Tilt Cove Exploration Drilling Program

Chapter 11: Marine Mammal and Sea Turtle VC

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11.0 ASSESSMENT OF POTENTIAL EFFECTS ON MARINE MAMMALS AND SEA TURTLES

The Marine Mammals and Sea Turtles VC includes baleen whales, large-toothed whales, delphinids, porpoises, seals, and sea turtles, focusing in particular on those species that are listed under Schedule 1 of SARA and considered at risk by COSEWIC. Marine Mammals and Sea Turtles was selected as a VC in recognition of the important habitat for these species in NL waters, their potential vulnerability to effects from Project components and activities (particularly underwater sound emissions), and the cultural and recreational value they hold for Indigenous groups and the general public. The EIS Guidelines also require the assessment of potential Project effects on marine mammals and sea turtles.

As noted in Section 6.3 of the EIS, the waters off eastern Newfoundland are known to support many species of marine mammals and sea turtles, including species designated as SAR or SOCC (see Section 6.3.7). Thirty-two species of marine mammals could occur within or near the Project Area, including twenty-six species of cetaceans (whales, dolphins, and porpoises) and six seal species. Most marine mammals occur in the region seasonally, but some use the area throughout the year. Four sea turtle species could also occur within or near the Project Area, but only leatherback and loggerhead turtles occur regularly within the RAA. Due to similarities in habitat use and the nature of potential interactions with Project components and activities, sea turtles are assessed with marine mammals.

This VC is linked to the Marine Fish and Fish Habitat VC (Chapter 9) because marine mammals and sea turtles feed on fish and marine invertebrates. It is also linked to the Special Areas VC (Chapter 12), as some of these areas, such as EBSAs, encompass important foraging habitat and migratory routes for marine mammals and sea turtles. No critical habitat has been designated for marine mammals and sea turtles in or near the Project Area.

11.1 SCOPE OF ASSESSMENT

11.1.1 Regulatory and Policy Setting

Marine mammals and sea turtles and their habitat are protected under the federal *Fisheries Act* and SARA. The *Fisheries Act* includes provisions that prohibit serious harm to fish (i.e., the death of fish or permanent alteration to, or destruction of, fish habitat). Marine mammals and sea turtles as “marine animals” are considered “fish” for the purposes of the *Fisheries Act*. SARA includes provisions to protect species listed on Schedule 1 as well as their critical habitat, which is defined as “habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in a recovery strategy or action plan for the species” (Section 2(1)).

SAR include all species listed under Schedule 1 of SARA as endangered, threatened, or special concern. SOCC include those that are listed as endangered, threatened, or special concern by COSEWIC, but not yet listed in Schedule 1 of SARA. Species listed in Schedule 1 of SARA are federally protected. SARA aims to prevent species from being extirpated or becoming extinct; provide for the recovery of species that are extirpated, endangered, or threatened as a result of human activity; and manage species of special concern to prevent them from becoming endangered or threatened. Sections 32, 33, and 58 of SARA contain

provisions to protect species listed under Schedule 1 of SARA and their critical habitat. Under Section 79 of SARA, ministerial notification is required if a project is likely to affect listed species or its critical habitat. This notification must identify the adverse effects of the project on listed wildlife species and its critical habitat and, if the Project is conducted, the notification must identify measures that will be taken to avoid or reduce those effects, along with monitoring commitments.

Populations of marine mammals and sea turtles that are stable and those listed under Schedule 1 of SARA or identified by COSEWIC as at risk are considered here. However, SAR and SOCC are given special attention and emphasis in the analysis and evaluation of potential Project effects and necessary mitigation measures.

11.1.2 The Influence of Consultation and Engagement on the Assessment

Questions and comments related to marine mammals and sea turtles were recorded during Suncor's Project-related engagement with government departments and agencies, stakeholder organizations, and Indigenous groups (see Chapter 3). Several Indigenous communities indicated concerns about potential Project-related effects on marine mammals in particular SARA-listed species including the blue and North Atlantic right whales. Sea turtles and marine mammals are among the culturally important species of concern to Indigenous groups.

11.1.3 Potential Effects, Pathways and Measurable Parameters

Routine Project activities and components have the potential to interact with marine mammal and sea turtle species due to underwater sound produced by operation of the MODU, VSP, supply vessels, and helicopter overflights. These potential sources of disturbance, as well as operational discharges, could result in direct or indirect (e.g., changes in habitat quality) effects on marine mammals and sea turtles. There is also the risk of mortality or physical injury as a result of vessel collisions. The Project could also affect a change in the availability, distribution, or quality of prey (see Chapter 9 on assessment of effects on prey species). The assessment of Project-related effects on marine mammals and sea turtles focuses on the following potential effects:

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

The measurable parameters used for the assessment of the environmental effects indicated above, and the rationale for their selection, are shown in Table 11.1. Effects of accidental events are assessed in Section 16.5.4.

Table 11.1 Potential Effects, Effects Pathways and Measurable Parameters for Marine Mammals and Sea Turtles

Potential Environmental Effect	Effect Pathway	Measurable Parameter(s) and Units of Measurement
Change in risk of mortality or physical injury	• Project-related activities (e.g., MODU, VSP, vessel transits, well abandonment) will introduce underwater sound to the marine environment and result in changes to the acoustic environment • Exposure to underwater sound levels at or above established acoustic thresholds has the potential to result in hearing impairment and/or injury to marine mammals and sea turtles • Marine vessel traffic has the potential to result in vessels strikes with marine mammals and sea turtles	• Degree and extent of underwater sound relative to established acoustic thresholds for marine mammals and sea turtles, based on available literature and acoustic modelling • Expected species occurrence and relative abundance (qualitative) in affected areas • Mortality or injury observed due to vessel strikes
Change in habitat quality and use	• Interactions between Project activities and the environment that result in acoustic or water quality changes to marine mammal and sea turtle habitat; this may include direct behavioural effects (e.g., avoidance) related to increased sound levels from Project activities and indirect effects related to changes in prey quantity and quality that may be related to increased sound levels and/or drilling discharges	• Change in water quality • Estimated underwater sound levels relative to acoustic thresholds, and available scientific understanding of potential behavioural responses to sound, for marine mammals and sea turtles • Expected species occurrence and relative abundance (qualitative) in the areas ensonified by Project activity sound sources where effects are predicted to occur • Change in area of habitat (qualitative) used for feeding, breeding, or migration

11.1.4 Boundaries

Spatial and temporal boundaries for the assessment of marine mammals and sea turtles are discussed in the following sections.

11.1.4.1 Spatial Boundaries

Spatial boundaries for the assessment of marine mammals and sea turtles are discussed below.

Project Area: The Project Area (Figure 11-1) encompasses the immediate area in which Project activities and components would occur. Specific well locations have not been identified but will occur within EL 1161. A 40 km buffer around the perimeter of EL 1161 defines the Project Area.

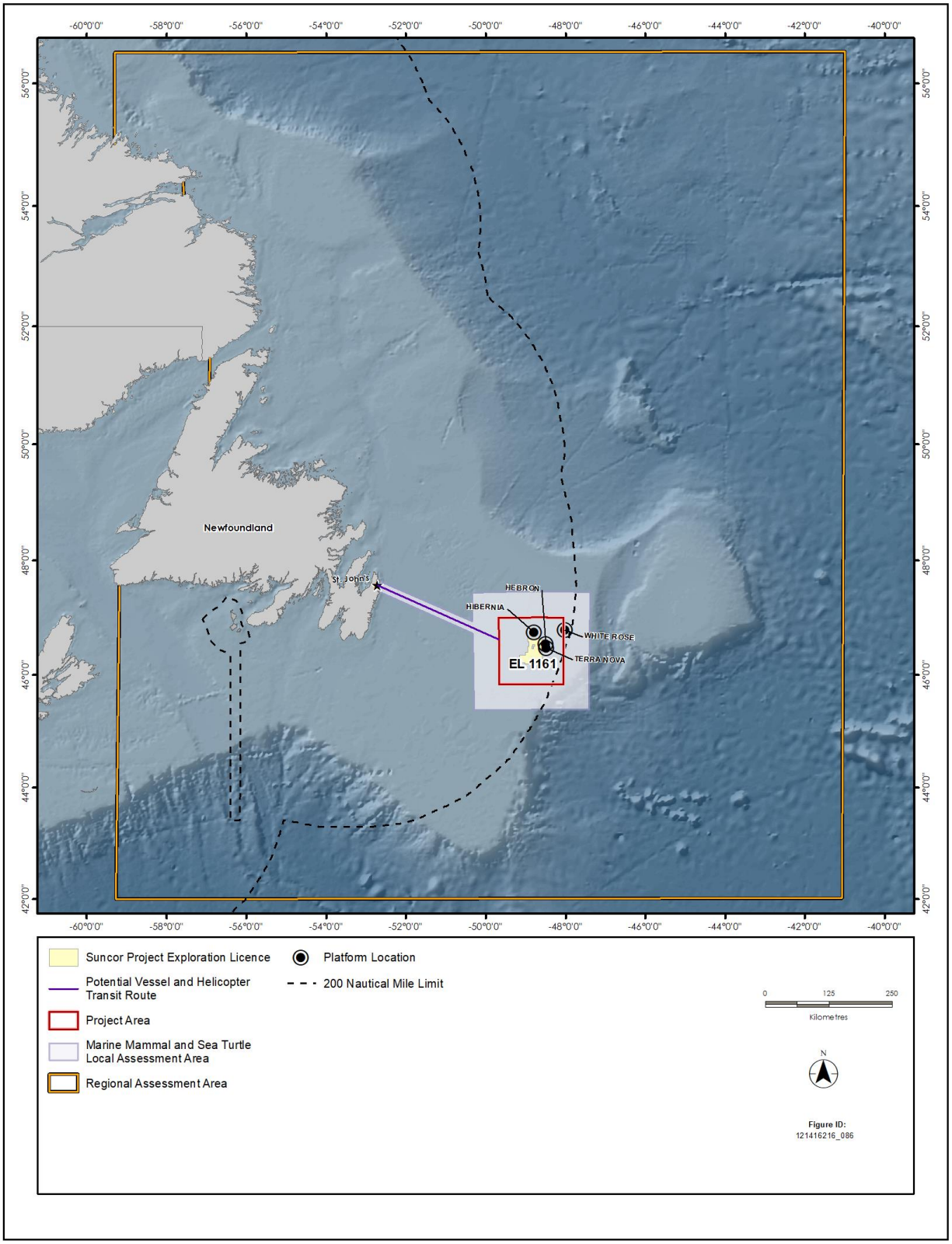

Figure 11-1 Marine Mammal and Sea Turtle Spatial Areas

Local Assessment Area (LAA): The LAA (Figure 11-1) 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 adjacent areas where Project-related environmental effects are reasonably expected to occur based on available information, including effects thresholds, predictive modelling, and professional judgement. The LAA also includes transit routes (vessel and aircraft) to and from the Project Area. The main Project-related environmental interactions that potentially affect marine mammals and sea turtles and their prey include underwater sound that will be generated by the MODU, supply vessels, and VSP surveys. The LAA for marine mammals and sea turtles is based on modeling results for distances to sound threshold criteria for behavioural change as well as scientific literature and is defined as a conservative 50-km buffer around the Project Area to encompass the maximum threshold distances for all activities. The LAA also includes a 10 km area around the associated vessel and aircraft traffic route to the Project Area.

Regional Assessment Area (RAA): The RAA (Figure 11-1) is the area within which residual environmental effects from operational activities and accidental events may interact with marine mammals and sea turtles that are outside the Project Area. The RAA also accounts for residual environmental effects related to routine activities that could interact cumulatively with the residual environmental effects of other past, present, and future (certain or reasonably foreseeable) physical activities.

11.1.4.2 Temporal Boundaries

The temporal boundaries for the assessment of potential Project-related environmental effects on marine mammals and sea turtles encompass all Project phases, including well drilling, testing, and decommissioning, suspension and abandonment. Suncor is currently planning to drill up to 12 exploration and delineation / appraisal wells over the term of EL 1161 (2019 to 2028). Project activities at each well could take approximately 120 days. Well testing, decommissioning, suspension and abandonment could also occur at any time during the temporal scope of this EIS (to end of 2029) and would be conducted over a one-month period after drilling. Wells may be decommissioned, suspended and abandoned at any time within the temporal boundaries but abandonment will likely occur following drilling and/or well flow testing. Drilling operations would not be continuous throughout the Project and would depend on rig availability and results from previous wells.

Marine mammals and sea turtles occur in the RAA year-round. However, summer is an important season offshore Newfoundland when many migratory species come north to feed before returning to more southerly latitudes for the winter. Seals could be more common during the winter and spring. Section 6.3 provides information on the marine mammal and sea turtle species that could occur in the RAA.

11.1.5 Residual Effects Characterization

The definitions used to characterize environmental effects as part of this effects assessment for marine mammals and sea turtles are provided in Table 11.2. These characterizations will be used throughout the chapter when describing potential residual environmental effects on marine mammals and sea turtles from routine Project activities. These characterizations are also applicable for accidental events, as discussed in Section 16.5.4.

Table 11.2 Characterization of Residual Effects on Marine Mammals and Sea Turtles

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 mortality, injury, health, or habitat quality in a direction beneficial to marine mammals and sea turtles relative to baseline **Adverse** – a residual environmental effect that moves mortality, injury, health, or habitat quality in a direction detrimental to marine mammals and sea turtles relative to baseline **Neutral** – no net change in mortality, injury, health, or habitat quality for marine mammals and sea turtles relative to baseline
Magnitude	The amount of change in mortality, injury, health, or habitat quality of marine mammals and sea turtles 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	**Project Area** – residual environmental effects are restricted to the Project Area **LAA** – residual environmental effects extend into the LAA **RAA** – residual environmental effects extend into the RAA
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 mortality, injury, health, or habitat quality of marine mammals and sea turtles 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
Reversibility	Pertains to whether mortality, injury, health, or habitat quality of marine mammals and sea turtles can return to its existing condition after the project activity ceases	**Reversible** – will recover to baseline conditions before or after Project completion **Irreversible** – permanent

Table 11.2 Characterization of Residual Effects on Marine Mammals and Sea Turtles

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Ecological and Socio-economic Context	Existing condition and trends in the area where residual effects occur	**Undisturbed** – The VC is relatively undisturbed in the LAA, 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 LAA, or the VC is likely not able to assimilate the additional change

11.1.6 Significance Definition

In consideration of the descriptors listed above, as well as consideration of requirements under SARA and associated regulations and recovery plans, the following threshold has been established to define a significant adverse residual environmental effect on marine mammals and sea turtles.

For the purposes of this effects assessment, a significant adverse residual environmental effect on marine mammals and sea turtles is defined as a Project-related environmental effect that results in one or more of the following:

- Causes a detectable decline in abundance or change in the spatial and temporal distribution of marine mammals and sea turtles within the overall RAA, such that natural recruitment may not re-establish the population(s) to its original level within one generation.
- Jeopardizes the achievement of self-sustaining population objectives or recovery goals for listed (SAR) species such that the overall abundance, distribution, and health of that species and its eventual recovery within the RAA is adversely affected.
- Results in permanent and irreversible loss of critical habitat as defined in a recovery plan or an action strategy for listed (SAR) species such that the overall abundance, distribution, and health of that species and its eventual recovery within the RAA is adversely affected.

11.2 PROJECT INTERACTIONS WITH MARINE MAMMALS AND SEA TURTLES

Table 11.3 identifies, for each potential effect, the physical activities that might interact with marine mammals and sea turtles and result in the identified environmental effect. These interactions are indicated by check mark and are discussed in detail in Section 11.3, in the context of effects pathways, standard and project-specific mitigation/enhancement, and residual effects. A justification for no effect is provided following Table 11.3.

Table 11.3 Project-Environment Interactions with Marine Mammals and Sea Turtles

Physical Activities	Environmental Effects	
	Change in Risk of Mortality or Physical Injury	Change in Habitat 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		

As described in Section 2.4.3, well testing involves flowing the well fluids through temporary test equipment located on the MODU and requires flaring of gases or other hydrocarbons that come to the surface for safe disposal. As these activities occur some distance above sea level, there is no potential for substantive interaction with marine mammals or sea turtles.

Discharge of drill muds and cuttings and routine discharges are not anticipated to interact with marine mammals and sea turtles leading to a change in the risk of mortality or injury; potential effects of discharges will be mitigated by treatment in accordance with the OWTG. Treated discharges may result in temporarily and localized reduction in water and sediment quality but this would not result in mortality or injury in marine mammals and sea turtles. Potential effects of these discharges on marine mammal and sea turtle prey are discussed in Section 11.3.2.3, in the context of change in habitat quality and use.

Well decommissioning, suspension and abandonment typically involves setting a series of cement and mechanical plugs within the wellbore. If a wellhead is removed, it will typically be done by using mechanical cutting means. As such, well decommissioning, suspension and abandonment activities using mechanical means are not anticipated to produce sounds that pose a mortality or injury risk to marine mammals or sea turtles.

11.3 ASSESSMENT OF RESIDUAL ENVIRONMENTAL EFFECTS ON MARINE MAMMALS AND SEA TURTLES

The following section assesses the environmental effects on marine mammals and sea turtles from potential interactions as indicated in Table 11.3. Given the similarities in Project description, proximity of activities in Orphan and Flemish Pass basins, and recency of data, the EIS incorporates information from recent EA documents for exploration drilling projects by EMCP (2017), Statoil (2017), BP (2018), Chevron (2020), and BHP (2020) in the Flemish Pass and Orphan basins, including comments received during Indigenous and stakeholder review processes, with updates incorporated as applicable.

11.3.1 Change in Risk of Mortality or Physical Injury

11.3.1.1 Project Pathways

There are two primary pathways from Project activities that may result in change in the risk of mortality or physical injury for marine mammals and sea turtles: vessel strikes and underwater sound generated by Project activities. The supply vessels transiting to and from the Project Area have the potential to collide with marine mammals or turtles, resulting in injury or mortality. The pathway of effect in the case of a vessel strike is the physical contact with a supply vessel. Underwater sound generated by VSP operations and other Project activities has the potential to cause temporary hearing changes in marine mammals or sea turtles (temporary threshold shift or TTS), and there is the possibility of permanent hearing damage (permanent threshold shift or PTS). Auditory injury from MODU operations, including support vessels, is considered unlikely. There have been no reported cases of marine mammal or sea turtle mortalities that have been causally linked to sounds generated during oil and gas exploration activities.

11.3.1.2 Mitigation

In consideration of the environmental pathways noted above, the following mitigation measures and standard practices will be employed to reduce the potential effects on marine mammals and sea turtles.

Vertical Seismic Profiling Operations

- As required in the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2019), mitigation measures applied during geophysical surveys (VSP) will be consistent with those outlined in the SOCP (DFO 2007). The following are key mitigation measures that will be employed during VSP surveys:
  - Marine Mammal Observers (MMOs) will monitor and report on marine mammal and sea turtle sightings during VSP surveys to implement shutdown and ramp-up procedures
  - A ramp-up procedure (i.e., gradual increase in seismic source level over a period of approximately 30 minutes until the operating level is achieved) will be implemented before any VSP activity begins. This measure is aimed at reducing the potential for auditory impairment to marine animals in close proximity to the source at the onset of activity. It is based on the assumption that the gradual increase in emitted sound levels will provide an opportunity for marine animals to move away from the sound source before potentially injurious sound levels are achieved close to the source. This procedure will include a pre-ramp up observation period. Ramp-up will be delayed if any marine mammal or sea turtle is detected within 500 m of the air gun array as per the Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2019).
  - MMOs will implement a pre-ramp up watch of 60 minutes prior to ramp-up. The longer 60-minute pre-ramp up watch versus the minimum 30-minute period required in the SOCP will be used to account for the longer dive times of beaked whales (and other deep-diving marine mammals) that may occur in the Project Area. This period is recommended by DFO (Moors-Murphy and Theriault 2017) in a recent review of the SOCP.
  - Shut down procedures (i.e., shutdown of source array) will be implemented if a marine mammal or sea turtle listed as endangered or threatened on Schedule 1 of SARA, as well as any beaked whale species, is observed within 500 m of the air gun array.
- Passive acoustic monitoring or an equivalent technology will be implemented for VSP

Supply and Servicing Operations

- Supply vessels will use existing shipping lanes as practicable; where these do not exist, supply vessels will follow a straight-line approach to and from the Project Area.
- During transit to and from the Project Area, supply vessels will travel at vessel speeds not exceeding 22 km/hour (12 knots), except as needed in the case of an emergency.
- If marine mammals or sea turtles are observed by vessel crews, they will reduce speed and/or alter course if practicable to avoid a collision. More specifically, supply vessels will be required to reduce speed to a maximum of 13 km/hour (7 knots) when a marine mammal or sea turtle is observed or reported within 400 m of a supply vessel, except if not feasible for safety reasons.

11.3.1.3 Characterization of Residual Project-related Environmental Effects

11.3.1.3.1 Presence and Operation of a MODU

The MODU will produce continuous (i.e., non-impulsive) sound during operations (see Section 2.8.4). The broadband sound source level for the MODU is assumed to be 193.7 dB re 1 µPa @ 1 m SPL_{rms}. This source level was selected based on the representative MODU *Seadrill West Sirius*. Acoustic modelling assumed that the MODU was operating in DP-assist anchor mode with four of eight thrusters operating at 50% maximum power, see section 3.3.2.1 of the sound modelling conducted for the EIS, “Underwater Sound Associated with the Tilt Cove Exploration Drilling Project”, in Appendix D (Alavizadeh and Deveau 2020). It is considered conservative for effects assessment purposes as reported values have been lower (Richardson et al. 1995; Hildebrand 2009; OSPAR 2009; Kyhn et al. 2011; MacDonnell 2017). Based on published threshold values for auditory injury or PTS for marine mammals (Table 11.4), it is highly unlikely that marine mammals would experience hearing damage from sound exposure from a MODU. Given the expected source SPL_{rms} of 193.7 dB for the MODU, sound levels would not reach the SPL_{peak} auditory injury thresholds for any marine mammal groups. Acoustic modeling conducted for a representative site in the Project Area showed that baleen whales (i.e., low-frequency hearing specialists) would have to occur and remain within a distance of up to 365 m of the MODU for a 24-hour period to experience sound levels above the SEL_{cum} threshold associated with PTS (Appendix D). Cetaceans considered mid-frequency and high-frequency hearing specialists are at a lower risk of incurring PTS from a MODU based on the acoustic modelling. Likewise, it is predicted that seals would have to occur within 14 m of the MODU to incur PTS based on the SEL_{cum} threshold. It is anticipated that most marine mammals will avoid the immediate area around the MODU (see below, Change in Habitat Quality and Use), thereby further reducing the likelihood of incurring hearing impairment. Although little is known about the effects of underwater sound on sea turtle hearing and behaviour, it is assumed that sea turtles would also exhibit localized avoidance of the MODU. Based on published threshold values for auditory injury or PTS for sea turtles (Table 11.4), it is highly unlikely that sea turtles would experience hearing impairment from sound exposure from a MODU. Therefore, it is highly unlikely that marine mammals or sea turtles are at risk of incurring auditory injury from exposure to underwater sound from the MODU.

Table 11.4 Acoustic Threshold Levels for Permanent Threshold Shift Onset for Marine Mammals and Sea Turtles

Hearing Group	PTS Onset Threshold Levels			
	Impulsive Sound		Non-impulsive Sound	
	dB SPL_{peak}	dB SEL_{cum}	dB SPL_{peak}	dB SEL_{cum}
Low-frequency Cetaceans[1]	219	183	219	199
Mid-frequency Cetaceans[1]	230	185	230	198
High-frequency Cetaceans[1]	202	155	202	173
Phocids (in water)[1]	218	185	218	201
Sea Turtles[2]	232	204	232	220

Notes:

dB (decibel) SPL_{peak} has a reference value of 1 µPa

dB SEL_{cum} has a reference value of 1 μPa^2s

[1] Guidelines released by National Marine Fisheries Service (NMFS) in July 2016 (NMFS 2016) and amended in 2018 (NMFS 2018) replace their previous interim dB SPL_{rms} criteria for injury (i.e., 180 dB SPL_{rms} for cetaceans and 190 dB SPL_{rms} for pinnipeds [NOAA Fisheries 2019).

[2] Guidelines from U.S. Navy (2017).

Residual effects associated with the presence and operation of a MODU or a change in risk of mortality and physical injury to marine mammals and sea turtles are predicted to be adverse, but negligible in magnitude, localized to the Project Area, an unlikely event, short- to medium-term in duration, and reversible.

11.3.1.3.2 Geophysical (including VSP), Geological, Geotechnical and Environmental Surveys

As discussed in Section 2.8.4, VSP surveys use air guns in a source array which produce intermittent impulsive sound. However, the size and total volume of the source array used during a VSP survey are generally much smaller than those used in traditional high-energy offshore seismic surveys; thus, VSP operations produce lower sound levels. VSP operations also occur over much shorter time frames (e.g., days instead of months) and are conducted over a much smaller spatial scale (i.e., limited to the wellsite). The impulsive nature of sound is range-dependent, becoming less harmful with distance from the source (Hastie et al. 2019). Although these factors greatly reduce the likelihood that marine mammals and sea turtles will incur hearing impairment from VSP operations, the potential does exist. During the Project, VSP will take one day or less to complete per well. Further description of VSP is provided in Section 2.4.2.1.

Temporary or permanent hearing impairment is possible when marine mammals are exposed to sound levels above certain thresholds (see Appendix 4 of LGL 2015 for details). TTS has been studied and demonstrated in a limited number of captive odontocetes and pinnipeds exposed to sounds (reviewed in Southall et al. 2007; Finneran 2015). There is no specific evidence that exposure to sound pulses from an air gun array can cause PTS in any marine mammal, even when large arrays are in use. However, based on available information and given the likelihood that some mammals (e.g., harbour porpoise and seals) close to an air gun array might incur at least mild TTS, there has been speculation about the possibility that some individuals occurring very close to air guns might incur PTS (e.g., Richardson et al. 1995; Gedamke et al. 2011). Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage;

however, repeated or in some cases, single exposures to a level well above that causing TTS onset, might elicit PTS (e.g., Kastak and Reichmuth 2007; Kastak et al. 2008). Nonetheless, research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Liberman 2016). Recent publications on marine mammal hearing effects have raised some doubts as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015, 2016; Houser 2021). Furthermore, Lucke et al. (2020) caution that some current thresholds may not be able to accurately predict hearing impairment and other injury to marine mammals due to noise.

Based on current knowledge, it is assumed that any impact is directly related to total received energy, although there is some evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of exposure, and gaps between individual sound signals within a period of exposure can also influence the auditory effect (Mooney et al. 2009; Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a, 2010b; Finneran 2012, 2015; Kastelein et al. 2012a, 2012b, 2013a, 2013b, 2013c, 2014, 2015, 2016a, 2016b, 2018, 2019; Ketten 2012; Supin et al. 2016). For a beluga whale, TTS produced by exposure to a fatiguing noise was larger during the first session of an exposure (or naïve subject state) than TTS that resulted from the same sound in subsequent sessions (experienced subject state) (Popov et al. 2017). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2014, 2015, 2016; Nachtigall et al. 2018).

It is not appropriate to assume that onset of TTS occurs at similar received levels in all cetaceans (cf. Southall et al. 2007), as TTS studies have involved a limited number of species (see Appendix 4 in LGL 2015). Finneran et al. (2015) indicated that the potential for air gun arrays to cause auditory effects in dolphins could be lower than previously thought; based on behavioural studies, no measurable TTS was reported in three bottlenose dolphins after exposure to 10 impulses from an air gun source. However, auditory evoked potential measurements were variable, with one dolphin showing a small threshold shift of 9 dB at 8 kHz. Received levels that elicit onset of TTS have been shown to be lower in porpoises than for other odontocetes (e.g., Lucke et al. 2009; Kastelein et al. 2012a, 2013a, 2014, 2015; Tougaard et al. 2016). Evidence from more prolonged (non-pulse and pulse) exposures suggests that harbour seals incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (e.g., Kastak et al. 1999, 2005, 2008; Ketten et al. 2001; Kastelein et al. 2013c). However, harbour seals may be able to decrease their exposure to underwater sound by swimming just below the surface where sound levels are typically lower than at depth (Kastelein et al. 2018). When captive spotted and ringed seals were exposed to single air gun pulses with SELs of 165 to 181 dB re 1 µPa²s and SPLs (peak to peak) of 190 to 207 dB re 1 µPa, no TTS was observed at low frequencies (Reichmuth et al. 2016).

The frequencies emitted in air gun pulses overlap substantially with those that sea turtles are capable of detecting. Sounds from an air gun array could cause TTS in a sea turtle if it does not avoid the immediate area around the air guns. However, some sea turtles show localized movement away from approaching air guns (Appendix 5 in LGL 2015). Received sound levels diminish rapidly with increasing distance; thus, even a small-scale avoidance response could result in a substantial reduction in sound exposure.

Nowacek et al. (2013) concluded that available data indicate that air guns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for seismic surveying are designed to detect marine mammals and sea turtles occurring near the

air gun array and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. Many cetaceans and (to a lesser degree) pinnipeds and sea turtles show some avoidance of the area where received levels of air gun sound are strong enough to potentially cause hearing impairment. Thus, the avoidance responses of the animals themselves will reduce the possibility of hearing impairment.

Assessments of hearing impairment are generally based on whether sound levels reach or exceed established thresholds. Canada has not developed or formally adopted guidelines regarding acoustic thresholds for hearing impairment to marine mammals and sea turtles, and there is no single standard for assessing effects on these species. This assessment considers the most relevant and available scientific information, and the criteria used in this assessment and the rationale for the selection is provided below.

Guidelines from the U.S. National Marine Fisheries Service (NMFS) provide the most current guidance on threshold levels of underwater sound for the onset of TTS and PTS in marine mammals (NMFS 2016, 2018). These guidelines take into account some of the recommendations made by Southall et al. (2007) as well as those presented by Finneran (2016). Southall et al. (2019) provided updated scientific recommendations regarding noise exposure criteria which are similar to those presented by NMFS (2016, 2018), but include all marine mammals (including sirenians) and a re-classification of hearing groups. Acoustic threshold levels for the onset of PTS proposed by NMFS (2016, 2018) are summarized in Table 11.4. The exposure criteria use dual metrics for threshold values for impulsive sounds, consisting of peak sound pressure levels (SPL_{peak}) and cumulative (over 24 hours) sound exposure levels (SEL_{cum}); conclusions are based on whichever metric is first exceeded. As with most acoustic thresholds, these values serve as a guide only and in many cases are based on limited data.

Threshold criteria provided by NMFS (2016, 2018) were developed specifically for marine mammals. NMFS intends to establish similar acoustic thresholds for onset of PTS in other species, such as sea turtles and marine fish, when more data become available (NMFS 2018). Under the American National Standards Institute-Accredited Committee S3, Subcommittee 1, an Animal Bioacoustics Working Group has established sound exposure guidelines for sea turtles that adopt some of the approaches for marine mammals in Southall et al. (2007). As there is little information on the effects of underwater sound on sea turtles, the Animal Bioacoustics Working Group has thus far only developed thresholds for potential sea turtle mortality in relation to explosions, air guns, and pile driving (Popper et al. 2014). However, given the high hearing thresholds measured for sea turtles, the U.S. Navy (2017) recently proposed a PTS threshold for sea turtles (Table 11.5) that matches the highest marine mammal threshold (for otariids). NMFS has also adopted the Navy's threshold criteria for TTS and PTS. However, there have been no new studies on TTS or PTS in sea turtles since the guidelines published by Popper et al. (2014).

Acoustic modelling of a 1,200 in^3 air gun array with a sound pressure source level (broadside; 10-25,000 Hz) of 220.4 dB re 1 µPa @ 1 m SPL_{rms} was undertaken (Appendix D). Two sound velocity profiles for the water column were used: February and August. These months represent the range of acoustic propagation conditions that may occur during drilling operations. Estimated sound levels from the VSP air gun array were above SPL_{peak} injury thresholds (PTS onset) for impulsive sounds for low- and high-frequency cetaceans 14 and 121 m from the array, respectively, and 14 m for seals. The PTS thresholds for mid-frequency cetaceans were not reached. Considering the SEL_{cum} metric for injury provided by NMFS (2016, 2018), marine mammals would have to occur and remain within close range of the air gun array (up to approximately 73 m for seals, but less for mid- and high-frequency cetaceans), to theoretically incur auditory injury (PTS). This approach assumes that marine mammals occur within these distances of the VSP air

gun array for a 24-hour period, which is considered highly unlikely. Low-frequency hearing specialists (i.e., baleen whales) are thought to be at greater risk of incurring auditory injury from VSP sounds because most of the acoustic energy in air guns is at lower frequencies. Based on the NMFS criteria, modelling results suggest that if a baleen whale occurs within less than 2.5 km of the VSP air gun array for a 24-hour period there is risk of auditory injury (PTS) (Appendix D). However, this is considered an unlikely scenario because baleen whales will likely exhibit localized avoidance behaviour of the VSP air gun array. The amount of acoustic energy received depends on where in the sound field an animal is when the sound source is on.

Popper et al. (2014) proposed guidelines for threshold levels where mortality may occur in sea turtles (210 dB SEL_{cum} and 207 dB_{peak}), which are consistent with those proposed for fish whose swim bladder is not involved with hearing. The U.S. Navy (2017) provided PTS thresholds of 204 dB SEL_{cum} and 232 dB_{peak}; these thresholds are similar to those for otariids (eared seals, such as sea lions) as presented by NMFS (2016, 2018). Sound levels from VSP activities are predicted to be below any of these levels within 10s of meters of the array (Appendix D). Popper et al. (2014) hypothesized that the rigid external anatomy of sea turtles may afford protection from the potential effects of impulsive sound and categorized the relative risk of non-mortal injury for turtles as ‘high’ in the ‘near’ field (tens of metres from the source), and ‘low’ at both ‘intermediate’ (hundreds of metres) and ‘far’ (thousands of metres) distances.

Based on the information summarized here, and with the implementation of mitigation measures (Section 11.3.1.2), it is unlikely that VSP surveys will result in injuries (PTS) for marine mammals or sea turtles. To mitigate potential effects from VSP operations, a ramp-up procedure for the air gun array will be implemented in consideration of the SOCP (DFO 2007). Ramp-up will be delayed if a marine mammal or sea turtle is detected within 500 m of the air gun array (C-NLOPB 2019). Air gun(s) will be shut down if a marine mammal or sea turtle listed as endangered or threatened on SARA Schedule 1 as well as a beaked whale is detected within the 500-m zone around the array. Overall, the risk for marine mammals and sea turtles incurring hearing impairment (injury) is considered low. This risk is even lower for SAR given the rare occurrence of these species, with the exception of fin whales (Schedule 1, special concern), which are common in the PA.

Residual effects associated with underwater sound from VSP operations related to changes in the risk of mortality and injury are predicted to be negligible to low in magnitude, localized to the Project Area, an unlikely event, short-to medium-term in duration, and reversible.

The Project will involve geological, geotechnical and environmental surveys conducted from survey-specific vessels, or from the MODU, within the Project Area potentially at all times of year over the course of the Project. This will add a small amount of additional vessel traffic and an associated increase in vessel strike risk when travelling through the Project Area. The effects are similar to those discussed in supply and servicing (Section 11.3.1.3.3). Mitigation measures outlined in Section 11.3.1.2 will be in place during Project operations to reduce the effects of vessel strike on marine mammals and sea turtles.

11.3.1.3.3 Supply and Servicing

The Project will involve the use of supply vessels including supply and support traffic to, from, and within the Project Area throughout the year over the course of Project activities. Exposure to vessel sounds is not expected to result in mortality or PTS (i.e., Richardson et al. 1995; see also Appendix D). Mortality or injury of marine mammals and sea turtles can occur as a result of a vessel strike. Although there are no known

marine mammal concentration areas along the transit route, it is possible that groups of foraging marine mammals may be encountered, especially during summer months. Sea turtles are considered rare along the transit route as well as in the Project Area.

Baleen whales are known to be more vulnerable to collisions with vessels than odontocetes and pinnipeds (Laist et al. 2001; Jensen and Silber 2003; Vanderlaan and Taggart 2007). All species of mysticetes that may occur in the Project Area have been reported as being struck by ships (Jensen and Silber 2003). Fin whales are the most frequently struck baleen whale, followed by humpback and right whales (Laist et al. 2001; Jensen and Silber 2003; Panigada et al. 2006; Douglas et al. 2008). Although it is unclear why whales are unable to avoid vessel collisions, even when vessels are traveling slowly, strikes may be more likely in areas where large numbers of whales aggregate to feed (Panigada et al. 2006). Vessel sounds are louder at the side and stern of the vessel than at the bow (Allen et al. 2012; McKenna et al. 2012), making it more difficult for a whale to detect an approaching vessel in front of the ship. The majority of lethal and severe injuries to large whales from ship strikes have occurred when vessels were travelling at ≥14 knots (25.9 km/hour; Laist et al. 2001). A reduction in vessel speed has been shown to reduce the number of marine mammal deaths and severe injuries due to collisions (Vanderlaan and Taggart 2007; Vanderlaan et al. 2008, 2009; van der Hoop et al. 2015; Wiley et al. 2016). Lethal strikes are infrequent if a vessel is traveling <14 knots and rare at <10 knots (18.5 km/h; Laist et al. 2001).

The International Whaling Commission (IWC) maintains a global ship strike database that reports nearly 1,200 incidents as of 2016 (Van Waerebeek and Leaper 2007; Ritter and Panigada 2016). The IWC released its Strategic Plan to Mitigate the Impact of Ship Strikes on Cetacean Populations in 2017 (Cates et al. 2017). The Plan advocates reducing the spatial overlap between concentrations of whales and vessels as the best means to mitigate strikes. Vessel speed restrictions are an alternate strategy in regions where spatial separation is not possible.

In their most recent five-year (2015-2019) baleen whale serious injury and mortality determinations for the east coast of North America, NOAA Fisheries reported an annual average of 9.2 large whale mortalities resulting from confirmed vessel strikes to the animal (Henry et al. 2022). The actual number of vessel strike mortalities is likely much greater due to underreporting, inability to recover all carcasses, and the fact that the cause of death cannot be determined in many cases.

While many large whale species have been involved in vessel collisions (Laist et al. 2001), of greatest concern is the small population of North Atlantic right whales. Ship strikes, entanglements in commercial fishing gear, and decreasing calving rates are believed to be main contributors to the lack of recovery of the North Atlantic right whale (Kraus 1990; Caswell et al. 1999; IWC 2001; Elvin and Taggart 2008; Kraus et al. 2016). Right whales may be particularly prone to vessel strikes because of behaviours that may make them less aware of their surroundings (Knowlton et al. 1997), the amount of time they spend just below the surface where they cannot be seen (Parks et al. 2012a; Baumgartner et al. 2017), and because they often fail to react to approaching vessels (Nowacek et al. 2004; Vanderlaan and Taggart 2007). Ship strikes were found to have caused the death of 21 (52.5%) of 40 North Atlantic right whales necropsied between 1970 and December 2006 (Campbell-Malone et al. 2008).

In 2017, the U.S. NOAA declared a North Atlantic right whale unusual mortality event, which is still active in 2022 (NOAA 2019, 2022). In 2017, 17 dead right whales were found stranded (12 in Canada and 5 in the U.S.), most in the Gulf of St. Lawrence. Another three mortalities occurred in 2018 in the U.S., and in 2019, there were eight mortalities in Canada and one in the U.S. There were two mortalities in each of 2020

and 2021 in the U.S. As of 23 March 2022, no mortalities have been reported for 2022 (NOAA 2022). In addition to the 34 mortalities since 2017, there have been 16 seriously injured free-swimming whales reported; therefore, NOAA considers the unusual mortality event to include 50 individuals (NOAA 2022). A report on seven of the whales that stranded in Canada found evidence of blunt force trauma, suggestive of a ship strike, for four whales, and likely blunt force trauma in a fifth whale that was too decomposed to determine cause of death (Daoust et al. 2017; DFO 2019). Themelis et al. (2016) reported a single non-fatal right whale ship strike for Atlantic Canada during 2008 to 2014. The recent mortality incidents, along with the changing distribution and habitat use of this species over the last several years require a change in the monitoring and management strategies for the right whale (Pettis et al. 2018). Modelling the risk of lethal collisions with right whales before and after of the vessel speed rule (vessel speeds ≤10 knots) in the SE U.S., Crum et al. (2019) estimated the seasonal mortality risk decreased on average by 22%. Although possible, it is unlikely that a right whale will occur in the Project Area and along the supply vessel routes.

Project vessels could strike sea turtles resulting in injury or mortality. Propeller and collision injuries from vessels are common for sea turtles in U.S. waters (NMFS 2008). Hazel et al. (2007) suggested that turtles may not avoid faster moving vessels. During a study in Australia, they found that the proportion of green turtles moving to avoid a vessel decreased with increased vessel speed.

Based on the information summarized here, and with the implementation of mitigation measures (Section 11.3.1.2), it is highly unlikely that supply vessels transiting to and from the Project Area and within the Project Area will strike a marine mammal or a sea turtle. Supply vessels will use existing shipping lanes as practicable. Where these do not exist, supply vessels will follow a straight-line approach to and from the Project Area. Supply vessels will travel at lower speeds (not exceeding 22 km/hour or 12 knots) than those generally associated with lethal ship strikes to marine mammals, except as needed in the case of an emergency. Supply vessels will be required to reduce speed to a maximum of 7 knots when a marine mammal or sea turtle is observed or reported within 400 m of the supply vessel (except if not feasible for safety or emergency reasons). Vessels may also alter course if practicable to avoid collision with a marine mammal (or sea turtle). Overall, the risk of marine mammals and sea turtles incurring injury or mortality is considered quite low. The risk is lower for SAR given the rare occurrence of these species, with the exception of fin whales (see Schedule 1, special concern).

Residual effects associated with the presence of supply vessels related to changes in the risk of mortality and injury are predicted to be negligible to low in magnitude, localized to the LAA, an unlikely event, short- to medium-term in duration, and reversible.

11.3.2 Change in Habitat Quality and Use

11.3.2.1 Project Pathways

A change in habitat quality and use for marine mammals and sea turtles may occur from Project activities, particularly due to the underwater sound generated by the MODU, VSP, and supply vessels. Marine mammals detect and produce sounds both passively and actively to communicate, locate prey and predators, navigate, and gather information about their surroundings (Richardson et al. 1995; Nowacek et al. 2007; Tyack 2008; Shannon et al. 2016). It is unknown how important underwater sound is to sea turtles, but it is likely less important than for marine mammals. Anthropogenic sound from vessel traffic and other offshore exploration activities has the potential to cause adverse effects on marine mammals and sea

turtles. This assessment focuses on disturbance or the potential changes in behaviour and distribution of animals that could be of sufficient magnitude to be “biologically important”. Communication masking of marine mammals is also considered, where a sound of interest is obscured by interfering sounds at a similar frequency.

11.3.2.2 Mitigation

Geophysical (including VSP), Geological, Geotechnical and Environmental Surveys

- The same measures as outlined above for 11.3.1.2 apply. These measures will not only minimize the risk of injury, but also reduce the sound levels that marine mammals and sea turtles are exposed to.

Discharges

- Refer to the waste management mitigation measures identified in the Marine Fish and Fish Habitat VC (Section 9.3.2).

Supply and Servicing Operations

- The same measures as outlined above for 11.3.1.2 apply, which will minimize the risk of injury and behavioural effects.

11.3.2.3 Characterization of Residual Project-related Environmental Effects

11.3.2.3.1 Presence and Operation of a MODU

Changes in habitat quality and use due to the presence and operation of a MODU are mainly associated with sound emissions from the MODU, which can lead to behavioural changes in marine mammals and sea turtles. Potential effects from waste discharges from the MODU are discussed below (discharges).

Behavioural responses of marine mammals to sound are difficult to predict and depend on species, state of maturity, experience, current activity, reproductive state, time of day, and numerous other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007, 2021; Weilgart 2007; Ellison et al. 2012, 2018). If a marine mammal changes its behaviour or moves a small distance in response to an underwater sound, the effects are unlikely to be biologically important to the individual, let alone the stock or population (e.g., New et al. 2013a). However, if a sound source displaces marine mammals from an important feeding or breeding area for an extended period of time, impacts on individuals and populations could be serious (Lusseau and Bejder 2007; Weilgart 2007; New et al. 2013b; Nowacek et al. 2015; Forney et al. 2017; Farmer et al. 2018).

Drilling will be conducted by a semi-submersible unit (MODU) rig operating in anchored mode in the shallow water depths of 61 to 87 m in EL 1161. The MODU will maintain station via anchors and the use of Dynamic Positioning (DP) system of thrusters to assist positioning maintainance. Sounds from MODUs are non-impulsive or continuous in nature. Vessels using DP typically create more sound than transiting vessels due to increased cavitation (Delarue et al. 2018). Based on measurements acquired during drilling of Shell Canada’s Monterey Jack exploration well in the Scotian Basin, the drillship Stena *IceMax* operating solely in DP mode (i.e., non-anchored) had a broadband source level of 187.7 dB re 1 µPa @ 1 m SPL_{rms} (MacDonnell 2017). Similarly, the drillship *Stena Forth* (also in full DP mode) had broadband source levels

of 184 dB re 1 µPa @ 1 m rms SPL during drilling and 190 dB re 1 µPa @ 1 m SPL_{rms} during maintenance work (Kyhn et al. 2011). Sounds from the drillship *Stena IceMax* were also recorded at acoustic receivers located 13 km away during Shell's Cheshire drilling program off the Scotia Shelf during spring/summer 2016; when drilling operations were underway, broadband ambient sounds increased by 10 dB SEL or 3.8 dB SPL (Delarue et al. 2018). The presence of drilling platforms also increased the soundscape substantially in the areas monitored, with sound at the seabed extending at least 15 km in deep water and 35 km in shallow water. Matthews et al. (2018) showed that DP thrusters from the semi-submersible drilling MODU *Seadrill West Hercules*, operating in full DP mode in ultra-deep waters, located 209 km from an acoustic recorder were faintly detectable but did not increase the overall broadband sound levels.

It is possible that marine mammals (and sea turtles) could change their behaviour in response to sounds produced by a MODU. There have been few studies of marine mammal behaviour in relation to drilling activity. However, available information suggests that effects are localized and temporary. Kapel (1979) reported several different species of baleen whales – mainly fin, minke, and humpback whales – within sight of active drillships (full DP mode) off West Greenland. Offshore California, grey whales responded when closer than 1 km around a semi-submersible drilling unit (Malme et al. 1983, 1984). Humpbacks showed no overt response to drillship broadband sounds of 116 dB re 1 µPa (Malme et al. 1985). Marine mammals are frequently sighted around oil and gas installations in the North and Irish seas (Todd et al. 2016; Delefoss et al. 2018).

Bowhead whales exhibit variable responses to drilling sounds. Some individuals have been seen less than a kilometre from drillships, whereas other have shown avoidance behaviour of up to 10 km (summarized in Richardson et al. 1995). Playback experiments of drilling sounds showed that bowhead whales typically did not respond to sound exposures in the 100 to 130 dB re 1 µPa rms range, although there were some minor behavioural changes (Richardson et al. 1990). Migrating bowheads in the Alaskan Beaufort Sea have been monitored during construction, drilling, and production activities at an artificial island (Northstar) just inshore of the migration corridor to determine if, at high-noise times, underwater sound propagating from Northstar and its support vessels deflected animals away from the southern part of the bowhead migration corridor (Richardson and Williams 2004). Localization methods were used to determine the locations of calling bowhead whales (Greene et al. 2004). The results showed slight offshore displacement of the proximal edge of the bowhead migration corridor at times when underwater sound levels were unusually high (Richardson 2008). The southern edge of the call distribution occurred 0.76 to 2.35 km farther offshore, indicating localized avoidance to industrial sound levels. However, the result was only apparent after intensive statistical analyses, and it is therefore unclear whether this represented a biological effect.

When belugas were exposed to playback sounds from a semi-submersible drillship in an Alaskan river, the whales swimming toward the sound source during two tests did not react overtly until they were within 50 to 75 m and 300 to 500 m (Stewart et al. 1983). Some individuals altered their course to swim around the source, some increased their swimming speed, and one reversed direction of travel (Stewart et al. 1983). Reactions to sound from a semi-submersible drill unit were less severe than those to motorboats with outboards (Stewart et al. 1982). Dolphins and other toothed whales have shown few behavioural responses to drill rigs and their support vessels (Richardson et al. 1995).

In the Arctic, ringed seals were often seen near drillships that were drilling during summer and fall (summarized by Richardson et al. 1995). Ringed and bearded seals approached and dove within 50 m of a projector transmitting drilling sound into the water at received levels of 130 dB re 1 µPa. Studies of seals

near active seismic vessels appear to confirm that seals tolerate offshore industrial activities (Harris et al. 2001; Moulton and Lawson 2002). There are no available data on sea turtle responses to sound from MODUs.

Behavioural disturbance thresholds are commonly used in marine mammal effects assessments of offshore geophysical programs in Canada and the U.S. (e.g., Stantec 2012, 2014a, 2014b; LGL 2014, BP 2016). The U.S. NMFS have provided thresholds for behavioural disturbance to assess the effects of sound on marine mammals. These generic threshold levels are SPL_{rms} 120 dB re 1 µPa for non-impulsive sounds (e.g., shipping, drilling) and SPL_{rms} 160 dB re 1 µPa for impulsive sounds (e.g., air guns used in VSP) and apply to cetaceans and pinnipeds. Here, these thresholds are considered as a guide for the assessment of potential effects of sound on behavioural responses of marine mammals, rather than an absolute indicator of such effects occurring. Where species-specific information on received sound levels is available (e.g., Southall et al. 2007), this information is considered.

Depending on the season, there was considerable variation in the modelled distances where sound levels were predicted to exceed the 120 dB re 1 µPa SPL_{rms} behavioural criterion. The MODU was predicted to produce sound levels ≥120 dB (using R_{max} - most conservative estimate) that ranged from approximately 38.4 km in August to 75.2 km in February. The corresponding $R_{95\%}$ distances were 34.0 km and 63.3 km in August and February, respectively. Long range sound propagation is limited in August (Appendix D). Based on the information presented earlier, it is highly unlikely that marine mammals, particularly odontocetes and seals, would avoid the MODU at these predicted distances; avoidance is expected to occur closer to the MODU. For example, marine mammals (i.e., humpback and minke whales) have been observed within hundreds of metres of the operating platforms on the Grand Banks (B. Mactavish, Senior Technician, LGL Limited, personal communication, 4 December 2019). Sound from the MODU is expected to result in localized avoidance by marine mammals. Sea turtles, considered rare in the Project Area, would be expected to exhibit localized avoidance.

Underwater sound, whether of anthropogenic or natural origin, may interfere with the abilities of marine mammals to communicate by masking sounds that are important to them. All marine mammal species produce sound which has been associated with important biological functions such as foraging, mating, rearing of young, social interaction, and group cohesion (Erbe et al. 2016). As such, masking could potentially impact individual fitness. Introduced underwater sound at higher levels but at a similar frequency and with signal characteristics of relevant biological sounds will, through masking, reduce the effective communication space of a species. Masking may occur if the frequency of the source is similar to that used by the marine mammal and if the anthropogenic sound is present for a substantial portion of the time (Richardson et al. 1995; Clark et al. 2009; Jensen et al. 2009; Gervaise et al. 2012; Hatch et al. 2012; Rice et al. 2014; Erbe et al. 2016; Tenessen and Parks 2016; Jones et al. 2017; Putland et al. 2017; Cholewiak et al. 2018; Dunlop 2018).

Baleen whale hearing systems are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly. The sounds important to toothed whales and pinnipeds are at higher frequencies than are the dominant components of MODU sounds, thereby limiting the potential for masking. The potential for masking of marine mammal calls and/or important environmental cues is considered low for the MODU given the relatively low source level. Some cetaceans are known to continue calling in the presence of anthropogenic sounds, and some change their calling rates, shift their peak frequencies, or otherwise modify their vocal behaviour in response to anthropogenic sounds (e.g.,

Blackwell et al. 2015, 2017; Papale et al. 2015; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Heiler et al. 2016; Robertson et al. 2017; Fornet et al. 2018; Tsujii et al. 2018). The potential biological costs of these changes in vocalizations are unknown. Masking release mechanisms (e.g., spatial release, orientation towards the sound, and comodulation masking release) are also used by marine mammals to enhance signal detection and reduce masking (Erbe et al. 2016).

Based on the information summarized here, the overall magnitude of the effect of the presence and operation of a MODU on marine mammals and sea turtles is anticipated to be low. Some localized and short-term behavioural effects (change in presence and abundance) are likely to occur, with some species potentially being displaced from the immediate area around the MODU. The localized, transient, and short-term nature of these disturbances at one location and time during Project activities considerably reduces the potential for adverse effects on individual marine mammals and sea turtles and their populations. It is thus unlikely that individuals will be displaced over extended areas or periods of time. Given that the zone of influence of the Project at one time or location will likely be a small proportion of the feeding, breeding, or migration area of species, marine mammals and sea turtles will not be displaced from important habitats or during important activities or be affected in a manner that causes adverse effects to overall populations in the region.

Residual effects associated with presence and operation of a MODU are primarily related to underwater sound. These may result in changes in habitat quality and use by marine mammals and sea turtles. These changes are predicted to be low in magnitude, generally localized to the Project Area but possibly extending into the LAA, short- to medium-term in duration, a multiple irregular event, and reversible.

11.3.2.3.2 Geophysical (including VSP), Geological, Geotechnical and Environmental Surveys

Most information on marine mammal behavioural response to air gun sounds comes from studies of 2D and 3D seismic surveys. Air gun arrays used during VSP are typically smaller, generating sound emissions that are more localized and of much shorter duration. Detailed reviews of responses of marine mammals and sea turtles to seismic surveys are provided in Appendices 4 and 5 of LGL (2015), respectively; an overview with a focus on newly available information is provided below.

Reactions of marine mammals to sound, if any, depend on sound levels and frequencies, exposure duration, species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (e.g., Harding et al. 2019; Kastelein et al. 2020a, 2020b, 2020c, 2020d, 2020e; Rako-Gospić and Picciulin 2019; Hückstädt et al. 2020; Hastie et al. 2021; Southall et al. 2021; Miller et al. 2022). As such, marine mammal behavioural reactions to sound are difficult to predict in the absence of site- and context-specific data, and numerous data gaps remain regarding the consequences of those responses (Elliott et al. 2019; Southall et al. 2021).

Baleen whales generally tend to avoid operating air guns, but avoidance radii are variable (refer to Appendix 4 of LGL 2015 for details). Whales are often reported to show no overt reactions to pulses from large air gun arrays at distances beyond a few kilometers, although sound levels from the air gun source remain above ambient sound levels out to much greater distances. In some cases, baleen whales react to sound from an air gun array by deviating from their normal migration route and/or interrupting their feeding and moving away. However, in the cases of migrating grey and bowhead whales, the observed behavioural

changes appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995). Stone (2015) examined data from 1,196 seismic surveys in the UK and adjacent waters and reported statistically significant responses to 500-in³ air gun arrays or larger for minke and fin whales. This included lateral displacement and change in swimming or surfacing behaviour, indicating that the whales remained near the water surface.

During studies examining humpback whale behaviour in response to seismic surveys off Australia, Dunlop et al. (2017a) found that humpbacks were more likely to avoid active small air gun sources (20 and 140 in³) within 3 km and received levels of at least 140 dB re 1 µPa²s. Responses to ramp up and use of a large 3,130 in³ array elicited greater behavioural changes when compared with small arrays (Dunlop et al. 2016). Humpbacks reduced their southbound migration, or deviated from their path thereby avoiding the active array, when they were within 4 km of the active large air gun source, where received levels were greater than 135 dB re 1 µPa²s (Dunlop et al. 2017b). However, some individuals did not show avoidance behaviours even at levels as high as 160 to 170 dB re 1 µPa²s (Dunlop et al. 2018). Dunlop et al. (2020) found that airgun sounds, and ship noise in general, reduced social interactions by humpbacks at greater distances than other behavioural changes, and at received sound levels <160 dB re 1 µPa²·s.

Matos (2015) reported no change in sighting rates of minke whales in Vestfjorden, Norway, during seismic surveys outside of the fjord. Data collected on grey whales during a seismic program in 2015 showed some displacement of animals from the nearshore feeding area and responses to lower sound levels than expected (Muir et al. 2016; Gailey et al. 2016; Sychenko et al. 2017). Vilela et al. (2016) recommended that environmental conditions should be considered when comparing sighting rates during seismic surveys, given that differences in sighting rates of rorquals (fin and minke whales) during seismic periods and non-seismic periods during a survey in the Gulf of Cadiz (Spain) was attributed to environmental variables.

There is limited systematic information available on reactions of odontocetes (toothed whales) to impulsive sound sources. However, there are systematic studies on sperm whales and narwhals, and there is an increasing amount of information about responses of various odontocetes to seismic surveys from monitoring studies (refer to Appendix 4 of LGL 2015 for details). Seismic operators and MMOs on seismic vessels regularly see dolphins and other delphinids near operating air gun arrays, but in general there is a tendency for most individuals to show some avoidance of seismic vessels with an operating source array. The avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance. Kavanagh et al. (2019) analyzed more than 8,000 hr of cetacean survey data in the northeastern Atlantic Ocean to determine the effects of the seismic surveys on cetaceans. They found that sightings of toothed whales were lower during active airgun surveys compared with inactive periods during seismic surveys. The beluga, however, is a species that (at least at times) shows avoidance of seismic vessels at greater distances (tens of kilometres) (Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behaviour when exposed to pulsed sounds similar in duration to those typically used in seismic surveys, but the animals' aversive behaviours typically occurred only after exposure to high received levels of sound (e.g., Finneran et al. 2000, 2002, 2005). Odontocete reactions to sound from large air gun arrays are variable and, at least for delphinids, seem to be confined to smaller distances than has been observed for the more responsive mysticetes and some other odontocetes. Small and medium-sized odontocetes, including beaked whales, showed a significant response (e.g., lateral displacement, localized avoidance, or change in behaviour) to sound from large air gun arrays (500 in³ or greater), with the exception of Risso's dolphin (Stone 2015). When investigating the auditory effects of

multiple underwater pulses from an air gun source on bottlenose dolphins at the highest exposure condition (peak sound pressure levels from 196 to 210 dB re 1 µPa), two of the three dolphins that were studied exhibited anticipatory behavioural reactions to sounds being presented at fixed time intervals, as is typically the case for seismic sources during marine seismic surveys (Finneran et al. 2015). Bottlenose dolphins exposed to multiple air gun pulses exhibited some anticipatory behaviour (Schlundt et al. 2016). McGeady et al. (2016) analyzed stranding data and found that the number of long-finned pilot whale stranding along Ireland's coast increased with seismic surveys operating offshore, although no causal link could be established.

Data from the Gulf of Mexico showed a correlation between reduced sperm whale acoustic activity and periods with air gun operations (Sidorovskaia et al. 2014). Thompson et al. (2013) reported reduced densities and acoustic detections of harbour porpoise in response to the presence of a seismic survey in Moray Firth, Scotland, at ranges of 5 to 10 km; however, animals returned to the area within a few hours (Thompson et al. 2013). Van Beest et al. (2018) exposed five harbour porpoises to a single 10 in^3 air gun for 1 min at 2 to 3 s intervals at ranges of 420 to 690 m and SELs of 135 to 147 dB μPa^2s; one porpoise moved away from the sound source but returned to natural movement patterns within 8 h, and two porpoises had shorter and shallower dives but returned to natural behaviours within 24 h. There have been recent studies of Arctic cetaceans, which further highlight the variability in marine mammal response to seismic sounds. Heide-Jørgensen et al. (2021) reported that narwhals exhibited avoidance reaction at distances >11 km from an active seismic vessel, as well as an increase in travel speed and changes in direction at distances up to 24 km from a seismic source. No long-term effects were reported. Tervo et al. (2021) reported that narwhal buzzing rates decreased in response to concurrent ship noise and airgun pulses (being 50% at 12 km from ship), that the whales discontinued to forage at 7 to 8 km from the vessel, and that exposure effects could still be detected >40 km from the vessel.

Pinnipeds tend to be less responsive to air gun sounds than many cetaceans and are not likely to show a strong avoidance reaction to air gun arrays (refer to Appendix 4 of LGL 2015 for details). Visual monitoring from seismic vessels typically has shown only slight, if any, avoidance of active air gun arrays by pinnipeds, and only slight, if any, changes in behaviour. Stone (2015) found that grey seals were displaced when large air gun source arrays of 500 in^3 or more in volume were active, as indicated by the lower detection rate during periods of seismic activity. Lalas and McConnell (2015) made observations of New Zealand fur seals from a seismic vessel operating a 3,090 in^3 air gun array in New Zealand during 2009, but the results were inconclusive in showing whether New Zealand fur seals respond to seismic sounds. When Reichmuth et al. (2016) exposed captive spotted and ringed seals to single air gun pulses, only limited behavioural responses were observed. Hastie et al. (2019) noted that the impulsive nature of sound is range-dependent, becoming less harmful and non-impulsive for marine mammals with distance from the source. Additionally, as SPLs for impulsive sounds are generally lower, just below the water surface, animals (e.g., seals) swimming near the surface are likely to be exposed to lower sound levels than when swimming at depth (Kastelein et al. 2018). However, the underwater sound hearing sensitivity for seals is the same near the surface and at depth (Kastelein et al. 2018).

Available information, some of which was described above, indicates that marine mammal and sea turtles show variable behavioural responses to air gun sounds; avoidance responses are typically localized and temporary. Using the NMFS recommended behavioural response criteria of SPL_{rms} 160 dB re 1 µPa for impulsive sounds and based on the modelling study undertaken by Alavizadeh and Deveau (2020), marine mammals may avoid an area of approximately 6.6 km (using R_{max} - most conservative estimate for

February) from the VSP air gun array. Using the more representative estimate ($R_{95\%}$) for February, the 160-dB threshold typically would be reached at 5.8 km from the VSP air gun array. Similar 160-dB threshold distances were predicted for August (6.09 km and 5.66 km for R_{max} and $R_{95\%}$, respectively) (Appendix D). Any avoidance by marine mammals is predicted to be temporary particularly given the short duration of VSP surveys (one day or less). Southall et al. (2021) highlight that using simple all-or-nothing behavioural thresholds (i.e., like the 120 dB rms and 160 dB rms put forward by the U.S. NMFS) and applying these thresholds across broad taxonomic groups of marine mammals and sound types can lead to much uncertainty in predicting effects. Once again, the use of behavioural thresholds and predicted distances to these sound levels in the EIS is a simple tool to highlight what is considered a likely worst-case scenario for potential behavioural effects on marine mammals in the Project Area (and LAA).

Because of the intermittent nature and low duty cycle of air gun pulses, marine mammals can emit and receive sounds during the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006), which could increase masking of relevant biological sound. Situations with prolonged strong reverberation have been considered infrequent, but there are increased indications that this may be more of a concern for marine mammals than previously thought, particularly in consideration of multiple, concurrent seismic surveys. It is common for reverberation to cause some elevation of the background level between air gun pulses (e.g., Gedamke 2011; Guerra et al. 2011, 2016); this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree.

The frequency and duration of the masking sound, strength, temporal pattern, and location of the introduced sound play a role in the extent of masking (Popov et al. 2020). Some cetaceans are known to continue calling in the presence of seismic sources, and their calls can be heard between source pulses. Cetaceans can also increase the source levels of their calls, shift their peak frequencies, or otherwise modify their vocal behaviour in response to increased noise (e.g., Blackwell et al. 2015; Thode et al. 2020; Fernandez-Betelu et al. 2021). Sills et al. (2017) reported that recorded air gun sounds at 1 km from the source may have masked the detection of low-frequency sounds by ringed and spotted seals completely at the onset of the air gun pulse when signal amplitude is variable (e.g., initial 200 ms). However, based on the reviewed information, the potential for masking of marine mammal calls and/or important environmental cues is considered low from the proposed VSP survey. Thus, masking is unlikely to be an issue of concern for marine mammals exposed to the sounds from VSP surveys, particularly considering that each survey will typically be one day or less in duration.

Based on available data, it is possible that sea turtles would exhibit behavioural changes and/or localized avoidance near a VSP survey (refer to Appendix 5 of LGL 2015 for details). The U.S. Navy (2017) considers the behavioural response threshold for impulsive sounds for turtles to be an SPL_{rms} of 175 dB re 1 µPa based on information presented by McCauley et al. (2000); this sound level is likely to be limited to a range of less than 2 km (Appendix D). However, there are no specific data that demonstrate the consequences to sea turtles if surveys with large or small arrays of air guns occur in important areas at biologically important times of year. To the extent that there are any adverse effects on sea turtles, operations involving air gun operations in or near areas where turtles concentrate are likely to have the greatest impact. Nelms et al. (2016) suggested that sea turtles could be excluded from critical habitats when exposed to anthropogenic sound. However, sea turtles are considered rare in the Project Area; if they do occur there, responses are expected to be localized and temporary, particularly given the short duration of VSP surveys.

As described in Chapter 9, significant effects to prey (fish, invertebrate) resources are not expected to occur because of the Project, and changes in the availability, location, or quality of prey for marine mammals and sea turtles related to VSP surveys are unlikely.

Based on the information summarized here, the mitigation measures summarized in Section 11.3.2.2, and the short-term and localized nature of VSP, the overall magnitude of the effect of VSP on marine mammals and sea turtles is anticipated to be low. Some localized and short-term behavioural effects (change in presence and abundance) are likely to occur, with some species potentially being displaced from the immediate area around the VSP air gun array. The localized, transient, and short-term nature of any behavioural responses at one location and time during the Project considerably reduces the potential for adverse effects on individual marine mammals and sea turtles or their populations. It is thus unlikely that individuals will be displaced over extended areas or periods of time. Given that the likely zone of influence of the Project at one time or location will represent a small proportion of the feeding, breeding or migration area of species, marine mammals and sea turtles will not be displaced from key habitats or during important activities or be otherwise affected in a manner that causes detectable adverse effects to overall populations in the region.

The Project will involve geological, geotechnical and environmental surveys conducted from survey-specific vessels, or from the MODU, within the Project Area potentially at all times of year over the course of the Project. The effects are similar to those discussed in supply and servicing (Section 11.3.2.3.5). Mitigation measures outlined in Section 11.3.1.2 will be in place during Project operations to reduce the effects of bird attraction due to offshore lighting from survey vessels.

Residual effects associated with geophysical (including VSP), geological, geotechnical and environmental surveys are primarily related to underwater sound generated by VSP activities. These may result in changes in habitat quality and use by marine mammals and sea turtles. These changes are predicted to be adverse, low in magnitude, localized to the Project Area, short- to medium-term in duration, irregular in frequency, and reversible.

11.3.2.3.3 Discharges

All discharges from Project supply vessels and the MODU will be in accordance with the OWTG and MARPOL, as applicable. Discharges are expected to be temporary, localized, non-toxic, and subject to dilution in the open ocean.

Drilling wastes such as cement, WBM, and cuttings released at the seafloor are unlikely to affect marine mammals and sea turtles. Water depths in the EL where exploration drilling would occur range from approximately 61 to 87 m. Drilling activities are unlikely to produce concentrations of heavy metals in muds and cuttings that could be harmful to marine mammals (Neff et al. 1980, in Hinwood et al. 1994). None of the marine mammals that regularly occur in the Project Area are known to feed on benthos. The bearded seal, which is considered a benthic feeder, may occasionally occur in the Project Area. These activities are expected to have minimal effects on marine mammals and sea turtles.

SBM cuttings are treated prior to discharge, and although they have a synthetic base fluid as a component, they only have a small, and permitted, fraction of residual SBM when discharged. Discharging the SBM-related drill cuttings below the water's surface further reduces the potential for marine mammals and sea turtles to contact the chemical components of SBM. With screening and selection of chemicals (including

use of non-toxic drilling fluids) in accordance with the OWTG, and proper disposal of drill muds and cuttings in accordance with the OWTG, potential effects on marine mammals and sea turtles due to disposal of drill muds and cuttings and associated waste materials are considered unlikely.

Other potential liquid discharges from offshore vessels and equipment relate to the possible release of oily water and other substances like produced water (if applicable), deck drainage, bilge water, ballast water, and liquid wastes. These discharges will be managed in accordance with the OWTG. Waste that cannot be discharged overboard will be stored and transported to shore for disposal in an approved facility (Section 2.9.3).

There is limited potential for interactions and effects of organic wastes disposed of from the MODU on marine mammals and sea turtles. Some prey species may be exposed to drill cuttings and discharges in the water column and in localized areas around the wellsites within the Project Area. However, they would not be affected to an extent that would result in a change in the quantity or quality of marine mammal and sea turtle prey. There is some potential that marine mammal prey may be attracted to discharged food wastes, but potential effects are considered negligible.

Residual effects associated with drilling and other marine discharges on marine mammals and sea turtle habitat quality and use is predicted to be negligible. Any such effects (adverse or positive) are predicted to be unlikely events, negligible in magnitude, restricted to the Project Area, short term in duration, and reversible.

The primary pathway for marine mammals and sea turtles during geological, geotechnical and environmental surveys is the sound generated by the operation of the survey vessel, the effects of which are similar to vessels used in supply and servicing (although typically of shorter duration). The effects of supply and servicing on marine mammals and sea turtles are described in Section 11.3.2.3.5.

11.3.2.3.4 Well Decommissioning, Suspension and Abandonment

There is little potential for marine mammals and sea turtles to interact with well decommissioning, suspension and abandonment activities. There is some potential that marine mammals may temporarily avoid a localized area around the wellhead during mechanical separation of the wellhead from the seabed due to underwater sound and other disturbance. The change in habitat quality and use as a result of well decommissioning, suspension and abandonment is predicted to be adverse but negligible in magnitude, restricted to the Project Area, unlikely to occur, short-term in duration, and reversible.

11.3.2.3.5 Supply and Servicing

The Project will involve supply vessel use including supply and support traffic to, from, and within the Project Area throughout the year during the Project life. In addition to supply vessel traffic, the Project will require helicopter use along the transit route from St. John’s to the Project Area at various times of year. Sound generated from supply vessels and to a lesser extent, helicopters, has the potential to cause changes to marine mammal and sea turtle habitat quality and use.

Marine mammal responses to vessels are variable and range from avoidance at long distances to little or no response or approach (Richardson et al. 1995). Responses depend on the speed, size, and direction of travel of the vessel relative to the animal. Slow approaches by a vessel tend to elicit fewer responses than fast, erratic approaches (Richardson et al. 1995; Erbe et al. 2019). Seals often show limited or no response

to vessels but have also shown signs of displacement in response to vessel traffic. Odontocetes sometimes show no avoidance reactions and occasionally approach vessels. However, some species, such as the harbour porpoise, are displaced by vessels or otherwise change their behaviour in response to vessel sounds (e.g., Wisniewska et al. 2018; Roberts et al. 2019). Vessel sounds have also been shown to elicit behavioural responses in harbour porpoise such as increased swimming speed and porpoising (e.g., Dyndo et al. 2015), and reduced foraging and echolocation (e.g., Teilmann et al. 2015; Wisniewska et al. 2018). Harbour porpoise occurrence decreased (as indicated by a decline in echolocation clicks) during vessel-related construction activities at Scottish offshore windfarms, and displacement was reported to occur at distances of up to 4 km from the activities (Benhemma-Le Gall et al. 2021). Buzzing activity (indicative of foraging) decreased during exposure to vessel-related construction sounds (Benhemma-Le Gall et al. 2021). Wisniewska et al. (2018) suggested that a decrease in foraging success could have long-term fitness consequences. However, Kastelein et al. (2019) surmised that if disturbance by noise would displace a harbour porpoise from a feeding area or otherwise impair foraging ability for a short period of time (e.g., one day), it would be able to compensate by increasing its food consumption following the disturbance. Baleen whales often change their normal behaviour and swim rapidly away from vessels that have strong or changing sound emission characteristics, in particular when a vessel heads towards a whale. Stationary vessels or slow-moving vessels generally elicit little response from baleen whales.

As noted above for drilling, sound from shipping, through masking, can also reduce the effective communication space of a marine mammal if sound levels are higher than relevant biological sounds, the frequency of the sound source is similar to that used by the animal, and the sound is present for a substantial period of time. In addition to the frequency and duration of the masking sound, the temporal pattern and location of the sound also play a role in the extent of the masking (e.g., Branstetter et al. 2013, 2016; Finneran and Branstetter 2013; Sills et al. 2017; Popov et al. 2020). Auditory masking, particularly the physical acoustic and/or biological processing aspects of auditory masking in marine mammals and/or fish with respect to exploration and production sound sources in marine mammals and fish, is poorly understood and is therefore a focus area of research (e.g., Joint Industry Programme on E&P Sound and Marine Life 2018). However, the potential for masking of marine mammal calls or important environmental cues is considered low from supply vessels, given the relatively low source level. As noted earlier, some baleen and toothed whales are known to continue calling in the presence of anthropogenic sounds, and some cetaceans change their calling rates, shift their peak frequencies, or otherwise modify their vocal behaviour in response to anthropogenic sounds. For example, harbour seals were reported to increase the minimum frequency and amplitude of their calls in response to vessel noise (Matthews 2017). However, harp seals did not increase the frequencies of their calls in areas with increased low-frequency sounds (Terhune and Bosker 2016). Masking release mechanisms are also used by marine mammals to enhance signal detection and reduce masking (Erbe et al. 2016).

Baleen whales are thought to be more sensitive to sound at low frequencies that are predominantly produced by vessels than are toothed whales (e.g., MacGillivray et al. 2014), possibly leading to localized avoidance of supply vessels. Reactions of grey and humpback whales to vessels have been studied (see Richardson et al. 1995, Southall et al. 2007 for reviews). For example, Dunlop et al. (2015) reported that southward migrating humpbacks off Australia decreased their dive time and swim speed slightly in response to a source vessel which was not operating air guns. Williamson et al. (2016) suggested that close approaches by small vessels may cause small and temporary behavioural changes in humpbacks, although for female-calf groups, the behavioural change may be greater and last longer.

There is little information available on the reactions of right whales and rorquals (e.g., fin and blue whales) to vessels. North Atlantic right whales can often be approached by slow moving vessels, but they swim away from vessels that approach quickly (Watkins 1986). In addition, they tend to show little responses to close passages of small steady-moving boats when mating or feeding (Mayo and Marx 1990; Gaskin 1991). The responses of North Atlantic right whales in the Bay of Fundy to ships, calls from conspecifics, and a signal to alert the whales were monitored using acoustic recording tags (Nowacek et al. 2004). The right whales responded overtly to the signal by swimming to the surface, thereby likely increasing rather than reducing the risk of a vessel strike. The whales reacted minimally to controlled exposure to calls of conspecifics, but showed no response to controlled sound exposure to recorded ship sounds as well as actual ships (Nowacek et al. 2004). Right whales are able to increase the source levels of their calls, shift their peak frequencies, or otherwise change their vocal behaviour in conditions with elevated ambient sound levels (e.g., Parks et al. 2007, 2011, 2012b, 2016; Gridley et al. 2016; Tenessen and Parks 2016). Rolland et al. (2012) suggested that ship noise causes increased stress in right whales. They showed that baseline levels of stress-related faecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels.

Off New England, fin whales had shorter than usual dive and surfacing times when whale-watch and other vessels were nearby (Stone et al. 1992). Watkins (1981) and Watkins et al. (1981) reported that fin whales showed limited responses to slow moving vessels but avoided boats that altered course or speed quickly. During marine mammal monitoring from a high-speed, catamaran ferry transiting the Bay of Fundy during the summers of 1998–2002, most baleen whales (including fin, humpback, and minke whales) observed from the ferry appeared to show avoidance behaviour such as heading away, changing heading, or diving (Dufault and Davis 2003). Blair et al. (2016) reported that increased levels of ship noise affect foraging by humpbacks. In the western Mediterranean, fin whale sightings were negatively correlated with the number of vessels in the area (Campana et al. 2015). Fin and blue whales in the St. Lawrence estuary either moved away from vessels or remained near a vessel but changed direction or dove, and the most overt responses occurred when vessels approached quickly or erratically (Edds and Macfarlane 1987). Fin and blue whales are able to increase the source levels of their calls, shift their peak frequencies, or otherwise change their vocal behaviour in the presence of increased sound levels such as from shipping (e.g., McKenna 2011; Castellote et al. 2012; Melcón et al. 2012). In addition to ship sounds, the physical presence of vessels has been shown to disturb the foraging activity of blue whales (Lesage et al. 2017). McKenna et al. (2015) reported a dive response by blue whales when a vessel approached, but no lateral avoidance, which could lead to an increased risk for vessel strike.

There are few systematic studies on sea turtle responses to vessels, but a response is likely to be minimal relative to reactions to sound from air guns. Hazel et al. (2007) examined behavioural responses of green sea turtles to a research vessel approaching at slow, moderate, or fast speeds (4, 11, and 19 km/h, respectively). Fewer sea turtles fled from an approaching vessel as speed increased, and turtles that fled from moderate to fast approaches did so at significantly shorter distances from the vessel than those that fled from slow approaches. Hazel et al. (2007) concluded that sea turtles may not be able to avoid vessels with speeds greater than 4 km/h. However, the studies employed a 6-m aluminum boat powered by an outboard engine, which would likely be more difficult for a sea turtle to detect than a supply vessel. Tyson et al. (2017) reported that a juvenile green sea turtle dove during vessel passes and remained still near the sea floor. Lester et al. (2013) reported that behavioural responses of semi-aquatic turtles to boat sounds are variable.

Routine transportation activities associated with helicopter support have potential to cause changes in habitat quality or use for marine mammals and sea turtles due to disturbance. Sounds produced by helicopters are primarily related to rotor and propeller blade revolutions, with most frequencies below 500 Hz (Richardson et al. 1995). The transmission of sound produced by helicopters into the marine environment is correlated to the altitude of the aircraft and sea surface conditions (Richardson et al. 1995). Underwater sounds from helicopters are generally stronger just below the water surface and directly below the aircraft, but underwater sounds attenuate over shorter distances than airborne sounds (Richardson et al. 1995). Available information indicates that single or occasional aircraft overflights will cause no more than brief behavioural responses in cetaceans and pinnipeds (summarized in Richardson et al. 1995). The majority of behavioural responses elicited in beluga and bowhead whales by an overhead helicopter traveling over the Beaufort Sea occurred when the aircraft flew at altitudes and lateral distances less than 150 and 250 m, respectively (Patenaude et al. 2002). As with other underwater sound sources, the degree of sensitivity of cetaceans to sounds produced by aircraft depend on their activity state at the time of exposure. Individuals in a resting state (as opposed to foraging, socializing, or travelling) appear to have the highest sensitivity to such disturbances (Würsig et al. 1998; Luksenburg and Parsons 2009). Cetaceans most commonly react to sounds from overhead aircraft by diving (Luksenburg and Parsons 2009). Other reported behavioural responses include decreased surfacing periods, changes in activity state, and breaching (Luksenburg and Parsons 2009).

There are no systematic data on sea turtle reactions to helicopter overflights. Given the hearing sensitivities of sea turtles, they can likely hear helicopters, at least when the aircraft fly at lower altitudes and the turtles are in relatively shallow waters. It is uncertain how sea turtles would respond, but single or occasional overflights by helicopters would likely elicit only brief behavioural responses.

Based on acoustic modelling for a representative supply ship (DSV *Fu Lai* with a broadband source level of 178 dB re 1 µPa @ 1 m SPL_{rms}), a supply vessel was predicted to produce sound levels ≥120 dB (using R_{max}—most conservative estimate) at distances that ranged from approximately 15.9 km in August to 17.7 km in February. The corresponding $R_{95\%}$ distances were 14.6 and 16.5 km in August and February, respectively. Based on the information presented above, it is unlikely that marine mammals, particularly odontocetes and seals, would avoid the MODU at these predicted distances, and avoidance is expected to occur closer to a supply vessel. Sound from a supply vessel is expected to result in localized avoidance by marine mammals. Sea turtles, considered rare in the Project Area, would be expected to exhibit localized avoidance.

Project-related supply vessel traffic represents a negligible contribution to the overall vessel traffic off eastern Newfoundland. Supply vessels will use existing shipping lanes as practicable, and where these do not exist, supply vessels will follow a straight-line approach to and from the Project Area. Whenever possible, vessels will maintain a steady course and constant speed. Additionally, during transit to/from the Project Area, supply vessels will travel at vessel speeds not exceeding 22 km/hour (12 knots), except as needed in the case of an emergency. In the event that a marine mammal or sea turtle is detected near the vessel, vessel speed will be reduced to a maximum of 7 knots when a marine mammal or sea turtle is observed or reported within 400 m of the vessel (except if not feasible for safety reasons).

Based on the information presented here, as well as the mitigation measures presented in Section 11.3.2.2, the overall magnitude of the effect of the supply vessels and helicopters on marine mammals and sea turtles is anticipated to be low. Some localized and short-term behavioural effects (change in presence and

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abundance) are likely to occur, with some species possibly being displaced from the immediate area around a supply vessel or helicopter. The localized, transient, and short-term nature of these disturbances at one location and time during the Project considerably reduces the potential for adverse effects on individual marine mammals and sea turtles or their populations. It is unlikely that individuals will be displaced over extended areas or timeframes. Given that the likely zone of influence of the Project at one time or location will represent a small proportion of the feeding, breeding or migration area of species, marine mammals and sea turtles will not be displaced from key habitats or during important activities or be otherwise affected in a manner that causes detectable adverse effects to overall populations in the region. However, there is some uncertainty as to whether the Project Area or portions thereof provide important habitat for marine mammals.

Residual effects associated with supply and servicing activities on a change in habitat quality and use are primarily related to underwater sound. These changes are predicted to be low in magnitude, localized to the LAA, short- to medium-term in duration, a multiple irregular event, and reversible.

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

Table 11.5 lists marine mammal and sea turtle SAR and SOCC that could potentially occur in the RAA, indicating their likely presence and potential interaction with Project activities. As discussed in Section 6.3.7 and summarized in Table 11.5, with the likely exception of fin whales, there is generally low potential for SAR or SOCC to interact with Project activities because these species are thought to occur infrequently in the Project Area, LAA, and (generally the) RAA, and because critical habitat has not been identified for marine mammals and sea turtles in the Project Area or LAA. Critical habitat has been considered for leatherback sea turtles in Placentia Bay (i.e., within the RAA) but there is negligible potential for interaction with routine Project activities and sea turtles which occur in this area.

Table 11.5 Marine Mammal and Sea Turtle Species at Risk and of Conservation Concern with Potential to Occur in the Project Area and RAA and Potential to Interact with Project Activities

Species	Season	*SARA* Status[a]	COSEWIC Status[b]	Summary of Potential Interactions
Baleen Whales (Mysticetes)				
North Atlantic Right Whale	Summer	Schedule 1: Endangered	Endangered	• Low potential for interaction with Project activities given rare occurrence in the Project Area (and RAA) • Proposed mitigation (Sections 11.3.1.2 and 11.3.2.2) will reduce risk of effects from underwater sound (VSP), discharges, and supply and servicing (supply vessel transit)
Fin Whale (Atlantic population)	Year-round, but mostly summer	Schedule 1: Special Concern	Special Concern	• High potential for interaction with Project activities given common occurrence in the Project Area and RAA • Proposed mitigation (Sections 11.3.1.2 and 11.3.2.2) will reduce risk of effects from underwater sound (VSP), discharges, and supply and servicing (supply vessel transit)

Table 11.5 Marine Mammal and Sea Turtle Species at Risk and of Conservation Concern with Potential to Occur in the Project Area and RAA and Potential to Interact with Project Activities

Species	Season	*SARA* Status[a]	COSEWIC Status[b]	Summary of Potential Interactions
Blue Whale (Atlantic population)	Year-round	Schedule 1: Endangered	Endangered	• Low potential for interaction with Project activities given uncommon occurrence in the Project Area and most of the RAA • Proposed mitigation (Sections 11.3.1.2 and 11.3.2.2) will reduce risk of effects from underwater sound (VSP), discharges, and supply and servicing (supply vessel transit)
Toothed Whales (Odontocetes)				
Northern Bottlenose Whale (Scotian Shelf population [c]; Davis Strait-Baffin Bay-Labrador Sea population [d]) [e]	Year-round	Schedule 1: Endangered [c] / No Status [d]	Endangered [c] / Special Concern [d]	• Low potential for interaction with Project activities given uncommon occurrence in relatively shallow waters of the Project Area and most of the RAA • Proposed mitigation (Sections 11.3.1.2 and 11.3.2.2) will reduce risk of effects from underwater sound (VSP), discharges, and supply and servicing (supply vessel transit)
Sowerby's Beaked Whale	Year-round	Schedule 1: Special Concern	Special Concern	• Low potential for interaction with Project activities given rare occurrence in relatively shallow waters of the Project Area and most of the RAA • Proposed mitigation (Sections 11.3.1.2 and 11.3.2.2) will reduce risk of effects from underwater sound (VSP), discharges, and supply and servicing (supply vessel transit)
Killer Whale (Northwest Atlantic population)	Year-round	No Status	Special Concern	• Low potential for interaction with Project activities given uncommon occurrence in the Project Area and RAA • Proposed mitigation (Sections 11.3.1.2 and 11.3.2.2) will reduce risk of effects from underwater sound (VSP), discharges, and supply and servicing (supply vessel transit)
Harbour Porpoise (Northwest Atlantic population)	Year-round, but mostly spring-fall	Schedule 2: Threatened	Special Concern	• Low potential for interaction with Project activities given uncommon occurrence in the Project Area and RAA • Proposed mitigation (Sections 11.3.1.2 and 11.3.2.2) will reduce risk of effects from underwater sound (VSP), discharges, and supply and servicing (supply vessel transit)

Table 11.5 Marine Mammal and Sea Turtle Species at Risk and of Conservation Concern with Potential to Occur in the Project Area and RAA and Potential to Interact with Project Activities

Species	Season	*SARA* Status[a]	COSEWIC Status[b]	Summary of Potential Interactions
Sea Turtles				
Leatherback Sea Turtle	April to December	Schedule 1: Endangered	Endangered	• Low potential for interaction with Project activities given rare occurrence in the Project Area and to a lesser extent the RAA • Proposed mitigation (Sections 11.3.1.2 and 11.3.2.2) will reduce risk of effects from underwater sound (VSP), discharges, and supply and servicing (supply vessel transit)
Loggerhead Sea Turtle	Summer and fall	Schedule 1: Endangered	Endangered	• Low potential for interaction with Project activities given rare occurrence in the Project Area and to a lesser extent the RAA • Proposed mitigation (Sections 11.3.1.2 and 11.3.2.2) will reduce risk of effects from underwater sound (VSP), discharges, and supply and servicing (supply vessel transit)

Note: Extralimital SOCC (e.g., beluga and bowhead whales) are not included here.

[a] Species designation under the *Species at Risk Act* (SARA website 2021).

[b] Species designation by COSEWIC (Committee on the Status of Endangered Wildlife in Canada; COSEWIC website 2021.

[c] Scotian Shelf population.

[d] Davis Strait-Baffin Bay-Labrador Sea population.

[e] Recent genetic analyses of northern bottlenose whale tissues collected near the Project Area suggest that this region may be an area of mixing between the two known populations (i.e., Scotian Shelf and Davis Strait-Baffin Bay-Labrador Sea), and other unknown populations, or possibly represent a new population (Feyrer et al. 2019).

Relevant threats identified for marine mammals and sea turtles at risk in associated recovery strategies and action plans under SARA include acoustic disturbance, marine pollution, and vessel strikes. Mitigation measures proposed to reduce disturbance from underwater sound associated with VSP air gun source arrays, manage discharges, and reduce supply vessel speeds (refer to Sections 11.3.1.2 and 11.3.2.2) will help to protect marine mammal and sea turtle species at risk. SAR marine mammal and turtle species are highly mobile, and many have large distributional ranges and undertake long migrations. Large seasonal and even daily variations in abundance within the Project Area are therefore likely, and the potential for overlap and interaction with Project activities is likely to be temporary. The Project will not occur in any identified concentration areas or critical habitat although it is acknowledged that detailed and systematic marine mammal (and sea turtle) baseline data are lacking. While there is limited potential for Project activities to increase the risk of mortality or injury in SAR, there is potential for sound from Project activities to result in a change in habitat use (i.e., avoidance response). Based on available information (including acoustic modelling), as well as the frequency and duration of Project activities, avoidance responses exhibited by SAR species are generally predicted to be short-term and localized.

The residual effects of the Project on marine mammal and sea turtle species at risk are predicted to be adverse, low in magnitude, generally localized to the Project Area but possibly extending into the LAA, an unlikely to perhaps irregular event, short- to medium-term in duration, and reversible.

11.3.4 Summary of Project Residual Environmental Effects

Table 11.6 summarizes the environmental effects assessment and prediction of residual environmental effects resulting from interactions between the Project and marine mammals and sea turtles. The greatest potential for environmental effects on marine mammals and sea turtles related to underwater sound is from the MODU and supply vessels and to a lesser extent from the short duration VSP surveys. It is possible that marine mammals may exhibit localized and temporary avoidance of the MODU, supply vessels, and VSP surveys. Similarly, in the unlikely event that a sea turtle occurred in the Project Area, there could be localized avoidance of Project activities. The risk of injury and mortality from vessel strikes is considered low. Supply vessels will maintain a constant course and speed whenever possible and reduce speed to a maximum of 7 knots when a marine mammal or sea turtle is observed or reported within 400 m of the supply vessel (except if not feasible for safety reasons). Similarly, the likelihood of a marine mammal and sea turtle incurring permanent hearing impairment (PTS) and physical injury from exposure to air gun pulses from VSP surveys is low, given the short duration of the activity and the implementation of mitigation measures. In summary, with the implementation of the various mitigation measures, the Project is not predicted to result in adverse population-level environmental effects on marine mammals and sea turtles, including species at risk.

Table 11.6 Summary of Residual Environmental Effects on Marine Mammals and Sea Turtles, 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 or Injury							
Presence and Operation of a MODU	A	N	PA	ST-MT	UL	R	D
Geophysical (including VSP) Surveys	A	N-L	PA-LAA	ST-MT	UL	R	D
Geological, Geotechnical and Environmental Surveys	A	N-L	PA	ST-MT	UL	R	D
Supply and Servicing	A	N-L	LAA	ST-MT	UL	R	D
Change in Habitat Quality and Use							
Presence and Operation of a MODU	A	L	PA-LAA	ST-MT	IR	R	D
Geophysical (including VSP) Surveys	A	L	PA-LAA	ST-MT	IR	R	D
Geological, Geotechnical and Environmental Surveys	A	L	PA	ST-MT	IR	R	D
Discharges	A	N	PA	ST	UL	R	D
Well Decommissioning, Suspension and Abandonment	A	N	PA	ST	UL	R	D
Supply and Servicing	A	L	LAA	ST-MT	IR	R	D

Table 11.6 Summary of Residual Environmental Effects on Marine Mammals and Sea Turtles, including Species at Risk

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

KEY: See Table 11.2 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 LAA: Local Assessment 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

11.4 DETERMINATION OF SIGNIFICANCE

Based on the nature of the interactions between the Project and marine mammals and sea turtles, the planned implementation of mitigation measures, and predicted residual changes to risk of mortality or injury, and to habitat quality and use, the Project is unlikely to result in significant adverse effects on marine mammals and sea turtles. Although Project-related activities may result in localized, short-term effects on some marine mammals and possibly sea turtles in the Project Area and LAA, the number of individuals that may be affected, and the temporary and reversible nature of these effects, indicates that the Project will not result in a detectable decline in overall marine mammal and sea turtle abundance or long-term changes in the spatial and temporal distributions of marine mammal and sea turtle populations. The potential for interactions between most species at risk and the Project is limited, although there is greater potential for Project interactions with fin whales. Nonetheless, effects on species at risk are predicted to be temporary, generally low in magnitude given the planned mitigation measures; there is no identified critical habitat in the Project Area or LAA. The Project is therefore not predicted to jeopardize the overall abundance, distribution, or health of species at risk. With mitigation and environmental protection measures, the residual environmental effects on marine mammals and sea turtles (including species at risk) are predicted to be not significant.

11.5 PREDICTION CONFIDENCE

This overall determination is made with a moderate level of confidence given there are several key uncertainties in predicting the effects of the Project on marine mammals and sea turtles. Firstly, there is a paucity of systematic baseline data on marine mammal and sea turtle use of the Project Area. Therefore, there is uncertainty as to whether the Project Area or certain portions of the Project Area are regularly used and important foraging areas, migratory corridors, and/or breeding areas for marine mammals. Another key data gap is the lack of information on marine mammal response to MODUs in Atlantic Canada; limited data from other jurisdictions have been used as a proxy for assessing effects. Data on hearing impairment for marine mammals and particularly sea turtles is limited. Because of these data gaps, there is scientific uncertainty in the frequency and magnitude of residual effects of underwater sound from the MODU, supply vessels, and VSP surveys, on marine mammals and sea turtles. Numerous studies referenced in this EIS show high levels of variability of response to underwater sound from MODU/drillship, vessel, and air gun source activities.

11.6 ENVIRONMENTAL MONITORING AND MONITORING

Suncor will develop a marine mammal and sea turtle monitoring plan to be implemented during VSP surveys as outlined in Section 11.3.1.2. The Plan will include MMO requirements, shutdown, and ramp-up procedures and reporting requirements. The following monitoring and mitigation measures will be implemented:

- MMOs will monitor and report on marine mammal and sea turtle sightings during VSP surveys to implement shutdown and ramp-up procedures.
- A ramp-up procedure will be implemented before any VSP activity begins.
- MMOs will implement a pre-ramp up watch of 60 minutes prior to ramp-up. Ramp-up will be delayed if any marine mammal or sea turtle is detected within 500 m of the air gun array.
- Shut-down procedures will be implemented if a marine mammal or sea turtle listed as endangered or threatened on Schedule 1 of SARA, as well as any beaked whale species, is observed within 500 m of the air gun array.
- Supply vessels will use existing shipping lanes as practicable; where these do not exist, supply vessels will follow a straight-line approach to and from the Project Area.
- During transit to and from the Project Area, supply vessels will travel at vessel speeds not exceeding 22 km/hour (12 knots), except as needed in the case of an emergency.
- If marine mammals or sea turtles are observed the vessel will reduce speed and/or alter course if practicable to avoid a collision.
- Supply vessels will be required to reduce speed to a maximum of 12 km/hour (7 knots) when a marine mammal or sea turtle is observed or reported within 400 m of the supply vessel (except if not feasible for safety reasons). Vessels may also alter course if practicable to avoid collision with a marine mammal (or sea turtle).

A report of the observational program will be submitted annually to the C-NLOPB and DFO, including documentation of marine mammal and sea turtle sightings. In the unlikely event of a Project vessel collision with a marine mammal or sea turtle, Suncor will contact DFO through their 24-hour emergency contact number (1-888-895-3003).

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