OFFSHORE WIND AND IMPACTS ON MIGRATORY WATERFOWL OF THE ATLANTIC FLYWAY

A Project

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ABSTRACT OF THE PROJECT OF

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Abstract

Wind energy has become increasingly discussed as part of a portfolio of renewable energy production to offset carbon emissions. In the U.S., New York and New Jersey are being explored for wind farm project proposals. However, these proposals are not without environmental impact. Although the U.S. has an extensive history of land-based wind farms, off-shore wind farms pose unique challenges to the environment and species dependent on that environment, specifically, migrating waterfowl. The United States has an extensive permitting process for offshore wind energy, including requirements under the National Environmental Policy Act (NEPA) to assess potential environmental impacts of offshore wind farms. As offshore wind farms are still relatively nascent on the east coast of the U.S., it is important to weigh the environmental impacts against the overall energy benefits. This paper explores these impacts and benefits specific to the proposals in New Jersey and X, that are part of the Atlantic Flyway for waterfowl. Using a case from Denmark, where offshore winds impact on waterfowl has been examined, and utilizing environmental impact statements (EIS) for east coast offshore wind development projects, this paper seeks to assess impacts to and potential mitigation of negative consequences to migrating waterfowl along the Atlantic Flyway.

Keywords

Waterfowl, Atlantic Flyway, Duck, Geese, Wind Farms; Turbines

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Statement of Project Topic: Potential impact of turbine presence within the Atlantic Flyway on waterfowl migrations

Study Problem: When Governor Phil Murphy became governor of New Jersey, his campaign focused heavily on climate change and green energy. In addition to a proposed facility for building wind turbines (a project titled the New Jersey Wind Port), he also proposed the state for a target of 7,500 MW by 2035. Current projects are facing multiple financial and political issues, with state efforts continuing forward to achieve the goals of large-scale offshore farms (Peticolas & Cavaiola 2021). There have been multiple conservation organizations raising concern and awareness for potential environmental impacts within marine and avian ecosystems. This paper will focus specifically on waterfowl impact during their migrations within the proposed project areas. It will also assess waterfowl behavioral changes due to wind turbine presence based on known data and apply this to what could be the outcome of large-scale wind farms on the northern portion of the east coast of the United States. Current policies in place will be addressed and evaluate if changes need to be made to better protect waterfowl.

Introduction

The United States continues to have one of the fastest growing wind markets in the world. This is due to a combination of both desires to move away from foreign oil, as well as wind energy technological advances. In 2011, the Director of US Bureau of Ocean Energy Management (BOEM) approved the first commercial offshore wind facility in the nation, the Cape Wind project off the coast of Massachusetts. Other projects were quickly proposed off coastal New Jersey and Delaware (BOEM 2024). The US Department of Energy (DOE) has a goal of 20% of American electricity to be wind powered by 2030, and 35% by 2050 (US DOE 2024).

Multiple wind turbine projects are currently in deliberation for coastal New Jersey, an area known for migrations of waterfowl along the Atlantic Flyway. A Danish company (Orsted) originally had plans for Ocean Wind 1 and Ocean Wind 2 located 15 miles off the New Jersey coast but were ultimately canceled citing financial issues that lead to the withdrawal (Ferguson 2023). A project called Atlantic Shores is still currently coming to fruition approximately 9 miles off the southern NJ coast near Atlantic City (BOEM 2024). Other projects are continuing to be in the works in accordance with Governor Murphy's green energy directives, including the New York Bight project of which is six large scale farms off coastal New York and New Jersey (BOEM 2024).

This capstone project will review potential impacts of proposed offshore wind turbine projects along the eastern coast of the United States on waterfowl. Concerns regarding offshore wind farms and their impacts on avian species include risk of collision, short-term habitat loss during construction, long-term habitat loss due to disturbance by turbines (this includes disturbance during times of maintenance), barriers forming along migration routes and disconnection of roosting and feeding sites. Most current studies focus on onshore turbine impact on birds, therefore not creating a clear representation of offshore impacts, in addition to current lack of data on migration routes and flight behavior of species. With efforts to move toward more renewable energy, specifically offshore windfarms, there is a need to assess impact on seabirds, waders, and waterfowl as well as any other migratory species (Exo et al. 2003). The objective of this paper is to evaluate existing offshore wind projects, specifically as they relate to potential issues for waterfowl during migrations, and to provide possible recommendations for outcomes regarding regulations of turbines to protect waterfowl.

Background

Offshore Wind Energy Regulations

The United States has authority over the oceans beginning at the coastline and extending 200 nautical miles out to sea, which is also known at the United States Exclusive Economic Zone (EEZ). The federal government has jurisdiction over potential offshore wind farm locations to the boundaries of the EEZ. Any wind energy project to be constructed in state waters is subject to applicable state regulation or permitting requirements. This includes facilities and any cables that would transmit power back to shore. The federal Coastal Zone Management Act (CZMA) recognizes: (1) "State establishment of criteria and standards for local implementation, subject to administrative review and enforcement"; (2) "[d]irect State land and water use planning and regulation"; and (3) regulation development and implementation by local agencies, with state-level review of program decisions (Offshore Wind 2023).

CZMA encourages coastal zone management plans for protection of habitats and resources. State coastal zone management programs approved by the Secretary of commerce receive assistance, both monetary and technical. State programs must designate conservation measures and address sources of water pollution. A federal statute governing offshore wind energy was enacted by the Energy Policy Act of 2005 (EPAct). Prior to this Act, some permitting was in place, but laws were controversial and often challenged in court. Prior to the EPAct, the Army Corps of Engineers used the Rivers and Harbors Act, amended by the Outer Continental Shelf Lands Act (OCSLA), to have jurisdiction over obstructions in navigable waterways. Section 388 of EPAct amended OCSLA to establish legal authority for federal review and approval of offshore energy projects (Offshore Wind 2023).

The EPAct also includes that offshore wind development continues to require a permit from Army Corps of Engineers and must comply with species protection laws. In January 2023, BOEM issued a notice to amend administrative processes for offshore wind leasing. This would require BOEM to schedule offshore wind leasing well in advance for planning purposes, reform auction process for offshore wind leases, and allow flexibility of oversight of surveying. National Environmental Policy Act (NEPA) requires federal agencies to disclose environmental consequences of their actions. Major federal actions that could significantly impact the environment require an environmental impact statement (EIS) (Offshore Wind 2023). This paper will review EIS of projects relevant to the Atlantic Flyway.

The Atlantic Flyway

The state of New Jersey is an important component of the Atlantic Flyway which is why it attracts both hunters and bird watchers alike to admire waterfowl as they make their way along their migratory route. Primary species of breeding waterfowl in New Jersey include mallards (*Anas platyrhncho*s), black duck *(A. rubripes*), wood ducks (*Aix sponsa*), and Canada geese (*Branta canadensis*), among many others. The species along this flyway are monitored by both the Atlantic Flyway Breeding Waterfowl Survey and the Eastern Breeding Waterfowl Population Survey. Both surveys are used to determine health of the species and determine potential need for habitat management (Nichols et al. 2015). Both surveys are used to also set harvest limits for hunting seasons.

The U.S. Fish and Wildlife Service and its partners monitor migratory birds as they move between feeding and resting areas, in collaboration state Fish and Wildlife agencies. The major migratory routes are classified into four flyways: Atlantic, Mississippi, Central and Pacific. Monitoring involves representatives from state and territorial agencies along each Flyway. The

Atlantic Flyway includes Connecticut, Delaware, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, and West Virginia. Outside of the United States it includes Eastern Canadian territories, U.S. territories of Puerto Rico and U.S. Virgin Islands (USFWS 2024).

The flyways were created in the 1940s and recognized by USFWS by 1947. They were designed to regulate hunting harvest regulations based on population fluctuations and number of hunters in each region. The states later became more involved after the creation of the Federal Aid in Wildlife Restoration (Pittman-Robertson) Act of 1937, taking advantage of the opportunity to increase habitat management. By 1951, an effective management system was in place with the International Association of Game, Fish and Conservation Commissioners, with councils established in all four flyways with oversight by USFWS representatives. Canada also quickly became involved, recognizing the importance of preservation along the flyways as they interconnect with the respective North American Flyways (Ducks Unlimited, 2016).

Waterfowl of the Atlantic Flyway

Merriam-Webster Dictionary defines waterfowl as a swimming game bird such as duck or goose. It is distinguished from an upland game bird or shorebird. Every year, millions of migratory waterfowl winter in Mexico, Central America, the Caribbean and South America, then later return to their nesting grounds in the United States in the spring. During these long migration routes, they encounter many obstacles including storms, predators, and habitat fragmentation among many other impediments (Roberts 2022). One of the major issues is visibility during storms, which also causes increased risk with turbine presence.

There are many waterfowl species that venture throughout the Atlantic Flyway. Species include, but are not limited to: mallards, black ducks, teal (green and blue-winged), gadwall, shovelers, pintails, wood ducks, black scoter, long-tailed, common eider, Canada geese, ross geese, Atlantic brant, and many more (Roberts 2022). Some species, more so than others, utilize coastal New Jersey as a stop in their travels, and are therefore prioritized when having specific hunting regulations for the area. Forty percent of the Atlantic Flyway's bird species are species of conservation need (Audubon 2024). This comes into consideration for not only statewide regulations, but nationwide as well. Many species across the different flyways have mutual breeding grounds (i.e. the Arctic, Great Lakes, or Prairie Potholes region of the Midwest) and are therefore regulated highly by USFWS before states consider setting harvest limits.

Landscape Changes

Disturbance by operating wind turbines can exclude birds from suitable breeding, roosting, and feeding habitats. The bases of turbines may not directly cause habitat disruption for birds; however, the vast size of an overall wind farm can cause alterations in landscape use by birds. Studies have shown in terrestrial habitats, a decreased radius of 800 meters of roosting and feeding birds around turbines have been observed, with migratory species impacted more commonly than local birds. This fact leads to the concern of turbines causing fragmentation between roosting and feeding sites (Exo et al. 2003). For the case of waterfowl migrating, it may cause them to move closer or further inland, causing energy expenditure.

Offshore wind farms include not only turbines larger in scale compared to land wind farms, but also overall area of the actual farm also being significantly larger in scale. Land turbines seldom exceed 100 meters, whereas offshore turbines reach about 150 meters. Land turbine farms often consist of 30-40 turbines compared to marine farms that take and area of 100 km^2 (Exo et al. 2003). The larger size and scale of turbines and farms entirely can lead to enhanced avoidance behaviors. Studies we will discuss later have shown not only do birds fly around wind farms, while some lower flying species will fly through the structures.

Worldwide, wind farms offshore are rich in bird species and especially species sensitive to disturbance. Some concerns that arise are not only the presence of a wind farm including size of the farm and size of individual turbines, but also the installation and maintenance phases of the turbines. There are also concerns for activities such as increased noise from ships and helicopters, as well as increased boat traffic. To date, there are no environmental assessments on the impact of these disturbances (Exo et al. 2003). There should likely be consideration for regulating boat traffic during construction to mitigate impact on the surrounding environment.

Bird species sensitive to the presence of wind farms and prone to habitat loss include divers, scoters, geese and waders as shown in worldwide studies. Divers and scoters have shown avoidance behavior of ships by a few kilometers and remain in areas of light sea traffic (Mitschke *et al.* 2001, Exo et al. 2003). Long-tailed ducks, of which breed in the high arctic but are present in multiple flyways including East Atlantic (includes Denmark) and the Atlantic Flyways (includes New Jersey), have shown avoidance behavior in Denmark studies of the Nysted Offshore Wind Farm. Studies have shown a significant decrease in their foraging of the area pre- and post-construction (Fox & Petersen 2019). Long-tailed ducks are very prevalent along the New Jersey coast during migration, and their avoidance behavior should be noted as concern when considering offshore wind farms.

Migratory Bird Treaty Act & Other Migratory Bird Protection Policies

The Migratory Bird Treaty Act (MBTA) protects hundreds of avian species under the enforcement of the United States Fish and Wildlife Service (FWS). MBTA was enacted in 1918 in response to overharvesting of migratory birds that began in the 1800s (Martin & Ballard 2013). Prior to MTBA, the first initial attempt to protect migratory birds from over hunting was the Lacey Game and Wild Bird Preservation Act of 1900 (Lacey Act), however, it was ineffective due to lacking an indirect enforcement mechanism. Congress passed the Weeks-McLean Migratory Bird Act of 1913, which was then deemed unconstitutional due to federal government involvement with states' rights in accordance with the Tenth Amendment. In 1916, the US and Great Britain formed a treaty to protect birds from indiscriminate slaughter. The MBTA ratified this treaty in 1918. The MBTA was also challenged as unconstitutional under the Tenth Amendment, however, the US Supreme Court upheld the Act under the Supremacy Clause because the MBTA implemented a treaty (Martin & Ballard 2013).

The FWS created the Land-Based Wind Energy Guidelines on March 23, 2012, to reduce impacts on migratory bird species. These guidelines seek to promote compliance with laws and scientific monitoring of land-based farms within the United States. There are five tiers for the Energy Guidelines. Tier 1 is a preliminary site evaluation, ruling out sensitive areas for proposed turbine sites. Tier 2 takes approximately 375 hours to complete, narrowing the focus on specific sites and evaluating species of concern in the area. Tier 3 takes approximately 2,880 hours to complete, assessing bird distribution and behavior. Tier 4 includes post-construction studies, and Tier 5 is complex and site specific (Rose 2014). The tiers are consuming of both time and finances as there is an extensive amount of experimentation that occurs to assess wildlife behavior within the area performed by specialists. The time and financial stress of incorporating these voluntary guidelines have deterred farms from implementing them, but the alternative is possible prosecution by the USFWS if there are an excessive number of protected species being killed by the presence of the turbines.

Over a thousand birds are protected by the MBTA, with authority delegated to the Secretary of the Interior. This authority then delegates to the FWS which provides enforcement. Any person, association, partnership, or corporation found in violation of the MBTA can be fined or imprisoned. Also, the MBTA is a strict liability statute, therefore one is subject to criminal punishment regardless of the crime committed was intentional or accidental. The latter part of the twentieth century led to courts evaluating if MBTA properly addressed incidental take. Circuit courts are split on whether wind energy developers violate MBTA when birds are killed directly due to turbines (Martin & Ballard 2013).

President Clinton enacted Executive order 13186 in 2001, clarifying that MBTA covered both intentional and unintentional take. The MBTA considers incidental take as a federal crime.

For 10 months, this was reversed. However, in 2021, Department of Interior changed the ruling it to it indeed being a federal crime once again. This dispute took place due to deliberation over the interpretation of "incidental take". The ruling also clarified that incidental take permits would be considered under certain circumstances (Auslander 2021). In lieu of an incidental take permit, FWS created the Land-Based Wind Energy Guidelines, of which as stated previously, are completely voluntary. The guidelines cover initial site evaluation to post-construction impact studies. To reiterate, guidelines are costly and time consuming, but so is the alternative (Rose 2014).

Duke Energy Renewables in Wyoming did not heed to the guidelines and killed 163 protected migratory birds quickly post-construction, leading to over a million dollars in fines, restitution, and community service. This is the first criminal enforcement against a wind energy developer regarding MBTA (Rose 2014). Altamont Pass in central California also dealt with post-construction mitigation. It is estimated 55 to 94 Golden Eagles have been killed at this area since 1998. Also, less are being born than are being killed in this location, causing a population sink (Martin & Ballard 2013).

The Endangered Species Act (ESA) is also enforced by FWS and allows for incidental take permits. Therefore, an owner of a potential wind development project can submit a Habitat Conservation Plan to FWS for approval with the potential outcome of an incidental take permit. The plan must address mitigating impact on species within the Act as well as propose ideas to minimize impact. The ESAs regulations include a rule where owners of wind projects will not be subject to enforcement of the Act if species taken were included in the Habitat Conservation Plan. ESA also allows for private citizen suits alleging violations. Some wind developers now request consultation from FWS in order to protect themselves from potential citizen suits (Martin & Ballard 2013).

Wind Turbine Development

Offshore wind has grown at an exponential rate, even prior to offshore considerations. Wind development has grown in the United States at a significant rate of 3011%, from 2,472 MW in 2000 to 74,421 MW in 2016 (Dorrell & Lee 2020; Brown et al. 2012; Rand & Hoen 2017; National Renewable Energy Research Laboratory 2018). The US government originally began subsidizing wind energy in 1978, with growth primarily occurring in the 21st century (Brown et al. 2012; Dorrell & Lee 2020; Sherlock 2012). During 2005 to 2009, the wind capacity grew at an average rate of 39% (Lu et al. 2011; Dorrell & Lee 2020). Numerous incentives have been implemented to encourage green energy initiatives.

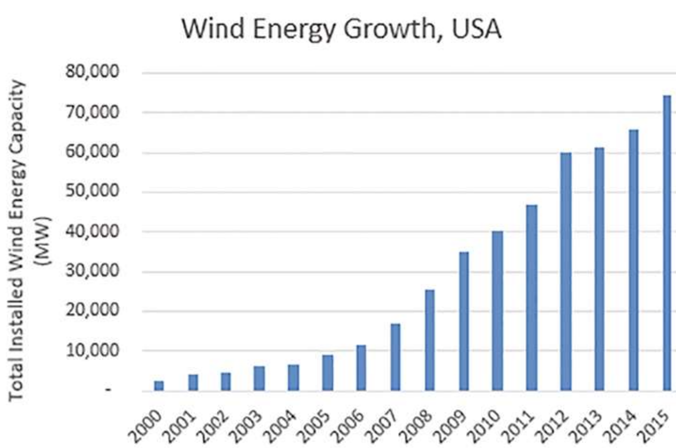


Fig. 1. Wind energy growth in the US. * US Department of Energy, 2018.

Wind energy is highly driven by government policy because it is required to achieve cost competitiveness (Shrimali et al. 2015; Dorrell & Lee 2020). The Federal Production Tax Credit (PTC) is a national tax credit policy that was created to provide credits to qualifying energy producers and provides economic stability for wind energy developers (Roach 2015; Dorrell & Lee 2020). There have been numerous studies proving a positive correlation between wind energy development and PTC but does not explain different levels of wind power development between states (Dorrell & Lee 2020). Another policy that assists with wind power is the Renewable Energy Credit (REC) of which is a marked based instrument that makes wind energy more economically feasible to producers. RECs are generated at one megawatt-hour (MWh) from a renewable energy source and the credits are sold from renewable energy producers to third parties. States can individually use and tailor RECs for their energy growth (Lu 2011; USEPA 2019; Dorrell & Lee 2020). An additional set of regulations are Renewable Portfolio Standards (RPS) policies that are state level instruments that promote renewable energy growth. They were originated in 1983 as the Alternative Energy Production law (Upton & Snyder 2017; Dorrell & Lee 2020). RPS requires suppliers to meet a certain percentage from renewable energy (Dorrell & Lee 2020; Lu 2011).

Policy Landscape

The BOEM commercial leasing process is extensive. The first phase is planning and analysis where BOEM works with government agencies to identify suitable wind energy areas. Leases are then issued, which allows lessee can develop a plan to be reviewed by BOEM. The site assessment phase includes submission of the Site Assessment Plan (SAP) which details the construction and structures such as buoys or meteorological towers. BOEM must approve this portion as well before the next phase. Construction and operations is the last phase and includes the Construction Operation Plan (COP) leading to environmental and technical reviews. Ongoing research continues as BOEM points out that extensive research needs to be done as sites for renewable energy have never undergone renewable energy development before (BOEM: Fact Sheet 2024).

The National Environmental Protection Act (NEPA) requires that BOEM conducts Environmental Impact Statements (EIS) for any federal projects. On March 18, 2024, BOEM published a Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for the Construction and Operations Plan (COP) submitted by Atlantic Shores Offshore Wind, LLC. The lease area is approximately 81,129 acres in total, extending from 8.4 miles off coastal New Jersey to 60 miles off New York with potential for 168 offshore structures. The publication of the NOI in the Federal Register opened a 45-day public comment period for the Atlantic Shores North EIS that ended on May 2, 2024. Public comments include concerns for migratory waterfowl and other waterbirds as they navigate the area. The EIS addresses this by stating their will be an Avian and Bat Post Construction Monitoring Plan (ABPCMP) developed by the Leesee with input from New Jersey Department of Environmental Protection, US Fish and Wildlife Service, and interested parties. The lessee will also be required to submit annual monitoring reports regarding both ESA and non-ESA birds and bats (US EPA 2024; Watch 2024).

BOEM announced another proposal, just north of Atlantic Shores Wind, the EIS for SouthCoast Wind Project off the coast of Massachusetts on November 8, 2024. This project includes up 147 wind turbines and five offshore substations covering 127,388 acres and is about 26 nautical miles south of Martha's Vineyard (Maritime Executive 2024). Studies for this project included an Avian Risk Assessment survey. This survey included an exposure assessment with sea ducks such as black scoter, common eider, long-tailed duck and surf scoter listed as moderate for annual exposure to the turbine area, with high numbers of the species in the area in Spring and Winter (See below chart). (Mayflower Wind 2021). The EIS advises it will mitigate impact to avian species by avoiding placing components in areas of high bird usage (BOEM: SouthCoast Wind 2024).

Table 1: Lease area bird assessments near SouthCoast Wind Project (BOEM: SouthCoast Wind 2024)

Species	Lease Area Estimates							
	Lease Area (Aerial HD)[a]				Lease Area Adjusted (Aerial HD)[b]			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
Common eider	0	0	0	34	0	0	0	112
Long-tailed duck	254	0	0	247	838	0	0	815
Red-breasted merganser	0	0	0	0	0	0	0	0
Surf scoter	4	0	0	3	13	0	0	10
White-winged scoter	247	0	0	2,486	815	0	0	8,199

Other projects proposed include another project off the coast of Maryland installing 114 turbines and four substation platforms. The lease area is approximately 9 nautical miles off of the coast of Maryland and Sussex County, Delaware. This project was announced July of 2024 (BOEM: Maryland 2024). Atlantic Shores South Wind Project was also announced around the same time, advising this lease area covers 102,124 acres, 9 miles off of New Jersey (BOEM 2024). The amount of proposed wind energy projects is extensive, and each one approaches public comment regarding various species of concern. The ultimate plan is integrating USFWS and local wildlife agencies to mitigate impact.

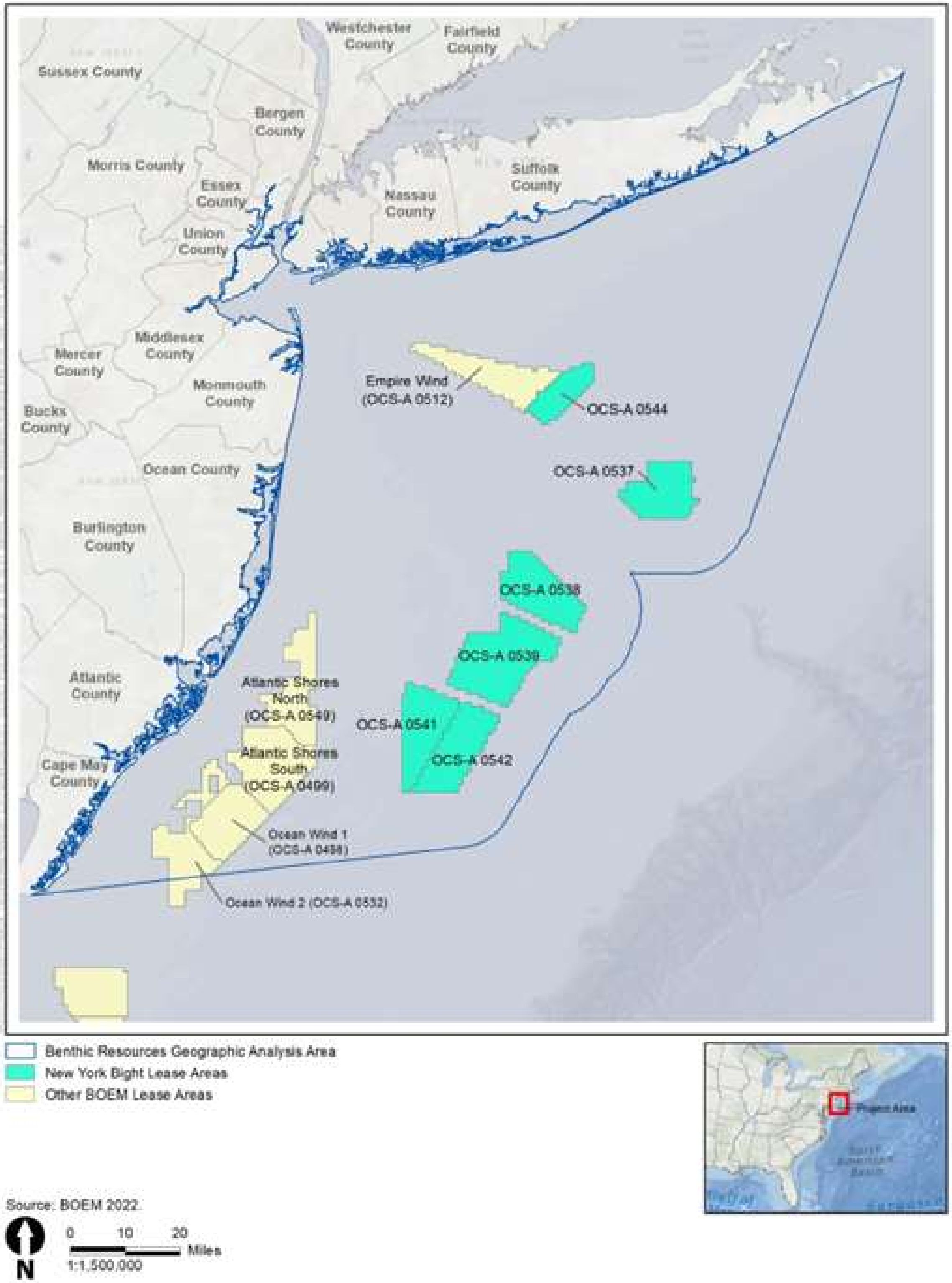
Methodology

This study was conducted utilizing qualitative research to answer key questions of how waterfowl could be impacted during migration if all the proposed wind farms are erected in the New York Bight protects, as well as how much offshore wind farms in general could impact flyways. I evaluated information from peer reviewed articles, as well as government websites with relevant information to the topic of waterfowl species native to the Atlantic Flyway. Shortcomings include lack of data within the United States specifically as offshore wind is only becoming more abundant as of recent, with most United States data applicable to land-based wind farms. The United States only recently began development of offshore wind farms, and therefore there is a significant lack of data to prove any direct correlations of turbine impact on native species. For this case study, a review of worldwide studies that correlate wind turbine impact with species native to the Atlantic Flyway are reviewed to determine potential outcomes upon development of the New York/New Jersey offshore farms.

A study performed on the Pacific Flyway tracking geese and their native range during migration will be evaluated, as well as studies in Denmark where wind farms have been in existence for years. Denmark is also an ideal area for review as there are many species that are native to the Atlantic Flyway that are also native to Denmark, and therefore provide a clear example of how their behaviors change in the presence of offshore wind farms. Although species are found on different flyways, they often have similar breeding grounds and therefore will be genetically similar with anticipated similar behavioral responses. Information gathered from this study could be applicable to both coastal Flyways, the Pacific and Atlantic. Regulations recommended would be applicable for the USFWS in surge of proposed offshore wind farm development nationwide.

Study Area

There are numerous proposed offshore wind turbine projects along the east coast of the United States, however, for the sake of this project, we will assess a handful of the many proposed projects along the New Jersey coastline. On July 2, 2024, the Department of Interior approved the Atlantic Shores Offshore Wind South Project (Atlantic Shores South) of which include Project 1 & 2, approximately 8.7 statute miles offshore New Jersey. Projects 1 & 2 expect to generate 2,800 MW of electricity. On October 21, 2024, BOEM announced their Final Programmatic Environmental Impact Statement (Final PEIS) for the development of six wind lease areas. These offshore leases extend along coastal New York and New Jersey in an area called the New York Bight (BOEM 2024). New Jersey has federal waters located three nautical miles offshore of the coast where the Federal Bureau of Ocean Energy Management (BOEM) is responsible for regulating renewable energy activities. BOEM facilitates lease of sales for the wind development facilities. They have issued two commercial leases offshore of New Jersey (NJDEP 2024). BOEM has performed Environmental Impact Studies (EIS) citing possible impacts of the proposed New York Bight project impacting birds by means of habitat alteration and possible collisions. New York Bight includes six commercial leases offshore of New York and New Jersey (BOEM 2024).



(BOEM EIS 2024).

Study Species

Species in question would be those considered in the Atlantic Breeding Waterfowl Survey, among other species that venture the flyway, through the turbine areas. The Atlantic Flyway Breeding Waterfowl Survey was initiated in 1988 and is designed to estimate populations of breeding waterfowl from Virginia to New Hampshire (Nichols et al. 2015). This survey focuses on mallards (*Anas platyrhncho*s), black ducks *(A. rubripes*), wood ducks (*Aix sponsa*), and Canada geese (*Branta canadensis*) as they are the primary breeding species of New Jersey (Nichols et al. 2015). Other species that frequent the New Jersey coast in the winter include common scoter *(Melanitta nigra),* Long-Tailed Duck *(Clangula hyemalis)* and Common Eiders *(Somateria mollissima)*. These species are native to the Atlantic Flyway, as well as other areas of the world including Denmark.

For the sake of this study, we look at Denmark because although it is part of a different flyway, it contains the same species that likely dispersed from the same breeding grounds and will likely exhibit similar behavior patterns, regardless of flyway location. Denmark has performed many assessments for behavioral patterns around multiple different wind farms for waterfowl. Denmark paved the path for large offshore wind turbine farms beginning in 1991, supplying us with significant data relevant to this case study (Fox & Petersen 2019). To analyze possible geese behavior, we will look at a study performed on the Pacific Flyway regarding migratory behavior and altitude choices comparative to locations of wind turbines (Weiser et al. 2024). Geese are also exhibit similar behavior across flyways, making the data important regardless of flyway.

Turbine Risks

Wind turbines pose a risk to birds by direct mortality through collisions and are known as a source of fatal collisions for many avian taxa (Weiser et al. 2024; Conkling et al. 2022). Wind turbines kill about 440,000 birds annually in the United States, according to studies addressed in this case study. Scientists believe that birds eyes cannot see the blades at high velocity, therefore the birds register it as a safe fly zone. Scientists also believe birds may focus on looking for prey or looking at the horizon and are unable to simultaneously perceive the turbines (Rose 2014). Local birds will often make lower altitude movements while migrating birds will often seek higher altitudes (Hüppop et al., 2006; Sugimoto & Matsuda, 2011; Zehtindjiev & Whitfield, 2011; Weiser et al. 2024).

Turbines can also cause birds to increase energy expenditure if they are trying to avoid the area (Fox & Peterson 2019; Weiser et al. 2024). Birds also can possibly be displaced from foraging or breeding habitat (Weiser et al. 2024; Furness et al. 2013; Shaffer & Buhl, 2016). Avian collision risk depends on frequency of encountering a wind farm, in addition to flight altitude, as well as the overall size of a wind turbine blade (Desholm & Kahlert 2005; Furness et al. 2013; Masden & Cook, 2016; Weiser et al. 2024). Concerns for avian impact arise when wind turbine manufactures are trying to make the turbines larger to be more effective. Modern turbines range from 200 to 400 tons with blade speeds of 180 miles per hour. Wind turbine blades can be manufactured at a size of 200 feet long (Martin & Ballard 2013; Rose 2014).

Migrating birds may fly at lower altitudes depending on headwinds, precipitation, cloud cover, cooler air temperatures and in darkness (Galtbalt et al., 2021; Hüppop et al., 2006; Lindström et al., 2021; Marcelino et al., 2021; Weiser et al. 2024). Most studies to date focus on terrestrial windfarms and local movements of seabirds, with little information of offshore migratory taxa. This study regarding the Pacific Flyway will be applicable to proposed wind farms >1 km off the west coast of the United States with blades spanning 20-200 m above sea level (asl) (Weiser et al. 2024). One single New York Bight project could include up to 285 structures, ranging from 30-53 nautical miles off the coast (BOEM 2024).

Collision risk is a greater concern for long-lived species with low mortality and productivity rates. Seabirds and waterfowl are classified as long-lived species. Concerns include that offshore turbines are larger with longer blades than on shore turbines, increasing possibility of collision risk compared to known studies performed on land. Disturbance and barrier effects show the highest conflict potential. There is unfortunately lack of data on migration routes and flight behavior above the sea (Exo et al. 2003).

Pacific Flyway Geese Behavior Study

Flight Altitude

Flight altitude influences collision risk with turbines and therefore any altitude-selection analyses are critical in measuring where and when waterfowl will maneuver through certain conditions. A study performed on the Pacific Flyway regarding geese migrating between Alaska, Washington and Oregon included placing electronic tags on the geese to monitor altitude selection on their migration path. Altitude selection of Arctic geese were quantified on migrations where wind farm development was just beginning to arise. This was a critical study as little was known of waterfowl flight characteristics during offshore migrations. Findings showed that geese would most likely be in the rotor-swept zone during times of little or light tailwinds, low clouds, minimal to no precipitation, and cool air temperatures. (Weiser et al 2024).

Other findings included geese exhibiting selection for the rotor swept zone in the spring and fall. The geese showed signs of avoidance when conditions were clear and visibility was high, such as during daylight hours and lacking inclement weather conditions. Geese were mostly at rest on the water during night hours. Figure 1 (below) demonstrates the flight patterns observed by the geese. There were 45 individuals tagged of three subspecies of two species: Pacific greater white-fronted goose (*Answer albifrons sponsa,* GWFG), tule greater white-fronted goose (*A.a. elgasi,* TWFG), and lesser snow goose (*A. caerulescens caerulescens*, LSGO) (Weiser et al 2024).

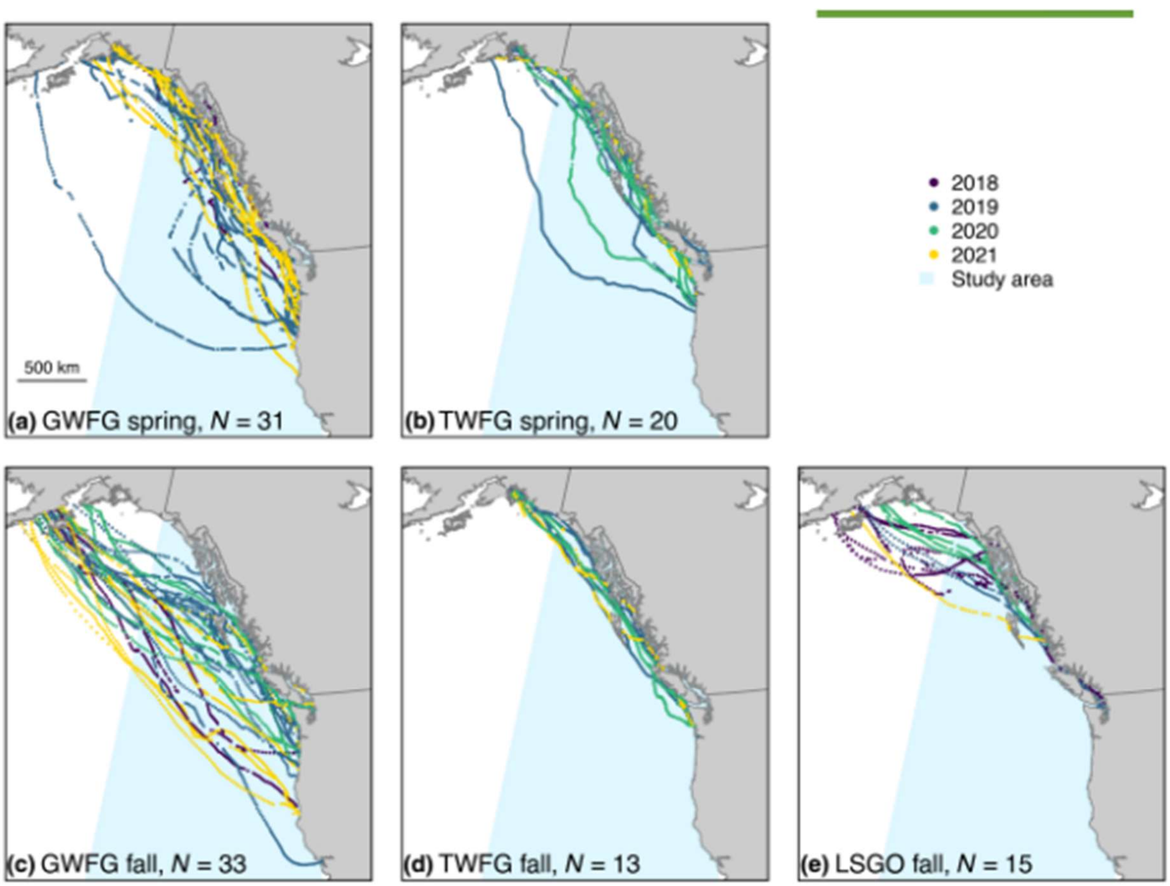
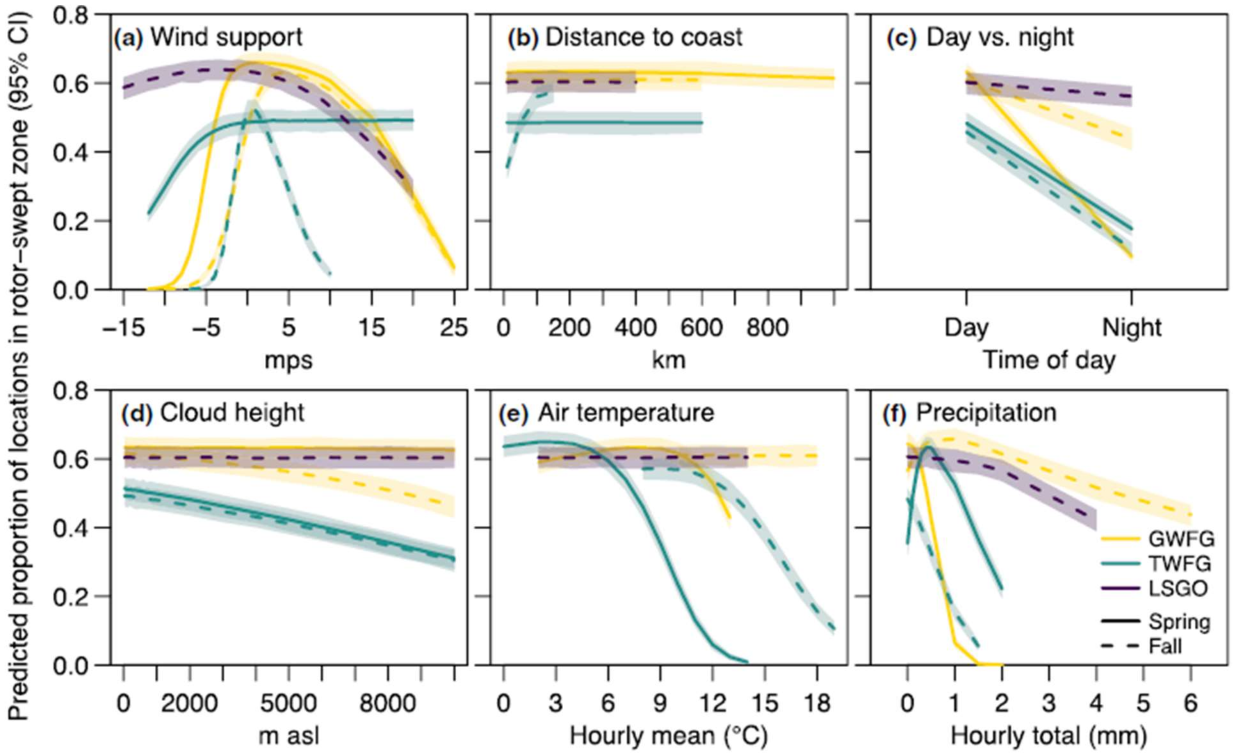


FIGURE 1 Mapped tracks for all offshore goose migration bouts (>1 km from the Pacific coast of the United States and Canada) (Weiser et al., 2024a). Points outside the study area (west of −141°) were excluded from the analysis. *N* is the number of migration bouts, where any given individual could have been tracked for multiple bouts (multiple years). LSGO in spring did not migrate over ocean and were thus excluded from this analysis. GWFG, Pacific greater white-fronted goose; LSGO, lesser snow goose; TWFG, tule greater white-fronted goose.

Analysis

The white-fronted goose, tule-greater white fronted goose, and lesser snow goose were fitted with trackers and monitored during fall and spring migration whereas altitude preference and flight versus being at rest were assessed. The correlation between behavior and ambient conditions was quantified. Based on this data, predictions were made of how frequently these populations would be within the rotor swept zone (20-200m above sea level, >1 km offshore). 114 migration bouts from 45 geese were tracked on their migration. Results found that most of their spring or fall migration was spent offshore. There was variability among the subspecies on their migration routes, most notably that the greater-white fronted goose particularly stayed offshore in the fall, while the lesser snow goose stayed more inland. Regarding covariates of flight probability, wind support had the most significant positive effect, while time of day had the most negative effect with most avoiding night flight (Weiser et al 2024).

Regarding altitude selection, all groups selected lower ranges and wind support. Also, moderate wind was associated with a higher probability of all three groups being within the rotor-swept zone (see below: Figure A). All groups were less likely to be in the rotor swept zone at night (see below: Figure C). During daylight hours, 56% of goose populations were expected to be in rotor- swept zones and 28% at night. Flight within the rotor-swept zone increased when conditions favored low altitude flight. Lesser snow geese migrated primarily over land and were therefore finding minimal impact from turbine presence. However, the other two subspecies were significantly found in the study area (Weiser et al 2024).



Headwinds lead the tule greater white-fronted goose and Pacific great white-fronted goose to fly below the rotor-swept zone. Strong tailwinds lead them to fly above the rotor-swept zone. Higher flight with tailwinds has also been seen in black brant (black brant are located on both Pacific and Atlantic Flyways). Cloud base also yielded altitude preference with the geese, for example, higher clouds leading to higher altitude preference. The greater white-fronted goose also chose higher altitudes during warmer temperatures or when they were near the shore in the fall (Weiser et al 2024).

Conclusively, the study explained that only a fraction of the geese migrating through this region would be maneuvering through a wind farm in a single year. However, it showed that they would be flying through the rotor-swept zone. An important note is that this study was performed in the absence of turbines and only assumes what could occur when the wind farm is built. The study also points out that the birds could exhibit avoidance behaviors upon turbine installation

(Weiser et al 2024). Although these specific subspecies are not on the Atlantic Flyway, their behaviors are significant when considering potential behavior patterns for offshore waterfowl.

Denmark Studies

Denmark was the first country to construct wind turbines beginning in 1991. There are now 13 offshore wind farms in existence and counting. Pre- and post-construction, Denmark performed extensive environmental impact assessments as they were aware that their waters are key areas for breeding, staging, molting and wintering waterbirds. Concerns when establishing the farms include disruption during the construction of offshore windfarms as well as disruption to normal patterns of behavior and characteristics related to different species based on fitness. Long-lived birds such as divers have low reproductive potential and are more susceptible to small increases in mortality annually. Concerns for displacement arose regarding separation of roosting and feeding sites as well (Fox & Petersen 2019).

Research had found that a visual stimulus can result in an avoidance response. Common Eiders *(Somateria mollisima)* were seen modifying their flight direction up to 3 km away from the Nysted Offshore Windfarm in Denmark. Birds would be seen flying horizontally around turbines or flying over them. Below, figure 1 shows eiders flight densities in relation to the Nysted Farm. Figure 2 shows flocks favoring the periphery of the wind farm, causing concern for survival and reproductive success. Some birds would fly through the turbines, with a majority choosing to mauver around the outer edge of the farm (Desholm & Kahlert 2005; Fox & Petersen 2019).

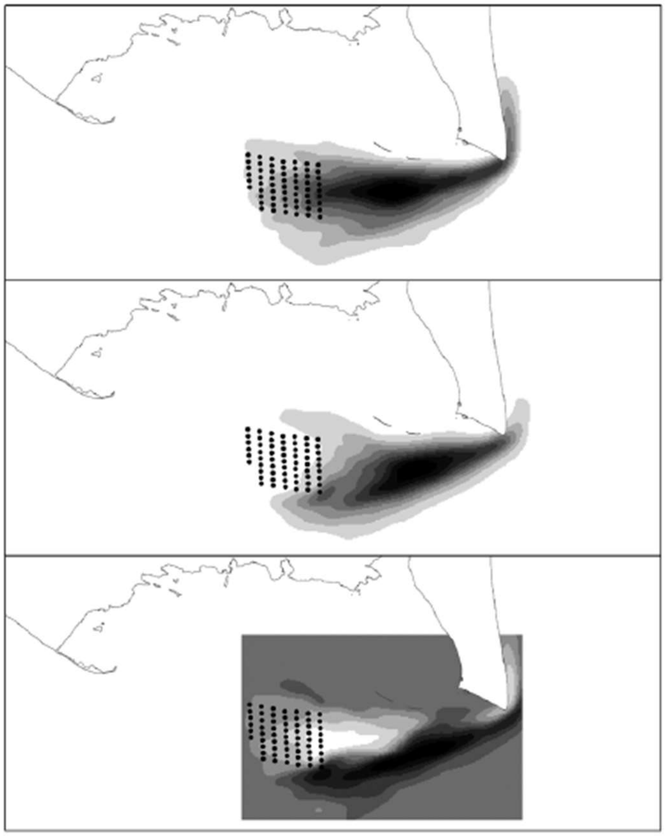


Fig. 1. Kernels of space use by autumn migrating Common Eiders flying around Gedser and onwards across the area of the Nysted Offshore Windfarm off southern Denmark. The space kernels represent the intensity of radar tracks of migrating individuals across the study area (a) pre-construction, (b) post-construction and (c) the difference in space use between (a) and (b). Darker shading represents the greatest use, white in (c) indicates reductions between (a) and (b). The black dots denote the ultimate positions of the individual turbines. Reproduced with permission from Masden *et al.* (2009).
Kernel-beregning af passagen af efterårstrækket af Ederfugle fra Gedser og vestpå til Nysted Havvindmøllepark. Kernel-værdierne repræsenterer intensiteten af radar-trækspor af flokke af Ederfugle (a) før opførelsen af Nysted Havvindmøllepark, (b) efter opførelse af vindmølleparken og (c) forskellen imellem intensiteterne før og efter opførelse af parken. Lyse/hvide områder i (c) repræsenterer områder med reduceret intensitet mellem (a) og (b). Sorte prikker angiver positioner for de enkelte turbiner.

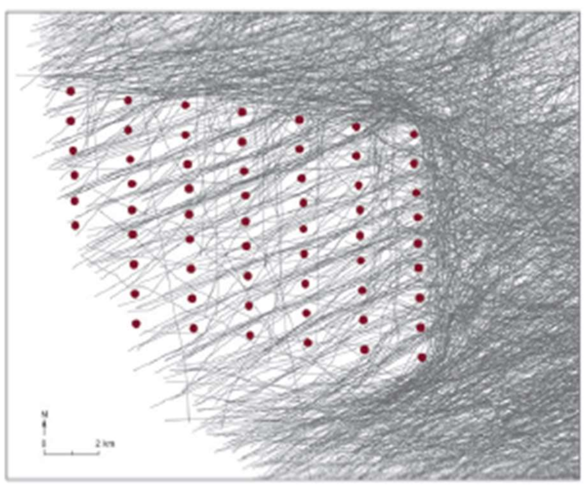


Fig. 2. The south-westerly and westerly orientated flight trajectories of waterbird flocks and individuals based on radar traces within the Nysted Offshore Windfarm during the initial post-construction operation of wind turbines at the site. Red dots indicate the positions of individual turbines, the scale bar represents 1000 m. Reproduced with permission from Desholm & Kahlert (2005).

Energy Expenditure

This avoidance behavior would only occur twice each year during the migration between breeding and wintering areas. The Eiders maneuvering around Nysted only added 500 m to a 1400 km flight, incurring trivial energetic costs. (Fox & Petersen 2019; Masden et al. 2009). There is, however, concern regarding if avoidance behavior increases, so will energetic cost. An example of this would be if breeding birds commuting between breeding colonies and offshore feeding areas are continually needing to travel farther to avoid expanding farms. Provisioning multiple times per day would increase energetic costs and likely impact reproduction and survival success. This would lead to a larger concern for birds with high wing loadings such as Cormorants and species similar in size (Fox & Petersen 2019).

Studies performed in Denmark included concerns for non-breeding sea ducks incurring the necessity to reposition themselves over optimal feeding areas. Inappropriate location of turbines could cause energy expenditure, although it was fortunately not seen in the Denmark studies (Piper et al. 2008; Fox & Petersen 2019). However, with the overwhelming increase of wind farms throughout the world, this could be an issue in the future. Geometric arrangements of turbine structures allowing for corridors could allow for passage of birds through concentrations of the structures (Masden et al. 2010a & 2012; Fox & Petersen 2019).

Behavioral Changes

Avoidance responses become a concern when functional habitat loss results from bird behavior. The Common Scoter *(Melanitta nigra)* and Red-Throated Diver *(Gavia stellata)* both avoided turbines in Denmark. Both species are also native to the Atlantic Flyway. Another species that is present in the Atlantic Flyway is the Long-Tailed Duck *(Clangula hyemalis)*. The

Long-Tailed Ducks that frequent the area of Denmark near the Nysted Offshore Windfarm was found to be foraging the area in lower quantities than they were prior to construction (Petersen et al. 2011; Fox & Petersen 2019). Red-Throated Divers that were present within Horns Rev wind farm in Denmark showed avoidance behavior as well during pre-construction footprint compared to post-construction. Across sites, however, they did see mixed responses of avoidance or adaptive behaviors to turbine presence in divers and scoters (Fox & Petersen 2019). Many diver species and scoters are found in the Atlantic Flyway, making this information critical in evaluating potential avoidance behaviors if the New York Bight projects come into fruition.

In the Denmark sites of Nysted and Horns Rev, the foundations never amounted to more than 2% loss of the overall farm. It was also speculated that foundations could provide habitat for fish and mussels of which could in time attract foraging birds such as Eiders. Currently, Danish studies have not shown increases in duck species being attracted to the turbine areas (Fox et al. 2006a; Fox & Petersen 2019). It is assumed the avoidance behavior would outweigh foraging opportunities. The Danish studies overall showed that avoidance behavior is probable, and higher likely during inclement weather, similar to the Pacific Flyway study.

Other studies around the world have shown varied avoidance and energy expenditure of waterfowl. Observations of geese, waders and terns have shown reactions to turbines up to a few hundred meters, often flying higher or changing direction all together (Exo et al. 2003). Radar studies in the Netherlands have indicated that some ducks will fly between turbines in the moonlight, while others will fly around turbines in clusters in times of poor visibility. It is assumed these are likely birds local to the farms (Spaans et al. 1998; Exo et al. 2003). Observations have overall shown that birds will fly closer to rotor blades at night than the day, and more collisions will occur at night (Winkelman 1990, Exo et al. 2003).

Discussion

As the United States moves towards an energy portfolio that includes offshore wind, mitigating the environmental impacts, including those of water birds, need to be addressed. Proactive analysis before, during, and post construction by USFWS, as well as ongoing studies to assess impact will be critical in mitigating wildlife impact in the process of offshore wind expansion. The Environmental Impact Statements address extensive plans to mitigate avian impact. There is an astounding number of large scales offshore wind farms about to come into fruition along the Atlantic Flyway and avian impact is most definitely a needed priority. EIS mitigation techniques included some monitoring studies to assess if turbine location would be impacting bird locations.

All EIS studies showed there is a marginal risk and certain times of the year that are higher for waterfowl. The EIS state they will work with USFWS and local agencies to assess wildlife impact. However, I would recommend having biologists on staff to continually monitor and regulate times turbines may need to be shut down to minimize impact. For example, if the biologists are monitoring cold fronts in the winter in the northern hemisphere, they can assume a massive migration is to begin and work with waterfowl biologists to assess times turbines should be inactive. Also, the first projects erected of turbines should have pre- and post- studies performed to evaluate presence of waterfowl and therefore provide valuable feedback to those soon to be erected. This project could be undertaken by USFWS as they can then ensure proper policy is in place for protections of the species in question.

In the effort to combat climate change, green energy is critical. However, understanding waterfowl are going to be impacted by climate change as well (i.e. drought, flooding or other inclement weather impacting breeding and wintering grounds) is important when considering adding energy expenditure to their migration. The New York Bight Project is going to cover a significant portion of coastal New Jersey if all projects come into fruition, and this is only one of many projects proposed along the Atlantic Flyway. Pre- and post- construction assessments, possibly as involved as the onshore land turbine guidelines, could be integral to mitigating impact.

Regarding waterfowl behavior, recommendations made by the Pacific Flyway study that could be applicable to any offshore turbine projects would include shutting down wind turbines during times when geese and other waterfowl would likely be in the area. Conditions for this requirement would likely be times of daylight, minimal wind or tailwinds, low clouds, minimal precipitation and cooler air temperatures. The study also points out that wind turbines would likely not be in use or productive during times of these conditions anyway (Weiser et al 2024).

The study by Fox & Petersen pointed out that concerns for survival and reproductive success would be higher in seabirds with higher wing loads, which would lead to a greater concern for the Canadian geese. All the studies involved exhibited potential avoidance behavior for waterfowl species, however, there is potential for adaptive behavior. This is less likely for birds migrating as turbines could be an unexpected obstacle if they are new to the area. Overall, the best scenario would be turning off wind turbines when they are present, but this does not account for the fact the turbines will still be there for them to maneuver around. With offshore wind being such a new concept to a new flyway, all precautions should be taken prior to installation.

Recommendations and Future Work

There is only a small window of time per year that waterfowl, among other avian species, would be migrating through potential offshore wind farm territory. Decisions could be set to mitigate impact by shutting down turbines when collision risk is high (Weiser et al. 2024). Recommendations that have been made by other studies should be applied into legally binding policy to have wind turbines slowed or turned off during times where impact is possibly high during migration seasons. Although migration is a short period of time each year, there are many birds that utilize this route and impact could be astronomical in a short time frame. Continuous studies, such as radar tracking during migration, can be key to proper turbine location assessments as offshore wind continues to expand along the coastline.

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