Tilt Cove Exploration Drilling Project

Chapter 9: Marine Fish and Fish Habitat VC

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9.0 ASSESSMENT OF POTENTIAL EFFECTS ON MARINE FISH AND FISH HABITAT

Exploration drilling activities are planned to occur within the marine environment, therefore, marine fish and fish habitat are considered a VC as per Section 7.1.3 of the EIS Guidelines due to their potential interactions with routine project operations and components (CEA Agency 2019). Marine fish and fish habitat are also of ecological (e.g., ecosystem functioning, food web interactions) and socio-economic importance (e.g., commercial, recreational and Indigenous fisheries) and therefore linked through these pathways to other VCs considered in this EIS including marine and migratory birds VC (Section 10.0), marine mammals and sea turtles VC (Section 11.0), special areas VC (Section 12.0), Indigenous peoples VC (Section 13.0), and fisheries and other ocean users VC (Section 14.0). Government acts and associated regulations provide conservation and protection to marine fish and fish habitats including the *Fisheries Act*, *Oceans Act*, and *Species at Risk Act* (refer to Section 9.1.1).

Project activities and components may influence the biological and physical aspects of the marine ecosystem through infrastructure presence, discharges and emissions from vessels and the MODU, vertical seismic profiling activities, and well decommissioning/abandonment. The Project Area encompasses shelf areas (approximately 60 to 140 m water depth) of the Grand Banks and a variety of plankton, fish and invertebrates occur in the area. An overview of the existing biological environment within the Project Area is described in Section 6.1, including environmental linkages, key species, species at risk, and species of Indigenous or socio-economic importance. Chapter 5 details the existing physical environment with an overview of atmospheric, oceanographic, and ice conditions. This information has been inherently considered as part of the assessment of Project activities on marine fish and fish habitat. For the purposes of this assessment, marine fish and fish habitat are considered as defined under the *Fisheries Act*:

- “Fish” includes any parts of and life history stages of fish, shellfish, crustaceans and marine animals
- “Fish habitat” includes water frequented by fish and other areas (e.g., spawning, nursery, rearing, food supply, and migration areas) that fish depend upon directly or indirectly to carry out life processes
- “Marine plants” include algae, marine flowering plants, and phytoplankton

9.1 Scope of Assessment

9.1.1 Regulatory and Policy Setting

Within the RAA, marine fish and fish habitat are managed by the Government of Canada and the NAFO. Within the offshore 200 NM EEZ from the Canadian coastline, the federal *Fisheries Act* provides protection to fisheries by managing the fish resources and habitats that support these activities. NAFO is an intergovernmental fisheries science and management body for fisheries resources in the Northwest Atlantic, including outside the Canadian EEZ.

Marine fish and fish habitat are protected under the *Fisheries Act*. Specifically, the Act prohibits against the death of fish, or harmful alteration, disruption, or destruction of fish habitat unless authorized by the Minister of Fisheries and Oceans. Section 36 of the *Fisheries Act* also prohibits the deposition of a deleterious substance in waters frequented by fish.

Marine fish SAR are protected under SARA. SARA focuses on the protection of species and associated habitat whose populations are not secure. Sections 32, 33, and 58 of SARA contain provisions to protect species listed on Schedule 1 of SARA and their critical habitat. On July 11, 2018, critical habitat was proposed for the northern wolffish and the spotted wolffish (refer to Section 9.3.3). If a Project is likely to affect a listed species or its designated critical habitat, ministerial notification is required under section 79 of SARA. In this case, the adverse effects of the Project on the listed species and its designated critical habitat must be identified, and if the Project is to be carried out, measures must be taken to avoid, reduce, and monitor these effects. Marine fish SAR may also be formally protected under the NL ESA. A list of marine fish SAR that may occur in the Project Area is provided in Section 6.1.3.5.

The *Oceans Act* provides protection and regulates activities related to marine protected areas. Further existing environment and VC assessment information on special areas including marine protected areas are discussed in Sections 6.4 and 12.0, respectively.

9.1.2 The Influence of Consultation and Engagement on the Assessment

There are currently no documented food, social and ceremonial (FSC) licences within or near the Project Area. However, Suncor acknowledges that species harvested for commercial or FSC purposes outside the Project Area may potentially interact with Project activities (planned or unplanned) during migration to traditional fishing grounds. Concerns raised were related to the potential effects from accidental events on migratory species. These species included Atlantic salmon and other culturally important species like American eel, swordfish, tuna, groundfish, lobster, crab, and sharks. The other point of note was inclusion of Indigenous knowledge, both traditional and ecological knowledge in the environmental assessment.

9.1.3 Potential Effects, Pathways and Measurable Parameters

The potential direct and indirect effects and associated pathways of planned offshore oil and gas exploration activities on marine fish and fish habitat have been described as part of the Eastern Newfoundland SEA that overlaps with the Project Area (IAAC 2021). Potential effects and pathways (adapted from AMEC 2014) include:

- Destruction, contamination, or alteration of marine habitats and benthic organisms due to discharge and deposition of drill cuttings and/or fluids as well as the deployment and use of Project equipment
- Contamination of fish / invertebrates and their habitats due to other Project discharges in the environment during planned oil and gas exploration drilling and other associated survey and support activities
- The attraction of marine fish to MODUs and vessels, with increased potential for injury, mortality, contamination, and other interactions
- Temporary avoidance of areas by marine fish due to exposure to underwater sound or other disturbances, that may alter their presence and abundance as well as disturbing movements / migrations, feeding, or other activities
- Changes in the availability, distribution, or quality of food sources and/or habitats for fish and invertebrates as a result of planned activities and their associated environmental emissions
- Injury, mortality, or other disturbances to marine fish as a result of exposure to sound within the water column during VSP survey activity

This summary of interactions reflect consultations with government departments and agencies, stakeholder organizations, and Indigenous groups associated with the marine fish and fish habitat (Section 9.1.2) and recent EAs for exploration activities in the region (e.g., Statoil Canada Ltd. 2017; BP Canada Energy Group ULC 2018; Nexen Energy ULC [Nexen] 2018, Chevron Canada 2020, BHP Petroleum (New Ventures) Corporation 2020). As a result of these considerations, the assessment of Project-related effects on marine fish and fish habitat is focused on the following potential effects:

- Change in risk of mortality or physical injury
- Change in habitat availability, quality, and use

These effects reflect *Fisheries Act* prohibitions against causing death of fish or habitat alteration, disruption and destruction and allow for consideration of effects on fish SAR. The measurable parameters used for the assessment of the environmental effects presented above, and the rationale for their selection, are provided in Table 9.1. Effects of accidental events are assessed separately in Section 16.5.1.

Table 9.1 Potential Effects, Effects Pathways and Measurable Parameters for Marine Fish and Fish Habitat

Potential Environmental Effect	Effect Pathway	Measurable Parameter(s) and Units of Measurement
Change in risk of mortality, injury or health	• Direct project effects on fish mortality, injury or health due to direct interactions with individuals (e.g., smothering as a result of deposition of cuttings/drill muds) or indirectly through a change in habitat quality (degradation of habitat quality affecting fish health)	• Mortality (may be either direct measurement or qualitative) focused on population level changes
Change in habitat availability, quality and use	• Direct project effects on habitat availability and quality through deposition of cuttings / drill muds, effects on water quality from biocides, wastewater • Direct effects on prey availability from effects on lower trophic levels due to waste discharges, presence of infrastructure • Effects of project components that may result in attraction or avoidance by fish species including lighting, food availability, foraging conditions, sound, and others	• Distribution of drill cuttings and area of seabed infrastructure • Amount and quality of habitat types • Areal extent of changes in water or sediment quality • Zone of influence for underwater sound and light emissions • Species abundance and presence • Spatial and temporal distribution patterns of various life history stages

9.1.4 Boundaries

The following sections describe the spatial and temporal boundaries associated with the assessment of marine fish and fish habitat.

9.1.4.1 Spatial Boundaries

Project Area: The Project Area (Figure 9-1) is defined as the area within which routine Project activities could occur. While specific well locations have not yet been identified, they will occur within EL 1161. The Project Area includes the EL and an approximate 40-km wide buffer zone around the EL.

Local Assessment Area (LAA): the LAA (Figure 9-1) is the maximum area within which environmental effects from routine Project activities and components can be predicted or measured with a reasonable degree of accuracy and confidence. It consists of the Project Area and the transit route (with a 10 km buffer) and vessel transit routes to and from the Project Area.

Regional Assessment Area (RAA): The RAA (Figure 9-1) is defined as the area within which potential residual environmental effects on marine fish and fish habitat due to routine Project activities could interact cumulatively with residual environmental effects on the same VC due to activities associated with past, present and reasonably foreseeable future physical activities. Results of Project-associated oil spill modelling are also often considered in the delineation of the RAA.

9.1.4.2 Temporal Boundaries

The temporal boundaries for the assessment of potential residual environmental effects on marine fish and fish habitat due to routine Project activities encompass all Project phases, including well drilling, testing, suspension and abandonment. Suncor is currently proposing to drill as many as 12-16 exploration / appraisal wells in the Project Area. It is anticipated that each well will require between 45-120 days for drilling, and each VSP survey will require at least one to two days to complete. Well suspension and abandonment will be conducted following drilling and/or well testing. Wells may be designed for suspension and re-entry, but this will be determined through further prospect evaluation. For this reason, the temporal scope of the EIS extends beyond the EL lease term to end of 2029. Timing of drilling operations, which will not be continuous during the temporal scope, will primarily depend on rig availability and results from previously drilled wells. Routine Project activities could occur at any time during the temporal scope.

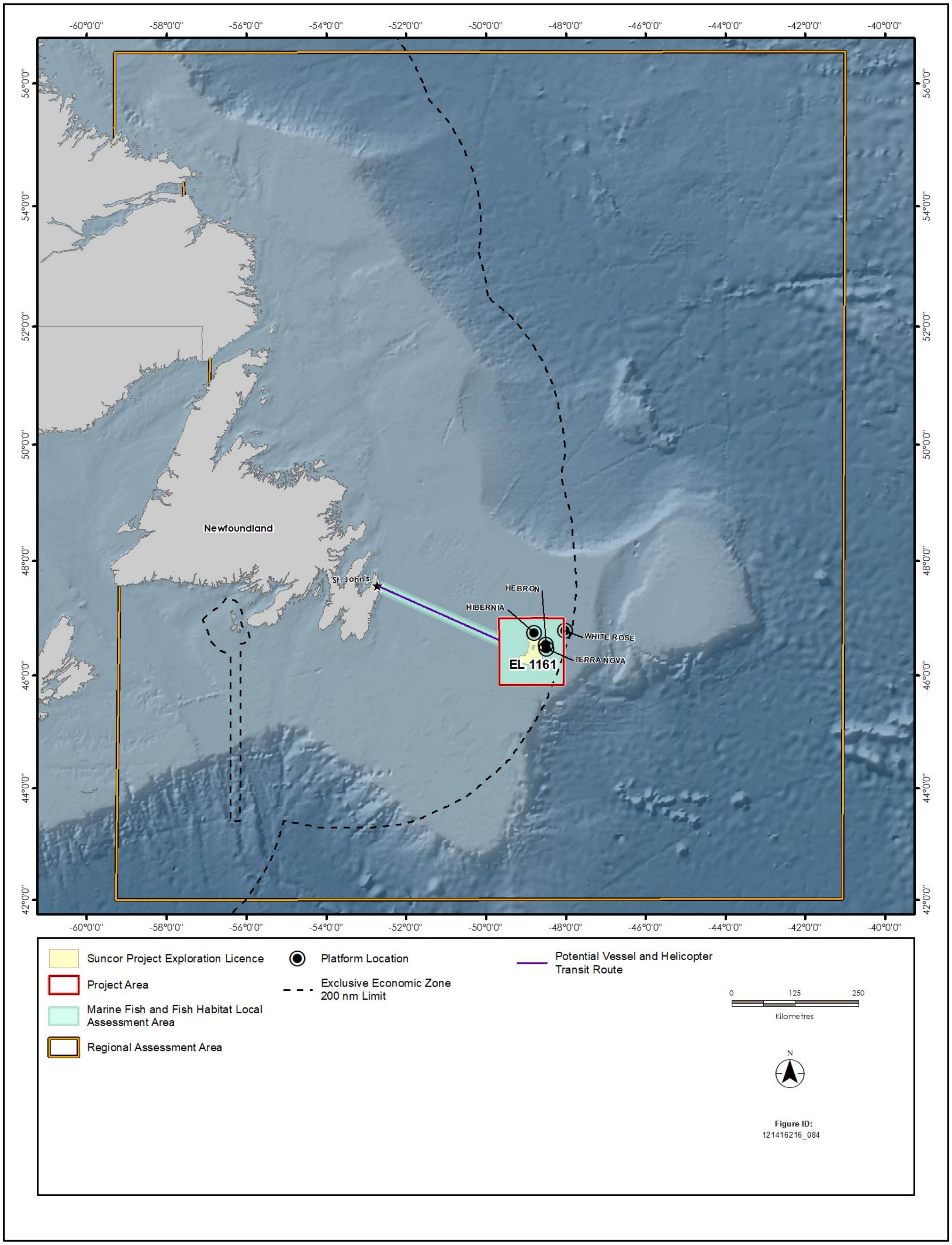

Figure 9-1 Marine Fish and Fish Habitat VC Spatial Boundaries

9.1.5 Residual Effects Characterization

Characterizations of the residual environmental effects used in this assessment on fish and fish habitat are defined in Table 9.2. These characterizations describe potential residual environmental effects on fish and fish habitat due to routine Project activities. These same characterizations are also used for the assessment of potential residual environmental effects on fish and fish habitat due to accidental events (see Section 16.5.1).

Table 9.2 Characterization of Residual Effects on Marine Fish and Fish Habitat

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

Table 9.2 Characterization of Residual Effects on Marine Fish and Fish Habitat

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

9.1.6 Significance Definition

Based on the descriptors listed in Table 9.2, as well as requirements under SARA and associated regulation and recovery, the following criteria have been established to define a Project-related significant adverse residual environmental effect on marine fish and fish habitat.

- A residual environmental effect that causes a significant decline in either abundance or change in distribution of fish populations within the RAA, such that natural recruitment may not re-establish the population(s) to its original level within one generation
- A residual environmental effect that jeopardizes the achievement of self-sustaining population objectives or recovery goals for SAR
- A residual environmental effect that results in permanent and irreversible loss of critical habitat as defined in a recovery plan or an action strategy
- A residual environmental effect that results in the death of fish or the harmful alteration, disruption or destruction of fish habitat (as defined by the *Fisheries Act*) that is either unauthorized, unmitigated, or not compensated through offsetting measures in accordance with DFO's Fisheries Protection Policy Statement (DFO 2019a)

9.2 Project Interactions with Marine Fish and Fish Habitat

Table 9.3 identifies, for each potential effect, the physical activities that might interact with marine fish and fish habitat and result in the identified environmental effect. These interactions are indicated by a check mark and are discussed in detail in Section 9.3, in the context of effects pathways, standard and project-specific mitigation/enhancement, and residual effects. A justification for no effects interaction is provided following Table 9.3.

Table 9.3 Project-Environment Interactions with Marine Fish and Fish Habitat

Physical Activities	Environmental Effects	
	Change in Risk of Mortality, Injury, or Health	**Change in Habitat Availability, Quality, and Use**
Presence and operation of a MODU (including drilling, associated safety zone, lights, and sound)	✓	✓
Geophysical (including VSP), Geological, Geotechnical, and Environmental Surveys	✓	✓
Discharges (e.g., drill muds / cuttings, liquid discharges)	✓	✓
Well Testing and Flaring (including air emissions)	-	-
Well Decommissioning, Suspension and Abandonment	-	✓
Supply and Servicing Operations (including helicopter transportation and Project supply vessel operations)	-	✓
Notes ✓ = Potential interaction – = No interaction		

Well evaluation and testing, including emissions and discharges associated with flaring and produced water, is not predicted to interact with marine fish and fish habitat in a way that could cause a change in risk of mortality or physical injury or habitat availability, quality and use. Well flow testing may be conducted if substantial hydrocarbons are indicated during exploration drilling to establish the viability and commercial potential of the reservoir (refer to Section 2.4.3). Produced hydrocarbons will be separated from produced water on the MODU if flaring is required as part of well flow testing. Furthermore, atmospheric, lighting, and thermal emissions associated with flaring will occur above the water and are not predicted to interact with marine fish and fish habitat. However, non-flaring methods of well evaluation using wireline techniques will be the preferred method of well testing during the drilling of exploration wells.

Well suspension and abandonment is not predicted to interact with marine fish and fish habitat in a way that could cause a change in risk of mortality or physical injury. The well suspension and abandonment program has not yet been defined (refer to Section 2.4.4); however, underwater sounds and discharges associated with well suspension and abandonment activities are not likely to pose a risk of physical injury or mortality to marine fishes and invertebrates due to their short-term and localized nature. It is anticipated that well suspension and abandonment will have reduced effects on habitat availability and use for marine fishes and invertebrates from remaining subsea infrastructure on the seabed as discussed in Section 9.3.2.3.4.

Supply and servicing operations are not predicted to interact with marine fish and fish habitat in a way that could cause a change in risk of mortality or physical injury. Supply and servicing operations would include the transit of vessels and helicopters between the MODU and shore. Helicopter sounds are primarily at frequencies below 500 Hz and are generally most intense just below the water surface and directly beneath the aircraft (Richardson et al. 1995). Sounds from helicopters typically attenuate over shorter distances underwater compared to than airborne sounds (Richardson et al. 1995). As single or occasional overhead flights have been observed to cause only brief behavioural response in marine mammals (Richardson et al. 1995). It can generally be inferred that effects on marine fish would also be less than for marine mammals and limited to eliciting brief behavioural response. Therefore, helicopter activities are not predicted to interact with marine fish and fish habitat that could cause a change in risk of mortality or physical injury. Due to the transient nature of vessel sound, it is not expected that marine fish would be exposed to continuous underwater sound levels for durations that would result in injury or mortality (Popper et al. 2014). Fish species in the water column would likely temporarily avoid immediate areas nearby supply vessel traffic, further reducing the risk of injury or mortality because of vessel strikes or propeller blade contact. Changes in habitat quality and use from supply and servicing waste discharges are discussed in Section 9.3.2.3.5.

9.3 Assessment of Residual Environmental Effects on Marine Fish and Fish Habitat

Potential effects of Project activities and components on marine fish and fish habitat include change in risk of mortality, injury, or health, and change in fish habitat availability, quality, and use. The following section assesses these environmental effects on marine fish and fish habitat with an identification of interaction pathways, overview of planned mitigations, and characterization of effects based on scientific literature, government and industry reports, and Project-specific modelling. The assessment incorporates information from previous offshore project EAs (e.g., exploration drilling, production) in the Northwest Atlantic, information from the Regional Assessment of Offshore Oil and Gas Exploratory Drilling East of Newfoundland and Labrador (IAAC 2021), and comments received during Indigenous and stakeholder processes. As indicated previously, potential effects on marine fish and fish habitat have ecological and socio-economic implications for other VCs and are discussed separately within the VC-specific assessments.

9.3.1 Change in Risk of Mortality, Injury, or Health

9.3.1.1 Project Pathways

A change in risk of mortality, injury, or health for individual marine fishes and invertebrates may result from potential interactions with the presence and operation of a MODU, geophysical (including VSP), geotechnical surveys, and discharges. The presence and operation of a MODU and VSP may affect sound levels and the quality of the underwater acoustic environment. Changes in mortality or injury may occur from acute changes in sound pressure and/or particle motion for fishes and invertebrates exposed to high sound levels in close proximity to the VSP array. Artificial lighting emissions from the MODU may also increase predation and foraging opportunities for fish. Aquatic invasive species may be transported through ballast water or on the hulls of ships and the MODU. Introduction of invasive species may compete for food resources, potentially resulting in changes to fish health. Drill cuttings discharges that settle on the seafloor may bury and smother low mobility benthic organisms. Well testing and flaring, well suspension and abandonment, and supply and servicing operations are not predicted to result in changes in risk of mortality, injury or health (refer to Section 9.2).

9.3.1.2 Mitigation

Project mitigation measures and standard practices that will be employed to reduce potential environmental effects on marine fish and fish habitat are described below. The mitigation measures consider environmental effects pathways, standard industry mitigation measures for similar exploration drilling projects, and environmental protection regulations and guidelines for offshore oil and gas activities (IAAC 2021; BP 2018; Nexen 2018).

Presence and Operation of a MODU

This Project activity and component will be planned and conducted in consideration of relevant regulations and guidance including C-NLOPB guidance for drilling activities where cold-water corals may be present, and Canada's Ballast Water Regulations as detailed below.

- An imagery-based, pre-drilling seabed survey will be conducted at the proposed wellsite(s) to assess the presence of shipwrecks, seafloor debris, unexploded ordinances and any aggregations of habitat-forming corals or sponges or any other environmentally sensitive features. If any aggregations of habitat-forming corals or sponges (or any other environmentally sensitive features) are identified, Suncor will change the location of the anchor(s) or well on the seafloor or redirect drill cuttings discharges to avoid affecting the aggregations of habitat-forming corals or sponges or other environmentally sensitive features (unless not technically feasible), as determined in consultation with the C-NLOPB.
- Artificial lighting will be reduced, where possible with consideration of safety and associated operational requirements. Lighting reductions may include avoiding use of unnecessary lighting, shading, and directing lights towards the deck.
- To reduce the potential spread of invasive species, ballast water will be managed in consideration of applicable Canadian and international ballast water management requirements (e.g., *Canada's Ballast Water Regulations*).

Geophysical (including VSP), Environmental and Geotechnical Surveys

VSP activities will be planned and conducted in consideration of relevant regulations and guidance including the Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment (SOCP; DFO 2007) and C-NLOPB Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2019) as detailed below.

- A ramp-up procedure will be carried out where seismic source elements are gradually increased over a period of approximately 30 minutes until the operating level is achieved. This measure, as outlined in the SOCP and C-NLOPB (2019) guideline, is intended to reduce potential risk of injury to marine animals (including fishes and invertebrates) in close proximity to the sound source at the start of the activity. A gradual increase in emitted sound levels is intended to provide an opportunity for mobile organisms to move away before potentially injury-inducing sound levels are achieved close to the sound source.
- VSP activities will be planned to avoid dispersing aggregations of fish from known spawning areas and diverting fish from known migration corridors as detailed in Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2019).

Discharges

Project activity discharges will be planned and conducted in consideration of relevant regulations and guidance including the Offshore Chemical Selection Guidelines (OCSG) (National Energy Board et al. [NEB] et al. 2009), Offshore Waste Treatment Guidelines (OWTG) (NEB et al. 2010), International Convention for the Prevention of Pollution from Ships (MARPOL), and *Transportation of Dangerous Goods Act* as detailed below.

- The selection and screening of chemicals to be discharged (e.g., drilling fluids) will be in accordance with the OCSG (NEB et al. 2009). Lower toxicity drilling muds will be used where technically feasible. Drilling mud and cement components will be selected in consideration of biodegradable and environmentally friendly properties. Chemical components rated as being least hazardous under the Offshore Chemical Notification Scheme (OCNS) and Pose Little or No Risk to the environment (PLONOR) by the Convention for the Protection of the Marine Environment of the North-East Atlantic (refer to Section 2.9.3 for more information on chemical selection) will be used where feasible.
- Operational discharges will be treated before release in accordance with OWTG (NEB et al. 2010) and MARPOL. Waste discharges will be transferred to shore for disposal if they do not meet regulatory guidelines for discharge at sea. Furthermore, a Project-specific environmental protection plan (EPP) and waste management plan (WMP) will be developed to prevent unauthorized waste discharges (refer to Section 2.10 for details on waste discharges and management).
- As described in Section 2.8.1, synthetic-based mud (SBM) drill cuttings will be returned to the MODU and treated before being discharged into the marine environment. SBM concentration on cuttings will be monitored onboard the MODU to ensure concentrations are below OWTG threshold for at-sea discharge. In accordance with OWTG, no excess or spent SBM will be discharged, and excess or spent SBM that cannot be reused will be brought back to shore for disposal. In accordance with OWTG, water-based mud (WBM) drill cuttings will be discharged at sea without treatment.
- Food waste generated offshore on the MODU and supply vessels, will be disposed according to OWTG and MARPOL requirements. Maceration of food waste will be conducted in accordance with MARPOL and OWTG and there will be no discharge of macerated food waste within 3 NM of land.
- The transfer of hazardous wastes will be conducted in accordance with the *Transportation of Dangerous Goods Act*, and applicable approvals for the transportation, handling, and temporary storage of hazardous waste will be obtained, as required.

9.3.1.3 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) in 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).

9.3.1.3.1 Presence and Operation of a MODU

The MODU may maintain positioning through the dynamic positioning (DP) system or anchoring. The placement of anchors may result in localized direct injury to low mobility organisms and short-term increase in turbidity and suspended sediment effects (Heery et al. 2017). Mobile fish and invertebrates would be able to avoid areas of disturbance from anchor placement. While there may be mortality in low mobility organisms, the small spatial footprint of anchors indicates that the effects would be limited to individuals and not have effects on the population. Increased turbidity and suspended sediment from anchor placement may result in reduced feeding for suspension feeding invertebrates (e.g., corals, sponges, brittle stars). However, any potential effects would be recoverable due to the dissipation and short-term nature of turbidity and suspended sediment effects. Generally, these effects for infrastructure placement are at spatial scales of tens of metres (Heery et al. 2017). Potential effects from turbidity and suspended sediment would also be low considering surficial sediments are primarily gravel and sand (refer to Section 5.1).

The operation of a MODU will generate continuous underwater sound primarily from DP system and drilling operations. Drilling operations would be the primary underwater sound generated if anchors are used for MODU positioning. Operational MODU underwater sounds will propagate through the water column and perhaps the seabed as well. This may potentially cause some behavioural disturbance to marine fishes and invertebrates occurring in the vicinity of the MODU. However, it is unlikely that exposure to MODU sound would result in either physical injury or mortality to fishes and invertebrates, based on available scientific literature.

Marine fish have a variety of behavioural responses to underwater sound that varies by species, life history stage, received sound levels and other factors. All fishes and invertebrates are able to detect the particle motion component of underwater sound while only particular fishes and no invertebrates can detect the pressure component of sound (Hawkins et al. 2015; Nedelec et al. 2016; Hawkins and Popper 2016; Popper and Hawkins 2018, 2019). Therefore, it is generally recognized that the establishment of a single-sound exposure criterion for marine fish and invertebrates for predicting physical and behavioural changes is impossible given the variability in anthropogenic sound characteristics, and inter- and intraspecific differences in how fish and invertebrates detect and respond to sound (Popper et al. 2014). As there is a lack of evidence for direct mortality or potential injury from exposure to continuous sounds such as vessel sounds, qualitative risk guidelines have been proposed based on distance between fishes and the sound source (Popper et al. 2014; Hawkins et al. 2015). Popper et al. (2014) considered the risk of mortality and potential injury low for ichthyoplankton (e.g., eggs and larvae) and all three fish types (i.e., without swim bladder, with swim bladder not involved in hearing, and with swim bladder involved in hearing), regardless of distance from the continuous sound source.

However, Popper et al. (2014) discussed evidence for impairment effects (i.e., temporary thresholds shifts (TTS) and auditory tissue effects) from exposure to continuous underwater sound in laboratory experiments with goldfish and Pictus catfish. These species use their swim bladders in hearing and are considered highly sensitive to sound pressures. Goldfish exposed to white noise with a sound peak level (SPL) of 170 dB re 1 µPa rms for 48 hours resulted in a recoverable loss of sensory hair cells and associated TTS of approximately 16 db (Smith et al. 2006, in Popper et al. 2014). Recovery of TTS required seven days while replacement of affected sensory cells required eight days (Smith et al. 2006, in Popper et al. 2014). In a second study, exposure to white noise with a SPL of 158 dB re 1 µPa rms for 12 hours resulted in 26 dB TTS in goldfish and a 32 dB TTS in Pictus catfish (Amoser and Ladich 2003, in Popper et al. 2014). Recovery of TSS for the goldfish and catfish in this study required three days and 14 days, respectively (Amoser and Ladich 2003, in Popper et al. 2014).

The source SPL associated with the MODU used in the acoustic modelling (Alavizadeh and Deveau 2020) for this Project ranged from 187.7 to 196.7 dB re 1 µPa rms. Using the 158 dB re 1 µPa rms received SPL reported in Amoser and Ladich (2003) as the reference point, modelling results indicate that received levels of 150 to 160 dB re 1 μPa rms from the MODU would occur approximately 78 m (160 dB re 1 μPa rms) to 522 m (150 dB re 1 μPa rms) from the sound source in February, and 81 m (160 dB re 1 μPa rms) to 607 m (150 dB re 1 μPa rms) in August (Alavizadeh and Deveau 2020). Popper and Hawkins (2019a, in Alavizadeh and Deveau 2020) have five groupings of fish based on their sensitivity to sound, with fish that use their swim bladder for hearing being the most sensitive. For these fish, mortality is expected to occur within 134 m of the MODU at 207 dB re 1 $\mu Pa^2 s$ with very little seasonal variation (sound exposure level [SEL_{24h}]) (Alavizadeh and Deveau 2020). Therefore, any potential for recoverable injury and/or TTS would be localized. Exposure to sound at such levels would be transient, as mobile fish would potentially respond at lower thresholds and move away before injury could occur. This would limit the potential for injury to individual fish and therefore limit potential effects on fish populations.

Chronic effects on marine fish result from exposure to continuous sound, not necessarily at high levels, over long time periods, and may result from increased vessel activity or other human activities (Hawkins et al. 2015). Chronic effects are often from sounds continuously generated over large areas, where the overall sound levels are higher than the natural background levels (Hawkins et al. 2015). This may occur in relatively stationary fishes that remain close to sound generating activities for long periods (Hawkins and Popper 2016). Potential chronic effects from sound exposure is expected to be low for Project activities, considering the short-term nature of exploration drilling. Many sound exposure studies on fish and invertebrates are based on laboratory conditions where individuals are unable to move away from sound as would be possible under natural conditions. Hawkins and Popper (2016) indicate the need for further research to determine longer-term effects of exposure to continuous sound on individual and population fitness considering the complexities of measuring sound effects in underwater environments.

Phototactic plankton may be attracted to artificial lighting around the MODU and may further attract planktivorous species (Keenan et al. 2007; Cordes et al. 2016). A change in risk of mortality and injury may occur from increased predation opportunities by fish and other species resulting from increased underwater illumination (Keenan et al. 2007). Light levels of studied offshore platforms in the Gulf of Mexico decreased to background levels within the survey area (250 m from source) below 5 and 10 m water depths (Keenan et al. 2007). Potential effects of artificial lighting from offshore structures may be localized from hundreds of metres to less than 1.5 km from the light source depending on structure design and activities (i.e., increased illumination with flaring) (Keenan et al. 2007; Simonsen 2013; Foss 2016).

Aquatic invasive species may result in a change to fish health from competition with local species for resources (e.g., food). The MODU and vessels may act as a vector for transmission of aquatic invasive species through attachment to the hulls or through discharge of ballast water. Furthermore, these offshore structures may provide “stepping-stone” habitat that enables colonizing invertebrates to spread to areas not typically within their range (Cordes et al. 2016; Oak 2020). However, the potential spread of invasive species is low with the application of standard mitigations (e.g., ballast water regulations for prevention and mitigation of spread of invasive species).

The residual environmental effects resulting in increased risk of mortality, injury, and health to marine fish and fish habitat due to the presence and operation of the MODU is predicted to be adverse, low in magnitude, restricted to the Project Area, medium-term in duration, to occur more than once at irregular intervals, and be reversible based on available science.

9.3.1.3.2 Geophysical (including VSP), Environmental and Geotechnical Surveys

VSP activities are predicted to generate the highest levels of underwater sound associated with the Project. The VSP sound source will be activated intermittently, with survey operations occurring over one to two days for each well. VSP surveys will be conducted as required only for discoveries during the life of the Project. Popper et al. (2014) have proposed threshold values in terms of both SPL and SEL for received sound from airgun source arrays used during seismic surveys with mortality, potential injury and recoverable injury to fishes ranging from 207 to 213 dB re 1 μPa peak, depending on 'hearing class' of fish. These guidelines are derived from data from impulsive sources with the primary ones being studies involving pile driving (Halvorsen et al. 2011, 2012a, 2012b). Although pile driving sound is also impulsive, it has some characteristics that are different from those associated with seismic airgun sound.

Sound modelling for VSP activities was based on a Dual Delta 1200 cubic inch airgun array (Alavizadeh and Deveau 2020). Modelling results indicate that received levels for SEL range from 218.1 to 217.5 dB re 1 μPa^{2}s (SPL of 220.2 to 220.4 dB re 1 μPa) from the VSP airgun array and would occur approximately 14 m of the sound source in both February and August (Alavizadeh and Deveau 2020). Using the criteria from Popper and Hawkins (2019a in Alavizadeh and Deveau 2020) for fish that use their swim bladder for hearing, mortality can occur up to 63 m in both seasons from an SEL_{24h} of 207 dB re 1 μPa^{2}s. VSP sound levels received by mobile fishes and invertebrates are unlikely to cause mortality or physical injury effects given their capability of moving away from the sound source. As per regulatory guidance and standard practices (refer to Section 9.3.1.2), a ramp-up period for the VSP source will be conducted during onset of the survey. A gradual increase in emitted sound levels is anticipated to provide an opportunity for mobile organisms to move away before potentially injury-inducing sound levels are achieved close to the sound source. VSP sound sources are stationary and the overall duration is low; therefore, mobile fishes and invertebrates are not likely to be subjected to cumulative exposures. However, low-mobility fishes and sessile invertebrates occurring in the immediate area of a VSP source would be exposed numerous times to relatively consistent levels of sound during a VSP survey. A mitigating factor is that while all fishes and invertebrates are able to detect the particle motion component of underwater sound, only some fishes and no invertebrates can detect the pressure component of sound.

Marine planktonic organisms could be affected physically by sound emitted during VSP activities but effects are typically localized to areas adjacent (<5 m) to the sound source (Kostyuchenko 1973; Booman et al. 1996; Østby et al. 2003; Boertmann and Mosbech 2011; Fields et al. 2019). Popper et al. (2014) suggested that potential mortality or physical injury to ichthyoplankton exposed to seismic airgun sound might result from a cumulative SEL >210 dB re 1 μPa^{2}s or peak SPLs >207 dB re 1 μPa. As noted, the received sound level guidelines presented by Popper et al. (2014) are based on experimentation using pile driving as the sound source. Mortality rates from airgun exposure are considered low relative to natural mortality (Saetre and Ona 1996, in Popper et al. 2014) and therefore not likely to have population level effects. A study by McCauley et al. (2017) suggested exposure to the sound emitted by a single airgun (150 cubic inches, SEL of 156 dB re 1 mPa^{2}s at a range of 509 to 658 m) may result in physical injury and even mortality to zooplankton within 1.2 km of the airgun source (Fields et al. 2019). However, a laboratory study with direct observations of seismic effects on *Calanus* copepods have demonstrated much lower spatial scales for mortality and injury effects at comparable exposure levels (SEL 186 dB re 1 mPa^{2}s at a range of 25 m) (Fields et al. 2019). Fields et al. (2019) observed direct mortality of copepods at exposure distances of 5 m from the seismic source, delayed mortality (one week) in copepods at exposure distances of 10 m from the seismic source and no measurable effects at exposure distances >10 m from the seismic source. A modelling study by Richardson et al. (2017) also indicates that even at the spatial scale and extent of seismic effects suggested by McCauley et al. (2017), it is unlikely that significant effects on zooplankton populations would occur.

Survey vessel movement is not expected to result in injury or mortality. The residual environmental effects resulting in increased risk of mortality and physical injury to marine fish and fish habitat exposed to underwater sound emanating from a VSP airgun source is predicted to be adverse, low in magnitude, restricted to the Project Area, short-term in duration, to occur more than once at irregular intervals, and be reversible based on available science.

9.3.1.3.3 Discharges

Exploration drilling programs generate drilling waste that is discharged from the MODU, and liquid wastes that are discharged from the MODU and supply vessels and managed in accordance with MARPOL and OWTG. The primary potential adverse environmental effect to benthic environments associated with exploration drilling is the discharge of drill mud and cuttings. Other potential liquid discharges from offshore vessels and equipment are related to the possible release of oily water from deck drainage and bilge water managed to regulatory discharge limits in the OWTG and MARPOL. Other substances are produced water (if applicable), ballast water and liquid wastes. Adherence of discharge activities to regulatory guidelines and standards are not expected to result in significant adverse effects to the environment (NEB et al. 2010).

Wastes (hazardous and non-hazardous) that cannot be discharged overboard will be stored and transported to shore for disposal at an approved facility (Section 2.8.3). Any biocides used for treatment of seawater for cooling purposes on the MODU will be selected in accordance with the OCSG (NEB et al. 2009). If formation flow testing is required, it may generate low quantities of produced water that may be flared. Relatively larger volumes of produced water may be treated on the MODU for discharge at sea in accordance with the OWTG (NEB et al. 2010). Therefore, produced water is not predicted to have effects on marine fish and fish habitat as it may be flared, treated and disposed in accordance with regulatory guidelines (e.g., OWTG (NEB et al. 2010), or shipped to shore (refer to Section 9.2).

Drilling fluids include WBMs that will be used for the riserless sections of a well and SBMs that are typically used to drill the deeper sections of the well once the riser has been installed. Discharges to the seafloor are primarily WBM cuttings that are associated with drilling of top hole sections. The marine riser connects the MODU to the well and allows for return of SBM cuttings for treatment and eventual disposal overboard. Drill cuttings discharges will result in turbidity and suspended sediment effects in the water column and near the seafloor and a drill mud and cuttings deposition area on the seabed. Larger particles and flocculated material typically settle quickly after discharge, forming a deposition area that is generally localized to the well head (Cordes et al. 2016; Ragnarsson et al. 2017; Gates et al. 2017). Benthic invertebrates that are sessile or have low mobility, are more likely to be subject to burial or suspended sediment effects relative to mobile organisms that can avoid deposition areas. As indicated from laboratory exposure studies, the toxicity and bioaccumulation effects from WBM and SBM cuttings are generally low. However, the physical (e.g., smothering, burial) and indirect effects (i.e., creation of anoxic environments) associated with drill cuttings deposition may affect fish mortality, injury, and health.

SBM cuttings are discharged near the surface in accordance with OWTG with short-term, non-persistent potential effects on the water column from the rapid dilution of drill cuttings (Koh and Teh 2011; IOGP 2016). Koh and Teh (2011) found that modelled suspended solid levels from drill cuttings discharge returned to background levels within hours after the discharge ceased. Increased turbidity levels associated with the drill cuttings discharge have been suggested to decrease light exposure and may have effects on photosynthesis activities in phytoplankton (IOGP 2016). However, the elevated levels of turbidity required for reducing photosynthesis activities were limited to within 25 m of the discharge source (IOGP 2016). Similarly, potential adverse effects from turbidity and suspended solids in the water column may affect respiration and feeding in zooplankton and ichthyoplankton; however, these effects are typically localized to the immediate area surrounding the discharge site (IOGP 2016). Mobile fish and invertebrates have a lower potential for injury as they are usually able to move away from plumes of suspended drill cuttings (IOGP 2016). Considering the localized and temporary nature of effects from suspended drill cuttings in the water column and implication of mitigations, near surface drill cuttings discharges are unlikely to have effects on the pelagic zone or the transfer of organic particulate matter from the pelagic zone to benthic areas. Therefore, these discharges are also unlikely to have population level effects. Suspension feeding benthic invertebrates, including bivalves, sponges, and corals, filter the water column for food and are therefore considered more sensitive to suspended drill cuttings exposure. Some species may have mechanisms for tolerating suspended sediments including reduced respiration and feeding, and sediment clearing (Smith et al. 2006; Smit et al. 2008; Bell et al. 2015). However, sublethal and growth effects may occur from prolonged use of these mechanisms for tolerating suspended sediments (Cranford et al. 1999; Smit et al. 2008; Bell et al. 2015; Ragnarsson et al. 2017). When exposed to suspended sediments of greater than 100 mg/L, *Geodia* sponges reduce their filter feeding to reduce intake of sediment particles (Tjensvoll et al. 2013; Kutti et al. 2015). Drill cutting component exposure studies with this species also showed evidence of adverse cellular effects at continuous and intermittent exposure to barite over 14 days (Edge et al. 2016). However, no health effects were observed on this sponge species with continuous barite exposures up to 10 mg/L or short-term bentonite exposures up to 100 mg/L (Edge et al. 2016). Increased enzyme activity and reduced gonad weight have also been observed in caged scallops and blue mussels placed within 250 m of WBM discharge and exposed to estimated suspended cuttings levels of 0.15 mg/L (Berland et al. 2006, in Bakke et al. 2013). While there are potential effects of suspended drill cuttings on sessile invertebrates, they are generally considered short-term and episodic (Bakke et al. 2013) and are unlikely to have population level effects considering the localized nature of effects.

On the Grand Banks shelf, the EEM programs at the Hibernia, Terra Nova, and White Rose producing oilfields have been ongoing over the past two decades and provide regional information on sediment toxicity related to historic cuttings discharge. Sediments surrounding the developments have shown limited to no evidence of project-related sediment toxicity. Amphipod survival assays were rarely considered toxic proximal to SBM cuttings depositional areas for the Terra Nova development (Whiteway et al. 2014). High survival rates (>90%) for amphipod and juvenile polychaetes in survival assays indicated low toxicity of sediments within 1 km of the Hibernia platform (Hibernia Management and Development Company Ltd. [HMDC] 2021). The White Rose EEM programs have shown >80% survival for amphipod survival assays for most sampling stations and indicate that sediments surrounding the development are predominantly non-toxic (Husky Energy 2022). Sediment sampling stations with amphipod toxicity responses were not associated with Project activities based on assessment of other physical and chemical parameters (Husky Energy 2022). Based on regional data, drill cuttings do not have direct toxicity effects on marine fish and fish habitat.

As part of the Hebron Environmental Characterization report for sediment and water, levels of various metals, hydrocarbons, and substrate types in sediment were measured at varying distances from several exploration wells (EMCP 2016). Distance from each of the seven wellsites ranged from less than 100 to over 10,000 m, with 95 sampling stations overall. None of the sampling stations closest to the wells (<1,000 m) exceeded the background concentration for any analyte (percentage of fines, sand, and gravel, lead, strontium, barium, vanadium, chromium, aluminum, or >C_{10}-C_{21} and >C_{21}-C_{32} hydrocarbons) (EMCP 2016). With the exception of strontium near one exploration well, no analyte was greater than two standard deviations from the background concentration within 1,000 m of any other well. The Hebron 2018 EEM program (EMCP 2021) indicated that there was a slight increase in barium concentration from samples taken in the near-field between 2014 and 2018. Hydrocarbon concentrations were similar between 2014 and 2018. Test wells examined here as part of the Hebron sediment characterization are within the current Project Area for EL 1161. The Terra Nova EEM indicated that barium and C_{10}-C_{21} hydrocarbons contaminated sediments out to 1 to 2 km from drill centres, confirming drill cuttings dispersion modelling conducted for that project. Concentrations increased as drilling progressed and decreased once drilling was reduced (DeBlois et al. 2014).

Drill mud components (e.g., barite, bentonite) and associated metals are not readily bioaccumulated. The trace metals in the barite are in the form of insoluble sulfides and hydroxides, which renders the metals largely unavailable to exposed marine organisms (IOGP 2016). Some invertebrate species with low mobility have been shown to accumulate metals (Ruus et al. 2005; Neff 2010; Edge et al. 2016; IOGP 2016) and reef-building corals have been shown to incorporate barite particles as far away as 600 m from the drill site (Ragnarsson et al. 2017). Several bioaccumulation bioassays using WBM cuttings found that metal concentration in the tissues of exposed animals were similar to those in the tissues of unexposed animals (IOGP 2016). In an assessment of available information on organic and inorganic contaminants associated historic cuttings piles in the North Sea and Gulf of Mexico, Hartley et al. (2003, in Bakke et al. 2013) concluded that there were no likely significant effects on the food chain in terms of bioaccumulation and biomagnification.

Drill muds and cuttings have low toxicity and bioaccumulation effects; however, potential changes in risk of injury, mortality, and health effects on benthic communities may result from burial, sediment alteration, and oxygen depletion from degradation of organic components (Kjeilen-Eilertsen et al. 2004; Smit et al. 2008; Neff 2010; Ellis et al. 2012; Paine et al. 2014; Tait et al. 2016; DFO 2019b). Smothering from drill cuttings may lead to mortality from the weight of discharges or inability to dig through the deposition layer from underneath (Kjeilen-Eilertsen et al. 2004; Trannum 2017). Deposited drill cuttings may also have lower nutrient levels relative to native sediments resulting in effects to health with lower growth rates for species living on the discharged particles (Kjeilen-Eilertsen et al. 2004). Sediment alterations may reduce suitability of habitat for larval survival with changes in particle size, sediment stability, and chemical and physical cues (Kjeilen-Eilertsen et al. 2004). Sediment alterations may also reduce reworking of sediments and bioturbation. The combination of these effects may result in a change in fauna community composition (Kjeilen-Eilertsen et al. 2004; Cordes et al. 2016; IOGP 2016).

Previous work has cited a burial limit of 6.5 mm for predicted no-effect threshold (PNET) based on average burial tolerances from a variety of species (Kjeilen-Eilertsen et al. 2004; Smit et al. 2006; Statoil Canada Ltd. 2017; Nexen 2018). Burial thicknesses at 6.5 mm corresponds to affecting 5% of species along a species sensitivity distribution curve for sedimentation and burial stress (Kjeilen-Eilertsen et al. 2004; Smit et al. 2006, 2008; Trannum et al. 2010). As the PNET was based on average tolerances, Kjeilen-Eilertsen et al. (2004) suggested a more conservative threshold of 1.5 mm for sensitive species; 5 mm less than the 6.5 mm PNET. These values were conservatively described from laboratory mesocosm studies using individual fauna’s tolerance to burial, focused primarily on bivalves (Kjeilen-Eilertsen et al. 2004; Husky

Energy 2019). However, the Grand Banks infauna community is dominated by polychaete species (Kenchington et al. 2001), which are considered to be relatively tolerant to burial compared to bivalve species. Infaunal species including polychaetes have been shown to escape burial depths of greater than 10 cm, whereas epibenthic species including bivalves are typically unable to escape burial depths greater than 1 cm (Trannum et al. 2010).

Trannum et al. (2011) conducted field recolonization experiments with sediments capped with 6 mm and 24 mm of ilmenite-based WBM cuttings at 200 m water depth in Norwegian waters. The field studies indicated no differences in recolonization by benthic fauna at 6 mm relative to controls; however, there was lower oxygen availability at 24 mm relative to controls (Trannum et al. 2011). For sediments capped with 24 mm of drill cuttings, total abundance and fauna composition was lower relative to control sediments, with no effects on total richness (Trannum et al. 2011). Recolonization of sediments was more affected by sediment grain size than drill cuttings exposures (Trannum et al. 2011). Relative to an associated mesocosm study (Trannum et al. 2010), the field study show weaker effects on benthic communities from drill cuttings due to a lack of an abrupt deposition event, lower depletion of oxygen in the field, and recruitment from surrounding areas (Trannum et al. 2011). Bakke et al. (1989, in Bakke et al. 2013) observed similar results in recolonization studies at 10 m water depth where sediments capped for less than two years with 10 mm of WBM cuttings had normal fauna diversity. In field experiments of benthic community responses, recolonization of sediments capped with 10 mm of WBM drill cuttings sediment was not different in overall diversity relative to native sediments after 1 year (Bakke et al. 1986, in Bakke et al. 2013). However, species composition had changed, likely due to the change in particle size from medium sand to very fine sand (Bakke et al. 1986, in Bakke et al. 2013). Additionally, mesocosm experiments may overestimate the effects of drill cuttings due to reduced water flow and other processes present in natural systems. This value is approximate, and variable based on site conditions, community structure, and different life stages present. Non-lethal and other effects can be present at much lower burial levels (Schaanning et al. 2008; Trannum 2017). Therefore, while previously cited PNETs describe initial effects, a recoverable threshold of burial by 10 mm of drill cuttings are considered for this assessment and comparison with drill cuttings modelling (Trannum et al. 2011; Husky Energy 2019).

The zone of influence from drill mud and cuttings discharges have been assessed globally through field monitoring studies of exploration and production drilling programs (Ellis et al. 2012; Gates et al. 2017; Stantec 2017). Ellis et al. (2012) assessed the zone of influence of sediment contamination and biological effects on benthic communities from 72 production and exploration drilling platforms (water depths from 12 m to 565 m). The spatial extents of WBM and SBM cuttings deposition based on barium concentration was approximately 2 to 20 km and 0.2 to 2 km from the discharge source respectively (Ellis et al. 2012). The range of biological effects (i.e., benthic community diversity, structure, and abundance) ranged from 0.1 to 1 km for both WBM and SBM (Ellis et al. 2012). Suncor's EEM program has consistently shown that sediment contamination does not extend beyond the zone of influence predicted in the Terra Nova Development EIS (Suncor 1996). Concentrations of $>C_{10}$-C_{21} hydrocarbons decreased to levels near the laboratory detection limit within approximately 3 km from drill centres and concentrations of barium decreased to background levels within approximately 1 km from drill centres (Suncor 2019).

Functional changes to benthic community structure included a loss of suspension-feeding species and increases in deposit feeders and polychaetes. Gates et al. (2017) provided an overview of six exploration drilling projects (114 to 600 m water depths) in the Northeast Atlantic and off Venezuela associated with the Scientific and Environmental ROV Partnership using Existing Industrial Technology (SERPENT) project. Sediment sampling during post-drilling monitoring indicated a disturbance gradient that decreased with distance from the discharge source. For example, barium concentrations were high at 6,000 mg/kg sediment dry weight at 10 m of the Ragnarokk well in the Northeast Atlantic, decreasing to 150 mg/kg sediment dry weight at 100 m from the well (Gates et al. 2017). Post-drilling monitoring showed benthic effects including reduced faunal abundance ranged from tens to hundreds of metres (Gates et al. 2017). Benthic faunal densities were highly reduced 50 to 75 m from two Australian well sites at 78 m water depth (drill cuttings discharge depth at -23 m) (Jones et al. 2021). Reduced epifauna was also observed between 75 and 200 m from the wellhead. Corals and sponges were still observed in this area, though occasionally with sediment attached (Jones et al. 2021). Underwater visual surveys have been conducted for the Shelburne Basin Venture Exploration Drilling Project off the Scotian Shelf in approximately 2,120 m of water to validate the modelling of drill cuttings discharge (Stantec 2017). Modelling results had indicated the deposition area would be primarily confined to within 100 m of the wellsite with 10 mm deposition thickness areas extending 122 to 155 m from the wellsite depending on seasonal scenario (Stantec 2017). Visual surveys indicated that cumulative drill cuttings deposition areas were observed mainly within 50 m from the wellsite with intermittent observations of drill mud and cuttings up to 200 m from the wellsite (Stantec 2017). The deposition areas extended further than predicted by the dispersion modelling; however, areas of high deposition remained localized to the wellsite with similar spatial extents of other drill cuttings discharge footprints. Spatial extents from drill cuttings discharges are typically limited to hundreds of metres to a kilometre, depending on the volume of cuttings and types of drilling fluids discharged, discharge water depths, oceanographic processes, particle size distribution, and flocculant formation (Cordes et al. 2016; IOGP 2016; Gates et al. 2017). Project-specific modelling was conducted to provide the potential spatial distribution of drill cuttings based on local oceanographic processes (Appendix C) and Project-specific details with the results summarized below.

Drill cuttings and fluids dispersion modelling was performed for the Project across summer and fall seasonal scenarios to assess the spatial extent and thickness of discharged drill cuttings. WBM cuttings (78% of total released mass) are released directly at the seabed and SBM drill cuttings (22% of total released mass) are treated and discharged 5 m below the water surface as described in Section 2.8.1. Modelling parameters, including assumptions and metocean inputs, are provided in Appendix C. Water depth within EL 1161 is approximately 100 m throughout. In the summer scenario, deposition is primarily to the southeast, and for the fall scenario deposition is both north and south, with heavier deposition to the north. Direction of deposition is controlled mainly by the metocean conditions within each seasonal scenario, with summer having calmer and less variable currents. Summer deposition is primarily ovoid in shape and near the wellhead, while fall deposition is more elongate to both the north and south due to stronger currents. In consideration of initial burial effects from drill cuttings, the 6.5 mm PNET is exceeded in the near field (within 0.11 km of the wellhead) in the summer scenario (maximum predicted thickness is 7.28 mm covering a maximum area of 0.003 km^2) but not in the fall. The conservative 1.5 mm PNET is commonly used for sensitive species, and this threshold is exceeded in the summer up to 0.47 km from the wellhead, and in the fall up to 0.55 km from the wellhead. However, as the 10 mm recoverable threshold is not exceeded in any modelled scenario, non-recoverable burial effects on benthic organisms is not predicted within EL 1161. Benthic mortality rates as a result of these discharges are not predicted to result in irreversible changes to local populations due to the negligible to low magnitude and spatial extent of potential effects.

Environmental changes associated with the discharge of drill muds and cuttings are detectable during the earlier phases of drilling within a localized area. These effects typically subside between one to five years, with recovery starting at the edges (Kjeilen-Eilertsen et al. 2004; Ellis et al. 2012; Gates and Jones 2012;

Bakke et al. 2013). The recovery of benthic communities from burial, changes in sediment properties, and organic enrichment occurs by colonization from larval dispersal and immigration from nearby undisturbed sediments (IOGP 2016). Results from the first ten years of EEM at the adjacent Terra Nova field indicate that biological effects from ten years of development drilling are limited and highly localized where they did occur (Neff et al. 2014).

Although it is acknowledged that there are fewer data on effects of drilling waste on corals and sponges, recovery rates for these communities are expected to be longer than for other invertebrates (Henry and Hart 2005; Henry et al. 2017; Ragnarsson et al. 2017; Gates et al. 2017; Liefmann et al. 2018; DFO 2019b, 2021). Physical injury resulting from exposure of abrasive sediments to soft corals have been shown to reduce recovery from sedimentation and burial (Slattery and Bockus 1997; Henry and Hart 2005; Liefmann et al. 2018). Repairs to injured areas are also energetically costly to corals and may result in impairments to growth, reproduction, and predation defence (Henry and Hart 2005). Corals and sponges of lower morphological complexity have been suggested to regenerate less well relative to more morphological complex corals (Henry and Hart 2005). Physical disturbance and the discharge of drilling muds has also been shown to decrease diversity and density of organisms associated with structure-forming, deep-sea sponges at a community level (Vad et al. 2018). Long-term experiments where the *Geodia* sponges were cyclically exposed to suspended crushed rock particles (50 mg/L) resulted in decreased oxygen consumption and metabolism (Kutti et al. 2015). However, this did not affect the energy content of the sponge, suggesting this species has coping mechanisms for turbidity and suspended sediments (Kutti et al. 2015).

Coral and sponge densities within the Project Area are relatively low (refer to Section 6.1.2); therefore, the Project is not predicted to result in population level effects on coral and sponge resources. Furthermore, an imagery-based, pre-drilling seabed survey will be conducted at the proposed wellsite(s) to assess the presence of environmentally sensitive features such as habitat-forming corals and sponges. The survey will be carried out prior to drilling and survey plans will consider the modelling spatial extent of the drill cuttings. If environmental or anthropogenic sensitivities are identified during the survey, Suncor will notify the C-NLOPB to discuss an appropriate course of action. This may involve further investigation and/or shifting the wellsite if it is feasible to do so. This survey will also be used to inform discussions on potential follow-up and monitoring with respect to drill waste discharges.

Quantities of produced water generated during exploration drilling are typically very small relative to production operations (Lee and Neff 2011; Statoil Canada Ltd. 2017; DFO 2019b). Produced water is not predicted to have effects on marine fish and fish habitat as it may be flared, treated and disposed in accordance with regulatory guidelines (e.g., OWTG), or shipped to shore.

The residual project-related environmental effects resulting in increased risk of mortality, injury, and to health to marine fish and fish habitat from discharges is predicted to be adverse, low in magnitude, restricted to the Project Area, short-term, to occur more than once at irregular intervals, and reversible based on available science.

9.3.2 Change in Habitat Availability, Quality, and Use

9.3.2.1 Project Pathways

A change in habitat availability, quality and use for marine fishes and invertebrates may result from the operation and presence of the MODU, geophysical (including VSP), environmental and geotechnical surveys, Project-related discharges, well suspension and abandonment, and supply and servicing operations. The operation of the MODU will result in light and sound emissions into the water column, and sound emissions into the seabed which result in substrate vibration. Use of anchors for the MODU will result in localized disturbance to the seabed. VSP surveys are predicted to temporarily generate high levels of underwater sound in the water column. During supply and servicing operations, underwater sound associated with vessel movement will be generated. Depending on the well suspension and abandonment program, which has yet to be defined (refer to Section 2.4.4), potential removal of the wellhead structure(s) could generate underwater sound, and potential abandonment of the wellhead(s) in place could cause a change in benthic habitat.

9.3.2.2 Mitigation

Project mitigation measures and standard practices that will be employed to reduce potential environmental effects on marine fish and fish habitat are the same as described in Section 9.3.1.2 to reduce the change in risk of mortality or physical injury to marine fish. Additional mitigations specific to reducing change in fish habitat availability, quality and use are described below. The mitigation measures consider environmental effects pathways, standard industry mitigation measures for similar exploration drilling projects, and environmental protection regulations and guidelines for offshore oil and gas activities (IAAC 2021; BP 2018; Nexen 2018).

Well Suspension and Abandonment

- Well decommissioning and suspension or abandonment for this Project will be carried out as per applicable industry practice and in compliance with relevant regulatory requirements. These activities will adhere to the requirements set out under the *Newfoundland Offshore Petroleum Drilling and Production Regulations* (or subsequent amended regulations) along with relevant requirements of the Drilling and Production Guidelines (C-NLOPB and CNSOPB 2017).

9.3.2.3 Characterization of Residual Project-related Environmental Effects

9.3.2.3.1 Presence and Operation of a MODU

The placement of anchors may result in avoidance of the area during initial placement with colonization of the hard structures over Project activities. Anchor placement may result in short-term turbidity and suspended sediment effects; however, these effects are typically localized to tens of metres (Heery et al. 2017) and may be lower due to the surficial substrate composition (gravel and sand). Presence of the anchors on the seafloor will result in localized addition of hard substrate for colonization by invertebrates. Elevated marine fish diversity and abundance has been associated with subsea infrastructure (Macreadie et al. 2011; Cordes et al. 2016; Lacey and Hayes 2019). However, considering the short-term nature of drilling activities and low spatial footprint of anchors, the potential effects on fish habitat are negligible.

Underwater sound emitted during MODU operations may affect the quality of the underwater acoustic environment for marine fishes and invertebrates (Cordes et al. 2016). The principal potential effects would be behavioural with a change in habitat availability from avoidance responses of mobile fishes and invertebrates, albeit in a localized area. Popper et al. (2014) proposed qualitative risk guidelines related to the behavioural effects of exposure to continuous sound on fishes based on distance between the fishes and the sound source based on available data. Quantitative guidelines are difficult to establish due to the lack of quantification of exposure sound levels that elicit behavioural responses to continuous sound (Popper et al. 2014). In general, the behavioural risk to fishes with swim bladders involved in hearing is considered high for individuals near the sound source (tens of metres), and moderate for fishes with no swim bladder or a swim bladder not involved in hearing near the sound source (Popper et al. 2014). Risk of behavioural effects for all three fish groups at intermediate (hundreds of metres) and far (thousands of metres) distances from the sound source range from moderate and low, respectively. The risk of behavioural effects on ichthyoplankton occurring is considered moderate at near and intermediate distances and low for far distances from continuous sound sources (Popper et al. 2014). The overall prediction on behavioural changes to fishes and invertebrates and associated use of fish habitat when exposed to continuous sound is difficult due to the variations in sound source characteristics, inter- and intraspecific differences in sound detection, effects of sound exposure, and available behavioural response information for fishes and invertebrates (Slabbekoorn et al. 2010; Popper et al. 2014; Hawkins et al. 2015; Popper and Hawkins 2018, 2019). Continuous sounds may result in behavioural effects of avoidance, attraction, or startle responses by individual fish (Clark et al. 2016). Motivational states would have effects on behavioural responses as individual fish and invertebrates engaged in reproductive behaviour may not respond to underwater sound while those same individuals may respond to the same sound while migrating. Fishes and invertebrates remaining in the area will likely habituate to the continuous sound and avoidance and startle responses will decrease over time during drilling activities. The source SPLs associated with the MODU used in the acoustic modelling (Alavizadeh and Deveau 2020) ranged from 187.7 to 196.7 dB re 1 μPa rms. Using 150 dB re 1 μPa rms received SPL as a conservative behavioural effect threshold level for fishes (Stadler and Woodbury 2009), modelling results indicate that received levels of 150 dB re 1 μPa rms from the MODU would occur approximately 522 m from the sound source in February and 607 m in August (Alavizadeh and Deveau 2020). Given the localized and temporary nature of the drilling activity, displacement of fish from habitats and population level disturbances are unlikely.

Marine fish and invertebrates may aggregate toward or avoid the illuminated areas and attributed to artificial lights on the MODU, resulting in potential changes in habitat quality and use. Marine fish behaviours (e.g., feeding, schooling, predator avoidance, and migration) may be altered by sharp light contrasts created by over-water structures due to shading during the day and artificial lighting at night (Nightingale and Simenstad 2002; Hanson et al. 2003 in (BP 2018). As with marine fish responses to sound exposure, behavioural responses may vary due to inter- and intraspecific differences in light detection and associated effects, and motivational state (e.g., foraging, reproduction, migration, predator avoidance) (Marchesan et al. 2005; Stoner et al. 2008). As previously described, lighting around the MODU may attract phototactic plankton and may provide increased opportunities for predation by fish and other species (Keenan et al. 2007; Cordes et al. 2016). Lighting has been detected at greater than 100 m from the active oil production platforms in the Gulf of Mexico and mainly near the surface (0.75 m water depth) (Keenan et al. 2007). Depending on the site and structures, light levels of studied platforms decreased to background levels within the sampling area (250 m from source) below 5 and 10 m water depths (Keenan et al. 2007). Species that undergo diel vertical migrations may avoid the illuminated area at night, resulting in weak diel periodicity within 100 m of the offshore structure (Simonsen 2013; Barker 2016). Potential effects of artificial lighting from the MODU are generally localized to hundreds of metres to less than 1.5 km from the light source (Keenan et al. 2007; Simonsen 2013; Foss 2016).

Aquatic invasive species may compete with local species for resources (e.g., colonizing habitat) and may result in a change to fish habitat availability and quality. The MODU and vessels may act as a vector for transmission of aquatic invasive species through attachment to the hulls or through discharge of ballast water. Furthermore, these offshore structures may provide “stepping-stone” habitat that enables colonizing invertebrates to spread to areas not typically within their range (Cordes et al. 2016). However, the potential for spread of invasive species is low with the application of standard mitigations (e.g., ballast water regulations for prevention and mitigation of spread of invasive species).

Drilling could occur at any time of the year and the sound and light generated would be continuous during the drilling of each well (approximately 120 days per well). The residual environmental effects from the presence and operation of a MODU resulting in increased risk of behavioural effects on marine fish and fish habitat are predicted to be adverse, low in magnitude, restricted to the Project Area, medium-term in duration, to occur more than once at irregular intervals, and reversible based on available science.

9.3.2.3.2 Geophysical (including VSP), Environmental and Geotechnical Surveys

Guidelines for received sound level thresholds that cause behavioural effects in fishes are limited. Popper et al. (2014) proposed qualitative risk guidelines related to the behavioural effects of exposure to seismic airgun sound on fishes based on distance between the fishes and the sound source. While fish exhibit behavioural responses when exposed to seismic airgun sound, Popper et al. (2014) indicate that there is currently insufficient data to develop quantitative guidelines. For fishes with swim bladders involved in hearing, the risk for behavioural effects is considered high for fishes at near to intermediate distances from the sound source, and moderate for those fishes occurring far from the sound source (Popper et al. 2014). For the other two fish groups (e.g., no swim bladder, and with a swim bladder not involved in hearing), the risks for individuals occurring at all three qualitative distances from the seismic airgun source are high, moderate and low, respectively. Popper et al. (2014) also indicated that the risk of behavioural effects on ichthyoplankton decreases with distance from moderate at near distances to low at intermediate and far distances from a seismic source.

Localized and temporary avoidance by a variety of fish species including salmonids, herring, and flatfish have resulted from exposure to impulsive underwater sounds, such as those generated during VSP (Feist et al. 1996; McCauley et al. 2000a, 2000b, in BP 2018). Other observed behavioural responses include a short duration “startle” response (flexion of body followed by a burst of faster swimming), and an “alarm” response with intense variable movements (Schwarz and Greer 1984; Feist et al. 1996; McCauley et al. 2000a, 2000b, in BP 2018).

The data on potential behavioural effects of exposure to seismic airgun sound on invertebrates is limited. Field studies on the Grand Banks with seismic sound from a 2D seismic array did not result in changes to catch rates of snow crab over days or weeks (Morris et al. 2018 2019). As indicated earlier, all invertebrates, as well as fishes, are sensitive to the particle motion component of sound. However, potential effects from particle motion are thought to be of little consequence near the sound source (Morris et al. 2018, 2019). No invertebrates and some fishes are sensitive to the sound pressure component (Nedelec et al. 2016; Hawkins and Popper 2016). Inclusion of measurement of particle motion in studies is only now becoming more common.

The United States National Marine Fish Service uses a threshold of 150 dB re 1 μPa for behavioural response (Stadler and Woodbury 2009), although Popper et al. (2014) indicate it is unclear if this is a peak or rms level. Sound modelling for VSP activities was based on a Dual Delta 1,200 cubic inch airgun array (Alavizadeh and Deveau 2020). Using 150 dB re 1 μPa rms received SPL as a conservative behavioural effect threshold level for fishes as was done for continuous sound above, modelling results indicate that received levels of 150 dB re 1 μPa rms from the VSP seismic airgun sound source could occur as far as 19.2 km from the sound source in February, and 16.6 km in August (Alavizadeh and Deveau 2020). Given the short-term nature of VSP activities (one day or less), it is unlikely that exposure to VSP sound will result in long-term behavioural responses. Fishes have habituated to similar received levels that far reaching behavioural effects on fishes are not anticipated.

The received sound pressure levels from VSP activities are predicted to have effects on marine fish and fish habitat with a short-term change in habitat quality and use. While mobile fishes could exhibit a variety of behavioural responses when exposed to sound from the VSP sound source, this seismic airgun source will have a lower source SPL than airgun arrays used during full mobile 2D and 3D seismic surveys and is much shorter in duration than mobile seismic surveys.

The residual environmental effects resulting in increased risk of behavioural effects on marine fish and fish habitat exposed to underwater sound produced by a VSP airgun source is predicted to be adverse, low in magnitude, restricted to the Project Area, short-term in duration, to occur more than once at irregular intervals, and reversible based on available science.

Geotechnical surveys may involve collecting seabed samples. They are typically limited to the MODU and anchor locations (if used), which are restricted to EL 1161. There are no significant benthic areas (SBAs) in EL 1161. The majority of the environmental surveys activities will have no physical contact with the seabed; therefore, there will be no direct interaction with or disturbance to benthic animals or their habitats. Survey vessel movement is not expected to result in a change in habitat availability or use.

9.3.2.3.3 Discharges

The discharge of drill mud and cuttings are predicted to result in changes in habitat availability and quality from physical and chemical changes to the water column and sediments. Drilling mud and cuttings discharges are the primary discharges expected to have effects on marine fish and fish habitat. As described in Section 9.3.1.3.3, drilling mud and cuttings discharges may result in a temporary increase in suspended particulate matter and turbidity in the water column. Potential effects to the water column can range from minutes to days, and will return to background levels within hours after cessation of discharges (Smit et al. 2006; Koh and Teh 2011; IOGP 2016). The potential effects in the water column are generally considered non-persistent and temporary with the rapid dilution and dispersal of drill cuttings.

Changes to habitat quality and availability from the deposition of drilling discharge may result from sediment alteration and degradation of organic components that lead to oxygen depletion (Kjeilen-Eilertsen et al. 2004; Smit et al. 2006, 2008; Neff 2010; Ellis et al. 2012; Paine et al. 2014; Tait et al. 2016; DFO 2019b). Macrofauna may be initially affected by these physical and indirect effects, with recovery to the area occurring quickly after degradation of drill cuttings components (Tait et al. 2016). Drill mud and cuttings discharges will be managed in accordance with the OWTG (NEB et al. 2010). Drill cuttings on the sediment may persist for months to years depending on local oceanographic processes that are involved in the redistribution of deposited cuttings (Kjeilen-Eilertsen et al. 2004; Gates et al. 2017). However, effects may subside between one to five years with recovery starting at the edges (Neff et al. 2000; Kjeilen-Eilertsen et al. 2004; Bakke et al. 2013; Tait et al. 2016; Gates et al. 2017).

Drilling mud and cuttings discharges may have effects on habitat-forming corals and sponges as described in Section 9.3.1.3.3 and therefore result in changes to habitat availability (Allers et al. 2013; Cordes et al. 2016; DFO 2019b). Coral and sponge densities within the Project Area are relatively low (refer to Section 6.1.2) and EL 1161 does not overlap with SBAs for corals and sponges (there are two small SBAs in the Project Area west of EL 1161, one identified for large gorgonian corals and one for small gorgonian corals). Effects to biogenic habitat are therefore expected to be limited. Furthermore, an imagery-based, pre-drilling seabed survey will be conducted at the proposed wellsite(s) to assess the presence of environmentally sensitive features such as habitat-forming corals and sponges.

These discharges will be managed in accordance with the OWTG and associated standards and guidelines and are not expected to result in significant adverse effects to the environment (NEB et al. 2010). Discharges are expected to be temporary, non-bioaccumulating, nontoxic, and highly diluted. If residual hydrocarbons are present in discharges, such as deck drainage and bilge water, they will be in low volumes and concentrations and not exceed limits stated in the OWTG and MARPOL.

The residual environmental effects resulting in changes to habitat availability, quality, and use for marine fish is predicted to be adverse, low in magnitude, restricted to the Project Area, medium in duration, occur more than once at irregular intervals, and reversible based on available science.

9.3.2.3.4 Well Suspension and Abandonment

Well suspension and abandonment activities are predicted to result in a temporary, localized disturbance that may result in avoidance of the area and change in habitat availability for the duration of the activity. Well suspension and abandonment for this Project will be carried out as per the *Newfoundland Offshore Petroleum Drilling and Production Regulations*, along with relevant requirements of the Drilling and Production Guidelines (C-NLOPB and CNSOPB 2017). If the wellhead is left in place during well suspension and abandonment it will provide hard substrate for colonization by benthic communities (Cordes et al. 2016; Lacey and Hayes 2019). Due to the small spatial extent of the wellhead infrastructure, these permanent effects would be low in magnitude with a localized nature of potential positive effects.

The residual environmental effects with well suspension and abandonment resulting in changes to habitat availability for marine fish are predicted to be negligible to adverse, low in magnitude, restricted to the Project Area and occur more than once at irregular intervals and reversible. Depending on the decommissioning strategy, potential effects may be short-term to permanent in duration. Residual environmental effects associated with removal of well head infrastructure (if applicable), including underwater sound and light emissions, would be short-term in duration.

9.3.2.3.5 Supply and Servicing Operations

Supply and servicing operations are expected to increase vessel traffic within the Project Area for the duration of Project activities. There may be localized, transient effects to fish habitat quality and use around the supply vessel traffic route due to increased vessel sound. The potential effects of continuous sounds on the marine environment are described in Section 9.3.1.3.1. The sound source generated by supply vessels will be irregular throughout the life of the Project, and the source levels associated with supply vessel operation for the Project are estimated to be 178 dB re 1 µPa m (Alavizadeh and Deveau 2020). Behavioural responses to vessels may vary due to inter- and intraspecific differences in light detection and associated effects, and motivational state (e.g., foraging, reproduction, migration, predator avoidance) (Marchesan et al. 2005; Stoner et al. 2008; de Robertis and Handegard 2013). Mobile fishes would potentially respond to lower received levels and move away from the vessel sound source. This would limit the potential for temporary injury to individual fish and subsequently adverse effect on fish populations. Changes to habitat availability, quality and use from supply vessel traffic is predicted to represent a small increment over similar effects from existing levels of marine traffic in the RAA.

Vessel discharges will be managed in accordance with MARPOL and are not expected to result in significant residual effects to the environment (NEB et al. 2010). Discharges are expected to be temporary, non-bioaccumulating, non-toxic, and highly diluted.

The residual environmental effects associated with supply and servicing operations on a change in habitat availability, quality and use for marine fish is predicted to be adverse, low in magnitude, occur within the Project Area, medium-term in duration, occur more than once at irregular intervals, and be reversible.

9.3.3 Species at Risk: Overview of Potential Effects and Key Mitigation

There are 23 species of fish listed as species at risk or otherwise of conservation concern with the potential to occur within the Project Area. This includes species listed under SARA, COSEWIC, and the NL ESA (Table 9.4). Four of these species are formally protected at the federal level on Schedule 1 under SARA and are further assessed: white shark, spotted wolffish, northern wolffish, and Atlantic wolffish. Details on the life history, spawning, feeding, and presence of these species in the RAA are provided in Sections 6.1.3.4.3.4 (northern wolffish), 6.1.3.4.3.4 (Atlantic wolffish), 6.1.3.5.1 (spotted wolffish), and 6.1.3.5.2 (white shark). American eel and Atlantic salmon as both species at risk and of Indigenous concern, are further described in Sections 6.1.3.6.1 and 6.1.3.6.2, respectively. Other SAR key species, such as common lumpfish, American plaice and thorny skate, are described in Section 6.1.3.4. Table 9.4 gives a summary of species presence and potential interactions for all species at risk.

Northern, spotted, and Atlantic wolffish are demersal species that potentially occur within the Project Area. As all three species are on Schedule 1 under SARA, a proposed recovery strategy for northern wolffish and spotted wolffish (both Endangered) and a management plan for the Atlantic wolffish (Special Concern) have been prepared to promote recovery of population levels (DFO 2020). Critical habitat has been identified for northern and spotted wolffish along the Northeast Newfoundland Shelf and Slope, to the north of the Project Area (DFO 2020). No overlap exists between the identified critical habitat and the Project Area (see Section 6.1.3.5.1). It is unlikely that wolffish would be affected by MODU-associated sound or geophysical (including VSP), environmental and geotechnical surveys, and wolffish also do not have swim bladders and are therefore only potentially susceptible to the particle motion component of seismic airgun sound. Different Project activities could potentially interact with wolffish at various life stages as eggs and adults are benthic, and larvae are pelagic, and a change in risk of mortality or physical injury or a change in habitat quality and use could result. However, with the use of mitigation described above (Sections 9.3.1.2 and 9.3.2.2), and the low spatial and temporal nature of effects, interactions with wolffish species in the Project Area would be localized and short-term. DFO (2020) indicates that while oil and gas exploration and production may have potential effects on wolffish from discharges, it would be highly localized and minor at the population level.

Table 9.4 Marine Fish Species at Risk or of Conservation Concern with Potential to Occur in the Project Area

Species		Status/Designation[1,2]			Relevant Population (Where Applicable)	Summary of Presence	Potential Interactions
Common Name	Scientific Name	NL ESA	SARA	COSEWIC			
Acadian redfish	*Sebastes fasciatus*			T	Atlantic (COSEWIC)	Likely to be present year-round in Project Area Larvae, juveniles, and adults all likely to be present	Potential interactions include larvae (pelagic) and juveniles / adults (demersal / pelagic) Potential exists for project effects, but reduced by Project mitigation measures and species mobility
American eel	*Anguilla rostrata*	V		T		Migratory / transient in Project Area Migrating juveniles and adults likely to be present	Potential life stage interactions include larvae (pelagic) and juveniles / adults (pelagic) Limited potential for Project interactions (mobile species, Project mitigation measures, no critical habitat)
American plaice	*Hippoglossoides platessoides*			T	Newfoundland and Labrador (COSEWIC)	Likely present in the Project Area year-round Eggs, larvae, juveniles, and adults all potentially present throughout the year	Potential life stage interactions include eggs (pelagic), larvae (pelagic), and juveniles / adults (demersal) Potential exists for Project effects, but reduced by Project mitigation measures and species mobility
Atlantic bluefin tuna	*Thunnus thynnus*			E		Migratory / transient in Project Area Only juveniles or adults likely to be present (spawning occurs in southern waters)	Potential interactions include juveniles / adults (pelagic) Limited potential for Project interactions (mobile species, Project mitigation measures)
Atlantic cod	*Gadus morhua*			E	Newfoundland and Labrador (COSEWIC)	Potentially present in the Project Area year-round May spawn in or near the Project Area, eggs, larvae, juveniles, and adults may be present	Potential life stage interactions include eggs (pelagic), larvae (pelagic), and juveniles / adults (demersal) Potential exists for Project effects, but reduced by Project mitigation measures and species mobility
Atlantic wolffish	*Anarhichas lupus*		SC	SC		Potentially present in the Project Area year-round Only juveniles and adults likely to be present	Potential interactions include juveniles / adults (demersal) Limited potential for Project interactions (mobile species, Project mitigation measures, no critical habitat)

Table 9.4 Marine Fish Species at Risk or of Conservation Concern with Potential to Occur in the Project Area

Species		Status/Designation[1,2]			Relevant Population (Where Applicable)	Summary of Presence	Potential Interactions
Common Name	Scientific Name	NL ESA	SARA	COSEWIC			
Atlantic salmon	*Salmo salar*			T	South Newfoundland	Migratory / transient in Project Area Only juveniles or adults likely to be present as they migrate through	Potential interactions include juveniles / adults (demersal) Limited potential for interaction (mobile species, Project mitigation measures, no critical habitat)
				SC	Quebec Eastern North Shore		
				SC	Quebec Western North Shore		
				E	Anticosti Island		
				SC	Inner St. Lawrence		
				SC	Gaspe-Southern Gulf of St. Lawrence		
				E	Eastern Cape Breton		
				E	Nova Scotia Southern Upland		
				E	Outer Bay of Fundy Population		
Basking shark	*Cetorhinus maximus*			SC	Atlantic (COSEWIC)	Migratory / transient in Project Area Only juveniles and adults likely to be present	Potential interactions include juveniles / adults (pelagic) Limited potential for interaction (mobile species, Project mitigation measures, no critical habitat)
Blue shark	*Prionace glauca*			NR	Atlantic (COSEWIC)	Migratory / transient in Project Area Only juveniles and adults likely to be present	Potential interactions include juveniles / adults (pelagic) Limited potential for Project interactions (mobile species, Project mitigation measures)
Common lumpfish	*Cyclopterus lumpus*			T	Atlantic (COSEWIC)	Potentially present in the Project Area year-round Only juveniles and adults likely to be present	Potential interactions include juveniles / adults (demersal) Limited potential for Project interactions (mobile species, Project mitigation measures)

Table 9.4 Marine Fish Species at Risk or of Conservation Concern with Potential to Occur in the Project Area

Species		Status/Designation[1,2]			Relevant Population (Where Applicable)	Summary of Presence	Potential Interactions
Common Name	**Scientific Name**	**NL ESA**	**SARA**	**COSEWIC**			
Cusk	*Brosme brosme*			E		Unlikely to be present in the Project Area Only juveniles and adults potentially present	Potential interactions include juveniles / adults (demersal) Limited potential for Project interactions (mobile species, Project mitigation measures)
Deepwater redfish	*Sebastes mentella*			T	Northern (COSEWIC)	Likely to be present year-round in Project Area Larvae, juveniles, and adults all likely to be present	Potential interactions include larvae (pelagic) and juveniles / adults (demersal / pelagic) Potential exists for Project effects, but reduced by Project mitigation measures and species mobility
Northern wolffish	*Anarhichas denticulatus*		T	T		Likely present within Project Area year-round Eggs, larvae, juveniles, and adults all potentially present Identified critical habitat exists to the north of the Project Area but does not overlap	Potential life stage interactions include eggs (demersal), larvae (pelagic), and juveniles / adults (demersal) Potential exists for Project effects, but reduced by Project mitigation measures and species mobility
Porbeagle	*Lamna nasus*			E		Migratory / transient species Only juveniles and adults potentially present	Potential interactions include juveniles / adults (pelagic) Limited potential for Project interactions (mobile species, Project mitigation measures)
Roundnose grenadier	*Coryphaenoides rupestris*			E	Atlantic and Arctic (COSEWIC)	Unlikely to be present in the Project Area Eggs, larvae, juveniles, and adults potentially present	Potential life stage interactions include eggs (pelagic), larvae (pelagic), and juveniles / adults (demersal) Potential exists for Project effects, but reduced by Project mitigation measures and species mobility
Shortfin mako	*Isurus oxyrinchus*			E	Atlantic (COSEWIC)	Migratory / transient species Only juveniles and adults potentially present	Potential interactions include juveniles / adults (pelagic) Limited potential for Project interactions (mobile species, Project mitigation measures)
Smooth skate	*Malacoraja senta*			E	Funk Island Deep (COSEWIC)	Unlikely to be present in Project Area Eggs, larvae, juveniles, and adults potentially present	Potential life stage interactions include eggs (demersal), larvae (demersal), and juveniles / adults (demersal) Limited potential for Project interactions (mobile species, Project mitigation measures, no critical habitat)

Table 9.4 Marine Fish Species at Risk or of Conservation Concern with Potential to Occur in the Project Area

Species		Status/Designation[1,2]			Relevant Population (Where Applicable)	Summary of Presence	Potential Interactions
Common Name	Scientific Name	NL ESA	SARA	COSEWIC			
Spiny dogfish	*Squalus acanthias*			SC	Atlantic (COSEWIC)	Unlikely to be present in Project Area Only juveniles and adults potentially present	Potential interactions include juveniles / adults (demersal) Limited potential for Project interactions (mobile species, Project mitigation measures)
Spotted wolffish	*Anarhichas minor*		T	T		Unlikely to be present in the Project Area Eggs, larvae, juveniles, and adults all potentially present Identified critical habitat exists to the north of the Project Area but does not overlap	Potential life stage interactions include eggs (demersal), larvae (pelagic), and juveniles / adults (demersal) Potential exists for Project effects, but reduced by Project mitigation measures and species mobility
Thorny skate	*Amblyraja radiata*			SC	Canada (COSEWIC)	Likely present in Project Area year-round Eggs, larvae, juveniles, and adults all potentially present	Potential life stage interactions include eggs (demersal), larvae (demersal), and juveniles / adults (demersal) Potential exists for Project effects, but reduced by Project mitigation measures and species mobility
White hake	*Urophycis tenuis*			T	Atlantic and Northern Gulf of St. Lawrence (COSEWIC)	Unlikely to be present in Project Area Eggs, larvae, juveniles, and adults all potentially present	Potential life stage interactions include eggs (pelagic), larvae (pelagic), and juveniles / adults (demersal) Limited potential for Project interactions (mobile species, Project mitigation measures)
White shark	*Carcharodon carcharias*		E	E	Atlantic (COSEWIC/SARA)	Migratory / transient species Only juveniles and adults potentially present Though listed on Schedule 1 of SARA, no critical habitat is established in Canada	Potential life stage interactions include juveniles / adults (pelagic) Limited potential for Project interactions (mobile species, Project mitigation measures)
Winter skate	*Leucoraja ocellata*			E	Eastern Scotian Shelf – Newfoundland (COSEWIC)	Unlikely to be present in Project Area Eggs, larvae, juveniles, and adults all potentially present	Potential life stage interactions include eggs (demersal), larvae (demersal), and juveniles / adults (demersal) Limited potential for Project interactions (mobile species, Project mitigation measures)

[1] Least Concern (LC), Vulnerable (V), Near Threatened (NT), Special Concern (SC), Threatened (T), Endangered (E), Critically Endangered (CE)
[2] Multiple designations refer to multiple populations or sub-populations.
Data Sources: SARA / COSEWIC (www.sararegistry.gc.ca), NL ESA (https://www.flr.gov.nl.ca/wildlife/endangeredspecies/index.html).

White sharks are large pelagic predators that may migrate through the Project Area. As shown in Section 6.1.3.5.2, Ocearch has tracked individual named sharks into the Project Area (Ocearch 2019). As apex predators, white sharks are vulnerable to bioaccumulation of contaminants through their position in the food web (Marsili et al. 2016, COSEWIC 2021) and contaminants may be transferred to offspring through maternal offloading (Lyons et al. 2013). Marsili et al. (2016) found relatively high levels of polycyclic aromatic hydrocarbons (PAHs) in white sharks relative to other top marine predators off South Africa where there are frequent oil shipping routes. White shark muscle and liver tissue were also found to have higher levels of polychlorinated biphenyls (PCBs) and chlorinated hydrocarbon pesticides relative to other fishes in the Bay of Fundy-Gulf of Maine area (Zitko et al. 1972, COSEWIC 2021). Health effects of toxins has not been well studied in sharks and accumulation of contaminants may have hormone-disrupting effects (Marsili et al. 2016). No negative health effects were observed in white sharks off South Africa with high arsenic and mercury concentrations that would be toxic to other fish, suggesting they may have natural protective mechanisms (Merly et al. 2019). As this species is highly mobile, with widely available prey, and with no critical habitat identified in the Project Area or RAA, white sharks are unlikely to be adversely affected by the Project with the implementation of mitigation measures identified in Sections 9.3.1.2 and 9.3.2.2.

Additional details on other SAR that may occur in the Project Area and RAA, including their timing of presence in the region, have been previously described in Section 6.1.3. As with the SAR species described above, the SOCC listed in Table 9.4 may also interact with Project activities based on occupation of various habitats at different life history stages. The same planned mitigation measures will be used to avoid or reduce potential adverse interactions on SOCC. Additional details on swordfish, bluefin tuna, Atlantic salmon and American eel are provided in Section 13.3.4 (Indigenous Peoples VC).

9.3.4 Summary of Project Residual Environmental Effects

Project activities associated with exploration drilling have the potential to adversely affect marine fish and fish habitat. The overall summary of Project residual environmental effects on marine fish and fish habitat is presented in Table 9.5. Implementation of mitigation measures and adherence to industry standards are inherently considered as part of the environmental effects assessment and prediction of residual effects.

Table 9.5 Summary of Residual Environmental Effects on Marine Fish and Fish Habitat, including Species at Risk

Residual Effect	Residual Environmental Effects Characterization						
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Change in Risk of Mortality, Injury or Health							
Presence and Operation of a MODU	A	L	PA	MT	IR	R	D
Geophysical (including VSP) Surveys	A	L	PA	ST	IR	R	D
Geological, Environmental and Geotechnical Surveys	A	L	PA	ST	IR	R	D
Discharges	A	L	PA	ST	IR	R	D

Table 9.5 Summary of Residual Environmental Effects on Marine Fish and Fish Habitat, including Species at Risk

Residual Effect	Residual Environmental Effects Characterization						
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Well Testing and Flaring	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Well Decommissioning, Suspension and Abandonment	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Supply and Servicing	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Change in Habitat Availability, Quality, and Use							
Presence and Operation of a MODU	A	L	PA	MT	IR	R	D
Geophysical (including VSP) Surveys	A	L	PA	ST	IR	R	D
Geological, Environmental and Geotechnical Surveys	A	L	PA	ST	IR	R	D
Discharges	A	M	PA	MT	IR	R	D
Well Testing and Flaring	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Well Decommissioning, Suspension and Abandonment	N-A	L	PA	ST-P	IR	R	D
Supply and Servicing	A	L	PA	ST-MT	IR	R	D

KEY: See Table 9.2 for detailed definitions N/A: Not Applicable Direction: P: Positive A: Adverse N: Neutral Magnitude: N: Negligible L: Low M: Moderate H: High	Geographic Extent: PA: Project Area RAA: Regional Assessment Area Duration: ST: Short-term MT: Medium-term LT: Long-term P: Permanent	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

Project activities are mainly adverse to marine fish and fish habitat but of low magnitude and generally localized to the Project Area. Effects on fish habitat from the presence and operation of the MODU are considered medium-term as various sound and light emissions and discharges occur irregularly over the life of the Project. Predicted spatial extent of effects from supply and servicing and geophysical (including VSP), environmental and geotechnical surveys activities range from the Project Area and the vessel transit route, due to the transit route to supply bases and spatial extents of sound effects. Predicted duration of effects are variable across Project activities, ranging from short-term geophysical (including VSP), environmental and geotechnical surveys activities to long-term for effects from drilling discharges. Drill cuttings discharge is anticipated to be of moderate magnitude considering the burial and sediment alteration effects of the deposition area. As recovery times for sensitive benthic species (e.g., corals and sponges) may take years, the duration of discharge effects is considered long-term. However, the localized geographic extent of drilling discharges and low distribution of corals and sponges within the Project Area reduces the overall potential effects on these species and associated biogenic habitat. It is predicted that recovery to baseline conditions would be long-term for drill cuttings discharge. Effects on habitat availability, quality and use associated with well suspension and abandonment may be permanent if the wellhead is left in place intact on the seafloor. With this exception, potential Project effects are predicted to be reversible with eventual recovery to baseline conditions after Project completion.

9.4 Determination of Significance

With implementation of mitigation and environmental protection measures, the residual environmental effects on marine fish and fish habitat are predicted to be not significant. Project activities are predicted to result in adverse environmental effects from exploration drilling emissions and discharges through changes in risk of mortality, injury or health and changes in habitat availability, quality, and use. However, predicted effects on marine fish and fish habitat are generally spatially or temporally limited due to the low magnitude or short-term nature of predicted effects. The resulting number of individuals or amount of habitat potentially affected by Project activities is not predicted to result in population-level effects on marine fish. The Project will not result in a detectable decline in overall abundance or changes to the spatial and temporal distributions of fish and invertebrate populations in the Project Area or RAA. Similarly, potential interactions between species of conservation concern and Project activities is limited through the implementation of mitigation and environmental protection measures. Routine Project activities also do not overlap with proposed critical habitats for northern and spotted wolffish. Project activities are not predicted to have implications on the overall abundance, distribution, or health of marine fish SAR or their eventual recovery. Potential for further effects on other ecological and socio-economic VCs through food web linkages and fisheries effects is limited as potential for population-level effects is low and changes to fish habitat are spatially limited.

Residual environmental effects on marine fish and fish habitat from Project activities are predicted to be not significant. This determination has been made with consideration of available scientific knowledge regarding predicted effects from exploration drilling activities, effectiveness of mitigation measures, and the existing environment within the spatial boundaries.

9.5 Prediction Confidence

The environmental assessment considers available scientific information from field and laboratory studies of the effects of exploration drilling activities on marine fish and fish habitat. This includes information from the Newfoundland and Labrador offshore region and information from monitoring of global oil and gas operations. As marine fish and invertebrates within the Project Area and RAA includes a diverse group of species with inter- and intraspecific responses to Project emissions and discharges, there is some uncertainty regarding species-specific responses to Project activities in this region. There is a general lack of information on behavioural effects from continuous and impulsive sounds and effects of particle displacement on marine fish and invertebrates. There is also uncertainty regarding sound and burial thresholds for effects and estimated recovery. Therefore, the determination of predicted effects is made with a moderate level of confidence. Project-specific modelling for sound and drilling mud and cuttings discharges was conducted by Suncor to address uncertainty in the effects from Project activities. While there are areas of uncertainty, the level of available information is sufficient for assessment of effects of the Project.

9.6 Follow-up and Monitoring

Suncor will conduct a pre-drilling visual seabed survey at proposed drilling locations to confirm the presence / absence of sensitive biological communities (e.g., corals and sponges). The visual surveys will also be used to confirm the absence of shipwrecks, debris on the seafloor, and unexploded ordnance. If any environmental sensitivities are identified during the survey, Suncor will notify the C-NLOPB to discuss an appropriate course of action. This may involve further investigation and/or moving the wellsite if feasible. If sensitive environmental features are found during the pre-drill survey, a follow-up program will be determined in consultation with the C-NLOPB and DFO. Results will be posted on the internet and indigenous groups informed of the posting.

9.7 Summary of Commitments

Presence and Operation of a MODU

The presence and operation of a MODU will be planned and conducted in consideration of relevant regulations and guidance including C-NLOPB guidance for drilling activities where cold-water corals may be present, and Canada's *Ballast Water Regulations* as detailed below.

- An imagery-based, pre-drilling seabed survey will be conducted at the proposed wellsite(s) to assess the presence of shipwrecks, seafloor debris, unexploded ordinances and any aggregations of habitat-forming corals or sponges or any other environmentally sensitive features. If any aggregations of habitat-forming corals or sponges (or any other environmentally sensitive features) are identified, Suncor will change the location of the anchor(s) or well on the seafloor or redirect drill cuttings discharges to avoid affecting the aggregations of habitat-forming corals or sponges or other environmentally sensitive features (unless not technically feasible), as determined in consultation with the C-NLOPB.
- Artificial lighting will be reduced where possible with consideration of safety and associated operational requirements. Lighting reductions may include avoiding use of unnecessary lighting, shading, and directing lights towards the deck.
- To reduce the potential spread of invasive species, ballast water will be managed in consideration of applicable Canadian and international ballast water management requirements (e.g., *Canada's Ballast Water Regulations*).

Geophysical (including VSP), Environmental and Geotechnical Surveys

VSP activities will be planned and conducted in consideration of relevant regulations and guidance including the SOCP (DFO 2007) and C-NLOPB Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2019) as detailed below.

- VSP activities will be planned to avoid dispersing aggregations of fish from known spawning areas and diverting fish from known migration corridors as detailed in Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2019).

- Prior to VSP activities, a ramp-up procedure will be implemented where seismic source elements are gradually increased over a period of approximately 30 minutes until the operating level is achieved. This measure, as outlined in the SOCP and C-NLOPB (2019) guideline, is intended to reduce potential change in risk of injury to marine animals (including fishes and invertebrates) in close proximity to the sound source at the start of the activity. Gradual increase in emitted sound levels are anticipated to provide an opportunity for mobile organisms to move away before potentially injury inducing sound levels are achieved close to the sound source.

Discharges

Project activity discharges will be planned and conducted in consideration of relevant regulations and guidance including the OCSG (NEB et al. 2009), OWTG (NEB et al. 2010), MARPOL, and *Transportation of Dangerous Goods Act* as detailed below.

- The selection and screening of chemicals to be discharged (e.g., drilling fluids) will be in accordance with the OCSG (NEB et al. 2009). Lower toxicity drilling muds will be used where technically feasible. Drilling mud and cement components will be selected for biodegradable and environmentally friendly properties. Chemical components rated as being least hazardous under the OCNS and Pose Little or No Risk (PLONAR) to the Environment by the Convention for the Protection of the Marine Environment of the North-East Atlantic (refer to Section 2.9.3 for more information on chemical selection) will be used where feasible.
- Operational discharges will be treated before release in accordance with OWTG (NEB et al. 2010) and MARPOL. Waste discharges will be transferred to shore for disposal if they do not meet regulatory guidelines for discharge at sea. Furthermore, a Project-specific EPP, and WMP will be developed to prevent unauthorized waste discharges (refer to Section 2.10 for details on waste discharges and management).
- As described in Section 2.8.1, SBM drill cuttings will be returned to the MODU and treated before being discharged into the marine environment. SBM concentration on cuttings will be monitored onboard the MODU to ensure concentrations are below OWTG threshold for at-sea discharge. In accordance with OWTG, no excess or spent SBM will be discharged, and excess or spent SBM that cannot be reused will be brought back to shore for disposal. In accordance with OWTG, WBM drill cuttings will be discharged at sea without treatment.
- Food waste generated offshore on the MODU and supply vessels, will be disposed according to OWTG and MARPOL requirements. Maceration of food waste will be conducted in accordance with MARPOL and OWTG and there will be no discharge of macerated food waste within 3 nautical miles from land.
- The transfer of hazardous wastes will be conducted in accordance with the *Transportation of Dangerous Goods Act*, and any applicable approvals for the transportation, handling, and temporary storage of hazardous waste will be obtained, as required.
- Post-drilling visual surveys will be conducted of the seafloor after drilling activities to assess the visual extent of sediment dispersion and validate the modelling for the discharges of drill mud and cuttings.

Well Decommissioning, Suspension and Abandonment

- Well decommissioning and suspension or abandonment for this Project will be carried out as per applicable industry practice and in compliance with relevant regulatory requirements. These activities will adhere to the requirements set out under the *Newfoundland Offshore Petroleum Drilling and Production Regulations* (or subsequent amended regulations) along with relevant requirements of the Drilling and Production Guidelines (C-NLOPB and CNSOPB 2017).

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