Regional Assessment of Offshore Wind Development in Nova Scotia
Committee Briefing: Potential Impacts of OSW Farms on Birds and Bats

Purpose

The purpose of this briefing document is to provide information on potential impacts of OSW farms on birds and the latest research findings that are either directly or indirectly related to offshore wind development and could be relevant to the Regional Assessment.

Background

There is the potential for OSW developments to have adverse effects on marine birds and bat populations through collision mortality, disturbance, or foraging habitat loss. Collision is more likely to occur if seabirds fail to avoid wind farms, whereas displacement from foraging habitat is more likely to occur if seabirds do avoid wind farms. Disturbance, caused by structures or by human activity associated with wind farms, may also cause displacement if birds move away from wind farms due to associated disturbance (Furness et al. 2013). While mortality, occurring when flying birds and bats collide with wind turbines, is well documented, displacement has only been studied more extensively in the last decade (Marques et. Al, 2021). Monitoring and follow-up studies are needed to validate potential impact predictions on both bird and bat species.

Research below provides a summary of the current understanding of impact pathways to birds and bats.

Research

<u>Presence of Vessels and Equipment Use</u>

- Ongoing disturbances from turbines and ship traffic can result in chronic stress among avian populations and may impact bird species' ability to thrive and reproduce successfully (Bech-Hansen et al. 2019; Breuner C.W. 2011).
- Marine mammals are negatively impacted by the underwater noise associated with shipping, but the impacts of noise on marine birds are virtually unknown. The majority of marine birds use sight to find prey while diving; however, some birds dive to depths where little light is available or frequently dive at night, which suggests that they are likely to rely on senses other than vision. Additionally, hearing is important for many birds in the air and while in their colonies. Emperor penguins and king penguins find their partners in large, noisy colonies by using distinctive sounds, a process that may be negatively impacted by nearby noise.70 Research in the high Arctic also shows that fish populations, such as arctic cod, are disturbed and displaced by vessel noise, which is problematic for the marine birds, such as black guillemots and northern fulmars, that prey upon them (Lyons and De Oliveira Menezes, 2020).
- Despite the lack of research about the effects of acoustic disturbance caused by shipping on marine birds, Dooling and Therrien postulate in their 2012 study that the impacts are likely similar to how land birds and other marine vertebrates experience acoustic disturbance. Birds in the air are known to be sensitive to continuous noise exposure and blast noise, both of which can cause physical damage to the auditory system. Noise above certain levels can also mask

communication between birds. Levels that are too low to mask communication could still result in harmful behavioural and physiological impacts (Dooling and Therrien, 2012).

Turbine Installation

- When placed in natural or seminatural habitats, infrastructures associated with the wind energy industry can modify the landscape, resulting in habitat loss and fragmentation, which may alter species behaviour, potentially leading to multiple ecological impacts, and ultimately population-level effects (Marques et al. 2021).
- Different seabird species respond differently to the development of OSW farms, with behavioural reactions ranging from complete avoidance to attraction. A recent review of 20 OSW farms in European waters found that species responded differently and sometimes inconsistently across studies, ranging from strong avoidance to strong attraction to OSW farms. Avoidance was mainly due to birds responding to OSW structures and was stronger when the turbines were operating, but could also occur as a result of boat traffic to and from the OSW farms (Garthe et al. 2023).

Lifecycle Alteration

- 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).
- 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).
- 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).

Avoidance/Attraction to OSW Farm Structures

- There are limited studies on the effects of OSW farms on birds during turbine construction, but there is evidence that enhanced ship and maintenance traffic, noise, lighting and concentrated activity in the development footprint of the windfarm are likely to be disruptive, and of a different nature, compared to the prior undisturbed situation, as well the subsequent operational phase. During this construction period, changes to shipping lanes and traffic and modification of fishing activity in the vicinity will also come into effect, while extreme disturbance (e.g. pile driving) can have potential effects on birds, as well as their prey (Fox and Petersen, 2019).

- For instance, migrating Eiders rounding the southern tip of the Gedser peninsula approaching the Nysted Offshore Wind farm showed adjustments to flight trajectories to avoid the turbines at distances up to 3 km away. Some species were almost never seen flying between the turbines (Red-throated Divers and Northern Gannets), others rarely (Common Scoter), while yet others showed little avoidance (e.g. Cormorants and large gulls). At Horns Rev, 71-86% of all large bird flocks heading towards the windfarm at 1.5-2 km distance avoided entering the wind farm and flying between the turbine rows. The same pattern was confirmed at Nysted (78%) predominantly amongst waterbirds, mostly migrating Eiders, but including a wide range of species (Fox and Petersen, 2019).
- Besides habitat alterations associated with wind farms, the visual intrusion caused by the turbines, the rotating blades, noise and vibration resulting from turbine operation, and human or vehicle circulation due to the construction or maintenance activities, may cause disturbance to birds, during both the construction and operational phases. Such activities may trigger an avoidance response that can occur at three spatial scales: macroavoidance when birds avoid the wind-power plant area as a whole, meso-avoidance if turbine arrays or single turbines are avoided, and micro-avoidance, which consists in last-second evasive movements of the rotor blades. Depending on the study design and wind farm layout (with clustered/random turbines) it may not be possible to fully separate macro and meso-avoidance (Marques et. Al, 2021).
- 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).
- Birds may be attracted to OSW farms 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).
- Taller turbine size, larger rotor dimensions, and faster rotor speeds have been shown to have an increase in bird collision risk (Thelander et al. 2003).
- Large birds with poor maneuverability (such as swans and geese) are generally at greater risk of collision with structures and species that habitually fly at dawn and dusk or at night are perhaps less likely to detect and avoid turbines (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.

- 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.
  - 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).
  - 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 ert 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).
- 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).
- The distribution and abundance of loons changed substantially from the 'before' to the 'after' periods in all five wind farm clusters in the North Sea. In all cases, the wind farms created a kind of halo around these constructions, with low to very low abundances of loons. After OSW farm construction, loons only aggregated in one area, with high densities at large distances from all the existing wind farms. This strongly suggests that OSW farms restrict the spatial freedom of loons, which is likely to be crucial for their ability to react flexibly to prey that is inhomogeneously distributed in time and space (Garthe et al. 2023).
- In general, taller structures cause more fatalities than shorter structures. The reason for this is simple: migratory birds fly at altitudes generally greater than 100m so taller structures are more likely to intercept passage migrants. It is also known that migratory birds may lose height during foggy or overcast conditions, which may bring flocks previously flying above turbine height into the collision risk zone (Avery et al. 1977, Huppop et al. 2006).

- Species strongly attracted by offshore wind farms (class 5): great cormorant and European shag. Both species use offshore wind farms as outposts, i.e. the possibility of resting on turbines, met masts and transformer platforms allows them to open new foraging areas far offshore (Dierschke et al. 2016).

Avoidance/Attraction of Turbine Lights/Noise

- 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).
- Observational work has also looked at the influence of colour and mode (steady, flashing or strobe) on collision risk. Gehring et al. (2009) looked at a range of lighting arrangements and showed that white, stroboscopic lights attracted fewest birds compared to red flashing lights and steady red lights. Kerlinger et al. (2010) also showed that steady red lights on turbines were more attractive to birds than flashing red lights. Flashing red lights reduced attraction and subsequent kills significantly. White lights appear to be better than red lights (birds appear to show an attraction to red light). Towers with no lighting were least attractive.
- Gehring et al. (2009) further suggested that it is the mode - flashing vs. non-flashing, steady lights - that is the principal factor that increases collision, and that colour may be a secondary consideration. It has been hypothesised that red lights interfere with magnetoreception (Gauthreux & Belser, 2006, Manville 2009) in migrating birds. When skies are clear birds may be able to use stars to navigate; in cloudy or foggy conditions such cues are not available, which may explain why birds are more likely to collide with towers and turbines during foggy/cloudy nights.
- The noise generated by offshore windfarms may cause marine birds to avoid the turbines and area surrounding them, though little is known about this behaviour or its possible repercussions (Wilson et al. 2010).
- Artificial light from offshore oil and gas rigs and offshore wind farms are known to have negative impacts on marine birds. Shipping also causes light pollution in the marine environment, but its impacts are not as well documented in the literature. The studies that discuss the impacts of light from ships emphasize the dangers of collisions with ships or structures. Marine birds may become disoriented by marine light pollution or be attracted to artificial light when visibility is low, leading to collisions. These collisions are especially common during migration and in the winter. Comparisons may be made with land birds, which are negatively impacted by artificial light. In addition to an increased risk of predation, land birds are also known to reach sexual maturity faster, forage more intensely and extend their dawn song as a result of artificial light (Lyons and De Oliveira Menezes, 2020).

Habitat Alteration

- When avoiding OSW farms, species may experience functional habitat loss due to displacement, which could in turn result in increased energy consumption if the alternative foraging habitats are of poorer quality or if the individuals have to travel longer distances to reach their foraging areas. In contrast, if seabirds do not avoid OSW farms or are even attracted to them, they risk colliding with the rotors or turbines, leading to increased mortality. However, the possible long-term effects of the different reactions towards OSW farms at the population level are difficult to estimate (Garthe, 2023).

- 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 frequented or abandoned.
- 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).
- 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 are recognized as potential barriers to bird movement during their migratory journeys (Fox and Petersen 2019).
- Impacts on ecosystem services birds provide (nutrient cycling and seed dispersal in marine and coastal ecosystems) (Hooper et al. 2017).

<u>Bats</u>

- Bats are more likely to be attracted to windfarms than to engage in avoidance behaviours (Cryan et al. 2014).
- 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).
- Bats rarely collide with stationary infrastructure. Within a wind farm, the greatest risk for bats is being struck by fast-moving turbine blades. Bats rarely collide with stationary structures such as buildings, communications towers, and nonoperating wind turbines. In addition, growing evidence indicates mortality from barotrauma, or lethal exposure to pressure variations that occur around wind turbine blades, is unlikely to be a significant contributor to bat mortality (Boonman, 2018; SEER, 2022).
- 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)
- Low wind speeds (e.g., less than 5 metres per second) have been shown to increase bat collisions (Cryan et al 2014)
- If OSW farms are in regions with relatively high average wind speeds (for example, >10 m/s, or 22 mph), and risk of bat collision is low, then curtailment may not be necessary (SEER, 2022).
- 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).
- 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).
- 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).

<u>Diving Birds</u>

- 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.
- Construction and support vessel operations will generate substantial noise profiles both above and below the water surface. This sub-surface noise has the potential to adversely affect seabirds foraging underwater, such as penguins, cormorants, shearwaters, diving petrels (Favaro and Pichegru 2018, Hansen et al. 2020, Pichegru et al. 2017)

Mitigation Measures

- Investing in long-term studies on the effects of OSW farms on avian species.
- Avoiding areas with sensitive species present.
- Feeding marine bird species are not randomly distributed at sea, so regular aggregations of seabirds attracted to known food resources should also be avoided as potential areas for offshore windfarms. In Denmark, there is a presumption to avoid development in very shallow waters (<10 m) to avoid major conflicts with potential feeding areas for seabirds feeding on benthos and on aggregations of organisms in the water column that are typically most common in such shallow waters. (Fox and Petersen, 2019).
- Using flashing lights that are believed to be less attractive to birds than steady lights, as well as white (or green) lights that are believed to be less attractive to birds than red lights, which may affect nocturnal migrant navigation.
- Using radar, acoustic deterrents, and bird detection systems to monitor bird activity and deter them from approaching wind turbines.
- Visual deterrents, including the use of ultraviolet light or painting a single turbine blade black, may alert flying animals to the presence of wind turbines. Audible noise deterrents for birds typically are not successful, as individuals can become habituated to the sound. Ultrasonic deterrents mounted on the nacelle of wind turbines have mixed results for deterring bats and more research is needed to demonstrate consistent reductions in mortality.
- Curtailment for wildlife involves feathering the wind turbine blades (i.e., adjusting the angle of the blades parallel to the wind) and increasing the cut-in speed of the turbine (i.e., the wind speed at which the turbine blades begin to spin and produce energy) to prevent turbine rotors from spinning during periods of risk.
- Future research should focus on whether displacement reduces foraging opportunities to the point that it would affect an individual's fitness.
- Future studies need to address the cumulative effects of anthropogenic impacts on marine birds to aid in better marine planning.

Questions

1. Does a bird's ability to avoid turbines depend on what activity they are doing (migrating vs. Feeding)?
2. What other research could be conducted on avifauna during wind farm studies that would be valuable to the research community?
3. More than 350 North American bird species are at risk of extinction due to climate change, would the potential negative effects of OSW be offset by the positive step towards combatting climate change?
4. OSW turbines may not have a large direct impact on birds and bats but how will they contribute to the cumulative impacts if many farms are spread out across a migratory area resulting in potential significant effects on vulnerable populations.

Focused Articles of Interest

1. What Offshore Wind Energy Can Teach Us About Seabirds | Audubon
2. Information note - The Effect of Aviation Obstruction Lighting on Birds at Wind Turbines, Communication Towers and Other Structures | NatureScot
3. SEER Educational Research Brief: Bat and Bird Interactions with Offshore Wind Farms (pnnl.gov)

4. Birds | Free Full-Text | Bird Displacement by Wind Turbines: Assessing Current Knowledge and Recommendations for Future Studies (mdpi.com)
5. Assessing the impacts of wind farms on birds - DREWITT - 2006 - Ibis - Wiley Online Library

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