispersed and thinned over time. Figure 16-10 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 remaining figures in this report will depict cumulative footprints as opposed to "snapshots" at given time steps to provide conservative estimates of potentially affected areas.

16.3.4.2.1 Surface Oil Exposure Cases

At the end of the 160-day simulations for the 95th percentile surface oil exposure for 30- and 120-day releases, large percentages of the oil were predicted to degrade (approximately 52 to 58%) and evaporate (approximately 25 to 28%), accounting for >77% of each modelled release. The amount of oil predicted to remain on the water surface was <3%, while <17% was predicted to remain entrained in the water column. Less than 4% of the released 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.

Frequent cycling of wind and calm events were evident in all surface oil exposure cases, as indicated by "see-sawing" between oil on the surface and entrained oil in the water column (Figure 16-11). During calmer more quiescent periods, oil was predicted to rise to the surface forming slicks, while during periods with wind, surface breaking waves were formed, which resulted in surface oil becoming entrained in the water column.

The 95th percentile 30-day surface oil exposure case was predicted to result in shoreline oiling of generally 100 to >500 g/m² (exceeding the socio-economic threshold) along approximately 358 km of northeastern Newfoundland, the northern Avalon peninsula, and southeastern Labrador coastlines (Table 16.7). The 95th percentile 120-day surface oil exposure case was not predicted to contact any shorelines. Sediment oil contamination was predicted to the south of the release location on the Grand Banks for each representative scenario at concentrations generally <0.1 g/m².

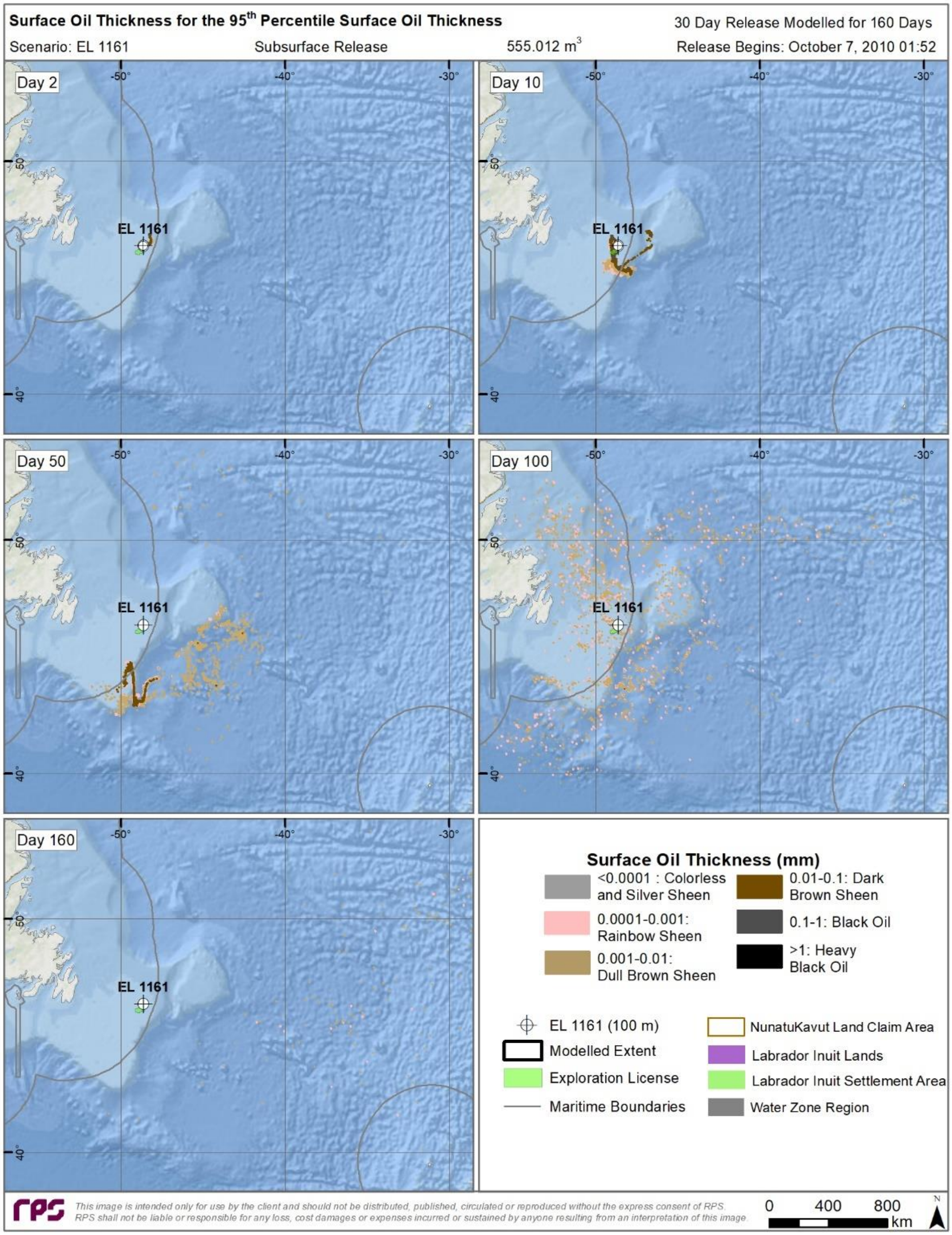
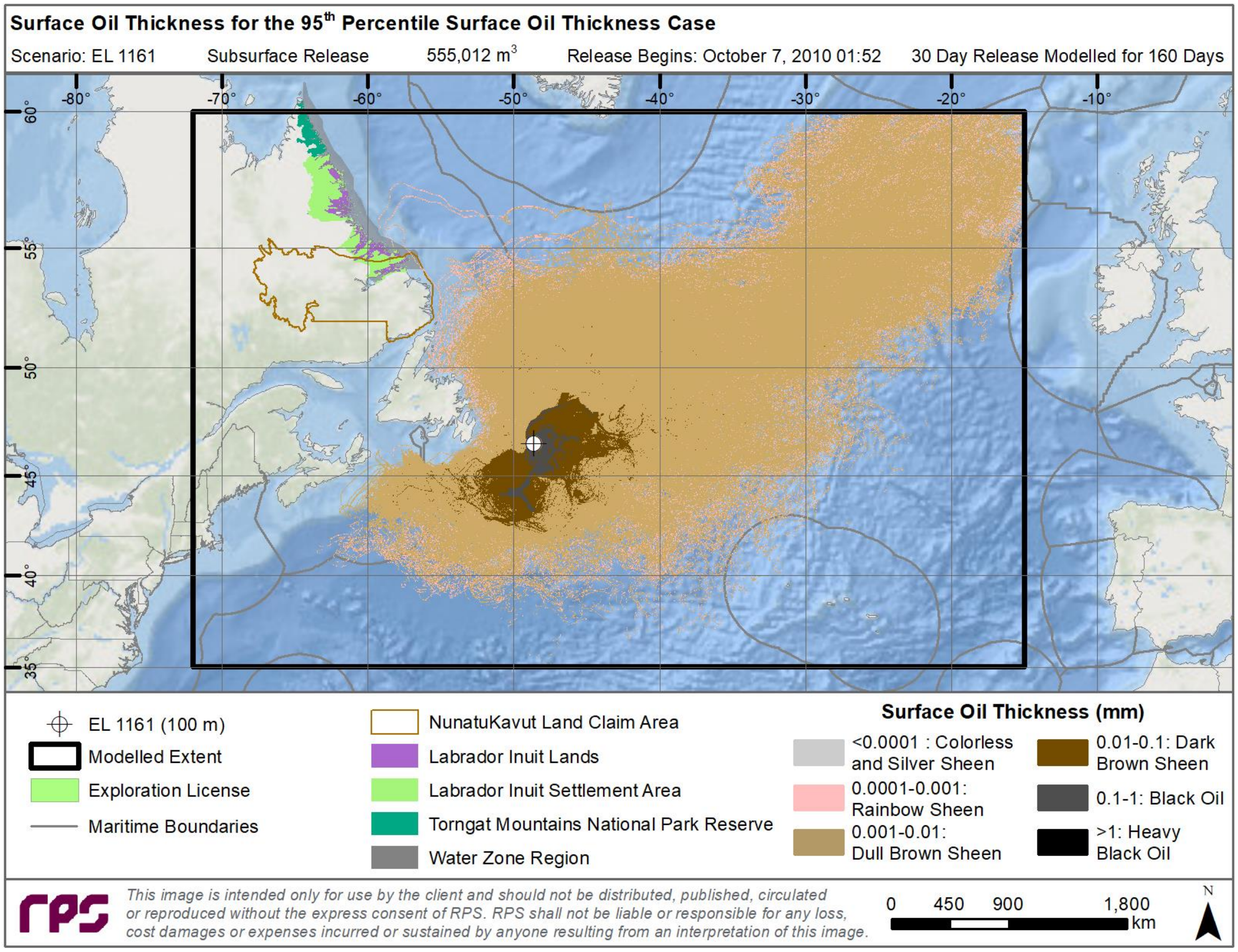


Figure 16-9 **Predicted surface oil thickness for the 95th percentile surface oil exposure case for the 30-day release at EL 1161 at days 2, 10, 50, 100, and 160 to illustrate the variation in size of the surface oil footprint over the course of the model duration**



Note that the information contained in this figure is from the same scenario that was presented in Figure 16-9.

Figure 16-10 Maximum cumulative surface oil thickness for the 95th percentile surface oil exposure case for the 30-day release at EL 1161 to illustrate the much larger size of the cumulative surface oil footprint over the entire model duration, compared to the size of the surface oil footprint on any one day or time step

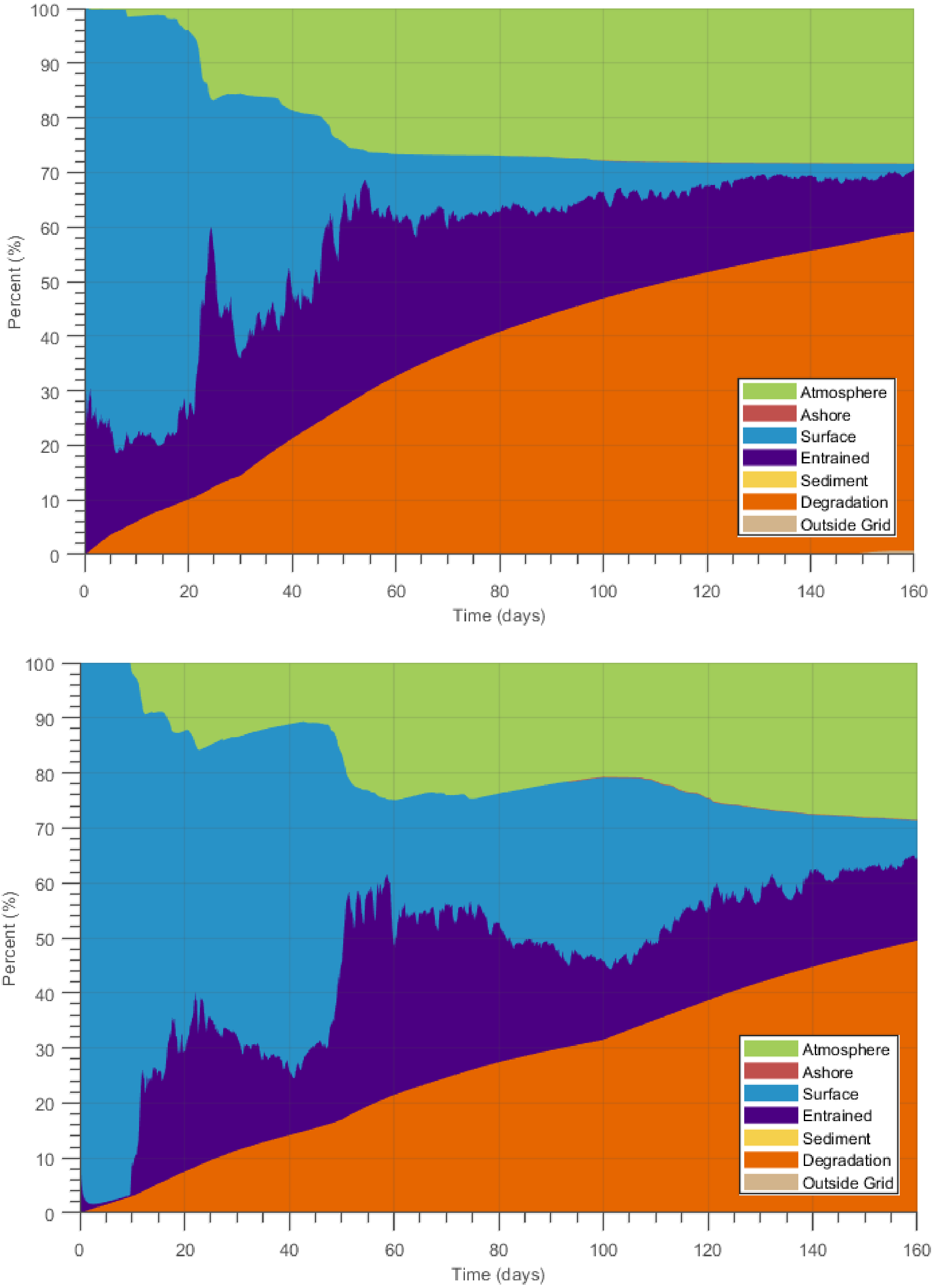


Figure 16-11 Mass Balance Plots of the 95th Percentile Surface Oil Thickness Cases Resulting from 30- (top) and 120-day (bottom) Blowouts at EL 1161

Table 16.7 Representative Deterministic Cases and Associated Areas, Lengths, and Volumes Predicted to Exceed Specified Thresholds for Representative Trajectories at EL 1161

95th Percentile Scenario	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/m^2)	Ecologic (100 g/m^2)	Socio-economic* (1 µg/L)
Subsurface Blowout Releases						
Surface oil exposure case - 30 d	555,012 m^3	2,817,000	286,800	358	340	224,050
Water column case - 30 d		2,236,000	438,100	87	83	228,550
Shoreline contact case - 30 d		1,728,000	334,700	1,461	1,452	138,800
Surface oil exposure case - 120 d	1,661,574 m^3	3,604,000	833,500	-	-	227,300
Water column case - 120 d		2,070,000	317,600	-	-	196,950
Shoreline contact case - 120 d		2,012,000	445,000	1,493	1,479	162,150
Batch Spill						
Surface Batch Spill	1,000 L	-	-	-	-	-
*There is only one category threshold (socio-economic) for THC – calculated by multiplying the area times the depth of the grid cell.						

16.3.4.2.2 Water Column Exposure Case

At the end of the 160-day simulations for the representative 30- and 120-day releases, large percentages of the oil were predicted to evaporate (28% to 29%) and degrade (51% to 52%), accounting for approximately 80% of each modelled release. The amount of oil predicted to remain on the water surface was <1%, with up to 19% to 20% 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 <0.4% of the released oil was predicted (Table 16.8). 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 16-12).

The 30-day representative case was predicted to contact shorelines, while the 120-day representative case was not predicted to reach the shore (Table 16.7). The representative 30-day release was predicted to result in 87 km of Newfoundland shorelines, predominantly along the southern Avalon peninsula, to be contaminated above the socio-economic threshold (Table 16.7).

Table 16.8 Summary of the Mass Balance Information for All Representative Scenarios

95th Percentile Scenario	Percent of Total Released Oil (%)						
	Surface	**Evaporated**	**Water Column**	**Sediment**	**Ashore**	**Degraded**	**Outside Grid**
Subsurface Blowout Releases							
Surface oil exposure case- 30 d	1.2	28.4	11.3	<0.1	<0.1	58.4	0.7
Water column case- 30 d	0.5	28.3	19.2	<0.1	0.4	51.7	0.0
Shoreline contact case- 30 d	0.2	27.5	12.7	<0.1	<0.1	59.4	0.1
Surface oil exposure case- 120 d	2.4	25.3	16.7	<0.1	0.0	52.2	3.4
Water column case- 120 d	0.2	29.2	19.6	<0.1	0.0	51.0	0.0
Shoreline contact case- 120 d	0.5	28.3	19.2	<0.1	0.4	51.7	0.0
Batch Spill							
Surface Batch Spill	0.0	43.9	14.6	0.0	0.0	41.4	0.0
All values represent a percentage (%) of the total amount of released oil at the end of the representative deterministic scenario							

16.3.4.2.3 Shoreline Exposure Case

At the end of the 160-day simulations of the 95th percentile shoreline exposure for 30- and 120-day releases, large percentages of the oil degraded (52% to 59%) and evaporated (28%), accounting for >80% of each modelled release. The amount of oil predicted to remain on the water surface was <1%, with 13 to 19% within the water column. Less than 1% of the released oil (predominantly persistent surface oil) was predicted to be transported outside of the modelled domain. Oil transported to the sediment was not a major fate pathway, with <0.1% predicted to settle on sediments; however, up to 0.4% was predicted to remain on the shoreline (Table 16.8 and Figure 16-13).

The identified representative shoreline exposure cases were predicted to result in 1,461 to 1,452 km of contaminated shorelines. The releases resulted in similar lengths of shoreline oiling with the potential for contamination along the southern and southeastern coasts of Newfoundland (including the Avalon Peninsula), mostly in excess of 500 g/m². In general, the oil that was predicted to reach shorelines was expected to be relatively weathered, patchy, and discontinuous, as it would have degraded for well over a week (or more) before contacting shore. Limited sediment contamination of generally <0.01 g/m² was predicted in the immediate vicinity (within approximately 100 km) of the release location.

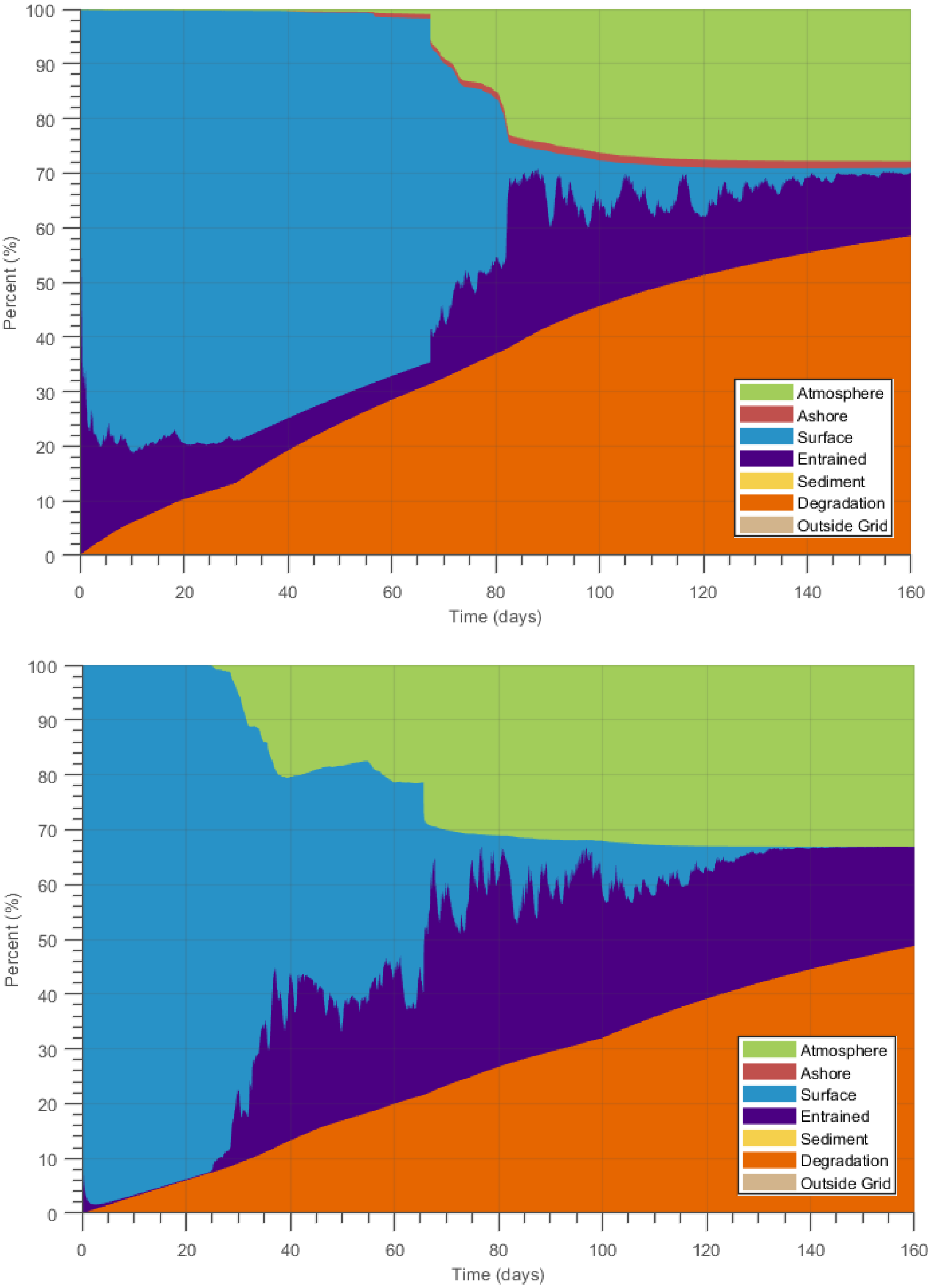


Figure 16-12 Mass Balance Plots of the 95th Percentile Water Column Cases Resulting from 30- (top) and 120-day (bottom) Blowouts at EL 1161

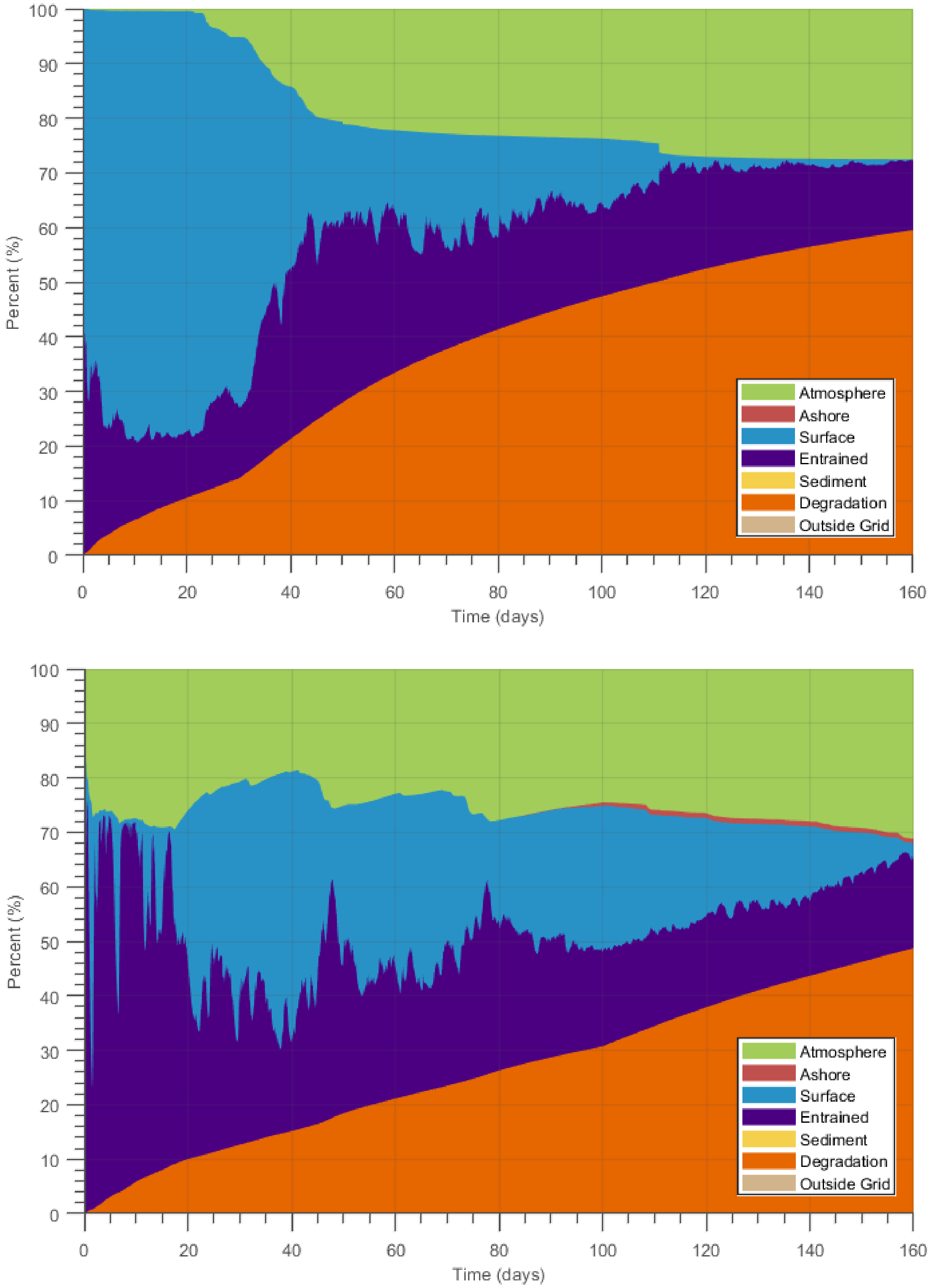


Figure 16-13 Mass Balance Plots of the 95th Percentile Shoreline Cases Resulting from 30- (top) and 120-day (bottom) Blowouts at EL 1161

16.3.4.2.4 Surface Diesel Batch Spill

Results for the hypothetical batch spill release of marine diesel from EL 1161 are provided. The simulation was comprised of a nearly instantaneous release of 1,000 L of marine diesel at the surface, which was then modelled for 30 days.

The batch spill release of 1,000 L marine diesel was predicted to result in silver or colorless sheens (<0.0001 mm) of oil floating on the water surface. Generally, oil within this representative scenario was predicted to be transported to the west and south, within 175 km of the release location. Note that total hydrocarbon (THC) and dissolved hydrocarbon (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 and the large amount of natural dispersion from wind and waves that dispersed and diluted the marine diesel. Thus, figures of THC and DHC are not presented below.

At the end of the 30-day marine diesel batch spill simulation, 44% was predicted to evaporated into the atmosphere, 42% degraded, 15% 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 settle on sediments in this representative scenario (Figure 16-14 and Table 16.8).

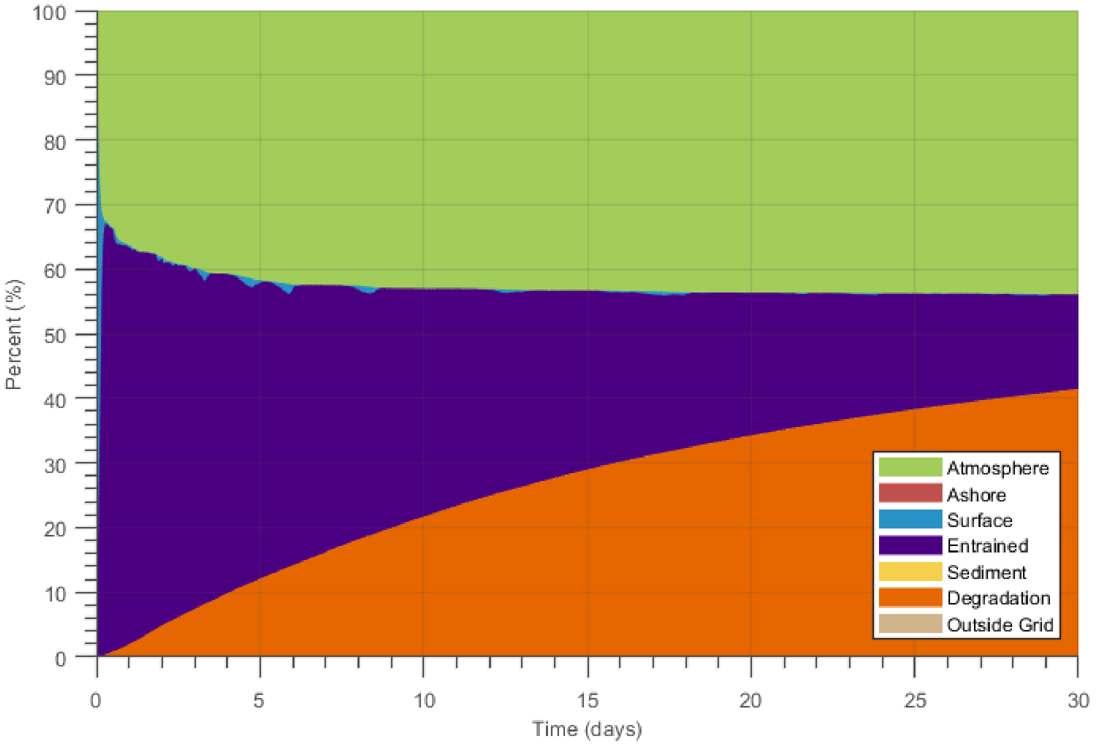


Figure 16-14 Mass Balance Plot of the Marine Diesel Batch Spill of 1,000 L at EL 1161

16.3.5 Model Uncertainty and Validation

The “pseudo-component” approach was used to simplify the tracking of thousands of chemicals comprising oil for modelling (Payne et al. 1984, 1987; French et al. 1996; Jones 1997; Lehr et al. 2000). Chemicals in the oil mixture are grouped by physical-chemical properties, and the resulting component category behaves as if it were a single chemical with characteristics typical of the chemical group. In this component breakdown, aromatic groups are treated as both soluble (i.e., dissolve into the water column) and volatile (i.e., evaporate to the atmosphere), while the aliphatic groups are only volatile. The total hydrocarbon concentration within the boiling range of volatile components is the sum of all aromatic and aliphatic components. The remainder of the oil is considered to be residual oil, which does not dissolve or volatilize but will degrade over time.

Degradation rates for each component and compartment (surface, upper water column, lower water column, and sediments) were based on biodegradation rates obtained from literature reviews that included estimates for compounds and/or components of crude oil generally (French McCay et al. 2018a: Annex C to Appendix II). For the semi-volatile components, degradation in floating oil would be considerably slower than volatilization. The rates for residual oil are consistent with studies by Zahed et al. (2011) and Atlas and Bragg (2009).

Through the modelled processes, the density and viscosity of the oil tend to increase as the oil weathers. It is possible for the weathered oil, especially in the presence of suspended particulate matter in the water column, to become denser than water and sink. In addition, the oil (including the residual fraction) does continue to degrade over time within the model. In addition, one must consider that the hypothetical long-term releases of oil (many months) continue to add fresh oil, which will increase the total amount of oil through time that will degrade. As time progresses, residual oil is all that remains of the early portions of the release while whole fresh oil continues to be released in later stages. In total, this may appear as though degradation rates are increasing, but it is rather a function of the static degradation rate and the increasing amount of oil (a portion fresh oil) through time.

A recent comprehensive model update with literature review of over a dozen of the most recent studies on oil degradation rates validating the use of modelled SIMAP degradation rates was conducted for work following the Deepwater Horizon Natural Resource Damage Assessment (French McCay et al. 2015) as well as for the United States Bureau of Ocean Energy Management (French McCay et al. 2018b, 2018c).

The long-term weathering and degradability of an oil (including microbial degradation, photo-oxidation, and other processes that may break down compounds or components of oil) may increase the tendency of an oil to sink. These processes are highly dependent upon the type of oil released and the environmental conditions of the receiving environment. A large amount of work is currently being undertaken to develop scientific consensus in this area; however, it is understood that compounds with a boiling temperature >380°C degrade slowly and that these compounds are difficult to measure. The modelled bulk disappearance is quite slow and would conservatively overestimate the effects following a release as oil would remain in the modelled system. The inclusion of compound-specific degradation would increase the degradation and reduce the amount of oil remaining in the model, therefore potentially skewing results towards less effects.

The SIMAP model has been developed over several decades to include past and recent information from laboratory-based experiments and real-world releases to simulate the trajectory and fate of discharged oil. However, there are limits to the complexity of processes that can be modelled, as well as gaps in knowledge regarding the affected environment. Assumptions based on available scientific information and professional judgment were made in the development of the model, which represent a best assessment of the processes and potential exposures that could result from oil releases.

The major sources of uncertainty in the oil fate model are:

- Oil contains thousands of chemicals with differing physical and chemical properties that determine their fate in the environment. The model must, out of necessity, treat the oil as a mixture of a limited number of components, grouping chemicals by physical and chemical properties.
- The fate model contains a series of algorithms that are simplifications of complex physical-chemical processes. These processes are understood to varying degrees.
- The model treats each release as an isolated, singular event and does not account for any potential cumulative exposure from other sources.
- Several physical parameters, including but not limited to hydrodynamics, water depth, total suspended solids concentration, and wind speed, were not sampled extensively throughout the entire modelled domain. However, the data that did exist were sufficient for this type of modelling. When data were lacking, professional judgment and previous experience was used to refine the model inputs.

SIMAP has been validated against many real-world releases including the DWH oil spill, where it was used in the US Government’s Natural Resource Damage Assessment. In this specific example, a small portion of the released oil may have sunk as a result of the interaction of released oil with sediments, drilling muds, and other material used in response efforts such as procedures used to seal a leaking well. These are currently areas of active research. While there are additional fate processes that may result in slight differences in the ultimate fate of oil, these processes are known to have relatively lower effects on the total volume of oil in each environmental compartment (on the order of single percentages different, depending on the release and receiving environment) as compared to the fate processes such as entrainment, which are already being modelled. The science and algorithms that may be used to model these processes have not been developed in the scientific community to the point of consensus or use in modelling. Ongoing research topics currently underway include the formation of marine oil snow, photo-degradation, droplet size distributions, and other research areas. These and other multi-year research projects are considered for incorporation in modelling nearly constantly. Due to these topics being in the research phase, without scientific consensus, they have not been included in this analysis.

In the unlikely event of an actual release of oil, the trajectory and fate will be strongly determined by the specific environmental conditions, the precise location, and a myriad of details related to the event and specific timeframe of the release. Modelled results are a function of the scenarios simulated and the accuracy of the input data used. The goal of this study was not to forecast every detail that could potentially occur, but to describe a range of possible consequences and exposures of oil releases under various representative release scenarios.

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.

16.4 Spill Risk and Probabilities

16.4.1 Historical Spill Data - Canada-NL Offshore Area

Worldwide, it has been estimated that there have been 50,000 wells drilled. Of the 20 largest historical blowout incidents, four have occurred during exploration drilling activities, including two large blowouts–the 1979 Ixtoc I well blowout, and the 2010 Macondo MC252 well blowout. The probability of a well blowout occurring depends on many factors, including but not limited to location, well characteristics, and operating conditions.

16.4.1.1 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 bbl annually, and in offshore areas, 2,700 bbl annually, for a total of 11,700 bbl. Spill volumes off Eastern Canada have decreased substantially in the last decade to approximately 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 exploration and production facilities have spilled a total of 2,759 bbl of oil in 478 incidents over the last 22 years activity in of Newfoundland and Labrador (this includes data through the end of 2021). One single event, the spill of 1,572 bbl of crude oil from the Husky Energy White Rose field in November 2018, made up nearly 57% of the total volume of spillage. Another spill event involving 1,037.8 bbl from Suncor'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). Approximately 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. Approximately 72% of these spills involved <1 bbl. Offshore exploration activities over the time period 1997 through 2018 also resulted in 11 synthetic-based fluid (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.

Worldwide, well-related spills occur relatively infrequently during offshore operations. Most spills involve releases of less than 100 bbl, or 16 m^3, over the course of less than one day. Additionally, large-scale production 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 blowout (DWH spill) 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.

16.4.1.2 Canada-Newfoundland and Labrador Offshore Spill Data

The C-NLOPB spill data for 1997 to 2021 were analyzed (C-NLOPB 2022a). The data were divided by operational phase into SBMs and other hydrocarbons (Table 16.9). There were 544 spills, of which 44 (8.1%) occurred during exploration and 500 (91.9%) occurred during development and production. During exploration, 809 bbl spilled, and during development and production, 4,133 bbl spilled.

A more detailed breakdown of spills of >1 L was available in the C-NLOPB data. The annual numbers and volumes of spills by oil type are shown in Table 16.10 for exploratory wells. The volumes of spillage are dominated by individual incidents, as is apparent for synthetic fluid spillage, where there were a total of 11 SBM incidents involving more than 1 L over the course of 25 years. When the volume of spillage is averaged over 25 years, the average is 31 bbl per year. This does not mean that 31 spills occur each year consistently. Similarly, crude oil spillage was dominated by two incidents involving 1,038 bbl and 1,572 bbl.

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 16.11 for exploration, with the addition of data on spills of 1 L or less that were provided by C-NLOPB that were not classified with regard to oil type.

Table 16.9 Newfoundland and Labrador Offshore Exploration and Production Oil Spills (1997 to 2021)

Year	Exploration						Development and Production						Total					
	Spill Number			Spill Volume (bbl)			Spill Number			Spill Volume (bbl)			Spill Number			Spill Volume (bbl)		
	HC	SBM	All	HC	SBM	All	HC	SBM	All	HC	SBM	All	HC	SBM	All	HC	SBM	All
1997	1	0	1	0.3	0.0	0.3	10	0	10	10.6	0.0	10.6	11	0	11	10.9	0.0	10.9
1998	4	0	4	20.1	0.0	20.1	22	2	24	3.7	12.6	16.3	26	2	28	23.8	12.6	36.4
1999	11	0	11	10.7	0.0	10.7	28	8	36	7.3	46.4	53.7	39	8	47	18.0	46.4	64.4
2000	1	0	1	1.0	0.0	1.0	4	5	9	0.4	29.6	30.0	5	5	10	1.4	29.6	31.0
2001	0	0	0	0.0	0.0	0.0	15	2	17	0.8	35.2	36.0	15	2	17	0.8	35.2	36.0
2002	0	0	0	0.0	0.0	0.0	24	2	26	0.2	77.1	77.3	24	2	26	0.2	77.1	77.3
2003	1	1	2	0.6	27.7	28.3	19	4	23	1.8	167.5	169.3	20	5	25	2.4	195.2	197.6
2004	0	0	0	0.0	0.0	0.0	50	5	55	1,043.5	680.0	1,723.5	50	5	55	1,043.5	680.0	1,723.5
2005	0	0	0	0.0	0.0	0.0	40	1	41	1.2	25.4	26.6	40	1	41	1.2	25.4	26.6
2006	3	1	4	0.1	3.8	3.9	31	3	34	3.9	19.1	23.0	34	4	38	4.0	22.9	26.9
2007	0	1	1	0.0	465.5	465.5	37	1	38	0.6	6.9	7.5	37	2	39	0.6	472.4	473.0
2008	0	0	0	0.0	0.0	0.0	35	1	36	30.3	0.6	30.9	35	1	36	30.3	0.6	30.9
2009	4	0	4	0.1	0.0	0.1	37	0	37	1.8	0.0	1.8	41	0	41	1.9	0.0	1.9
2010	3	0	3	0.0	0.0	0.0	16	0	16	1.2	0.0	1.2	19	0	19	1.2	0.0	1.2
2011	2	5	7	0.3	180.8	181.1	36	2	38	3.5	28.9	32.4	38	7	45	3.8	209.7	213.5
2012	0	0	0	0.0	0.0	0.0	7	0	7	0.1	0.0	0.1	7	0	7	0.1	0.0	0.1
2013	0	0	0	0.0	0.0	0.0	11	2	13	39.3	1.4	40.7	11	2	13	39.3	1.4	40.7
2014	0	1	1	0.0	5.4	5.4	11	3	14	1.4	6.9	8.3	11	4	15	1.4	12.3	13.7
2015	1	1	2	0.0	92.9	92.9	1	1	2	0.0	0.9	0.9	2	2	4	0.0	93.8	93.8
2016	1	0	1	0.0	0.0	0.0	3	0	3	0.0	0.0	0.0	4	0	4	0.0	0.0	0.0
2017	1	1	2	0.0	0.0	0.0	5	0	5	0.0	0.0	0.0	6	1	7	0.0	0.0	0.0
2018	0	0	0	0.0	0.0	0.0	4	2	6	1,574.6	176.1	1,750.7	4	2	6	1,574.6	176.1	1,750.7
2019	0	0	0	0.0	0.0	0.0	5	0	5	89.7	0	89.7	5	0	5	89.7	0	89.7
2020	0	0	0	0.0	0.0	0.0	1	1	2	0.008	2.0	2.008	1	1	2	0.008	2.0	2.008

Table 16.9 Newfoundland and Labrador Offshore Exploration and Production Oil Spills (1997 to 2021)

Year	Exploration						Development and Production						Total					
	Spill Number			Spill Volume (bbl)			Spill Number			Spill Volume (bbl)			Spill Number			Spill Volume (bbl)		
	HC	SBM	All	HC	SBM	All	HC	SBM	All	HC	SBM	All	HC	SBM	All	HC	SBM	All
2021	0	0	0	0	0	0	3	0	3	0.01	0	0.01	3	0	3	0.01	0	0.01
Total	33.0	11.0	44.0	33.2	776.1	809.3	455.0	45.0	500.0	2,815.9	1,316.6	4,132.5	488.0	56.0	544.0	2,849.1	2,092.7	4,941.8

C-NLOPB data current through December 2021 (C-NLOPB 2022a).
HC = Hydrocarbon; SBM = synthetic-based mud

Table 16.10 Newfoundland and Labrador Exploration Spill Number and Volumes (1997 to 2021)

Year	Number of Spills >1 L / Volume Spilled (bbl)					
	Crude Condensate	Diesel / Jet Fuels	Hydraulic / Lube Oils	Other Types (Oil)	Synthetic Fluids	Total
1997	0	0	0	1 / 0.25	0	1 / 0.25
1998	0	4 / 20.1	0	0	0	4 / 20.10
1999	4 / 4.79	5 / 5.72	1 / 0.03	1 / 0.19	0	11 / 10.73
2000	1 / 1.01	0	0	0	0	1 / 1.01
2001	0	0	0	0	0	0.00
2002	0	0	0	0	0	0.00
2003	0	1 / 0.63	0	0	1 / 27.68	2 / 28.31
2004	0	0	0	0	0	0.00
2005	0	0	0	0	0	0.00
2006	0	0	3 / 0.1	0	1 / 3.77	4 / 3.87
2007	0	0	0	0	465.45	465.45
2008	0	0	0	0	0	0.00
2009	0	0	0	2 / 0.05	0	2 / 0.05
2010	0	0	1 / 0.02	0	0	1 / 0.02
2011	0	0	2 / 0.28	0	5 / 180.78	7 / 181.06
2012	0	0	0	0	0	0.00
2013	0	0	0	0	0	0.00
2014	0	0	0	0	1 / 5.41	1 / 5.41
2015	0	0	0	0	1 / 92.23	1 / 92.23
2016	0	0	1 / 0.01	0	0	1 / 0.01
2017	0	0	0	0	1 / 0.02	1 / 0.02
2018	0	0	0	0	0	0.00
2019	0	0	0	0	0	0.00
2020	0	0	0	0	0	0.00
2021	0	0	0	0	0	0.00
Total	5 / 5.8	10 / 26.45	8 / 0.44	4 / 0.49	11 / 775.34	38 / 808.52
Average/Year	0.20 / 0.23	0.4 / 1.06	0.32 / 0.02	0.16 / 0.02	0.44 / 31.01	1.52 / 32.34

C-NLOPB data current through December 2021 (C-NLOPB 2022b).
Note: 1 bbl = 158.99 L

Table 16.11 Spill Volumes for Exploration in Newfoundland and Labrador

Volume Category (bbl)	% Total Spills >1 L					% Total All Spills (w/<1 L)
	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%
Note: 1 bbl = 158.99 L						

16.4.2 Probabilities of Spills from the Project

Spill probabilities for individual wells depend on the release type. These probabilities do not indicate the release volume or imply the release would be a worst-case discharge. A blowout is 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 (a surface blowout), flow through a diverter, or uncontrolled flow resulting from a failure of surface equipment or procedures. A well release is an incident in which there is flow of oil from some point in the well or associated structures where flow is not intended, such as through the drill pipe, tubing, or flow lines. The overall mean probability of a spill from each individual well is 0.00013 (1 in 7,700) for a subsurface blowout and 0.00011 (1 in 9,400) for a well release. The probabilities are for the duration of the exploration period.

Since there would be up to 12 to 16 exploratory wells that could be in drilling phase for the Project lasting up to 120 days, there are up to approximately 5 years of potential time during which an exploration well blowout or release might occur. The probabilities and chances of well blowouts and releases for the Project are shown in Table 16.12 based on the number of wells (the data are shown for 12 to 16 wells).

Table 16.12 Probabilities and Chances of a Spill by Well Number

Number Wells	Probability / Chances of a Spill during Exploration		
	Blowouts with Spill	Well Releases	All Spills
1	0.00013 / 1 in 7,700	0.00011 / 1 in 9,400	0.00024 / 1 in 4,200
2	0.00026 / 1 in 3,800	0.00022 / 1 in 4,700	0.00048 / 1 in 2,100
3	0.00039 / 1 in 2,600	0.00033 / 1 in 3,100	0.00072 / 1 in 1,400
4	0.00052 / 1 in 1,900	0.00044 / 1 in 2,400	0.00096 / 1 in 1,100
5	0.00065 / 1 in 1,500	0.00055 / 1 in 1,900	0.00120 / 1 in 840
6	0.00078 / 1 in 1,300	0.00066 / 1 in 1,600	0.00144 / 1 in 700
7	0.00091 / 1 in 1,100	0.00077 / 1 in 1,300	0.00168 / 1 in 600

Table 16.12 Probabilities and Chances of a Spill by Well Number

Number Wells	Probability / Chances of a Spill during Exploration		
	Blowouts with Spill	Well Releases	All Spills
8	0.00104 / 1 in 960	0.00088 / 1 in 1,200	0.00192 / 1 in 530
9	0.00117 / 1 in 860	0.00099 / 1 in 1,000	0.00216 / 1 in 470
10	0.00130 / 1 in 770	0.00110 / 1 in 940	0.00240 / 1 in 420
11	0.00143 / 1 in 700	0.00121 / 1 in 860	0.00264 / 1 in 380
12	0.00156 / 1 in 640	0.00132 / 1 in 790	0.00288 / 1 in 350
13	0.00169 / 1 in 590	0.00143 / 1 in 700	0.00312 / 1 in 320
14	0.00182 / 1 in 550	0.00154 / 1 in 650	0.00336 / 1 in 300
15	0.00195 / 1 in 510	0.00165 / 1 in 610	0.00360 / 1 in 280
16	0.00208 / 1 in 480	0.00176 / 1 in 570	0.00384 / 1 in 260

In the event that a spill does occur, the spill will not necessarily involve the maximum outflow. Most spills are relatively small and rarely does a spill result in a volume that would be classified as very large. If a spill does occur from the well, there is a distribution of potential spill volumes ranging from small to extremely large. The total volume is dependent on the duration of flow and flow rate. There are no data available to determine the potential volumes of blowouts after abandonment, and here are no such blowouts recorded in Newfoundland waters.

16.4.2.1 Probability of Subsurface Blowouts from the Project

Blowouts involve flow at a certain rate for a few hours to a number of days, depending on the time to natural bridging or successful intervention by capping, relief well, or other means. 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, the high flowrate for this Project–as high as 5,242 bbl per hour during the first day–means that even with a few hours of flow, there would be a spill in the tens of thousands of barrels (assuming no intervention). The probability distribution of blowout volumes was combined with the probability of a blowout with the results shown in Table 16.13.

Table 16.13 Per-Well Probability of Subsurface Blowouts by Volume Category

Volume Category (this Volume or Larger)	Mean Probability Per Well over Exploration and Abandonment	Mean Chance per Well over Exploration and Abandonment
Any Volume	0.00023	1 in 4,300
1,000 bbl	0.00023	1 in 4,300
10,000 bbl	0.00023	1 in 4,300
100,000 bbl	0.00020	1 in 5,000
1,000,000 bbl	0.000036	1 in 28,000
Scenario SB-30: 3,490,847 bbl	0.0000023	1 in 430,000
Scenario SB-115: 10,202,358 bbl	0.000000023	1 in 43,000,000
Note: 1 bbl = 158.99 L		

16.4.2.2 Probability of Non-blowout Well Releases from the Project

Non-blowout releases tend to involve relatively small volumes of <1 bbl to approximately 100 bbl, because they, by definition, do not involve uncontrolled flow. There are relatively rare instances in which the release is as much as 3,145 bbl (C-NLOPB 2022a). If the number of wells increases, the overall probability increases in direct proportion to the number of wells. The probabilities of well releases by volume are summarized in Table 16.14.

Table 16.14 Per-Well Non-blowout Release Probability by Volume

Volume Category	Per-Well Probability Exploration through Abandonment	Per-Well Chance Exploration through Abandonment
Any Volume	0.00011	1 in 9,100
1 bbl or Larger	0.00010	1 in 10,000
10 bbl or Larger	0.000075	1 in 13,000
100 bbl or Larger	0.000022	1 in 45,000
1,000 bbl or Larger	0.0000011	1 in 910,000
Note: 1 bbl = 158.99 L		

16.4.2.3 Probability of Batch Spills

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 Project is shown in Table 16.15 by well number (12 to 16) and by drilling time frame, which varies up to 120 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 one bbl. The expected frequencies are for spills of any volume and are dependent on the number of exploratory wells drilled. There is no difference in expected frequencies based on location.

Table 16.15 Expected Frequency of Batch Spills

Wells	Expected Frequency	Probability	Chances
1	0.14	0.14	1 in 7.1
2	0.28	0.26	1 in 3.8
3	0.42	0.36	1 in 2.7
4	0.56	0.45	1 in 2.2
5	0.70	0.53	1 in 1.9
6	0.84	0.60	1 in 1.7
7	0.98	0.65	1 in 1.5
8	1.12	0.70	1 in 1.4
9	1.26	0.74	1 in 1.3
10	1.40	0.78	1 in 1.3
11	1.54	0.81	1 in 1.2
12	1.68	0.84	1 in 1.2

Table 16.15 Expected Frequency of Batch Spills

Wells	Expected Frequency	Probability	Chances
13	1.82	0.86	1 in 1.2
14	1.96	0.88	1 in 1.1
15	2.10	0.90	1 in 1.1
16	2.24	0.91	1 in 1.1

The probability and chances of batch spills of different volumes, including the modelled scenario, as shown in Table 16.16. The expected frequencies of batch spills over the course of the Project will depend on the number of exploratory wells drilled.

Table 16.16 Probabilities / Chances of Batch Spills by Size and Well Number

Wells	Probabilities / Chances 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**	**Modelled Scenario (6.3 bbl)**
1	0.14 / 1 in 7.14	0.07 / 1 in 14.29	0.001 / 1 in 1,000	0.0001 / 1 in 7,143	0.07 / 1 in 14.29
2	0.26 / 1 in 3.84	0.14 / 1 in 7.40	0.002 / 1 in 500	0.0003 / 1 in 3,572	0.14 / 1 in 7.40
3	0.36 / 1 in 2.75	0.20 / 1 in 5.11	0.004 / 1 in 334	0.0006 / 1 in 2,381	0.20 / 1 in 5.11
4	0.45 / 1 in 1.21	0.25 / 1 in 3.97	0.005 / 1 in 250	0.0007 / 1 in 1,786	0.25 / 1 in 3.97
5	0.53 / 1 in 1.89	0.30 / 1 in 3.29	0.005 / 1 in 200	0.0007 / 1 in 1,429	0.30 / 1 in 3.29
6	0.60 / 1 in 1.86	0.35 / 1 in 2.83	0.006 / 1 in 167	0.0008 / 1 in 1,191	0.35 / 1 in 2.83
7	0.65 / 1 in 1.53	0.40 / 1 in 2.51	0.007 / 1 in 143	0.0010 / 1 in 1,021	0.40 / 1 in 2.51
8	0.70 / 1 in 1.453	0.44 / 1 in 2.27	0.008 / 1 in 125	0.0011 / 1 in 893	0.44 / 1 in 2.27
9	0.74 / 1 in 1.35	0.48 / 1 in 2.09	0.009 / 1 in 112	0.0013 / 1 in 794	0.48 / 1 in 2.09
10	0.78 / 1 in 1.28	0.52 / 1 in 1.94	0.010 / 1 in 100	0.0014 / 1 in 715	0.52 / 1 in 1.94
11	0.81 / 1 in 1.24	0.55 / 1 in 1.82	0.011 / 1 in 91	0.0015 / 1 in 650	0.55 / 1 in 1.82
12	0.84 / 1 in 1.20	0.58 / 1 in 1.72	0.012 / 1 in 84	0.0017 / 1 in 596	0.58 / 1 in 1.72
13	0.86 / 1 in 1.16	0.61 / 1 in 1.64	0.013 / 1 in 77	0.0018 / 1 in 550	0.61 / 1 in 1.64
14	0.88 / 1 in 1.14	0.64 / 1 in 1.57	0.014 / 1 in 72	0.0020 / 1 in 511	0.64 / 1 in 1.57
15	0.90 / 1 in 1.12	0.66 / 1 in 1.51	0.015 / 1 in 67	0.0021 / 1 in 477	0.66 / 1 in 1.51
16	0.91 / 1 in 1.10	0.69 / 1 in 1.46	0.016 / 1 in 63	0.0022 / 1 in 447	0.69 / 1 in 1.46

Based on C-NLOPB Data for 1997 to 2018.

* Note that when the “chances” are 1 in 1 or 1 in a number less than 1, it means that there is a high likelihood that there will be at least one incident in the time frame.

16.4.3 Summary

Offshore exploration and production facilities off NL have spilled a total of 2,849 bbl of oil in 485 incidents over the last 24 years. Approximately 99% of the total volume of oil spillage occurred during development and production activities. A total of 33 hydrocarbon incidents totaling 33 bbl occurred during exploration activities. Approximately 72% of these spills involved less than 1 bbl. Offshore exploration activities over the time period 1997 through 2020 also resulted in 11 SBM spills, for a total of 776 bbl. There has also been a significant trend of reduced spill numbers in exploration and production activities in offshore NL after 2005. Reducing the number of spills was a focus area for both operators and the C-NLOPB. This reduction can be attributed to technological advances, lessons learned from investigation, an enhanced safety culture and improvements in the management systems and process of operators in the basin.

16.5 Contingency Planning and Spill Response

Analyses conducted to support the exploration drilling environmental assessment (Section 16.4) predict that there is a very low probability of a major crude oil spill occurring during exploration drilling. The probability that small batch spills of fuel, crude, or hydraulic oil could occur during routine operations is, however, slightly higher.

Oil spill trajectory modelling shows that there is only a remote probability of oil reaching the coastline prior to dispersion (Section 16.3) due to the prevailing wind and current conditions on the Grand Banks. In the unlikely event that conditions do allow oil spilled on the Grand Banks to approach shore, there will be no change to the management system described within the Suncor's OSRP, however, response techniques will change to coastal and shoreline applications.

Suncor has developed a four-layered escalation approach to respond, support and manage emergency situations both offshore and onshore for its worldwide operations. These layers consist of: i) Physical Response at the facility; ii) Response Support; iii) Response Management; and iv) Crisis Management (Figure 16-15). Four layers are identified with each having a corresponding team in place. While these teams coordinate with and support each other, they each have a distinct mandate under which they operate. This approach is aligned across Suncor to ensure consistency across the organization and to provide the ability for up-scaling the response in the event of a large or sustained emergency response operation.

In the event of a well control emergency, the following documents will provide the basis of the Intervention Action Plan:

- Business Process for Emergency Management
- East Coast Oil Spill Response Plan
- Bridging Document for Suncor Energy and MODU
- MODU Emergency Response Bridging Document
- Blowout Contingency Plan
- Wildlife Response Plan

Figure 16-15 Suncor Emergency Response Structure

Suncor's MODU Blowout Contingency Plan provides an action plan based on a worst-case well control scenario. The described action plan is meant as supplementary to the above procedures in the event of a well control event. Response actions are to be initiated as quickly as possible, but they should never interfere with or take priority over the safety of rig site personnel affected by the well control incident.

Blowouts in floating drilling operations generally occur underground or in the wellhead / BOP area rather than at the surface. This section addresses all responses to blowout situations, including damage to the rig. Response should be scaled to the consequence of a blowout event. The response to well control emergencies is grouped into the three categories

- Immediate Response (first 12 to 24 hours)
- Interim Actions (day 2 to completion)
- Extended-Term Response Planning

16.5.1 Oil Spill Response Plan

Suncor has an existing OSRP which will be used to develop a Project-specific OSRP for the exploration drilling program. This section summarizes the contents of the existing OSRP.

The OSRP covers the management, countermeasures, and strategies that will be used in an oil spill response for Suncor's East Coast production and drilling operations.

The OSRP describes the actions to be taken in the event of an oil spill and is specifically oriented to situations where Suncor has direct responsibility for the spill incident and its immediate and long-term impacts. Spill contingency plans for Suncor's operations include:

- Provisions for spill surveillance and monitoring
- On-water response equipment
- Appropriate training for response personnel
- Bio-monitoring plans for large spills
- Mutual aid plans with other nearby operators

The OSRP has been specifically developed to support East Coast drilling and production operations. The techniques, procedures and policies outlined in the OSRP allow Suncor to respond to a spill as it escalates and moves away from its point of origin.

At the time of an oil spill, a response strategy must be developed quickly. While every spill response situation will be unique, there are a few basic strategies that can be practically considered. The response options available during an offshore spill may include any of the following, where appropriate and if regulatory approval is in place (for chemical dispersion and/or *in situ* burning):

- Surveillance and monitoring
- Mechanical dispersion
- Containment and recovery
- Chemical dispersion
- *In situ* burning
- Wildlife measures

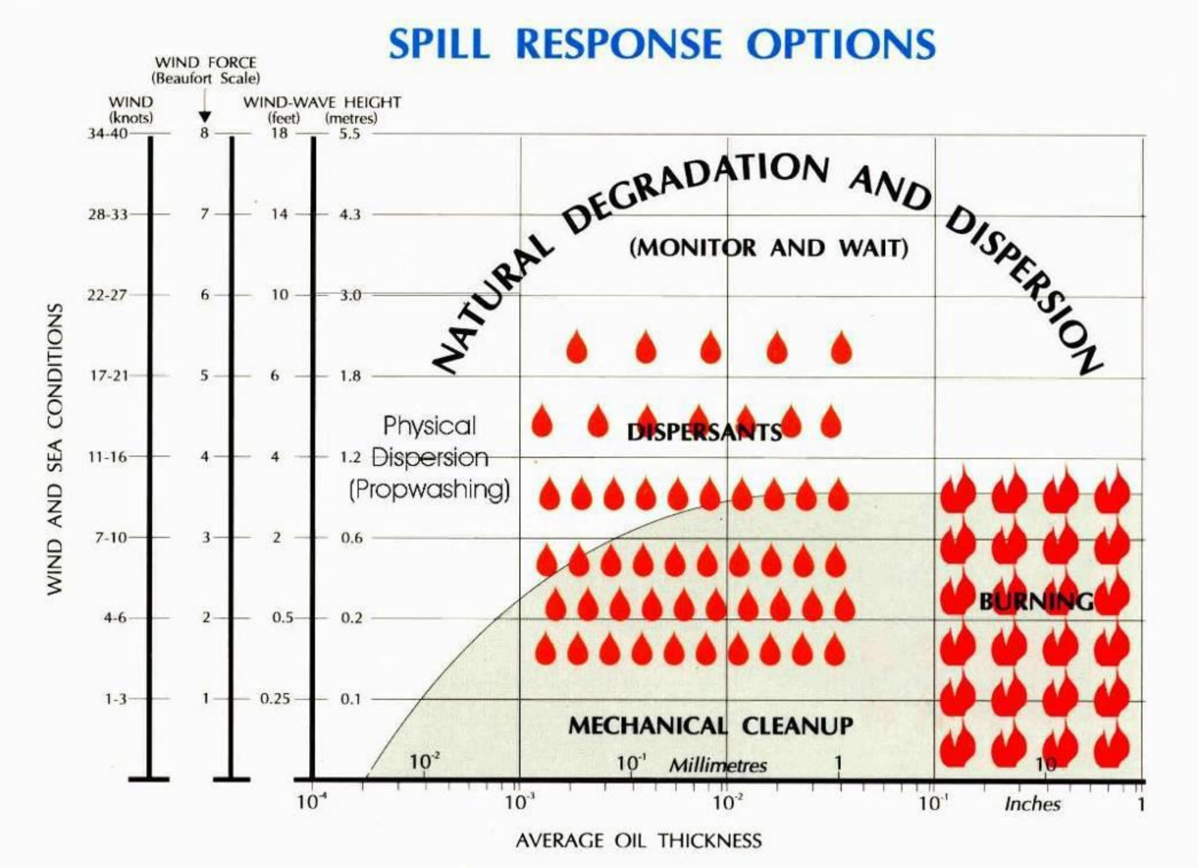
All strategies used during spill response will include some combination of these techniques. The actual strategy developed for any incident may include::

- Type and amount of oil or fluid spilled
- Operating conditions at the time of a spill
- Environmental resources at risk
- Logistical considerations
- Availability of response equipment
- Suncor's general emergency response structure
- Existing contract services
- Provisions made through mutual emergency assistance agreements with other offshore operators
- The requirements of the C-NLOPB
- Input from other stakeholders (i.e., Canadian Coast Guard [CCG], Environmental Emergencies Science Table and others as applicable to the particular event, including but not limited to Indigenous Groups, fishing organizations, and environmental non-governmental organizations)

Suncor’s oil spill response capability will include:

- A first response capability based on a network of equipment and vessels on the East Coast
- Eastern Canada Response Corporation (ECRC) Operational Spill Management services personnel and equipment provided on contract to Suncor
- Membership within Oil Spill Response Limited (OSRL) to provide access to international equipment and trained personnel
- Contracts with internationally recognized well capping and control subject matter experts

Determining an appropriate response strategy is dependent on the environmental conditions at the site of the spill. Figure 16-16 shows approximate operating windows for specific techniques.



Source: Al Allan, Spiltec as reproduced in the OSRL Oil Spill Response Handbook

Figure 16-16 Operating Conditions for Oil Spill Response Countermeasures

The countermeasures presented in each figure are generic and apply to any level of response. There is considerable overlap in the abilities of each technique to handle spilled oil and so, for any given scenario, there is not always a prescribed strategy that must be used. The On-Scene Commander (OSC) should feel confident that they have some options when considering the actual spill situation.

Guidelines for the use of techniques for the development of the response strategy to a specific oil spill incident immediately available to the OSC) are shown in Figure 16-17. All of the techniques described have some latitude in the conditions in which they can be implemented. The OSC shall assess the situation to implement the best available response option.

Suncor will consider the requirements of the C-NLOPB as the lead agency and other regulators during any spill. The Environmental Emergencies Science Table (EEST) is a multidisciplinary table of experts providing consolidated advice, information and assistance to the C-NLOPB under a memorandum of understanding. ECCC would convene and chair a Science Table when one or more triggers are met, or it is requested by the C-NLOPB. The triggers are:

- Environmental emergency is significant and/or complex/severe;
- Incident has international or cross-jurisdictional component; or
- Need to coordinate information impedes the Lead Agency at fulfilling its response monitoring role.

In a blowout situation, and after the initial situation is analyzed, the blowout response members of the Response Management Team (RMT) would be set-up in two separate groups. One group would examine capping operations (Section 16.5.3) and another group would commence relief well drilling activities (Section 16.5.4).

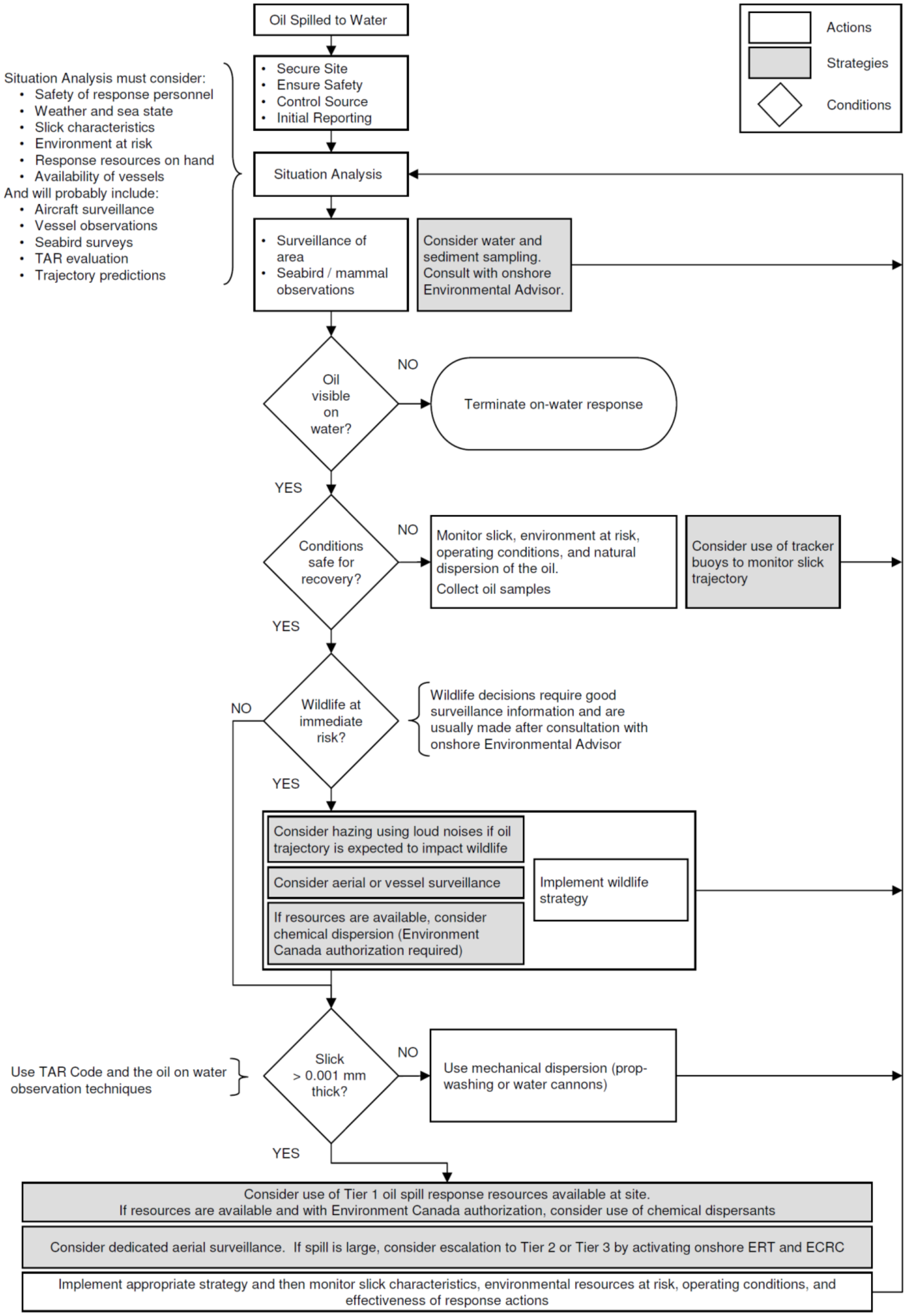


Figure 16-17 Decision-Making Guidelines for a Spill Response Strategy

16.5.2 Tiered Response

Suncor's OSRP follows a tiered approach for planning the response to oil spills, as per IPIECA-IOGP guidelines (Table 16.17).

Table 16.17 Tiered Level Response Description

Tier	Description
1	**Resources necessary to handle a local spill and/or provide an initial response** All spills have Tier 1 component, making it the foundation of preparedness and response of spills, regardless of cause or consequence. A Tier 1 response has the capacity to respond immediately with operational spills.
2	**Shared resources necessary to supplement a Tier 1 response** If the requirements of a response escalate beyond the scope of Tier 1 capabilities, a Tier 2 response is enacted to provide response specialists and a wider selection of equipment suited to a range of strategic response options. Tier 2 service providers are specialists with appropriate professional training; they have knowledge of the legislation and domestic practices in the countries / regions in which they work. Tier 2 responders can also provide access to expertise for specific elements of spill response (e.g., communication systems, marine logistics, aircraft, and other emergency-related services)
3	**Global resources necessary for spills that require a substantial external response due to incident scale, complexity and/or consequence potential** Tier 3 provides response personnel and access to well-established, industry-controlled equipment stockpiles at key strategic locations and with defined geographical limits. Pre-established contracts and agreements provide industry and governments access to cooperatively held resources. These pre-established resources include surety of response services and response times to any given risk location

Source: IPIECA-IOGP 2015

Listed below are considerations that can be used when developing an oil spill response strategy.

- Safety is always foremost.
- The OSC at site will always make the most informed decision and should be confident in their judgment.
- Seabirds are the primary environmental resource at risk. If birds are observed in the area, hazing techniques (e.g., ship noises and electronic noise-generating devices) can be employed to scare them away from the spill site.
- If seabirds are oiled, an effort will be made to capture live seabirds and transport them to shore for rehabilitation and collect oil samples.
- The trajectory of the slick can be monitored by use of tracker buoys.
- If there are birds or other sensitive wildlife nearby, the use of physical or chemical dispersion should be considered to remove the oil from the sea surface. Prop-washing will work well on thin films and sheens chemical dispersants or spill treating agents, such as Corexit® EC9500A, work best on thicker slicks but can be used on sheen if the threat to wildlife is great.
- Prop-washing is not effective for heavy oils or thick slicks.
- Use of chemical dispersants will be considered and must be authorized by ECCC.
- In poor weather conditions, natural degradation and dispersion is enhanced.
- Sorbent booms should be considered as an option for any small spill because of the speed of deployment.
- If the volume of oil spilled is unknown or if conditions are hard to control, arrangements should be made to mobilize the Suncor Single Vessel Side Sweep system early in the response, regardless of the technique chosen for first response.

- Aerial surveillance will be considered. Aerial surveillance is always useful. Use any aircraft (including government of Canada pollution flights and/or private flights chartered by Suncor) working in the area at the time of the spill. If the volume of oil spilled is unknown or if conditions are hard to control, arrangements should be made for dedicated aerial reconnaissance.
- Every planned task should include frequent situation analysis to determine the success of the operation and to help the OSC with decision making.
- Waste disposal capability and requirements will be considered in every spill response situation. Temporary storage on collection vessels and tankers for longer-term storage and shipping must be included in any strategy.
- In larger spills, several systems will be required for collection and recovery

Summaries of the strategies to be employed for each tier in a response are presented in Table 16.18. Suncor recognizes that for some of the response strategies in Tier 2 and 3 there will be consultation with the EEST and some of the response strategies will require advice and permits from regulators. This will be taken into account in the planning section of the response management team.

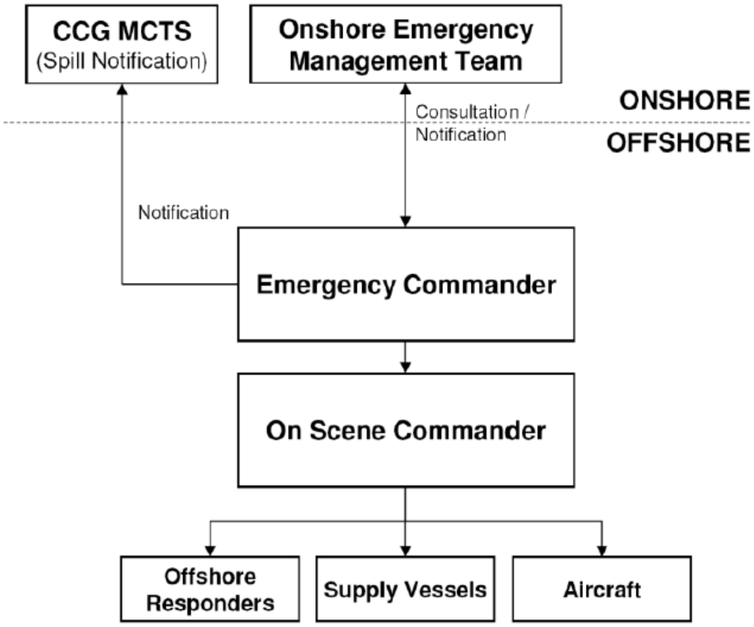
Table 16.18 Suncor Tiered Strategy Summaries

Component	Tier 1	Tier 2	Tier 3
Spill Description			
Spill Type	• Small batch spill • Instantaneous	• Large or very large batch spill • Instantaneous or continuous discharge over short period	• Blowout or very large batch spill • Continuous over extended period (days to weeks)
Product	• Diesel • Crude • Other Hydrocarbons	• Crude – will mat or emulsify and be persistent	• Crude – will mat or emulsify and be persistent
Volume	• <30 m³ ((Diesel / Other) • <8m³ (Crude) • Storage capacity of supply vessel will be 250-1,000 m³	• >8 m³ (Crude) • More than can be stored in existing offshore waste tanks	• Very worst case is 20,000 m³/day (day 1 or release)
Source	• Identified • Quickly stopped	• Not quickly stopped • Major repairs may be necessary	• Continuous flow – days to weeks • Relief well and/or major repairs will be required
Simultaneous Events	• Unlikely	• Probable	• Very probable (abandon installation, well control, disconnect)
Continued Risk	• Low	• Moderate to high	• Very high
Examples	• Fuel transfer with supply vessel • Minor process leaks • Failure of installation drainage system • Failure of MODU SBM solids controls	• Installation process failure	• Loss of well control • Installation storage cell rupture

Table 16.18 Suncor Tiered Strategy Summaries

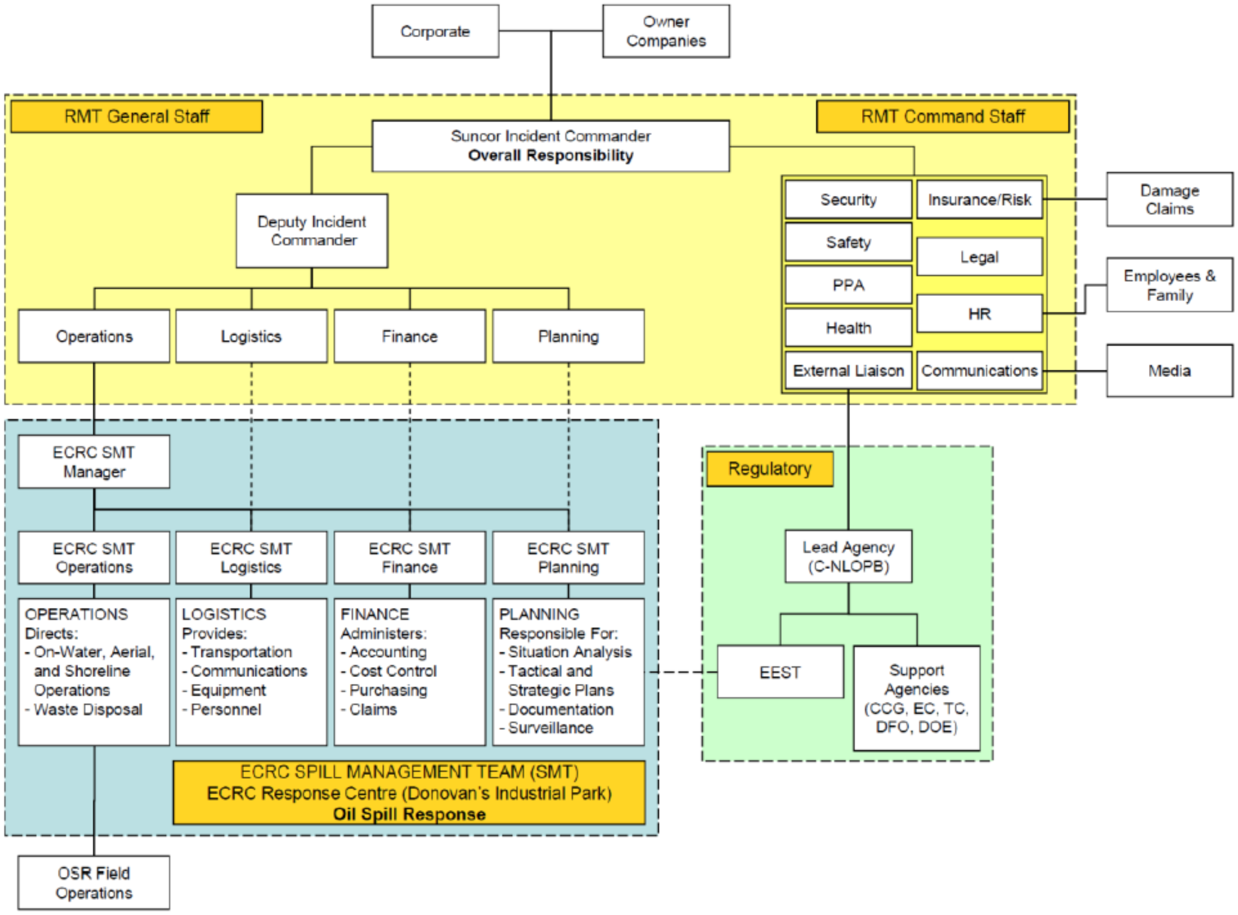
Component	Tier 1	Tier 2	Tier 3
Response Description			
Response Management	• Response managed by Emergency Commander at spill site • Response initiated with 1 hour of spill	• Response management on shore by RMT with assistance from ECRC • Resources from shore at site within 24 hours of spill	• Response management on shore by RMT with assistance from ECRC • Suncor Crisis Management Team activated to cover corporate concerns
Response Strategy	• Prop wash for small volumes, thin slick • Recover with sorbent boom if volume <1 m³ and slick thickness 0.001 mm • Chemical dispersion for fresh oil with slick thickness >0.001 mm and with authorization of ECCC • If volume >1 m³ or if crude forming mats, recover with Single Vessel Side Sweep System • Consider dedicated aerial surveillance for spills >1 m³	• Contain and recover crude oil, heavy metals, follow-up • Chemical dispersion for fresh oil with slick thickness >0.001 mm and with authorization of ECCC • Surveillance will be continuous and routine	• Contain and recover for oil in heavy mats • Chemical dispersion – ongoing for fresh oil • In situ burning – for fresh, thick oil • Surveillance – continuous, routine

Suncor's Tier 1 oil spill response management structure is illustrated in Figure 16-18 and Tiers 2 and 3 oil spill response management structure are illustrated in Figure 16-19.



Note: MCTS = Marine Communications and Traffic Services

Figure 16-18 Tier 1 Offshore Oil Spill Response Management Structure



Note: RMT = Response Management Team; PPA = Plan Process Advisor; HR = Human Resources; ECRC = Eastern Canada Response Corporation; SMT = Spill Management Team; OSR = Oil Spill Response; EEST = Environmental Emergencies Science Table; TC = Transport Canada; DOE = NL Department of Environment and Climate Change; CCG = Canadian Coast Guard; EC = Environment an Climate Change Canada; DFO = Fisheries and Oceans Canada

Figure 16-19 Tier 2 and 3 Oil Spill Response Management Structure

16.5.3 Blowout Contingency (Source Control) Planning

Capping operations are an integral part of most blowout intervention projects. In many instances, capping of the blowout well is the primary objective, the first major step in regaining control of the well. The term "capping" is sometimes loosely used to refer to the whole process of surface intervention. The more precise definition is the placement of a competent pressure control device onto the wellhead under flowing conditions. Capping operations involve the use of specialized equipment to control the flow using the existing wellbore. If the original rig is no longer available to carry out the work, a specialized support vessel or rig may be brought in. Suncor has an agreement with well control specialists and responders who would be incorporated into the response operations. Once the new control device (e.g., BOP, valve) is positioned over the well, there must be a means of attaching the device so that pressure integrity can be regained. Capping operations also include preparing the wellhead for placement of the capping stack. This sometimes involves removal of part or all of the existing wellhead / BOP stack.

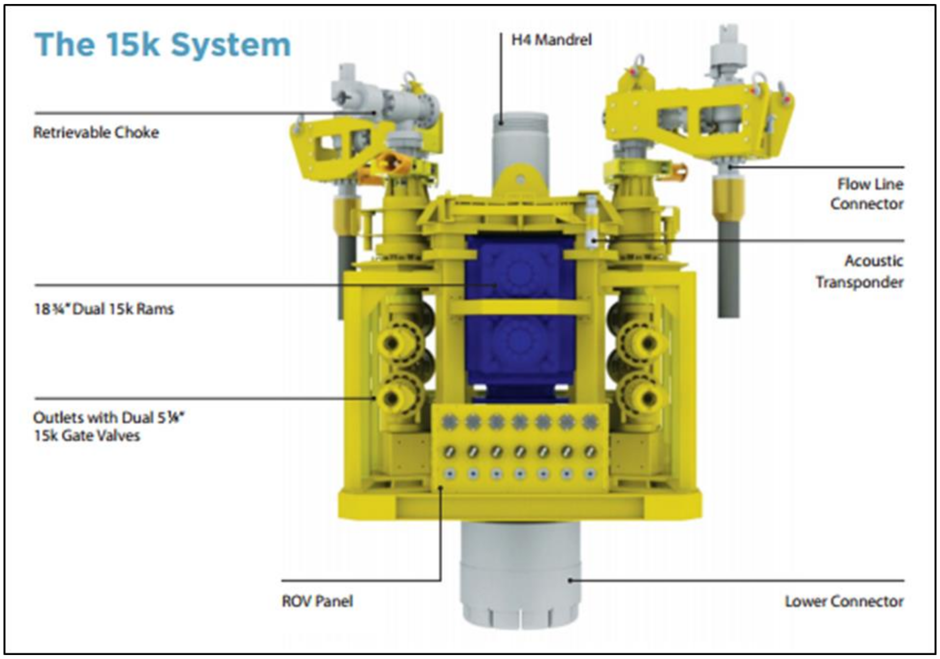
The equipment is available for use on the majority of international subsea oil wells at water depths of up to 3,000 m. It can be transported by sea or air from various international storage locations. The equipment is owned, stored and maintained by internationally recognized well capping and control subject matter experts. Suncor retains responsibility for the transportation of the equipment, provision of ROVs and support vessels, coiled tubing units for dispersant supply, and well control specialists. Suncor is also a member of OSRL where it can access various oil spill response equipment and services.

In the event of an incident, Suncor's primary plan is to use a capping stack rated to 15,000 psi working pressure (Figure 16-20). Suncor will have a contract in place for provision of the stack. This capping stack is an air-freightable capping stack, capable of being transported by air in one single fully assembled unit. The necessary on-site activities would occur simultaneously while the capping stack is transit, including engineering analysis, technical review, debris clearance, and site preparations, allowing installation of the capping stack upon arrival at the wellsite.

16.5.4 Relief Well Drilling

In the event that drilling of a relief well will be required, Suncor will act in accordance with the NL Basin Mutual Emergency Assistance Agreement (MEAA). The MEAA enables Suncor access to a suitable rig in the event of a well control incident. This Agreement is in place among oil and gas companies operating in East Coast Canadian waters and address resource sharing in the event of an emergency situation.

A relief well drilling team would need to include specialists in relief well interception, surveying, and directional work. Third-party expertise includes pumping specialists and a well kill coordinator to calculate and plan for the eventual well kill. In a subsea blow-out, the decision to drill a relief well would be made quickly. An approximate estimate for mobilizing a rig and drilling the relief well is ±52 days for a typical Terra Nova well. A drilling rig for a relief well will likely come via the NL Basin Mutual Emergency Assistance Agreement (MEAA).



Source: OSRL 2014

Figure 16-20 15,000 psi Capping Device

Different scenarios that are the trigger points for drilling a relief well include:

- Unsuccessful re-entry of the blowout well
- Re-entry that fails to restore well control
- Failure to kill and/or underground blowout
- Failure of a re-entry to provide the needed isolation and abandonment of the flowing zones
- Wellhead crater
- Wellhead failure

Depending upon the extent of damage to the blowout well, an additional rig and/or BOP equipment may need to be obtained from outside the operating region and/or from another operating company and contractor. Items such as high pressure, high volume pumps may also need to be obtained and mobilized from another region.

Various scenarios will be developed so that adequate hazard mitigation and operational practices can be developed to ensure the reliability of the relief well drilling and kill operations. Scenarios might include limited injection capabilities, disruption of annular bridges, or premature intercept.

16.5.5 Wildlife Response and Monitoring

The exploration drilling OSRP will include several appendices, including guidance on environmental issues such as seabird observation and monitoring protocols, and oil and wildlife sampling procedures.

Suncor has a Wildlife Response Plan for the Terra Nova field. A project specific plan will be developed for this Project and will address all of the various procedures and strategies required to mount an effective wildlife response. At minimum, it will include the following information:

- The wildlife potentially at risk in the area
- Mitigation measures to deter non-affected wildlife from affected areas
- Mitigation and response measures to be undertaken if wildlife and/or sensitive habitats become contaminated by the incident (including treatment of oil-affected wildlife)
- The type and extent of wildlife monitoring that would be conducted during and following a pollution incident

Suncor will consult with ECCC-CWS during development of the plan. It is also important to note that permits issued by ECCC-CWS may be required prior to deterring or relocating Migratory Birds and/or Species at Risk. This will be detailed in the plan.

Seabirds that live on or close to the sea surface have been identified as the biological resource most vulnerable to an offshore oil spill. Marine mammals (i.e., whales) are present in low numbers at selected times during the year and potential impacts on whale populations, even from major spills would be negligible. Suncor may undertake the following operations in the event of an offshore spill:

- Monitoring of the area to identify seabirds and other marine animals at risk
- Using available bird hazing techniques to deter seabirds from the affected area using vessels, aircraft, and noise making devices
- Implementing procedures for sampling bird carcasses
- Collecting and transporting live oiled seabirds to shore for cleaning and rehabilitation at Suncor's Seabird Cleaning and Rehabilitation Centre in St. John's that operates under a permit issued by the Canadian Wildlife Service and the NL Department of Environment Climate Change. Alternatively, Suncor may access third-party cleaning and rehabilitation expertise to support wildlife response activities

All Suncor East Coast offshore platforms and vessels have been equipped with sampling equipment to collect oil, oil and water, or oiled wildlife samples for analyses. In any spill situation, ECCC may request that Suncor collect as many oiled bird carcasses as possible. Once a seabird is oiled, it is the property of the Government of Canada.

Monitoring efforts should be directed towards the potential impact area of the spill. In open ocean conditions, it will be difficult to monitor the effects of small volumes of oil. A scalable approach is necessary to ensure that the effort put into monitoring the area where the oil may be present. The guidelines presented in Table 16.19 are based on an increasing level of monitoring effort as the level of the spill response increases from Tier 1 to Tier 3. In small spills where the level of response is low, monitoring will be limited to visual observations that are associated with surveillance operations that support the physical response to the spill. As the size of the spill and level of response increase, more directed monitoring will be required and may involve sampling, dedicated resources and studies, or long-term monitoring programs.

Table 16.19 Guideline for Oil Spill Environmental Monitoring

	Type of Monitoring	Tier 1	Tier 2	Tier 3
Monitoring during Oil Spill Response Operations	Oil in Water	• Surveillance from platform or vessel at site	• Surveillance from platform or vessel at site • Aerial surveillance • Satellite imagery	• Surveillance from platform or vessel at site • Aerial surveillance • Satellite imagery
	Wildlife	• Surveillance from platform or vessel at site	• Surveillance from platform or vessel at site • Dedicated seabird observers on vessels or aircraft	• Surveillance from platform or vessel at site • Dedicated seabird observers on vessels or aircraft
Post-spill Monitoring	Oil in Water	n/a	• Consider one-off water column sampling study	• First stage of long-term water column sampling program
	Wildlife	n/a	• Survey for remaining oiled seabirds	• Survey for remaining oiled seabirds
	Sediments	n/a	• Consider one-off assessment study	• Initiate long term sampling program
	Biota	n/a	• Consider one-off fisheries effects study	• Initiate fisheries or biological sampling program
Long-term Monitoring	Oil in Water	n/a	• Consider sampling program	• Long term sampling program
	Wildlife	n/a	• Consider population assessment	• Long term population and habitat studies
	Sediments	n/a	• Consider sampling program	• Long term sampling program
	Biota	n/a	• Consider sampling program	• Long term sampling program

16.5.6 Spill Impact Mitigation Assessment

Suncor will prepare a Spill Impact Mitigation Assessment (SIMA), an evaluation applied to an oil spill to aid in the selection of the appropriate spill response(s) that results in the best overall recovery of resources of concern (either ecological, socio-economic and/or cultural). The reduction of environmental impacts often requires multiple response options. 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

Suncor will develop their SIMA as per the Guidelines on Implementing Spill Impact Mitigation Assessment (SIMA) (IPIECA-API-IOGP 2017). Suncor will consider all feasible response options that would be potentially effective in the Project Area and will develop their SIMA in consultation with ECCC, the Canadian Science Table, and the C-NLOPB. This will be developed prior to operations as part of the Operations Authorization (OA) process with the C-NLOPB.

16.6 Environmental Effects Assessment

The EA for accidental events considers the following accidental spill scenarios:

- subsurface blowout
- Continuous 30-day (capping stack scenario) and 120-day (relief well scenario) subsurface blowout of Terra Nova crude oil at Suncor wellsite (approximately 100 m water depth)
- Instantaneous 30-day spill of 1,000 L of marine diesel from the MODU
- spill from a supply vessel in transit to or from the MODU
- SBM spill from the MODU and the marine riser

16.6.1 Marine Fish and Fish Habitat

The EIS considers the potential effects of accidental events on marine fish and fish habitat within the RAA. The RAA includes coastal, shelf, slope, and abyssal habitats within the Northwest Atlantic. Nearshore coastal habitats may function as feeding, spawning, and nursery areas for a variety of fish species such as Atlantic cod and capelin. Eelgrass beds and macroalgae in nearshore areas may also provide biogenic habitat and support nursery and rearing areas for fish and invertebrates. Key offshore features of the Northwest Atlantic ecosystem include the Grand Banks, Flemish Pass, Flemish Cap, Orphan Basin, and various seamounts and abyssal areas. The Northwest Atlantic is inhabited by a variety of species including plankton, fish and invertebrates that occupy benthic to pelagic habitats. This includes the SAR or SOCC that may occupy the RAA either year-round or seasonally. Critical habitats for SARA (Schedule 1) listed northern and spotted wolffish are also present in the RAA. Large transient seasonal migrants may also occur within the RAA including sharks, tuna, sunfish, and swordfish.

16.6.1.1 Project Pathways for Effects

Accidental events that result in the release of oil or SBM into the marine environment have the potential to affect marine fish and fish habitat depending on the nature, scale and duration of an offshore spill. The availability and quality of fish habitats may change from accidental events, with potential effects on water and sediment quality, and effects on biogenic habitats (e.g., eelgrass, macroalgae, corals, sponges). Change in habitat quality may also result in a change of habitat use (e.g., avoidance of these areas by marine fishes). Direct exposure to released substances by fish and invertebrates within these habitats may also result in changes in risk of mortality, injury or health depending on toxicity of released substances, mitigations employed (e.g., dispersants, *in-situ* burning), exposed life history stage, and uptake pathways. Marine fish may also migrate to other areas if there are potential declines in prey species from accidental release exposures. Potential effects on marine fish and fish habitat from accidental effects may have effects on other environmental (e.g., marine and migratory birds, marine mammals and sea turtles) or socio-economic (e.g., commercial fisheries and other ocean users, Indigenous peoples) VCs.

16.6.1.1.1 Potential Effects of an Oil Spill on Fish and Fish Habitat

Hydrocarbon releases in the marine environment may potentially interact with the water column, benthic, and coastal habitats and associated biogenic habitats (e.g., macroalgae, seagrass beds, coral and sponge areas). Changes to fish habitat availability and quality are dependent on the oil state (e.g., fresh oil, weathered oil, tar balls) and overall nature, scale, and duration of the oil spill. Oil exposure may diminish water and sediment quality for fishes and invertebrates living in the marine environment and thereby result in increased avoidance of these areas by some mobile finfish and invertebrates. Species may also move away from these habitats if oil exposure reduces prey availability. A general review of the effects is presented below.

Planktonic species may be affected by surface oil through reduced air-water exchange or light penetration that would affect respiration and photosynthesis (Abbriano et al. 2011; Ozhan et al. 2014). Planktonic organisms typically do not have avoidance capabilities to oil spills as their movements are mainly dependent on oceanographic conditions (e.g., currents, wind). The species-specific nature of hydrocarbon exposure effects on plankton and associated plankton dynamics generally result in a shift in community composition (Teal and Howarth 1984; Abbriano et al. 2011; Gilde and Pinckney 2012 in BP 2018; Salas et al. 2006; Bretherton et al. 2019). Oil exposure to phytoplankton results in a range of effects from growth inhibition and disruption of cell functioning to no effects or even stimulatory effects (Jiang et al. 2010; Almeda et al. 2018; Bretherton et al. 2019). In general, diatoms and phytoflagellates become the dominant species groups within the community following exposure to oil (Bretherton et al. 2019). Gilde and Pinckney (2012 in BP 2018) indicated that some phytoplankton (e.g., diatoms, cyanobacteria, euglenophytes, and chlorophytes) were observed to be relatively resistant to contamination, while other phytoplankton (e.g., cryptophytes) were found to be relatively vulnerable within a saltmarsh estuarine phytoplankton community.

Laboratory studies indicate that zooplankton are sensitive to hydrocarbons resulting in lethal and sublethal effects following exposure (Utne 2017; Almeda et al. 2018; Toxværd et al. 2018). *Calanus* copepod species make up the majority of zooplankton biomass on the Grand Banks and their population dynamics have implications for higher trophic levels (refer to Section 6.1.1.3). Adult *Calanus* copepods exposed to hydrocarbons did not result in reductions in egg hatching success rates; however, increased oxygen consumption and metabolism effects occurred in exposed early life history stages with negative implications for development (Utne 2017). Zooplankton may accumulate hydrocarbons through ingestion of contaminated phytoplankton or direct ingestion (Almeda et al. 2014, 2016). Zooplankton have oil-degrading bacteria that aid in hydrocarbon detoxification through fecal excretion (Almeda et al. 2014, 2016); this is also a mechanism that removes oil from surface waters (Varela et al. 2006). While accumulated hydrocarbons in zooplankton have been shown to be depurated within days of being moved to clean water (Trudel 1985, in BP 2018), rates of uptake and depuration are species-specific and dependent on environmental conditions (Agersted et al. 2018). Potential recovery of zooplankton communities from hydrocarbon exposure are aided by short generation times and high fecundity (BP 2018). Oil spills in areas with dynamic oceanographic conditions may reduce the potential effects on plankton communities with increased dispersion of oil and improved water quality with mixing of water from unaffected areas (Varela et al. 2006).

For microbial communities in the water column, hydrocarbons serve as a food source that they are able to metabolize for energy and growth (ASM 2011). Therefore, in the presence of oil spills, microbes are able to proliferate and multiply quickly (ASM 2011). Consumed hydrocarbons are degraded into marine “snow” and shuttled to benthic areas where they continue to degrade (Passow et al. 2012; Daly et al. 2016; Passow 2016). This mechanism of microbial consumption of hydrocarbon compounds in conjunction with physical processes (e.g., evaporation, dissolution, dispersion, and photo-oxidation) can eventually clean up an oil spill with the end products typically carbon dioxide and water under aerobic conditions (ASM 2011).

There are large variations in sensitivity among different finfish and invertebrate species that use different habitats, have different life histories, and different development stages (Lee et al. 2015). Hydrocarbon exposure in adult fish has been associated with a variety of effects including impairments to growth, health, fitness, and reproduction (Khan 1990; Sánchez et al. 2006; Klinger et al. 2015; Bayha et al. 2017; Suzuki et al. 2018). Many of these studies are laboratory based with little capacity of fish to avoid oil exposures (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). Ingestion of oil-contaminated prey may also result in growth impairments that may have effects on risk to predation, future ability to feed, and reproduction effects (Sánchez et al. 2006). In a monitoring study of effects of the *Prestige* oil spill, there were no apparent effects to diet composition or stomach fullness for monitored fish and invertebrate species (Sánchez et al. 2006). Potential effects on mobile adult pelagic and benthic fish and invertebrates may be reduced due to their capacity for avoidance of oiled areas (Irwin et al. 1997; Law et al. 1997 in BP 2018; Barnett and Toews 1978; Weber et al. 1981; Alvarez Piñeiro et al. 1996; Stagg et al. 1998). For example, Atlantic cod have been shown to generally avoid oil concentrations of 50 to 100 µg/L in laboratory experiments (Bøhle 1986). Large pelagic species such as Atlantic bluefin tuna are able to travel long distances of approximately 100 km per week (Hazen et al. 2016), reducing prolonged exposure to oil and increasing the opportunity to find uncontaminated food sources. Recovery of fish would depend on the nature of exposure; however, biomarkers in demersal fish monitored during the *Prestige* oil spill showed decreasing enzyme activity over time and indicated reduced exposures two to three years after the spill (Martínez-Gómez et al. 2009). Oil contaminated sediments in nearshore and benthic environments may also result in repeated exposures in benthic species. However, the dynamic oceanographic processes in nearshore environments may also further promote degradation of oil.

Oil-exposed coastal habitats that act as nursery or rearing habitats may also have growth and developmental effects on early life history stages of various fish and invertebrates. Early life history stages have limited avoidance capabilities and are sensitive to lower concentrations of hydrocarbons, and as such, have a greater risk of exposure (Incardona et al. 2013; Lee et al. 2015). Lethal and sublethal effects from hydrocarbon exposures have been observed in laboratory exposures of marine fish and invertebrate early life stages (e.g., Suchanek 1993; Pollino and Holdway 2002; Incardona et al. 2011; Gardiner et al. 2013). This has included increased mortalities or developmental issues (e.g., cranial and cardiac deformities) in larvae or embryos of Atlantic herring, capelin, Atlantic cod, Atlantic haddock, tuna, and Arctic cod (Paine et al. 1992; Incardona et al. 2011; Ingvarsdóttir et al. 2012; Gardiner et al. 2013; Sørensen et al. 2017; Laurel et al. 2019). Stefansson et al. (2016) conducted laboratory exposures of larval invertebrates (e.g., echinoderm and bivalve species) to water accommodated fractions (WAF) of weathered and fresh oil from the Deepwater Horizon spill. No effects on survival or development of larval invertebrates were observed as a result of exposure to weathered WAF; however, adverse effects were observed from exposure to WAF from fresh oil. While the component of fresh oil resulting in adverse effects was not known, the study was consistent with other laboratory studies that found higher toxicity of fresh oil relative to weathered oil (Stefansson et al. 2016). Potential accidental events during the seasonal phytoplankton plume would pose potentially more risk to species with the associated increased concentration of eggs, larvae, and juveniles in the water column (Stige et al. 2018; Samuelsen et al. 2019). Potential effects on larval stages are typically adverse; however, effects to the population would be species-specific and dependent on the nature of the spill. For example, modelling of oil spill effects on cod species in the Arctic indicate that the adverse effects do not necessarily result in population level effects (Gallaway et al. 2017; Carroll et al. 2018). In Arctic cod the wide range of age classes added resilience of the population to adverse effects from oil spill as it reduced potential effects on any single recruitment year (Carroll et al. 2018). Only portions of life history stages may also be affected by a spill if early and adult stages occupy different habitats such as for wolffish (DFO 2020).

Macroalgae and seagrasses in nearshore habitats have ecological roles as rearing, nursery, and foraging areas (Gurney and Lawton 1996) and these functions may be adversely affected by oil exposures. The overall response of macroalgae to oiling events is dependent on species, and length and degree of exposure (Stepaniyan 2008). At low concentrations oil may have no response on macroalgae and in some instances may have a stimulatory effect. Laboratory exposures to crude oil (5 to 30 mg/L) did not affect growth rates of some brown alga but did reduce growth in other brown and red algal species (i.e., reduced growth rates at 20-30 mg/L crude oil exposures) (Stepaniyan 2008). In experimental oil releases of 3 to 30 mg/L, Cross et al. (1987) observed either no visible effects and/or some stimulatory growth effects on macroalgae from the Canadian Arctic depending on the species. In monitoring of oil effects from the *Prestige* oil spill, algal richness, coverage, or diversity did not differ among years (Díez et al. 2008). The authors of these studies indicated that the lack of effects was likely from low oil exposures due to dispersion (Cross et al. 1987; Díez et al. 2008). Following the Deepwater Horizon spill, macroalgae richness decreased by 83% in an area west of the wellsite which had cascading adverse effects on the associated assemblages living on the macroalgae (Felder et al. 2014). Recolonization was supported by crustose coralline algae that acted as a seed bank for the area (Felder et al. 2014). Heavily affected areas by oil exposure resulted in the removal of brown algae from the intertidal zone after the *Exxon Valdez* spill and recovery was impaired by the lack of canopy cover to protect juveniles from desiccation and wave action (Stekoll and Deysher 1996). However, recovery of macroalgae to the intertidal was experimentally supported by the introduction of artificial turf mats (Stekoll and Deysher 1996).

Similar to macroalgae, the overall effects on seagrasses is species-specific and depends on overall length and degree of oil exposure (Fonseca et al. 2017). Oil exposure may result in blade or shoot mortality, physiological effects, and effects on reproduction with more immediate effects resulting from direct exposure than sediment fouling (Fonseca et al. 2017). While the effects of oiled sediments on seagrass are likely adverse, the mechanism for effects on plant tissue is unclear (Fonseca et al. 2017). Laboratory experiments with Greater Caribbean Basin seagrass species showed low oil exposures were sufficient to result in mortality; sublethal effects occurred at oil exposures of 0.53 mg/L and greater (Thorhaug et al. 1986). Oil exposures of 0.53 mg/L and 1.05 mg/L have resulted in shorter and wider roots and fewer inflorescences, which has implications for increased risk of dislodgement and reduced reproductive output (Martin et al. 2015). Effects from various oil spills have shown variable effects on seagrasses, largely due to the varying conditions and nature of the spill. Oil exposures following the sinking of a tanker off the coast of Italy resulted in massive mortality of seagrass shoots (Fonseca et al. 2017). Nine years after the incident oil could not be detected in the area; however, rhizome growth was consistent with reduced growth under stressed conditions (Fonseca et al. 2017). Within a couple of years following the Deepwater Horizon spill, aerial surveys indicated declines in seagrass coverage where there was confirmed oiling at the Chandeleur Islands; however, there was an overall net gain of seagrass coverage along the back barrier shelf (Kenworthy et al. 2017). *Zostera marina*, the seagrass present in most of Atlantic Canada, was studied in relation to the *Exxon Valdez* oil spill (Dean et al. 1998). Dean et al. (1998) found little difference in biomass and germination between seagrasses from a heavily oiled bay and a reference site. Furthermore, there were no signs of elimination of seagrass beds and initial reductions in shoot density and inflorescences were not detectable between sites within a year (Dean et al. 1998). Although effects are variable, oiling would likely have adverse short-term effects on seagrasses with recovery possible if seagrasses are not extirpated from the area.

Corals and sponges are sessile, long-lived marine organisms that may provide biogenic habitat to other species in slope and deepwater areas of the RAA (Ross and Quattrini 2007; Baillon et al. 2012, 2014; Beazley et al. 2013; Kenchington et al. 2013). While effects of oil exposure are not well described for regional species, this has been assessed globally for other corals and sponges. Effects on corals and associated recovery are dependent on initial effects and overall nature of exposure (Hsing et al. 2013; Girard et al. 2019). Following the Deepwater Horizon spill, signs of effects and stress from oil exposure were observed in coral colonies up to 6 to 22 km from the release site, including tissue loss, retracted polyps, sclerite enlargement, excess mucous production, bleached commensal ophiuroids, the presence of brown flocculant, and mortality (White et al. 2012a, 2012b; Buskey et al. 2016; Etnoyer et al. 2016; Silva et al. 2016; Hourigan et al. 2017, Schwing et al. 2020). Follow-up surveys indicated a patchy distribution of stressed corals and patchy distribution of stress on corals potentially due to the nature of the oil released in deep water (Hsing et al. 2013; Fisher et al. 2014). Other signs of deterioration included colonization of damaged areas of stressed corals by hydroids and reduction of biomass from branch loss (Hsing et al. 2013; Fisher et al. 2014; Girard et al. 2018). Subsequent benthic surveys found some indications of recovery (Fisher et al. 2014). Individuals with low initial impact (low coverage of flocculant of <20%) exhibited recovery of those branches after 16 months as determined by visual surveys (Hsing et al. 2013; Fisher et al. 2014). Modelled recoveries of pre-established corals affected by the Deepwater Horizon spill indicated recovery times of 10 to 30 years for individuals to become healthy; however, recovery of overall biomass was projected to be longer (Girard et al. 2018). For heavily impacted sites from the Deepwater Horizon spill that require replacement of entire colonies, *Paramuricea* sp. population growth and recruitment models suggest timescales of 100 to >600 years for recovery (Schwing et al. 2020). Aside from health effects on adult corals, reproductive processes may be affected by oil exposure with potential effects on planulae and potential survival and settlement (Negri and Heyward 2000; Goodbody-Gringley et al. 2013; Fisher et al. 2014; Hartmann et al. 2015). Although not specifically studied, the recovery of slow-growing coral biogenic habitat from oil exposure in the RAA is likely in the order of decades (Cordes et al. 2016; Ragnarsson et al. 2017; Girard et al. 2018).

Studies on adult sponges indicate that sponges may bioaccumulate oil or oil components that can lead to damage to sponge DNA (Zahn et al. 1983; Batista et al. 2013; Gentric et al. 2016; Stévenne 2018). However, rate of accumulations may be highly variable among individuals due to filtering adaptations and altered feeding behaviours when exposed to oil (Vad and Duran 2017). Laboratory studies with *Geodia barretti* sponges, a species that occurs within the RAA, did not demonstrate strong sublethal stress effects, changes to microbial community, or significant effects on respiration rates at oil exposures of 33, 100, 300 µg/L over eight days (Stévenne 2018). Signs of cellular stress and variations in metabolic performance that occurred in response to exposures were also not evident after a 30-day recovery period (Stévenne 2018). Stévenne (2018) suggests that a longer duration of oil exposure may be required to induce stronger physiological effects and further investigations are required to determine whether the combination of sponge filtering and microbial activity may be a mechanism for detoxification following an oil spill. Oil exposures may also have implications for settlement and development of sponge larvae (Cebrian and Uriz 2007; Negri et al. 2016; Vad et al. 2018) and therefore recovery from a spill. Laboratory studies with a shallow-water Mediterranean sponge showed reductions in sponge larvae settlement after 10 days of PAH exposures (500 and 1,000 mg/L) (Cebrian and Uriz 2007). Biogenic sponge habitats are vulnerable to anthropogenic effects and deep-sea sponges are considered slow growing and long-lived organisms (Cordes et al. 2016; Vad et al. 2018). Relatively slow growth rates have been observed in deep-sea sponges, with strong seasonal growth rates ranging from a few millimetres to a couple centimetres per year (Vad et al. 2018). Depending on initial exposures, these characteristics suggest a long recovery time from adverse effects. Although not specifically studied, recovery of slow-growing sponge biogenic habitats from oil exposure in the deep-sea areas of the RAA is conservatively predicted to be on the order of decades (Cordes et al. 2016; Vad et al. 2018).

16.6.1.1.2 Potential Effects of Dispersants on Fish and Fish Habitat

Oil dispersants are a combination of solvents and emulsifiers that break oil into small droplets that can disperse into the water column. This removes oil from that water surface and creates a larger surface area for the breakdown of spilled oil by specialized microbes (Lee et al. 2013; AORST-JIP 2014; Coelho et al. 2017). The ideal ratio of dispersant to spilled oil is still under debate, but any proportion takes surficial oil and increases its overall surface area by dispersing it throughout the water column (Brakstad et al. 2014, 2015, Kleindienst et al. 2015; Seidel et al. 2016). Effects on marine fish and invertebrates from an oil spill are typically localized at the surface, while the use of dispersants increases the risk of exposure down into the water column and potentially the seafloor (Ramachandran et al. 2004). However, such water column concentrations can temporarily increase the bioavailability of oil components to oil-degrading microorganisms and can also be rapidly diluted (DFO 2021).

Concern for pelagic and demersal fish and fish habitat from the use of dispersants is typically related to the increased exposure to concentrations of the toxic components of oil (e.g., PAHs), or the potential interaction of both oil and dispersant together (Pace et al. 1995; DeLeo et al. 2016). Eggs and juveniles typically have increased sensitivity compared to adults, and as they typically occupy the upper layers of the water column their risk of exposure is higher (Cordes et al. 2016; DeLeo et al. 2016). Atlantic herring eggs exposed to dispersed oil had increased deformities and mortality compared to unexposed eggs (Greer et al. 2012; de Jourdan et al. 2021). Capelin exposed to dispersed oil in laboratory conditions had decreased fertilization activity, hatching success, survival, and heart rate, as well as upregulation of genes used in oil biotransformation (Beirão et al. 2018, 2019). While Atlantic cod eggs exposed to the water-accommodated fraction of a chemical dispersant showed sublethal responses, there was no difference at hatching when compared to eggs exposed to the water-accommodated fraction of crude oil (de Jourdan et al. 2021; Scovil et al. 2022). For invertebrates, northern shrimp exposed to dispersed oil had decreased larval fitness (growth, feeding, and development) after short-term exposures (1 to 6 hours) (Keital-Gröner et al. 2020). For sessile invertebrates, dispersed oil has been found to reduce larval settlement and cause tissue degradation and abnormal development (Cordes et al. 2016). Settlement and post-settlement survival of deep-sea coral in the Gulf of Mexico showed that treated oil was more toxic than untreated oil (DeLeo et al. 2016).

While early life history stages of marine fish and fish habitat are vulnerable to dispersed oil, it is difficult to study population level effects especially as effects may be species-specific although there have been some efforts to review the effects specific to the Northwest Atlantic and the Grand Banks in particular (DFO 2014). Modelled effects of dispersed oil on Arctic cod populations found that lethal and sublethal effects on juveniles and eggs may be insignificant to the regional population overall (Gallaway et al. 2017). Arctic cod produce numerous small eggs, and so the modelled worst-case dispersed oil spill had little to no effect on the population (Gallaway et al. 2017). However, fish species in the RAA employ a variety of spawning strategies, and so the effect of dispersants during an oil spill likely differs depending on life history and sensitivity. Comparisons between work done in Arctic, temperate, and tropical waters show that relative sensitivity to dispersed oil is similar among studied fish and invertebrate species in these areas (Olsen et al. 2011; Bejarano et al. 2017). However, there are still some data gaps with a large amount of uncertainty around the persistence of dispersed oil and the long-term effects on fish and fish habitat (Lee et al. 2015).

16.6.1.1.3 Potential Effects of *in situ* Burning on Fish and Fish Habitat

In situ burning is the ignition of concentrated oil to reduce the overall mass present on the water's surface. Oil is then continuously collected using fireproof booms to maintain a combustible thickness of 2 to 5 mm (IPIECA and IOGP 2016). This leaves a thinner layer of oil at the surface after combustion is complete, with much of it released to the atmosphere as smoke. Depending on the source oil, burn time, and temperature, this remaining oil may then continue to float or sink as it cools depending on its density (Allen 1990; Buist et al. 1997). Studies in Newfoundland found that toxicity below the burning oil was elevated, but within the natural range below that of unburned oil (Daykin et al. 1994). A test burn in Newfoundland did not result in elevated sea surface temperatures due to the continual replacement of cooler unburned oil and seawater using the boom (Fingas et al. 1995).

The main potential impact on fish and fish habitat is the burning oil itself and the remaining residue, as atmospheric smoke will not impact fish. The thin remaining residue oil is simply un-combusted oil, and so the effects would be similar to those described above for the effects of oil on marine fish and fish habitat. However, the remaining oil that makes up the slick can be chemically different than the original oil depending on burn time and the composition of the source oil (Fritt-Rasmussen et al. 2015). *In situ* burning residue may have higher metal concentrations and reduced light PAH (three rings or less) concentration but greater concentrations of heavy PAHs (four or more rings) (Wang et al. 1999; Faksness et al. 2012). Additional research on local conditions and oil composition is required in relation to *in situ* burning.

Many important fish species in Newfoundland and Labrador (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 (Kocan et al. 1987). *In situ* burning is likely to result in mortality within the surface microlayer (top 1 mm of the water column), though the overall area affected would be small in scale as oil is concentrated in order to sustain combustion. As *in situ* burning would be a rare event within a localized area, any mortality is unlikely to have a population-level effect. Any species within the microlayer will be replenished from nearby sources after combustion is complete (Shigenaka and Barnea 1993). Species that are capable of locomotion, such as adult pelagic fish, will likely avoid *in situ* burning areas and should not be affected.

16.6.1.1.4 Potential Effects of an SBM Spill on Fish and Fish Habitat

An accidental SBM spill would potentially affect fish and fish habitat through similar effects pathways from routine drill cuttings discharge (see Sections 9.3.1.3.3 and 9.3.2.3.3). Released SBM fluids may result in disturbance to the water column (e.g., turbidity and suspended solids) and disturbance to benthic areas (e.g., burial, creation of anoxic environments) (Kjeilen-Eilertsen et al. 2004; Smit et al. 2008; Neff 2010;

DeBlois et al. 2014a, 2014b; Cordes et al. 2016; Tait et al. 2016; IOGP 2016; DFO 2019). These changes to fish habitat may also result in effects on fish and invertebrates living in these environments.

In the event of a surface SBM spill a thin surface sheen may result with similar but more limited effects as described for hydrocarbon spills. SBMs are heavy and dense fluids that sink rapidly in the water column, suggesting that potential suspended solid and turbidity effects are non-persistent and temporary (BP 2018). Mobile finfish and invertebrates are likely able to avoid suspended sediments and depositional areas, therefore low mobility invertebrates have a higher potential for effects from an accidental SBM spill (IOGP 2016). Environmental effects are mainly associated with smothering, sediment alteration, and addition of organic matter that may lead to anoxic areas with implications for sessile or low mobility organisms (see Sections 9.3.1.3.3 and 9.3.2.3.3). Drilling fluids are screened and selected in accordance with the Offshore Chemical Selection Guideline (OCSG) (NEB; National Energy Board et al. 2009). Drilling fluids that have environmentally friendly characteristics of acceptable low toxicity and biodegradability are used where technically feasible. SBM drilling fluids were developed for low toxicity and fast degradation properties (Neff et al. 2000; Centre for Offshore Oil, Gas and Energy Research (COOGER) and Lee 2009; Li et al. 2009; Jagwani et al. 2011; Paine et al. 2014; Tait et al. 2016).

Timescales for initial recovery of SBM spills are predicted to occur on the order of weeks to months, with full recovery within years. Laboratory studies of SBM fluids on marine sediments for four weeks at 5ºC showed decreases of total petroleum hydrocarbon (TPH) levels by 31% and 14% in fresh and recycled SBMs, respectively (COOGER and Lee 2009). SBM degradation at lower seafloor temperatures would likely be lower, however, COOGER and Lee (2009) suggest that native bacteria adapted to the cold-water environments may facilitate degradation. SBM spills have occurred in deep Canadian waters offshore Nova Scotia. Approximately 354 m^3 of SBM fluid was released from a riser flex joint in approximately 2,067 m of water in 2004 and approximately 136 m^3 of SBM fluid was released from the mud system piping in approximately 2,800 m of water in 2018. Follow-up ROV surveys confirmed that SBMs settled on the seafloor in narrow ribbons from the wellhead, cascading out in thin layers rather than forming piles around the wellhead (CNSOPB 2005, 2019). The CNSOPB had concluded there were no significant environmental effects associated with the spills based on considerations of SBM properties (acceptable toxicity, biodegradation and bioaccumulation properties), absence of habitat-forming benthic organisms, and lack of accumulation of drilling fluid (CNSOPB 2005, 2019). The operator involved in the 2018 SBM spill incident also conducted SBM spill modelling that indicated maximum depositional thicknesses of 3.7 mm, which was considered to be lower than thicknesses that could result in smothering of organisms (CNSOPB 2019). In assessments of 390 m^3 SBM spill at 1,841 m water depth in the Gulf of Mexico in 2003, the United States Department of the Interior Minerals Management Service (USDOI MMS) (2004) indicated that benthic species would likely be affected by smothering and resulting anoxic environments. However, mobile species were considered able to avoid burial effects (USDOI MMS 2004). It was determined that partial recovery of benthic communities would likely occur within weeks or months of the accidental SBM release with full recovery in a couple years (USDOI MMS 2004). The USDOI MMS (2004) considered the spill not to have significant environmental effects considering the dispersion of SBM fluid and low toxicity characteristics of SBM.

16.6.1.2 Mitigation of Project-related Environmental Effects

Spill prevention measures are the most effective way to mitigate potential effects from accidental events. Suncor’s strategy for contingency planning and spill response is described in Section 16.5. Mitigation of potential accidental events is incorporated as part of the regulatory processes (e.g., OA, ADW), project-specific safety and response plans (e.g., safety plan, OSRP, EPP), and well design (e.g., 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 subsea injection), in situ burning, shoreline protection and clean-up, and oiled wildlife response. Further details on spill responses are provided in Section 16.5. 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 well control and prevention of blowouts are described in Section 2-5. 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 Suncor company standards.

In the unlikely event of a spill, specific monitoring (e.g., environmental effects monitoring) and follow-up programs may be required and will be developed in consultation with applicable regulatory agencies.

16.6.1.3 Characterization of Residual Project-Related Environmental Effects

The characterization of residual project-related environmental effects is in line with DFO’s framework (DFO 2017a, 2017b; Thornborough et al. 2017) such that the residual effects are assessed in terms of exposure criteria (concentration of populations, mobility of populations, and interactions with sea surface / sediment), sensitivity criteria (reduction in feeding / photosynthesizing, toxicity impairment), and recovery criteria (population dynamics, reproductive capacity, distribution constraints).

16.6.1.3.1 Subsurface Blowout

Potential effects from a subsurface blowout accidental event will depend on the extent and duration of the spill, spill trajectory, and overlaps in space and time with marine fish and fish habitat. If a subsurface blowout were to occur, it would potentially have effects on marine fish and fish habitat through changes in risk of mortality, injury or health of fishes, and changes in habitat availability, quality and use. Project-specific modelling was conducted as described in Chapter 16 and Appendix E (RPS Group 2020) to describe the spatial extents of potential subsurface blowouts. The modelling results were assessed against the lower socioeconomic threshold (oil surface thickness: 0.04 µm, water column concentration: 1.0 µg/L dissolved PAH or 100 µg/L THC, and shoreline oiling: 1 g/m²) and conservative ecological thresholds (oil surface thickness: 10 µm), water column concentration: 1.0 µg/L dissolved PAH or 100 µg/L THC, and shoreline oiling: 100 g/m²).

Stochastic modelling results for unmitigated subsurface blowouts (30- and 120-day oil release durations) indicated that the highest potential likelihood (>90%) to exceed surface oil socio-economic and water column socioeconomic and ecological exposure thresholds occurred primarily east of the release site, up to 1,500 km away. The spill footprint is largely in open waters off the continental shelf with exposure to waters above the Flemish Cap and Southern Grand Banks in the 120-day scenarios. As the spill trajectory is largely eastward and the release location is far from shore, the maximum average annual probability of shoreline exposure above socio-economic threshold (>1g/m²) was approximately 4% and 8% for 30- and 120-day scenarios respectively. However, maximum probabilities of shoreline hydrocarbon exposure ranged from 18% to 45% depending on the release scenario, primarily on the Avalon Peninsula of Newfoundland. Stochastic modelling results for various scenarios are based on conservative socio-economic thresholds and footprints of areas reaching higher ecological thresholds would be smaller.

Deterministic scenarios modelled representative credible “worst-case” scenarios of subsurface blowouts and predicted black oil (>10 µm ecological threshold) extending nearly 300 km mainly east of the drilling installation in surface oil exposure cases. Surface area exceeding the ecological thickness threshold (10 µm) was approximately 286,800 and 833,500 km² for 30- and 120-day deterministic scenarios, respectively. Worst-case scenarios for water column exposure showed low concentrations of hydrocarbons (<10 µg/L) that were below ecological thresholds extending south and east of the drilling installation with higher concentrations near the source. The modelling results for an unmitigated subsurface blowout suggest that surface waters and the water column areas affected would likely be around the southern Grand Banks, Flemish Pass, and Flemish Cap. Therefore, plankton present in the mixed surface layers of water would likely experience a temporary decline in abundance within the immediate area of the spill with community composition changes (i.e., changes from increases and declines in particular species resulting from oil exposure or changes to trophic interactions). Short generation times of phytoplankton and zooplankton would aid in recovery from the spill once it has subsided from spill responses and mitigations (e.g., containment, recovery, dispersion) and natural weathering. Employing dispersants may speed up degradation of hydrocarbons but may also increase initial plankton declines.

The potential surface water and water column effects of a subsurface blowout on fish and invertebrates would depend upon the timing of the event and how it coincides with seasonal migrations and timing of particular life history stages. Oil exposure of early life history stages would likely result in lethal and sublethal developmental effects in fish and invertebrates. A mitigative factor would be that fish and invertebrate species spawn over large spatial scales and it is unlikely that the spill would encompass the full geographic extent of spawning range for a species. Therefore, the effects from a subsurface blowout are not predicted to affect natural recruitment such that organisms may not re-establish populations to levels prior to an accidental event. Mobile fish and invertebrates may also be able to avoid hydrocarbon exposure or contaminated food sources through temporary migration. Lethal and sublethal effects are predicted for slow moving or sedentary fish and invertebrates near an accidental release site. Oil transported away from the release site during an unmitigated spill would be highly weathered, patchy and discontinuous resulting from natural degradation processes occurring over a week or more. Mass balance analysis of surface and water column worst case scenarios indicated that >77% of the oil was predicted to evaporate or degrade at the end of 160-day simulations for the representative 30- and 120-day release scenarios. The remaining oil was predicted to remain on the water surface (<3%) or entrained in the water column (<20%). Entrainment and resurfacing processes may result in the oil alternating between surface and water column environments, depending on wind and wave conditions. Fish and invertebrate populations occupying the water column and surface areas are estimated to recover within a few years after the spill has subsided. Potential pathways of effects from hydrocarbon releases would be similar for SAR and secure species. However, SAR species may be more vulnerable to adverse effects on individuals or habitat. Mitigative measures employed to protect secure species from accidental releases would also be protective of SAR species.

Cold-water corals and sponges occupy slope and bottom areas of the Grand Banks, Flemish Pass, and Flemish Cap. Potential effects and associated recovery times from a subsea hydrocarbon release by corals and sponges is highly dependent on the nature and extent of initial exposure. Although few directed studies have been conducted on local coral and sponge species, information from other regions indicate recovery may be on the scale of decades. However, oil transported to the sediment was not a major fate pathway in all deterministic modelled scenarios (surface oil, water column, shoreline exposure), with <0.1% predicted to settle on the sediments and exposure levels of <1 g/m². Sediment exposure was also to occur near the release site with modelled footprints within 100 km. Therefore, with limited initial exposure, potential adverse effects to corals and sponges and special areas established for benthic features (see Section 16.6.4.3) would be limited. With limited benthic effects, there would also be limited exposure to other benthic organisms and wolffish critical habitat (DFO 2020) within the region.

Deterministic worst-case scenarios for 30- and 120-day releases for shoreline exposure predicted up to approximately 1,450 to 1,480 km of contaminated shoreline (≥100 g/m² ecological threshold). Shoreline exposure was mainly along the southern and southeastern coasts of Newfoundland at levels greater than 500 g/m². This oil would likely be weathered, patchy, and discontinuous from the more than a week of degradation prior to reaching shore. Coastal seagrasses and macroalgae that support spawning and rearing habitats may initially decline, however the adverse effects may be low with exposure to weathered oil. Marine plants and associated biogenic habitats are estimated to recover within three to five years after the spill has subsided.

Stochastic and deterministic model scenarios and associated potential effects are based on an unmitigated subsea release. In the event of an actual spill, implemented emergency response and mitigation measures (see Section 16.5) would limit the magnitude, duration, and extent of a spill. Potential effects on shorelines and coastal fish and fish habitat could also be mitigated through shoreline protection measures.

The residual environmental effects from an unmitigated subsurface blowout on marine fish and fish habitat are predicted to be adverse and of moderate to high magnitude. This is based on the range of responses to hydrocarbon exposure from fish and invertebrates and potential effects on fish habitat. The geographic extent of a subsurface blowout would be beyond the RAA based on modelling; however, oil would be weathered, patchy, and discontinuous at those distances. Subsurface blowout effects would be moderate to long-term duration depending on the nature and extent of the accidental event but considered reversible.

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 depending on the nature and extent of the accidental event. With applied preventative procedures, a subsurface blowout is considered unlikely.

16.6.1.3.2 Marine Diesel Spill

A surface marine diesel spill (1,000 L) was modelled from the drilling installation and was predicted to result in oil floating on the water surface with silver or colourless sheens whose thickness would be below 0.0001 mm (RPS Group 2020). The deterministic model of the worst-case scenario used the calmest wind-speed period during summer/ice-free conditions that would result in the largest amount of oil on the water surface. The predicted transport of this spill indicated it could be within 175 km of the release location to the south and west. The oil thickness, in addition to the small quantity of spilled diesel released, was below the socio-economic and ecological thresholds. Mass balance estimations after the 30-day diesel batch spill simulation suggested that more than 85% was predicted to be evaporated to the atmosphere or degraded.

Batch spills of these volumes would likely have minimal impacts on marine fish and fish habitat. Effects from a diesel spill would be similar to those described in Section 16.6.1.3.1 for other hydrocarbon releases. Early life history stages (eggs, larvae, and juveniles) are typically more vulnerable to spills, as they have limited or no capacity to avoid the spill. As many fish species in the northwest Atlantic have eggs and larvae living near the sea surface, they are more likely to be exposed to a surface spill and may experience lethal or sublethal effects. If the spill reaches shore, nearshore habitats including spawning and rearing areas may be affected. Spilled oil can have immediate toxic effects on intertidal and subtidal organisms, such as sea grasses and macroalgae (Stepaniyan 2008; Fonseca et al. 2017).

These effects from spilled diesel would likely be short-term in nature as volatiles would evaporate, and the oil would breakdown. The effect on pelagic species would be minimal, due to the small spatial extent of a spill and minimal exposure below the surface. If the spill reaches shore, recovery would likely be within months to years after the spill has subsided. The potential effects would be similar for SAR and secure species. Mitigation measures described in Section 16.5 would be implemented if a spill took place, and would reduce the magnitude, duration, and extent of a spill and reduce any effects on marine fish and fish habitat. Accordingly, residual environmental effects from a marine diesel spill on marine fish and fish habitat are predicted to be adverse, low in magnitude, localized to the RAA, short-term to medium-term, and reversible.

16.6.1.3.3 Fuel Spill Along a Supply Vessel Transit Route

Accidental releases from vessels travelling to shore from the drilling installation were modelled as part of BHP’s EIS for the exploration licence in EL 1157 and EL 1158. A batch spill was modelled of 3,200 L of marine diesel from a vessel along the planned vessel transit route from the Orphan Basin to the Avalon Peninsula of Newfoundland (RPS Group 2019). The model predicted a spill of this volume would result in patchy distributions of silver or colourless sheens whose thickness would be below 0.0001 mm (RPS Group 2019). Some model simulations predicted diesel would extend from the spill site and wrap around the southern portion of the Avalon peninsula. Spilled diesel would not exceed the ecological threshold in either stochastic modelling or worst-case deterministic scenarios for surface oiling and water column. Approximately 9 km of shoreline exceeded the ecological threshold in the 95th percentile worst-case scenarios.

A vessel spill with a volume of <3,200 L would likely produce the same effects as those described for a batch diesel spill of 1,000 L, described above. As described in the batch diesel spill, these effects would likely be short-term in nature as volatiles would evaporate, and the oil would breakdown. Accordingly, residual environmental effects from a marine diesel spill on marine fish and fish habitat are predicted to be adverse, low in magnitude, localized to the RAA, short-term to medium-term, and reversible.

16.6.1.3.4 SBM Spill from the MODU and the Marine Riser

Two scenarios for accidental SBM release were modelled as part of Nexen Energy's Flemish Pass Exploration Drilling Project (Amec Foster Wheeler 2018; Nexen Energy 2018) at a shallow-water site on the eastern slope of the Flemish Pass (EL 1150; 378 m depth). While deeper than the Project Area's average water depth, these models were used to inform the potential effects of an SBM spill for the Project. The first scenario considers the release of the entire capacity of the active mud system (approximately 440 bbl or 64 m^3) at the sea surface over a period of 1 to 2 hours. Maximum radial distance from site for this scenario ranges from 322 m (summer) to 424 m (winter). The maximum spatial footprint (area) of the spill ranges from 9,000 m^2 (summer) to 9,900 m^2 (winter, spring, and fall). Maximum layer thickness for this spill is 7.1 cm for all seasonal scenarios, with the average thickness ranging from 2.6 cm (winter, spring, fall) to 2.7 cm (summer).

The other scenario is a subsurface release of SBM contents from the marine riser and associated transport lines due to an emergency disconnect, with an expected capacity of 89 m^3 released 15 m above the seafloor over approximately two hours as a worst-case scenario. The maximum distance from site for this scenario ranges from 41 m (winter) to 57 m (spring, summer, and fall). The footprint area is 2,700 m^2 for all seasonal scenarios. The maximum thickness is 9.9 cm for all seasons, and the average layer thickness ranges from 7.7 cm (spring and fall) to 8.2 cm (winter).

Both the average and maximum thickness for both spill scenarios exceed the 6.5 mm and 1.5 mm PNET for burial effects, indicating potential burial effects for benthic organisms. These predicted burial thicknesses are not uniform throughout the spill footprint but will be localized based on prevalent currents and bottom topography. Modelled bottom currents at EL 1161 are slightly higher than those modelled for EL 1150, therefore the spatial extent of both spills may be larger with a lower predicted thickness (RPS Group 2019). This will likely reduce the effect on benthic organisms within the spill footprint. In June 2018, a drilling riser on the Scotian Shelf released 136 m^3 of SBM, and subsequent environmental monitoring found no indications of SBM constituents 500 m from the well site (at 2,800 m depth) (CNSOPB 2019). The CNSOPB concluded that no significant adverse environmental effects resulted from the SBM release (CNSOPB 2019).

As modelled results for EL 1150 are not specifically representative of conditions at EL 1161, even doubling the maximum distance for the surface release scenario results in effects to marine fish and fish habitat being limited to 1 km from the release site. Potential changes to risk of mortality, injury, and health on fish and fish habitat would be limited to sessile benthic species unable to avoid burial. Changes to water and benthic habitats in the area would be temporary and reversible. As discussed in Section 16.6.1.1, SBMs biodegrade rapidly and acute toxicity is considered to be relatively low. The residual effects from SBM spills are therefore predicted to result in low magnitude adverse effects that are localized to the Project Area and reversible. Depending on the nature and extent of the spill, the duration of the effect may range from short- to long-term. As described in Section 16.6.1.1, partial recovery is on the order of weeks to months, with total recovery within three to five years. Potential pathways of effects from SBM releases would be similar for SAR and secure species. However, SAR species may be more vulnerable to adverse effects on individuals or habitat. Mitigative measures employed to protect secure species from accidental releases would also be protective of SAR species.

16.6.1.3.5 Summary

Table 6.20 provides a summary of predicted residual environmental effects of accidental events on marine fish and fish habitat.

Table 16.20 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							
Blowout Incident	A	M-H	RAA*	LT	UL	R	D
Marine Diesel Spill	A	L	RAA	ST-MT	UL	R	D
Vessel Spill on Transit Route	A	L	RAA	ST-MT	UL	R	D
SBM Spill	A	L	PA	ST-LT	UL	R	D

KEY:
See Table 9.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project 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:
UL: Unlikely
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

16.6.1.4 Determination of Significance

Based on the characterization of potential effects and significance criteria (Section 9.1), the predicted residual adverse effects from accidental event scenarios (subsurface blowout, marine diesel spill, SBM spill) on marine fish and fish habitat are predicted to be not significant. This assessment considers the potential adverse effects from the scientific literature, modelled levels and spatial extents of predicted effects, the conservative nature of the spill modelling and assumptions, and the use of mitigation measures to prevent and reduce the effects of a spill. Although accidental events may result in adverse effects on marine fish and fish habitat through lethal and sublethal effects, these residual effects are predicted to be reversible at the population level. Fish habitat contaminated by hydrocarbon or SBM exposure would also recover through natural degradation processes and employed mitigative measures. Fish species within the RAA spawn over large geographic areas, and a spill is not predicted to encompass all of these areas to a degree that organisms may not re-establish to affected areas given the low probability for large spill events and associated mitigative response measures. 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, recoverable and localized spatial extent of likely effects. For subsurface blowouts and marine diesel spills, assessments are made with a medium level of confidence given the uncertainties associated with an actual spill event (i.e., duration and extent of a spill, locations, time of year and regional responses and recoveries). With implementation of mitigative measures implemented to reduce scale of potential effects, spill scenarios are not predicted to result in permanent alteration or irreversible loss of SAR.

16.6.2 Marine and Migratory Birds

As described in Sections 6.3.2 to 6.3.4 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 depending on their specific life histories and habitat requirements, and could be present in the RAA at the time of an accidental event.

Seabirds, ducks, geese, loons, grebes, and shorebirds (plovers, sandpipers) are the most vulnerable of bird species to oil spills since 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; some are abundant year-round (such as large gull species and black-legged kittiwake, some alcid species, and northern fulmar) while others are more likely to be present in the winter (dovekie, thick-billed murre, ivory gull, sea ducks) or the nesting and migration seasons (Leach’s storm-petrel). Several sites providing important habitat 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 IBAs, Migratory Bird Sanctuaries, Seabird Ecological Reserves, nesting sites around coastal NL, and EBSAs in the Northwest Atlantic designated in part due to their importance to seabirds (see Figure 6-49).

There are 15 marine and migratory bird SAR that are likely to occur within the marine and/or coastal regions of RAA (Section 6.3.4.). 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 10, there is a low potential for these SAR (listed in Table 10.4 in Section 10.3.3) 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, birds are at risk from oil spills, regardless of their conservation status designation.

16.6.2.1 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).

16.6.2.1.1 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 (Butler et al. 1988). 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; Hunter et al. 2019), behavioural changes such as increased time spent preening at the expense of foraging and breeding, and potentially death (Morandin and O'Hara 2016), 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). This 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; Minerals Management Service 2001; Hunter et al. 2019). Greater heat loss accompanied by an increase in food consumption has been documented in double-crested cormorants (Cunningham et al. 2017; Mathewson et al. 2018). A model based on data for this species from Mathewson et al. (2018) predicts a significant increase in resting metabolic rate, which would require an increase in foraging time per day during the breeding season that has the potential for population effects (Dorr et al. 2020). A decrease in body temperature from plumage oiling has been documented in another marine bird species (Maggini et al. 2017a). The effects of oil on feather structure and function also affect flight efficiency, requiring increased energy demand during flight. External oiling (applied experimentally to homing pigeons released to fly 50, 80, or 100 miles) 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, 2017b, 2017c). Experimentally applying a light oiling to the plumage of a marine bird reduces takeoff speed by 30% and increases flight energy cost by 20-45% (Maggini et al. 2017a, 2017b, 2017c).

Acute toxic effects from exposure to sheens are considered unlikely (Morandin and O'Hara 2016), and some studies have 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). However, other studies have shown effects from this kind of exposure (Hartung and Hunt 1966; McEwan and Whitehead 1980; Miller et al. 1980; Trivelpiece et al. 1984; Butler et al. 1986, 1988; Khan and Ryan 1991; Alonso-Alvarez et al. 2007). The potential sublethal toxic effects from ingesting small amounts of oil are becoming better understood due to research in the wake of the Deepwater Horizon spill and suggest that such exposure may have greater effects on bird populations than acute mortality (Barron 2012; Bursian et al. 2017a).

Oil ingested through diet and through preening can cause hemolytic anemia, which causes fatigue and reduction in energy available for metabolic processes. Oxidative injury to cytoplasmic hemoglobin (hemolytic anemia) due to oil ingestion has been documented in six species of marine birds, and results consistent with hemolytic anemia were found in a seventh species (Bursian et al. 2017b; Dean et al. 2017; Harr et al. 2017a; Horak et al. 2017; Maggini et al. 2017a; Pritsos et al. 2017; Fallon et al. 2018). Species-specific differences were found in this effect, potentially due to physiology, foraging strategies, habitat preferences, and behaviour (Fallon et al. 2018). The development of anemia due to oil exposure was studied with controlled dosing in a bird species well-adapted to captivity (zebra finch [*Taeniopygia guttata castanotis*]; Fallon et al. 2021). Birds dosed with 10 ml of artificially weathered Deepwater Horizon oil per kilogram of food showed a significant increase in reticulocyte (slightly immature erythrocyte, i.e., red blood cell) percentage, mean corpuscular hemoglobin, and liver mass compared with birds receiving 3 ml/kg and control birds. An increase in the number of reticulocytes in circulation is an indicator of a physiological response to a decrease in the number of mature erythrocytes. These effects have the potential to reduce survival and lifetime reproductive success. Hemolytic anemia can have its greatest effects during migration, when metabolic oxygen requirements are very high (Bursian et al. 2017a).

Effects on internal organs have also been observed. Damage has been found to liver (Khan and Ryan 1991; Harr et al. 2017b), brain (Lawler et al. 1978), gastrointestinal tract (Fallon et al. 2021), and lungs (pneumonia) (Hartung and Hunt 1966). Increases in liver and kidney weights have been found in two species (Harr et al. 2017c; Horak et al. 2017). The mechanism causing documented liver hypertrophy and altered lipid biosynthesis and transport in birds exposed to oil has recently been investigated in seaside sparrows (*Ammodramus maritimus*) collected from saltmarshes that had been exposed to the Deepwater Horizon spill (Bonisoli-Alquati et al. 2020). Several genes related to liver function were expressed differently in oil-exposed birds than birds from control areas. These genes are thought to control a coordinated response to oil contamination that promotes liver cell proliferation and regeneration, while inhibiting liver apoptosis (normal cell death), necrosis (cell death due to disease, injury or inadequate blood supply), and steatosis (fatty liver disease). The expression of other liver function genes was also affected (i.e., those regulating energy homeostasis, including carbohydrate metabolism and gluconeogenesis, and the biosynthesis, transport and metabolism of lipids). Effects on other organs have been found in a species of marine bird, i.e., lesions in kidney, heart, and thyroid gland (Harr et al. 2017b). 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. 2017b).

Oil exposure can cause toxic effects on the immune system of birds (Barron 2012). Weathered Mississippi Canyon 252 crude oil (Deepwater Horizon spill) orally dosed to zebra finches caused tissue-specific changes in the expression of mRNA: decreased proinflammatory cytokine expression in the intestine, but increased expression in liver and spleen, and a lower heterophil:lymphocyte ratio (Goodchild et al. 2020a). Dosed birds also show reduced activity, a behaviour indicating illness. Oil-exposed zebra finches have also shown lymphocyte proliferation in the spleen (Fallon et al. 2021). These effects suggest that oil spills may affect physiological and behavioural components important for disease defense in birds. Such effects could, in turn, hinder recovery of bird populations impacted by oil spills.

Oil transferred from the plumage of adults to eggs can have sublethal toxic effects on embryos. Weathered Mississippi Canyon 252 (Deepwater Horizon) crude oil applied (1.0 or 2.5 μL) externally to the eggshells of zebra finches resulted in lower embryonic heart rate and metabolic rate on the 12th day of incubation (Goodchild et al. 2020b). Such effects could potentially lead to an increase in the time necessary to complete embryonic development and to impaired heart performance following hatching. Chicken eggs treated with 5 μL on day 10 of embryo development show a decrease in hematocrit, red blood cell concentration, and hemoglobin concentration at day 15 (do Amaral-Silva et al. 2021). Eggs treated with 3 µL of oil show no change. Treatment with 1 µL causes an increase in those hematological variables, suggesting physiological compensation for the negative effects of the oil.

Sublethal toxic effects of oil ingestion on adult birds could potentially have effects on their reproductive success. Adult king quails (*Synoicus chinensis*) were exposed through their diet to 800 or 2,400 ng of PAH per gram of food to study the effects on adults, their eggs, and their hatchlings. (Bautista et al. 2021). The parents showed no effect of PAH on body mass, metabolic variables (e.g., oxygen consumption, carbon dioxide production) or respiratory variables (e.g., ventilation frequency and volume). However, the low dose significantly increased partial pressure of blood oxygen in parents and the high dose significantly decreased this measure. Oxygen saturation was lower in both low and high dose parent groups compared with controls. Heart mass was smaller in oil-exposed groups, but kidney mass was higher in the low-dose group. Eggs from parents of the high oil exposure level group showed increased water loss through the eggshell. Respiratory variables in hatchlings were unaffected by the oil exposure of the parents, but hatchlings of the high-dose group showed reduced ability to maintain body temperature when exposed to cooling. Nest survival was studied in seaside sparrows nesting in Louisiana saltmarshes from the second to eighth years after the Deepwater Horizon spill (Hart et al. 2021). A large majority of nests failed and most of those failures were caused by predation. Daily nest survival rate was not correlated with sediment polycyclic hydrocarbon concentrations or estimated predator abundance. Although nest survival was consistently lower on plots that had received Deepwater Horizon oil, this effect was confounded by site context, which influenced both vegetation community characteristics and the likelihood of initial oiling from the Deepwater Horizon spill.

Prior to the Exxon Valdez spill, the impacts of spills were thought to be short-term and controlled by monoaromatic and less persistent components of oil (Barron et al. 2020). However, study of that spill, the Deepwater Horizon spill and others have since shown that highly weathered oil contains substantial proportions of hydrocarbon and heterocyclic aromatics, and oxidized PAHs. For example, biomarkers in harlequin ducks (a SAR) 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).

Morandin and O'Hara (2016) and Barron et al. (2020) reviewed several short- and long-term studies of marine oil spills and reinforced the scientific consensus that these effects have the potential to cause increased mortality rates, physiological impairment, reduced reproductive success and, in severe cases, possible long-term population declines. In the breeding season following the Deepwater Horizon spill, brown pelicans (*Pelecanus occidentalis*), great egrets (*Ardea alba*), and tricolored herons (*Egretta tricolor*) 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 Deepwater Horizon spill did not have different demographic rates than those on unoiled coastlines (Gibson et al. 2017). However, the bird species at greatest risk to the immediate effects of a spill are those that spend a considerable time resting or foraging on the water surface (i.e., alcids, sea ducks, loons, and grebes [Wiese and Robertson 2004; Boertmann and Mosbech 2011]). Most seabird species have a long lifespan, delayed sexual maturation, small clutch size (one egg in most species) and, in some species, long intervals between breeding. 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, making these species 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). Northern gannets nesting at Bonaventure Island, Québec, and wintering in the Gulf of Mexico (exposed to weathered Deepwater Horizon oil) were found to have higher feather corticosterone and plasma thyroid hormone levels than those wintering elsewhere (Champoux et al. 2020). These elevated levels indicate increased energetic demands and/or exposure to environmental stressors, likely due to exposure to Deepwater Horizon oil and subsequent sublethal effects. No differences were found in PAH or trace metal concentrations.

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). Consistent with this, an analysis of 45 spills found a weak correlation between spill volume and reported bird mortality (Burger 1993). More recently, an analysis of 90 spills for which wildlife mortality was reported found no clear relationship between spill size and mortality (Chilvers et al. 2021). As a result, the effects of oil spills on bird populations are difficult to predict. Regardless, the accidental release of oil 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). This is because, as noted above, seabirds have a life history strategy that makes them susceptible to long-term effects on population size from a spill (Esler et al. 2002; Wiese and Robertson 2004). A spill that caused high adult mortality could therefore potentially have significant effects on bird populations (e.g., the Deepwater Horizon spill caused a decrease in the relative abundance in piping plover and Wilson’s plover [Darrah et al. 2021]). 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 Deepwater Horizon spill, sanderlings had lower feeding 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.

16.6.2.1.2 Potential Effects of Dispersants on Marine and Migratory Birds

The use of dispersants, which is intended to enhance the natural microbial degradation of oil, 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 bibliometric review 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). Mallards and common eiders exposed to oil / dispersant mixture showed enhanced plumage contamination, probably due to the surfactant component of dispersants (Jenssen and Ekker 1991). However, a study of the effect of dispersant use on feather structure, waterproofing, and buoyancy of common murres show 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 murres, 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 Deepwater Horizon spill 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 droplet size is 5 to 10 times smaller (NAS 2020). As a result, 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.

16.6.2.1.3 Potential Effects of *In Situ* Burning on Marine and Migratory Birds

The effect of *in situ* burning of oil on birds is largely unknown. Combustion reduces the total quantity of hydrocarbons, and the burn residue submerges or sinks, removing the hydrocarbons from the surface (Fritt-Rasmussen et al. 2015). This reduces the risk of birds coming into contact with hydrocarbons, so *in situ* burning is generally regarded as beneficial for birds on the surface (Fritt-Rasmussen et al. 2015). Smoke and heat from *in situ* burning would presumably repel marine and migratory birds, preventing acute effects of smoke or heat on birds. Fritt-Rasmussen et al. (2016) found that the microstructure of common eider feathers suffered similar or greater fouling and damage from burn residues as from a corresponding amount of fresh oil. Contamination of prey items by burn residue may also be a possibility. However, the net benefit of removing hydrocarbons from the surface is likely to be greater with *in situ* burning than leaving the fresh oil on the surface.

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

SBM is considered to have 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 total suspended solids (TSS) in the water column and possibly a small thin sheen on the surface. The effects of contact with a sheen are potentially similar to those discussed above for sheens resulting from a hydrocarbon spill, 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.

16.6.2.2 Mitigation of Project-Related Environmental Effects

Project-wide mitigation measures related to a potential accidental release are described in Section 16.6. Of particular relevance to marine and migratory birds are the commitments related to shoreline protection and clean-up, and oiled wildlife response (refer to Section 16.5.5). In the event that oil threatens or reaches the shoreline, shoreline protection measures, including deflection from sensitive areas, will be implemented as practical. Shoreline Clean-up 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 and will also be used to monitor and evaluate the effectiveness of the clean-up operations.

Suncor will develop a Wildlife Response Plan and, for incidents where wildlife is threatened, engage specialized expertise to implement the Plan, including the recovery and rehabilitation of wildlife species as needed or required (refer to Section 16.5 for Suncor's oiled wildlife response approach).

In the unlikely event of a spill, specific monitoring (e.g., environmental effects monitoring) and follow-up programs may be required and will be developed in consultation with applicable regulatory agencies.

16.6.2.3 Characterization of Residual Project-Related Environmental Effects

16.6.2.3.1 Subsurface Blowout

A subsea well blowout's potential effects will be determined by the spill's characteristics, its trajectory, and how the spill trajectory coincides in time and space with marine and migratory birds. Such a blowout is unlikely to occur, but it 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 whether the oil would have effects on marine and migratory birds. These thresholds are based on the habitats of seabirds (open water) and shorebirds (the intertidal zone of shorelines). There is potential for direct effects from oil from a blowout on the nesting habitat of a subset of marine-associated species, but most seabird species nest well above the high tide mark. As a result, there is greater potential for direct effects on habitat at sea (i.e., those used for foraging, loafing, and roosting). The greatest potential risk of mortality or injury from oil for seabirds at-sea is from exposure to oil on the sea surface. Surface oil causes lethal effects to seabirds above a threshold thickness of 10 μm (>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 the potential ecological effects on shoreline fauna and flora of 100 g/m² (100 μm thick) was used. The threshold has typically been >100 g/m² (100 μm thick) (French McCay 2009).

Change in risk of mortality or physical injury to marine birds from exposure to hydrocarbons is exhibited as hypothermia and drowning leading to death, and sub-lethal effects causing lower reproductive rates or premature death, as discussed in 16.5.2.1.1. 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. The survival rate for oiled birds is very low and most past attempts at rescue and cleaning of oiled birds did not appreciably raise survival rates (French McCay 2009). However, recent attempts with African penguins in South Africa have resulted in over 90% of individuals successfully released after de-oiling in recent years (Wolfaardt et al. 2009). Similarly, survival rate of cleaned little blue penguins in New Zealand following their release back into the wild did not differ from control (unoiled) birds

(Sievwright et al. 2019a). Rehabilitated pairs of this species had lower hatching success than control birds in the first season following rehabilitation and showed no other signs of reduced reproductive success (Sievwright et al. 2019b). Brown pelicans oiled during the Refugio, California, spill, that were cleaned, rehabilitated, and released did not differ in their survival rate from that of control birds from an unoiled area (Fiorello et al. 2021). The effects of cleaning and rehabilitation on feather structure and thermoregulation was studied in an experiment in which MC252 Deepwater Horizon oil was applied to ring-billed gulls (*Larus delawarensis*), some of which were cleaned, and in control birds (Horak et al. 2020). Feather clumping in oiled / rehabilitated and oiled / not rehabilitated birds was initially significantly higher than control birds, but this difference declined significantly over time. Feather microstructure in rehabilitated birds did not differ from control birds within three weeks of washing. In oiled / unrehabilitated birds the feathers still had significant clumping one month after oiling. There were no differences in internal body temperature and external temperature among the three groups, suggesting that oiled birds were able to maintain thermoregulatory homeostasis. The significant reduction in feather clumping seen the oiled / unrehabilitated birds suggests that rehabilitation of lightly oiled birds may unnecessary. Nevertheless, oiled birds are still widely regarded to have a very low survival rate (approximately 0% to 5%). As a result, the probability of lethal effects on birds is assumed to be dependent primarily on exposure probability, which is influenced by behaviour (i.e., the percentage of the time an animal spends on the water or shoreline, as well as oil avoidance behaviour) (French McCay 2009). French McCay (2009) calculated vulnerability scores based on the combined probabilities of encountering oil and mortality once oiled, which is, effectively, 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, an aerial seabird, moult their flight feathers and, as a result, spend a greater amount of time on the sea surface than between moults (Hedd et al. 2012). Although unstudied, great shearwaters, northern fulmars, and Manx shearwaters also moult their flight feathers in Newfoundland waters in summer and therefore probably also spend a larger proportion of their time on the surface than between moults (Huettmann and Diamond 2000). The vulnerability score of moulting shearwaters and fulmars, therefore, may be closer to that of surface-diving seabirds than aerial seabirds. Table 16.21 provides the combined probabilities of oiling and mortality (once oiled) for various generic behaviour categories.

Table 16.21 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, alcids, 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.

The ecological risk to marine birds was assessed here by using this index and the threshold surface oil thickness causing marine bird mortality (10 µm, 10 g/m²) and the threshold shoreline oil thickness causing mortality (100 µm, 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 temporarily reduced, or birds may temporarily avoid affected habitat. However, spill cleanup and natural weathering processes are likely to eventually result in the recovery of affected habitat. For example, marine bird abundance and use of oiled shoreline sites in Prince William Sound, Alaska, following the 1989 Exxon Valdez oil spill recovered to estimated (naturally variable) baseline levels within 12 years in all of the species surveyed (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 6.3.5). Interactions could occur in foraging habitat, whether it takes place inshore where nesting birds feed on pelagic fish that have come inshore to spawn, or on the continental shelf slope used by nesting, summering, staging, or wintering birds. Nesting birds also use inshore waters close to nesting colonies in large numbers to rest and preen. Although stochastic modelling shows the maximum average annual probability of oil from a blowout contaminating the shoreline with a concentration above the socio-economic threshold (1 g/m²) of the Avalon Peninsula is 4% (30-day release) to 8% (120-day release), and the representative 95th percentile shoreline exposure case predicted less than 1% (see RPS Group 2020a; Appendix E) 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 alcids are vulnerable to interactions with oil in inshore waters during the nesting season while foraging and while resting near their nesting colonies (Section 6.3.5). 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 common murres is south of the Project Area, this species winters in relatively large numbers in the continental shelf slope waters. Dovekies and thick-billed murres are vulnerable in those shelf slope waters because of the globally significant numbers of birds overwintering along the Northeast Newfoundland Shelf and the Labrador Shelf. In recognition of these globally significant bird concentrations portions of these waters are designated as the Northeast Shelf and Slope EBSA (Table 6.3) and Seabird Foraging Zone in the Southern Labrador Sea CBD EBSA (Figure 6-49).

Among the species of gulls, black-legged kittiwakes concentrate inshore during spring and summer while foraging and attending nests in coastal colonies. In the post-breeding season late summer, kittiwakes are most vulnerable in shelf slope and deeper waters of the Northeast Newfoundland Shelf and the Labrador

Shelf where the globally significant concentrations overwinter. Great black-backed gulls, herring gulls, and other large gull species are at risk on inshore foraging grounds and near the colonies during the nesting season. Great black-backed gulls are also at risk in fall migration in offshore waters. 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 gannets are most vulnerable to interactions with oil during the nesting season in coastal areas, where they feed on spawning fish and attend nesting colonies, and during the fall when the young fledge from the colonies (Garthe et al. 2007).

Leach's storm-petrels are 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 RAA (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 shearwaters and large numbers of sooty shearwaters are vulnerable to oiling during the summer months in coastal and offshore waters because most of the world's great and sooty shearwaters summer in the Northwest Atlantic (Carvalho and Davoren 2019; Carvalho et al. 2022). Northern 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 in EL 1161 demonstrated that the highest potential likelihood (>90%) to exceed the ecological threshold 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 16.3.4).

Oil was predicted to strand on shorelines in several simulations. The maximum probability of shoreline oiling above the socio-economic threshold (1 g/m^2) from a blowout in EL 1161 lasting 30 days was 21% during winter and 18% in summer (Table 16.6). The minimum time to shore was 3.7 days in winter and 28 days in summer. For a 120-day release the probability was 45% in winter and 40% in summer. The minimum times to shore were 9.2 days in winter and 28 days in summer.

Representative credible "worst-case" deterministic scenarios of a subsurface blowout at EL 1161 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) was less than 4%. 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 95th percentile of simulations was 286,800 km^2 in the 30-day release and 833,500 km^2 in the 120-day release (Table 16.6).

The length of shoreline affected by oil concentrations above the ecological threshold (100 g/m^2) in the representative credible "worst-case" scenario simulations were 1,452 km for the 30-day release and 1,479 km for the 120-day release. For the 30 day-release the coastlines affected by oil concentrations above the ecological threshold included the northeast coast from Cape Bonavista to Cape St. Francis, the Avalon Peninsula and most of the island's southern coast. In the 120-day release the affected coastlines were the northeast coast from Bonavista Bay to Cape St. Francis, the Avalon Peninsula and most of the island's southern coast. Shoreline oil would be highly weathered, patchy and discontinuous. Major nesting colonies of marine bird in eastern Newfoundland are listed in Section 6.3.2 (Tables 6.8 and 6.9), and locations of IBAs (including Migratory Bird Sanctuaries), Seabird Ecological Reserves, and seabird EBSAs in eastern Newfoundland potentially affected by oil from subsurface blowout reaching shore are illustrated in Figure 6-49.

The modelling results suggest that the areas most likely to be affected by an unmitigated, subsurface well blowout are Jeanne d'Arc Basin, the Newfoundland Basin, Flemish Pass, the areas to the east, and, in the 120-day simulations, the Southeast Shoal. As a result, a blowout during summer would have the potential to interact primarily with the relatively high concentration of summering 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. Low average wind speeds during summer also increase the amount of time these species spend on the sea surface because, as species employing dynamic soaring rather than powered flight, they depend more heavily on wind for lift than other species using only powered flight. 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 Seabird Ecological Reserves on the Avalon, such as Cape St. Mary's, Witless Bay Islands, and Baccalieu Island, there is potential for marine and migratory birds present and nesting in these areas to interact with surface oil. It is probable that only a small proportion of local populations would be affected. 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 in Section 10.3.3) to interact with accidental hydrocarbon releases.

Mitigation measures may include subsurface dispersant injection; however, this will be on a case by case basis and documented in the Suncor specific SIMA for this Project. Applying dispersants to an oil slick shortly after the spill has occurred, can protect shoreline environments and sea-surface dwelling animals, such as some marine bird species, limiting individuals or local populations from the consequences of coming into contact with large quantities of oil. It is generally believed that the benefits of dispersant use outweigh the negative impacts if dispersants are chosen to be used in a certain spill scenario. It is acknowledged dispersants may have negative impacts on marine biota. Osborne (2023) recommends that oil spill responders incorporate the known benefits and costs of dispersants into a decision-making framework with consideration of Pathway of Effects conceptual model. The effects of dispersants on seabird plumage, physiology, and food sources are similar to those of oil (Section 16.6.2.1.2). However, the dispersant itself would be highly dispersed in the water column. As a result, even those seabird species that dive during foraging would be unlikely to come in contact with a sufficient volume of dispersant or ingest a large enough quantity of contaminated prey to be affected (NAS 2020). Consequently, the residual effects of dispersant use on Marine and Migratory Birds are predicted to be adverse, potentially low in magnitude, short- to medium-term in duration, within the RAA, a single event, and reversible in nature.

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.

16.6.2.3.2 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 1,000 L marine diesel at EL 1161 simulated for 30 days were predicted to result in patchy, silver or colourless sheens (<0.0001 mm, 0.1 µm) of oil floating on the water surface over a much smaller area than a well blowout scenario. Generally, oil marine diesel within these representative scenarios was predicted to be transported to the west and south, within 175 km of the release location (Figure 4-36 in Appendix E). At the end of the 30-day marine diesel batch spill simulations, 44% was predicted to evaporated into the atmosphere, 42% degraded, 15% 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 16-5 and 16-8). 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 16.1).

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. However, the model predicts surface hydrocarbon thickness well below the ecological threshold and no probability of shoreline contact. A batch spill of diesel is therefore not expected to create permanent or irreversible changes to habitat quality and use.

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 well 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.

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.

16.6.2.3.3 Fuel Spill Along a Supply Vessel Transit Route

A project supply vessel spill of fuel 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. For the BHP Orphan Basin drilling EIS, batch spill releases of 3,200 L marine diesel were modelled from a nearshore location (12 km east of St. John’s) along a potential supply vessel route (RPS Group 2020b). The modelling predicted silver or colourless sheens (<0.0001 mm, 0.1 µm) of oil floating on the water surface. Representative worst-case scenarios predicted the spill to be transported to the south, potentially bringing it within the boundaries of the Witless Bay Islands SER and, in some modelled cases, the slick travelled westward around the south shore of the Avalon peninsula to the west, towards the Burin Peninsula. 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.

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 sheen modelled for the BHP nearshore spill predicted thicknesses well 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 nesting species would be most vulnerable. Among those species, the most vulnerable would be those spending the greatest amount of time on the water such as common murre and Atlantic puffin, which nest in the Witless Bay Seabird Ecological Reserve in large numbers, along with smaller numbers of equally vulnerable 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 Seabird Ecological Reserve would not suffer mortality or sublethal effects.

Such a 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 suitable habitat available to marine and migratory birds at sea. Affected habitat could potentially include shoreline. When a diesel spill interacts 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, lasting 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, including habitat within the Witless Bay Islands Seabird Ecological Reserve. 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.

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.

16.6.2.3.4 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). However, a sheen would be limited in size, temporary, and moderate wind and wave conditions would quickly break it up. Given that the low surface oil thickness required to result in a sheen (0.04 µm) is well below the ecological threshold surface oil thickness, it is expected that effects would be minor and unlikely to result in seabird mortality. Potential effects of an SBM 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.

16.6.2.3.5 Summary

Table 16.22 provides a summary of predicted residual environmental effects of accidental events on Marine and Migratory Birds.

Table 16.22 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							
Subsurface Blowout	A	H	RAA*	ST-MT	UL	R	D
Marine Diesel Spill	A	L	LAA	ST	UL	R	D
Vessel Spill on Transit Route	A	L	LAA	ST	UL	R	D
SBM Spill	A	L	LAA	ST	UL	R	D

KEY:
See Table 10.2 for detailed definitions

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:
UL: Unlikely
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

16.6.2.4 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 an 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 mitigate 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, and effectiveness of mitigation.

16.6.3 Marine Mammals and Sea Turtles

There are 25 marine mammal species that are known or expected to occur in the Project Area and/or RAA on a regular basis, including 19 cetacean species (whales, dolphins, and porpoises) and 6 seal species. In addition, there are records of eight cetacean species in the RAA which are considered extralimital (i.e., outside their normal ranges). Two species of sea turtle occur within or near the Project Area and/or RAA on a regular basis. 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 6.15 and 6.16). Most of these SAR are expected to be rare or uncommon in the Project Area, although fin whales occur there regularly. Nonetheless, an accidental release of oil may 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 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 the time 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 most likely to be found in coastal areas within the RAA include humpback whale, fin whale, minke whale, Atlantic white-sided dolphin, short-beaked common dolphin, killer whale, harbour porpoise, harbour seal, grey seal, ringed seal, and bearded seal. Although considered rare, North Atlantic right whales and blue whales also occur in coastal areas. Polar bears are also known to occur in coastal areas of the RAA, particularly Labrador.

Sections 6.1.10 and 6.5 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 6.4.

16.6.3.1 Project Pathways for Effects

An accidental release of oil or SBM can affect marine mammals and sea turtles through two primary pathways: direct exposure resulting in a change in risk of mortality or physical “injury” (i.e., health effects) and/or a change in habitat quality and use which can lead to behavioural responses (e.g., avoidance) and/or the ability of marine mammals and sea turtles to successfully perform life functions (e.g., foraging). 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), as well as a multitude of other factors, such as environmental condition, type, magnitude, and duration of oil released, ecological communities present, and response and clean up measures undertaken (Barron et al. 2020).

The analysis of potential effects of oil spills on marine mammals and sea turtles is considered conservative in that it assumes geographic and temporal overlap occur and the modelling results assume that mitigation measures are not implemented.

16.6.3.1.1 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; Deepwater Horizon Natural Resource Damage Assessment Trustees [NRDA] 2016; Ruberg et al. 2021). 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 result 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 Deepwater Horizon 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, 1990), 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), as well as other cell and tissue abnormalities and organ dysfunction (Ruberg et al. 2021; Takeshita et al. 2021). Examination of deceased common bottlenose dolphins that had been exposed to oil during and after the Deepwater Horizon 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. 2015a). 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); lung disease was still evident in dolphins during 2016–2018 health assessments (Smith et al. 2021). Higher antibiotic resistance and a greater number of pathogens were also found in dolphins one year after they were exposed to high concentrations of oil from the Deepwater Horizon spill (Shen et al. 2020). Schwacke et al. (2021) noted that a decade after the Deepwater Horizon spill, this population still suffers from chronic disease and impaired reproduction. De Guise et al. (2021) also noted that immunological alterations have been passed down across generations, as indicated by T-cells in bottlenose dolphins (*Tursiops* spp.) inhabiting the heavily-oiled Barataria Bay, Louisiana. Linnehan et al. (2021) reported cardiac abnormalities in Barataria Bay eight years after the Deepwater Horizon spill, although it was inconclusive whether these were related to Deepwater Horizon oil exposure. The population is estimated to have declined by 45% since the spill (Schwacke et al. 2021).

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) (refer to Section 15.5.2). 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 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, Steller's 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 live 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 Deepwater Horizon spill in the Gulf of Mexico, a total of 1,141 cetaceans died between March 2010 and July 2014 (NOAA 2022a); most of these were bottlenose dolphin (Venn-Watson et al. 2015b). Williams et al. (2011) noted that oil spill severity is often underestimated due to low carcass recovery rates of cetaceans (typically as low as 2%). 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 (Williams et al. 2011; Lee et al. 2015). Nonetheless, numerous studies of dolphin populations inhabiting areas of the Gulf of Mexico that were affected by the Deepwater Horizon oil spill have indicated that elevated petroleum compounds contributed to increased numbers of dolphin mortalities (Schwacke et al. 2014; Venn-Watson et al. 2015a; NOAA 2022a). Pregnancy success rates of dolphins inhabiting the exposed area were also depressed (Lane et al. 2015; Kellar et al. 2017). Poor reproductive success may have been caused by increased concentrations of genotoxic metals in these animals (Wise et al. 2018a). 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

Certain aspects of sea turtle behaviour and biology increase their vulnerability to oil spills. Sea turtles make pre-dive inhalations, forage indiscriminately, and available evidence shows that they do not exhibit avoidance behaviour of spills (Lutcavage et al. 1995; Milton et al. 2003; Vander Zanden et al. 2016; Reich et al. 2017). Exposure pathways for effects of oiling 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 2003; Lee et al. 2015; NRDA 2016; Wallace et al. 2020). Furthermore, sea turtles can directly ingest oil, which has been reported to obstruct and damage tissue of the gastrointestinal tract and reduce food assimilation. The potential direct effects of oil exposure on sea turtles include skin alterations, sensory organ interference, haematological / immune changes, physiological process changes, cellular / organ effects, and metabolism / detoxification changes, while the potential indirect effects include loss of food resources and habitat (Mitchelmore et al. 2017; Wallace et al. 2020; Takeshita et al. 2021).

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 Deepwater Horizon spill (Vander Zanden et al. 2016; Reich et al. 2017). 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; Witherington et al. 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). The ingestion of tar balls can cause positive buoyancy disorders due to blockage of the intestine and/or the accumulation of gases caused by fermentation in the gastrointestinal tract. Buoyancy disorders inhibit a sea turtle’s ability to forage and to avoid danger (Milton et al. 2003; Manire et al. 2017). 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). Sea turtles are especially susceptible to prolonged exposure to petroleum vapours resulting from their diving behaviour, which requires rapidly inhaling large volumes of air before diving and continually resurfacing (Milton et al. 2003). Hall et al. (1983) observed seven live and three dead sea turtles following the Ixtoc 1 oil subsurface blowout 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. The most acute adverse effect on sea turtles from the Deepwater Horizon 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 Deepwater Horizon spill showed isotopic evidence of oil exposure in their scutes. Shaver et al. (2021) reported greater embryo deformities in Kemp’s ridley sea turtles after the Deepwater Horizon spill compared to before.

Sea turtles are ultimately susceptible to mortality from oil exposure. Several studies have reported sea turtle mortality associated with oil spills and estimated sea turtle mortality from oil exposure. 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.

In the United Arab Emirates, sea turtle strandings were positively correlated with the number of spills entering shallow coastal waters (Yaghmour 2019). Following the Deepwater Horizon spill in 2010, there was an increase in sea turtle stranding 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, 1,700 standings were reported between May 2010 and November 2012 (Beyer et al. 2016). More than 1,000 turtles were collected, including at least 450 living but oiled turtles (McDonald et al. 2017; Stacy et al. 2017); the remainder were deceased. The live oiled turtles were cleaned and released back into the wild (NOAA 2022b). It is likely that 100% of heavily oiled turtles died from the effects of oiling, and it was estimated that 30% of oceanic turtles that were not heavily oiled succumbed to the effects from oil ingestion (Mitchelmore et al. 2017). In total, it was estimated that up to 7,600 adults and large juveniles and as many as 160,000 small juveniles were killed by the spill (NRDA 2016). A total of 2,360 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).

In this assessment 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.

16.6.3.1.2 Effects of Dispersants on Marine Mammals and Sea Turtles

The use of dispersants is considered controversial (Beyer et al. 2016) and there is no clear consensus whether dispersants, chemically dispersed oil, or non-dispersed oil are relatively more or less toxic to marine mammals and sea turtles (Frasier 2020). The effects of dispersants on marine mammals and sea turtles are not well known (Frasier et al. 2020), but used as intended to change the characteristics of an oil spill, they may expose certain biota to oil longer and/or increase long-term oil toxicity in the water column (Dupuis and Ucan-Marin 2015; Beyer et al. 2016; Frasier 2020). According to Prince (2015) however, the positive effects of its use on a spill likely outweigh the environmental consequences.

Marine mammals and sea turtles are susceptible to floating oil due to the fact they need to surface at regular intervals to breathe. The use of dispersants may be beneficial for marine mammals and sea turtles within a spill area by reducing the exposure to floating oil on the sea surface. The use of dispersant after the Deepwater Horizon spill was largely responsible for the formation of a deep oil plume (~1,100-m depth) and at depth dispersant release may be a new pathway for potential hydrocarbon exposure to deep-diving marine mammals such as sperm and beaked whales (Frasier et al. 2020). The dispersion of oil 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). Laboratory tests using biopsied skin tissues from live, free ranging sperm whales demonstrated that contamination by chemically dispersed crude oil was more toxic to the health and genetic material of skin cells than non-chemically dispersed oil (Wise et al. 2014, 2018b). 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). Hydrocarbons and chemical dispersants may also cause immunological changes in marine mammals. Leukocytes from peripheral bottlenose dolphin blood demonstrated an immune response following in vitro contact with Louisiana sweet crude oil and Corexit chemical dispersant, including the immunosuppression of lymphocyte proliferation and enhancement of natural killer cell activity, simultaneously decreasing disease resistance and increasing tumor or virus detection capabilities (White et al. 2017).

Effects on sea turtles from exposure to chemical dispersants or chemically dispersed oil are unknown but may include digestion and lung or salt gland disfunction (Shigenaka 2003, in Frasier et al. 2020) and represent a toxicity concern (Mitchelmore et al. 2017), particularly at established foraging sites. During 2011 and 2012, satellite-tracked loggerhead sea turtles in the Gulf of Mexico exhibited long-term site fidelity and did not significantly change their foraging patterns despite exposure to oil and chemical dispersants following the Deepwater Horizon spill (Vander Zanden et al. 2016). Kemp’s ridley’s sea turtles were similarly found to continue to forage in oiled areas in the northern Gulf of Mexico (Frasier et al. 2020). Altered blood chemistry, electrolyte imbalances, and improper hydration were evident during a loggerhead hatchling exposure study to crude oil, dispersant, and a combination of oil and dispersant, and hatchlings exposed to dispersant and the oil/dispersant combination also failed to gain weight (Harms et al. 2014, in Frasier et al. 2020). Conversely, Bailey (2019) did not find significant effects on hatchling loggerhead blood chemistry from laboratory exposure to crude oil and Corexit dispersant, although Corexit exposure resulted in decreased concentrations of lactate, taurine, and cholines in heart tissue samples and altered metabolism in the liver.

16.6.3.1.3 Potential Effects of In Situ Burning on Marine Mammals and Sea Turtles

The effect of in situ burning of oil on marine mammals and sea turtles is unstudied. The primary effect of in situ burning likely would come from the vessel and aircraft traffic associated with the in situ burn operation. Such traffic would likely temporarily disturb and displace those marine mammals and sea turtles not repelled by the odour of the hydrocarbons from the vicinity of the burn operation (BOEM 2015). There was no reported increase in acute toxicity to a prey species of baleen whales, the copepod *Calanus finmarchicus*, in the water column beneath an oil slick following burning (Faksness et al. 2012). However, temperature elevation in the microlayer at the sea’s surface could potentially have lethal effects on zooplankton prey species of baleen whales within that layer (BOEM 2015). Levels of nitrous oxides, sulfur dioxide, and carbon monoxide in the vicinity of a burn would likely not increase to detectable levels (Fingas et al. 1995). Volatile organic compound emissions would likely be below levels emitted by unburned oil, and concentrations of polycyclic aromatic hydrocarbons and particulate matter would not increase to harmful levels (BOEMRE 2011). Polar bears could potentially suffer respiratory effects from soot or ingest soot while grooming if there was sea ice with polar bears close to a burn and if the bears were exposed to enough smoke (BOEM 2015). The temporary displacement of marine mammals and sea turtles caused by the vessel and aircraft traffic associated with the in situ burn operation would likely prevent marine mammal or sea turtle exposure to potential toxins or reduced prey concentrations caused by in situ burning.

16.6.3.1.4 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 in SBM wherever practicable. Environmental effects are mostly restricted to physical smothering effects on the sea floor (C-NLOPB 2011). Any 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. A subsea release of SBM at the wellsite would not interact with sea turtles given the water depth.

16.6.3.2 Mitigation of Project-Related Environmental Effects

Project-wide mitigation measures related to a potential accidental release are described in Section 16.6. Of particular relevance to marine mammals and sea turtles are the commitments related to oiled wildlife response (refer to Section 16.5.5). In the event that oil threatens or reaches the shoreline, shoreline protection measures, including deflection from sensitive areas (e.g., seal haul out sites), 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.

Suncor will develop a Wildlife Response Plan and, for incidents where wildlife is threatened, engage specialized expertise to implement the Plan, including the recovery and rehabilitation of wildlife species as needed (refer to Section 16.5.5 for Suncor’s oiled wildlife response approach).

In the unlikely event of a spill, specific monitoring (e.g., environmental effects monitoring) and follow-up programs may be required and will be developed in consultation with applicable regulatory agencies.

16.6.3.3 Characterization of Residual Project-Related Environmental Effects

16.6.3.3.1 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 will likely be higher for subsea releases of larger scale and extended duration, as was observed during the Deepwater Horizon 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 (i.e., inhalation, ingestion, aspiration, surface exposure, and absorption). 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). 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 blowout for a release site in EL 1161 demonstrated that the highest potential likelihood (>90%) to exceed thresholds of potential surface oil exposure primarily occurred to the east, up to 1,500 km from the release site due to prevailing winds and currents (Section 16.3.4).

Representative credible “worst-case” deterministic scenarios of a subsurface blowout at EL 1161 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) was less than 4%. 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 95th percentile of simulations was 286,800 km² in the 30 day release and 833,500 km² in the 120 day release (Table 16.2.4).

The modelling results suggest that areas most likely to be affected by an unmitigated, subsea well blowout are Jeanne d’Arc Basin, Newfoundland Basin, Flemish Pass and the areas to the east; in the 120 day simulations, the Southeast Shoal would also be affected. As a result, a blowout would have potential to interact with marine mammals that inhabit both the shallower waters of the Grand Banks and adjacent deeper waters. Sea turtles are expected to be rare in Jeanne d’Arc 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 occur 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 some 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 marine mammals and sea turtles would be reduced.

As detailed in Section 16.3.4, 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 were 1,452 km for the 30-day release and 1,479 km for the 120 day release. For the 30 day-release, the coastlines affected by oil concentrations above the ecological threshold included the northeast coast from Cape Bonavista to Cape St. Francis, the Avalon Peninsula, and most of the island’s southern coast. In the 120-day release, the affected coastlines were the northeast coast from Bonavista Bay to Cape St. Francis, the Avalon Peninsula, and most of the island’s southern coast. Shoreline oil would be highly weathered, patchy and discontinuous particularly at longer ranges from the release site. Harbour and grey seals that are known to haul-out in small numbers and use coastal areas, particularly on the Avalon and Burin peninsulas, could potentially 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 6.4.7, there are five marine mammal SAR and two sea turtle SAR 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 SAR 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.

16.6.3.3.2 Marine Diesel Spill

A batch spill of marine diesel 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.

Project-specific deterministic modelling for a batch release of diesel (1,000 L) was undertaken at EL 1161. Modelling results predicted that the marine diesel release would result in a patchy and discontinuous colourless or silver sheen (<0.1 µm thick). Surface oil thickness was not predicted to exceed 0.04 µm. Generally, marine diesel within these representative scenarios was predicted to be transported to the west and south, within 175 km of the release location (Figure 4-37 in Appendix E). At the end of the 30-day marine diesel batch spill simulations, 44% was predicted to evaporated into the atmosphere, 42% degraded, 15% remained entrained in the water column, while 0.1% of the released volume was predicted to remain floating on the water surface. The modelled batch spill was not predicted to reach shorelines.

16.6.3.3.3 Fuel Spill Along a Supply Vessel Transit Route

As indicated in Section 16.1.2, the hypothetical 3,200 L release of marine diesel from a nearshore location (12 km east of St. John’s) along a potential supply vessel route was predicted to result in silver or colorless sheens (<0.0001 mm) of oil floating on the water surface over a substantially smaller area than a well blowout scenario. This modelling was conducted as part of the EIS for BHP's Exploration Drilling Project (see Figure 15-44 in BHP 2020 for depiction of area that may be exposed to sheens). Generally, marine diesel spill scenarios conducted as part of the BHP EIS were predicted to be transported to the south and in some cases wrap around the Avalon Peninsula to the west, towards Saint Lawrence, Newfoundland (see Figure 15-44 in BHP 2020). At the end of the 30-day marine diesel batch spill simulations, 64% to 80% of the marine diesel 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. The ecological thresholds for oiling were not exceeded.

With spill prevention and response procedures in place, potential effects of a batch spill of marine diesel 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.

16.6.3.3.4 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, any reductions 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.

16.6.3.3.5 Summary

Table 16.23 provides a summary of predicted residual environmental effects of accidental events on Marine Mammals and Sea Turtles.

16.6.3.4 Determination of Significance

Based on consideration of the information presented above, the predicted residual adverse environmental effects from the accidental release of oil, marine diesel, and SBM 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 were based on 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 scenario given the larger geographic extent of the affected area as well as the potential for marine mammal species at risk to occur in the affected area.

Table 16.23 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							
Subsurface Blowout	A	M	RAA	MT – LT	UL	R	D
Marine Diesel Spill	A	L	LAA	ST	UL	R	D
Vessel Spill on Transit Route	A	L	LAA	ST	UL	R	D
SBM Spill	A	L	PA	ST	UL	R	D

KEY:
See Table 11.2 for detailed definitions

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:
UL: Unlikely
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

16.6.3.5 Determination of Significance

Based on consideration of the information presented above, the predicted residual adverse environmental effects from the accidental release of oil, marine diesel, and SBM 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 were based on 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 scenario given the larger geographic extent of the affected area as well as the potential for marine mammal species at risk to occur in the affected area.

16.6.4 Special Areas

Special areas within the RAA have been identified as special mainly due to biological and/or ecological characteristics. Though most of these special areas have no associated legislated conservation measures, some have provincial, federal or other regulatory mandates to protect natural features and/or cultural assets, or to permit scientific research, education, or recreation as described in Section 6.5 of this EIS.

Chapter 11 provided an assessment of the potential effects of routine Project activities on special areas and focused on a change in habitat quality. Special areas and their important characteristics may also be vulnerable to an accidental event, as such incidents may affect habitats for which they have been identified and/or protected. Change in habitat quality is also the focus for the assessment of accidental events on special areas, though the pathways for effects may be different. The effects assessment for Special Areas is closely linked to the assessment of accidental effects on marine fish and fish habitat (Section 16.6.1), marine and migratory birds (Section 16.6.2), and marine mammals and sea turtles (Section 16.6.2).

16.6.4.1 Project Pathways for Effects

Accidental releases of oil or SBM fluids have the potential to result in a change in habitat quality in special areas through potential effects on the sea surface, in the water column, or on the seabed. The extent of potential effects is dependent upon the nature, scale, and duration of a spill, how the spill trajectory and special areas overlap, and the types of special areas that occur in affected locations. The environmental assessment of these effects is conservative (i.e., overlap is assumed to occur, and modelling results assume mitigation measures are not implemented). However, in the event of an accidental release, appropriate responses to avoid or reduce harm would be implemented.

16.6.4.2 Mitigation of Project-Related Environmental Effects

Spill prevention measures are the most effective way to mitigate against potential effects of accidental events. While there are no specific mitigation measures specific to special areas, if a spill does occur, the SIMA may observe special considerations when evaluation response tactics (i.e., whether or not to use dispersants).

16.6.4.3 Characterization of Residual Project-Related Environmental Effects

Special areas identified and/or protected for the presence of sensitive species or important habitats may be comparatively more vulnerable, to the environmental effects of accidental events, than other areas. Effects on special areas, in the unlikely event of an accidental release of hydrocarbons or other substances, include potential degradation of the integrity of the special area so that it is not capable of providing the same biological or ecological function, or use, for which it was designated. The Special Areas VC is therefore closely linked to other VCs considered in this assessment, particularly the biological VCs. The potential effects of Project-related accidental events on marine fish and fish habitat, marine and migratory birds, and marine mammals and sea turtles, including species at risk, are discussed in Sections 16.6.1, 16.5.2, and 16.5.3, respectively. Potential effects on these three VCs are summarized in this section, as relevant to special areas that may interact spatially with areas affected by accidental releases, and where such interactions may affect habitat quality for the particular types of sensitive species and habitats for which these special areas are identified.

16.6.4.3.1 Subsea Blowout

Given the potentially large amount of oil that could be associated with an unmitigated subsurface well blowout, and the possibility for a spill to extend over a large geographic range, a blowout is the accidental event of greatest concern. A blowout, though extremely unlikely, has the potential to result in a change in habitat quality of special areas in the RAA.

For modelled releases in EL 1161, stochastic analyses (Section 16.3.4.1) indicated that the highest potential probability (>90%) for exceeding ecological effects thresholds for surface oil and water column exposure occurred primarily to the east of the modelled release site (Section 16.3.4.1; see also Appendix E). Due to prevailing winds and currents, released oil was predicted to move eastward up to 1,500 km from the release site (Figures 16-3 to 16-8). Thus, the average probability of oil above the identified thresholds reaching the Canadian coast was low, with a maximum average probability of 4 to 9% for the 30- and 120-day spill release durations, respectively, and depending on the season. In any case, oil potentially reaching shorelines would likely be highly weathered, discontinuous and patchy (Section 16.3.4) (Figures 16-5 and 16-8).

Table 16.24 summarizes the predicted overlap between special areas in the RAA and the results of the 95th percentile deterministic analyses of the worst-case scenario for conservative ecological effects thresholds for surface oil thickness (10 µm), THC in the water column (100 µg/L) and shoreline sediment contact (100 g/m²). 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) oil spill scenarios without mitigation. Table 16.24 also provides the primary reason for designation of the special area (e.g., marine fish and fish habitat, marine and migratory birds, marine mammals and sea turtles, and others). Detailed information and descriptions of the special areas are presented in Section 6.5. As detailed information is not available for candidate NMCAs, species and habitats in these areas are assumed based on other specials areas with which they intersect.

Table 16.24 includes those special areas where modelling indicated potential for spatial interaction, above ecological effects threshold, with areas affected by oil the sea surface, in the water column, or on the shoreline. Oil above ecological effects thresholds were not anticipated to occur in any world heritage sites, migratory bird sanctuaries, or national parks. Modelling for this Project determined that oil transported to bottom sediment was not a major fate pathway for completely unmitigated subsurface blowouts with <0.01% predicted to settle on sediments. Thus, analysis of the spatial relationship between special areas and sediment concentration was excluded from Table 16.24, as were special areas identified and/or protected primarily for benthic habitats. These include UN FAO VMEs, NAFO Fisheries Closures and DFO SBAs, though it is understood that these special areas are intrinsically connected to other ecosystem components and functions. There are no special areas in EL 1161 and with the exception of two small SBAs, there are no special areas in the Project Area.

The 95th percentile deterministic modelling for an unmitigated subsurface blowout predicted that oil on the sea surface could occur in areas that overlap with special areas and in a credible worst-case scenario, hydrocarbons could exceed the conservative ecological effects thresholds for surface oil thickness (10 µm). The 30-day surface oil thickness case was modelled to begin in October and the 120-day case to begin in July. This could result in a change in habitat quality in specials areas identified for the presence of marine fish and fish habitat. These include CBD EBSAs, Canadian EBSAs, MPAs, marine refuges, candidate NMCAs, critical habitat for northern and spotted wolffish, and Canadian Fishery Closure Areas (Table 16.24). Section 16.6.1, which discusses potential effects of an unmitigated blowout on marine fish and fish habitat, concludes that with spill prevention plans and response procedures in place, residual effects on marine fish and fish habitat would be not significant (Section 16.6.1.4).

Modelling predicted that surface oil in exceedance of the ecological effects threshold (10 µm) could interact with special areas identified for the presence of marine and migratory birds. This could result in a change in habitat quality in special areas. These include CBD EBSAs, IBAs, Canadian EBSAs, candidate NMCAs, and provincial ecological reserves (Table 16.24). The predicted effects of an unmitigated subsurface blowout on marine and migratory birds were assessed in Section 16.6.2.4, which concluded that these effects could be significant, though unlikely to occur (see Section 16.4.2.1 [subsea blowout probabilities]).

Table 16.24 Potential (95th Percentile) Unmitigated Subsurface Blowout “Credible Worst Case” Interactions with Special Areas in the RAA Based on Deterministic Modelling

Special Area	Primary Reason for Designation	Surface Oil		Water Column THC		Shoreline Oil Contact	
		Spill Release Duration (days)					
		30	120	30	120	30	120
UN 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		
Southeast Shoal and Adjacent Areas on the Tail of the Grand Bank	Marine fish and fish habitat Marine and migratory birds Marine mammals and sea turtles	X	X	X	X		
Seabird Foraging Zone in the Southern Labrador Sea	Marine and migratory birds	X	X	X	X		
BirdLife International IBAs							
Baccalieu Island	Marine and migratory birds					X	X
Big Barasway		X				X	
Cape St. Francis						X	X
Cape St. Mary’s		X				X	X
Corbin Island		X				X	X
Grand Bay West to Cheeseman Provincial Park						X	X
Grates Point						X	X
Green Island		X				X	X
Middle Lawn Island		X				X	X
Mistaken Point						X	X
Placentia Bay		X			X	X	X
Quidi Vidi Lake						X	X
The Cape Pine and St. Shotts Barren						X	X
Witless Bay Islands						X	X

Table 16.24 Potential (95th Percentile) Unmitigated Subsurface Blowout "Credible Worst Case" Interactions with Special Areas in the RAA Based on Deterministic Modelling

Special Area	Primary Reason for Designation	Surface Oil		Water Column THC		Shoreline Oil Contact	
		Spill Release Duration (days)					
		30	120	30	120	30	120
UNESCO World Heritage Sites							
Mistaken Point Ecological Reserve	Natural history Marine and migratory birds					X	X
DFO Newfoundland and Labrador Shelves EBSAs							
Haddock Channel Sponges	Marine fish and fish habitat	X			X		
Southeast Shoal	Marine fish and fish habitat Marine and migratory birds	X	X	X	X		
Baccalieu Island	Marine fish and fish habitat Marine and migratory birds Marine mammals and sea turtles				X	X	X
Bonavista Bay						X	X
Eastern Avalon		X				X	X
Fogo Shelf							
Labrador Slope		X					
Lilly Canyon-Carson Canyon		X	X	X	X		
Northeast Slope		X		X	X		
Orphan Spur		X					
Smith Sound						X	X
South Coast		X				X	X
Southwest Slope		X	X	X	X		
St. Mary's Bay		X			X	X	X
Virgin Rocks		X	X	X	X		
Laurentian Channel (NL Shelves Bioregion)	Marine fish and fish habitat Marine mammals and sea turtles	X	X	X	X		
Placentia Bay	Marine and migratory birds Marine mammals and sea turtles	X			X	X	X

Table 16.24 Potential (95th Percentile) Unmitigated Subsurface Blowout “Credible Worst Case” Interactions with Special Areas in the RAA Based on Deterministic Modelling

Special Area	Primary Reason for Designation	Surface Oil		Water Column THC		Shoreline Oil Contact	
		Spill Release Duration (days)					
		30	120	30	120	30	120
DFO Scotian Shelf EBSAs							
Stone Fence	Marine fish and fish habitat	X	X	X	X		
Laurentian Channel Cold Seep Communities		X	X	X	X		
Eastern Shoal	Marine fish and fish habitat Marine and migratory birds	X	X	X	X		
Misaine Bank		X					
Eastern Scotian Shelf Canyons	Marine fish and fish habitat Marine and migratory birds Marine mammals and sea turtles	X	X	X			
St. Anns Bank		X					
Laurentian Channel (Scotian Shelf Bioregion)	Marine fish and fish habitat Marine mammals and sea turtles	X	X	X	X		
Scotian Slope		X	X	X	X		
DFO MPAs							
Laurentian Channel	Marine fish and fish habitat Marine mammals and sea turtles	X		X	X		
St. Anns Bank		X					
The Gully		X	X	X			
DFO Marine Refuges							
Northeast Newfoundland Slope Closure	Marine fish and fish habitat	X		X			
Division 3O Coral Closure	Marine fish and fish habitat Marine mammals and sea turtles	X	X	X	X		
Parks Canada Candidate NMCAs							
East Avalon / Grand Banks	Marine fish and fish habitat Marine and migratory birds Marine mammals and sea turtles	X		X	X	X	X
South Burin / St. Pierre Bank	Marine and migratory birds Marine mammals and sea turtles	X		X	X	X	X
West Avalon / Green Bank		X		X	X	X	X

Table 16.24 Potential (95th Percentile) Unmitigated Subsurface Blowout “Credible Worst Case” Interactions with Special Areas in the RAA Based on Deterministic Modelling

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

Table 16.24 Potential (95th Percentile) Unmitigated Subsurface Blowout “Credible Worst Case” Interactions with Special Areas in the RAA Based on Deterministic Modelling

Special Area	Primary Reason for Designation	Surface Oil		Water Column THC		Shoreline Oil Contact	
		Spill Release Duration (days)					
		30	120	30	120	30	120
DFO Canadian Fisheries Closures							
Snow Crab Stewardship Exclusion Zone - 5A	Marine fish and fish habitat					X	
Snow Crab Stewardship Exclusion Zone - 6A						X	X
Snow Crab Stewardship Exclusion Zone – 6C		X			X	X	X
Snow Crab Stewardship Exclusion Zone – 8A		X			X	X	X
Snow Crab Stewardship Exclusion Zone - 8BX		X	X	X	X		
Snow Crab Stewardship Exclusion Zone - 9A		X			X	X	X
Snow Crab Stewardship Exclusion Zone - Near Shore		X			X		
Parks Canada National Parks and NHSs							
Cape Spear NHS	Cultural history					X	X
Signal Hill NHS						X	X
NL Department of Environment and Climate Change Ecological Reserves							
Baccalieu Island	Marine and migratory birds					X	X
Cape St. Mary’s		X				X	X
Lawn Bay		X				X	X
Witless Bay						X	X

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 effects thresholds for surface oil thickness (10 µm), THCs (100 µg/L), and shoreline contact (100 g/m²)
THC = Total hydrocarbons

Modelling also predicted that surface oil in exceedance of the ecological effects threshold (10 µm) could interact with special areas identified for the presence of marine mammals and sea turtles. These include a CBD EBSA, Canadian EBSAs, MPAs, a marine refuge, and candidate NMCAs (Table 16.24). The effects of an unmitigated subsurface blowout on marine mammals and sea turtles were assessed in Section 16.6.3.4, which concluded that with spill prevention plans and response procedures in place, residual effects on marine mammals and sea turtles would be not significant.

The 95th percentile deterministic modelling for an unmitigated subsurface blowout predicted that oil in the water column could occur in areas that overlap with special areas and in a credible worst-case scenario, hydrocarbons could exceed the conservative ecological effects thresholds for THC in the water column (100 µg/L). The 30-day surface THC in the water column case was modelled to begin in March and the 120-day case to begin in April. This could affect habitat quality in special areas identified for marine fish and fish habitat including CBD EBSAs, Canadian EBSAs, MPAs, marine refuges, candidate NMCAs, critical habitat for northern and spotted wolffish, and Canadian Fishery Closure Areas (Table 16.24). Section 16.6.1.4 determined that with spill prevention plans and response procedures in place, residual effects on marine fish and fish habitat would be not significant.

Based on modelling, areas that could be potentially affected by THC above ecological effects threshold (100 µg/L) in the water column spatially intersect with special areas identified for the presence of marine and migratory birds (Table 16.24). These include CBD EBSAs, IBAs, Canadian EBSAs, and candidate NMCAs. Section 16.6.2.4 indicates that a subsea well blowout has potential to change habitat quality in the habitats of seabirds (open water) and shorebirds (the intertidal zone of shorelines) with much greater potential for direct effects from surface oiling rather than through THC in the water column.

Modelling also predicted that in-water THC concentration could exceed the ecological effects threshold (100 µg/L) in areas that overlap with special areas identified for the presence of marine mammals and sea turtles. This could affect habitat quality in special areas identified for marine mammals and sea turtles including a CBD EBSA, Canadian EBSAs, MPAs, a marine refuge, and candidate NMCAs (Table 16.24). Section 16.6.3.4 determined that with spill prevention plans and response procedures in place, residual effects on marine mammals and sea turtles would be not significant.

The 95th percentile deterministic modelling for an unmitigated subsurface blowout predicted that oil in shoreline sediment could occur in areas that overlap with special areas and in a credible worst-case scenario, hydrocarbons could exceed the conservative ecological effects threshold for shoreline sediment contact (100 g/m^2). The 30- and 120-day shoreline cases were modelled to begin in April. Any oil making its way to the shoreline would likely be patchy and discontinuous due to the considerable weathering that would take place over the time (i.e., 9 to 28 days) for oil exceeding the ecological effects threshold to make contact.

Shoreline oiling could affect habitat quality in special areas identified for the presence of marine fish and fish habitat. This includes Canadian EBSAs (NL Shelves Bioregion only), a candidate NMCA, critical habitat for spotted wolffish, and Canadian Fishery Closure Areas (Table 16.24). The effects of an unmitigated subsurface blowout on marine fish and fish habitat were assessed in Section 16.6.1.4, which concluded that effects would be not significant.

Shoreline oiling could affect habitat quality in special areas identified for the presence of marine and migratory birds. These special areas include IBAs, a world heritage site, Canadian EBSAs (NL Shelves Bioregion only), candidate NMCAs, and provincial ecological reserves (Table 16.24). The effects of an unmitigated subsurface blowout on marine and migratory birds are described in Section 16.6.2.4, which concluded that effects could be significant, though such an event is unlikely to occur.

Shoreline oiling could affect habitat quality in special areas identified for the presence of marine mammals. These include Canadian EBSAs (NL Shelves Bioregion only) and candidate NMCAs (Table 16.24). The effects of an unmitigated subsurface blowout on marine mammals and sea turtles were assessed in Section 16.6.3.4, 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, high in magnitude, within the RAA, short-term to medium-term in duration, a unlikely and reversible. These conclusions are based on the worst-case scenario, which could result in a change in habitat quality in special areas identified for the presence of marine and migratory birds.

16.6.4.3.2 Potential Effects of Dispersant Use

There are two SBAs within the Project Area. Effects of dispersants on marine fish and invertebrates are described in Section 16.6.1.1. The use of dispersants increases the risk of exposure down into the water column and potentially the seafloor (Ramachandran et al. 2004). For sessile invertebrates, dispersed oil has been found to reduce larval settlement and cause tissue degradation and abnormal development (Cordes et al. 2016). Settlement and post-settlement survival of deep-sea coral in the Gulf of Mexico showed that treated oil was more toxic than untreated oil (DeLeo et al. 2016). There are still some data gaps with a large amount of uncertainty around the persistence of dispersed oil and the long-term effects on fish and fish habitat (Lee et al. 2015).

16.6.4.3.3 Potential Effects of *In Situ* Burning

Depending on the source oil, burn time, and temperature, the oil remaining oil after in situ burning may then continue to float or sink as it cools depending on its density (Allen 1990; Buist et al. 1997). The thin remaining residue oil is simply un-combusted oil, and so the effects would be similar to those described for the effects of oil on marine fish and fish habitat. However, the remaining oil that makes up the slick can be chemically different than the original oil depending on burn time and the composition of the source oil (Fritt-Rasmussen et al. 2015). As *in situ* burning is likely to result in mortality within the surface microlayer (top 1 mm of the water column), effects on the SBAs within the Project Area are unlikely.

16.6.4.3.4 Potential Effects of a Marine Diesel Spill

Modelling results of a 1,000 L release of marine diesel for this Project predicted silver or colourless sheens (<0.01 µm) of oil floating on the surface within 175 km of the spill site. Stochastic modelling showed that no areas, and thus no special areas, would be exposed to surface oil or shoreline sediment (Figure 4-37 in Appendix E) concentrations above the ecological effects threshold (or the lower socio-economic effects threshold) from such a spill. Project-specific modelling was not conducted for a marine diesel spill from an in-transit vessel to or from the MODU for this Project.

16.6.4.3.5 Potential Effects of a Fuel Spill Along a Supply Vessel Transit Route

Modelling was conducted for BHP’s Exploration Drilling Project (2019-2028) for a supply vessel spill 12 km east of St. John’s. BHP’s modelled hypothetical release is relevant given that EL 1161 is located closer to shore than many of the offshore exploration projects. The batch spill releases of 3,200 L of marine diesel from BHP’s modelling were also predicted to result in silver or colorless sheens well below the ecological effects threshold of 10 µm (BHP 2020), which also did not reach special areas. Thus, given the results of modelling for a batch spill for the Suncor and BHP exploration projects, a marine diesel spill from this Project is not anticipated to interact or adversely affect habitat quality in special areas.

16.6.4.3.6 Potential Effects of an SBM Spill from the MODU and the Marine Riser

SBM spill modelling was not conducted specifically for Suncor’s exploration Project. Conclusions from SBM spill modelling prepared for CNOOC’s (formerly Nexen Energy [2018]) Flemish Pass Exploration Drilling Project (2018-2028) (described in Section 16.1.3.) were used to understand the potential effects of an SBM release from this Project. As discussed in Section 16.6.1, the results of spill modelling for the CNOOC Project suggest that if SBM were to be released within EL 1161, potential effects on fish and fish habitat could occur up to 1 km of a deposition site.

A portion of the Snow Crab Stewardship Exclusion in Crab Fishing Area 8BX intersects EL 1161. Two SBAs (one identified for the presence of small, and one for large, gorgonian corals) overlap the Project Area but are a minimum of 14 km from EL 1161. Thus, habitat in a special area could potentially be exposed to released drilling muds from an SBM spill. The effects of an SBM spill on fish and fish habitat was assessed in Section 16.6.1.4, which concluded that residual effects would be not significant. No special areas identified for marine and migratory birds or marine mammals and sea turtles overlap the Project Area.

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 PA, short-term to long-term in duration, an unlikely event and reversible. These conclusions are based on the worst-case scenario, which would result in a change in habitat quality in special areas identified for the presence of marine fish and fish habitat, particularly benthic habitats.

16.6.4.3.7 Summary

Table 16.25 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 effects determinations for the biological VCs depending on the types of special areas that may be affected as a result of modelling predictions for accidental events. Marine diesel spills were determined to be not applicable to special areas as modelling indicates that these spills would not result in effects above the ecological effects threshold. Conclusions regarding the effects of a well blowout on habitat quality in special areas are based on residual effects on marine and migratory birds as this represents the most sensitive species and therefore special areas. Conclusions regarding the effects of an SBM spill on habitat quality in special areas are based on residual effects on marine fish and fish habitat 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 16.25 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	H	RAA	ST-MT	UL	R	D
Marine Diesel Spill	A	L	LAA	ST	UL	R	D
Vessel Spill on Transit Route	A	L	LAA	ST	UL	R	D
SBM Spill	A	L	PA	ST-LT	UL	R	D

KEY:
See Table 12.2 for detailed definitions

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:
UL: Unlikely
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

16.6.4.4 Determination of Significance

Based on the characterization of residual effects described above (and in Sections 16.6.1, 16.6.2, and 16.6.3), a precautionary conclusion is drawn that the residual adverse environmental effects of an unmitigated blowout incident is predicted to be significant for special areas identified for marine and migratory birds given that such an event could be significant over a larger area of the RAA and above the surface oil ecological effects threshold thickness of 10 µm. However, a significant effect is unlikely to occur on the basis of spill prevention plans and response procedures in place. An SBM release, would be not significant for special areas based on the conclusions for marine fish and fish habitat. The residual adverse effects of an accidental marine diesel spill are considered not significant for special areas.

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 accidental spills could result in adverse effects on habitat quality in 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 and locations of special areas. A medium level of confidence is assigned for subsurface blowouts 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.

16.6.5 Indigenous Peoples

There were 41 Indigenous groups identified in the EIS Guidelines that may be influenced by routine Project activities and/or potential accidental events and were therefore considered in the scope of the environmental assessment. This included 5 groups in NL, 13 groups in NS, 16 groups in NB, 2 groups in PE, and 5 groups in QC. 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. Several Indigenous groups hold commercial-communal and/or FSC licenses for species in areas that overlap the LAA and/or the RAA. There are no documented FSC licenses within the Project Area; however, some species targeted in FSC fisheries can potentially migrate through the Project Area and/or the LAA. Commercial communal licenses are held in NAFO Areas that overlap with the RAA, however there are no documented commercial communal licenses within the LAA or the Project Area. Further information on these Indigenous groups is provided in Section 7.4. The following section assesses two potential effects identified under the assessment of routine effects:

- A change in commercial communal fisheries
- A change in current use of lands and resources in the unlikely event of an accident.

16.6.5.1 Project Pathways for Effects

An accidental spill has the potential to affect fisheries resources, both directly and indirectly through effects to harvested species, displacement from traditional fishing areas, gear loss or damage, as well as reducing the marketability of commercial fish products and associated economic losses, resulting in changes to commercial-communal fisheries. A change in current use of lands and resources for traditional purposes could occur through effects to migratory species harvested for FSC purposes elsewhere. An accidental event may also indirectly affect socio-economic conditions, quality of life and well-being of Indigenous peoples. The extent of potential effects depends on the type and volume of a spill, the oceanographic conditions and how the spill trajectory and the VC overlap in both space and in time.

This section focuses on the effects related to the commercial-communal fisheries and current use of resources for traditional purposes, and in turn, the well-being and quality of life of Indigenous peoples. The potential biophysical effects associated with an accidental spill are discussed in Section 16.6.2 for marine fish and fish habitat, Section 16.6.3 for marine and migratory birds, and Section 16.6.4 for marine mammals and sea turtles. Discussion on potential biophysical effects to harvested species is not repeated in this section.

16.6.5.1.1 Potential Effects of an Oil Spill on Commercial-Communal Fisheries

An oil spill has the potential to impede the ability of Indigenous fishers to harvest fish, therefore, affecting the commercial-communal fisheries. An oil spill may affect the biological health of the commercial-communal fish species thereby reducing the marketability of fish products. Exposed fish (from the uptake of oil and PAHs) may pose a threat to human consumers and the marketability of catches. Perceptions of poor product quality in the market (i.e., tainting) may persist following results of safe exposure levels for consumption. Tainting is further discussed in Section 16.6.7 (Commercial Fisheries and Other Ocean

Users). This may result in prolonged effects to Indigenous fishers, including adverse socio-economic effects on Indigenous communities, as revenue from commercial communal licenses may be used in some communities to support community programs.

Although there is limited fishing in the LAA, in the event of an oil spill, hydrocarbons are free moving, and could reach outside the LAA where harvesting activity may be more concentrated. In the event of an oil spill, fishing gear may be lost or damaged. Physical contamination of fishing gear could result in transfer of oil to the catch (ITOPF 2011). To reduce the risk of contamination during an oil spill, the closure of fisheries is often recommended and intended to reduce the risk of contamination of gear and to protect consumers from potentially contaminated species. Restricting access during this time; however, can result in adverse socio-economic effects on Indigenous peoples and their communities by reducing quantity of catch available.

Swordfish and tuna have been noted as being of primary commercial-communal importance to the Newfoundland and Labrador Indigenous communities. The potential effects of a hydrocarbon spill are discussed for these species below.

16.6.5.1.1.1 Swordfish

Swordfish are a large, highly migratory pelagic species that are distributed widely throughout the Atlantic Ocean. They are known to forage in Canadian waters from June to October. Several Indigenous groups from the Maritime provinces have commercial-communal licenses to fish for swordfish in the RAA. Given swordfish are a highly mobile species, along with their seasonal distribution and non-schooling behavior, they are likely to avoid crude oil spills through temporarily migrating from the affected area (Arocha 2007). During an accidental event, it is unlikely that large concentrations of swordfish would be present in a spill area. Exposure to hydrocarbons via direct contact, respiration, or through diet, will generally not pose a bioaccumulation risk as hydrocarbons will be easily metabolized by the species. Larvae are more vulnerable to potential effects associated with an oil spill; however, spawning and nursery habitats are distant from the RAA (e.g., Gulf of Mexico, eastern continental shelf of the United States) (Arocha 2007) and therefore, coming into contact with hydrocarbons from a Project-related spill is unlikely.

16.6.5.1.1.2 Bluefin Tuna

Similarly, tuna are highly migratory species, moving across vast ranges in the offshore waters of NL. There are no known spawning or rearing habitats for larval or juvenile stages in Canadian waters (COSEWIC 2011). Several Indigenous groups from the Maritime provinces have commercial-communal licenses to fish for tuna in the RAA. The species covers a scale of approximately 100 km per week and could potentially migrate through the Project Area in search of prey. However, it is unlikely that the species would be present in an affected area in large concentrations due to their highly mobile nature and ability to avoid direct exposure to oil for prolonged periods (Hazen et al. 2016).

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

Current use of lands and resources for traditional purposes are harvesting activities that collect resources to provide nourishment or for use in traditional ceremonies and social gatherings. Although Suncor is not aware of FSC fishing occurring in the Project Area, migratory fish, bird, and/or mammal species traditionally harvested by Indigenous groups (or species linked to these harvested species [e.g., prey species]) elsewhere, may 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 groups through changes in cultural practices, and/or direct (e.g., direct contact) or indirect (e.g., ingestion of contaminated food) exposure to contaminants.

Marine and migratory birds and eggs are commonly harvested by Indigenous communities from the shore and nearshore areas within the RAA. 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 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). Exposure to hydrocarbons can occur in three different ways: external exposure to oil (resulting in coating of oil on feathers); inhalation of particulate oil and volatile hydrocarbons; and ingestion of oil. 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. Based on the characterization of residual effects 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. 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. Infrequent small spills, as well as an SBM release, would be not significant for marine and migratory birds.

Indigenous groups harvest seals for FSC purposes. Harp, grey, hooded and ringed seals are harvested by Indigenous groups in NL. 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 for marine mammals (see Section 16.6.4). 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. The predicted residual adverse environmental effects from the accidental release of oil, marine diesel, and SBM on marine mammals and sea turtles is predicted to be not significant. It would be highly unlikely that marine and migratory birds, and marine mammals (seals) would experience effects that could result in a decrease of availability of resources for Indigenous fisheries.

American eel and Atlantic salmon are migratory species that have potential to migrate through the Project Area at some point in their life cycle. Indigenous groups have expressed concern over these species in particular because of their cultural importance and for their use in traditional ceremonies and social events. In the event an oil spill, if fish became exposed to oil, harvesting these fish then exposes a potential threat to human consumers due to the uptake of oil and PAHs by exposed fish. Consumers of seafood for subsistence use (e.g., members in Indigenous communities) may have higher seafood consumption rates, compared to the general population, as they rely more heavily on local seafood resources as sources of protein (Yender et al. 2002). Therefore, the potential effects on health and well-being of Indigenous groups from an oil spill may be higher in magnitude than that of the general population. Potential effects of a hydrocarbon spill are discussed for the Atlantic salmon and the American eel below.

16.6.5.1.2.1 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. There are several populations of Atlantic salmon, which can be found in the RAA. Salmon migration routes can vary considerably due to variations in environmental conditions, such as sea surface temperature. Research vessel surveys have identified salmon within the Project Area in the spring; however, their potential for occurrence in the Project Area and RAA is considered low; there is no information with regards to salmon overwintering in relation to the Project Area. 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. Should Atlantic salmon occur within the Project Area and/or RAA, it is likely that they would be migrating through, occurring in deep waters and limiting their exposure risk (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 Project Area and RAA during migration periods, and potential ability to avoid contaminated waters, it is unlikely that Atlantic salmon would experience population level effects from an accidental spill.

16.6.5.1.2.2 American Eel

American eel is a catadromous fish (i.e., migrating down rivers to the sea to spawn) that lives primarily within freshwater and estuarine environments. It has a broad distribution throughout the northwest Atlantic Ocean (COSEWIC 2012). The potential for occurrence in the Project Area is considered low, as migrating adult eels travel along the continental shelf before swimming over deeper waters to reach the Sargasso Sea There is a potential transitory presence within the RAA during migration periods; however, little information is available on specific migration patterns of American eel. American eel have been shown to induce oil degrading enzymes with a 5 mg/kg dose, making them less sensitive to oil. 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. It would also be highly unlikely that American eel would experience effects that could result in a decrease of availability of resources for Indigenous fisheries.

Potential Effects of Dispersants and In Situ Burning on Indigenous Peoples

As discussed in Section 16.5.6, Suncor will develop a SIMA to consider the benefits and drawbacks of various spill response tactics, including the use of dispersants and in situ burning. This includes consideration of biophysical and socio-economic effects of dispersant use on Indigenous peoples and the biophysical resources upon which they depend. Sections 16.6.1 to 16.6.3 describe potential effects of dispersants on marine fish, marine and migratory birds, and marine mammals and sea turtles. While tactical decisions and resulting effects will depend on specific spill scenario characteristics, in general, response tactics that are shown to be effective in reducing the spatial or temporal footprint of a spill will result in net benefits to Indigenous peoples. Potential adverse effects to Indigenous peoples as a result of dispersant use or in situ burning are not predicted.

16.6.5.1.3 Potential Effects of an SBM Spill on Indigenous Peoples

If released accidentally as a bulk spill, SBM would sink rapidly through the water column because it is a dense low toxicity fluid (Neff et al. 2000; CNSOPB 2005, 2018). 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 and commercial communal harvesting does not occur within the Project Area, including harvesting for benthic species. Therefore, potential interactions with marine resources harvested for FSC or commercial communal purposes are not anticipated to occur. Consequently, associated socio-economic and health effects to Indigenous peoples are not anticipated to occur either.

16.6.5.2 Mitigation of Project-Related Environmental Effects

As described in Section 16.5, if an accident were to occur, Suncor's contingency planning and spill response measures would be implemented as appropriate. Suncor has an OSRP, which will be used to develop a Project-specific OSRP for the exploration drilling program. Suncor will prepare a SIMA that 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.

In addition to the measures described in Section 16.5 and Sections 16.6.1.2 and 16.6.6.2 (for Marine Fish and Fish Habitat and Commercial Fisheries, repectively) 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.
- Actual loss or damage, which includes income, including future income, and, with respect to any Aboriginal peoples of Canada, loss of hunting, fishing and gathering opportunities. In the event of damage to gear as a result of a subsurface blowout, damaged gear will be compensated in accordance with industry best practices in the NL offshore and relevant industry guidance material such as the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activities (C-NLOPB and CNSOPB 2017).

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 stakeholders, as applicable.

16.6.5.3 Characterization of Residual Project-Related Environmental Effects

16.6.5.3.1 Subsea Blowout

Due to the large spatial and temporal scale associated with a subsurface blowout, there is a potential for effects on the availability of fisheries resources (e.g., effects on fisheries species), fouling of fishing gear, and access to fisheries resources. These effects may potentially result in changes to commercial-communal fisheries, as well as adverse effects on socio-economic conditions for Indigenous peoples, such as food insecurity and/or economic loss. Many Indigenous communities rely on revenue generated from commercial-communal fishing to fund community ventures, social programs and benefits, and therefore, may also result in indirect socio-economic effects.

There is also potential for adverse effects to FSC species harvested elsewhere that may migrate through the LAA. These effects have the potential to result in lasting outcomes on the quality of life of the Indigenous peoples, lasting longer than the physical effects of the spill itself.

Affected areas in the event of a subsurface blowout would be closed to fishing to reduce human contact and consumption of potentially contaminated food sources. Reduced marketability is more likely to occur following a spill due to reduced consumer confidence of seafood (ITOPF 2011). A fish can absorb oil-derived substances into its tissues, causing petroleum tastes and odors following exposure to low hydrocarbon concentrations. Although tainting is reversible, there is perceived contamination concerns that may linger after seafood has been determined safe for consumption, further leading to potential economic losses and reduced marketability (Yender et al. 2002; ITOPF 2011). This can have adverse health and socio-economic effects on affected Indigenous communities.

Due to the primarily eastward transport of oil from wind and currents, and the distance of the release location to the shoreline of Newfoundland, trajectory modelling indicated that maximum probabilities of shoreline oil contamination at specific points ranged from 18% to 45%, depending on the release scenario and season, focused on the Avalon Peninsula (Figures 16-4 and 16-7). Oil that was predicted to make its way to Canadian shorelines would be patchy and discontinuous due to the considerable amount of weathering and natural dispersion that would take place over the weeks or months that were required for oil to reach shore.

Given the eastward transport of oil, it is unlikely that in the event of a subsurface blowout, oil will intersect areas traditionally harvested and areas harvested for commercial-communal fisheries. Through the implementation of an Indigenous Fisheries Communication Plan, Indigenous groups will be informed of an accidental event thereby giving fishers with the opportunity to haul out gear from the affected areas and reducing the potential for fouling of fishing gear. Actual loss or damage, which includes income, including future income, and, with respect to any Aboriginal peoples of Canada, loss of hunting, fishing and gathering opportunities will be compensated in accordance with industry best practices in the NL offshore and relevant industry guidance material such as the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activities (C-NLOPB and CNSOPB 2017).

There is, however, a potential for interaction with commercial-communal or FSC harvested species (e.g., fish, murres, seals) that may migrate through a spill area before the species is harvested in a non-affected area. Effects on marine fish are assessed in Section 16.6.2, effects on marine and migratory birds are assessed in Section 16.6.3, and effects on marine mammals are assessed in Section 16.6.4. 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. For example, 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 (see Section 16.6.3). Based on the characterization of residual effects 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. 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. Infrequent small spills, as well as an SBM release, would be not significant for marine and migratory birds. 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 highlighted 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. However, it is important to note that the model scenarios are based on unmitigated subsurface blowout scenarios and in the event of a subsurface blowout, emergency response and mitigations measures, as detailed in Section 16.5, would be implemented to reduce the magnitude, duration, and extent of a spill. Shoreline protection measures would also reduce effects on shorelines and coastal habitat for harvested species.

Residual environmental effects from an unmitigated subsurface blowout on Indigenous peoples 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. This effect is considered reversible with a medium to long-term duration and is predicted to be an unlikely event.

16.6.5.3.2 Marine Diesel Spill

Effects of a marine diesel spill on marine fish and fish habitat are limited (see Section 16.6.2), with temporary and reversible degradation in habitat quality at the water surface and localized, patchy distributions of oil. Similarly, effects on marine and migratory birds (see Section 16.6.3), and marine mammals (see Section 16.6.4) are also not likely to occur over a large area. Therefore, adverse effects to commercial-communal and FSC fisheries are anticipated to be low.

A surface batch spill is a silver or colourless sheen on the water surface, which is predicted to evaporate quickly. There is a limited potential that the biophysical effects of a diesel spill will have an adverse effect on the presence of abundance, distribution, quality or overall availability of resources for harvesting activities by Indigenous groups within their traditional harvesting areas. Therefore, there are limited effects on the quality or cultural value of these traditional activities by Indigenous groups. It is also unlikely that these effects will extend or affect the physical (e.g., through ingestion of toxic materials) or social health and well-being of Indigenous people or communities.

Actual loss or damage, which includes loss of hunting, fishing and gathering opportunities, will be compensated in accordance with industry best practices in the NL offshore and relevant industry guidance material such as the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activities (C-NLOPB and CNSOPB 2017).

Residual environmental effects from a marine diesel spill on Indigenous peoples are predicted to be adverse and low magnitude considering the small scale of the spill. The geographic extent of potential effects would likely be localized to the Project Area. This short-term effect is predicted to be an unlikely event and is considered reversible.

16.6.5.3.3 Fuel Spill Along a Supply Vessel Transit Route

BHP (2020) modelled a 3,200 L batch release of marine diesel (from a rupture of a diesel storage tank) along a supply vessel route similar to the transit route that Suncor would use. The modelled nearshore location was approximately12 km east of St. John's. Results of the modelling show that the release of 3,200 L of marine diesel from a vessel would result in patchy distributions of silver or colourless sheens (<0.0001 mm) of oil on the water surface (BHP 2020). The silver or colourless sheen on the water surface 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 (BHP 2020). There is a limited potential that the biophysical effects of a diesel spill will have an adverse effect on the presence of abundance, distribution, quality or overall availability of resources for harvesting activities by Indigenous groups within their traditional harvesting areas. Therefore, there are limited effects on the quality or cultural value of these traditional activities by Indigenous groups. It is also unlikely that these effects will extend or affect the physical (e.g., through ingestion of toxic materials) or social health and well-being of Indigenous people or communities.

As with a batch spill of marine diesel within the Project Area, effects of a marine diesel spill on marine fish and fish habitat are limited, with temporary and reversible degradation in habitat quality at the water surface and localized, patchy distributions of oil. Effects on marine and migratory birds and marine mammals are also not likely to occur over a large area. Therefore, adverse effects to commercial-communal and FSC fisheries are anticipated to be low.

Considering the small scale of the spill, residual environmental effects from a marine diesel spill on Indigenous peoples are predicted to be adverse and low in magnitude. There is potential for spills to occur along vessel traffic routes, and therefore the geographic extent is localized to the LAA. This short-term effect is predicted to be an unlikely event and is considered reversible.

16.6.5.3.4 SBM Spill from the MODU and the Marine Riser

It is anticipated that in the event of an SBM spill from the MODU, SBM will rapidly sink to the seafloor and be localized to the area surrounding the MODU, therefore resulting in temporary degradation to the benthic habitat and potential smothering of benthic fauna. There is a potential for an effect to occur to marine fish and fish habitat from a localized deposition area within 1 km from the Project site. Studies have shown that there is little or no risk of the bioaccumulation of drilling based chemicals occurring in the tissues of benthic animals or transfer through marine food webs to fishery species (Neff et al. 2000). The residual effects from SBM spills are therefore predicted to result in low magnitude adverse effects that are localized to the Project Area and reversible. The effects on FSC and commercial-communal fisheries are expected to be negligible given the localized extent of benthic interaction.

A surface sheen from an SBM spill could result in physical injury or mortality of marine birds. However, as discussed in Section 16.6.3, this would only occur to marine birds in the immediate area of the spill and is not predicted to result in population effects that would affect the Indigenous harvesting of marine birds. Given that the low surface oil thickness required to result in a sheen (0.04 µm) is well below the ecological threshold surface oil thickness, it is expected that effects would be minor and unlikely to result in seabird mortality. Adverse effects on seals are not predicted as a result of an SBM spill.

It is predicted that the residual environmental effects from an SBM spill on Indigenous peoples would be adverse and negligible to low in magnitude, taking into the consideration 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 considered reversible with short-term duration and is only predicted to be an unlikely event.

16.6.5.3.5 Summary

Table 16.26 provides a summary of predicted residual environmental effects of accidental events on Indigenous peoples.

Table 16.26 Summary of Residual Project-Related Environmental Effects on Indigenous Peoples – Accidental Events

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

KEY:
See Table 13.2 for detailed definitions

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:
UL: Unlikely
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

16.6.5.4 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 relied upon 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 communities, such that there are associated detectable and sustained decreases in the quality of life of a community
- A decrease in the established employment and business activity in commercial-communal fisheries (e.g., due to changes in fish mortality and/or dispersion of stocks) such that there is a detectable adverse effect on the economy of the affected Indigenous community
- A reduction in the quality of ambient air, water, fish, wildlife, or other resources at concentrations predicted to result in unacceptable human health risks, with an associated detectable increase in the incidence of health issues
- Unmitigated damage to fishing gear

On a larger spatial and temporal scale, a subsurface blowout could affect Indigenous peoples, with the 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 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 traditional resources. A significant effect is conservatively predicted for Indigenous peoples in the event of a subsurface blowout, 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. However, the likelihood of this significant effect occurring is considered low, given the potential for a blowout incident to occur and provided that the response measures are in place to mitigate the potential effects.

Given the limited spatial and temporal exposure of spilled diesel to Indigenous fisheries and resources use in the RAA, the adverse effects of a marine diesel spill and / or fuel spill along the supply vessel transit route are predicted to be not significant for Indigenous peoples and communities. 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.

The effects of an SBM spill are predicted to not be significant on Indigenous peoples given the predicted affected area, the temporal period of measurable effect on water quality and the low toxicity of the product. Fisheries closures are not anticipated and given the small spatial and temporal footprint of the spill event, fouling of gear would be unlikely. This determination is made with a high level of confidence.

16.6.6 Commercial Fisheries and Other Ocean Users

The Project Area is located within portions of NAFO Divisions 3L and 3N, specifically, Unit Areas 3Lr, 3Lt, 3Na, and 3Nb. The Project Area is mostly contained within the Canadian EEZ, with just 4% overlapping with the NAFO Fishing Footprint. The RAA Overlaps with all or portions of the following NAFO divisions and subdivisions (see Figure 7-2): 1F; 2H; 2J; 3K; 3L; 3M; 3N; 3O; 3Ps; 3Pn; 4Vn; 4Vs; 4W; and 4R.

Fishing effort in the RAA is dominantly by domestic fleets; however, due to the geography of the RAA, foreign fleets from St. Pierre and Miquelon and other NAFO nations also participate in commercial fishing activities. Quota sharing agreements are in place between Canada and St. Pierre and Miquelon for stocks managed by DFO, as well as between NAFO and Canada, for NAFO managed stocks (Section 7.2.1).

To date, there is minimal commercial fishing in the Project Area and EL 1161, although this does not necessarily mean there will be none in the future. The Project Area is situated near a known fishing area for snow crab on the Grand Banks and commercial fishing activity for snow crab has occurred continuously within the southeast corner of the Project Area from 2016 to 2020. There has been no commercial fishing activity for groundfish within the Project Area since 2013; however, groundfish are harvested within the RAA, mainly along the slopes of the NL shelves and on the Tail of the Grand Banks (see Figure 5-16). The main active groundfish fisheries are for Greenland halibut, redfish and yellowtail flounder, while cod and American plaice are harvested as bycatch only. In 2018, clam species were commercially fished within the Project Area.

Species harvested by international commercial fisheries outside the Canadian EEZ, within the NAFO Fishing Footprint, include groundfish species managed by NAFO within Divisions 3L and 3N, and include redfish, Greenland halibut, thorny skate, and white hake. American plaice, Atlantic cod, and Witch flounder are caught and harvested as bycatch only.

The Project Area is located in Shrimp Fishing Area 7, which is currently closed to all harvesting of northern shrimp fishing for both domestic and foreign fleets.

Atlantic cod, smelt, Atlantic salmon, lobster, and trout are all fished recreationally in near-shore and mid-shore areas off the coast of NL. Aquaculture operations on the east coast of NL, within the RAA, and in the Atlantic Ocean include blue mussels, Atlantic cod, trout, and oysters (see Figure 7-30).

In addition to commercial and recreational fishing activity and aquaculture, portions of the Project Area and RAA may be subject to other human-related activities that take place within offshore NL, which include marine research, marine transportation, other offshore oil and gas activity, military operations, and subsea infrastructure (Section 7.2).

16.6.6.1 Project Pathways for Effects

An accidental event can interact directly and indirectly with commercial fisheries and other ocean users by causing a change in availability of resources. For commercial fishers, the resource would be commercially harvested fish species. For other ocean users, the resource would be marine species of interest, in the case of research vessel surveys, or access to ocean areas (surface, subsurface or sea floor) for research and other purposes (i.e., marine transportation or military training). Direct interactions can include displacement from fishing grounds and damage to gear, vessels or instruments. Changes in fish health or quality, and fish avoiding popular fishing grounds due to changes in water quality, are considered as indirect effects. Indirect effects on commercially fished species and species targeted during research activities due to change in abundance, distribution and quality are discussed in the assessment of accidental events on Marine Fish and Fish Habitat (Section 16.6.1) and are not repeated in the following discussion.

16.6.6.1.1 Potential Effects of an Oil Spill on Commercial Fisheries and other Ocean Users

The uptake of oil and hydrocarbons present in the water column by exposed fish poses a potential threat to human consumers and affects the marketability of catches. According to ITOPF (2011a), the presence of taint, when a food product has an unusual odour or flavour (e.g., petroleum taste or smell), can be influenced by the type of oil, species affected, extent and duration of exposure, hydrographical conditions, and water temperature. The hydrocarbon concentrations at which tainting can occur are very low (no reliable chemical threshold has been established) with the presence of taint determined by sensory testing.

If seafood is taint-free, it is considered safe to eat, since contaminant levels detected during sensory testing are so low (ITOPF 2011b).

Market perceptions of poor product quality (e.g., tainting) can persist even when results demonstrate safe exposure levels for consumption, prolonging the economic effects for fishers. Reduced demand for seafood that is perceived to be tainted can also lead to depressed market prices. As demonstrated in the Gulf of Mexico following the Deepwater Horizon spill, lack of consumer confidence in seafood quality and in the validity of government testing methods can have effects that persist beyond the period of actual effects. Even after federal and state testing showed Gulf seafood to be safe to eat, sales remained depressed due to lack of consumer confidence (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011; Andrews et al., 2021)

Aquaculture and recreational fishing activities may be subject to a change in availability of resources if the oil reaches coastal locations, as it is predicted in some modelled accidental spill scenarios. Direct effects would be similar to effects on offshore activities, and result in spatial and/or temporal displacement of activities. Perceived contamination of fish catch may also be a concern for coastal subsistence and recreational fisheries (de Oliveira Estevo et al. 2021). However, unlike offshore activities, coastal activities take place further away from where the potential accidental event would occur, and the amount of time for the oil to reach the shore would provide plenty of time to remove gear and equipment until the area is cleared for activity again.

Physical contamination of boats, fishing gear, and aquaculture facilities can also occur, with flotation equipment (e.g., buoys, nets, fixed traps) and shoreline cultivation facilities at higher risk. In some cases, fouling of gear can result in oil being transferred to the catch or product (ITOPF 2011b, Alvernia et al. 2021).

Fishery closures may be imposed after a spill to prevent gear from being contaminated and to protect or reassure seafood consumers during spill remediation. Closures areas are also implemented to reduce interferences of other vessels with those associated with spill remediation and clean up. Fishery closures are most likely to be implemented in areas where (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011):

- Surface oil thickness is in excess of 0.04 µm (i.e., a visible sheen exists on the ocean surface)
- There are noticeable quantities of subsurface oil
- Surface oil is predicted to occur based on trajectory modelling.

The implementation of a fishery closure would prevent harvesting of fish in the affected area. While this may ease concerns about marketing of tainted product, it also means that harvesting activities are stalled or displaced to another location for a period of time. Closures typically remain in place until there is no visible sheen, there is low risk of future exposure based on predicted trajectory modelling, and seafood has passed a chemical analysis for oil contamination as well as a sensory test (e.g., smell and taste) (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011).

For other human components and activities, behavioural and physical effects on fish could indirectly affect research activities, and Project activities may also limit certain areas for research or military exercises, which may result in changes in schedules, or relocation of vessels to alternate areas. Damage to vessels or research equipment may also occur.

Potential Effects of Dispersants and In Situ Burning on Commercial Fisheries and Other Ocean Users

As discussed in Section 16.5.6, Suncor will develop a SIMA to consider the benefits and drawbacks of various spill response tactics, including the use of dispersants and in situ burning. This includes consideration of biophysical and socio-economic effects of dispersant use on commercial fisheries and the biophysical resources upon which they depend. Section 16.6.1 describes potential effects of dispersants on marine fish. While tactical decisions and resulting effects will depend on specific spill scenario characteristics, in general, response tactics that are shown to be effective in reducing the spatial or temporal footprint of a spill will result in net benefits to commercial fisheries. Potential adverse effects to commercial fisheries and other ocean users as a result of dispersant use or in situ burning are not predicted to occur.

16.6.6.1.2 Potential Effects of an SBM Spill on Commercial Fisheries and Other Ocean Users

If released accidentally as a bulk spill, SBM would sink rapidly through the water column because it is a dense low toxicity fluid (Neff et al. 2000; CNSOPB 2005, 2018). Although marine benthos within a localized area around the wellsite may be affected, studies have shown that there is little or no risk of the bioaccumulation of drilling based chemicals occurring in the tissues of benthic animals or transfer through marine food webs to fishery species (Neff et al. 2000). Although most of the SBM would sink to the seafloor, there is a possibility that a surface sheen may be present. However, this footprint would be relatively small and not expected to extend beyond the Project Area. Since commercial fisheries and other ocean users do not harvest benthic resources within the Project Area and effects would not extend to the snow crab harvesting area outside the Project Area, potential adverse effects on commercial fisheries and other ocean users as a result of an SBM spill are not anticipated to occur.

16.6.6.2 Mitigation of Project-Related Environmental Effects

If an accidental event were to occur, Suncor will implement contingency planning and spill response measures as appropriate, in order to reduce risk of incidents occurring and mitigate potential consequences (refer to Section 16.5). Suncor has an OSRP, which will be used to develop a Project-specific OSRP for the exploration drilling program. Suncor will prepare a SIMA, an evaluation applied to an oil spill to aid in the selection of the appropriate spill response(s) that provides responder safety and results in the best overall recovery of resources of concern (either ecological, socio-economic, and/or cultural).

Mitigation to reduce effects from an accidental spill on Commercial Fishers and Other Ocean Users include:

- A Fisheries Communication Plan will be used to facilitate coordinated communication, including procedures for informing commercial fishers of an accidental event and planned response. Emphasis will be on timely communication, allowing fishers to haul out gear from affected areas, reducing potential of fouling of fishing gear. This engagement will be coordinated through One Ocean, Fish, Food and Allied Workers-Unifor, Ocean Choice International, Association of Seafood Producers, and Groundfish Enterprise Allocation Council

- Actual loss or damage, which includes income, will be compensated in accordance with industry best practices in the NL offshore and relevant guidance material including the Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activities (C-NLOPB and CNSOPB 2017) (applicably when a spill results in gear loss or damage), Canadian East Coast Offshore Operators Non-attributable Fisheries Damage Compensation Program (CAPP 2007), and the Geophysical, Geological, Environmental, and Geotechnical Program Guidelines (C-NLOPB 2019), the latter of which indicates that operators should implement a gear and/or vessel damage compensation program.
- Suncor will maintain ongoing communications with the NAFO Secretariat, through DFO as the Canadian representative, regarding the occurrence of an accidental event, including timely communication on restricted access zones and applicable buffers.

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.

16.6.6.3 Characterization of Residual Project-Related Environmental Effects

If an accidental even were to occur, it may affect commercial fisheries and other ocean users through:

- Loss of access to marine areas
- Damage to or fouling of gear, vessel, or equipment
- Reduced marketability of resources

The threshold of <0.04 µm was used for spill trajectory modelling of surface oiling and represents the threshold at which socio-economic impacts may occur. In recognition of the possibility of a fisheries closure occurring at this threshold, >0.04 µm is also the threshold for a change in availability of resources in this assessment. The threshold for socio-economic impacts along nearshore environments on the shoreline is a mass per unit area threshold of 1 g/m². This threshold would result in impacts on nearshore aquaculture and commercial fishing for sessile spices like clams, scallop, whelk, and sea cucumber.

16.6.6.3.1 Subsea Blowout

A subsea blowout scenario has the potential to cause a change in the availability of resources for commercial fisheries and other ocean user, depending on the spatial and temporal scale of the spill and overlap with known uses of the marine areas. In 90% of the 171 modelled simulations for the 30-day unmitigated spill, a total area of 450,400 km² exceeded the. socio-economic effects threshold (<0.04 µm). For the stochastic scenarios for a 120-day release, the total area exceeding the socio-economic effects threshold (<0.04 µm) was 1,155,000 km². In both the short- (30-day) and long-term (120-day) modelled scenarios, 90% of scenarios resulted in released oil travelling to the east, out into international waters.

At one day the approximate area of oil exceeding 0.04 µm is 8,500 km² and is mostly contained within the Project Area. By approximately five to ten days, the modelled area of oil exceedance would reach nearby fishing grounds on the Grand Banks. This delay would allow time to let fishers in the area know that an accidental event has occurred and they are able to retrieve gear before fouling can take place. Due to the primarily eastward transport of oil from wind and currents, and the distance of the release location to the shoreline of Newfoundland, the maximum average annual probability of shoreline exposure above the 1 g/m² threshold was approximately 4% and 8% for the 30-day and 120-day modelling results, respectively.

Maximum probabilities of shoreline oil contamination at specific points ranged from 18 to 45% depending on the release scenario and season. The time for the oil to reach the shoreline is approximately 50 days and exposed shoreline areas are concentrated on the Avalon Peninsula.

A subsurface release of oil is likely to cause a change in availability of resources for commercial fisheries and other ocean users. Key mitigation, aside from spill response, includes early and effective communication and compensation for actual loss or damage. Residual effects of a subsurface release at EL 1161 on fisheries and other ocean uses are predicted to be adverse, high in magnitude, long-term in duration, unlikely to occur, and reversible. Effects may extend beyond the RAA, towards the east, into international waters.

16.6.6.3.2 Marine Diesel Spill

A marine diesel spill is not likely to result in effects over a large area. Based on modelled results, it is predicted that a batch spill release of 1,000 L marine diesel will not result in a surface sheen that is in excess of 0.04 µm and therefore would not result in a fisheries closure. Generally, oil was predicted to be transported to the west and south, within 175 km of the release location within EL 1161. At the end of the 30-day marine diesel batch spill simulation, 44% was predicted to be evaporated into the atmosphere, 42% degraded, 15% 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 settle on sediments in the modelled scenario.

With the implementation of mitigation measures, potential effects of a marine diesel spill, on commercial fisheries and other ocean users are predicted to be adverse, low in magnitude, occur within the RAA, short-to-medium term in duration, unlikely to occur, and reversible.

16.6.6.3.3 Fuel Spill Along a Supply Vessel Transit Route

There is also the unlikely potential that a marine diesel spill could occur from a supply vessel in the nearshore environment during transit to or from the MODU. Depending on the spill location, there is potential for nearshore or shoreline interaction. Modelled results for a hypothetical batch spill of 3,200 L of marine diesel 12 km east of St. John’s resulted in in the 95% shoreline oiling case affecting 1,010 km of shoreline along the southern parts of the Avalon Peninsula. If a marine diesel spill from the supply vessel occurs near shore during transit, temporary displacement of inshore fleets and/or fouling of fixed gear (gill nets and pots) and vessels may occur. Equipment associated with aquaculture facilities also have the potential to be affected; however, the modelled batch spill from a supply vessel near shore does not reach the mussel aquacultures sites in Placentia Bay, or the salmon aquaculture sites along the south coast of Newfoundland. The majority of spilled diesel would evaporate and disperse fairly quickly, so the time (short-to medium-term) and spatial extent of diesel oil exposure on would be limited.

With the implementation of mitigation measures, potential effects of a marine diesel spill, including a nearshore spill from a supply vessel, on commercial fisheries and other ocean users are predicted to be adverse, low in magnitude, occur within the RAA, short-to-medium term in duration, unlikely to occur, and reversible.

16.6.6.3.4 SBM Spill from the MODU and the Marine Riser

It is anticipated that in the event of an SBM spill from the MODU, SBM will rapidly sink to the seafloor and be localized to the area surrounding the MODU, resulting in temporary degradation to the benthic habitat and potential smothering of benthic fauna. Studies have shown that there is little or no risk of the bioaccumulation of drilling based chemicals occurring in the tissues of benthic animals or transfer through marine food webs to fishery species (Neff et al. 2000).

Although unlikely to occur, an SBM spill may potentially result in a surface sheen. However, it is unlikely that a sheen at this scale within the Project Area would result in a fisheries closure or pose risk to gear fouling. Given the localized extent of the benthic interaction, short-term duration, and known behaviour of SBM, effects on commercial fisheries and other ocean users are expected to be adverse, negligible to low in magnitude, occur within the Project Area, short term in duration, unlikely, and reversible.

16.6.6.3.5 Summary

A summary of predicted residual environmental effects of an accidental hydrocarbon release on commercial fisheries is provided in Table 16.27. Indicated value is based on the conservative approach (unmitigated, worst case scenario) as used for the spill modelling.

Table 16.27 Summary of Residual Project-Related Environmental Effects on Commercial Fisheries and Other Ocean Users – 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							
Well Blowout Incident	A	M-H	RAA*	MT-LT	UL	R	D
Marine Diesel Spill	A	L	RAA	ST-MT	UL	R	D
Vessel Spill during Transit	A	L	RAA	ST-MT	UL	R	D
SBM Spill	A	L	PA	ST	UL	R	D

KEY:
See Table 14.2 for detailed definitions

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:
UL: Unlikely
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological / Socio-Economic Context:
D: Disturbed
U: Undisturbed

16.6.6.4 Determination of Significance

As previously defined in Section 14.1.6, a significant adverse effect on commercial fisheries and other ocean users includes an environmental effect in which any one of the following occurs:

- Local fishers are displaced or unable to use substantial portions of the currently fished area for all or most of a fishing season
- Other ocean users are displaced or unable to use substantial portions of currently used areas for one or more years
- Local fishers experience a change in the availability of fisheries resources (e.g., fish mortality and/or dispersion of stocks) such that resources cannot continue to be used at current levels within the RAA for more than one fishing season
- There is unmitigated damage to fishing gear and/or equipment

The significance of spill-related adverse environmental effects is ultimately dependant the magnitude and spatial and temporal scale of the spill, and the appropriate implementation of mitigation measures to prevent and reduce effects from a spill. However, even in consideration of a worst-case scenario for a subsea blowout, considering predictive modelling results and planned mitigation (including compensation), the overall predicted residual environmental effects from a subsea blowout scenario on commercial fisheries and other ocean users is considered not significant.

Given the limited spatial and temporal exposure of spilled diesel to commercial fisheries and other ocean users and resources use in the RAA, the adverse effects of a marine diesel spill are predicted to be not significant.

The effects of an SBM spill are predicted to not be significant on commercial fisheries and other ocean users given the predicted affected area, the temporal period of measurable effect on water quality and the low toxicity of the product. Fisheries closures are not anticipated and given the small spatial and temporal footprint of the spill event, fouling of gear would be unlikely. The adverse effects of a SBM spill on commercial fisheries and other ocean users are predicted to be not significant.

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