Regional Assessment of Offshore Wind Development in Nova Scotia Committee Briefing: Potential Impacts of OSW Farms on Marine Mammals and Sea Turtles

Purpose

The purpose of this briefing document is to provide information on marine mammals and sea turtles and the latest research findings that are either directly or indirectly related to offshore wind development and could be relevant to the Regional Assessment.

Background

Overall, there is uncertainty regarding the potential impacts of offshore wind development, operation, and decommissioning on marine mammals and sea turtles. More information is needed to help us better understand the potential short-term and long-term impacts of this industry on species at risk, as well as the cumulative effects of these activities on marine mammals in the context of stressors already present in the marine environment. This is especially relevant to Nova Scotia, where no offshore wind currently exists. Monitoring and follow-up studies are needed to validate potential impact predictions on marine mammal and sea turtle species.

Table 1 below provides a summary of the current understanding of impact pathways to marine mammals and sea turtles, as well as what those potential impacts are.

Table 1. Potential impacts to marine mammals and sea turtles from OSW development

Impact	Description	OSW Development Phase
Sonar/Acoustic Seafloor Mapping	• Technologies are used for penetrating the seafloor and can introduce sound into the water column, which may cause behavioural impacts in some species (CSA, 2021). • There are several concerns for animals exposed to elevated noise levels including temporary or permanent hearing impairment, acoustic masking, and behavioural disturbance (Nowacek et al., 2007; Kaldellis et al., 2016; NYSERDA, 2017f; Erbe et al., 2019; SEER, 2022). • Behavioural effects of marine mammals to underwater sound include displacement and avoidance of habitats, changes in vocalizations, changes in respiration, swim speed, diving, and foraging behaviour, increased stress and immune depression, and in rare cases, strandings (Tyack, 2008; Weir, 2008; Castellote et al., 2012; NRC, 2003; Parks et al., 2007; Holt et al., 2009; Di Iorio & Clark, 2010; Risch et al., 2012; Stone & Tasker, 2006; Nowacek et al., 2007; Southall et al., 2007; Wright et al., 2007a, 2007b, 2011; Weilgart, 2007). • Although there are no known studies documenting sea turtle response to offshore wind farms, 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). Auditory studies suggest that sea turtles, specifically loggerhead and green turtles, are capable of hearing and responding to low frequency sound, but their hearing threshold appears to be high (DFO, 2004).	Pre-construction
Seismic (Streamer) Surveys	• Potential biological effects of air gun noise include physical/physiological effects, behavioral disruption, and indirect effects associated with altered prey availability (Gordon et al., 2003). • 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). • 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 and potential significance of these changes on a population level remain a topic of debate and research ((DFO, 2004; Pirotta et al., 2014). • Studies have shown variable responses of odontocetes (toothed whales) to seismic sound, with some showing no evidence of displacement and others showing some level of avoidance (Lee et al., 2005; Moulton & Holst, 2010; Stone & Tasker, 2006; Weir, 2008). • Mysticetes (baleen whales) have been shown to respond to intense sound pulses from sound source arrays including limited avoidance	Pre-construction

	behaviour or in some cases, a much broader deviation or disruption of feeding behaviours (Malme et al., 1985; Richardson et al. 1986; Miller et al., 1999; Gordon et al., 2003; Stone & Tasker, 2006; Moulton & Holst, 2010). • Based on observations from over 200 seismic surveys in UK and adjacent waters, 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 (Stone & Tasker, 2006). • Several studies have examined the potential for communication masking in marine mammals by seismic sounds and documented associated behavioural effects such as a decrease in vocalizations or modification to calling rates (e.g., changing calling rates or peak frequencies). It has been suggested that species utilizing low frequency ranges (such as baleen whales) are particularly sensitive to masking (Clark et al., 2009; Nieukirk et al., 2012; Blackwell et al., 2013, Erbe et al., 2015; Cerchio et al., 2014; Pirotta et al., 2014; Blackwell et al., 2015; Di Iorio & Clark, 2010; Blackwell et al., 2015). • 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 & Moulton, 1999; Harris et al., 2001; Southall et al., 2007). • There are fewer studies on the effects of seismic sounds on sea turtles, although studies on hearing sensitivity for sea turtles indicate they are able to detect low frequency sounds, which suggests that their hearing ranges overlap with the peak amplitude, low frequency sound emitted by seismic airguns (Nelms et al. 2016; Dow Piniak et al., 2012; Martin et al., 2012), . • Various studies have documented behavioural effects from seismic sound on sea turtles including changes in swimming patterns, diving and overall avoidance responses 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 (O'Hara & Wilcox, 1990; McCauley et al., 2000; Lenhardt, 2002; Weir, 2007; DeRuiter & Doukara, 2012; Weilgart et al., 2013; Nelms et al., 2016). • There is some evidence that chronic exposure from long-term consequences of sound pollution could affect marine mammals by changing prey accessibility (Gordon et al., 2003).	
Presence of Vessels and Equipment	• The operation of marine vessels (e.g., research vessels, supply vessels) can affect marine mammals through exposure to underwater sound and/or vessel strikes (Erbe et al., 2019). • Marine mammal species that conducts surface-level activities (resting, foraging, nursing, migrating, and socializing) or that conduct shallow-diving are at higher risk of vessel collisions and often result in sharp force trauma, such as propeller injury (NMFS & USFWS 2008; Moore et al. 2013; SEER 2022).	Pre-construction/ Construction

	- Sound from vessel traffic can be a source of chronic stress for marine mammal populations and in some cases, reduce the effectiveness of marine mammal communication through masking (Rolland et al., 2012; Clark et al., 2009; Erbe et al., 2015; Putland et al., 2017; CSA, 2021) - 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, while other studies have documented cetaceans and seal species adjusting their movement behaviour around ships and/or modifying their vocal patterns (Nowacek et al., 2004; Würsig et al., 1998; Lesage et al., 1999, 2017; Clark et al., 2009; Castellote et al., 2012). - Several cetacean species are susceptible to injury or mortality from direct collisions with vessels, with fin, right, and humpback whales being the most reported species hit (Laist et al., 2001; Jensen & Silber, 2003; Vanderlaan & Taggart, 2007; Williams & O'Hara, 2010). - There are few studies on sea turtle reactions to vessels although propeller and collision injuries from ships in US waters are common. A study 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 (Schwartz, 2009; Hazel et al., 2007). - Transmission of sound from helicopters into the marine environment is related primarily to the altitude and sea surface conditions. Behavioural responses of cetaceans to aircraft noise can include diving, reduced surfacing periods, and breaching, and reactions can depend on the animal's activity at the time of exposure (Richardson et al., 1995a).	
Installation of Turbines and Associated Foundations / Anchors	- Non-lethal and non-injury causing noise levels and pressure waves can elicit avoidance reactions from marine animals, such as startling, hiding, or fleeing. There is evidence for behavioral avoidance in harbor porpoises during pile driving. These effects do not appear to be permanent because porpoises have also been observed returning to an area after pile driving ceased (Carstensen et al., 2006; Dähne et al., 2013). - Marine mammals use their auditory systems for communication, orientation, and locating prey and underwater noise can cause nonauditory injury, hearing loss, auditory masking, or behavioural disturbance in marine mammals and sea turtles (Kaldellis et al., 2016; NYSERDA, 2017f; Erbe et al., 2019; SEER, 2022). - Based on their call frequencies, the North Atlantic right whale, blue whale, humpback whale, and fin whale, may be of greater concern are considered to be sensitive to the low frequency sounds produced during pile driving (Board & NRC, 2005; Madsen et al., 2006; Southall et al., 2007; Bailey, Brookes, & Thompson, 2014). - Sea turtles may be able to detect the high-intensity, low-frequency sounds associated with construction and pile-driving over large temporal or spatial scales (Dow Piniak et al., 2012).	Construction

	• Visual and spatial disturbance from foundation installation has the potential to cause marine mammals to exhibit avoidance behavior at windfarm sites because of increased noise and vibration from installation activities, such as pile driving (DONG Energy et al., 2006; Anderson, 2011; Dähne et al. 2013; Verfuss et al., 2015). • Benthic disturbances during construction activities are associated with seafloor foundation installation will result in temporary, localized increases in sediment suspension within the water column, which will increase turbidity may decrease feeding efficiency for marine mammals causing avoidance behaviours (Stantec, 2022).	
Installation of Cables / Cable Protection	• Subsea power cables may potentially emit EMF that can interfere with some marine animals that detect naturally occurring electric/or magnetic fields for essential life functions. Avoidance behaviours may be elicited from higher-strength EMFs while lower-strength EMFs may attract other electrosensitive species, as these could mimic the EMFs from prey (Taormina et al., 2020; NYSERDA, 2017f). • The physical interactions between cable-induced EMF and naturally occurring EMF are poorly understood; however, it is possible that EMF from subsea cables may impact some species' ability to use natural EMF cues (Taormina et al., 2020). • Benthic disturbances during construction activities are associated with cable burying that will result in temporary, localized increases in sediment suspension within the water column, which will increase turbidity and may decrease feeding efficiency for marine mammals and sea turtles causing avoidance behaviours (Stantec, 2022).	Construction
Operation of Wind Turbines	• During the operation phase, OSW farms can produce nearly continuous underwater noise at relatively low amplitudes that vary with the wind speed and turbine size; however, operational noise from turbines does not significantly exceed natural noise levels (Stantec, 2022). • Depending on size and wind speed such noise may mask communication among certain species and result in permanent avoidance of the affected area (Dow Piniak et al., 2012; Kaldellis et al., 2016; SEER, 2022). • Sea turtles detect sounds underwater and in air with auditory sensitivity overlapping with frequencies and source levels produced by low-frequency anthropogenic sources such as drilling, pile driving, and operating wind turbines and vessels (Dow Piniak et al., 2012). • Artificial lighting present during the operational phase of OSW projects are considered low risk for marine mammals. Artificial lighting has not been shown to disturb sea turtle behaviour regardless of light colour or intermittent flashing lights with a very short on-pulse and a long off-interval. However, some marine and sea turtle species may be attracted to structures for foraging opportunities if fish or plankton are attracted to light sources (Orr et al., 2013; Stantec, 2022).	Operations

	• The operation of wind turbines has no significant negative effect on marine mammal abundance and distribution especially compared to impacts from other more common anthropogenic and natural noise sources (Madsen et al., 2006; Verfuss et al., 2015). • Beneficial effects from offshore wind project installation and operations include creating habitat comparable to artificial reefs, with increased biodiversity, abundance, and biomass, as well as providing enhanced foraging opportunities and refuge areas for many species of marine mammals (ICF, 2020).	
Presence of Subsea Infrastructure (including foundations and cables)	• Subsea power cables may potentially emit EMF that can interfere with some marine animals that detect naturally occurring electric/or magnetic fields for essential life functions. Avoidance behaviours may be elicited from higher-strength EMFs while lower-strength EMFs may attract other electrosensitive species, as these could mimic the EMFs from prey (NYSERDA 2017f; Taormina et al., 2020). • Floating OSW farm cable systems can result in secondary entanglement of marine debris that becomes snagged. Secondary entanglement poses a threat to cetaceans, sea turtles and marine mammals (Taormina et al., 2020; Maxwell et al., 2022; SEER, 2022). • Visual and spatial disturbance from increased vessel activity, foundation installation, and ongoing maintenance activities has the potential to cause marine mammals to exhibit avoidance behavior at windfarm sites (CSA, 2021). • Primary entanglement caused by floating OSW farm cable systems is of low risk to marine mammals and sea turtles because mooring lines and cables are large in diameter and sufficiently heavy enough to prevent entangling these species (SEER, 2022). • Marine mammals, such as harbor seals and harbor porpoises, are attracted to foundations to forage, and sea lions may use them as a source of shelter (Lindeboom et al. 2011; Russell et al., 2014, as cited in English et al., 2017). • Several studies suggest that sea turtles associate with and use foreign underwater structures such as artificial reef-like structures and offshore oil rigs for foraging, including loggerhead sea turtles (Lohoefener et al., 1990; Gorham et al., 2014; ICF 2020). • Attraction effects from foundations are likely beneficial to marine mammals due to the improved feeding opportunities and available roosting and resting areas. Turbine foundations with larger surface areas may offer greater beneficial effects, as well as larger structure volumes creating larger wakes may also offer greater beneficial effects (ICF, 2020).	Operations
Removal of Turbines and Foundations	• The decommissioning phase involves the use of support vessels to dismantle the various components of an OSW farm and can generate noise levels that could disturb marine mammals (Maxwell et al., 2022). • There is potential for masking, displacement, physiological stress, and other impacts during the decommissioning phase, especially if marine life is aggregated in habitats around OSW farm foundations (Bailey, Brookes, & Thompson, 2014; Maxwell et al., 2022).	De-commissioning

	• The sound pressure levels of water jets used to cut a steel pile mast during the decommissioning of a British wind turbine. Peak sound pressure levels could be quite high (198–199 dB re 1 µPa) at distances of 10–50 m from the source. The majority of this acoustic energy was between 250 Hz and 1,000 Hz. It is difficult to predict whether disturbances occurred, yet there is certainly the potential for masking, displacement, physiological stress, and other factors, especially if they are aggregated in habitats around a wind farm pile or foundation (Mooney et al., 2020).	

Mitigation Measures

- Exclusion zones around vessels. Operators must establish an “acoustic exclusion zone” for geophysical surveys, so that the zone is clear of any marine mammals and sea turtles for a certain amount of time before acoustic sound sources can be operated.
- Visual monitoring by trained third-party, independent Protected Species Observers, that look for marine mammals so that the possibility of vessel strikes is minimized and to shut down any sound sources if marine mammals are detected within a certain distance.
- Independent reporting by Protected Species Observers during geophysical surveys. Any interactions with protected species are immediately reported to NOAA Fisheries and BOEM.
- Careful selection of cable routes and cable burial methods, including horizontal directional drilling which may avoid or reduce damage to intertidal areas. For locations used by species that are sensitive to suspended sediment, techniques may be selected to ensure the lowest resuspension of sediment where possible. Mitigation may include avoiding locating near or anchoring on known sensitive seafloor habitats and using dynamic positioning vessels and jet plow embedment to minimize sediment disturbance and alteration during cable-laying.
- Establishing designated traffic lanes, keeping vessel traffic to a minimum during construction and decommissioning, minimizing changes in vessel traffic where at-risk species are likely to occur, and maintaining a mandatory distance from species at risk.
- To mitigate the effects of these sounds, several countries including Canada have adopted precautionary principles in their approvals process for seismic survey activities. These policies aid in mitigating the impacts of these sounds by restricting the timing, location, and duration of seismic exploration.
- Use of quieting technologies such as bubble curtains that are effective at reducing noise during pile-driving. Bubble curtains work by creating a physical bubble barrier around the pile driving platform, which reduces noise outside the curtain and helps protect marine life. Other examples include vibratory pile drivers, isolation casings, cofferdams, and hydro sound dampers. This technique was documented to reduce a porpoise disturbance area by 90% in a noise mitigation study.
- A gradual ramp up of hammer energy for impact pile driving includes an initial set of strikes from the impact hammer at reduced energy. This initial set of strikes is followed by a waiting period and this process is repeated several times prior to the initiation of pile driving.
- Trained observers are used to maintain an exclusion area around pile driving activities for certain species. Pile driving activities must be shut down and delayed if a marine mammal or sea turtle is observed entering or within the relevant exclusion zones.
- During construction, certain activities (e.g., pile driving) may be scheduled to avoid high animal densities or sensitive periods such as species spawning or migration periods. This may be the

only option in particularly sensitive areas where an OSW project would otherwise not go ahead because of predicted negative impacts on protected species.

- Burying cables to a depth of at least one metre (3.3 ft) may mitigate impacts of the strongest magnetic and induced electrical fields by employing sediment as a physical barrier to sensitive species. Selecting highly permeable armour material, highly conductive armour and sheath material, and proximity/bundling of conductors can also create a barrier to sensitive species. In the event that the substrate is rocky and a cable cannot be buried, the cable may be installed on top of the seafloor with an additional protective layer around it.
- Proper waste management procedures can greatly reduce the amount of debris in the ocean environment, thus reducing the risk of entanglement. Other mitigation measures include the use of underwater cameras to monitor mooring and line loads or motion, and the use of ROVs to detect and remove marine debris.
- Pingers and Lofi tech seal scarer can have a deterrent effect on harbor porpoises and can therefore greatly reduce the risk of physical injury for porpoises during offshore piling. They rely on the evocation of strong behavioral reactions to move animals away from the zone of impact rather than preventing behavioral impacts such as displacement and/or disturbance to normal activities. However, animals can habituate to these devices, which would result in a decrease of the effectiveness of such devices over time. Furthermore, not all animals may respond, especially if other factors, such as food availability, may motivate the animals to stay within the impact zone.

Questions

- What is the standard exclusion zone for seismic surveys?
- How will climate change shift marine mammal habitats and how should that be considered in OSW farm planning?
- How will wind turbines effects feeding patterns of marine mammals (specifically baleen whales)?
- Are there recorded incidences of marine mammal entanglement in floating turbine cables?

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