Request for Advisory Group Input on Effects Research to Date

Committee for the Regional Assessment of Offshore Wind Development in Newfoundland and Labrador

December 11, 2023

Contents

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This document was developed for use by the Regional Assessment Advisory Group Members and is provided in English only. The working language of the Committee is English. Please let us know if you would like to meet with us in French and/or would like any English-only materials we post to be provided in French.

Request for Advisory Group Input on Effects Research to Date

The Committee conducting the Regional Assessment of Offshore Wind Development in Newfoundland and Labrador (the Committee) is requesting input from the Indigenous Knowledge, Scientific Information and Community Knowledge, and Fisheries and Other Ocean Uses Advisory Groups (Advisory Groups) about the activities associated with offshore wind (OSW) development and its potential effects on environmental, health, social and economic components.

As per the Agreement to Conduct the Regional Assessment of Offshore Wind Development in Newfoundland and Labrador (the Agreement), the Committee is identifying and considering effects of OSW activities, and is focusing on potential effects to the following components:

- Air Quality and Greenhouse Gases;
- Marine Fish and Fish Habitat;
- Avifauna;
- Marine Mammals and Sea Turtles;
- Protected and Special Areas;
- Indigenous Communities, Activities, Interests and Rights;
- Fisheries;
- Other Ocean Uses;
- Visual Aesthetics and Viewscapes;
- Acoustic Environments;
- Physical and Cultural Heritage;
- Health; and
- Communities and Economy.

While Committee work continues, this document summarizes information and literature the Committee has begun to compile on these topics[1]. Section one focuses on information about activities associated with OSW. It also includes information about potential malfunctions and accidental events that could be

[1] The Committee's work to assess the effects of OSW development is ongoing. **This summary is preliminary in nature and not a complete or final literature review**. To date, the Committee has been more focused on constraints analysis for identifying potential offshore wind licensing areas, and engagement to inform that process. As such, identifying effects of OSW on each component has progressed to various degrees. For components where limited information has been compiled to date, this document includes a partially completed or templated table where Advisory Group members may input any information they'd like to share with the Committee, based on their own expertise and research.

Also, the Committee has intentionally omitted sections on some components. For example, the document does not include a stand-alone section for effects on health because OSW activities indirectly affect health through other components. Effects on health are therefore described under sections such as effects on Air Quality and Greenhouse Gases. The Committee has also not included, in this document, a table summarizing effects on Indigenous Communities, Activities, Interests, and Rights. The Committee intends to work directly with the Indigenous Knowledge Advisory Group and Indigenous communities within the Regional Assessment Focus Area to gather such information.

caused by the environment or by other means. Section two outlines potential impact pathways by which these activities could affect specific components. It includes information about effects of OSW on specific components.

Please review and provide feedback and additional information on any topics for which you may have expertise. You do not need to review the entire document.

Please consider the following when providing your feedback:

- Do you agree/disagree with any of the information presented? Please provide supporting evidence for your views.
- Are there activities, impact pathways, effects, and/or relevant information not covered here? Please provide this information to the degree that it is available to you. Please provide specific information (i.e., information on effects related to specific activities) wherever possible.
- Are there information sources you recommend that the Committee has not listed?

Please complete your review directly in this document using the 'Track Changes' and/or 'Comment' tools in Microsoft Word. Once completed, we strongly encourage you to submit a PDF version of your input using the "Submit a Comment" tool on the Regional Assessment Registry Page. You may also provide your submission by email to OffshoreWindNL-EolienneExtracotiereTNL@iaac-aeic.gc.ca or another means convenient to you.

All information submitted will be publicly available on the Regional Assessment Registry Page unless confidentiality is requested in advance. If you wish to submit confidential information, please submit a written request to OffshoreWindNL-EolienneExtracotiereTNL@iaac-aeic.gc.ca as per the Committee's Confidentiality Procedures.

We appreciate your effort!

1. Activities Associated with Offshore Wind Development

The table below identifies activities associated with OSW development and information the Committee has gathered to date about these activities, which could support understanding their potential impacts. **<u>Please review the table. Provide feedback and additional information including references.</u>**

Activity	Summary of Current Knowledge
Pre-construction	
Sonar/Acoustic Seafloor Mapping	• Pre-construction site surveys for OSW use multi-beam and side-scan sonar, sub-bottom profiles, and other geophysical technologies to characterize seafloor and site conditions. These are low-energy (i.e., quieter) systems and technologies that introduce sound into the water column (Bat et al., 2013; Mooney et al., 2020; CSA, 2021;)
Seismic Surveys	• Uses sound to generate images of the seafloor and its underlying geology. Airguns produce high intensity, low-frequency impulsive sounds at regular intervals. Arrays of airguns are towed by vessels (McCauley et al., 2000; Gausland, 2003). Common configurations include: o 2-D: single airgun array and single streamer of hydrophones; generates 2-D image. o 3-D: two airgun arrays with ten or more parallel streamers; creates a complete three-dimensional image. • Seismic surveys generate short duration broadband impulse sounds with high peak source levels (220-255 dB re 1 µPa at 1 m) (Nowacek et al., 2007).
Vessel and Equipment Use	**<u>Information on noise produced by vessels:</u>** • Vessels are a primary source of anthropogenic noise and contribute to ambient ocean noise; predominantly in low-frequency (LF) bands under 500 Hz (Hildebrand, 2009). • A large portion of the noise from vessels comes from engine noise and propeller cavitation (CSA, 2021). • In the open water, vessel noise can influence ambient noise levels at distances of thousands of kilometers; however, the effects of vessel noise in shallower shelf and coastal waters are more variable due to physical and geological properties of the seabed, sea surface, and water column which influence reflection, refraction, absorption, and thus propagation of noise in the water (CSA, 2021). • The acoustic signature (i.e., low or high frequency sounds) produced by a vessel varies based on the type of vessel, and vessels that use dynamic positioning thrusters generate substantial underwater noise (CSA, 2021). • Vessel noise is characterized as low frequency, typically <1,000 Hz with peak frequencies between 10 and 50 Hz, non-impulsive and continuous, meaning there are no substantial pauses in the noise that vessels produce. The acoustic signature produced by a vessel varies based on the type of vessel (e.g., tanker, bulk carrier, tug, container ship) and vessel characteristics (e.g., engine specifications, propeller dimensions and number, length, draft, hull shape, gross tonnage, speed) (CSA, 2021). **<u>Common vessels and equipment used during pre-construction may include:</u>** *Sources: US EPA, n.d.; Corio, 2022; NYSERDA, 2017b* • Survey vessels: perform geotechnical or geophysical surveys.
Construction	
Installation of wind turbines, substations, converter stations, and foundations/anchors	• Installation of OSW turbines require a staging port for floating foundations and a port used to launch the turbine and towed to the intended site (Tang and Kilpatrick, 2021). • Fixed foundation turbines have installation vessels which require various components to install the turbine, foundation, and anchor (Tang and Kilpatrick, 2021). • Impact pile driving produces high intensity sound pulses at levels capable of producing acoustic injury to marine animals (Popper et al., 2014; CSA, 2021). Subsequent effects from impact pile driving noise are dependent upon the physical characteristics of the environment, which influence noise propagation, receiver species, and the implementation and effectiveness of environmental protection measures such as noise attenuation systems (NAS) (CSA, 2021). • Impact pile driving noise produced from foundation installation is expected to fall predominately within LF bandwidths (below 1,000 Hz); however, Bailey et al. (2010) measured

	broadband noise within 1 km of impact pile driving in the Moray Firth off the coast of Ireland (CSA, 2021).
Installation of cables/cable protection	• Methods for installing the subsea cables include cable burial ploughs, tracked cable burial machines, free swimming remotely operated vehicles (ROVs) with cable burial capabilities, and burial sleds (NYSERDA, 2017a). • The cables are inserted into the soil at a depth of approximately 1.5 to 3 m (Tang and Kilpatrick, 2021).
Vessel and heavy equipment use	**<u>Common vessels and equipment used during the construction phase may include:</u>** *Sources: US EPA, n.d.; Corio, 2022; NYSERDA, 2017b* • Heavy lift crane vessels: Lifts, holds, and positions parts of each wind turbine generator and substation platform during installation. Used for foundation installation. • Jack-up vessels: Extends legs to the ocean floor to provide a secure work platform for offshore crew and transports wind turbine generator components to site. • Multipurpose offshore support vessels: Clears the seabed floor of any obstructions prior to laying subsea cables. • Ocean-going heavy transport vessels: Transports components (e.g., monopiles to the site). • Pile-driving hammer engines: Drives the wind turbine generator's foundation into the ocean floor. • Scour protection vessels: Places a layer of stone on the seafloor around the foundations of the wind turbine generator and substation platform to stop sediment from being removed. It is also used to cover parts of offshore cable. • Service operation vessels: Transports crew to the site and provides offshore living accommodation and workspace. • Survey vessels: perform geotechnical or geophysical surveys. • Tugboats: Transports equipment and barges to sites. • Drones.
Operation	
Presence/operation of turbines	• Turbine components include the blades, the nacelle (containing the generator), the rotor hub, and the tower. • Turbines typically have three blades. Blades are made primarily of fiberglass and carbon fiber materials. They are designed with a curve to create a difference in air pressure across the two sides of the blades that make the blades spin. They range in size and can exceed 100 m in length offshore (US Department of Energy, 2022). • Standard ground clearance (vertical distance between ground or sea level and the lowest point of the turbine) varies with region. In the United States, most jurisdictions require a minimum of 25 m for onshore wind turbine ground clearances (Oteri, 2008). Offshore minimum ground clearance is reported to be 22 m to 30 m (NYSERDA, n.d.). • Turbine size (i.e., tower height, rotor, and blade size) has significantly increased overtime. Larger turbines generate more energy because windspeed and force increases with height. Turbine growth is projected to increase (US Department of Energy, 2022). • Turbines are typically spaced with 5 to 10 rotor diameters between turbines within a row and 7 to 12 rotor diameters between rows. Depending on the turbine size, this results in spacing of approximately 0.5 km to 1 km between each turbine (Horwath et al., 2020). • The principal source of sound from an operational wind farm is turbine noise that propagates into the tower and foundations, coupling the sound into the water and seabed (Hawkins et al., 2015). Most of the noise appears to be generated below about 700 Hz and is dominated by narrowband tones (Hawkins et al., 2015). However, sound levels within wind farms are not significantly higher than the background noise (Nedwell et al. 2007; Hawkins et al., 2015;). There is also a particle motion component to sounds generated by wind farms. There is also a particle motion component to sounds generated by wind farms, the sound component detected by all fishes, including sharks, and many invertebrates (Hawkins et al., 2015).
Presence of subsea infrastructure (foundations, cables)	**<u>Foundations</u>** • OSW turbines can have fixed or floating foundations. Fixed foundations are connected to the seabed through different types of base structures while floating structures have an anchor that provides buoyancy to the wind turbine to restrict the pitch, roll, and heave motions of the structure in turbulent waters. • Various base structures can be used in fixed foundations. Their suitability varies based on the forces and friction working on the structure, water depth and substrate. Fixed foundation types/base structures include:

	- Monopile: single pillar extending to seabed. - Jacket: use a tower frame similar to oil platforms and are most applicable in water depths between 30 to 60 m (Horwath et al., 2020). - Tripod: combine monopile and jacket structures producing a central column frame with triangular supports that insert into the seabed. The legs of the tripod foundation are spaced from 20 m to 40 m apart (Horwath et al., 2020). - Tri-pile: used in water depths between 25 m to 40 m. Similar to the tripod foundation, the tri-pile design uses cylindrical legs and a triangular shape for robust structural support. - Jack-up: similar to jack-up foundations used in offshore oil and gas projects;has a buoyant platform and legs that can change height and commonly used in depths up to 100 m. - Suction bucket: uses large suction caissons as a single base similar to the monopile; has a wide base that can obstruct current and cause scour which can eventually weaken the base. - Gravity: have wide and heavy bases that support a single column of the turbine; weight and dimensions of this foundation type depend on the oceanography, turbine, and wind, wave, and current forces; typically restricted to shallow water less than 20 m. • Floating foundations are suitable for deeper waters ranging from 50 m to 1000 m. Floating technologies are relatively new. Three types of floating foundations are well understood, and type of foundation used must consider the soil conditions, subsea geology, anchor embedment depth, and direction of forces of the selected site. - Semi-submersible: have connected hauls for the turbine, with a mooring line connecting each haul to the seabed floor. - Spar buoy: have one cylinder that extends under the water to keep the structure upright, with mooring lines connected to the sea floor. - Tension leg platforms (TLPs): have a single tower for the turbine, and the mooring lines are connected to the seabed with tension to help stabilize the foundation. • A variety of anchors can be selected for floating OSW foundations including gravity anchors and drag embedment. **<u>Cables</u>** • Used to transmit energy to offshore and onshore substations. • Cable type used depends on the voltage, turbine size and distance from shore (NYSERDA, 2017a). • Subsea power cables can carry either AC (alternating current) or DC (direct current) power and both systems produce magnetic fields. DC power cables are capable of carrying higher power levels generating stronger magnetic fields than AC power cables (Normandeau et al., 2011). • Cables are buried in the seabed and considered a constraint on where OSW projects can be located. • Techniques used to lay cable provide cable protection. They are chosen according to the desired protection of the cable and ecological impact to the surrounding benthic system. - Concrete mattresses: long, rectangular concrete block placed over the cable. - Riprap: uses rock and other materials to cover the cable on top of the seabed floor. - Burying: burying methods include disturbing the seabed floor and inserting the cable in a trench. - Frond mats: mats that cover the cable, reduce current velocity and resulting seabed scour.
Marine vessel operation and helicopter use	• Common vessels and equipment used during the operation phase include jack-up vessels, scour protection vessels, service operation vessels, survey vessels and tugboats (see descriptions under construction phase – vessel and heavy equipment use) (US EPA, n.d.; Corio, 2022; NYSERDA, 2017b). • *See Information on Noise produced by vessels under pre-construction, vessel and equipment use*
Decommissioning	
Structure inspection	• Before decommissioning, many of the OSW farm structures will be inspected, likely with sonars and ROVs with cameras. Removal challenges will likely increase as wind turbines increase in size, although experience with removal should presumably help address those challenges. Two options for alleviating these disturbances are to refurbish turbines and

	to leave some structures such as foundations and cables in place, like oil and gas industry “rigs-to-reefs” practices (Smyth et al., 2015).
Vessel and equipment use	• Decommissioning is expected to use similar vessels and equipment as Construction (US EPA, n.d.; Corio, 2022; NYSERDA, 2017b).
Removal of turbines and foundations/anchors	• In one of the few studies reported, Hinzmann et al. (2017) measured 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. Most of this acoustic energy was between 250 Hz and 1,000 Hz. Particle motion levels were not reported. It is difficult to predict whether disturbances will occur.
Removal of cables/cable protection	• Remove or leave in place, like oil and gas industry “rigs-to-reefs” practices (Smyth et al., 2015).
Malfunctions and Accidental Effects *Including any attributed to effects of the environment (e.g., extreme weather events, collisions with icebergs etc.) or any other cause (e.g., vessel collisions, equipment malfunctions etc.)*	
Structural failure / loss of turbine	• The anticipated scale and geographical location of development (specifically of offshore wind) must result in some overall increase in vessel collision risk, either through direct collision with a fixed installation or through constriction of available routes for safe navigation, particularly of larger vessels. (UK Department for Business, Energy and Industrial Strategy, 2022).
Fire / Mechanical Fire	
Discharge of Fluids	• Accidental events can include oil or chemical spills from construction and service/maintenance ships and vessels (UK Department for Business, Energy and Industrial Strategy, 2022). • There is low anticipated frequency and consequence of spills occurring during fuel or oil transfers, maintenance operations etc. associated with OSW farms (UK Department for Business, Energy and Industrial Strategy, 2022).

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2. Potential Impact Pathways and Effects of Offshore Wind Development on Components Assessed under the Regional Assessment

Please review and add specific information about the potential effects of each activity associated with OSW on the various components the Committee is assessing, and about indirect effects on other components.[2] Please add your input in the tables below and include citations. Please also provide feedback on the information already gathered.

You do not need to review each component. Please focus on the components for which you have expertise.

[2] Indirect effects on other components refers to effects on a component caused by effects of an activity on a different component. For example, OSW activities may displace birds from feeding habitat, and would indirectly effect fish because birds prey on fish.

I. Air Quality and Greenhouse Gases

The Committee is still in the process of compiling information on this topic. Based on the Committee's findings to date, potential effects of OSW development on air quality and greenhouse gases (GHGs) include:

- Pollutants and GHGs emission reduction during operation,
- Climate change and air quality benefits with respect to the environment, economy, human health, and fish and fish habitats,
- Increase in air pollutants and GHG emissions during construction and decommissioning phases.

The Committee has found:

- The environmental impacts (emissions to the air) are mainly caused by fossil fuel combustion during equipment manufacturing, transportation, and vessel operations at the different activity phases listed in the table below (Dolan & Heath, 2012; NYSERDA, 2018).
- The scope of the impacts will differ among the different phases, with the greatest impacts occurring at the construction and decommissioning phases, as many work boats and associated equipment will be used (Corio, 2022).
- Several studies have found that wind energy can help reduce combustion-based electricity generation and provide air quality and GHG emission benefits (Browning & Lenox, 2020; Delarue et al., 2009; Denny & O'Malley, 2006; Holttinen & Tuhkanen, 2004; Millstein et al., 2017; Nordman VanderMolen, 2014).

About related effects on other components, the Committee generally understands that vessel activities throughout OSW development phases, will have an impact on air quality and GHG emissions. Poor air quality and elevated concentrations of GHGs will have both direct and indirect effects on the environment, economy, marine fish and fish habitats, marine mammals and sea turtles, avifauna, and human health.

- Human Health: Poor air quality, because of pollutant emissions, has been linked to respiratory and cardiovascular illness, hospitalization, and mortality. Harmful health outcomes related to air pollution can range from respiratory symptoms to the development of disease and premature death – encompassing acute irritation and respiratory problems, the development or worsening of existing respiratory and/or cardiovascular disease, and cancer (Health Canada, 2016)
- GHG emissions and their increasing concentrations in the atmosphere are already having impact on the Environment, Economy, and Human health (ECCC, 2023b). According to the United States Environmental Protection Agency (U.S. EPA), more people may be exposed to extreme weather like heat, floods, droughts, storms and wildfires as a result of climate change (U.S. EPA, 2022b). The health effects are wide-ranging, and the impacts will vary depending on a person's age, medical condition, income and where they live.
- Extreme weather due to climate change (e.g., heat, floods, droughts, storms, and wildfires), will likely impact marine fish and fish habitat, marine mammals and sea turtles, and Avifauna.

Potential Impact Pathways and Effects of Offshore Wind Development on Air Quality and GHGs				
Activity	**Impact Pathway**	**Effects**	**Summary of Current Knowledge**	**Related effects on other components**
Pre-Construction				
Sonar/Acoustic seafloor mapping Seismic surveys Vessels and equipment use	Emissions to the air (GHG and other pollutant) from associated vessel activities	Increase in air pollutants and GHG emissions.	• The contaminants are mainly caused by fossil fuel combustion during vessel operations, with major air contaminants being NO_x, SO_2, particulate matter, CO_2 and CH_4 (NYSERDA, 2018)	
Construction				
Installation of wind turbines, substations, converter stations, and foundations/anchors Installation of cables/cable protection Vessel and heavy equipment use	Emissions to the air (GHG and other pollutant)	Increase in air pollutants and GHG emissions.	• The contaminants are mainly caused by fossil fuel combustion during vessel operations, with major air contaminants being NO_x, SO_2, particulate matter, CO_2 and CH_4 (NYSERDA, 2018)	
Operations				
Presence/operation of turbines	Emissions to the air (GHG and other pollutant)	Potential air contaminant emissions from backup generators	• There is the potential for air contaminant emissions from backup generators at the turbines or power transmission facilities during OSW operations (U.S. EPA, 2022)	
Presence of subsea infrastructure (foundations, cables)	N/A	N/A	N/A	N/A
Marine vessel operation and helicopter use	Emissions to the air (GHG and other pollutant)	Increase in air pollutants and GHG emissions	• The contaminants are mainly caused by fossil fuel combustion during vessel operations, with major air contaminants being NO_x, SO_2, particulate matter, CO_2 and CH_4 (NYSERDA, 2018)	
Decommissioning				
Structure inspection	Emissions to the air (GHG and other pollutant)	Increase in air pollutants and GHG emissions		

Vessel and equipment use	Emissions to the air (GHG and other pollutant)	Increase in air pollutants and GHG emissions	• The contaminants are mainly caused by fossil fuel combustion during vessel operations, with major air contaminants being NO_x, SO_2, particulate matter, CO_2 and CH_4 (NYSERDA, 2018)	
Removal of turbines and foundations/anchors	N/A			
Removal of cables/cable protection	N/A			
Malfunctions/Accidental Events				
Structural failure / loss of turbine	N/A			
Fire / Mechanical Fire	Emissions to the air (GHG and other pollutant)	Increase in air pollutants and GHG emissions.		
Discharge of Fluids	N/A			
Literature Compiled to Date				

<u>Positive effects of OSW development on Air quality and GHGs</u>

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II. Marine Fish and Fish Habitat

Activities throughout the life cycle of OSW projects primarily affect fish by producing noise and vibration or by altering habitats.

To date, the Committee has gathered some information about effects on fish and fish habitat related to specific activities associated with OSW. The Committee also generally understands any impact on fish or fish habitat could impact commercial fisheries, and that impacts on fish and fish habitat could influence any predatory species including avifauna, marine mammals and/or sea turtles.

Note, in addition to the information presented in the table, the Committee has gathered more general information about the effects on noise and vibration on fish. This information could be applicable to various sources and activities associated with OSW but is not about any specific activity.

Information about effects of noise and vibration not attributed to specific sources:

- Potential effects of anthropogenic sound sources on marine animals range from disturbance that may lead to displacement from feeding or breeding areas, to auditory damage, tissue trauma and mortality (Caroll et al., 2017; Popper and Hawkins, 2012).
- Most studies suggest that if behavioural effects of fish to underwater sound are brief and outside a critical period, they are not expected to result in biological or physical effects (McCauley et al. 2000a, 2000b; Dalen, 2007). However, the implications of measurable displacement of fish (as demonstrated in some studies measuring catch rates) are not fully understood (Streever et al., 2016).
- A growing body of literature shows anthropogenic sounds exceeding normal ambient noise may result in temporary threshold shift (TTS), whereby fish experience a temporary reduction in hearing sensitivity because of exposure to intense sound, but will recover overtime (Caroll et al., 2017; Popper et al., 2005; Popper and Hastings, 2009; Popper et al., 2014).
    - TTS can have fitness consequences by reducing ability to communicate and detect prey or predators (Popper et al., 2014) and by interfering with the ability of an animal to detect and/or use its ‘acoustic’ or ‘auditory’ scene (Caroll et al., 2017; Popper and Hastings, 2009; Popper et al., 2014).
    - The sound level and duration of exposure that causes TTS varies widely. It may be linked to factors including sound pressure level (SPL), repetition rate, frequency, and duration of sound; as well as the health of the exposed organism and unknown developmental and/or genetic factors (Popper and Hastings, 2009; Popper et al., 2007).
- There is little information available on permanent hearing loss in fish (often referred to as permanent threshold shift, (PTS) resulting from exposure to high-intensity sounds, although this type of physical response may be considered less likely to occur given the ability of fish to regenerate lost or damaged sensory cells of the ear (Caroll et al., 2017; Smith, 2016).
- In some cases, marine species may experience no effect of exposure to intense sources of sound. The area over which anthropogenic noise may adversely impact marine species depends upon multiple factors including the extent of sound propagation underwater, its frequency characteristics and duration, its distribution relative to the location of organisms, and the absolute sensitivity and range of spectral hearing among species (Caroll et al., 2017; Popper and Hawkins, 2012).
- There remain considerable gaps in the understanding of anthropogenic sound on fish and invertebrates (Popper and Hastings, 2009; Hawkins et al. 2015; Carroll et al., 2017; Hawkins and Popper, 2017; Weilgart, 2018; Popper and Hawkins, 2019
- When addressing the effects of sounds on fishes and invertebrates, it is vital to describe the sounds in terms of particle motion as well as sound pressure (CSA, 2021; Mooney et al., 2020; Hudson et al., 2022).
- All fishes (including elasmobranchs), and an increasingly identified number of invertebrates, detect, and use particle motion, particularly at frequencies below several hundred hertz (Mooney et al., 2020).

- Some fish also detect pressure in water via a compressible cavity (i.e., an air bubble or swim bladder). Some fishes have evolved with air bubbles located just under external hair cells or with a variety of swim bladder extensions to the inner ears, all adaptations that enhance their detection of pressure (Mooney et al., 2020).
- Also important to consider, sound detection and sensitivity varies among fish type (Mooney et al., 2020).
    - Clupeidae (a family of fishes that includes herrings, sardines, menhaden, and shad) have relatively sensitive hearing for fish and can detect not only the low frequencies typical of many fish, but also mid-frequency sonar ranges (Mooney et al., 2020).
    - The cartilaginous fishes (i.e. elasmobranchs) have the highest sensitivity to low frequency sound (~20 Hz to ~1500 Hz) (Caroll et al., 2017). This group's lack of a swim bladder or other gas-filled chambers restricts their detection capabilities to the particle motion component of sound (Caroll et al., 2017).
    - Evidence suggests that pelagic species have more sensitive hearing (thresholds at lower frequencies) than demersal species. However, studies have been conducted on only a small number of the 1200+ extant species to date, and the hearing sensitivities of most elasmobranchs are generally very poorly understood (Caroll et al., 2017). Most studies have examined either the acoustic thresholds of species or the attracting power of low-frequency sound (Caroll et al., 2017).
    - Some species possess a swim bladder, but only use particle motion to detect sound (e.g., Atlantic salmon) These species are susceptible to physical injury such as barotrauma (Caroll et al., 2017; Popper et al., 2014).
    - Species such as squirrel fish, mormyrids, herrings and a diverse range of other species are not only sensitive to particle motion but are also highly sensitive to sound pressure due to specialized otophysic connections between pressure receptive organs and the inner ear (Caroll et al., 2017).

Potential Impact Pathways and Effects of Offshore Wind Development on Fish and Fish Habitat				
Activity	**Impact Pathway**	**Effects**	**Summary of Current Knowledge**	**Related effects on other Components**
Pre-construction				
Sonar/Acoustic seafloor mapping	Noise and vibration	• Temporary Threshold Shift (TTS) • Temporary behavioural change (e.g., displacement)	• *See text on **Information about effects of noise and vibration not attributed to specific sources** above.* • Technologies used to conduct pre-construction site surveys for OSW, including use of multibeam and side-scan sonar can impact marine fish species (CSA, 2021; Mooney et al., 2020). • Lower-energy (i.e., quieter) systems and technologies used for penetrating the seafloor and can introduce sound into the water column, which may cause behavioural impacts in some species (CSA, 2021; Mooney et al., 2020; Bat et al., 2013). • Some clupeids (a family of fishes that includes herrings, sardines, menhaden, and shad) can detect not only the low frequencies typical of many fish, but also mid-frequency sonar ranges (Mooney et al., 2020). Yet, within the maximum levels tested, adult herring have not shown behavioral responses to a variety of MFA sonar signal (Mooney et al., 2020). • Although actual studies are sparse, direct mortality or damage to internal tissues are not expected, and overall populations are not considered at risk from these types of sonar signals (Mooney et al., 2020; Hawkins et al., 2015; Sivle et al., 2014).	

Seismic Surveys	Noise and vibration	• Temporary Threshold Shift (TTS) • Temporary behavioural change (e.g., displacement, change in swimming direction, speed, and depth) • Mortality of larvae, juveniles, and adults • Auditory damage	• *See text on* ***<u>Information about effects of noise and vibration not attributed to specific sources</u>*** *above.* • Optimum frequency range for a particular array is a trade-off between resolution and depth of penetration. Most ranges are within the detectable hearing range of most fishes and elasmobranchs (Popper et al., 2003; Popper and Fay, 2011; Ladich and Fay, 2013) and can also elicit a neurological response in cephalopods (Mooney et al., 2010) and decapods (Lovell et al., 2005). **<u>Seismic Streamer Surveys</u>** • Effects of seismic testing on fish can include death of larvae, juveniles, and adults due to underwater noise, effects on population dynamics and feeding performance, as well as loss of feeding area, migration options, and spawning grounds (Bat et al., 2013; Caroll et al., 2017). • A study by Day et al (2016), suggested that stress associated with dredging may have synergistically interacted with air gun exposure to depress hemocytes (Caroll et al., 2017; Day et al., 2016). This study indicates that seismic surveys may act as a tipping point at which other stressors may cause adverse effects on some marine invertebrates (Caroll et al., 2017). • Seismic air guns extensively damaged fish ears at distances of 500 m to several kilometres from seismic surveys. No recovery was apparent 58 days after exposure (Weilgart, 2013). • Airguns used in seismic surveys can have significant effects on marine fish and invertebrates but may show no effects in isolation until combined with other stressors such as temperature and food competition (Caroll et al., 2017; Day et al., 2016). **<u>Vertical Seismic Profiling</u>** • Seismic surveys can result in physical, physiological and/or behavioural effects on fish and invertebrates (Weilgart, 2013). • Behavioural responses of fish to underwater sound, including seismic sound, can vary greatly among species and can include a startle response, change in swimming direction, speed or depth, change in feeding behaviour and/or temporary avoidance of the area (Engås et al. 1996; McCauley at el. 2000a, 2000b; McCauley et al., 2003; Slotte et al., 2004; Fewtrell and McCauley, 2012; Løkkeborg et al. 2012). • Some studies have shown no measurable behavioural change at all when fish are exposed to seismic sound source arrays (Wardle et al., 2001; Peña et al., 2013). • Early life stages of fish (e.g., eggs, larvae, fry), which are less mobile and unable to avoid	

			high levels of sound pressure levels are more likely to experience physiological effects (mortality, non-lethal effects) (Dalen, 2007). Popper at al. (2014) suggests that exposure of eggs and larvae to sound levels >210 dB SEL_{cum} (>207 dB_{peak}) could result in mortality and/or potential mortal injury for eggs and larvae. However, it has been suggested that mortality rates caused by exposure to seismic energy are relatively low compared to natural mortality, such that the environmental effect of seismic activity on recruitment to a fish stock would be negligible (Gausland, 2003; Dalen et al. 1996). • Reviews of studies on the effects of seismic sound on marine life report no direct evidence of mortality of adult fish or shellfish in response to seismic sound exposure at field operating levels (DFO, 2004, Payne et al., 2009; CEF 2011; Streever et al. 2016). • Fish with connections between the inner ear and swim bladder (e.g., herring) have increased hearing sensitivity and may be more susceptible to sound pressure (Carroll et al., 2017). Organisms that rely exclusively on particle motion to detect sound (most invertebrates) are more resilient to anthropogenic sound exposure (Morley et al., 2014; Hawkins et al., 2014). Deep water species and those lacking swim bladders may be less vulnerable to effects from seismic survey activities (Boertmann and Mosbech, 2011). • Sound exposure guidelines for seismic activities for fish suggest that temporary threshold shift (TTS) may occur at over 186 dB SEL_{cum}, recoverable injuries may occur between 203 and 216 dB SEL_{cum} (or 207-213 dB_{peak}), and mortality or potential lethal injuries may occur between 207 and 219 dB SEL_{cum} (207-213 dB_{peak}) (Popper at al., 2014). • Although there are fewer studies on the effects of seismic sound on zooplankton, it has been suggested that where seismic sound causes significant mortality to zooplankton it could have greater ramifications for ecosystem structure and health (MacCauley et al., 2017).	
Vessels and equipment use	Noise and vibration	• Temporary Threshold Shift (TTS) • Temporary behavioural change (e.g., displacement) • Communication masking • Short-term stress response • Acclimation to acoustic stressors	• *See text on* ***Information about effects of noise and vibration not attributed to specific sources*** *above.* • Noise associated with vessel support can mask the communication signals of some fish species and can also induce physiological stress and impair foraging and predator responses in fish and invertebrates (CSA, 2021). • Increased levels of cortisol have been reported in giant kelpfish (Heterostichus rostratus) in response to vessel noise, and cod (Gadus spp.) exposed to linear frequency sweeps of sufficient amplitude (CSA, 2022). Temporary stressors such as impact vessel noise may cause a short-term stress response in fish, but the potential for these activities to cause longer term growth and fitness consequences has not been demonstrated in a field setting. In general, fish may acclimate to long-term exposure to acoustic stressors (CSA, 2022).	

Construction				
Installation of wind turbines, substations, converter stations, and foundations/anchors	Noise and vibration due to pile driving	• Acoustic injury • Barotrauma • Short-term stress response • Temporary behavioural change	• Produces high intensity sound pulses at levels capable of producing acoustic injury to marine animals (CSA, 2022; Popper et al., 2014). • Current understanding of the potential effects of particle motion on fish and invertebrates is very limited; it is expected that particle motion associated with impulsive noise sources, such as impact pile driving, will have similar effects to pressure waves in fish species (CSA, 2022). • Non-auditory injury (sometimes referred to as barotrauma) results from rapid and instantaneous changes in the ambient pressure level in the water and subsequently within the fluids and tissue of an animal, causing physical injury to soft tissue and organs. This form of non-auditory, physiological injury can occur in fish exposed to rapid pressure changes that can theoretically be realized within proximity to an impulsive noise source such as impact pile driving or MEC/UXO disposal activities (CSA, 2022; (Kaldellis et al., 2016; Lüdeke et al., 2017). • Temporary stressors such as impact pile driving may cause a short-term stress response in fish, but the potential for these activities to cause longer term growth and fitness consequences has not been demonstrated in a field setting (CSA, 2022). • Both intermittent (e.g., pile driving) and continuous (e.g., vessel traffic, drilling) noises elicited behavioral changes in fish, but the time it took to return to normal baseline behavior was longer in response to intermittent noises compared to continuous noises (CSA, 2022; Neo et al., 2014).	

	Installation and presence of infrastructure	• Behavioural change (e.g., disorientation, displacement, attraction)
		• Increased stress
		• Habitat disturbance and/or loss
		• Habitat alteration
			• Potential impacts from installation of turbines and foundations on fish, according to Bat et al. (2013):
			  ○ Disruption of orientation, especially for migratory fish species; Impediment of foraging activities.
			  ○ Habitat loss-not just from the actual wind turbines, fish may move out of areas due to increased stress levels.
			  ○ Damage to fish eggs.
			  ○ Alteration of fish species availability and abundance.
			  ○ Alteration of fish community composition and abundance.
			  ○ Disturbance and redistribution of sediments.
			  ○ Scouring of sediments around the base of turbines.
			  ○ Re-suspension of pollutants within the sediment.
			  ○ Accidental release of chemicals and hydrocarbons during installation.
			• Turbine and foundation installations can affect some benthic organisms, but the species are thought to return once construction ceases (Bat et al., 2013).
			• Foundations may alter the existing sandy-bottom habitat and structural relief that may	

			act as an artificial reef (CSA, 2022).	
Installation of cables/cable protection	Ground preparation for cable installation	• Temporary disturbance/loss of fish and shellfish habitat	• Ground preparation for cable installation can affect some benthic organisms, including by displacement, but the species are thought to return once construction ceases (Bat et al., 2013; CSA, 2022).	
	Presence of infrastructure	• Habitat alteration	• Scour protection and IAC and OSS-Link Cable protection throughout the 20- to 35-year life of the Project will alter the existing sandy-bottom habitat and structural relief that may act as an artificial reef (CSA, 2022).	
	Electromagnetic fields	• Behavioural change (e.g., attraction, avoidance, increased movement, increased foraging behaviour) • Anatomical change (e.g., earlier hatching) • Potential impact on ability to use natural EMF cues	• Electromagnetic fields (EMFs) created by cables have the potential to interact with aquatic organisms that are sensitive to electric and magnetic fields. This affects both bony fishes and elasmobranch fishes and may be transient as the organism moves through the area and, alternatively, magneto-sensitive species may be attracted to or may actively avoid the area (Bat et al., 2013). • Some marine animals can detect naturally occurring electric and/or magnetic fields (e.g., sharks, salmon, and sea turtles) and use these to support essential life functions such as navigating and hunting for prey (NYSERDA, 2017b). • When EMFs are present, some marine animals that can detect electro-magnetic fields (EMFs) exhibit attraction or avoidance behaviours. Avoidance behaviours may be elicited from higher-strength EMFs. Lower-strength EMFs may attract other electrosensitive species, as these could mimic the EMFs from prey (Scott et al., 2018; SEER 2022). • 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). • Research suggests that marine species may be more likely to detect and react to magnetic fields from DC cables than from AC cables (Normandeau et al., 2011). • Some studies have documented marine animals demonstrating behavioural responses (i.e., increased foraging and exploratory movements) when near subsea cables; however, there is no conclusive evidence to determine that EMF from an OSW farm cause impacts to individual animals or populations (Stantec, 2022). • Species may exhibit different behavioural responses to EMFs. For example, American lobster (Homarus americanus) exhibits an increased likelihood of exploratory behaviours when EMFs are encountered, while the European lobster (Homarus gammarus) exhibits no attraction, foraging, or exploratory behaviours when exposed to static EMFs. Brown crab (Cancer pagurus) has been shown to exhibit attraction to EMFs (Scott et al., 2018; SEER 2022). • EMFs can elicit anatomical responses during the entire life cycle of an animal. For example, when exposed to a static magnetic field, rainbow trout (Oncorhynchus	

			mykiss) were observed to hatch a day earlier (Scott et al., 2018; SEER 2022).	
Vessel and heavy equipment use	Noise and vibration	• Temporary Threshold Shift (TTS) • Temporary behavioural change (e.g., displacement) • Communication masking • Short-term stress response • Acclimation to acoustic stressors	• *See information under Pre-construction, vessel and equipment use.*	
Operation				
Presence/operation of turbines	Noise and vibration	• Behavioral change and adaptation	• Operational sound has the potential to cause chronic effects to marine animals over much longer periods (Hawkins et al., 2015). • While the noise levels generated during the operational phase are not high enough to cause direct physical injury, there may be behavioural impacts to marine life near turbines. Studies have suggested that the low intensity turbine noise is unlikely to cause hearing impairment in fish (Kaldellis et al. 2016), and that fish might adapt to these noises (Thomsen et al. 2006).	
Presence of subsea infrastructure (foundations, cables)	Presence of foundations and cables	• Habitat alteration/creation	**Artificial Reef Effect** • The presence of subsea infrastructure (including foundations and cables) can create additional hard substrate that may provide artificial reef habitat suitable for benthic communities (Bray et al., 2016). • European and US experiences indicate a critical need for focused research to evaluate reef effects of installed, and eventually decommissioned, offshore wind foundations and to establish the appropriate baseline monitoring techniques for comparative studies of biomass and density changes, attraction versus production of species, and ecosystem trophic shifts (Perry & Heyman, 2020). • The presence of subsea infrastructure can have impacts on turbulence and mixing, surface wave energy, sediment dynamics, biogeochemistry, mesoscale flows, upwelling and downwelling, and meteorology, which may impact the presence of fish (Farr et al., 2021). • Food web impacts on fish ecology were documented at several Belgian OSW farms; these impacts were linked to changes in demersal and benthopelagic fish diets (SEER 2022). • Higher trophic level organisms such as piscivorous fish species and marine mammals	Avifauna - the artificial reefs formed by the infrastructure of wind farms can attract marine life, creating a more abundant and diverse food source for birds (Degraer et al. 2021b)

			responded positively to the aggregation of biomass, piles, and scour protections based on modelling by Raoux et al. (2017) in Svendsen et al. (2022). • An increased abundance of certain fish and shellfish species were observed at several OSW farms in the vicinity of fixed-bottom turbines and their associated scour protection; these species include crab, cod, sea bass, and mackerel (SEER, 2022). • Studies at OSW farms in the North Sea documented that not all fish species appear to be attracted to structures of OSW farms. For example, Atlantic cod (Gadus morhua) were attracted to foundations while there was no evidence that common sole (Solea solea) were attracted to similar foundations (SEER, 2022). • A long-term study conducted by Stenberg et al. (2015) and in Svendsen et al., 2022) reported that fish abundance increases slightly in and around the OSW farm area, while fish abundance declined at a control site 6 km away. The study also reported that species diversity was significantly higher close to the OSW turbine foundations. • Preliminary studies documented that fish abundance has either increased (e.g., cod, whiting, sole) or has not been affected (SEER, 2022). • Multi-year measurements collected at the Block Island Wind Farm have demonstrated quick colonization of structures and increased local diversity (SEER, 2022). Observations around fixed-bottom turbine foundations have indicated dense mussel aggregations, organic rich sediments, and the presence of juvenile crabs, black sea bass (Centropristis striata), and other native benthopelagic fish (SEER, 2022). Black sea bass (Centropristis striata) and Atlantic cod (Gadus morhua) abundance were significantly higher near the OSW farm during operation compared to a control area. Artificial reef effect was not observed by the abundances of schooling species such as Atlantic herring (Clupea harengus) (Wilber et al. 2022 in Svendsen et al. 2022). **<u>Potential Negative effects:</u>** • Newly introduced structures may also create hospitable conditions for invasive species to colonize and spread (ICF, 2020; NYSERDA, 2017c).	
Marine vessel operation and helicopter use	Noise and vibration	• Temporary Threshold Shift (TTS) • Temporary behavioural change (e.g., displacement) • Communication masking • Short-term stress response • Acclimation to acoustic	• *See information under Pre-construction, vessel and equipment use.*	

		stressors		
Decommissioning				
Structure inspection				
Vessel and equipment use	Noise and vibration	• Communication masking • Physiological stress • Behavioural change (displacement)	• 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 fish (Maxwell et al., 2022). • In one of the few studies reported, Hinzmann et al. (2017) measured 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. Most of this acoustic energy was between 250 Hz and 1,000 Hz. Particle motion levels were not reported. 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). • 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 (Maxwell et al., 2022; Kikuchi, 2010).	
Removal of turbines and foundations/anchors	Removal of infrastructure	• Habitat disturbance/loss	• Partial, rather than complete removal of OSW may have environmental and economic benefits, especially if habitat created on the structures has conservation or commercial value (Smyth et al., 2015).	
Removal of cables/cable protection			• Removal of cables/cable protection may increase suspended sediment/water turbidity, scouring, and sedimentation as well as temporary disturbance/loss of fish and shellfish habitat under inter-array cables, prepared ground and construction plant movements (Bat et al., 2013).	
Malfunctions and Accidental Events				
Structural failure / loss of turbine	Cable failure		• Cable failures (e.g., due to abrasions) may affect the reef effect of subsea floating and buried cables subsequently impacting fish (Svendsen et al., 2022). A combination of wear in the power cables (due to e.g., biofouling or hydrodynamic forces in the water column) and the increasing cable length and capacity required to facilitate long-distance energy transport at increasing current strengths to shore, may further enhance emissions of anthropogenic EMFs associated with floating OWFs (Svendsen et al., 2022).	
Fire / Mechanical				

Fire				
Discharge of Fluids	Water contamination		• Accidental release of chemicals and hydrocarbons during installation can affect fish and fish habitats (Bat et al., 2013).	

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III. Avifauna

As set out in the Agreement, Avifauna refers to birds, bats, and associated species at risk. Based on the Committee's findings to date, potential effects of OSW on avifauna primarily include:

- physical injury or mortality due to collisions;
- temporary or permanent behavioural changes such as avoidance, habituation, displacement, attraction, and disorientation; and
- temporarily increased or chronic stress.

As can be seen in the table below, most information the Committee has gathered on this topic relates to the operation phase of OSW development. For other phases/activities the Committee has identified likely impact pathways and effects based on that information and the following more general findings:

- Several studies have found birds may be displaced from habitats because of the presence of offshore structures, noise, vibration, activity of vessels and personnel, altered water quality and/or physical alternation to the environment during all phases of OSW development (Dierschke et al., 2016; Drewitt and Langston, 2006; Exo et al., 2003; Harwood et al., 2017; Hernandez C. et al., 2021; Ren et al., 2021).
- Regarding stress, at least some activities during each phase of OSW development (e.g., vessel and equipment use) increase noise levels and human activities, and these have been linked to elevated stress levels in birds (Platteeuw et al., 2017; Society for Endocrinology, 2009).

About related effects on other components, the Committee generally understands that marine fish and commercial fisheries could be impacted in during any activities that displace avifauna from existing foraging habitat. Avifauna would be forced to forage elsewhere and would impact fish population through predator-prey interactions. This would subsequently impact commercial fisheries if increased risk of predation displaces fish and/or leads to decreased fish populations.

Potential Impact Pathways and Effects of Offshore Wind Development on Avifauna (birds, bats, and associated species at risk)				
Activity	**Impact Pathway**	**Effects**	**Summary of Current Knowledge**	**Related effects on other Components**
Pre-construction				
Sonar/Acoustic seafloor mapping	Noise and vibration	• Avoidance, displacement and/or other behavioural changes (diving birds only) • Increased stress (diving birds only)		
Seismic surveys	Noise and vibration	• Avoidance, displacement and/or other behavioural changes (diving birds only) • Increased stress (diving birds only)		
Vessels and	Noise	• Avoidance, displacement		

equipment use		and/or other behavioural changes • Increased stress		
	Artificial lighting	• Attraction		
	Increased human activity	• Avoidance, displacement and/or other behavioural changes • Increased stress		
Construction				
Installation of wind turbines, substations, converter stations, and foundations/anchors	Physical alteration to environment	• Avoidance, displacement and/or other behavioural changes		
Installation of cables/cable protection	NA	NA	NA	NA
Vessel and heavy equipment use	Noise	• Avoidance, displacement and/or other behavioural changes • Increased stress		
	Artificial lighting	• Attraction		
	Increased human activity	• Avoidance, displacement and/or other behavioural changes • Increased stress		
Operation				
Presence/operation of turbines	Presence of infrastructure	• Behavioural changes such as avoidance, displacement, habituation and/or attraction) • Physical injury or mortality due to collision (birds) • Increased stress	**<u>Behavioural Changes</u>** <u>Avoidance</u> Avian avoidance observed at OSW farms refers to alterations in flight path or heights to avoid encounters with turbines. • Observed avoidance includes last-second maneuvering to avoid collisions, redistribution of birds within a windfarm due to turbines/turbine rows or redistribution outside the	

			perimeters of wind farms (Skov et al. 2018; SEER 2022). • Avoidance has been observed at small or larger scales ranging from within 10 m of turbines to 1.5 – 3.0 km (Skov et al. 2018) and as far as 4 km (Petersen et al. 2006). • Studies at OSW projects have generally reported seabirds engage in micro-avoidance behaviours at a rate greater than 95% (Skov et al. 2018). • Migratory birds may also adjust their migration timing to avoid high-risk periods near wind farms, potentially leading to asynchrony with mating patterns, critical resources and breeding conditions (Pulido 2007, Nemes et al. 2023). Displacement Several studies have demonstrated displacement of birds due to the presence of offshore wind farms and related disturbances (e.g., regular ship traffic or continuous turbine operation) (Furness et al 2013, Garthe et al. 2023, Lagerveld et al., 2016, Peschko et al. 2020; Velando and Munilla 2011). Displacement occurs when habitats frequently used by birds (e.g., for transiting, resting, roosting, or foraging) are less frequently used or abandoned. Negative consequences of displacement include: • Birds having to travel greater distances to find food, increased energy expenditure and potential fitness consequences for birds during sensitive periods (breeding, migration) (Dierschke et al. 2016; Exo et al. 2003; Leopold et al. 2013; Masden et al. 2010; Pettersson 2005). • Reduced foraging efficiency and nutritional stress if birds must settle for suboptimal foraging areas (lower prey availability, less suitable prey in terms of size and type) (Langston and Pullan 2003; Reid et al. 2022). • Increased competition and territorial disputes with resident individuals in new foraging areas (Humphreys et al 2015; Leopold et al. 2013, Pettersson 2005). • Breeding and nesting disruption potentially leading to nest abandonment, reduced reproductive success, and population decline overtime (Peschko et al. 2020). Displacement may impact species groups differently. Studies in the U.K. show species observed in lower numbers at OSW farms post-construction included scoters, loons, gannets, and alcid species. Some species were displaced up to 2-4 km of the OSW farm boundary (Dierschke et al. 2016; Kahlert et al. 2004; Petersen 2005; Petersen et al. 2006) In some cases, displacement could be temporary. For example, Dierschke et al. (2016) found avoidance during the first year of operation at some wind farms in Europe followed by an	

			eventual increase in species' abundance. This increase was assumed to result from increased prey availability around underwater structures (i.e., artificial reef effect). <u>Barrier Effect</u> The barrier effect is an avoidance-based phenomenon where birds alter their migration path, local flight pathway, or flight altitude to avoid structures. Offshore wind farms have been recognized as potential barriers to the movement of birds during their migratory journeys (Fox and Petersen 2019). Negative impacts of barrier effect can include: • Increased distance travelled which increases energy expenditure and can affect individual fitness and the ability of some species to complete their migration successfully (Drewitt and Langdon 2006; Masden et al. 2009; Petterson 2005; SEER 2022). • Decreased genetic exchange among bird populations, which can have long-term implications for genetic diversity and adaptation (Justen and Delmore 2022). <u>Attraction</u> • Birds maybe attracted by perching opportunities. This may increase collision risk (Dierschke et al. 2016; Hill et al. 2014; NatureScot 2020). • Cormorant and gull species have been observed roosting on turbines and showing preference for locations along the perimeter of offshore wind farms in Europe (Kahlert et al. 2004; SEER 2022). Cormorants and falcons have been observed perching on offshore wind turbine fixed foundations in Europe and the US (Hill et al. 2014; Stantec 2020). • Gull and tern abundance has been observed to increase post-construction compared to other seabirds at an offshore wind farm in the UK (Petersen 2005). It is unclear if this attraction was related to roosting opportunities on above water infrastructure, new food sources from the creation of artificial reefs, or if they were attracted by vessel activity (Petersen 2005). Bats are more likely to be attracted to windfarms than to engage in avoidance behaviours (Cryan et al. 2014). • Studies at European OSW projects suggest offshore structure provide roosting platforms, which bats may take advantage of to rest during migration (Ahlén 2006;	

			Ahlén et al. 2007, 2009; Hutterer et al. 2005).
			• Bats may be attracted to wind turbines for roosting or breeding if the represent tall structures on an otherwise flat landscape, as bats appear to be attracted to tall structures, such as trees and lighthouses (Alhen et al. 2009; Kunz et al. 2007; Horn et al. 2008; Guest et al. 2022).
			• Alhen et al. (2009) documented wind turbines being used for roosting 5.8 km from shore.
			• Bats maybe attracted to insects that gather close to turbines, microclimates at turbines (lower windspeed, temperature variation), and lights, noise and rotation of turbines (Cryan and Barclay 2009; Cryan et al. 2014; de Jong et al. 2021; Guest et al. 2022; Kunz et al. 2007; Orr et al 2013; Pelletier et al. 2013; SEER 2022).
			
			<u>Collisions</u>
			
			Bird collision rates may be influenced by project location and design, species type, abundance and characteristics, individual characteristics, and weather conditions:
			• Turbine size, rotor dimensions, and turbine alignment have been shown to influence bird collision risk (Drewitt and Langston 2006).
			• Lower collision rates have been observed at OSW farms located further offshore and at greater distances from high bird density areas (e.g., breeding colonies, migratory flyways, frequently used flight paths, areas where birds use shallow waters and upwellings and currents for foraging) (Drewitt and Langston 2006; Everaert and Stienen 2006; Hill et al. 2014; Kerlinger and Curry 2002; Petterson 2005).
			• Species /species group may influence collision risk.
			  o Passerines (e.g., warblers, vireos, thrushes, sparrows) account for nearly 60 percent of avian fatalities documented at onshore wind facilities (AWWI 2020a; Erickson et al. 2014) and, similarly, have been the most found carcass types at offshore and coastal structures including lighthouses, platforms, and ships (Hill et al. 2014; Huppop et al. 2016). Passerines are the most abundant group of birds occurring in North America and migrate nocturnally.
			  o Observed collisions at nearshore and OSW sites in the U.S. and Europe include gulls, terns, phalaropes, cormorants, jaegers, skuas, sea ducks, pelicans, and songbirds. Notably, these include large birds with less maneuverability (e.g., gull and waterfowl species) (Everaert and Stienen 2006; SEER 2022).
			  o Large raptors, such as eagles and hawks, and species that are known to frequent offshore areas, including seabirds and waterfowl, are considered at a	

			higher risk of collisions with OSW turbines (Watson 2022, Goodale et al. 2019). ○ Migratory birds that traverse offshore wind farm areas during their seasonal migrations are also susceptible (Degraer et al. 2021). • Individual characteristics (e.g., age, health, behaviour such as foraging, breeding and migration) can impact collision risk. For example, research conducted at lighthouses, oil platforms, and ships shows collision risk increased with periods of increased activity (Hill et al. 2014; Huppop et al. 2016). • Poor weather conditions (e.g., fog and rain) can increase collision risk due to poor visibility. Strong headwinds and low-lying clouds also influence collision rates as migrating birds tend to fly lower under these conditions (Willmott et al. 2013). Bird morality due to collisions may have negative consequences such as: • Population-level impacts overtime, especially for species with small or declining populations (Furness et al. 2013, Brabant et al. 2015, Horswill et al. 2022). • Exacerbating the decline of threatened and endangered species (Schwemmer et al. 2023). • Increasing disturbance and stress among bird populations (Larsen and Guillemette 2007). • Impacts on ecosystem services birds provide (nutrient cycling and seed dispersal in marine and coastal ecosystems) (Hooper et al. 2017). Research about bird collisions at OSW sites should be interpreted with caution. • Methods commonly used at land-based farms, such as carcass searches are not feasible at OSW sites, limiting post-construction monitoring at OSW farms to incidental observations and remote collision detection monitoring technologies, which are currently developing. This may lead to under-reporting collision rates (Drewitt and Langston 2006; Kaldellis et al 2016; SEER 2022). • Bird collision risk at OSW sites may not be comparable to collision risk at other structures such as lighthouses, oil platforms and ships due to differences in lighting and structural features. Research shows, among other factors, lighting, masts, and guywires of these structures contributed to collision risk and these are different than features associated with OSW. (Hill et al. 2014). • Bats rarely collide with stationary infrastructure (Boonman 2018). **<u>Stress</u>** • The presence of wind farms and the associated mortality risks (i.e., collisions) can lead	

			to increased disturbance and stress among bird populations. This can disrupt normal behavior patterns, such as breeding, foraging, and migration, potentially affecting reproductive success and survival (Larsen and Guillemette 2007). **Positive Effects** • Reduced human disturbance: The presence of offshore wind farms may act as a deterrent to human activities in certain areas, reducing disturbances such as shipping traffic and fishing (Degraer et al. 2021). This reduction in human disturbance can create quieter zones that are more suitable for bird breeding, roosting, and foraging. • Protection of coastal habitats: By harnessing wind energy offshore, the need for onshore or near shore development, which could potentially impact coastal bird habitats, is reduced. Offshore wind farms can contribute to the preservation of coastal ecosystems and their associated bird populations (Leopold et al. 2013). • Deterrence of Predators: The structures of offshore wind farms can serve as elevated perches, deterring ground-based predators that might threaten bird colonies. This protective effect can enhance the safety of nesting and roosting areas for certain bird species.	
	Movement of turbine blades	• Physical injury or mortality due to collisions (birds and bats)	Rotor speed has been shown to influence bird collision risk (Drewitt and Langston, 2006). Bat collision risk at onshore windfarms in North America is well documented (Arnett et al. 2008; Cryan and Barclay 2009; Hayes 2013; Smallwood 2013; Martin et al. 2017; Pettit and O'Keefe 2017; Allison et al. 2019). • Fatality estimates due to collisions at onshore wind farms in the U.S. range from 4-7 bats per MW per year up to 50 bats per MW per year at windfarms located along forested ridgelines in the southeastern U.S. (AWWI 2020b). • Collision mortality has affected migratory tree-roosting bats with long-distance migrant fatalities (e.g., hoary bat, eastern red bat, silver-haired bats) most found at North American onshore wind farms (Kunz et al. 2007; AWWI 2020b) • More collisions at onshore wind farms have been recorded during high activity periods, and between mid-July and mid-October in North America (Arnett et al. 2008; Cryan et al 2014; True et al. 2021). • Low wind speeds (e.g., less than 5 metres per second) have been shown to increase bat	

			collisions (Cryan et al 2014) Bats also risk collision at OSW sites, although bats are observed to be less common offshore compared to onshore locations (Guest et al. 2022; Pelletier et al., 2013; Stantec 2016b). • According to records from other offshore structures (e.g., lighthouses) and acoustic and telemetry surveys, several bat species may migrate offshore and use offshore structures as stopover sites (Pelletier et al. 2013; Stantec 2016a and b; Dowling et al. 2017). Furthermore, bats have been recorded as occurring up to 130 km off the Atlantic Coast in the U.S. (Stantec 2016 b), and bats have been observed at OSW farms in Europe during seasonal migration (Guest et al. 2022; Rydell et al. 2010). • Acoustic monitoring surveys have indicated that long-distance migratory bat species occur more frequently offshore than other species of bats, and their activity is increased offshore during migratory periods and periods with low wind speeds, like patterns observed at onshore locations (Stantec 2016b) • Bat collisions may occur nearshore more often than at greater distance as studies show higher bat activity here (Guest et al. 2022; Pelletier et al., 2013; Stantec 2016b). Some studies suggest turbines located greater than 26 km offshore may have limited impacts on bats, but closer turbines could have effects similar to onshore wind farms (Lagerveld and Mostert, 2023; Sjollema et al. 2014; Stantec 2016).	
	Noise and vibration	• Attraction (bats)	• Bats maybe attracted to insects that gather close to turbines, microclimates at turbines (lower windspeed, temperature variation), and lights, noise and rotation of turbines (Cryan and Barclay 2009; Cryan et al. 2014; de Jong et al. 2021; Guest et al. 2022; Kunz et al. 2007; Orr et al 2013; Pelletier et al. 2013; SEER 2022).	
	Artificial lighting	• Attraction and/or disorientation	• Research conducted at lighthouses, oil platforms, and ships shows lighting during inclement weather can disorient and/or attract birds. This may increase collision rate. As above, these findings may not be comparable to OSW (Hill et al. 2014; Huppop et al. 2016). • Some species may be attracted to wind farms due to artificial lighting and/or perching and foraging opportunities. This may increase collision risk (Dierschke et al. 2016; Hill et al. 2014; NatureScot 2020). • Bats maybe attracted to insects that gather close to turbines, microclimates at turbines (lower windspeed, temperature variation), and lights, noise and rotation of turbines (Cryan and Barclay 2009; Cryan et al. 2014; de Jong et al. 2021; Guest et al. 2022; Kunz	

			et al. 2007; Orr et al 2013; Pelletier et al. 2013; SEER 2022).	
Presence of subsea infrastructure (foundations, cables)	Presence of infrastructure	• Physical injury or mortality due to collision (diving birds)	• Diving birds (sea ducks, alcids, loons, gannets, cormorants, and terns) are known to sustain injury when plunge-diving into obstructions such as boat decks or fish holds when foraging (Mowbray 2002). They may similarly risk collision with underwater mooring systems; however, this risk is expected to be low as many marine birds favor shallow water for foraging, or dive to relatively shallow depths while pursuing underwater prey, and mooring systems are typically associated with deeper waters.	
Marine vessel operation and helicopter use	Noise	• Avoidance, displacement and/or other behavioural changes • Increased/chronic stress	• Ongoing disturbances from turbines and ship traffic can result in chronic stress among avian populations and may impact the ability of birds to thrive and reproduce successfully (Bech-Hansen et al. 2019; Breuner C.W. 2011).	
	Artificial lighting	• Attraction		
	Increased human activity	• Avoidance, displacement and/or other behavioural changes • Increased/chronic stress		
Decommissioning				
Structure inspection		•		
Vessel and equipment use	Noise	• Avoidance, displacement and/or other behavioural changes • Increased stress	• Few OSW projects have been decommissioned to date but impacts are expected to be comparable to construction with regard to vessel requirements and resulting noise (NRCan 2021).	
	Artificial lighting	• Attraction		
	Increased human activity	• Avoidance, displacement and/or other behavioural changes • Increased stress		
Removal of turbines and foundations/anchors	Physical alteration to environment	• Avoidance, displacement and/or other behavioural changes		
Removal of cables/cable protection				

Malfunctions and Accidental Events				
Structural failure / loss of turbine				
Fire / Mechanical Fire				
Discharge of Fluids	Exposure to contaminates	• Mortality from oil coverage preventing flight and/or ingestion (birds) • Reduction in ability to forage (birds)		

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IV. Marine Mammals and Sea Turtles

Based on the Committee's findings to date, potential effects of OSW on marine mammals and sea turtles include:

- physical injury or mortality due to collisions;
- temporary or permanent behavioural changes such as avoidance, habituation, displacement, attraction, and disorientation; and
- temporarily increased or chronic stress.

As can be seen in the table below, most information the Committee has gathered on this topic relates to the operation phase of OSW development.

The Committee has also found behavioural changes and stress can be associated with all phases of OSW. Several studies have found marine mammals and sea turtles may be displaced from habitats because of the presence of offshore structures, noise, vibration, activity of vessels and personnel, altered water quality and/or physical alternation to the environment during all phases of OSW development (Richardson et al. 1995; Gordon et al., 2003; Nedwell et al. 2003; DFO, 2004; Dong Energy et al., 2006; Kaldellis et al. 2016; NYSERDA 2017f; Erbe et al, 2019; CSA, 2021; Maxwell et al 2022; SEER 2022). Regarding stress, at least some activities during each phase of OSW development (e.g., vessel and equipment use) increase noise levels and human activities, and these have been linked to elevated stress levels in marine mammals and sea turtles (Richardson et al. 1995; Gordon et al., 2003; Nedwell et al. 2003; DFO, 2004; Dong Energy et al., 2006; Kaldellis et al. 2016; NYSERDA 2017f; Erbe et al, 2019; CSA, 2021; Maxwell et al 2022; SEER 2022).

About related effects on other components, the Committee generally understands that marine fish and commercial fisheries could be impacted during any activities that displace marine mammals and sea turtles from existing foraging habitat. Marine mammals and sea turtles would be forced to forage elsewhere and would impact fish population through predator-prey interactions. This would subsequently impact commercial fisheries if increased risk of predation displaces fish and/or leads to decreased fish populations.

Potential Impact Pathways and Effects of Offshore Wind Development on Marine Mammals and Sea Turtles				
Activity	**Impact Pathway**	**Effects**	**Summary of Current Knowledge**	**Related effects on other Components**
Pre-Construction				
Sonar/Acoustic seafloor mapping	• Noise and vibration related to all pre-construction activities. • Artificial lighting related to vessel and equipment use. • Vessel	• Temporary or permanent behavioural changes (e.g., increased activity, change in swimming direction, avoidance). • Temporary or permanent phycological changes (increased stress). • Temporary or permanent changes in prey availability	• Most marine mammals, namely toothed whales (odontocetes), are capable of hearing higher frequency sources of underwater noise such as mapping-sonar signals (Varghese & Curran, 2021). • 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)	
Seismic surveys			• Chronic exposure from long-term consequences of sound pollution could affect marine mammals by changing prey accessibility (Gordon et al., 2003). • In three studies the following behavioral responses of sea turtles in enclosures exposed to airgun sounds were sometimes observed: increased swimming speed, increased activity, change in swimming direction, and avoidance (DFO, 2004).	

	navigation.	• Temporary or permanent increased risk of collisions. • Temporary changes to communication (e.g., avoidance, habituation, displacement, attraction, disorientation).	• Marine turtles show a strong initial avoidance response to air-gun arrays at a strength of 175 dB re 1µPa rms or greater (O'Hara & Wilcox, 1990; McCauley et al., 2000; Weilgart et al., 2013) • Protocols and guidelines for minimizing acoustic disturbances to marine mammals from seismic surveys are provided by Castellotte (2006) in a general review article.	
Vessels and equipment use			• All vessels (fishing vessels, cruise ships, research vessels, etc.) produce underwater noise in a nearly omni-directional pattern (Erbe et al., 2019) and can mask the communication signals of marine mammals (CSA, 2021). • Marine species that conducts surface-level activities (resting, foraging, nursing, migrating, and socializing) are at higher risk of vessel collisions and often result in sharp force trauma, such as propeller injury (NMFS & USFWS, 2008; Schoeman et al., 2020). ○ Collisions with larger vessels may be less likely for marine species that conducts surface-level activities due to surface behavior, deep diving, maneuverability, and/or vessel aversion (SEER, 2022). ○ Collision may be less likely with vessels associated with floating OSW farms because pre-constructed components are often towed at low speeds to the site and installed in relatively short amounts of time, and maintenance may be done using helicopters, thus reducing overall vessel traffic (Maxwell et al., 2022). • Species of concern: Cuvier's beaker whale, harbor porpoises, NARW, killer whales, fin hales. (CSA, 2020)	
Construction				
Installation of wind turbines, substations, converter stations, and foundations/anchors	• Noise and vibration related to various activities. • Artificial lighting related to vessel and equipment use. • Vessel navigation. • Sediment suspension.	• Temporary or permanent behavioural changes (e.g., avoidance). • Auditory injury • Temporary or permanent changes in feeding efficiency • Temporary or permanent increased risk of collisions	• Pile driving generates significant underwater noise that may cause auditory injury within close-range (Kaldellis et al., 2016; Lüdeke et al., 2017). High frequency cetaceans are at the highest risk for injury due to their sensitivity to high frequency components of pile driving (NYSERDA, 2017f). • Pile driving occurs during installation of some monopile, jacket, tri-pile, tripod, and floating foundations. Therefore, acoustic effects are anticipated to be relatively similar across these foundation types, though the size of piles used for floating foundations is often much smaller than monopile and effects would be also less (BOEM, 2020). • Construction (particularly pile driving) is more likely to generate high-intensity, low-frequency sound that could be detected by sea turtles over large temporal or spatial scales (Dow Piniak et al., 2012). • Benthic disturbances during construction activities are associated with seafloor preparation, cable burying, foundation installation, and vessel anchoring. Construction activities at the	

	• Visual and spatial disturbance.		seafloor will result in temporary, localized increases in sediment suspension within the water column, which will increase turbidity may decrease feeding efficiency for marine mammals and sea turtles causing avoidance behaviours (Stantec, 2022). • Most avoidance-causing effects to fishes, marine mammals, and potentially sea turtles occur during foundation installation because of increased noise and vibration from installation activities, such as pile driving (Ridgway et al., 1969; Anderson, 2011; Dähne et al., 2013). • There is evidence for behavioral avoidance in harbor porpoises during pile driving (Carstensen et al., 2006). These effects do not appear to be permanent because porpoises have also been observed returning to an area after pile driving ceased (Dähne et al., 2013). • Species of concern: Humpback whales (CSA, 2020)	
Installation of cables/cable protection				
Vessel and heavy equipment use			*Same as under 'Pre-construction'*	
Operations				
Presence/operation of turbines	• Noise and vibration related various activities. • Artificial lighting related to vessel and equipment use. • Hot water out-take from HDVC system • Presence of infrastructure • Ground preparation for cable installation • Electromagnetic	• Temporary or permanent behavioural changes (e.g., avoidance, habituation, displacement, attraction, disorientation). • Temporary or permanent phycological changes (increased stress) • Temporary or permanent increased risk of collisions • Permanent changes in foraging behaviour due to prey habitat alterations and reef effect • Entanglement risk. • Potential impact on ability to use natural EMF cues.	Adverse: • Artificial lighting on marine mammals during the operational phase of OSW projects are considered low risk, and regardless of colour, intermittent flashing lights with a very short on-pulse and a long off-interval have not been demonstrated to disturb sea turtle behaviour (Orr et al., 2013). ○ Some marine and sea turtle species may be attracted to structures for foraging opportunities if fish or plankton are attracted to light sources (Stantec, 2022). • Some effects to marine species from the HVDC system may occur from the intake pipes and discharge outflow. NEPA analysis for offshore HVDC systems is in progress, but comparisons may be made to other sea water intake systems, such as desalinization plants, to assess effects from intake pumping and filtration systems (BOEM, 2022). Positive effects: • Beneficial effects from OSW 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 fishes, seabirds, sea turtles, and marine mammals (BOEM, 2020). • The operation of wind turbines has no significant negative effect on marine mammal	

	fields • Presence and navigation of vessels and equipment	• Temporary masking of communications between marine mammals and sea turtle species due to noise from vessels.	abundance and distribution as any effects are likely to be small, especially compared to impacts from other more common anthropogenic and natural noise sources (Madsen et al., 2006; Verfuss et al., 2015).	
Presence of subsea infrastructure (foundations, cables)			Adverse: • Some marine animals (sharks, salmon, sea turtles) detect naturally occurring electric/or magnetic fields for essential life functions and may be affected by the EMF emitted by power cables (Taormina et al., 2020; NYSERDA, 2017f). • When EMFs are present, some marine animals that can detect EMFs exhibit attraction or avoidance behaviours. Avoidance behaviours may be elicited from higher-strength EMFs. Lower-strength EMFs may attract other electrosensitive species, as these could mimic the EMFs from prey. • Secondary entanglement accused by marine debris becoming snagged in floating OSW farm cable systems pose a threat to cetaceans, sea turtles and marine mammals (Taormina et al., 2020; Maxwell et al., 2022). This poses a threat to some of the migratory species at risk in NL including the fin whale, loggerhead sea turtle, harbour seal, and harbour porpoises. (Maxwell et al., 2022; SEER, 2022). Positive effects: • The risk of marine fish, marine mammals, and sea turtles becoming entangled in floating OSW farm cable systems ('primary entanglement') is low because mooring lines and cables are large in diameter and sufficiently heavy enough to prevent entangling these species. • Higher trophic level organisms such as piscivorous fish species and marine mammals responded positively to the aggregation of biomass, piles, and scour protections based on modelling (Raoux et al., 2017 in Svendsen et al., 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 (Russell et al. 2014, as cited in English et al., 2017; Lindeboom et al., 2011). Hawksbill sea turtles are also known to use artificial reef-like structures for foraging (Gorham et al., 2014) and other sea turtles, primarily loggerhead sea turtle as well as green sea turtle (*Chelonia mydas*) and Kemp's ridley sea turtle, have also been found to associate with offshore oil rigs in the Gulf of Mexico (Lohoefener et al., 1990; BOEM, 2020). • Attraction effects from foundations are likely beneficial to marine mammals and sea turtles 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. Thus, overall attraction effects are expected to be similar across monopile, jacket, tripod, tri-pile, jack-up, suction bucket, and gravity foundations types based on a combination of useable surface area, artificial reef effects (food sources), and/or magnitude of wake effects. Floating foundations may have similar beneficial effects at floating components in the surface water layer, but would have less attraction effects at greater depths, where only tether lines and anchor structures are present (BOEM, 2020).	
Marine vessel operation and helicopter use			*Same as under 'Pre-construction'*	
Decommissioning/Abandonment				
Structure inspection				
Vessel and equipment use				
Removal of turbines and foundations/anchors	• Noise and vibration related to all decommissioning activities. • Artificial lighting related to vessel and equipment use. • Presence and navigation of vessels and equipment.	• Temporary or permanent behavioural changes (e.g., avoidance, habituation, displacement, attraction, disorientation). • Temporary or permanent phycological changes (increased stress) • Temporary increased risk of collisions • Permanent changes in foraging behaviour due to prey habitat alterations and removed reef effect • Temporary masking of communications between marine mammals and sea turtle species due to noise from vessels	• 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 (CSA, 2020).	
Removal of cables/cable				

protection				
Malfunctions/Accidental Events				
Structural failure / loss of turbine	• Electromagnetic field emissions	• Temporary or permanent behavioural changes (e.g., avoidance, habituation, displacement, attraction, disorientation) • Potential impact on ability to use natural EMF cues.	• A combination of wear in the power cables (due to e.g., biofouling or hydrodynamic forces in the water column) and the increasing cable length and capacity required to facilitate long-distance energy transport at increasing current strengths to shore, may further enhance emissions of anthropogenic EMFs associated with floating OWFs (Svendsen et al., 2022).	
Fire / Mechanical Fire	N/A	N/A	• No studies found discussing this potential event for OSW to date.	N/A
Discharge of Fluids	• Environmental Pollution	• Temporary changes to the environment, feeding, and species distribution.	• Accidental release of chemicals and hydrocarbons during installation (Bat et al., 2013). • Accidental releases are distinct from routine discharges, the latter typically consisting of authorized operational effluents controlled through treatment and monitoring systems and permit limitations (BOEM, 2023).	
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V. Protected and Special Areas

Protected and Special Areas refer to any ocean areas designated with legal safeguards to conserve and manage their natural resources, biodiversity and/or ecosystems (MPAs, EBSAs, AOIs, Refuges, Fishery Closure Areas, etc.). Based on the Committee's finding to date, potential effects of OSW on protected and special areas include:

- Benthic disturbance and suspension of sediment;
- Noise and vibration; and
- Presence of infrastructure.

As seen in the table below, most information the Committee has included relates to the construction and operation phases of OSW.

The Committee also understands that the effects on protected and special areas can also be seen across various components, such as fish, marine mammals and sea turtles, benthic and intertidal habitat and fisheries. Due to the nature of protected and special areas that help protect or maintain these components, most effects are more indirect, as they directly effect the species within the protected or special area.

Potential Impact Pathways and Effects of Offshore Wind Development on Protected and Special Areas				
Activity	**Impact Pathway**	**Effects**	**Summary of Current Knowledge**	**Related effects on other Components**
Pre-Construction				
Sonar/Acoustic seafloor mapping	• Benthic disturbance and suspension of sediment • Noise and vibration	Sonar/acoustic seafloor mapping, seismic surveys, and the presence of vessels and equipment will result in a change in the underwater soundscape, thereby potentially affecting habitat quality and use of affected special areas.		
Seismic surveys				
Vessels and equipment use				
Construction				
Installation of wind turbines, substations, converter stations, and	• Benthic disturbance and suspension of sediment		• Acute noise-related impacts during construction phase (driving, drilling and dredging operations) (Spiropoulou et al., 2014). • Generation of polluted sediments during construction and their re-suspension (Spiropoulou et al., 2014).	

foundations/anchors	• Noise and vibration		**Special Areas of Importance for Marine Fish (including Special Areas with Defined Benthic Conservation Objectives)** • Initial installation and construction of offshore wind turbines will alter marine fish habitats, but once complete can create additional hard substrate that may act as an artificial reef suitable for benthic communities depending on the type of turbine substructures (monopile versus floating) (Bray et al., 2016). • Noise production from construction and installation of turbine foundations (e.g. towing floating turbine structures to site, pile driving for monopiles, etc) may have direct or indirect impacts on in situ or nearby fish spawning grounds within marine protected areas (Bray et al., 2016).	
Installation of cables/cable protection				
Vessel and heavy equipment use				
Operations				
Presence/operation of turbines	• Noise and vibration • Presence of infrastructure		**Special Areas of Importance for Marine Fish and Marine Mammals and Sea Turtles:** • Operation of offshore wind turbines and associated foundations may require imposing fishing restrictions within the OSW near marine protected areas, which could provide additional refuge for select marine fish species and act as a de facto marine protected area (MPA) (Bray et al., 2016). • While some regions, such as Brazil, experience challenges with enforcement of fishing restrictions in traditional MPAs, designation of an area within a series of fixed structures like OSW could aid in enforcement of fishing restrictions as fishermen may be likely to avoid trawling gear within turbines for risk of entanglement. Fixed cameras on wind turbines can also aid in monitoring fishing activity of static and recreational fishermen (Bray et al., 2016). • The presence of turbine foundations and cables during operations may require imposing fishing restrictions within the OSW for additional refuge of select marine fish species and could even act as a de facto marine protected area (MPA) (Bray et al., 2016; Gusatu et al., 2021). • Potential effects that OSWs can have on the environment, including areas near to existing marine protected areas, include impacts on turbulence and mixing, surface wave energy, sediment dynamics, biogeochemistry, mesoscale flows, upwelling and downwelling, and meteorology are highlighted (Farr et al., 2021).	

				• Creation of the artificial reef, with concomitant impacts on biodiversity (Spiropoulou et al., 2014) • Chronic impacts due to continual operational noise and vibrations emanating from OSW (Spiropoulou et al., 2014). The noise has a significant impact on a wide range of different aquatic organisms such as vertebrates, seals and many cetaceans. Also, the intraspecific communication of fish affected and are likely to lose their orientation or become easier prey (Thomsen et al., 2006; Spiropoulou et al., 2014). • Electromagnetic impacts (underwater cable networks) that may interfere with animal navigation (Spiropoulou et al., 2014). The resulting electromagnetic fields have the potential to affect magneto sensitive species such as bony fish, elasmo branches, marine mammals and sea turtles (Spiropoulou et al., 2014). EMFs could also affect animals which use geomagnetic cues during migration (Spiropoulou et al., 2014). • Thermal impacts that may aggravate the impacts of other stressors on the benthos (Spiropoulou et al., 2014). • Impacts of episodic traffic increase for troubleshooting (Spiropoulou et al., 2014). • Several species of animals are able to perceive such low frequency vibrations through their skin. It is this ability which enables several animals to 'foresee' earthquakes and tsunamis before the calamities actually strike them (Grant & Halliday, 2010). Also, the vibrations caused by OSW may mislead marine species and to perceive the sound as something else (Spiropoulou et al., 2014).	
Presence of subsea infrastructure (foundations, cables)				• The big difference between 'artificial reefs' from that of natural reefs may impact the biodiversity of surrounding areas. Structural elements placed in sand bottoms may result in greater benthic diversity, but this may also affect adjacent communities through greater predation. With this technique, some species are favoured as the benthos and some not (Spiropoulou et al., 2014). • Behavioural effects, such as avoidance of the area, have to be considered in particular when areas of special biological interest for a species, like breeding grounds, migratory routes, or schooling areas are concerned (Thomsen et al., 2006). • While restricting or rearranging fishing activities, OSWs have the potential to affect ecosystem structure and functioning in diverse ways. Positive impacts can include increased nursery areas for key species supporting the fish community. In contrast, OSWs can potentially have a negative impact on the seabird community through collisions or as habitat loss by avoidance. Furthermore, they also likely modify the ecosystem through structural changes by adding hard substrate that can potentially increase the abundance of epifauna, like the bivalve Mytilus edulis, which in turn may impact ecosystem functioning (Püts et al., 2023). • In a study by Puts et al (2023), their results showed that the size and location of the	

			closed fishing areas is crucial to reach an overall impact. While all three scenarios, MPA, Kempton's Q and IUCN close the fishing grounds up to 30%, the impact on catch-based indicators is quite diverse, highlighting that also the location and coherence of the closed areas is an important factor (Püts et al., 2023). • Size, coherence and location of the closed areas influenced the spatial distribution of fish and total biomass. While closing the areas only for OSWs already led to visible changes in distribution, adding MPA closures further influenced the magnitude of change (Püts et al., 2023). Not surprisingly, the effect of closed areas was dependent on their individual sizes, where especially large closures were significantly more effective than small ones, which is supported by other studies that have found that larger MPAs may be needed to reach conservation goals. Yet even small OSW may have larger effects than observed due to the coarse resolution of the model. Even though no specific test for spatial connectivity was carried out, results showed closing large areas (IUCN and Kempton scenarios) performed better compared to the OSW and MPA scenarios that represent many small-scale closures distributed throughout the southern part of the North Sea. This result may be in part due to the importance of cohesion when designing closures (Püts et al., 2023).	
Marine vessel operation and helicopter use				
Decommissioning				
Structure inspection				
Vessel and equipment use				
Removal of turbines and foundations/anchors				
Removal of cables/cable protection				
Malfunctions/Accidental Events				
Structural failure / loss of turbine				
Fire / Mechanical Fire				

Literature on Effects to Protected and Special Areas Compiled to Date

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VI. Fisheries

Based on the Committee's findings to date, potential effects of OSW on fisheries include:

- Loss of access to fishing grounds
- Changes in fisheries resources
- Disruption in vessel navigation
- Increased risk of collision, allision and vessel/infrastructure damage
- Gear loss or damage (only during construction and operation)

The Committee is still in the process of compiling information for this topic across all phases of development for OSW. Potential effects and summary of current knowledge compiled to date can be found in the table below.

About related effects on other components, the Committee generally understands that activities throughout the phases of OSW that have an impact on fisheries, could also potentially impact birds and bats, fish, marine mammals, and sea turtles, viewshed, benthic and intertidal habitat and other ocean users.

Potential Impact Pathways and Effects of Offshore Wind Development on Fisheries				
Activity	**Impact Pathway**	**Effects**	**Summary of Current Knowledge**	**Related effects on other Components**
Pre-Construction				
Sonar/Acoustic seafloor mapping	• Vessel and equipment activity	• Loss of access to fishing grounds • Changes in fisheries resources • Disruption in vessel navigation • Increased risk of collision, allision, and vessel/infrastructure damage	**Indirect effects on fisheries:** • Pre-construction site surveys for OSW use multibeam and side-scan sonar, sub-bottom profiles, and other geophysical technologies to characterize the seafloor and site conditions which can impact marine fish species (CSA, 2021; Mooney et al., 2020). These lower-energy (i.e., quieter) systems and 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; Mooney et al., 2020; Bat et al., 2013).	
Seismic (streamer) surveys			**Direct effects on fisheries:** • Commercial fisheries are often excluded from OSWs during the pre-construction phase due to their incompatibility with geo-physical surveys (Roach et al., 2022). • Seismic survey shooting performed during the pre-construction period of OSW can negatively affect the abundances of fish and may cause catch reductions (Bat et al., 2013). Low catch rates were observed 18 nautical miles from the seismic shooting area, but the most pronounced decrease of fish abundance occurred within the shooting area (Bat et al., 2013).	
Vessels and equipment use			**Direct effects on fisheries:** • Fishers concerned about the effects of noise on marine life and the displacement of	

			other fishers into their grounds (Hooper et al., 2015). • The acoustic signature (i.e., low or high frequency sounds) produced by a vessel varies based on the type of vessel, and vessels that use dynamic positioning thrusters generate substantial underwater noise (CSA, 2021). • Intermittent site surveys and ship noise can mask the communication signals of haddock (Melanogrammus aeglefinus), cod, and other taxa (Stanley et al., 2017). Such noise may also induce physiological stress and impair foraging and predator responses in both fish and invertebrates (Mooney et al., 2020). Interestingly, the intermittent nature of vessel noise seems to be an important factor in elevating stress related responses (Wysocki et al., 2006). • Vessel activities have been shown to elevate ambient sound pressure levels by 20–30 dB within 1 km of the turbine site (Mooney et al., 2020).	
Construction				
Installation of wind turbines, substations, converter stations, and foundations/anchors	• Vessel and equipment activity • Presence of Infrastructure	• Loss of access to fishing grounds • Gear loss or damage • Changes in fisheries resources • Disruption in vessel navigation • Increased risk of collision, allision, and vessel/infrastructure damage	**<u>Direct effects on fisheries:</u>** • Installation of foundations is most often achieved using impact or vibrational/percussive hammers that can produce a wide range of peak source sound levels. Contact of the pile with the water and striking of the hammer on the pile create acoustic waves that radiate out from the pile through the water column and substrate via multiple paths, resulting in loud, high-energy, impulsive sounds with sharp rise times (Andersson et al., 2017). Underwater sound levels (both particle motion and sound pressure) and detection distances vary substantially by site and depend on many factors, including substrate characteristics, depth, pile diameter, size of impact hammer, and how they are measured. The measured frequency range directly overlaps the auditory bandwidth of many fish and invertebrate species across multiple lifestyles (e.g., pelagic, epibenthic, demersal), including cod, salmon, black sea bass, flatfish, and squid, to name a few (Chapman and Sand, 1974; Mooney et al., 2010; Popper et al., 2019). Predicting effects can be complicated because an acoustic pulse changes as it propagates. The particle motion component and substrate transmission have been far less monitored and reported. However, the particle motion component is likely far more relevant to many important fisheries species (fishes and invertebrates) (Mooney et al., 2020). • The way windfarms are lit-up also has a considerable effect on fishing vessel navigation and the use of scour and other activities to reverse or stop environmental damage increases the loss of fishing ground (BOEM, 2022a).	
Installation of cables/cable protection			**<u>Direct effects on fisheries:</u>** • Seafloor preparation, installation of the foundations, vessel anchoring, and installation of the IAC and OSS-Link Cable will temporarily displace existing communities both on and in	

			the sediment in the RWF, which is expected to alter the existing benthic habitat (CSA, 2022). • The presence of the RWF foundations and scour protection and IAC and OSS-Link Cable protection throughout the 20- to 35-year life of the Project will alter the existing sandy-bottom habitat and structural relief that may act as an artificial reef, a phenomenon known as the "reef effect" (CSA, 2022). • Poorly sited wind farm locations and subsequent loss of fishing grounds and transit routes, increased transit times, due to obstruction from subsea and floating cable arrays (BOEM, 2022a). **Indirect effects on fisheries:** • Installation (or removal) of cables/cable protection may increase suspended sediment/water turbidity, scouring, and sedimentation as well as temporary disturbance/loss of fish and shellfish habitat under inter-array cables, prepared ground and construction plant movements (Bat et al, 2013). These actions, and turbine and foundation installations, can affect some benthic organisms, but the species are thought to return once construction ceases (Bat et al., 2013). • Fishers express a need for more research into the implications of electromagnetic fields and the effects of OSWs on the different life stages of commercial shellfish (Hooper et al., 2015). **Effects of Electromagnetic fields (EMF)** • Specifically, electromagnetic fields (EMFs) created by cables have the potential to interact with aquatic organisms that are sensitive to electric and magnetic fields. This affects both bony fishes and elasmobranch fishes and may be transient as the organism moves through the area and, alternatively, magneto-sensitive species may be attracted to or may actively avoid the area (Bat et al., 2013). • Some marine animals can detect naturally occurring electric and/or magnetic fields (e.g., sharks, salmon, and sea turtles) and use these to support essential life functions such as navigating and hunting for prey (NYSERDA, 2017b). • When EMFs are present, some marine animals that can detect electro-magnetic fields (EMFs) exhibit attraction or avoidance behaviours. Avoidance behaviours may be elicited from higher-strength EMFs. Lower-strength EMFs may attract other electrosensitive species, as these could mimic the EMFs from prey (Scott et al., 2018; SEER 2022; Taormina et al., 2020). • Subsea power cables can carry either AC (alternating current) or DC (direct current) power and both systems produce magnetic fields. DC power cables are capable of	

			carrying higher power levels generating stronger magnetic fields than AC power cables, and research suggests that marine species may be more likely to detect and react to magnetic fields from DC cables than from AC cables (Normandeau et al., 2011). • Some studies have documented marine animals demonstrating behavioural responses (i.e., increased foraging and exploratory movements) when near subsea cables; however, there is no conclusive evidence to determine that EMF from an OSW farm cause impacts to individual animals or populations (Stantec, 2022). • Species may exhibit different behavioural responses to EMFs. For example, American lobster (Homarus americanus) exhibits an increased likelihood of exploratory behaviours when EMFs are encountered, while the European lobster (Homarus gammarus) exhibits no attraction, foraging, or exploratory behaviours when exposed to static EMFs. Brown crab (Cancer pagurus) has been shown to exhibit attraction to EMFs (Scott et al., 2018; SEER 2022). • EMFs can elicit anatomical responses during the entire life cycle of an animal. For example, when exposed to a static magnetic field, rainbow trout (Oncorhynchus mykiss) were observed to hatch a day earlier (Scott et al., 2018; SEER 2022).	
Vessel and heavy equipment use			**<u>Direct effects on fisheries:</u>** • One of the key concerns of the US and European fishing industries is the overall footprint that OSW developments will occupy (including safety exclusions zones), as well as their proximity to and geographical overlap with historic fishing grounds (Mackinson et al. 2006; Methratta et al. 2020). • Fishers may lose access to fishing grounds altogether if exclusion zones are established within the OSW development (e.g., safety zones during construction) or may have accessbut with restrictions on the types of gear that can be used within the project footprint (Gray et al. 2016). **<u>Indirect effects on fisheries:</u>** • The presence of vessels and equipment during construction may create noise and vibration, electromagnetic fields, disturbance-maintenance activities, which may affect communication in fishes and invertebrates (Hawkins et al., 2015) and can lead to permanent loss of fish and shellfish seabed habitat (Bat et al., 2013).	
Operations				
Presence/operation of turbines	• Vessel and equipment activity •Presence of	• Loss of access to fishing grounds • Gear loss or damage	**<u>Direct effects on fisheries:</u>** • Other considerations of OSW which may hinder fisheries operations include potential collisions, allisions, and gear loss or damage from gear caught on OSW turbine foundations, subsea powerlines, and scour protection (Methratta et al., 2020; NYSERDA,	
Presence of subsea infrastructure				

(foundations, cables)	Infrastructure	• Changes in fisheries resources • Disruption in vessel navigation • Increased risk of collision, allision, and vessel/infrastructure damage	2022). Additionally, in the UK, fishing vessels are concerned with the risk of vessel breakdown in an OSW farm area and risk of collision with a turbine (Gray et al., 2016) • If OSW turbine foundations and subsea cables are not properly installed or buried, fishing gear with weighted nets, chain bags, or lines such as otter trawls, beam trawls, scallop dredges, gillnets, and demersal longlines can become lost or damaged if snagged on any scour protection (NYSERDA, 2022). • Floating cables and anchors, depending on water depth, type of mooring system and other factors, when connected to floating OSW farms may present obstacles to safe vessel operations and fishing methods (Methratta et al., 2020). • Compared to larger vessels, fishing vessels may interact with export cables as their anchors are not large enough to penetrate to the depth which they are buried (NYSERDA, 2017a). • Exclusion zones may influence changes in seafloor communities, specifically for benthic communities, within OSW farms (known as the fisheries exclusion effect) (Van Hoey et al., 2021). • Whilst effects were observed during the construction phase, these tended to be positive results to size structure and LPUE of lobsters in the windfarm site likely the result of exclusion of fishing effort due to safety concerns. Overall, there was a short-term increase in size and catch rates of lobsters associated with the construction phase of the offshore windfarm site, but this was not observed during the subsequent operational phase surveys (Roach et al., 2022). • Compatibility of static gear fisheries and OSW farms can be influenced by the layout of the array and environmental factors such as tidal current and direction (Roach et al., 2022). • Oil and gas platforms have been found to harbour large numbers of larval and juvenile fish, and wind turbine support structure can be expected to have a similar effect. In oil and gas platforms, fish that remain within the jacketed structures may be less vulnerable to fishing pressure than others (Bat et al., 2013). • An example of increase in biomass of 50 to 150 times occurred at Horns Rev in Denmark, an OSW farm with subsea infrastructure and reef effect which now provides a food source for fish species (Bat et al., 2013). • Multi-mesh gillnet catches near monopile structures showed attraction of this cod, bullrout, edible crab, velvet crab (van Hal et al., 2017). • The presence of this subsea infrastructure may also provide scour protection from trawl fisheries, barrier effects (fish migration, spawning etc.), as well as impacts to hydrodynamics, sediment transport, and other users (access and navigation) (Bat et al., 2013).	

			• The most common issue raised by fishermen, which was acknowledged by local fisheries officers was the risk associated with turbines stanchions, exposed cables, rock armouring, cable crossing points and waste material (debris) to fishing. These risks were cited as the major deterrent to fishing inside OSWs (Gray et al., 2016). • Based on their experience and the results of wind farm monitoring, fishermen and fisheries officers raised concerns over the potential adverse environmental effect of OSWs. Fishermen reported reduced quantity and quality of Nephrops and lower quantities of commercial demersal fish when approaching and within OSWs. Some Northwest of England fishermen were concerned over the apparent use of limestone to protect cables and attributed the local mortality of marine life to the use of this rock (Gray et al., 2016). **Indirect effects on fisheries:** • Wind turbines may increase habitat for benthic species, increasing local food availability, which may bring some migrant species into the area. Predators moving into the area with OSW infrastructure may result in prey depletion of fish species (Bat et al., 2013). • Colonization of the new structures will begin shortly after construction but may take several years for the colonization to be completed (Bat et al., 2013). • Avoidance of the hard substrate surrounding monopiles was shown for flatfish species and whiting, while increased abundance of fish in the vicinity of monopiles was shown only during two of the five days with Dual-Frequency Identification Sonar (DIDSON) observations (van Hal et al., 2017). • The presence of subsea infrastructure can have impacts on turbulence and mixing, surface wave energy, sediment dynamics, biogeochemistry, mesoscale flows, upwelling and downwelling, and meteorology, which may impact the presence of fish (Farr et al., 2021).	
Marine vessel operation and helicopter use			Direct effects on fisheries: • Wind farm maintenance can cause disruption to fishing activities and an increase in steaming distances to fishing grounds despite fishers having full access to the OSW sites (Gray et al., 2016). • Wind farm maintenance work was cited as causing disruption to fishing operations within and around wind farms. Conflict with OSW maintenance vessels, excessive area closures for maintenance work, and poor communication between fishermen and maintenance vessel operators was reported by fishermen. Fishermen complained about the increased steaming distance and time to fishing grounds beyond the OSW (Gray et al., 2016). Indirect effects on fisheries: • During the operation phase, underwater noise is generated by routine and non-routine	

			maintenance activities and the turbines themselves. 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 (SEER 2022).	
Malfunctions/Accidental Events				
Structural failure / loss of turbine	• Exposure to contaminates. • Vessel and equipment activity •Presence of Infrastructure		• Cable failures (e.g., due to abrasions) may affect the reef effect of subsea floating and buried cables subsequently impacting fish (Svendsen et al., 2022). A combination of wear in the power cables (due to e.g., biofouling or hydrodynamic forces in the water column) and the increasing cable length and capacity required to facilitate long-distance energy transport at increasing current strengths to shore, may further enhance emissions of anthropogenic EMFs associated with floating OSWs (Svendsen et al., 2022).	
Fire / Mechanical Fire			No studies found discussing this potential event for OSW to date.	
Discharge of Fluids			Accidental release of chemicals and hydrocarbons during installation (Bat et al., 2013).	
Vessel Collisions			• The constant increase of offshore wind farms in the German EEZ and a simultaneous expansive increase of European maritime traffic and ship size developments in recent years lead to an increasing safety risk due to limited available fairways (Weigell and Jahn, 2022). These increasing frequencies can lead to direct collisions between offshore wind turbines and ships or other accidents. As an example, in the area of the southwestern Baltic Sea, 1520 reported shipping accidents occurred in the period 2011-2015 with a level of about 300 accidents per year. The German Bight of the North Sea is one of the most frequented maritime sea routes in the world. Human error is responsible for most collision accidents. 95% off all accidents between 2015 and 2020 in Korean waters for example were caused by human error (Weigell and Jahn, 2022). • Ensuring the safety and ease of shipping traffic is governed by international and national regulations and is an explicit part of the "Strategy of the Federal Government for the Utilization of Wind Energy at Sea" from 2002 (Weigell and Jahn, 2022). • Additionally in the planning phase of an offshore wind farm there is the obligation to do an NRA (Navigational Risk Assessment) by the developer to be aware of potential nautical risks and thus mitigate the risks of collisions (Weigell and Jahn, 2022).	
Decommissioning				
Structure inspection				
Vessel and equipment use				
Removal of turbines and foundations/anchors				
Removal of cables/cable protection				

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VII. Other Ocean Users

Other Ocean Users takes into account all users of the ocean that are not covered under fisheries (e.g., marine shipping, tourism, recreational boaters, etc.). Based on the Committee's findings to date, the potential effects of OSW on other ocean users include:

- Disruption in vessel navigation;
- Increased risk of collision, allision, and vessel/infrastructure damage;
- Rerouting; and
- Conflicts with space.

As seen in the table below, the Committee is in their primary stages of collecting information on effects for this topic, but do understand that birds and bats, fish, marine mammals and sea turtles, benthic and intertidal habitat, viewshed and fisheries may share related effects with other ocean users.

Potential Impact Pathways and Effects of Offshore Wind Development on Other Ocean Users				
Activity	**Impact Pathway**	**Effects**	**Summary of Current Knowledge**	**Related effects on other VCs**
Pre-Construction				
Sonar/Acoustic seafloor mapping	• Vessel and equipment activity • Presence of infrastructure	• Disruption in vessel navigation • Increased risk of collision, allision, and vessel/infrastructure damage • Rerouting • Conflicts with space		Birds and Bats, Fish, Marine Mammals and Sea Turtles, Benthic and Intertidal Habitat, Viewshed, Fisheries
Seismic (streamer) surveys				
Vessels and equipment use				
Construction				
Installation of wind turbines, substations, converter stations, and foundations/anchors	• Artificial lighting • Movement of turbine blades • Vessel and equipment activity • Presence of infrastructure	• Disruption in vessel navigation • Increased risk of collision, allision, and vessel/infrastructure damage • Rerouting • Conflicts with space	• The construction stage of OWF developments did not result in a reduction in tourism (in one study), visitor spending, or tourism-related employment. In fact, most locations showed better local employment growth than the wider region (Glasson et al., 2022).	Birds and Bats, Fish, Marine Mammals and Sea Turtles, Benthic and Intertidal Habitat, Viewshed, Fisheries

Operations				
Presence/operation of turbines Presence of subsea infrastructure (foundations, cables) Marine vessel operation and helicopter use	• Artificial lighting • Movement of turbine blades • Vessel and equipment activity • Presence of infrastructure	• Disruption in vessel navigation • Increased risk of collision, allision, and vessel/infrastructure damage • Rerouting • Conflicts with space	• Due to geographic differences and small sample of studies in this area, there is no conclusive answer on the effects of OSW on coastal tourism. It is speculated that OSW off of the US Atlantic coastal region may experience more objections than less populated coastal areas, with ties to non-tourist, commercial use such as Denmark (Lilley et al., 2010). • Spacing between turbines, typically less than 1000 meters, poses a constraint on large commercial vessel maneuverability, necessitating careful navigation (Rawson & Rogers, 2015).	Birds and Bats, Fish, Marine Mammals and Sea Turtles, Benthic and Intertidal Habitat, Viewshed, Fisheries
Malfunctions/Accidental Events				
Structural failure / loss of turbine				
Fire / Mechanical Fire				
Discharge of Fluids				
Vessel, helicopter, and equipment use for emergency response and/or repair				
Decommissioning				
Structure inspection				
Vessel and equipment use				
Removal of turbines and foundations/anchors				
Removal of cables/cable protection				

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VIII. Visual Aesthetics and Viewscapes

To date, the Committee has identified some potential impact pathways and effects on visual aesthetics and viewscapes related to specific activities associated with OSW. Generally, the Committee understands effects on visual aesthetics and viewscapes could effect the following other components assessed under the RA:

- Tourism operators (under Other Ocean Users);
- Economy and communities;
- Physical and cultural heritage;
- Protected and special areas.

Please provide any information you may have on this topic, including citations, in the table below.

Potential Impact Pathways and Effects of Offshore Wind Development on Visual Aesthetics and Viewscapes				
Activity	**Impact Pathway**	**Effects**	**Summary of Current Knowledge**	**Related effects on other Components**
Pre-construction				
Sonar/Acoustic seafloor mapping	• Presence of vessels and equipment • Artificial lighting	Temporary change to seascape and visual aesthetic.		
Seismic surveys				
Vessels and equipment use				
Construction				
Installation of wind turbines, substations, converter stations, and foundations/anchors	• Presence of vessels and equipment • Artificial lighting	Temporary change to seascape and visual aesthetic.		
Installation of cables/cable protection				
Vessel and heavy equipment use				
Operation				

Presence/operation of turbines	• Presence of turbines • Artificial lighting • Presence of vessels and helicopter	Temporary, long term (duration of project) change to seascape and visual aesthetic.		
Presence of subsea infrastructure (foundations, cables)				
Marine vessel operation and helicopter use				
Malfunctions and Accidental Events				
Structural failure / loss of turbine	• Presence of infrastructure • Presence of vessels, equipment, and/or helicopter • Artificial lighting	• Increased magnitude of seascape and visual impacts. • Temporary change to seascape and visual aesthetic.		
Fire / Mechanical Fire				
Discharge of Fluids				
Vessel, helicopter, and equipment use for emergency response and/or repair				
Decommissioning				
Structure inspection				
Vessel and equipment use				
Removal of turbines and foundations/anchors				
Removal of cables/cable protection				

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IX. Acoustic Environments

Please provide any information you may have on this topic, including citations, in the table below.

Potential Impact Pathways and Effects of Offshore Wind Development on Physical and Cultural Heritage				
Activity	**Impact Pathway**	**Effects**	**Summary of Current Knowledge**	**Related effects on other VCs**
Pre-Construction				
Sonar/Acoustic seafloor mapping				
Seismic (streamer) surveys				
Vessels and equipment use				
Construction				
Installation of wind turbines, substations, converter stations, and foundations/anchors				
Installation of cables/cable protection				
Vessel and heavy equipment use				
Operations				
Presence/operation of turbines				
Presence of subsea infrastructure (foundations, cables)				
Marine vessel operation and helicopter use				
Malfunctions/Accidental Events				
Structural failure / loss of turbine				
Fire / Mechanical Fire				
Discharge of Fluids				
Vessel, helicopter, and equipment use for				

emergency response and/or repair				
Decommissioning				
Structure inspection				
Vessel and equipment use				
Removal of turbines and foundations/anchors				
Removal of cables/cable protection				
Literature Compiled to Date				

Ecology and Environment Engineering, P.C. (2017, December). *New York State Offshore Wind Master Plan: Cultural Resources Study*. New York State Energy Research and Development Authority: Offshore Wind Master Plan. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Research/Biomass-Solar-Wind/Master-Plan/17-25h-Final-Cultural-Resources-Study.pdf

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X. Physical and Cultural Heritage

Please provide any information you may have on this topic, including citations, in the table below.

Potential Impact Pathways and Effects of Offshore Wind Development on Physical and Cultural Heritage				
Activity	**Impact Pathway**	**Effects**	**Summary of Current Knowledge**	**Related effects on other VCs**
Pre-Construction				
Sonar/Acoustic seafloor mapping				
Seismic (streamer) surveys				
Vessels and equipment use				
Construction				
Installation of wind turbines, substations, converter stations, and foundations/anchors				
Installation of cables/cable protection				
Vessel and heavy equipment use				
Operations				
Presence/operation of turbines				
Presence of subsea infrastructure (foundations, cables)				
Marine vessel operation and helicopter use				
Malfunctions/Accidental Events				
Structural failure / loss of turbine				

Fire / Mechanical Fire				
Discharge of Fluids				
Vessel, helicopter, and equipment use for emergency response and/or repair				
Decommissioning				
Structure inspection				
Vessel and equipment use				
Removal of turbines and foundations/anchors				
Removal of cables/cable protection				
Literature Compiled to Date				

Ecology and Environment Engineering, P.C. (2017, December). *New York State Offshore Wind Master Plan: Cultural Resources Study*. New York State Energy Research and Development Authority: Offshore Wind Master Plan. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Research/Biomass-Solar-Wind/Master-Plan/17-25h-Final-Cultural-Resources-Study.pdf

Firestone, J., Bates, A., & Knapp, L.A. (2015). See me, Feel me, Touch me, Heal me: Wind turbines, culture, landscapes, and sound impressions. *Land Use Policy, 46*(2015), 241-249. https://doi.org/10.1016/j.landusepol.2015.02.015

XI. Communities and Economy

To date, the Committee has identified some potential impact pathways and effects on communities and economy related to specific activities associated with OSW. Please provide any information you may have on this topic, including citations, in the table below.

Potential Impact Pathways and Effects of Offshore Wind Development on Communities and Economy				
Activities	**Impact Pathways**	**Effects**	**Summary of Current Knowledge**	**Related effects on other VCs**
Pre-construction				
Sonar/Acoustic seafloor mapping Seismic (streamer) surveys Vessels and equipment use	• Potential local business and/or employment opportunities to conduct mapping, surveys, and operate vessels and equipment. • Potential restriction to access areas where pre-construction activities take place. • Use of ports, vessels, and equipment.	• Increase in local employment and economy. • Temporarily restricted access to resources. • Temporary strain on existing infrastructure and services		
Construction				
Installation of wind turbines, substations, converter stations, and foundations/anchors Installation of cables/cable protection	• Potential local business and/or employment opportunities to install project components and operate vessels and equipment.	• Increase in local employment and economy. • Increased revenue and economic activity within region. • Physical disturbance or restricted access to resources in project area.		

Vessel and heavy equipment use	• Tax revenue to local governments from construction activities. • Presence of infrastructure. • Use of ports, vessels, and equipment.	• Temporary strain on existing infrastructure and services.		
Operation				
Presence/operation of turbines Presence of subsea infrastructure (foundations, cables) Marine vessel operation and helicopter use	• Potential local business and/or employment opportunities for project maintenance and operation, including vessel and helicopter operation. • Presence of infrastructure • Use of ports, vessels, and helicopters. • Tax revenue to local governments from project activities.	• Increase in local employment and economy. • Increased revenue and economic activity within region. • Physical disturbance or restricted access to resources in project area. • Temporary strain on existing infrastructure and services.		
Malfunctions and Accidental Events				
Structural failure / loss of turbine				

Fire / Mechanical Fire				
Discharge of Fluids				
Vessel, helicopter, and equipment use for emergency response and/or repair				
Decommissioning				
Structure inspection				
Vessel and equipment use				
Removal of turbines and foundations/anchors				
Removal of cables/cable protection				
Literature Compiled to Date				

Annex 1: Key Requirements about the Analysis of Effects set out in the Agreement to Conduct a Regional Assessment of Offshore Wind Development in Newfoundland and Labrador

The following excerpt from section A1.6 paragraphs l-t of the Agreement describes the Committee's key responsibilities related to analyzing the potential effects of OSW and its mitigation and follow-up. It states:

> "In conducting the Regional Assessment, the Committee will…
>
> l) identify and consider the potential positive and adverse effects, including cumulative effects of future offshore wind development activities in the Study Area.
>
> This will include consideration of:
>
> i. The potential effects of planned physical activities associated with offshore wind development activities in the Study Area;
> ii. The potential effects of possible malfunctions or accidents;
> iii. Any cumulative effects that may result from the effects of offshore wind development activities in the Study Area in combination with other physical activities that have been or will be carried out; and
> iv. The result of any interaction between the effects referenced above.
>
> m) In identifying and considering potential positive and adverse effects, the Committee will focus on the following environmental, health, social and economic components:
>
> i. Air Quality and Greenhouse Gases (GHGs) Marine Fish and Fish Habitat (including species at risk)
> ii. Avifauna (including birds, bats, and associated species at risk)
> iii. Marine Mammals and Sea Turtles (including species at risk)
> iv. Protected and Special Areas (established and proposed)
> v. Indigenous Communities, Activities, Interests, and Rights
> vi. Fisheries and Other Ocean Uses
> vii. Visual Aesthetics / Viewscapes and Acoustic Environments
> viii. Physical and Cultural Heritage (including structures, sites or things of historical, archaeological, paleontological, or architectural significance)
> ix. Health
> x. Communities, and
> xi. Economy
>
> The Committee will also consider the interactions and interrelationships between these components, as applicable, and associated environmental, health, social and economic systems based on the information and knowledge that is made available to the Committee.

The Committee may, based on its analysis and engagement activity, further refine or add to the list of components listed above. If that is the case, the Committee will clearly document in its Report the rationale for doing so, including how public, stakeholder and/or Indigenous input have informed and influenced this.

n) Identify and consider the effects, both positive and adverse, that offshore wind development activities in the Study Area may have on any Indigenous peoples, and any impact that they may have on the rights of the Indigenous peoples recognized and affirmed by section 35 of the Constitution Act, 1982.

o) Identify and consider technically and economically feasible mitigation measures and other approaches for eliminating, reducing, controlling, or offsetting potential adverse effects and creating and maximizing potential positive effects resulting from offshore wind development activities in the Study Area.

p) Identify and consider existing legislation, regulations, guidelines and standards, and associated approvals or authorizations, that are relevant to avoiding or reducing adverse effects or creating and maximizing potential positive effects resulting from offshore wind development activities in the Study Area.

Other Considerations and Requirements

q) Identify and consider the extent to which offshore wind development activities in the Study Area and their potential effects, would: a) contribute to sustainability; and b) hinder or contribute to the federal and provincial governments' ability to meet their environmental obligations and commitments in respect of climate change, and make recommendations on the manner in which future licencing decisions and/or impact assessments should consider and address these factors.

r) Consider the intersection of sex and gender with other identity factors and make recommendations on the manner in which future impact assessments should consider and address these factors.

s) Take into account any scientific information, Indigenous knowledge — including the knowledge of Indigenous women — and Community knowledge provided with respect to the Regional Assessment, as per the requirements of subsection 97(2) of the IAA.

t) Ensure that the information that it uses in conducting the Regional Assessment is accessible to the public through the Canadian Impact Assessment Registry or by other means, unless it is required to keep certain information confidential by law."

Under Section A2.4 of the Agreement, the Committee is also required to include in their report an identification and analysis of any change to offshore wind development activities that may be caused by the environment.