# *MODULE 9:*
# MARINE MAMMALS AND SEA TURTLES: OVERVIEW OF POTENTIAL EFFECTS

## 9.1 Introduction

The waters off Eastern Newfoundland support a variety of marine mammal and sea turtle species that are known or considered likely to occur within the Study Area at various times of the year (Module #). These species are often considered to be ecologically, economically and culturally important, and they are managed and protected under the federal *Fisheries Act.* Certain species have been listed and are therefore protected under the *Species at Risk Act* (*SARA*), or have been identified as species of conservation concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). While there is currently no designated critical habitat for marine mammals or sea turtles within the Study Area, the identification and designation of various special areas off Eastern Newfoundland has also been due in part to their use by and importance to these species (Module #).

## 9.2 Planned Drilling Activities and Emissions

Potential interactions between exploratory drilling and associated activities and marine mammals and sea turtles, and possible resulting environmental effects on this Valued Component (VC), include:

- Temporary hearing impairment or permanent injury caused by exposure to very loud and instantaneous underwater noise (such as may be experienced in close proximity to a seismic sound source used during vertical seismic profiling (VSP) surveys) at or above identified threshold levels for such effects.
- Avoidance of certain areas due to underwater noise or other disturbances which can alter the presence, abundance and overall distribution of marine mammals and sea turtles and their movements, feeding and other activity.
- Attraction of individuals to drill rigs or other equipment, resulting in increased potential for injury, mortality or health effects through collisions, contamination or other disturbances.
- Interference with sounds in the marine environment that originate from or are used by marine animals, such as in communication, echolocation, and the identification and detection of predators and prey.
- Potential injury or mortality due to collisions or other interactions with supply vessels.
- Changes in the availability, distribution or quality of food sources or habitats for marine mammals and sea turtles due to emissions and other disturbances (noise, light, liquid and solid waste materials).

The main potential for interactions between offshore exploratory drilling and associated activities this VC relate to underwater noise and other emissions, which are summarized in Table 9.1, may result in physical (injury, mortality or sub-lethal health effects) or behavioural (avoidance, other changes in distribution or activities) effects on marine mammals and sea turtles. These effects may result from direct exposure to these disturbances, the disruption of key life history activities, or from changes in the availability, quality or use of important habitats or food sources used by these species.

An overview of the various effects on marine mammals and sea turtles that may result from these interactions (and their interrelationships) is summarized in Table 9.1 below.

**Table 9.1 Marine Mammals and Sea Turtles: Potential Effects of Planned Drilling Activities and Emissions**

| Potential Effects | Overview |
|---|---|
| 1) Change in Mortality / Injury Levels and Health | • Offshore exploratory drilling and associated activities have the potential to result in mortality, injury or other sub-lethal health effects to marine mammals and sea turtles.<br>• These can result from increased underwater noise within the affected areas at or above published thresholds (see later Table 9.4), which may originate from drill rigs (including their positioning systems) as well as other activities such as VSP.<br>• Supply vessel traffic also has the potential to result in vessel strikes and other interactions with marine mammals and sea turtles.<br>• Other environmental emissions such as the release of waste materials during routine offshore activities may also cause direct contamination of individuals and associated health effects, or can affect food sources or habitats (See #3 and #4 below).<br>• Increased levels of mortality, injury and health effects can have resulting implications for the overall presence, density and diversity of marine mammals and sea turtles in a region (See #2 below). |
| 2) Behavioural Effects and Resulting Changes in Distributions and Activities | • Exposure to increased levels of underwater noise resulting from offshore exploratory drilling and associated activities can result in behavioral effects such as changes in activity, movement, feeding or communication patterns in marine mammals and sea turtles. Underwater noise resulting from such activities may also interfere with or "mask" noises that originate from or are used by marine mammals.<br>• Behavioural effects (attraction or avoidance) may alter the presence, abundance, and overall distribution of marine mammals and sea turtles in the affected area.<br>• These behavioural changes and other interferences can also, in turn, have implications for mortality, injury or health (See #1 above), particularly if these disturbances occur repeatedly or for extended periods of time, if important and sensitive life history stages are disrupted, or if they result in displacement of individuals from important habitats or food sources (See #3 and #4 below). |
| 3) Change in Habitat Use, Availability or Quality | • Offshore exploratory activities and their environmental disturbances can result in the displacement of marine mammals and sea turtles from important habitats due to behavioural (attraction or avoidance) effects (See #2 above), and through effects on habitat quality due to associated environmental disturbances and emissions.<br>• Any changes in the use, availability or quality of habitats have the potential to affect the distribution (See #2 above) of marine mammals and sea turtles in the affected areas, as well as having health effects (See #1 above) due to displacement from or loss of important habitats that result in increased energy expenditure and other effects. |
| 4) Change in Food Availability or Quality | • Routine offshore exploratory activities and their environmental discharges can also lead to changes in the availability, distribution, quantity and quality of food sources, such as fish, for marine mammals and sea turtles.<br>• These increases or decreases in food availability or quality can lead to behavioural effects that could affect the presence, abundance and distribution of marine mammals and sea turtles in an area (See #2 above), as well as potentially affecting the health (See #1 above) of individuals. |

Table 9.2 indicates which of the various components and activities that are associated with offshore exploratory drilling and their associated emissions and disturbances are potential contributors to these effects on this VC.

**Table 9.2 Potential Contributors to Effects on Marine Mammals and Sea Turtles (Planned Components and Activities)**

| Potential Effects | Potential Contributors: Planned Components and Activities | | | | | | | Potential Contributors: Associated Emissions / Disturbances / Interactions | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Drill Rig and Associated Equipment | Well Drilling (Exploration and Delineation) | Vertical Seismic Profiling | Other Survey Activities | Well Evaluation and Testing | Well Abandonment or Suspension | Supply and Servicing (Vessels and Aircraft Use) | Presence and Operation of Drill Rig | Lights, Heat and Noise | Underwater Noise | Air Emissions | Drill Fluids and Cuttings | Other Liquid Discharges | Other Waste Materials |
| 1) Change in Mortality / Injury Levels and Health | • | • | • | | • | | • | | | • | | • | • | |
| 2) Behavioural Effects and Resulting Changes in Distributions and Activities | • | • | • | • | • | • | • | • | | • | | | • | |
| 3) Change in Habitat Availability or Quality | • | • | • | | • | • | • | • | | • | | • | • | |
| 4) Change in Food Availability or Quality | • | • | • | | • | • | • | • | | • | | • | • | |

Table 9.3 summarizes current information and knowledge from the literature and other sources on the nature and degree of these potential effects.

**Table 9.3 Potential Effects on Marine Mammals and Sea Turtles: Summary of Current Knowledge (Planned Components and Activities)**

| Physical Activities/Components | Potential Effects: Summary of Current Knowledge |
|---|---|
| Presence and Operation of Drill Rig | <u>Underwater Sound (Continuous)</u><br>• Operation of an offshore drill rig (including dynamic positioning and drilling activities) typically generates continuous (steady-state), non-impulsive sound that ranges from approximately 130 to 190 dB re 1 µPa at 1 m with a peak frequency range of 10 HZ to 10,000 Hz (Hildebrand 2005; OSPAR 2009; MacDonnell 2017).<br>• There are several concerns for animals exposed to elevated noise levels including temporary or permanent hearing impairment, acoustic masking (e.g., sound covers a desired signal) and behavioural disturbance (Nowacek et al. 2007). In general, the effect of noise on the animal depends to a large degree on the proximity of the animal to the noise source and the received level of the signal by the animal (NRC 2003). Acoustic modelling is often conducted during drilling environmental assessments to predict received sound levels and zones of influence for effects relative to established effects thresholds (e.g., NMFS 2016; Southall et al. 2007).<br>• Exposure to noise with sufficient duration and sound pressure level may result in a loss of hearing sensitivity (noise-induced threshold shift [NITS]). If the hearing threshold eventually returns to normal, the NITS is called a temporary threshold shift (TTS); if thresholds remain |

<table>
<tr><th>Physical Activities/Components</th><th>Potential Effects: Summary of Current Knowledge</th></tr>
<tr><td></td><td>
elevated after some extended period of time, the remaining NITS is called a permanent threshold shift (PTS) (Finneran 2016). TTS can last from minutes or hours to days depending upon the species involved, as well as the magnitude, frequency range, and duration of the noise source (Richardson et al. 1995a; Kastelein et al. 2016).<br>
<u>Effects on Marine Mammals – Physical Injury</u>
<ul>
<li>Based on acoustic level thresholds for permanent injury (e.g., Permanent Threshold Shift [PTS] onset) in marine mammals and sound source levels for drill rigs, most species are unlikely to experience injury from the sound produced by drill rigs. However, cetaceans with high frequency hearing (e.g., porpoises) are at a slightly higher risk of incurring PTS at lower threshold values for non-impulsive sounds.</li>
<li>Table 9.4 presents suggested sound exposure thresholds for marine mammals and sea turtles for impulsive (e.g, seismic) and non-impulsive (e.g., shipping, drilling) sounds. Given that these cetaceans would have to remain in close proximity to the sound source in order to maintain this received sound level threshold for 24 hours to sustain injury and that behavioural effects (which can include avoidance behaviour) are predicted to occur at lower thresholds, continuous exposure and resulting injury is unlikely to occur.</li>
</ul>
<u>Effects on Marine Mammals – Communication Masking and Behavioural Effects</u>
<ul>
<li>Marine mammals use and produce sounds both passively and actively to communicate, navigate, locate prey and predators, and to gather information about their surroundings (NRC 2003; Nowacek et al. 2007; Tyack 2008; Erbe et al. 2015). These sounds may be “masked” or interfered with by anthropogenic sources, particularly when their frequency ranges overlap (Richardson et al. 1995a; Erbe et al. 2015). Sounds important to toothed whales and pinnipeds (seals) are predominantly higher than the low-frequency sounds of the drill rig, therefore the potential for masking for these animals is lower.</li>
<li>Behavioural response to sound by marine mammals, if any, can range widely based on a variety of factors and can be difficult to predict in absence of site and context-specific data. In addition to sound pressure level and other properties (e.g., frequency, duration), habituation, the physical and behavioural state of the animals when exposed to the sound source, and the ambient acoustic and ecological features of the environment can also influence behavioural response (Richardson et al. 1995a; Hildebrand 2005).</li>
<li>Documented behavioural effects of marine mammals to underwater sound (including non-impulsive and impulsive [e.g., seismic] sounds) include displacement and avoidance of habitats (Tyack 2008; Weir 2008; Castellote et al. 2012); changes in vocalizations (NRC 2003; Parks et al. 2007; Holt et al. 2009; DiIorio and Clark 2010; Risch et al. 2012); changes in respiration, swim speed, diving, and foraging behaviour (Stone and Tasker 2006; Nowacek et al. 2007; Southall et al. 2007); increased stress and immune depression (Wright et al. 2007a, 2007b, 2011); and in rare cases, strandings (Weilgart 2007).</li>
<li>There are limited studies examining effects of marine mammals in response to sounds produced by a drill rig. Based on observations of beluga whales to playback of oil drilling sounds, Stewart et al. (1983) concluded that direction of whale movement and general activity (feeding, traveling) was not greatly affected by these sounds, especially if the sound source was constant. Malme et al. (1984) observed changes in swimming speed and deflection up to 3 km from drill rigs by gray whales during migration offshore California. Ringed seals have been often observed near drillships in the Arctic in summer and fall (Richardson et al. 1995b).</li>
</ul>
<u>Effects on Sea Turtles - Physical, Physiological and Behavioural Effects</u>
<ul>
<li>Although there are no known studies documenting sea turtle response to drill rigs, sea turtles have been shown to exhibit short-term physical, physiological and behavioural effects as a result of sound-related disturbances (McCauley et al. 2000). Sea turtles appear</li>
</ul>
</td></tr>
</table>

| Physical Activities/Components | Potential Effects: Summary of Current Knowledge |
|---|---|
| | to be most sensitive to low-frequency sounds, such as those produced by an operating drill rig (Ketten and Bartol 2005). |
| Vertical Seismic Profiling (VSP) | <u>Underwater Sound (Impulsive)</u><br>• Seismic surveys generate short duration broadband impulse sounds with high peak source levels (220–255 dB re 1 µPa peak at 1 m) (Nowacek et al. 2007). Typically, the sounds associated with both commercial and research airguns occur repetitively every 10 to 20 seconds over a time span of days to several weeks, with occasional interruptions (Nieukirk et al. 2004).<br>• The size and total volume (and therefore energy output) of the source array used for VSP are typically smaller than those used in a traditional offshore seismic survey and VSP operations occur over much shorter time frames (days instead of weeks). However, most of the available knowledge on the effects of VSP sound on marine mammals is derived from studies on traditional two-dimensional or three-dimensional seismic surveys.<br>• The frequency, duration of the exposure, and occurrence of gaps between individual sound signals within the period of exposure can influence the auditory effect of impulsive sounds (Nowacek et al. 2007; Kastelein et al. 2016).<br>• Potential biological effects of air gun noise include physical/physiological effects, behavioral disruption, and indirect effects associated with altered prey availability (Gordon et al. 2004).<br>• There is no evidence that seismic programs can cause serious injury, death, or stranding of marine mammals or sea turtles when exposed to sequences of airgun pulses under realistic field conditions even in the case of large airgun arrays (DFO 2004; Abgrall et al. 2008).<br><u>Effects on Marine Mammals – Communication Masking and Behavioural Effects</u><br>• As discussed above for the non-impulsive, steady-state sounds associated with the operation of the drill rig, physical and behavioural effects in response to seismic sound have been shown to be highly variable among species and across a range of activities and environmental conditions (Stone and Tasker 2006; Weilgart 2007; Miller et al. 2009). Immediate behavioral reactions to exposure to seismic sound have been widely documented in marine mammals (e.g., avoidance behaviour, change in vocalizations). However possible longer-term consequences of short-term behavioral changes (DFO 2004) and potential significance of these changes on a population level (Pirotta et al. 2014) remain a topic of debate and research.<br>• Studies have shown variable responses of odontocetes to seismic sound, with some showing no evidence of displacement (Lee et al. 2005; Moulton and Holst 2010), and others showing some level of avoidance (Stone and Tasker 2006; Weir 2008).<br>• Baleen whales have been shown to respond to intense sound pulses from sound source arrays including limited avoidance behaviour (Malme et al. 1985; Richardson et al. 1986) or in some cases (particularly in response to larger source arrays), a much broader deviation or disruption of feeding behaviours (Miller et al. 1999; Gordon et al. 2004; Stone and Tasker 2006; Abgrall et al. 2008; Moulton and Holst 2010).<br>• Based on observations from over 200 seismic surveys in UK and adjacent waters, Stone and Tasker (2006) generalized that small odontocetes showed the strongest lateral spatial avoidance (extending at least as far as the limit of visual observation) in response to active airguns, while mysticetes and killer whales showed more localised spatial avoidance. Long-finned pilot whales showed only a change in orientation and sperm whales showed no statistically significant effects. These varied results suggest that different taxonomic groups of cetaceans may adopt different strategies for responding to acoustic disturbance from seismic surveys (Stone and Tasker 2006).<br>• Several studies have examined the potential for communication masking in marine mammals by seismic sounds (Nieukirk et al. 2012; Blackwell et al. 2015, Erbe et al. 2015), and documented associated behavioural effects such as a decrease in vocalizations (Pirotta |

| Physical Activities/Components | Potential Effects: Summary of Current Knowledge |
|---|---|
| | et al. 2014; Blackwell et al. 2015) or modification to calling rates (e.g., changing calling rates or peak frequencies) (Di Iorio and Clark 2010; Blackwell et al. 2015). It has been suggested that species utilizing low frequency ranges (such as baleen whales) are particularly sensitive to masking (Clark et al. 2009) although the discontinuous nature of seismic pulses makes significant masking effects unlikely even for baleen whales (Abgrall et al. 2008).<br>• Seals tend to be less responsive to air gun sound than many cetaceans with most monitoring studies documenting little to no avoidance behaviour around a seismic sound source array (Lawson and Moulton 1999; Harris et al. 2001; Southall et al. 2007).<br><u>Effects on Sea Turtles</u><br>• There are fewer studies on the effects of seismic sounds on sea turtles (Nelms et al. 2016), although studies on hearing sensitivity for sea turtles indicate they are able to detect low frequency sounds (Dow Piniak et al. 2012; Martin et al. 2012), which suggests that their hearing ranges overlap with the peak amplitude, low frequency sound emitted by seismic airguns.<br>• Various studies have documented behavioural effects from seismic sound on sea turtles including changes in swimming patterns, diving and overall avoidance responses (McCauley et al. 2000; Weir 2007; DeRuiter and Doukara 2012) although most studies also acknowledge that study limitations and an inadequate understanding of sea turtle behaviour at sea make it difficult to draw firm conclusions about effects and their significance (Nelms et al. 2016).<br><u>VSP Monitoring</u><br>• Visual and acoustic monitoring for marine mammals and sea turtles during VSP surveys for exploration wells drilled offshore Nova Scotia revealed no marine mammal or sea turtle detections during the VSP survey that required implementation of ramp-up delays or air source shutdowns (LGL and JASCO Applied Sciences 2016, 2017). However, an unidentified whale was observed approximately 5 km away during airgun activity during one VSP survey in September 2016 (LGL and JASCO Applied Sciences 2016). |
| Well Drilling and Associated Marine Discharges | • There is no readily available literature on the effects of drilling and associated marine discharges on marine mammals and sea turtles. Refer to the *Literature Table for Marine Fish and Fish Habitat* for potential effects on prey species including results of environmental effects monitoring which demonstrate little to no toxicity of discharges to marine fish. |
| Well Evaluation and Testing | • During formation flow testing, produced water may be discharged in small volumes (if not sent to the flare for disposal).<br>• Water quality monitoring of produced water discharges at the Sable Offshore Energy Project (SOEP) found produced water was highly diluted within 5 m of the discharge caisson and no toxic results were observed in water column samples collected adjacent to the platform (CNSOPB 2018a).<br>• As a natural gas production project, SOEP generates less produced water and oil-in-produced water than the production of crude oil (CNSOPB 2018a) so although still an over-representation of the volumes of produced water that may be discharged during well evaluation and testing for an exploration drilling program, these environmental effects monitoring results are more applicable than other east coast operations. |
| Supply and Servicing (Vessel and Helicopter Use) | • The operation of marine vessels (e.g., supply vessels) can affect marine mammals and sea turtles through exposure to underwater sound and/or vessel strikes.<br><u>Vessel Use - Underwater Noise</u><br>• Sound from vessel traffic can be a source of chronic stress for marine mammal populations (Rolland et al. 2012) and in some cases, reduce the effectiveness of marine mammal communication through masking (Clark et al. 2009; Erb et al. 2016; Putland et al. 2017) (see above for more information on communication masking by continuous, non-impulsive sounds). |

| Physical Activities/Components | Potential Effects: Summary of Current Knowledge |
|---|---|
| | • Baleen whales are thought to be more sensitive to the low frequency sound produced by vessels. However, they, like toothed whales, have shown a wide range of reactions to vessel traffic. Some studies have shown no response to vessels (Nowacek et al. 2004), while other studies have documented cetaceans and seal species adjusting their movement behaviour around ships (Würsig et al. 1998), modifying their vocal patterns (Lesage et al. 1999; Clark et al. 2009; Castellote et al. 2012) and/or modifying diving and foraging patterns (Lesage et al. 2017).<br>Vessel Use – Risk of Injury or Mortality<br>• Several cetacean species are susceptible to injury or mortality from direct collisions with vessels (Laist et al. 2001; Williams and O'Hara 2010; Jensen and Silber 2003; Vanderlaan and Taggart 2007), with fin, right, and humpback whales being the most reported species hit (Laist et al. 2001; Jensen and Silber 2003).<br>• Reducing the spatial overlap between high numbers of cetaceans and vessels (Cates et al. 2017) and reduction of vessel speeds have been shown to reduce the number of marine mammal deaths and severe injuries due to vessel strikes (Vanderlaan and Taggart 2007; Vanderlaan et al. 2008, 2009; van der Hoop et al. 2012). Lethal strikes are considered infrequent at vessel speeds less than 14 knots and rare at speeds less than 10 knots (Laist et al. 2001).<br>• There are few studies on sea turtle reactions to vessels although propeller and collision injuries from ships in US waters are common (Schwartz 2009). Hazel et al. (2007) demonstrated the proportion of green sea turtles maneuvering to avoid a vessel decreased with increased vessel speed, suggesting turtles may not avoid faster moving vessels.<br>Helicopter Use<br>• Transmission of sound from helicopters into the marine environment is related primarily to the altitude and sea surface conditions (Richardson et al. 1995a). Helicopter sound frequencies are mainly below 500 Hz, with sounds most intense just below the water surface and directly beneath the aircraft, attenuating over shorter distances underwater than in the air (Richardson et al. 1995a).<br>• Behavioural responses of cetaceans to aircraft noise can include diving, reduced surfacing periods, and breaching (Patenaude et al. 2002; Luksenburg and Parsons 2009), and reactions can depend on the animal's activity at the time of exposure (Würsig et al. 1998; Luksenburg and Parsons 2009).<br>• Based on observations of bowhead whales during spring migration in Alaska, Richardson et al. (1995b) concluded that while some bowheads exhibited short-term behavioral reactions, single helicopter overflights at altitudes of 150 m (or below) did not appear to disrupt the distribution, movements or behavior of bowheads visible during spring migration in a biologically significant way. |
| Well Abandonment or Suspension | • Well abandonment and decommissioning could cause localized effects on habitat quality and use for marine mammals and sea turtles, depending on specific activities undertaken.<br>• If the wellhead is removed using mechanical means (e.g., cutting), there will be temporary and localized underwater sound and light emissions.<br>• If a mechanical cutter cannot be used, an explosive charge may be used to sever the wellhead from the seabed. Reactions of marine mammals to underwater explosives range from no obvious behavioral reaction (Todd et al. 1996) to a transitory effect on behaviour (Continental Shelf Associates Inc. 2003).<br>• Various models have been used to predict safe distances from explosions to marine mammals. In the Gulf of Mexico, the NMFS ruled on the use of explosives to remove offshore oil and gas structures setting a radius of effect for injury to be 915 m (Continental Shelf Associates, Inc. 2003). In Canada, the Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters state no explosive is to be knowingly detonated within 500 m |

| Physical Activities/Components | Potential Effects: Summary of Current Knowledge |
|---|---|
| | of any marine mammal (or no visual contact from an observer using 7x35-power binocular) (Wright and Hopky 1998) and the Drilling and Production Guidelines establish a 1 km buffer for marine mammals for explosive operations (C-NLOPB and CNSOPB 2017).<br>• There is very little data on the specific effects of explosives on sea turtles (Viada et al. 2008; Popper et al. 2014) although there have been documented injuries and mortalities of a small number of sea turtles as a result of explosives use for removal of offshore oil and gas structures in the Gulf of Mexico (Klima et al. 1988; Gitschlag and Herczeg 1994).<br>• If the wellhead is left in place after the well is decommissioned, the structure may serve as a hard substrate for colonization by potential prey for marine mammals. |

As illustrated above, underwater noise emissions are a key area of concern with respect to the possible effects of offshore oil and gas related activities on marine mammals and sea turtles. Although there are currently no formal guidelines or regulatory thresholds for protection of marine mammals and sea turtles from the effects of underwater sound in this jurisdiction, there are recent and generally accepted thresholds presented in the literature, of which the United States NOAA National Marine Fisheries Service (NMFS) guidelines (NFMS 2016) are the most commonly used.

The NOAA guidelines provide threshold levels for both peak sound pressure levels (SPLpeak) and 24-hour cumulative sound exposure levels (SELcum), with the onset of injury (PTS) assumed to occur when sound exposure exceeds either criterion. Guidelines are provided for both impulse and non-impulse noise sources. Thresholds vary for high-frequency cetaceans (such as porpoises), mid-frequency cetaceans (including toothed whales and dolphins) and low-frequency cetaceans (baleen whales) as well as for pinnipeds (seals) (Table 9.4). In addition, previous guidance from the NOAA also provides sound pressure level thresholds for broadband underwater noise levels that may cause behavioural disruption of marine mammals (NOAA n.d.).

**Table 9.4 Acoustic Threshold Levels and Sound Exposure Guidelines for Marine Mammals and Sea Turtles[1]**

| Guideline / Threshold Type | Source | Effect | Cetaceans | | | Pinnipeds | | Sea Turtles |
|---|---|---|---|---|---|---|---|---|
| | | | Low-frequency | Mid-frequency | High-frequency | Otariid | Phocid | |
| Impulsive Sound (dB $SPL_{peak}$)[2] | NMFS (2016) | PTS | 219 | 230 | 202 | 232 | 218 | n/a |
| | NOAA (n.d.) | Behavioural | 160 | | | | | n/a |
| | Popper et al. (2014) | Mortality and Potential Mortal Injury | n/a | | | | | >207 |
| | | Behavioural | n/a | | | | | Risk of behavioural effect is high in near field (10s of metres from source), moderate in intermediate field (100s of metres) and low in far field (1000s of metres) |
| Impulsive Sound (dB $SEL_{cum}$)[3] | NMFS (2016) | PTS | 183 | 185 | 155 | 203 | 185 | n/a |
| | Popper et al. (2014) | Mortality and Potential Mortal Injury | n/a | | | | | 210 |
| Non-Impulsive Sound (dB $SPL_{peak}$)[2] | NMFS (2016) | PTS | No threshold defined | | | | | n/a |
| | NOAA (n.d.) | Behavioural | 120 | | | | | n/a |
| | Popper et al. (2014) | Mortality and Potential Mortal Injury | | | | | | No quantitative threshold; risk is low for near, intermediate and far field exposure |
| | | Behavioural | | | | | | Risk of behavioural effect is high in near field, moderate in intermediate field, and low in far field |
| Non-Impulsive Sound (dB $SEL_{cum}$)[3] | NMFS (2016) | PTS | 199 | 198 | 173 | 219 | 201 | n/a |

Notes:

1. In absence of formal guidelines or regulatory thresholds, these threshold levels and sound exposure guidelines are generally accepted and commonly used to evaluate environmental effects associated with sound exposure.
2. dB (decibel) $SPL_{peak}$ has a reference value of 1 µPa.
3. 24 hour cumulative sound exposure; dB $SEL_{cum}$ has a reference value of 1 µPa2-s

Source: Modified from Nexen (2018)

## 9.3 Unplanned Events

As described in Module #, various species of marine mammals and sea turtles have been reported in the Study Area, including several that are considered to be at risk or otherwise of special conservation concern. Therefore, there is the potential for them to be present during, and thus affected by, an accidental event. Overall abundance of marine mammals is highest from late spring to autumn, but some species may be present year-round.

Accidental events such as oil spills can lead to changes in their presence, abundance, distribution and/or health of marine mammals and sea turtles. These biota may experience a change in mortality or injury (acute or immediate effects) if directly exposed to accidentally released hydrocarbons or associated volatiles and aerosols. They may experience a change in health (sub-lethal effects) from direct contact with hydrocarbons or consumption of contaminated prey. As outlined in Section 9.2, the main potential effects on this VC include:

- Change in mortality / injury levels and health
- Behavioural effects and resulting changes in distributions and activities
- Change in habitat availability or quality
- Change in food availability or quality

Table 9.5 summarizes current information and knowledge from the literature and other sources on the nature and degree of the potential effects of accidental events on marine mammals and sea turtles.

**Table 9.5 Potential Effects on Marine Mammals and Sea Turtles: Summary of Current Knowledge (Unplanned Events)**

| Potential Accidental Event | Potential Effects: Summary of Current Knowledge |
|---|---|
| Oil Spills (Batch Spills and Blowouts) | Effects on Marine Mammals<br>• While there is some evidence suggesting that marine mammals may be able to detect oil spills and adjust their activities in response to them (Smultea and Würsig 1995; Ackleh et al. 2012), most species do not consistently exhibit avoidance behaviours (Geraci and St. Aubin 1980; St. Aubin et al. 1985; Matkin et al. 2008; Dias et al. 2017) and therefore become exposed to floating oil.<br>• The main pathways for effects of oil spills on marine mammals are dermal exposure (i.e., external coatings of oil on fur, baleen, skin), ingestion, and inhalation (Helm et al. 2015).<br>• Direct contact with oil can cause irritation (particularly in sensitive membranes of the eyes and mouth) (Geraci and St. Aubin 1988; Dias et al. 2017) and coat baleen, causing a reduction in feeding efficiency of baleen whales (Geraci and St. Aubin 1980).<br>• Although oil exposure has less of an effect on thermoregulation for cetaceans that rely on blubber for insulation, aquatic mammals that rely on fur for insulation (e.g., fur seals) face the same issues of acute mortality due to thermoregulatory failure as do birds, with even a light oiling potentially leading to serious heat loss and the risk of death by hypothermia or starvation(French-McCay 2009; Lee et al. 2015).<br>• Cetaceans may also ingest oil with water or by consuming contaminated prey, which can be absorbed into the tissues and have toxic effects (Ross et al. 2000). Although ingested oil may be metabolized and excreted, some is stored in blubber and other fat deposits (Lee et al. 2015).<br>• The greatest risk for most cetaceans from an oil spill is through inhalation of oil and petroleum vapours since inhalation and aspiration of oil compounds can result in inflammation and possible absorption of hydrocarbons into the bloodstream (Helm et al. 2015). |

| Potential Accidental Event | Potential Effects: Summary of Current Knowledge |
|---|---|
| | • Although there may be a lack of direct evidence of long-term effects resulting from hydrocarbon contact or ingestion, long-term studies have implicated oil spills with mortality of cetaceans (Dahlheim 1994; Matkin et al. 2008) including the Deepwater Horizon oil spill which has been blamed for the largest and longest marine mammal unusual mortality event ever recorded in the Gulf of Mexico (Litz et al. 2014; Wallace et al. 2017).<br>Effects on Sea Turtles<br>• Sea turtles do not necessarily avoid oiled areas (Milton et al. 2010; Vander Zanden et al. 2016) and like marine mammals, they are at risk of adverse effects from oil spills through dermal exposure, ingestion and inhalation.<br>• Since sea turtles surface to breathe and take large inhalations prior to diving, they may be particularly susceptible to oiling and inhalation of hydrocarbons and associated effects (Vargo et al. 1986; Ylitalo et al. 2017).<br>• Sea turtle consumption of oiled prey can lead to toxicological effects including mortality (Vargo et al. 1986; Mitchelmore et al. 2017). Sea turtles have also been known to ingest tar balls (Milton et al. 2010; Shigenaka 2010) which can also lead to mortality through starvation from gut blockage, decreased absorption efficiency, absorption of toxins, effects of general intestinal blockage, interference with fat metabolism, and buoyancy problems caused by the buildup of fermentation gases (Milton et al. 2010).<br>• Since the 2010 Deepwater Horizon oil spill, an increase in sea turtle mortality rates have been recorded. Although the cause of death is still being investigated, it is suspected that exposure to oil is contributing factor (Dupuis and Ucan-Marin 2015). |
| Drill Fluids (SBM) Spill | • SBM is a dense, low toxicity fluid, which sinks rapidly through the water column (Neff et al. 2000; CNSOPB 2005, 2018b).<br>• There is no available literature on effects of SBM spills on marine mammals or sea turtles. |

## 9.4 References


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