OFFSHORE WIND FACTS

BIRDS & BATS

What you should know:

- The risk of birds and bats colliding with wind turbine blades is a primary concern for wildlife management. While collision mortality has been observed at land-based wind farms, the rate of bird collisions with offshore wind turbines is expected to be lower.
- Offshore wind farms are typically situated in more remote environments than land-based wind farms, and so it is expected that smaller numbers of birds and bats will interact with the turbines.
- Environmental monitoring data is typically used to select offshore wind development areas that have minimal overlap with areas of high seabird activity when practicable.
- Bird species exhibit different types of avoidance behavior when they encounter an offshore wind farm; the type of behavior can determine the impact a wind farm has on a species.
- Waterbirds and bats are highly sensitive to the effects of climate change, with 78% of waterbird species being at risk of extinction due to changing ocean, vegetation, and prey conditions as temperatures rise.
- Offshore wind contributes meaningful solutions to slow the rate of climate change. Many of the potential negative effects on these species from offshore wind can be mitigated through monitoring and planning.

Spotlight Question: Are collision risks high for birds and bats in offshore wind areas?

The risk of birds and bats colliding with wind turbine blades is a primary concern for wildlife management. While collision mortality has been observed at land-based wind farms (Loss et al., 2015), the rate of bird collisions with wind turbines offshore is expected to be lower (Fox & Petersen, 2019). As for bat interaction, there have been zero known bat fatalities at offshore wind energy areas (Solick & Newman, 2021); additional research is being done to better understand potential impacts to bat species.

While the presence of offshore wind structures represents a major change in the habitat of marine birds, the reaction to these structures varies by species; and it is these reactions that determine collision risk. While some species are attracted to the structures, other species will avoid them. In North America and Europe, studies have found that cormorants exhibit a strong attraction to offshore wind structures, whereas gulls, terns, and the Red-breasted Merganser show only a weak attraction, or a mixture of attraction and indifference (Krijgsveld, 2014; Dierschke et al., 2016). Sea ducks, loons, shorebirds, and gannets were found to have a strong avoidance of structures, while inconsistent displacement was observed among shearwater and alcid species (Dierschke et al., 2016; Peschko et al., 2021; Marques et al., 2021). Seabirds showing attraction to structures may be drawn to the increase in prey availability around structure foundations, or in the case of cormorants and gulls, attracted to the structures as potential roosting or resting sites (Kelsey et al., 2018). Attraction to structures does not necessarily lead to a high collision risk for bird species, as other factors such as flight patterns and avoidance behaviors are important in determining risks. Seabird avoidance of structures varies in scale. Birds may avoid the offshore wind area entirely (macro-avoidance), avoid individual wind turbines in the area (meso-avoidance), or avoid the individual turbine rotor blades (micro-avoidance) (Figure 1).

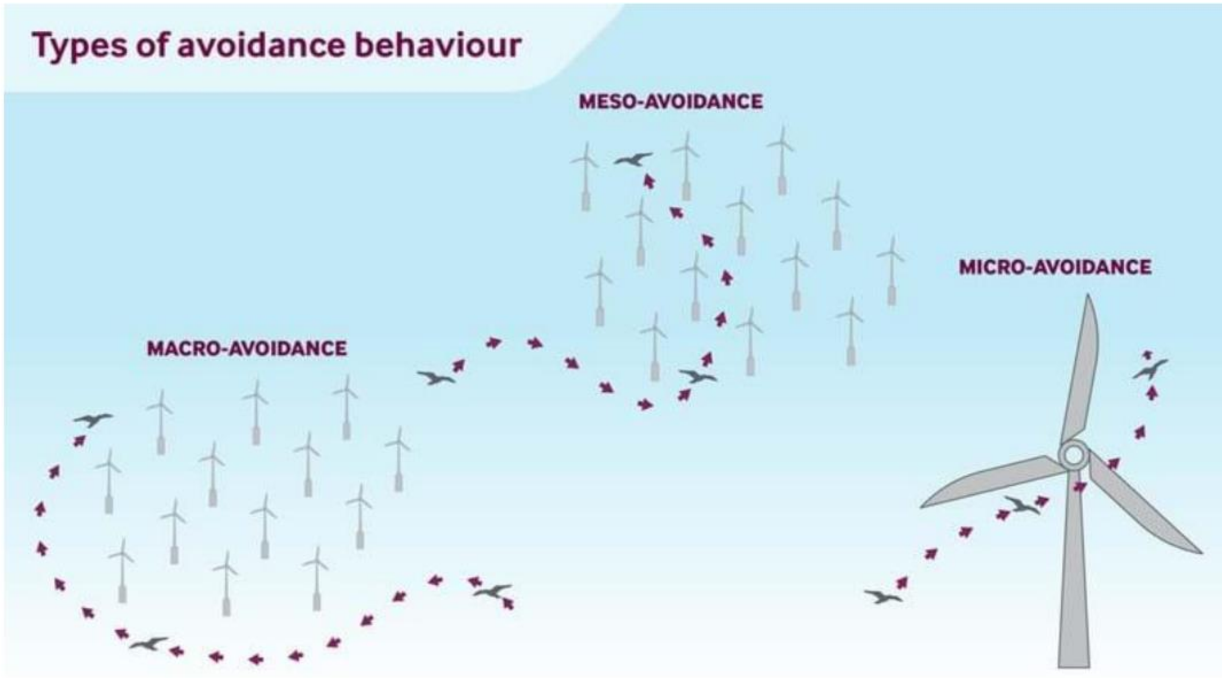

Figure 1. Birds may avoid offshore wind turbines at three scales: 1) macro-avoidance: flying around the entire set of turbines; (2) meso-avoidance: using flight maneuvers to dodge individual turbines within the farm; or (3) micro-avoidance: making last minute flight adjustments to avoid the turbine rotor blades (KeyFactsEnergy, 2023).

In addition to avoidance behaviors, the average flight height of each species is a key factor in determining a species risk of collision with wind turbines. Birds that typically fly at a height within the rotor sweep zone, the area where the turbine's rotor blades spin, are especially at risk. Therefore, birds exhibiting weak micro-avoidance are the most at-risk for collisions. Other factors influencing the risk of collisions are the amount of time spent flying over water and nocturnal flight activity (Furness et al., 2013; Robinson Willmott et al., 2013). This means gulls, phalaropes, cormorants, Northern Gannets, and jaegers are particularly prone to collisions (Robinson Willmott et al., 2013).

An important caveat to the discussion of bird and bat collisions with offshore wind turbines is the acknowledgement that direct measurements of mortality are more difficult to assess because of the challenge in finding corpses at sea (Bailey et al., 2014). However, recent studies show indications of low collision rates. A study by the European energy company, Vattenfall, found that the avoidance behavior of most seabirds takes place within a 100- to 120-meter distance from the turbine rotors. Of the birds that came within 10 meters of the rotor blades, more than 96% adjusted their flight paths to avoid collision. In two years of study and over 10,000 videos recorded by radar camera, no collisions were recorded. This data suggests that the risk of collision with offshore wind structures during the daytime is low, because the birds can make effective micro-avoidance maneuvers (Tjørnløv et al., 2023). Another study on UK offshore wind farms recorded only six collisions in two years (Skov et al., 2018). Collisions with wind turbine blades are thought to be a minor source of bird mortality in the offshore environment, with most wind turbine-related mortalities occurring at land-based wind farms (Loss et al., 2015). Further, strikes from rotor blades are not anticipated to make a large enough demographic impact to harm populations of most marine bird species; however, measures are in place to dissuade bird attraction to wind turbines. Mitigation measures are discussed further in the sections that follow.

Bat collisions and fatalities are also more common at land-based wind farms, as tree-roosting bats are attracted to the structures for foraging and roosting habitat (Arnett et al., 2016). However, few studies have been conducted on the effects of offshore wind facilities on bats. Bats are most likely to encounter offshore wind farms while following migratory routes during autumn. While these migratory routes may cross water, most overwater bat flights are expected to occur close to shore (Pelletier et al., 2013). Accordingly, migratory tree bats are the only species likely to encounter offshore wind structures (True et al., 2021). The primary impact on migrating bats is risk for collision with spinning rotor blades. While there have been instances of bats showing attraction to offshore wind structures (Arnett et al., 2016), these structures are generally isolated enough from bat populations that encounters with offshore wind turbines are considered unlikely to occur, and so the risk of collision overall is low.

Key Species

Birds that may be encountered in offshore wind project areas include resident seabirds or passing migrants. Resident seabirds spend all or most of the year in the offshore environment. This includes bird groups such as shearwaters, gulls, terns, and sea ducks, which use offshore waters as feeding grounds. Other birds only travel through offshore areas during migration. The U.S. Atlantic Coast and adjacent offshore areas are part of a major bird migration route known as the Atlantic Flyway. Over 200 species of waterbirds and terrestrial birds follow this route to move between their breeding and wintering grounds. Birds from across high latitudes of North America and Europe funnel into the Atlantic Flyway during migratory seasons. Most migration occurs close to shore, with waterbirds flying somewhere between the shoreline and several kilometers offshore. Terrestrial songbirds typically fly along the shoreline to several kilometers inland, but may be found flying over water offshore as well (Watts, 2010). Off the Northeast coast of North America, there are three federally listed birds that may occur in offshore project areas: the Piping Plover, the Red Knot, and the Roseate Tern. Piping Plovers and Red Knots are shorebirds that may be encountered offshore during their spring and fall migrations. Roseate Terns may also be found offshore, feeding on forage fish known as sand lance.

Bat use of the offshore environment is not well understood. While encountering bats offshore is rare, there is evidence that bats will travel over water offshore during spring and fall migrations. In North America, bats can be categorized into two groups: the cave hibernating bats and the migratory tree bats. The cave-hibernating bats are bats that migrate short distances to caves or other hibernation sites for the winter. Migratory tree bat species will migrate long distances and roost in trees throughout the winter. While cave-hibernating bats are not expected to make long flights offshore, migratory tree bats have been observed crossing offshore waters, with surveys detecting bats up to 130 kilometers from shore. Silver-haired bats, eastern red bats, and hoary bats are among the migratory tree bat species in the Northeast U.S. that may use offshore migration routes (Solick & Newman, 2021).

Climate Change Effects

Climate change is a major threat to bird populations. The National Audubon Society has identified 389 species of birds at risk of extinction under a three degrees Celsius warming scenario (Wilsey et al., 2019). Waterbirds are particularly at risk, with 78% of waterbird species vulnerable to climate-related extinction. Warming temperatures are already causing birds to shift their home ranges, as their current habitats become unsuitable for survival. Arctic birds, waterbirds, and boreal forest birds live in habitats that are very sensitive to temperature change and climate-driven effects. Rising sea levels and a collapse of the local vegetation community due to climate change, threatens to leave these birds without any livable habitat (Bateman et al., 2020). Almost 30% of seabirds are already threatened and with continued habitat loss, overfishing, and spread of invasive species, most seabird populations are projected to decline (Wilsey et al., 2019). Additional pressures from climate change, including warming oceans and ocean acidification, will only intensify the pressures on seabird populations.

Studies indicate that bats are also expected to be sensitive to climate change. Bats are especially prone to dehydration, making it difficult for them to survive changes in precipitation and making heat waves and droughts major causes of population decline. Moreover, bats are slow to adjust to any large environmental change, given their slow reproductive rates (Festa et al., 2022). Bat species in eastern North America are already experiencing population declines, most notably due to the spread of white-nose syndrome, an infection caused by a pathogenic fungus. This fungus is highly contagious and spreads among hibernating bat colonies, causing mortality during hibernation (Hoyt et al., 2021). These already at-risk bat populations face the threat of further population decline with the added impacts from climate change.

Offshore Wind Effects

Air Pollutants

Air pollutants may be produced during both the wind farm construction and operation phases, mainly from construction or crew transport vessels. Air emissions are measured under guidelines from the National Ambient Air Quality Standards (NAAQS) established by the U.S. Environmental Protection Agency (EPA). The pollutants measured include carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ozone, sulfur dioxide (SO_2), and other particulate matter. Air emissions related to offshore wind development are not expected to have any direct impacts on bird or bat species. The emissions generated during construction are intermittent, localized, and typically dispersed across a large project area. As such, the risk of harm to birds or bats from air emissions is minimal.

Any emissions created by vessel traffic associated with offshore wind construction will likely be negated by a decrease in fossil fuel usage in the markets where the wind energy is delivered. As fossil fuel power plants generate much more significant air emissions throughout their operational life cycle, a shift from fossil fuel dependency to wind energy would result in an improvement in regional air quality. An overall decrease in air pollutants would be nominally beneficial to the health of local bird and bat populations.

Displacement

While birds displaying micro-avoidance behavior (flying through the wind farm but avoiding turbine blades) are at greater risk of collision, birds displaying macro-avoidance behavior (flying around the entire wind farm) are at risk of being displaced from their habitat. Birds displaced from their habitat may need to expend more energy to forage at different locations (Fox & Peterson, 2019). Studies have found seabirds that use very particular habitat features for feeding, such as shallow banks, water mass frontal systems, or bivalve beds, were more prone to displacement as a result of offshore wind development (Furness et al, 2013). Loons, alcids, and sea ducks have been identified as the seabird groups most vulnerable to displacement.

Light

Offshore wind turbines and other offshore platforms use lights to aid vessels and aircrafts in their navigation around these structures. Hazard and navigation lights are installed on all wind turbines and offshore platforms and may have the potential to attract some species of seabirds. Many seabirds exhibit nocturnal activity, in part to avoid other avian predators (namely gulls) or to prey upon bioluminescent organisms that rise to the ocean surface at night. For nocturnally active marine birds, artificial lights may be attractive due to birds mistaking them for bioluminescent prey or star patterns used for navigation (Montevecchi, 2006). Studies suggest that artificial light may also disrupt a bird’s internal magnetic compass leading to aimless flight behavior (Poot et al., 2008). Seabirds are not the only birds using the offshore environment at night, as several terrestrial bird species fly over water as part of nighttime migrations. Lights on offshore structures would have the greatest impact for species making nocturnal migrations. Studies have found that under poor visibility conditions, such as fog or rain, migrating birds may become disoriented and circle offshore lights instead of continuing their migratory route (Hüppop et al., 2006). It is unclear whether light color has an impact on bird behavior. Some studies have found that red-colored lights, which are commonly used on land-based turbines, did not cause any increase in avian mortality (Kerlinger et al., 2010; Orr et al., 2013). Other studies observed nocturnally migrating birds to be disoriented by red and white lights because they may interfere with the magnetic compass of the birds, and least disoriented by blue and green lights (Poot et al., 2008).

Mitigation measures have been designed to lessen the impact of offshore wind structure lights on migrating birds. Many wind farms utilize Aircraft Detection Lighting Systems (ADLS), which only activates lights when an aircraft has entered a predefined space. The use of ADLS lights would significantly reduce the amount of time lights are activated, as this lighting system only flashes in a short, synchronized duration. Lights can also be shut off if large flocks of migrating birds are found to be flying towards the wind farm area. Wind farm structures are usually sited in locations that are known to have low bird abundances and typically are not located in the middle of migratory pathways. Federal regulators use existing avian data to site federal wind energy areas outside of migratory pathways to the extent possible, which limits the number of birds that encounter offshore lights from wind farms. Although, in some areas (e.g., portions of state waters in the Gulf of Mexico) this kind of siting optimization has not been done.

Bats, while less likely to be found offshore, still have the potential to be impacted by artificial light. Like seabirds, bats use magnetic senses for navigation, which might also be impacted by artificial light (Rowse et al., 2016). On land, bats have been found to use artificial light sources, where their insect prey congregate, as foraging areas (Rowse et al, 2016). There is evidence to suggest that bats may also visit offshore structures to feed (Arnett et al., 2016). If bats are attracted to the lights on turbines, the potential risk of collisions with rotor blades would increase. While the impact of artificial lights on migrating bats in the offshore environment is not well studied, the current understanding is that most over-water flights by bats occur close to shore and the number of bats present in the offshore environment is expected to be minimal (Pelletier et al., 2013). Further, the placement of wind turbines in areas where bats are unlikely to occur should minimize any light impacts. Wind farms are typically sited far enough from shore that most bat flights over water will not encounter them, based on the current understanding of the relatively limited data, in this case. Bats will also benefit from the use of ADLS and other light mitigation measures that reduce the amount of time lights are activated.

Noise

Birds within a wind farm area may be exposed to noise both above water and below water. Sources of noise include vessels traveling to and from the offshore project area, construction activities, and the operation of wind turbines after construction is completed. In general, construction vessel use in offshore wind development does not produce enough noise to significantly alter the baseline levels of noise in the offshore environment. The most significant noise during the construction of offshore wind farms is produced during the pile driving of turbine foundations. Certain seabird groups, such as sea ducks, alcids, and loons, have been found to possess soft tissue structures that conduct underwater sound. These structures indicate that marine birds may have underwater hearing abilities comparable to seals and toothed whales (Hansen et al., 2017; McGrew et al., 2022). Alcid and penguin species have been found to avoid areas with high levels of underwater noise (Pichegru et al., 2017; Anderson et al., 2020).

Several mitigation measures can be implemented to reduce the noise impacts from pile driving. Soft starts, which use slower impact speeds and produce sounds at non-harmful levels, may be used to flush birds away from the pile driving zone before noise levels escalate. To further reduce the intensity of underwater noise produced by impact pile driving, noise attenuation devices such as bubble curtains may be deployed. These types of devices lessen the impact of noise underwater and reduce the distance noise travels from the pile driving activities. Additionally, the area around which pile driving is occurring may be monitored for large flocks of birds, just as it is monitored for marine mammals and sea turtles. Shutdowns or low power operations can be triggered if flocks enter a defined safety zone. Seasonal restrictions can also reduce the impact of noise on seabirds. For example, during the winter months, when high numbers of diving birds are present in Atlantic offshore regions, time restrictions can be implemented on construction activities.

Though bats will not encounter the underwater noise produced by impact pile driving, they may still be impacted by noise during the construction and operation phases of offshore wind development. Bats have sensitive hearing, and although no temporary or permanent hearing loss would be expected from the noise levels produced during wind farm construction or operation (Simmons et al., 2016), excessive noise may potentially disrupt migration routes due to the avoidance response exhibited by migrating tree bats (Schaub et al., 2008). If bats do encounter noise from construction, it is expected that this will cause a behavioral response of bats moving away from the construction noise. However, the noise from the operation of wind farms is not expected to significantly impact bats, as bats have been found not to be disturbed by anthropogenic noises at similar intensity levels (Brack et al., 2004).

Proper siting of wind farm locations avoids introducing construction-related noise to bat migration routes. Given that wind farm locations are farther offshore than bats typically fly, noise from offshore wind construction is not expected to interrupt bat migrations in a significant way. Any bats that happen to be in the offshore area while construction is occurring will benefit from soft start pile driving mitigation measures, which would allow the bats to avoid the area before noise levels escalate.

Traffic

Vessel and aircraft traffic will increase while offshore wind farms are undergoing construction and will continue as personnel are sent to the installation during operation and maintenance. There is concern that the increase in traffic could lead to an increase in collisions for birds and bats. However, the increase in vessel and aircraft traffic is not expected to be significant when compared to baseline conditions. General aviation traffic accounts for approximately two bird strikes per 100,000 flights (Dolbeer et al., 2019). Traffic-related collisions with birds and bats are considered very unlikely events and are not expected to pose a significant threat to bird or bat populations.

Mitigation Innovations

While some effects may be unavoidable, all potential impacts from an offshore wind project are evaluated within a mitigation framework. The aim is to avoid, minimize, or mitigate adverse effects as much as is feasible. The most effective way to reduce the impacts of offshore wind development on birds and bats is through optimal siting of wind farm locations. Marine spatial planning uses ocean data sets and bird habitat usage data to identify areas suitable for construction. Suitable areas are considered those which overlap the least with marine habitats used by birds and other protected species (Best & Halpin, 2019). For example, on the Atlantic and Gulf coasts of the U.S., bird habitat usage is at its highest along the shoreline and again along the continental shelf edge. By siting offshore wind development in middle shelf waters, bird abundance hotspots can be avoided and the number of birds that will encounter wind farm structures is minimized (Virtanen et al., 2022). Proper siting will also prevent marine birds from being displaced from productive habitat, as wind farms would be developed in areas not known to harbor significant seabird foraging grounds. Offshore structures can also be fitted with anti-perching devices, which dissuade traveling birds from perching and resting upon them. The installation of anti-perching devices would also prevent certain species, such as cormorants, from being attracted to offshore wind structures. Collision risk can be further reduced by using specific visual patterns. The use of achromatic patterns on the blades and pylons of turbines increases their visual contrast for birds, allowing the birds to detect the blades early enough to alter their flight paths (Martin & Banks, 2023).

Collision risk models (CRMs) are the primary means used to assess the potential risk of collision for avian species. CRMs provide estimated collision rates based on input parameters. These models are very sensitive, so accurate input data is required to create accurate predictions. The number of birds in an area, corpse detection rate, rotor speed, bird flight speed, and habitat usage are all parameters which could impact the output of CRMs. Accurate data on seabird movements and the migratory pathways of shorebirds and songbirds are gathered through a combination of acoustic monitoring, visual monitoring, radio telemetry, and radar. Using data gathered from risk modeling, potential impacts from offshore wind development can be minimized. Data inputs used in CRMs are made available for public comment and review. Adaptive management allows for construction and management decisions to be flexible and based on the most current data from radar, monitoring, and CRM results (Band, 2012).

Specific monitoring for bats is used to inform strategies to reduce bat collisions with offshore wind turbines. Traditionally, carcass surveys would be used on land-based wind turbines to determine bat mortality rates. It is not feasible to survey carcasses in the aquatic environment, so alternate methods using acoustic monitoring and radio telemetry are needed. Acoustic monitoring and the tracking of nanotagged bats can be used to estimate bat flight heights and assess their risk of flying within the wind turbine rotor sweep zone. Collision detection technology is currently being deployed to record bat collisions even when the carcasses cannot be found. This data can then be used to determine when bats are most vulnerable to collisions. Knowledge on the conditions that lead to bat collisions can be applied in adaptive management strategies such as the temporary shutdown of rotor blades while bats are migrating through a wind farm area (Smallwood & Bell, 2020).

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