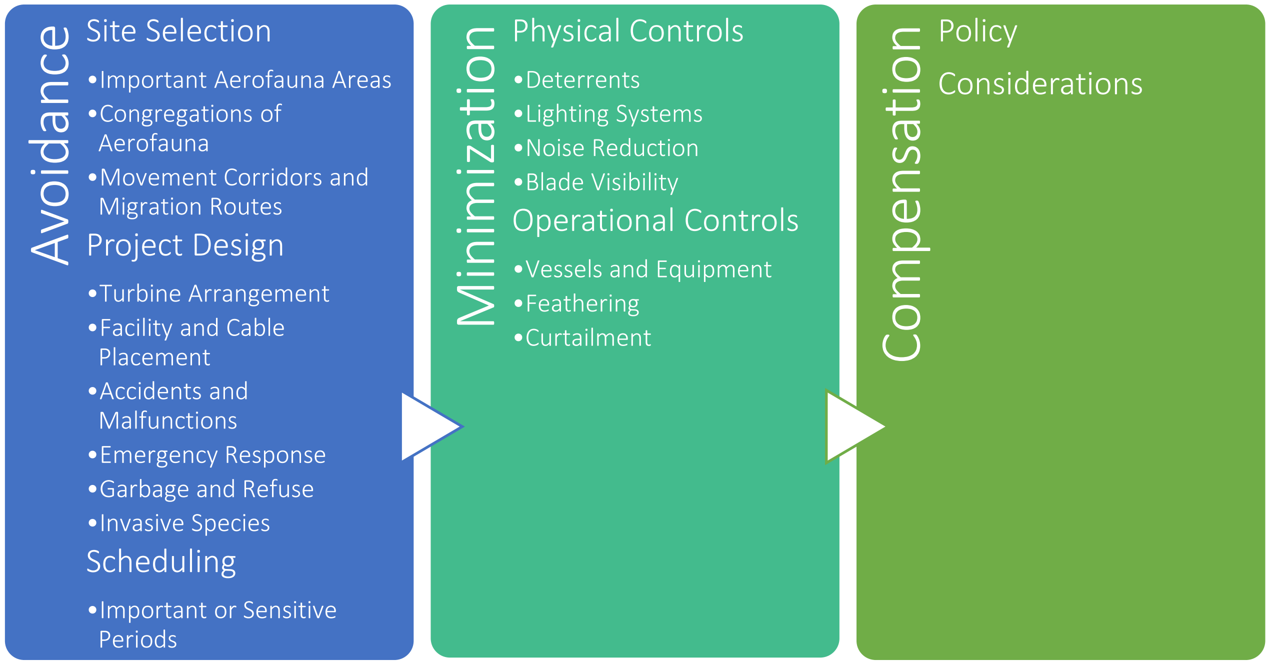
Mitigations for Impact Producing Factors from Offshore Wind Energy Development

Product Objective

Environment and Climate Change Canada-Canadian Wildlife Service (ECCC-CWS) has developed a summary of Impact Producing Factors (IPFs) (commonly referred to as "stressors") and known mitigation strategies in response to the NS Committee's request for input on factors that may impact aerofauna. This summary is largely generated from ongoing work by the Biodiversity Research Institute and ECCC-Science and Technology Branch (ECCC-STB) to develop an offshore wind energy (OSW) mitigations database and associated manuscript (Gulka et al., 2024). Additional sources of information include the Bat Standard Operating Procedure (ECCC-CWS, 2024; undergoing internal review), the Conservation Evidence Website (Conservation Evidence: Evidence Data), and ECCC standard advice used in Environmental Impact Assessments. ECCC has expanded the list of OSW development phases from the Committee's *Table 1: Impact Producing Factors, Issues and Mitigation Measures – Aerofauna*, to include mitigation measures at the planning and siting phases (Figure 1). Additionally, ECCC has expanded the list of IPFs to consider invasive species, garbage and refuse, and monitoring surveys.

The standard mitigation hierarchy is 1. Avoidance; 2. Minimization; 3. On-site restoration; and 4. Compensation. While this is suitable for most terrestrial environments, on-site restoration in offshore environments to mitigate impacts on aerofauna are not currently available. On-site restoration should be considered for any residual impacts resulting from OSW development in terrestrial environments (i.e., cable landfall, laydown areas) that cannot be mitigated through avoidance or minimization measures. This document presents mitigations relevant to impacts from OSW development in the offshore/marine environment.

Effective mitigation planning prior to construction greatly increases the effectiveness of additional measures during later development phases. Studies to assess effectiveness of mitigations will be required. The information provided herein is current as of the date of submission to the NS and NL Regional Assessment Committees.



General Measures

- Ensure that all project staff, contractors, and sub-contractors receive education and training related to federal regulations, permits, and policies.
- Collection of migratory birds (stranded, injured, mortalities) requires federal permits under the *Migratory Birds Convention Act* and/or *Species at Risk Act*. Please contact ECCC for more information about potential permit requirements.
- Reduce project scope creep by ensuring all relevant project components, boundaries, and phases of development are assessed together.

Avoidance

Avoidance – Site Selection

Many impact producing factors (IPFs), including direct, indirect, and cumulative effects, are best addressed by influencing siting decisions to avoid important locations for aerofauna (i.e., birds, bats, and flying insects). Proper site selection can reduce the dependence on minimization and compensation mitigations, many of which are untested or unverified for effectiveness (Gulka et al., 2024). Appropriate site selection is likely the best approach to avoiding impacts in all phases of offshore wind energy (OSW) development (pre-construction, construction, operations, maintenance, decommissioning).

Site Selection - Measure 1: Avoid Important or Sensitive Habitats

Goal: Ensure wind energy projects, and any related project activity, are not sited in areas that are important to aerofauna, reducing the need for additional minimization or compensation mitigations.

Stressors: Presence of Vessels and Equipment (Noise), Presence of Vessels and Equipment (Light), Collision, Displacement, Releases, Accidents, Malfunctions, Emergencies, Invasive Species, Garbage and Refuse

Plan wind energy sites and related project activities to avoid sensitive aerofauna areas in or near coastal areas as well as offshore. Reduce the extent of disturbance and disturbed areas during all phases of development. In other jurisdictions, buffer zones aim to protect most birds from human disturbance and may incorporate a range of distances depending on the season or site-specific characteristics (Goodship and Furness, 2022). Examples of important areas include, but are not limited to:

- Bird colonies or rookeries (coastal and islands).
- Critical habitat.
- Designated important aerofauna, wildlife, or biodiversity areas.
- Sensitive wildlife features (e.g., bat roosts and hibernacula, bird foraging, stopover, staging, loafing, and non-breeding sites).
- Beaches, coastal islands and spits, eelgrass beds.

Bird Colonies or Rookeries: Offshore wind energy sites, and planned activities, should avoid known bird colonies or nesting areas. Setbacks should be determined on a case-by-case basis, as recommendations are species- and activity-specific. Please consult ECCC for advice and see the following list of parameters to be considered when determining colony setback distances for wind energy development sites (ECCC Colony Setback Parameters).

Specific guidelines for planned activities:

- Maintain a minimum distance of 500m (Swedish Ornithological Society, as cited in Rydell et al., 2012) from a colony, or the entire island where the colony is located, if applicable.
- Maintain a minimum vertical distance of 500m from a colony (aircraft, drones) during the species-specific courtship, breeding, nesting, and chick-rearing seasons.
- Maintain a minimum distance of 1,000m from a colony for short-duration, high disturbance activities (e.g., drilling, blasting, pile driving) during the species-specific courtship, breeding, nesting, and chick-rearing seasons.

Critical Habitat: Offshore wind energy sites, and planned activities should avoid and maximize distance from identified critical habitat, as shown in proposed and final recovery documents for Threatened and Endangered listed species (*Species at Risk Act*; Species at Risk Registry). Please consult with ECCC for specific advice on SARA-listed species that could be affected by wind energy development site selection and associated activities. Additionally, please consult with ECCC for specific advice on habitats important for Special Concern SARA-listed species, and species assessed by COSEWIC as Endangered, Threatened, or Special Concern that are not SARA-listed.

Specific considerations should be given to:

- SARA-listed species with coastal and/or marine critical habitat:
  - Piping Plover (*melodus* subspecies), Endangered (ECCC, 2022c)
  - Roseate Tern, Endangered (EC, 2010)
  - Horned Grebe (Magdelin Island population), Endangered (EC, 2013a)
  - Bank Swallow, Threatened (ECCC, 2022d)

- SARA-listed species with important coastal and/or marine habitats:
  - Red Knot (*rufa* subspecies), Endangered (ECCC, 2017)
  - Barrow's Goldeneye (Eastern population), Special Concern (EC, 2013a)
  - Harlequin Duck (Eastern population), Special Concern (EC, 2007a)

- Roseate Tern, Endangered (EC, 2010)
- Piping Plover (*melodus* subspecies), Endangered (ECCC, 2022c)
- Ivory Gull, Endangered (EC, 2014a)
- Ipswich Sparrow, Special Concern (EC, 2006)
- Least Bittern, Threatened (EC, 2014b)
- Red-necked Phalarope, Special Concern (ECCC, 2023a)
- Buff-breasted Sandpiper, Special Concern (ECCC, 2022b)
- Eskimo Curlew, Endangered (EC, 2007b)

- COSEWIC Assessed Species Under Consideration for Listing:
  - Eastern Red Bat, Assessed as Endangered (COSEWIC, 2023)
  - Hoary Bat, Assessed as Endangered (COSEWIC, 2023)
  - Silver-haired Bat, Assessed as Endangered (COSEWIC, 2023)
  - Leach's Storm-petrel, Assessed as Threatened (COSEWIC, 2020a)
  - Hudsonian Godwit, Assessed as Threatened (COSEWIC, 2019)
  - Lesser Yellowlegs, Assessed as Threatened (COSEWIC, 2020b)

- Priority Species for COSEWIC Assessments:
  - Bermuda Petrel
  - Arctic Tern
  - Black Tern
  - Common Tern
  - Snowy Owl

<u>Designated Important Areas:</u> Offshore wind energy sites, and planned activities, should avoid identified important aerofauna, wildlife, or biodiversity areas. Setbacks should be determined on a case-by-case basis, as recommendations are species- and activity-specific. Please consult ECCC for advice when determining setback distances from designated important areas.

List of potential important areas to consider, but not limited to:

- Important Bird Areas (Bird Studies Canada, 2015) / Key Biodiversity Areas (BirdLife International, 2024)
- Sea Duck Key Habitat Sites (Bowman et al., 2022)
- WHSRN Shorebird Sites (WHSRN, 2019)
- Regionally Important Shorebird Sites (ECCC, 2023)
- Migratory Bird Sanctuaries (ECCC, 2024)
- National Wildlife Areas (ECCC, 2023b)

Specific Guidelines:

- Maintain a minimum distance of 300m from known important, species-specific, migratory shorebird stop-over or staging areas during the migration seasons. Some shorebird species are more sensitive to disturbance than others. Additionally, roosting shorebirds are more sensitive to disturbance than foraging shorebirds. These require a larger minimum setback of 500m.
- Maintain a minimum distance of 500m (Dehnhard et al., 2019; Kingsley, 2006; Sabina Gold and Silver Corporation, 2019) from known moulting, staging, or overwintering sites for waterfowl. Some waterfowl species are more sensitive to disturbance than others; an adaptive management approach based on monitoring results is recommended.

Site Selection - Measure 2: Avoid Congregations of Aerofauna

Goal: Ensure wind energy projects, and any related project activity, are not sited in areas where aerofauna are known to congregate, that are not previously identified in Site Selection - Measure 1. This will reduce the need for additional minimization or compensation mitigations.

Stressors: Presence of Vessels and Equipment (Noise), Presence of Vessels and Equipment (Light), Collision, Displacement, Releases, Accidents, Malfunctions, Emergencies, Invasive Species, Garbage and Refuse

Plan wind energy development sites and related project activities to avoid concentrations of aerofauna that are foraging, migrating, or resting. Best management practices (Eshleman and Elmore, 2013) from the offshore oil and gas industry recommend using seasonal restrictions during construction to avoid species-specific migratory and breeding periods. Examples of data products that include seasonal densities of aerofauna include, but are not limited to:

- Seasonal high densities of avifauna (ECSAS Densities).
- Predicted seasonal high densities of seabirds (ECCC Predictive Models).
- Foraging colonial birds (Foraging Models).
- Shorebird VIZ (eBird).
- Waterfowl seasonal habitat suitability (Waterfowl Models).

Specific Guidance:

- Avoid siting wind energy developments in areas of known foraging areas for seabirds, sea ducks, and shorebirds.
- Avoid siting wind energy developments in areas of known high prey density of marine birds.
- Avoid siting wind energy developments in shallow waters and waters in proximity to shore.

Site Selection - Measure 3: Avoid Movement Corridors or Migration Routes

Goal: Ensure wind energy projects, and any related project activity, are not impacting the connectivity between habitats and life history stages. Avoiding movement routes will reduce collision-related impacts on aerofauna. Ensuring wind energy sites do not bisect movement or migration routes will reduce the reliance on minimization or compensation mitigations.

Stressors: Presence of Vessels and Equipment (Light), Collision, Displacement

Plan wind energy sites to avoid intersecting areas between breeding sites and foraging areas, or within known migration corridors. Contact ECCC for species-specific guidance on where important movement patterns may occur, both transitory and migratory. Examples include, but are not limited to:

- Between foraging areas and bird colonies.
- Between nesting areas and staging areas.
- Between stopover sites and main migration routes.
- In areas of known bat migration activity.

A summary of species currently listed under SARA, or anticipated for assessment, that are at-risk of impacts during movement or migration can be found here.

Site Selection - Knowledge Gaps

- Appropriate site selection is likely the most efficient and effective avoidance mitigation for aerofauna available for offshore wind. However, evaluating the effectiveness of site selection avoidance measures is difficult (Gulka et al., 2024).

Avoidance – Project Design

Following site selection, appropriate project design is key to avoiding impacts in all phases of offshore wind energy (OSW) development (pre-construction, construction, operations, maintenance, decommissioning). Proper project design can reduce the dependence on minimization and compensation mitigations, many of which are untested or unverified for effectiveness (Gulka et al., 2024).

Project Design - Measure 1: Turbine Arrangement and Placement

Goal: Ensure wind energy developments place turbines in such a way that avoids conflict with aerofauna or their habitats. Properly planned offshore wind farms should reduce risk of collision and attraction of wildlife.

Stressors: Presence of Vessels and Equipment (Light), Collision, Displacement

Implement appropriate micro-siting that avoids placing turbines and other infrastructure within a project footprint to avoid negative effects on aerofauna. Project design will require consultation with ECCC to consider the best potential layout, given species-specific and area-specific conditions. Spacing, turbine height, distance to shore, distance to important aerofauna habitats, proximity to known movement corridors, and habitat connectivity concerns will influence the most appropriate site plan. Siting plans need to consider, but are not limited to:

- Number of turbines.
- Turbine layout (e.g., clustering, rows) and spacing between structures.
- Turbine size (overall height, size of "air gap" below the lower edge of rotor-swept zone).
- Distance to coast, and distance to islands.

Specific Guidelines:

- Avoid placing turbines and infrastructure that overlap with known high concentrations of aerofauna.
- Avoid placing turbines and infrastructure that intersect known local flight paths (e.g., between nests and foraging areas, between roosting and stopover sites, etc.).
- Avoid wind energy site expansion by repowering turbines.
- Design turbine placement using information on prevailing wind conditions to minimize barriers to aerofauna flight paths. Align turbines parallel to aerofauna flight paths, not perpendicular.
- Consider including gaps (several km) between turbines to act as movement corridors through the site.
- Avoid using guy wires.

Monitoring Implications:

- Monitor and record detailed behavioural observations of flying aerofauna at the proposed wind energy site to locate local flight paths, including height and direction.
- Monitor and record areas of high habitat use and concentration within the wind energy site.
- Monitoring plans should consult the displacement guidance for pre- and post-construction monitoring (E-TWG, 2024). Detecting changes in distribution caused by displacement requires monitoring on multiple spatial and temporal scales. Cumulative effects with other offshore activities should be considered as

habitat displacement thresholds may correlate to other variables (e.g., disturbance distance, density of turbines, etc.).

Project Design - Measure 2: Facility and Cable Placement

Goal: Ensure wind energy developments install supporting facilities, substations, and cables in areas that avoid conflict with aerofauna or their habitats. Properly planned equipment and infrastructure should reduce the risk of collision and attraction of wildlife.

Stressors: Presence of Vessels and Equipment (Light), Presence of Vessels and Equipment (Noise), Collision, Displacement

Implement appropriate facility and cable placement within a project footprint to avoid negative effects on aerofauna. Project design will require discussion with ECCC to consider the best potential layout given species-specific and area-specific conditions.

Specific Guidelines:

- Minimize infrastructure associated with offshore wind energy development projects.
- Avoid placing turbines that intersect known local flight paths (e.g., between nests and foraging areas, between roosting sites, etc.).
- Avoid placing infrastructure that overlaps with known high concentrations of aerofauna.

Project Design - Measure 3: Accidents, Releases, and Malfunctions

Goal: Ensure that aerofauna considerations are included in any pollution management, contingency plans, or other associated plans for wind energy projects.

Stressors: Accidents, Releases

Accidental release of deleterious substances should be addressed by site pollution management plans and contingency plans. Plans should focus on avoiding any releases and ensure aerofauna, or their habitat, are not impacted by these events. Environmental Protection Plans should consider any damage or destruction of turbines, or associated infrastructure, that could deposit hazardous and noxious substances (HNS) into the marine environment, oceanic currents, and coastlines. Examples of this include, but are not limited to:

- Unplanned or accidental releases of substances that may cause an adverse effect to the environment.
- Damage or destruction of turbine tower or blade which deposits hazardous and noxious substances into the environment.
- Explosions or fires at turbines, facilities, support vessels, or other project infrastructure.

Specific Guidelines:

- Obtain required permits and adhere to all applicable conditions and environmental laws.
- Vessels and crews to be trained to execute work tasks, assess field conditions, and handle severe weather conditions.
- Use trained observers to watch changes in sea state and weather conditions.
- Vessels should have reliable and maintained navigation systems, propulsion systems, and control systems including adequate reserve power and sufficient redundancy in these systems. Technical systems may be further developed to decrease the effect of human error in accident causation.

- Establish a reporting system to record and follow up on incidents and near misses. This system must also identify trends and allow further controls to be implemented (adaptive management).
- Use of underwater cameras to monitor potential planned, or unplanned or releases of chemicals and hydrocarbons during work to monitor and mitigate negative impacts.
- Monitoring the use of water by migratory birds in or around releases or discharges. Prevent birds from encountering contaminants resulting from the project or project activities.
- Create response and reporting measures for when migratory birds or sensitive habitat becomes contaminated with harmful substances resulting from the project or project activities.
- Avoid waste management or other activities, such as fueling and servicing of equipment, in or near environmentally sensitive areas.
- Ensure that policies and protocols are developed and implemented for handling toxic or deleterious substances.
- Maintain hazardous spill response kits and equipment on site and vessels and ensure all personnel are trained on proper use of all response equipment.
- Implement remote monitoring systems of turbines and facilities so any damage or destruction is reported as near to real-time as possible.
- Report any stranded vessels, or vessels that need to be salvaged.

Project Design - Measure 4: Emergency Response

Goal: Ensure wind energy projects plan for catastrophic events that release an accidental, abnormal, or inadvertently large, in quality or quantity, pollutant into the environment.

Stressors: Releases

Proponents of wind energy development projects should prepare and implement a Wildlife Response Plan that considers, and is implemented, for all phases of the project. Wildlife Response Plans should be identified in the project's Oil Spill Prevention and Response Plan to ensure that polluting incidents affecting wildlife are effectively managed. Please consult with ECCC while preparing the Wildlife Response Plan and follow the *Guidelines for Effective Wildlife Response Plans*. Wildlife Response Plans should include, but are not limited to:

- Mitigation measures to deter migratory birds from encountering contaminants resulting from the project or project activities.
    - Monitoring the use of water by migratory birds, as well as monitoring the presence of substances in water bodies or areas harmful to migratory birds.
    - Implementing measures to deter migratory birds from encountering harmful substances.
    - Implementing measures to haze migratory birds off water bodies containing harmful substances if birds do land.
- Response measures if migratory birds or sensitive habitat becomes contaminated with harmful substances.
- The type and extent of monitoring conducted during various water contamination or releases.
- Follow advice given in the Guidance and Protocols for Wildlife Surveys for Emergency Response (ECCC, 2022a).

Project Design - Measure 5: Garbage and Refuse

Goal: Ensure proponents prepare and implement waste management plans and policies. Properly planned waste and refuse strategies should reduce risk of attraction and mortality.

Stressors: Attraction, Garbage and Refuse

Proper waste management procedures must be followed to reduce attraction of aerofauna to offshore wind energy development sites, equipment, or vessels. Waste management plans should include, but are not limited to:

- Managing garbage and waste from vessels.
- Reducing the chance of providing food resources that attract birds.
- Minimize pollution that could entangle birds.
- Minimize plastic pollution that could be ingested by birds.

Project Design - Measure 6: Invasive Species

Goal: Ensure proponents prepare and implement an invasive species management plan and policy.

Stressors: Invasive Species

Proper invasive species management programs should avoid invasive species/predator introductions that can indirectly affect foraging habitat for marine birds. Plans should include, but are not limited to:

- Proper strategies for managing biofouling and ballast water discharge associated with vessel traffic.
- Strategies for cleaning equipment and vessels that arrive from other locations.
- Monitoring for invasive species and address if detected.
- Strategies to remove and/or eradicate invasive species/predators introduced by changes in vessel traffic, offshore infrastructure, and associated scour protection. This includes surfaces that can be used as introduction vectors (e.g. ship hulls, platforms, and turbine foundations).

Project Design - Measure 7: Stranded Aerofauna

Goal: Ensure proponents prepare and implement a plan and policy for dealing with stranded birds on all vessels, turbines, and project infrastructure during all phases of development.

Stressors: Presence of Vessels and Equipment (Light), Collision

Birds can be attracted to offshore infrastructure for roosting and/or foraging opportunities, as well as attraction to potentially disorienting artificial light at night (ALAN) sources. Please see Minimization: Measure 2: Lighting Systems for additional approaches. In Atlantic Canada, nocturnal migrants and night-flying seabirds (e.g., storm-petrels) are most at risk of attraction to ALAN. Capturing and handling any stranded birds requires permits and authorizations from ECCC. Searches for stranded birds can be systematic or opportunistic, however, proponents of offshore wind energy development projects should develop site-specific protocols for carrying out stranded bird searches, where applicable. Stranded bird plans should be made in consultation with ECCC. Consider stranded bird plans that include, but are not limited to:

- Develop site-specific systematic stranded bird protocols following Guidance for Developing Systematic Stranded Bird Survey Protocols for Vessels and Platforms.
- Follow protocols outlined in ECCC's Procedures for Handling and Documenting Stranded Birds Encountered on Infrastructure Offshore Atlantic Canada.
- Develop an incidental aerofauna siting program for all vessels, infrastructure, and planned activities, over all phases of the project. Sightings of stranded birds should result in action following the stranded bird plan.
- Sightings should note when aerofauna are resting, roosting, or foraging from vessels, infrastructure, and turbines.
- Sightings of species at risk should be submitted to ECCC.

Project Design - Knowledge Gaps

- Turbine Layout
- Turbine Size

Avoidance - Scheduling

Proponents must be aware of the significant time periods (i.e., breeding, nesting, migrating, etc.) for aerofauna likely to interact with all phases of project development. Timing project activities to avoid disturbance during sensitive time periods should also include any project activities in the terrestrial environment (i.e., cable landfall, stockpile/laydown sites, etc.).

Scheduling - Measure 1: Avoid Important or Sensitive Periods

Goal: Ensure wind energy projects and project activities are planned to avoid seasonal or annual important times of the year. Avoiding certain time periods/seasons should reduce the need for additional minimization or compensation mitigations.

Stressors: Presence of Vessels and Equipment (Noise), Presence of Vessels and Equipment (Light), Collision, Displacement, Releases, Accidents, Malfunctions, Emergencies, Invasive Species, Garbage and Refuse

Planned activities should avoid predicted periods of high abundance of birds and bats throughout the entire project area, including areas between the coast and the project development site. Please contact ECCC to discuss species-specific and area-specific guidance. Examples of this include, but are not limited to:

- Active nesting periods (Nesting periods - Canada.ca). The breeding season for most birds within the region occurs between mid-April and mid-August, however some species protected under the *Migratory Birds Convention Act* (MBCA) nest outside of this period. Some species are also active at breeding sites or areas, following hatch, while chick-rearing and fledging occurs.
- Peak migration periods for birds and bats (True et al., 2023).
- Non-breeding periods, species-specific.

Specific Guidelines:

- Avoid vessels and vessel traffic during species-specific periods (e.g., colonies, nesting areas).
- Avoid planned maintenance of turbines, facilities, cables, and other infrastructure during species-specific migratory and breeding periods.
- Avoid construction during species-specific migratory and breeding periods.
- Avoid short-duration, high disturbance activities (e.g. drilling, blasting, pile driving) within 1,000m, minimum, of a colony during the species-specific courtship, breeding, nesting, and chick-rearing seasons.
- Avoid construction activities at night to prevent increased lighting from equipment and vessels in the development area.

Minimization

Minimization - Physical Controls

Goal: Adapt wind energy project physical designs to minimize impacts to aerofauna.

Physical Controls - Measure 1: Deterrents

Goal: Adopt deterrent technology to reduce likelihood of aerofauna injury and mortality from collisions and barotrauma.

Design turbines with integrated automated deterrent systems to minimize mortalities of bats, and birds. Use of acoustic deterrents on birds has not been shown to be effective in offshore environments (Gulka et al. 2024). Ultrasonic deterrents have been shown to reduce bat mortality and collision rates at terrestrial wind energy developments; however, they have not been widely tested in the offshore. Additionally, one study found that deterrents could increase mortality events for Eastern Red Bat, but this has not been assessed in the offshore. Visual deterrents, such as lasers, have been tested in offshore environments with some evidence of effectiveness. Physical deterrents have proven effective for some species of marine birds, such as gulls, and are typically used on horizontal surfaces. Combining visual and acoustic deterrents, and allowing for random effects, should decrease risk of birds habituating to deterrents, and could increase potential effectiveness. Please see Gulka et al. (2024) for examination of deterrent effectiveness. Deterrent plans should be developed in consultation with ECCC. Example components of deterrent plans include, but are not limited to:

- Identification of deterrent components with proposed targeted taxa (physical, visual, auditory, laser, etc.).
- Identification of deterrent system design to incorporate multi-stimuli and randomized components.
- Use of automated designs to deploy deterrents if aerofauna are detected at turbines.
- Identification of monitoring programs to inform effectiveness of deterrents.

Specific Guidance:

- Bat deterrent programs are recommended for all offshore wind energy projects. Since the migratory tree bats have all been COSEWIC-assessed as Endangered, and may be listed under SARA prior to project commissioning, and following the precautionary approach, proponents should consider preventing bat mortalities a high priority. Confirming bat mortalities in the offshore environment is challenging, so the precautionary principle should be adopted.

Physical Controls - Measure 2: Lighting Systems

Goal: Use artificial lighting designs and plans to reduce attracting aerofauna to development sites and associated infrastructure.

Design lighting of turbines and offshore infrastructure to minimize the risk of attracting aerofauna to offshore wind sites, to the extent possible, while adhering to regulatory and safety requirements. Lighting designs should include, but are not limited to:

- Identify the type, hue, or source lighting that is known to minimize attracting aerofauna.
- Consider light placement plans within an offshore wind development site.
- Consider flashing light rates.
- Use technology that will automatically turn lights on or off, to reduce the amount of permanent light sources in the offshore.

Specific Guidance:

- Minimize artificial light exposure by limiting construction activities between dawn and dusk.
- If artificial lights are required between dawn and dusk:
  - Minimize the use of flood lighting, especially on nights with reduced visibility (rain, fog, cloud cover) (Gauthreaux and Belser, 2006).

- Minimize the use of white lights, as these may attract birds more than other wavelengths of artificial light (Poot et al., 2008). Use red lights, as these are less attractive to birds (Evans et al., 2007).
- Minimize permanent lighting by turning off all unnecessary lighting when not in use.
- Minimize artificial light exposure by down-shielding light on vessels and infrastructure to illuminate only required areas (minimize upwards illumination that may impact aerofauna) (BOEM, 2021; NYSERDA, 2020).
- Minimize indirect light on the water's surface to reduce effects of artificial light on prey species (Maragoni et al., 2022).
- Minimize artificial light exposure by using low intensity (i.e., low lumen) lighting, such as dimming, low wattage lights to mitigate bat attraction (Berthinussen et al., 2021).
- Minimize artificial light exposure by using flashing light and avoid the use of continuous lighting. Reduced flash durations combined with increased intervals between flashes are recommended (Cook et al., 2011; Evans et al., 2007; Gartman et al., 2016; Gehring et al., 2009; Kerlinger et al., 2010).
- Minimize attraction and collision risk by using UV light to increase turbine visibility (Baasch et al., 2022; Gorrensen et al., 2015).

- Minimize lighting throughout the entire offshore wind energy development site. Consider lighting only the perimeter structures of the development area (Mockrin and Gravenmier, 2012; Rebke et al., 2019; USDA 2012). If perimeter lighting is not always possible it should be implemented on nights with reduced visibility (e.g., rain, fog, cloud cover) (Langston, 2013).
- Implement detection systems so that turbine towers and nacelles are only lit when required (BOEM, 2021, 2022, 2023, 2024; Gartman et al., 2016).
  - Radar-based Aircraft Detection Lighting Systems (ADLS) that activate when aircraft are in the vicinity of the development area (USFWS, 2015).
  - Vessel navigation triggered lighting around turbine bases during all periods of poor visibility.
  - On-demand lighting systems on infrastructure and vessels that turn off when areas are not in use (e.g., timers, heat sensors, motion sensors, ambient condition sensors). If this is not always possible it should be implemented on nights with reduced visibility (e.g., rain, fog, cloud cover).

Physical Controls - Measure 3: Noise Reduction

Goal: Use noise reduction designs and plans to reduce disturbing aerofauna in, near, or enroute to wind energy sites and associated infrastructure. Underwater works may affect important prey resources during critical times of the year (nesting, chick-rearing).

Specific Guidance:

- Minimize loud construction work (e.g., pile driving) in areas where aerofauna and important prey species for aerofauna congregate, during critical times of the year.
- Vessels and equipment that create loud, intermittent, or random noise (Ortega, 2012) should be well muffled or fitted with sound-reduction technology to reduce excessive noise disturbance. Vessels and equipment should be well maintained and in good working order.

Physical Controls - Measure 4: Blade Visibility

Goal: Modify turbine blades in a manner that aerofauna will be able to detect the presence and speed of the turbine rotations. This should minimize collision between aerofauna and turbine blades.

Painting or texturizing turbine blades and towers may increase visibility of hazards to aerofauna. Increasing contrast between blades could increase detection of blade rotation speed (Blary et al., 2023) and reduce bird and bat collision mortalities (May et al., 2020). Painting the base of turbine towers decreased collisions around terrestrial wind turbines (Gartman et al., 2016) and can lower mortality rates (Stokke et al., 2020). White and grey colours may attract foraging bats as these colours may attract insects (Long et al., 2011).

Specific Guidance:

- Paint at least one blade black on each turbine.
- Paint turbine foundations.
- Consider using ultraviolet paints.

Physical Controls - Knowledge Gaps

- Lighting: Although there is still uncertainty about optimal lighting regimes, avoiding white lights, avoiding steady-burning lights, avoiding floodlighting, and down-shielding lights (but not directly on water surfaces) should be adopted. Using red aviation safety lighting with the slowest possible flash rate has also been used for wind energy developments. Lighting regimes have been well-studied, but research on wavelengths (colour) that best reduce attraction, and under varying weather conditions, for certain taxa, is needed. Knowledge gaps on bat response to lights and why they approach (e.g., foraging opportunities) is needed. Many mitigations have been tested for terrestrial wind energy development, but not wind energy development in the offshore. See Gulka et al. (2024) for more details.

Minimization – Operational Controls

Goal: Manage wind energy project activities to minimize impacts to aerofauna.

Operational Controls - Measure 1: Vessel and Equipment Presence

Goal: ensure wind energy project vessels (boats, aircraft, drones, etc.) and project equipment are planned to minimize impacts to aerofauna or their habitats. Minimizing interactions should reduce the need for additional compensation mitigations.

Stressors: Presence of Vessels and Equipment (Noise), Presence of Vessels and Equipment (Light), Collision, Displacement, Releases, Accidents, Malfunctions, Emergencies, Invasive Species, Garbage and Refuse

Vessels and equipment required for site assessment, monitoring, construction, maintenance, and decommissioning should be planned and implemented to minimize negative interactions with aerofauna. This control is most effective after successful implementation of avoidance mitigations presented previously in Site Selection. Vessel and equipment plans should be implemented following an adaptive management framework, capable of adjusting to unforeseen situations, with the ability to update with new information derived from monitoring programs, pre-construction surveys, research, etc. Operation plans should be drafted after useful avoidance mitigations are in place, and should include, but are not limited to:

- Minimize vessel traffic (e.g., ships, marine drones, fixed-wing aircraft, rotary aircraft, aerial drones, etc.) and equipment in or near natural concentration of birds.
- Minimize the extent of disturbed area and disturbance caused by all phases of development.
- Minimize vessel traffic during critical and sensitive time periods (e.g., breeding, nesting, migration).

Specific Guidance:

- Minimize disturbing concentrations of seabirds and waterfowl in marine habitats by lowering speeds near concentrations of birds to minimize escape or abandonment responses. Vessels are known to disturb some marine species at distances of 400 – 600m (Dehnhard et al., 2019; Larsen and Laubek, 2005; Ronconi and St. Clair, 2002; Schwemmer et al., 2011), varying with vessel size, speed, and species.
- Minimize disturbing concentrations of shorebirds along coastal habitats, or shorebirds (i.e., phalaropes) foraging in marine habitats. Some shorebird species are more sensitive to disturbance than others. Additionally, roosting shorebirds require a larger minimum setback of 500m.
- Vessels should limit or avoid flashing lights within a minimum distance of 400m from rafts of overwintering waterfowl, and coastal congregations of waterfowl.
- Vessels should lower their speed when navigating around congregations of seabirds and waterfowl. Additionally, a speed limit of 25 km/h has been suggested to reduce the probability of birds flushing to 10% in most cases (Ronconi and St. Clair, 2002).
- Turbine construction should sequence piling and turbine erection in a direction to minimize effect on nearby colonies or other important habitat during the breeding season.

Monitoring Implications:

- Real-time vessel-based monitoring should accompany all activities.
- Confirmed observations of concentrations of birds or bats, or any observations of COSEWIC-assessed and/or SARA-listed species should lead to management and mitigative action.
- All monitoring data should be shared with ECCC, the C-NSOPB, as well as conservation data centers and other data management platforms identified in the future.

Operational Controls - Measure 2: Feathering

Goal: Ensure offshore wind turbines feather blades below a cut-in speed, resulting in slower blade rotations, and reducing collisions with aerofauna.

Stressors: Collision

Turbine blades will spin when below the cut-in speed (i.e., the wind speed at which the turbine starts to generate electricity, and the blades are allowed maximum rotation speed), but at slow speeds. These blades can be feathered (i.e., adjust the pitch of the blade) to slow rotation. Feathering has been found to be effective for reducing bat collisions with terrestrial wind turbines (Arnett et al., 2016). As with curtailment, there is a lack of testing and evidence for the effectiveness of feathering as a mitigation measure for birds. There was also no evidence of effectiveness in the offshore context. Feathering blades to reduce bat mortality has shown to be effective in 5 of 6 studies in North America (Berthinussen et al., 2021). Cut-in speeds should be used to minimize bat mortality, as the migratory tree bats in Canda have all been assessed as Endangered by COSEWIC and may be listed on SARA before project commissioning. A cut-in speed of 5.5 m/s could reduce bat mortality by upwards of 74% (Good et al., 2012).

Specific Guidance:

- Feathering blades below cut-in speed should be done during periods when bats are potentially active offshore (March through November) (True et al., 2023).
- Feathering should be adopted during daytime and nighttime; offshore bat activity has been shown, in some areas, to be equally distributed between night and day.
- When turbines are not producing electricity, blades should have rotations of less than 2 RPM.

Operational Controls - Measure 3: Curtailment

Goal: Use operational minimization approaches for offshore wind turbines. Altering turbine operations can minimize aerofauna collisions with project infrastructure.

Stressors: Collision

Curtailment, or operational minimization, can be based on environmental data (True et al., 2021), predicted activity based on taxa-specific life history, or on trigger-based algorithms. Standard or blanket curtailment refers to altering turbine operations based on wind speed or time of day. Algorithm-based curtailment uses data from nearby terrestrial and pre-construction surveys to predict bat occurrence throughout the development site. Operational minimization can be modelled to target avoidance of bats using the area. This should be verified through post-construction monitoring. Acoustic-based curtailment uses real-time bat acoustic data to assess risk and make operational decisions. Currently, systems use acoustic monitoring detectors on nacelles and turbine bases to determine bat activity periods. Other sensors have been implemented (e.g., video, RADAR) which are also used for avian curtailment. This curtailment is likely most applicable at sites with low, sporadic, and difficult to predict bat activity. Such curtailment has been used to reduce bat mortality at terrestrial wind energy developments (May et al., 2015).

Specific Guidance:

- Curtailment should use best available data to model potential bat activity at a site. Due to limited data on bats offshore in Atlantic Canada, a target of 90% avoidance from these models is suggested.
- Use post-construction monitoring and collision monitoring to create more informed curtailment approaches and more robust models.
- Consider the use of acoustic-triggered curtailment.
- Cut-in speeds should be used to minimize bat mortality, as the migratory tree bats in Canda have all been assessed as Endangered by COSEWIC. For example, a cut-in speed of 5.5 m/s could reduce bat mortality by upwards of 74% (Good et al., 2012).

Monitoring Implications:

- Consider using acoustic sensors (4 minimum per project as suggested by Weller and Baldwin, 2011) at the nacelle and base of turbines to detect bat presence near turbines at the perimeter of the development area to inform smart curtailment measures.

Operational Controls - Knowledge Gaps

- Uncertainty: Implementation and field testing at terrestrial wind energy developments indicate that curtailment effectively reduces bat mortality (80% effectiveness; 72% certainty; Berthinussen et al., 2021), however, additional research is required to evaluate the effectiveness for birds (Allison et al., 2019) and effectiveness in the offshore environment. Field-testing is needed to further verify effectiveness.

Compensation

Compensation, or offsetting, approaches have been implemented in other jurisdictions to achieve net-neutral, or net-positive, outcomes. The United States and the European Union use regulations, acts, and policies to guide compensatory mitigation efforts. Canada has developed a draft policy for offsetting (ECCC, 2020), that is not yet finalized and has been adapted from existing policy on Operational Framework for Use of Conservation Allowances (ECCC, 2012).

There are few marine restoration/reclamation/rehabilitation options for aerofauna and OSW beyond decommissioning a site and removing above-water infrastructure. Further, restoration is not an option for impacts related to the collision and displacement of aerofauna. While avoidance and minimization approaches are critical, it is unlikely that these measures are enough to avoid residual negative effects to aerofauna. Where residual negative effects are likely, consideration should be given to the application of compensation measures. Without these measures, ECCC must rely on avoidance and minimization approaches alone to achieve net-neutral outcomes from offshore wind energy development. See Gulka et al. (2024) for a review on the state of knowledge on mitigation effectiveness. Under ECCC's 2012 Operational Framework for Use of Conservation Allowances, considerations for compensation exist under the *Migratory Birds Convention Act* (MBCA) and the *Species at Risk Act* (SARA), which could help mitigate residual environmental effects.

Compensatory measures are a "last resort" after all other mitigations for avoidance and minimization have been applied and residual adverse effects remain. Follow-up monitoring will be a critical component of any compensatory measures to evaluate effectiveness. As such, a compensation plan should be developed that clearly outlines the approach, responsibilities of various parties, monitoring plans, and measurable outcomes to evaluate effectiveness.

Examples of compensation activities are included in Gulka et al. (2024) using three different approaches: direct implementation by a project, mitigation banking, and in-lieu fee programs. Most compensation programs have not been monitored for effectiveness. Examples of existing compensation programs for offshore wind energy development in other jurisdictions include, but are not limited to:

- Colony conservation
  - Removal of mammals from islands with colonies (e.g., rats, feral cats, mink).
  - Encouraging establishment of new colonies.
  - Exclusion of gulls at tern colonies.
  - Flood and vegetation control at colonies.
  - Fencing colonies to exclude foxes.
- Reduce impacts from other sources
  - Restricting fishing or recreation access in or near important seabird areas.
  - Closing fisheries in important wintering areas.
  - Reducing by-catch.
- Reduce culling or harvest of bird species
  - Reducing harvest of target species.
  - Reducing culls of target species.

Monitoring

ECCC is developing guidance documents for monitoring and mitigation related to OSW development that are currently under review and will be made available upon final approval:

- ECCC. *In prep*. Interim Guidance on Environmental Assessment and Protocols for Monitoring Impacts from Offshore Wind Energy Development on Migratory Birds and Aerial Species at Risk.
- ECCC. *In prep*. Best Management Practices for Bats and Wind Energy Development (Terrestrial and Offshore).

In the absence of finalized ECCC guidance documents related to monitoring, the following guidelines and protocols are provided for insight on best available resources for monitoring impacts of offshore wind energy development to aerofauna:

- BOEM, 2020. Guidelines for Providing Avian Survey Information for Renewable Energy Development on the Outer Continental Shelf. National guidance to support compliance with avian information requirements as part of environmental assessments. Promotes the early communication with federal agencies and adherence to guidelines. This document describes the key avian species and habitats within survey areas that could be affected by proposed operations, including:
  - Identification and confirmation of which birds are using the project site, and when they are present in areas of proposed development.
  - Establishment of pre-construction baselines related to abundance and distribution of avian species to assess whether detectable changes associated with proposed operations occurred post-construction.
  - Collection of information to reduce uncertainty with baseline estimates and/or to inform the interpretation of survey results.
  - Development of approaches to quantify changes in the distribution and abundance of avian species associated with proposed operations.
- BOEM, 2023b. Guidelines for Submission of Geospatial Data for Offshore Renewable Energy Development. National guidance to support the collection of geospatial data for site characterization, planned activities, and reports, including biological surveys. Provides guidance on submitting one complete dataset to regulators to minimize duplication and redundancy.
- Kinlan et al., 2012. Statistical analyses to support guidelines for marine avian sampling: final report. Guidelines for estimating the sampling effort required to detect marine bird abundance and occurrence offshore. Provides a schematic "decision tree" on how to use the proposed approach and a general framework for avian survey design. Approach has five components:
  - Review of literature on developing distributions to model seabird counts.
  - Evaluation of statistical power to detect "hot-spots" or "cold-spots" of occurrence and abundance.
  - Modelling of the selection procedures to determine statistical distributions to describe counts of a given species in a particular region and season.
  - Using at-sea seabird survey data to identify statistical distributions for modeling species by season.
  - Modelling of the relationship between temporal scale of sampling and variance captured in time series with environmental correlates of marine bird abundance.
- Lierness and Kinlan, 2018. Additional Statistical Analyses to Support Guidelines for Marine Avian Sampling. Provides updated guidance to the report above. Guidance on identification of species-specific "hot-spots" and "cold-spots" for marine birds and the statistical power to detect them in the context of offshore wind energy development on the Atlantic offshore and continental shelf.
- Avian Displacement Guidance Committee, 2024. Guidance for Pre- and Post-Construction Monitoring to Detect Changes in Marine Bird Distributions and Habitat Use Related to Offshore Wind Development. This report provides supplementary guidance to the BOEM 2020 guidelines above. The goal of this publication is to advance recommendations on detecting and characterizing changes in distributions and habitat use of marine birds in relation to OSW energy development. Includes a literature review of studies from Europe and other jurisdictions that examined displacement, attraction, and macro- to meso-scale avoidance in marine birds as well as existing power analysis studies to inform recommendations. Recommendations focused on the following:
  - Marine birds and OSW energy development in the US Atlantic (they note that this report is broadly relevant to other jurisdictions).
  - Studies of changes in movement behavior, distributions and habitat use, namely displacement, attraction, and macro- to meso-scale avoidance.

 - Studies intended to detect effects from OSW energy development, not assess risk or characterize avian resources at the site level prior to construction.
 - Site-specific studies of the effects of individual lease areas. These recommendations are intended to inform project-specific monitoring.

- Avian Displacement Guidance Committee, 2023. Recommendations for Evaluating the Use of Existing Baseline Observational Survey Data for Birds in Offshore Wind Site Characterization Processes for the U.S. Atlantic. This guidance provides information on using observational surveys to inform site characterization with timelines and appropriate study design. This report also provides guidance on the sufficiency of existing avian observational survey data for site characterization purposes. Criteria are established based on whether existing data is considered sufficient for site characterization purposes, or if new data for site characterization is required.
- Loring et al., 2023a. Guidance Document for Deploying Motus Stations on Offshore Wind Turbines and Buoys. This report provides the technical specifications needed to deploy and operate Motus automated radio telemetry stations on offshore structures (e.g., offshore wind turbines) to obtain data on movements of tagged aerofauna. This document provides operators with details on how to set up, calibrate, maintain, and report data from offshore Motus stations. This guidance has six appendices: equipment list for turbines, equipment list for buoys, workflow, example set up guides, calibration guides, and Motus frequencies.
- Motus, 2024. Informing the Design and Implementation of Offshore Motus Systems (IDIOMS). An online tool to help users optimize site-specific Motus study designs at offshore wind energy facilities.
- Loring et al., 2023b. Monitoring Framework for Automated Radio Telemetry at Offshore Wind Projects in the U.S. Atlantic. This report provides details on developing consistent, transparent, and efficient Motus studies to address specific avian and bat monitoring needs during multiple phases of offshore wind energy development. Recommendations include:
    - Proponents should deploy and calibrate receiving stations on offshore buoys and wind turbines within their project areas, support ongoing maintenance of nearby priority coastal stations, and contribute to centralized funding for tagging efforts for species of interest.
    - Offshore wind turbine radio telemetry stations should be deployed during the construction phase and operated through the lifetime of the project to help address priorities for consistent, long-term monitoring data.
    - All Motus station data, tag data, and metadata should be provided as non-proprietary information so that data are available for use with regional assessments, which are necessary when studying migratory species at meaningful scales.
    - All offshore stations should be configured for dual frequency monitoring and operated following document guidance and the IDIOMS study design tool.
    - Tagging studies should be focused on offshore wind energy development monitoring and use power regulated tags programmed to a standardized transmission rate of 5 seconds, where possible.
- Skov, 2023. Bat and bird monitoring guidance. This document provides guidance for operating offshore wind energy sites. European focussed, and applicable to other jurisdictions. The focus of this document is managing the risk of collision and related monitoring technologies. The guidance assessed: radar (2D and 3D); camera; accelerometer; acoustic equipment; large-scale survey platforms; and large-scale telemetry. Each technology was assessed for monitoring performance, installation complexity, retrofitting potential, and cost/quality ratio. Table 2 (included below) presents an overview of the assessment. Section 5.2 presents decision flowcharts.

Table 2. Scoring system applied in the assessment of monitoring technologies (next page).

		Implementation			Density		Species				Avoidance			Collision	
Type	Equipment	Retrofit	Installation Complexity	Cost of equipment	Flux outside OWF[1]	Flux inside OWF[1]	Distribution and behaviour	Species id	Flight speed	Flight height	Macro avoidance	Meso avoidance	Micro avoidance	Collision rate	Shutdown
Radar	3D Radar[2]	●	▼	▼	▲▲	▲▲	▲	▼	▲▲	▲▲	▲▲	▲▲	▼	▼	▲
	2D Radar[2]	●	▼	●	▲▲	▲▲	▲	▼	▲▲	-	▲▲	▲▲	▼	▼	▲
	Radar coupled to camera[2]	●	▼	▼	▲▲	▲▲	▲▲	▲▲	▲▲	▲▲	▲▲	▲▲	▲▲	▲▲	▲▲
	Radar with fixed antenna[2]	●	●	●	●	●	▼	▲	●	-	▲	▲	▼	▼	●
Camera	Fixed camera[2]	▲	▲	▲	-	-	▼	▲	▼	-	▼	▼	▲▲	▲▲	●
	Dome with multiple fixed cameras	●	●	▼	-	-	▲▲	▲▲	▼	-	▼	▼	▲▲	▲▲	●
	Moving camera	▲	▲	●	-	-	▲▲	▲▲	▼	-	▼	▼	▲▲	▲▲	●
Other	Accelerometer as single sensor	▼	▼	▼	-	-	-	-	-	-	-	-	-	●	-
	Accelerometer coupled to camera	▼	▼	▼	-	-	-	-	-	-	-	-	-	▲	-
	Microphone[2]	▲	▲	▲▲	-	-	-	▲▲	-	-	-	-	-	-	●
Survey Platform	Ship-based surveys	-	-	▼	●	●	▲	▲▲	-	▲▲	▲▲	●	▼	▼	▼
	Aerial visual surveys	-	-	▼	▼	▼	●	▲▲	-	▲▲	▲▲	●	▼	▼	▼
	Aerial digital surveys	-	-	▼	▼	▼	●	▲▲	-	▲▲	▲▲	●	▼	▼	▼
	UAV/drone surveys	-	-	▼	▼	▼	●	▲▲	-	▲▲	▲▲	●	▼	▼	▼
Telemetry	Radio transmitters	▼	▼	●	▼	▼	▲▲	▲▲	▲▲	▲▲	▲▲	●	▼	▼	▼
	Satellite transmitters	▼	▼	●	▼	▼	▲▲	▲▲	▲▲	▲▲	▲▲	●	▼	▼	▼
	Archival tags	▼	▼	●	▼	▼	▲▲	▲▲	▲▲	▲▲	▲▲	▼	▼	▼	▼
	Acoustic telemetry	▼	▼	●	▼	▼	▲▲	▲▲	▲▲	-	●	▼	▼	▼	▼

Very good	▲▲
Good	▲
Average	●
Bad	▼
Not Available	-

[1] Birds/hour*kilometre (MTR)

[2] Useful for bats

- NatureScot, Marine Energy, 2023. Guidance for developers. This resource provides information for offshore wind energy developers related to energy development and risks, including risks to birds. Specifically, 11 guidance notes are presented for offshore wind applications and birds.
  - Note 1: Marine Ornithology – Overview
  - Note 2: Advice for Marine Ornithology Baseline Characterisation Surveys and Reporting
  - Note 3: Identifying Theoretical Connectivity with Breeding Site Special Protection Areas Using Breeding Season Foraging Ranges
  - Note 4: Determining Connectivity of Marine Birds with Marine Special Protection Areas and Breeding Seabirds from Colony SPAs in the Non-Breeding Season
  - Note 5 :Recommendations for Marine Bird Population Estimates
  - Note 6: Impact Pathways for Offshore Wind Developments
  - Note 7: Advice for Assessing Collision Risk of Marine Birds
  - Note 8: Advice for Assessing the Distributional Responses, Displacement and Barrier Effects of Marine Birds
  - Note 9: Advice for Seasonal Definitions for Birds in the Scottish Marine Environment
  - Note 10: Advice for Apportioning Impacts to Breeding Colonies
  - Note 11: Recommendations for Seabird Population Viability Analysis (PVA)

In addition to the resources listed above, the following upcoming work will also lead to new information and data related to mitigations and mitigation effectiveness for potential impacts of OSW energy development:

- Regional Wildlife Science Collaborative for Offshore Wind (RWSC) – Bird and Bat Subcommittee. Offshore Acoustic Monitoring for Bats: Guidance for Deployment on Wind Turbines. This guidance will be available on from the RWSC when completed. This guidance is targeted to offshore wind energy developers and others for bat monitoring efforts at offshore wind energy facilities. The guidance focusses on stationary acoustic detectors on wind turbines to address questions related to the conditions and locations associated with bat activity around offshore wind infrastructure. Additional guidance on mobile transects on ocean-going vessels will also be produced.

Monitoring – Baseline

Baseline monitoring is required to confirm existing conditions related to aerofauna. Monitoring must adequately account for natural variability in these systems and areas and must have the statistical power that allows for analyses and modelling of impacts to ecosystem components. It should also facilitate the evaluation of predictions made in environmental impact assessments. ECCC should be consulted when developing baseline study approaches, data collection methods, survey designs, modelling methods, sources of uncertainty, error estimates, and any assumptions or biases.

<u>Table 1:</u> *References for temporal and spatial recommendations for aerofauna monitoring methods.*

Monitoring Method	Temporal Recommendations	Spatial Recommendations	Reference
Surveys (Aerial/Boat-Based)	Minimum of two annual cycles of surveys to capture inter-annual count variation: 1) Conducted monthly to capture peak annual abundance. 2) Conducted in all seasons that species of interest are present.	Buffer proposed commercial blocks by at least 1 nautical mile to account for edge effects.	Table 1-3; BOEM, 2020
	To capture variation in species distributions, 12–16 surveys per year should be conducted for at least two years pre-construction.	Buffer zone of 4–20 km should be surveyed around the OSW project footprint. - Should incorporate the predicted effect distance for focal taxa plus 10%.	Avian Displacement Guidance Committee, 2024
MOTUS	Continuous, year-round monitoring if maintained.	Two types of offshore structures: wind turbines and buoys. Turbines: outer maximum detection range of <5 to 15km. Buoys: outer detection range of 500m to 1km.	Loring et al., 2023
Tracking	Program duty cycles to optimise coverage of important periods of time and locations.	Tracking can provide data to describe bird behaviour more accurately over large area, including habitat use.	Skov, 2023
Power Analyses	Existing data should be used in site-specific power analyses to inform the spatial and temporal coverage of surveys based on the focal taxa at each site.		Avian Displacement Guidance Committee, 2024

Monitoring - Follow-Up

Follow-up monitoring is required to confirm changes to aerofauna, relative to baseline, and to confirm or refute predicted effects. Follow-up monitoring must be developed in a manner so that effects to aerofauna can be detected. This should also identify if additional mitigation measures are required. ECCC should be consulted when developing the follow-up program, including sample design, effort, power analyses, frequency and location of monitoring, methods, and what scale or level of effect can be detected by the proposed approach.

Table 2: *References for temporal and spatial recommendations for follow-up monitoring considerations.*

Consideration	Temporal Recommendations	Spatial Recommendations	Reference
Data Collection	Use consistent data collection methods over space and time, including complementary methods to baseline studies		BOEM, 2020
Power Analysis	Avoid pooling data across seasons.	Evaluate whether expected data types and sample sizes are sufficient to detect a reasonable level of observable effect.	Avian Displacement Guidance Committee, 2024
Confirming Effects	Post-construction surveys should be conducted within 5 years of pre-construction survey completion. Separate site assessment and pre-construction surveys may be required.	Use Before-After-Gradient (BAG) study designs.	Avian Displacement Guidance Committee, 2024
Post-construction	Should include no less than 3 years of 12–16 surveys per year. Low abundance species and/or those with low effect sizes may require additional surveys.	At least 20% spatial coverage of the survey area.	Avian Displacement Guidance Committee, 2024
Tracking	**Radio Telemetry:** Continuous tracking when birds are within range of operational offshore wind energy developments. - Allows for assessment of meso-avoidance. **GPS Telemetry:** Intermittent location data across broad areas - Provides information on macro-avoidance behaviour. - Repeated tracking of the same individuals may help identify changes in individual responses over time to existing developments.	Requires a breeding colony of the target bird species located in the region.	Skov, 2023

Mitigation Effectiveness and Adaptive Management

Monitoring is critical for the management and mitigation of OSW energy development impacts to aerofauna. Given the general absence of confirmed effectiveness for several mitigations provided in Gulka et al. (2024), as well as this document, monitoring for effectiveness is recommended for all adopted mitigations. Monitoring and analytical approaches should be developed in consultation with ECCC. The proposed approaches should be able to verify whether the mitigation is influencing the effects to aerofauna (i.e., is the mitigation changing any outcome) and to what extent is the mitigation effective (i.e., how much of the effect is being mitigated). This is important for confirming, at minimum, net-neutral outcomes for listed species at risk. For example, monitoring collisions of aerofauna with turbine blades is challenging; new and novel monitoring technology, such as thermal video, strike detectors, radar, etc., should be implemented and tested to verify avoidance and minimization mitigations. Outcomes from mitigation programs and follow-up studies should be incorporated into an adaptive management plan that allows for continuous improvement to the mitigation approaches throughout the entire development site, throughout the entire project lifecycle.

Data Sharing

Real-time vessel-based observations should be implemented during all work related to project development. Any confirmed observations of concentration of birds or bats, or any observations of COSEWIC-assessed and/or SARA-listed species should lead to management and mitigative action (i.e., stoppage of work, curtailment, increased monitoring, etc.). All data collected during monitoring should be made accessible via open data and sharing platforms. Aerofauna data should be shared with ECCC, as well as regulatory authorities, conservation data centers, and other data management platforms identified in the future. Site-based data may be used to help update regional datasets and knowledge of these systems to inform distribution, movement, or impact-related understanding.

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