Avian Risk Assessment

Maryland Offshore Wind Project

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1.0 DESCRIPTION OF PROPOSED ACTION

US Wind is developing the Maryland Offshore Wind Project[1] (the Project), an offshore wind project of up to 2 gigawatts within OCS-A 0490 (the Lease), an area off the coast of Maryland on the Outer Continental Shelf. US Wind obtained the Lease in 2014 when the company won an auction for two leases from the Bureau of Ocean Energy Management (BOEM) which in 2018 were combined into the Lease. The Project will include as many as 121 wind turbine generators (WTG), up to four (4) offshore substations (OSS), and one (1) met tower in the roughly 80,000-acre Lease area. The Project will be interconnected to the onshore electric grid by up to four new 230 kV export cables into a substation in Delaware. The proposed project layout is provided in Figure 1.

[1] The Project includes MarWin, a wind farm of approximately 300 MW for which US Wind was awarded Offshore Renewable Energy Credits (ORECs) in 2017 by the state of Maryland; Momentum Wind, up to 1205.4 MW, which US Wind bid into a second round Maryland OREC process in 2021; and any subsequent development within the Lease area.

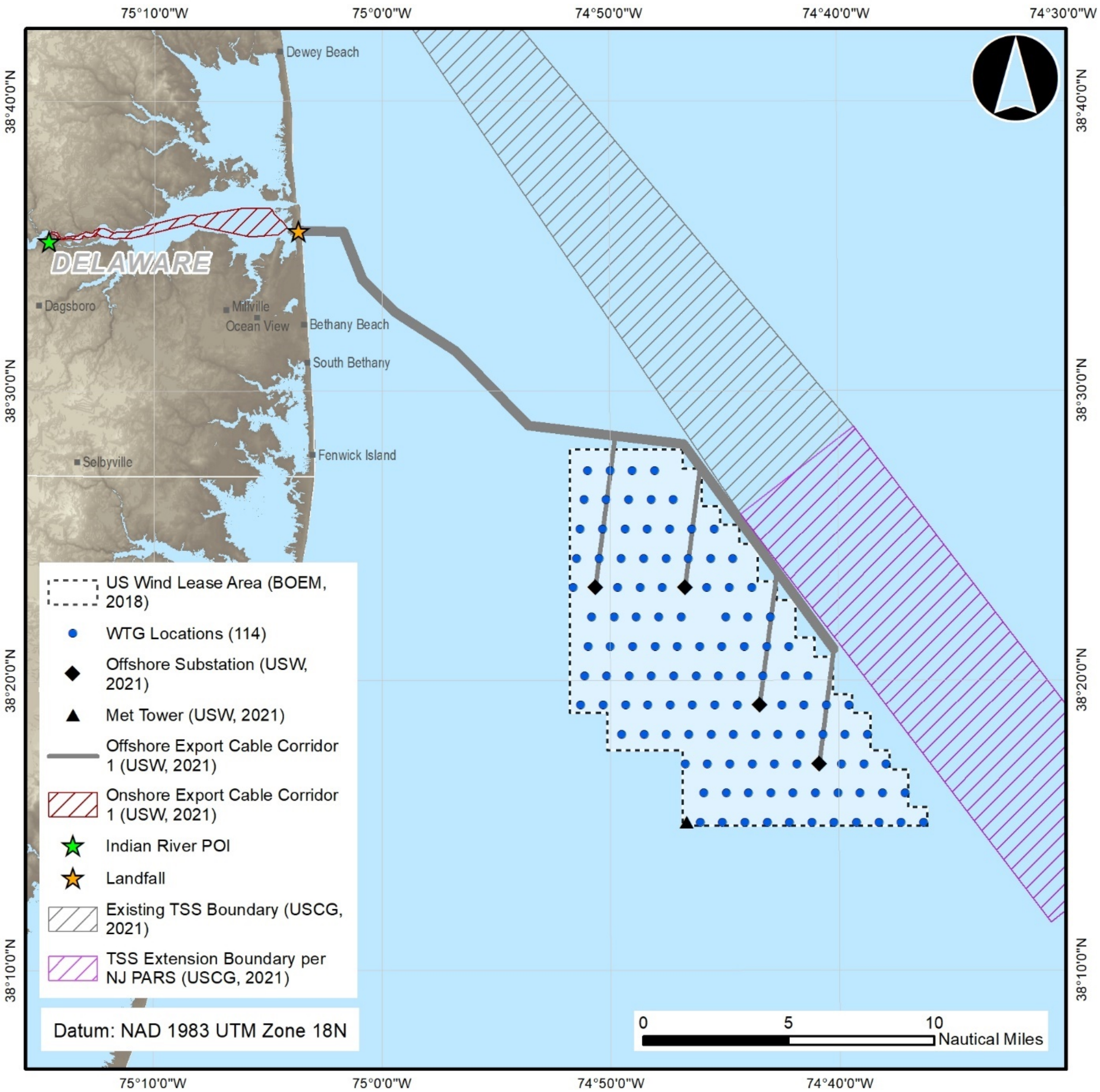


Figure 1 – Proposed Project Layout

2.0 AVIAN RISK ASSESSMENT

This Avian Risk Assessment identifies the avian species found in the Lease area by prior studies. It also examines their risk of exposure to collision with the Project's wind turbine blades to support evaluation of potential impacts and proposed mitigations.

2.1 Description of Affected Environment

Marine birds are avian species adapted to life in the marine environment, which is characterized by relatively deep, offshore waters generally located 5.5 km (3 nm) or more from the coast. Marine birds may be distinguished from coastal birds, which are adapted to life in relatively shallow, nearshore waters and associated habitats along shorelines, and from terrestrial birds (or "land birds") that primarily occur in terrestrial habitats inland from the coast. While some marine bird species may be found in coastal areas and vice versa, marine birds are the species most likely to regularly occur offshore. Many marine bird species spend much of their life cycle at sea, coming to land only during the nesting season. The marine bird community in the mid-Atlantic consists of species that breed outside of the region and spend all or part of the non-breeding season in the region (such as gannets and alcids), and of species that breed in coastal areas in the region and take advantage of marine habitats for foraging or resting (such as gulls and terns).

2.1.1 Avian Families

Nearly 30 species of marine birds have been documented in the Lease area (Williams et al. 2015a, 2015b). The discussion of marine birds potentially occurring in the Project area will focus on the taxonomic family level. Species within a given taxonomic family typically share key life history and morphological characteristics and can thus be discussed more effectively as a group. Federally listed marine bird species are discussed individually in Section 2.1.2. This section will focus on the nine avian families expected to occur in the Project area, based on the results of the Mid-Atlantic Baseline Studies (MABS) Project surveys (Williams et al. 2015a, 2015b). These nine avian families are summarized in Table 1 and discussed further in the following sections. The MABS surveys and results are discussed in detail in Section 3.0.

Table 1 – Marine Bird Families Occurring in the Project Area

Common Name	Family	No. Species[1]	Seasonal Occurrence	Breeds in Mid-Atlantic
Alcids	Alcidae	2	Fall - Winter	No
Gannets	Sulidae	1	Fall - Winter	No
Grebes	Podicipedidae	1	Winter	Yes
Gulls and Terns	Laridae	11	Year-round	Yes
Jaegers and Skuas	Stercorariidae	2	Spring and Fall	No
Loons	Gaviidae	2	Fall - Spring	No
Sea Ducks	Anatidae	2	Fall - Winter	No
Shearwaters and Fulmars	Procellariidae	5	Spring	No
Storm-petrels	Hydrobatidae	1	Spring - Summer	No

[1] The approximate number of species that regularly occur in the Project area, based on MABS survey results.

Alcids (Alcidae)

Alcids (also known as auks) – including species such as razorbill (*Alca torda*) and dovekie (*Alle alle*) – are small, hearty seabirds that breed in isolated colonies along northern rocky coastlines and overwinter in marine waters as far south as the mid-Atlantic. Alcids are generally solitary and strongly pelagic outside of the breeding season and rarely come close to shore. Alcids feed on fish and crustaceans, which are captured by diving into the water from the surface.

Gannets (Sulidae)

This family is represented by a single species in the Project area – the northern gannet (*Morus bassanus*). The northern gannet is a large pelagic bird commonly found in the mid-Atlantic during the winter. Northern gannets are strongly associated with nearshore and offshore marine environments and are almost never seen over land, except at breeding colonies. Northern gannets are often found in flocks containing a few dozen to several hundred individuals that feed and rest offshore. Gannets display a unique foraging strategy that includes performing steep, vertical dives into the ocean from heights of 10 to 40 m (33 to 131 ft), then pursuing prey underwater. Northern gannets feed exclusively on fish and squid.

Grebes (Podicipedidae)

Grebes are small to medium-sized waterbirds that range throughout North America. These species, including red-necked grebe (*Podiceps grisegena*), are strongly aquatic and typically leave the water only to nest. Grebes consume aquatic organisms such as fish, crustaceans, mollusks, and insects. Grebes typically nest in inland wetlands, and some species disperse to coastal and marine areas during the winter.

Gulls and Terns (Laridae)

Gulls are medium to large-sized waterbirds that can be found in a variety of habitats including inland lakes, coastlines, and offshore waters. Gulls are omnivorous and opportunistic foragers, and may consume fish, aquatic invertebrates, amphibians, small mammals, plant matter, and human refuse. Several species of gull nest in colonies on coastal beaches and small islands in the mid-Atlantic region, including great black-backed gull (*Larus marinus*), herring gull (*Larus argentatus*), and laughing gull (*Leucophaeus atricilla*). A few species are found in the area year-round, while others are present only during the winter or migration.

Terns are small to medium-size waterbirds associated with coastal environments and large inland waterbodies, though individuals may forage in offshore waters. Terns are predominantly piscivorous, but may also consume arthropods and other aquatic animals. Terns feed either by plunge-diving or picking small prey from the surface of the water. Terns nest on sandy beaches and flats above the high tide line in colonies, which may be large and include multiple species. Multiple species of terns occur in the mid-Atlantic, including common tern (*Sterna hirundo*), royal tern (*Thalasseus maximus*), and Caspian tern (*Hydroprogne caspia*). Some species breed in the mid-Atlantic, while others are found there only casually or during migration.

This group includes one federally listed species, the roseate tern (*Sterna dougallii*). See Section 2.1.2 for further discussion of this species.

Jaegers and Skuas (Stercorariidae)

Superficially similar to gulls, jaegers and skuas are medium to large-sized seabirds that feed on fish, smaller birds, and food items stolen from other species. Jaegers and skuas nest outside the mid-Atlantic region but occur in offshore waters along the Atlantic coast during other times of year. All species are highly pelagic during the non-breeding season and are rarely seen from shore. This group includes species such as parasitic jaeger (*Stercorarius parasiticus*) and pomarine jaeger (*Stercorarius pomarinus*).

Loons (Gaviidae)

Loons are relatively large waterbirds that nest at inland lakes in northern latitudes. Loons are highly aquatic and typically leave water only to nest. During the non-breeding season, loons disperse to a variety of coastal and marine habitats, including estuaries, protected bays, coastal ponds, rocky coastlines, and offshore waters. Loons feed by diving from the surface and pursuing fish underwater, which are captured using their large, dagger-like bills. Two species of loons – common loon (*Gavia immer*) and red-throated loon (*Gavia stellata*) – regularly occur in the waters of the mid-Atlantic region.

Sea Ducks (Anatidae)

The waterfowl family Anatidae is represented in eastern North America by over 30 species of ducks, geese, and swans that use a variety of aquatic habitats including shallow marshes, large lakes and embayments, rocky coastlines, and marine waters. While most waterfowl species primarily inhabit relatively shallow, protected waterbodies, a few species can be commonly found in the deeper waters of the offshore environment. These "sea ducks" include five species found in the mid-Atlantic: black scoter (*Melanitta americana*), surf scoter (*Melanitta perspicillata*), white-winged scoter (*Melanitta deglandi*), common eider (*Somateria mollissima*), and long-tailed duck (*Clangula hyemalis*). Sea ducks are adapted to the marine environment, as evidenced by their ability to dive from the water's surface in search of mollusks and crustaceans, which form the bulk of their diet. The sea ducks breed in northern latitudes (Canada and Alaska) and migrate to southern wintering grounds along the coast. The mid-Atlantic region represents the southern limit of the wintering range of common eider and long-tailed duck, while the three species of scoter may overwinter as far south as the southern Atlantic and Gulf of Mexico.

Shearwaters and Fulmars (Procellariidae)

Like the jaegers and skuas, shearwaters and fulmars are superficially similar to gulls, yet exhibit unique life history and morphological characteristics. This group includes highly pelagic and aerial seabirds which range throughout the world's oceans, such as greater shearwater (*Puffinus gravis*), Cory's shearwater (*Calonectris borealis*), Manx shearwater (*Puffinus puffinus*) and northern fulmar (*Fulmarus glacialis*). These species (along with the smaller storm-petrels) are commonly referred to collectively as "tubenoses" due to their tubular nasal passages that enhance their ability to detect food at sea by scent. Shearwaters and fulmars feed primarily from the surface or by performing shallow dives. Shearwaters and fulmars rarely come close to shore except during the nesting period, and do not breed in the mid-Atlantic.

This group includes one federally listed species, the Bermuda petrel (*Pterodroma cahow*). See Section 2.1.2 for further discussion of this species.

Storm-Petrels (Hydrobatidae)

Storm-petrels – including Wilson's storm-petrel (*Oceantes oceanicus*) – are small seabirds that nest outside of the mid-Atlantic region and range widely during the non-breeding season. Like other seabird families, storm-petrels are found in pelagic environments throughout much of the year and return to land only to nest. Like the larger shearwaters and fulmars, storm-petrels have tubular nasal passages that improve their ability to find food at sea. Storm-petrels exhibit a unique foraging behavior that includes "pattering" on the water's surface to feed on crustaceans and fish.

2.1.2 Rare, Threatened, and Endangered Species

The federal Endangered Species Act (ESA) provides protection at the federal level to animal and plant species considered to be at risk for extinction, including prohibitions against "take" of listed species and permits for their incidental take under certain circumstances (16 USC § 1531 et seq.). The Delaware Department of Natural Resources and Control (DNREC) and the Maryland Wildlife and Heritage Service, Natural Heritage Program also maintain lists of endangered, threatened, and special concern species in their respective states (DNREC 2015; MDNR 2016). Several of these federally and state listed species are found in marine and coastal areas of the mid-Atlantic as identified in Section 2.1.1; however, only a few of these species may occur in the Project area based on one or more of the following criteria:

1. the species was documented in the Maryland Study Area during the MABS aerial and boat surveys (Williams et al. 2015a, 2015b);

2. the species was identified as potentially occurring in the Project area based on a review of the United States Fish & Wildlife Service (USFWS) online Information for Planning and Consultation (IPaC) tool; or

3. the species was identified as potentially occurring in the Project area based on correspondence with DNREC.

The federally and state listed species that meet these criteria are listed in Table 2 and discussed below.

Table 2 – Federally- and State-Listed Marine Bird Species Potentially Occurring in the Project Area

Common Name	Scientific Name	Federal Status	DE State Status	MD State Status
Roseate Tern	*Sterna dougallii*	E	-	X
Bermuda Petrel	*Pterodroma cahow*	E	SC	-
Common Tern[BR]	*Sterna hirundo*	-	E	E
Forster's Tern[BR]	*Sterna forsteri*	-	E	I
Least Tern	*Sternula antillarum*	-	E	T
Royal Tern	*Thalasseus maximus*	-	-	E

E = Endangered; **T** = Threatened; **X** = Endangered/Extirpated (MD only); **BR** Breeding population only; **SC**= Special Concern; **I** = In Need of Conservation

Roseate Tern (52 FR 42064)

Roseate terns (*Sterna dougallii*) are medium-sized waterbirds that are strongly associated with coastal and marine habitats, including seacoasts, bays, estuaries, and offshore waters. Roseate terns forage mainly by plunge-diving and contact-dipping (in which the bird's bill briefly contacts the water) or surface-dipping over shallow sandbars, reefs, or schools of fish. They are adapted for fast flight and relatively deep diving and often submerge completely when diving for fish (USDOI and USFWS 2015). Along the Atlantic Coast, roseate terns nest primarily on islands in sandy beach, open bare ground, and grassy habitats, typically near areas with cover or shelter (NatureServ 2015).

Roseate tern is a widespread but localized species in coastal habitats throughout the world. The Atlantic subspecies (*S. d. dougallii*) breeds in two discrete areas in the western hemisphere: northeastern North America from the Canadian Maritime Provinces to Long Island, New York, and the northern Caribbean, including the Bahamas and the Florida Keys (USDOI and USFWS 1998). The northeastern population is listed as endangered by the governments of the United States and Canada, as well as by several northeastern states. Historically, the northeastern breeding population extended as far south as Virginia; however, several factors have caused the breeding range of the population to contract (USDOI and USFWS 2015). Northeastern roseate terns are thought to migrate through the eastern Caribbean and along the northern coast of South America to wintering grounds along the eastern coast of Brazil (USDOI and USFWS 2010). The most current abundance estimate for the northeastern population is approximately 3,200 nesting pairs (Nisbet, Gochfeld, and Burger 2014). The Caribbean breeding population is listed as threatened at the federal level. Individuals from this population are occasionally found nesting along the southeastern coast of the United States as far north as the Carolinas (USDOI and USFWS 2015).

The need for extending ESA protections to the roseate tern was identified based primarily on the concentration of the population into a small number of breeding sites, and to a lesser extent, observed declines in the population (USDOI and USFWS 1998). The most important factor in breeding colony loss was predation by herring gulls (*Larus smithsonianus*) and/or great black-backed gulls (*Larus marinus*). To date, critical habitat for roseate tern has not been designated by the USFWS.

Roseate tern breeding colonies once existed on Assateague Island in Maryland (Stewart and Robbins 1958); however, there are currently no roseate tern breeding colonies in Maryland or Delaware. During boat and aerial surveys conducted between 1978 and 2009 this species was observed in Maryland and Delaware waters during spring months (O'Connell *et al*. 2009). Roseate tern was not detected in the WEA during the MABS surveys (Williams et al. 2015a, 2015b).

Bermuda Petrel (35 FR 8491)

The Bermuda petrel (*Pterodroma cahow*), also known as the cahow, is a medium-sized petrel in the tubenose family that also includes shearwaters and fulmars. Like other tubenoses, Bermuda petrels are strongly aerial and pelagic. Feeding occurs at sea and individuals come to land only to nest on a few small, rocky islands in the Bermuda Archipelago.

The Bermuda petrel population declined rapidly in the years following European colonization of Bermuda due primarily to predation by introduced pests and over-exploitation by humans. The decline of the Bermuda petrel occurred so rapidly that by the early to mid-1600s the species was believed to be extinct. Scattered observations of living and deceased birds were reported in the early 20th century, prompting the organization of a formal survey effort. In 1951, seven pairs of Bermuda petrels were discovered nesting on a few small islands off Bermuda. The government of Bermuda implemented measures to conserve the species following its rediscovery, which have resulted in population gains (Madeiros, Flood, and Zufelt 2014). Nevertheless, the Bermuda petrel continues to be imperiled due to several factors, including low population size, restricted geographic range, predation, hurricanes and climate change. Recent estimates indicate a total population of approximately 400-500 individuals (Madeiros 2005, 2012). In 1970, the Bermuda petrel was listed by the U.S. Department of the Interior under the Endangered Species Conservation Act of 1969 (35 FR 6069, 83 Stat. 275), later replaced by the Endangered Species Act of 1973.

Despite its highly restricted breeding range, Bermuda petrels may occur over a relatively large area of the northwestern Atlantic Ocean during the non-breeding season. The non-breeding range of the species is poorly understood due to the low number of confirmed observations; Bermuda petrels are similar in appearance to other related species that also occur in the northwestern Atlantic, and distinguishing between species at sea can be challenging. Bermuda petrels may occur in deep waters between Newfoundland and South Carolina, based on a combination of visual observations and a satellite telemetry study of twelve individuals (Madeiros 2012).

Due to the small population size and the relatively small size of the Project area relative to the potential range of Bermuda petrels in the northwestern Atlantic, this species is unlikely to occur in the Project area.

Federal Candidate Species

Candidate species are those species for which sufficient information is available to support a proposal for listing as federally endangered or threatened, but for which preparation and publication of a proposal is precluded by higher priority listing actions by USFWS (50 CFR 424.15). No federal candidate species have been identified in the Project area.

State-Listed Species

The common tern (*Sterna hirundo*) is listed as endangered by both the states of Delaware and Maryland (DNREC 2015; MDNR 2016). It occurs throughout the continental United States and winters along the coastline in subtropical or tropical waters (National Audubon Society 2021). Common terns feed mostly on fish, but also crustaceans, insects, worms, and small squid. Common terns currently nest in concentrated coastal colonies along the coast from North Carolina to Maine, placing them at risk to the impacts of climate change.

Forster's tern (*Sterna forsteri*) is listed as endangered in Delaware and in need of conservation in Maryland (DNREC 2015; MDNR 2016). It typically lives within freshwater or saltwater marshes and winters along the coast, usually around estuaries, lagoons, inlets, and sheltered bays (National Audubon Society 2021). Forster's tern numbers have declined due to the loss or degradation of marsh habitat, with wakes from recreational boaters potentially having an impact on nesting success. Threats due to climate change include wildfires and spring heat waves, which can negatively affect nesting young birds (National Audubon Society 2021).

The least tern (*Sternula antillarum*) is listed as endangered in Delaware and threatened in Maryland (DNREC 2015; MDNR 2016). It occurs predominantly along the coastline, living on sandy beaches with nearby shallow water for feeding on fish, crustaceans, and insects (National Audubon Society 2021). One threat to least terns are anthropogenic disturbances (i.e. beachcombing, coastal development) on sandy beaches, where terns nest on open ground.

The royal tern (*Thalasseus maximus*) is listed as endangered in the state of Maryland (MDNR 2016). It lives along the Gulf Coast and southern Atlantic coast near warmer waters and typically breeds along the shoreline of Virginia and Maryland and as far north as the coast of Cape Cod, Massachusetts (National Audubon Society 2021). Royal terns are vulnerable to the loss of their nesting sites, due to sea level rise and coastal development.

2.1.3 Migrant Passerines and Shorebirds

Migratory bird species are those that travel long distances at regular time intervals (USDOI and USFWS 2015). Many avian species complete their annual reproductive cycle in one region and then spend the remainder of the year in a different region. When these predictable, seasonal movements cross international borders, the species is considered to be migratory. The Migratory Bird Treaty Act (MBTA) of 1918 is a federal law that protect migratory birds, their parts, and nests (16 USC § 703 et seq). The MBTA incorporates agreements between the United States, Canada, Mexico, Japan, and Russia regarding the protection of bird species that cross international boundaries between these jurisdictions. Over 800 migratory bird species are currently afforded protection under the MBTA.

North America is divided into four migratory flyways (the Atlantic, Mississippi, Central, and Pacific) that represent the general routes followed by a variety of avian species between their southerly wintering grounds and northerly breeding territories (Brown et al. 2001; Morrison et al. 2001). Avian species that breed along the Atlantic seaboard – from Florida to Newfoundland and Labrador – generally follow the Atlantic Flyway, though there is significant inter-species variation in the overall path and distance of the migratory route followed (Rappole 1995). Several hundred species representing dozens of avian families follow the Atlantic flyway twice per year. Depending on the species, birds may follow distinctive geographic features such as coastlines, ridgelines and major rivers, or take a more direct route that entails long-distance flights over the open ocean. Species travelling along the Atlantic flyway, especially those that take a direct, open-ocean flight path, may pass through the Project area.

An analysis by Willmott *et al.* (2013) presented summary data examining the annual occurrence of bird species on the Atlantic Outer Continental Shelf (AOCS) from North American and European studies. To determine the amount of time migrant passerines and shorebirds were over the AOCS, Willmott *et al.* (2013) estimated the distance flown (using the most direct route an individual bird could take) divided by flight speed (using the lower end of a species speed range) to determine the annual occurrence in hours. To represent this data, the average annual occurrence per migrant passerine and shorebird family were determined. The results, in both hours and years, for migrant passerines and shorebirds are presented in Table 3. Descriptions for these species can be found in Volume II, Section 6.1.1 under Birds.

Table 3 – Migrant Passerine and Shorebird Annual Occurrence over the AOCS

Family	Average Annual Occurrence in AOCS (hours)	Average Annual Occurrence in AOCS (year)
Phaethontidae (Tropicbird)	5040	0.58
Phalacrocoracidae (Comorants)	6540	0.75
Pelecanidae (Pelicans)	4320	0.49
Ardeidae (Herons)	4	0.00046
Threskiornithidae (Ibises and Spoonbills)	4	0.00046
Pandionidae (Ospreys)	4	0.00046
Accipitridae (Eagles and Hawks)	4	0.00046
Rallidae (Rails)	5	0.00057
Charadriidae (Plovers and Lapwings)	15	0.0017
Haematopodidae (Oystercatchers)	15	0.0017
Recurvirostridae (Avocets and Stilts)	15	0.0017
Scolopacidae (Sandpipers)	477	0.054
Falconidae (Falcons and Caracaras)	15	0.0017
Hirundinidae (Swallows and Martins)	20	0.0023
Polioptilidae (Gnatcatchers)	20	0.0023
Turdidae (Thrushes)	20	0.0023
Parulidae (New World Warblers)	20	0.0023
Passerellidae (New World Sparrows)	20	0.0023
Cardinalidae (Cardinals)	20	0.0023
Icteridae	20	0.0023

Family	Average Annual Occurrence in AOCS (hours)	Average Annual Occurrence in AOCS (year)
(New World Blackbirds)		
Fringillidae (Finches)	20	0.0023

3.0 RISK ASSESSMENT

The overall risk of adverse impacts to marine birds from the construction, operation, and decommissioning of the Project is influenced by two primary elements: (1) the nature of the potential impact producing factors and (2) the potential for exposure of birds to those impact producing factors. Some factors are temporary in nature and entail very minor alterations to the environment (such as noise generated by vessels during submarine cable installation activities), and therefore represent a low risk to birds. Similarly, some bird species - either due to their geographic distribution, behavior, or both - have a relatively low risk of exposure to factors associated with the Project.

This assessment examines exposure to the Project (and the impacts associated with the Project) in two different contexts: geographic exposure and behavioral exposure. Geographic exposure is defined as the relative frequency of occurrence of a given species within the Lease area and hence can be conceptualized as exposure to the Project on the horizontal plane. This assessment is focused on the Lease area only as the majority of construction activities, and the primary impacts to birds, will occur in this area. Species or groups that are relatively more abundant in the Lease area are considered to have a higher geographic exposure, while species or groups that are relatively less abundant in the Lease area are considered to have a lower geographic exposure.

Behavioral exposure is defined as the relative likelihood of a species or group passing through the rotor-swept zone of the WTGs based on the average expected flight elevations of that species or group. Collison with rotating turbine blades is widely recognized as the most significant potential impact to birds from offshore wind energy facilities; therefore, characterizing behavioral exposure in this context is presumed to be valid. The design envelope for the Project considers different size wind turbines, usually associated with capacity ratings of 14.7 – 18 MW. The height and rotor diameter will vary for each. The proposed 14.7 MW WTG will have a hub height of 139 m (456 ft) above the surface of the ocean and a rotor radius of 110 m (361 ft), which equates to a rotor-swept zone of between 29 m (95 ft) and 249 m (817 ft). The 18 MW WTG will have a hub height of 161 m (528 ft) above the surface of the ocean and a rotor radius of 125 m (410 ft), which equates to a rotor-swept zone of between 36 m (118 ft) and 286 m (938 ft). Using the project design envelope approach and assuming the widest rotor-swept zone between the two WTG sizes, birds are considered to be exposed to the Project (and the potential for collision with rotating blades) on the vertical plane when flight altitudes are between approximately 29 m (95 ft) and 286 m (938 ft) above the surface of the ocean. Behavioral exposure also includes displacement sensitivity.

Geographic exposure and behavioral exposure are independent of one another, but together provide an approximation of the overall relative risk to a given species or group in the context of Project-related impacts. For example, one species may be relatively uncommon in the Lease area but may exhibit flight behavior that regularly places it within the elevation range of the rotor-swept zone. The geographic exposure of such a species would be relatively low, yet the behavioral exposure would be relatively high. Therefore, the overall characterization of risk for this species may be: the species is relatively unlikely to occur in the Lease area and thus has a relatively low risk of exposure to the Project in general; however, individuals that do enter the Lease area may be at a relatively higher risk of adverse impacts compared to other species. Conversely, another species may be relatively abundant within the Lease area, but may rarely fly high enough to enter the rotor-swept zone of the WTGs. The geographic exposure of such a species would be relatively high, yet the behavioral exposure would be relatively low. Therefore, the overall risk characterization for this species may be: the species is likely to occur in the Lease area and thus has a relatively high risk of exposure to the Project in general; however, based on the species' specific behaviors, individuals within the Project area are at a relatively lower risk of being impacted by the Project compared to other species.

The assessment of geographic and behavioral exposure relies primarily on data from the MABS Project, which was conducted between 2012 and 2014 to study marine mammal, sea turtle, and avian distributions, movements, and densities on the mid-Atlantic OCS (Williams *et al.* 2015a). To supplement these surveys, the Maryland DNR and the Maryland Energy Administration funded an expansion of the MABS study area (Maryland Study Area) in 2013 to collect additional baseline data on wildlife abundance and distribution in and around the Maryland WEA (Williams *et al.* 2015b). The location of the MABS Study Area is shown in Figure 2. The MABS surveys used high resolution digital video aerial surveys and offshore boat-based surveys to collect data regarding avian use of the study area consistent with BOEM's recommended guidelines for avian surveys. The MABS surveys resulted in thousands of observations of dozens of avian species over the two-year study period, and are the primary source used in this section to characterize avian occurrence in the Project area.

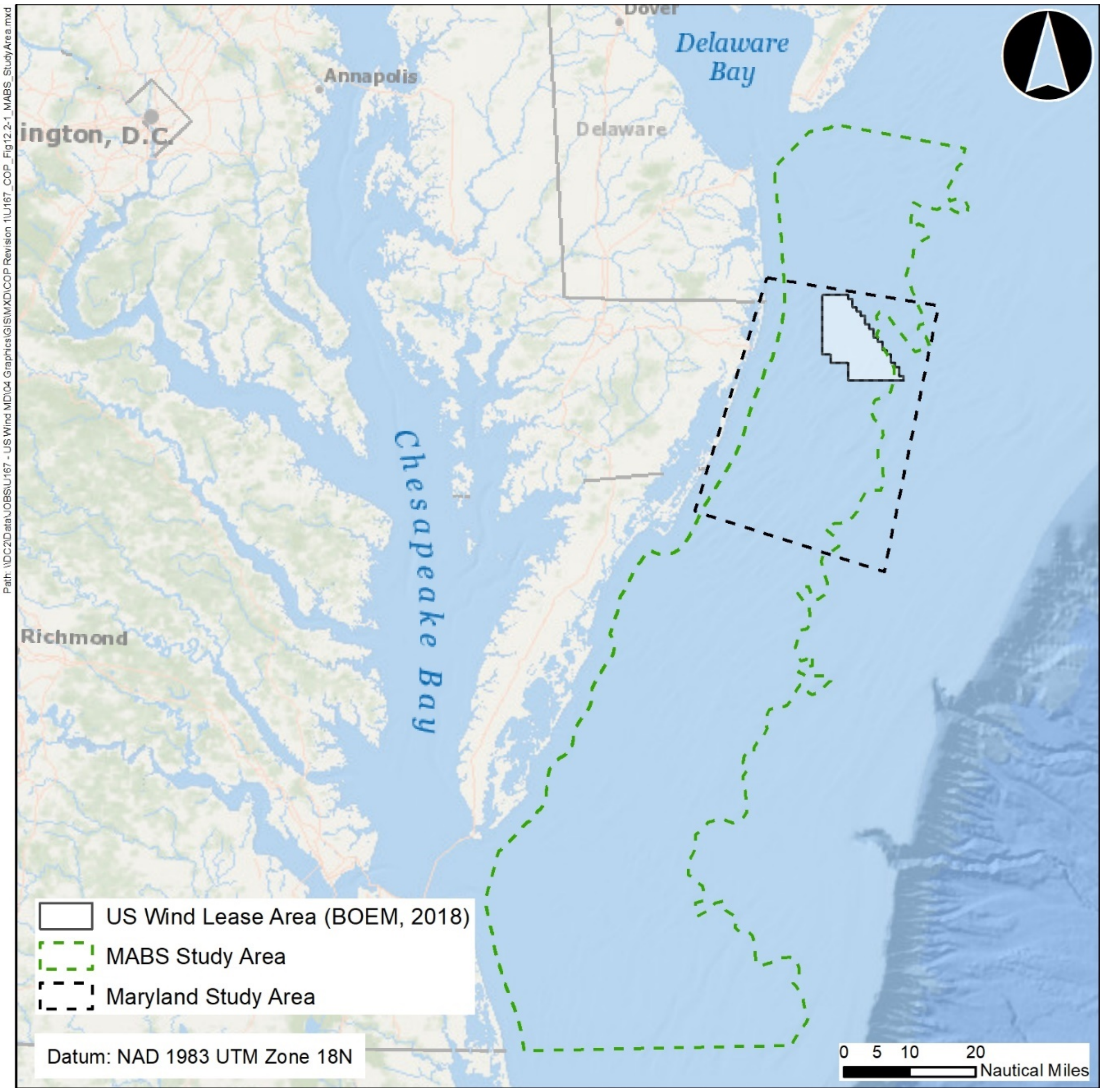


Figure 2 – MABS & Maryland Study Areas

The MABS Project consisted of three types of surveys: fine-scale high resolution digital video aerial surveys and boat-based visual surveys in and around the three WEAs located within the MABS study area (including the Maryland WEA), and broad-scale high-resolution digital video aerial surveys throughout the entire MABS study area. Within the Maryland WEA, the high-resolution digital video aerial surveys (fine-scale and broad-scale combined) collected approximately 22.8 hours of data across approximately 5,700 transect kilometers, while the boat-based visual surveys collected approximately 30.0 hours of data across approximately 555 transect km (345 mi).

3.1 Geographic Exposure

As discussed above, geographic exposure in the context of this assessment is defined as the relative frequency of occurrence of a given species within the Lease area compared to other species. Geographic exposure hence can be conceptualized as exposure to the Project on the horizontal plane. Species or groups that are relatively more abundant in the Lease area are considered to have a higher geographic exposure, while species or groups that are relatively less abundant in the Lease area are considered to have a lower geographic exposure.

The counts of bird species per square kilometer in the Lease area was assessed using the results of the MABS surveys (Williams et al. 2015a, 2015b). The results of the aerial surveys – fine-scale high resolution digital video and broad-scale high-resolution digital video – were combined in the final MABS report and are reported combined here in Table 4 (MABS Study Area and Maryland Study Area survey data combined). The results of the boat-based surveys are presented in Table 5. The combined MABS Study Area and the Maryland Study Area is 13,245 km^2 for both analyses.

Table 4 – Aerial Video Survey Counts per Square Kilometer in the Lease area

Species	Counts per Square Kilometer			
	Winter	Spring	Summer	Fall
Alcids (Alcidae)				
Dovekie	0.0002	0	0	0.0006
Razorbill	0.0007	0	0	7.55E-05
Total Unidentified Alcid	0.0190	0	0	0.0161
Gannets (Sulidae)				
Northern Gannet	0.4324	0.0058	0.0002	0.0997
Grebes (Podicipedidae)				
Red-necked Grebe	0	0	0	7.55E-05
Gulls and Terns (Laridae)				
Bonaparte's Gull	0.0114	0	0	0.0691
Great Black-backed Gull	0.0020	0.0019	0.0016	0.0126
Herring Gull	0.0019	0.0011	0.0009	0.0038
Lesser Black-backed Gull	0.0002	0.0002	0.0002	0.0003
Laughing Gull	7.55E-05	0.0010	0.0055	0.0013
Ring-billed Gull	0.0002	0	0	7.55E-05
Black Tern	0	0	0.0025	0
Caspian Tern	0	0.0002	0.0005	0.0003
Royal Tern	0.0002	0	7.55E-05	0
Total Unidentified Laridae	0.0368	0.0400	0.0502	0.0840
Jaegers and Skuas (Stercorariidae)				
Parasitic Jaeger	0	0.0002	0	0
Pomarine Jaeger	0	7.55E-05	0	0
Unidentified Stercorariidae	0	0.0003	0	7.55E-05

Species	Counts per Square Kilometer			
	Winter	Spring	Summer	Fall
Loons (Gaviidae)				
Common Loon	0.0147	0.0196	7.55E-05	0.0120
Red-throated Loon	0.0052	0.0035	0	0.0048
Unidentified Gaviidae	0.2159	0.0257	0.0004	0.1063
Scoters, Ducks, and Geese (Anatidae)				
Black Scoter	0.7066	0.0002	0	0.0474
White-winged Scoter	0.0005	0	0	0.0013
Total Unidentified Anatidae	0.4060	0.0109	0	0.3413
Shearwaters and Fulmars (Procellariidae)				
Manx Shearwater	0	0	0	0.0002
Cory's Shearwater	0	0.0006	0.0002	0.0004
Greater Shearwater	0	0.0043	0	0.0002
Northern Fulmar	0.0005	7.55E-05	0	0.0002
Sooty Shearwater	0	0.0002	0	0
Unidentified Procellariidae	7.55E-05	0.0005	0.0002	0.0007
Storm-petrels (Hydrobatidae)				
Wilson's Storm-petrel	0	0.004	0.003	0

Table 5 – Boat-based Survey Counts per Square Kilometer in the Lease area

Species	Counts per Square Kilometer			
	Winter	Spring	Summer	Fall
Alcids (Alcidae)				
Dovekie	0.0243	0	0	0.0093
Razorbill	0.0627	0.0010	0	0.0181
Total Unidentified Alcid	0.0097	7.55E-05	0	0.0003
Gannets (Sulidae)				
Northern Gannet	0.5179	0.1306	0.0003	0.4248
Grebes (Podicipedidae)				
Red-necked Grebe	0.0012	0.0002	0	0
Gulls and Terns (Laridae)				
Bonaparte's Gull	0.0674	0.0211	0	0.4747
Great Black-backed Gull	0.0219	0.0051	0.0074	0.0437
Black-legged Kittiwake	0.0017	0	0	0.0014

Species	Counts per Square Kilometer			
	Winter	Spring	Summer	Fall
Herring Gull	0.0245	0.0231	0.0008	0.0235
Lesser Black-backed Gull	0.0008	0.0006	0.0002	0.0006
Laughing Gull	0.0004	0.0342	0.0649	0.0809
Ring-billed Gull	0.0018	0	0	0.0041
Black Tern	0	0	0.0016	0
Caspian Tern	0	7.55E-05	0.0002	7.55E-05
Common Tern	0	0.0446	0.0507	0.0009
Royal Tern	0	0.0109	0.0249	0.0012
Total Unidentified Laridae	0.002	0.0131	0.0108	0.0403
Jaegers and Skuas (Stercorariidae)				
Parasitic Jaeger	0	0.0010	0	0.0005
Pomarine Jaeger	0	7.55E-05	0	0
Total Unidentified Stercorariidae	0	0.0005	7.55E-05	0.0002
Loons (Gaviidae)				
Common Loon	0.0500	0.0787	0.0007	0.1429
Red-throated Loon	0.0501	0.0397	0	0.0302
Unidentified Gaviidae	0.0042	0.0079	0	0.0248
Scoters, Ducks, and Geese (Anatidae)				
Black Scoter	0.1361	0.0137	0	0.0704
White-winged Scoter	0.0103	0.0011	0	0.0078
Total Unidentified Anatidae	0.9405	0.0732	0	0.1952
Shearwaters and Fulmars (Procellariidae)				
Manx Shearwater	0.0008	0.0009	0	0.0032
Cory's Shearwater	0	0.0026	0.0022	0.0002
Greater Shearwater	0	0.0049	0	0
Northern Fulmar	0.0006	0.0002	0	0.0002
Sooty Shearwater	7.55E-05	0.0048	0	7.55E-05
Total Unidentified Procellariidae	0.0002	0.0005	0.0003	0.0027
Storm-petrels (Hydrobatidae)				
Wilson's Storm-petrel	0	0.0273	0.0335	0

The relative frequency of species within the Lease area was assessed seasonally. The raw counts of individuals within each season were standardized to a count-per-unit-effort (i.e., the number of individuals detected per hour of survey effort) to account for variations in the level of effort between the various survey methodologies employed during the MABS study (boat-based surveys and broad-scale and fine-scale high-definition digital video aerial surveys) (Williams et al. 2015a, 2015b). The standardized counts-per-unit-effort for each of the three survey methodologies were then summed to produce the number of individuals of each species within each season detected per hour of total survey effort, as summarized in Table 6.

Table 6 – Seasonal Counts per Survey Hour in the Lease area

Species	Seasonal Counts per Survey Hour			
	Winter	Spring	Summer	Fall
Alcids (Alcidae)				
Dovekie	0.20	0.00	0.00	0.22
Razorbill	0.60	0.00	0.00	0.00
Unidentified Alcid	0.54	0.00	0.00	0.88
Gannets (Sulidae)				
Northern Gannet	14.44	0.87	0.00	2.42
Grebes (Podicipedidae)				
Red-necked Grebe	0.03	0.00	0.00	0.00
Gulls and Terns (Laridae)				
Bonaparte's Gull	0.77	0.17	0.00	1.18
Great Black-backed Gull	0.33	0.13	0.00	0.75
Black-legged Kittiwake	0.03	0.00	0.00	0.00
Herring Gull	0.49	0.59	0.00	0.30
Lesser Black-backed Gull	0.00	0.00	0.00	0.04
Laughing Gull	0.00	0.29	0.50	0.63
Ring-billed Gull	0.07	0.00	0.00	0.00
Black Tern	0.00	0.00	0.13	0.00
Caspian Tern	0.00	0.04	0.00	0.00
Common Tern	0.00	0.34	0.10	0.00
Royal Tern	0.00	0.00	0.17	0.00
Unidentified Laridae	1.83	3.91	0.57	1.40
Jaegers and Skuas (Stercorariidae)				
Parasitic Jaeger	0.00	0.03	0.00	0.07
Pomarine Jaeger	0.00	0.03	0.00	0.00
Unidentified Stercorariidae	0.00	0.08	0.00	0.00
Loons (Gaviidae)				
Common Loon	3.05	2.15	0.00	0.93

Species	Seasonal Counts per Survey Hour			
	Winter	Spring	Summer	Fall
Red-throated Loon	1.77	0.62	0.00	0.23
Unidentified Gaviidae	12.20	2.10	0.04	2.40
Scoters, Ducks, and Geese (Anatidae)				
Black Scoter	0.07	0.00	0.00	0.03
White-winged Scoter	0.03	0.00	0.00	0.00
Unidentified Anatidae	0.03	0.03	0.00	0.15
Shearwaters and Fulmars (Procellariidae)				
Manx Shearwater	0.00	0.00	0.00	0.03
Cory's Shearwater	0.00	0.22	0.03	0.00
Greater Shearwater	0.00	1.09	0.00	0.00
Northern Fulmar	0.00	0.04	0.00	0.08
Sooty Shearwater	0.00	0.04	0.00	0.00
Unidentified Procellariidae	0.00	0.20	0.00	0.00
Storm-petrels (Hydrobatidae)				
Wilson's Storm-petrel	0.00	0.64	0.40	0.00

The data were further analyzed to determine total counts per hour in the Lease area for each of the nine marine bird families for each season and annually. Total seasonal counts per hour for the family level were obtained by taking the sum of the counts per hour for all species within that family for each season. Total annual counts per hour at the family level were obtained by taking the sum of all count-per-hour values across all species and seasons within each family. Each family was ranked on a numerical scale based on the total count per hour for each of the four seasons and annually. A family's ordinal position in this ranking system indicates their assessed relative geographic exposure on a seasonal and annual basis compared to other families (i.e., the lower the numerical rank, the higher the relative exposure). The results of this analysis are presented in Table 7.

Table 7 – Family-level Seasonal and Annual Geographic Exposure Relative Ranks in the Lease area

Family	Winter		Spring		Summer		Fall		Annual	
	Count per Hour	Seasonal Rank	Count per Hour	Seasonal Rank	Count per Hour	Seasonal Rank	Count per Hour	Seasonal Rank	Average Count per Hour	Annual Rank
Alcids (Alcidae)	1.34	4	0	8	0	5	1.1	4	0.61	4
Gannets (Sulidae)	14.44	2	0.87	4	0	5	2.42	3	4.43	2
Grebes (Podicipedidae)	0.03	6	0	8	0	5	0	8	0.01	9
Gulls and Terns (Laridae)	3.52	3	5.47	1	1.47	1	4.3	1	3.69	3
Jaegers and Skuas (Stercorariidae)	0	7	0.14	6	0	5	0.07	7	0.05	8
Loons (Gaviidae)	17.02	1	4.87	2	0.04	3	3.56	2	6.37	1
Sea Ducks (Anatidae)	0.13	5	0.03	7	0	5	0.18	5	.08	7
Shearwaters and Fulmars (Procellariidae)	0	7	1.59	3	0.03	4	0.11	6	0.43	5
Storm-petrels (Hydrobatidae)	0	7	0.64	5	0.4	2	0	8	0.26	6

In the winter, loons (family Gaviidae) are the most abundant group in the Lease area with a total of about 17 individuals detected per hour of survey. Close behind is the northern gannet (family Sulidae), with nearly 14.5 individuals detected per hour. Gulls and terns (family Laridae) and alcids (family Alcidae) ranked third and fourth during the winter, with 3.5 and 1.3 individuals detected per hour, respectively. Sea ducks (family Anatidae) and grebes (family Podicipedidae) were also detected in winter, but at very low densities. Jaegers and skuas (family Stercorariidae), shearwater and fulmars (family Procellariidae), and storm-petrels (family Hydrobatidae) were not detected in the Lease area during the winter.

In the spring, the total family-level counts per hour level off. Gulls and terns are the most abundant group during the spring, followed closely by loons, with nearly 5.5 and 5.0 individuals detected, respectively. Gulls and terns, jaegers and skuas, shearwaters and fulmars, and storm-petrels all reach their highest densities in the Lease area during the spring. Alcids and grebes are absent from the Lease area in the spring, and sea duck numbers continue to be very low.

In the summer, frequency of detection for all families dropped off considerably, and most marine bird families are either absent or found in very low numbers. Gulls and terns are the most abundant family in the Lease area during the summer with nearly 1.5 individuals detected per hour of survey. Storm-petrels are the only other marine bird family functionally present in the Lease area during this season.

In the fall, the frequency of detection for most families increases, though storm-petrels and grebes are absent from the Lease area and jaegers and skuas, sea ducks, and shearwaters and fulmars continue to be found in very low numbers. Gulls and terns are the most abundant group during the fall (4.3 individuals detected per hour of survey), followed by loons, gannets, and alcids, with about 3.6, 2.4, and 1.1 individuals detected per hour, respectively.

The family-level geographic exposure relative ranks vary seasonally, yet some families are clearly more abundant in the Lease area on an annual basis than others. Total annual frequency of detection for the nine marine bird families appear to be naturally divided into three distinctive groups. Loons, gannets, and gulls and terns are by far the most abundant groups in the Lease area on an annual basis, with nearly 6.4, 4.4, and 3.7 individuals detected per hour of survey, respectively. Alcids, shearwaters and fulmars, and storm-petrels fall in the middle on an annual basis, with between 0.26 and 0.61 individuals detected per hour of survey. The least abundant families on an annual basis are sea ducks, jaegers and skuas, and grebes, all of which had fewer than 0.1 individuals detected per hour of survey annually.

An analysis by Willmott *et al.* (2013) presented summary data examining the annual occurrence of bird species on the Atlantic Outer Continental Shelf (AOCS), for migrant passerines and shorebirds. For birds that are seasonal residents, Willmott *et al.* (2013) used the entire season the species was expected to be in the area. For birds that are year-round residents, Willmott *et al.* (2013) used the entire year for the species annual occurrence. The results of this analysis were averaged and are presented in Table 8, in both hours and years.

Table 8 – Seasonal Resident and Year-Resident Species Annual Occurrence over the AOCS

Family	Average Annual Occurrence in AOCS (hours)	Average Annual Occurrence in AOCS (year)
Alcids (Alcidae)	8020	0.92
Gannets (2 species) (Sulidae)	6540	0.75
Grebes (3 species) (Podicipedidae)	3364	0.38
Gulls and Terns (Laridae)	3405	0.39
Jaegers and Skuas (Stercorariidae)	5472	0.62
Loons (2 species) (Gaviidae)	6120	0.70
Sea Ducks, Scoters, and Geese (Anatidae)	1869	0.21
Shearwaters and Fulmars (Procellariidae)	6300	0.72
Storm-petrels (3 species) (Hydrobatidae)	4560	0.52

Summary of Tracking Studies in the mid-Atlantic Region

Recent studies have focused on determining the occurrence of marine bird species in the mid-Atlantic, specifically focusing on their interaction with current WEAs and lease areas.[2] Red Knots (*Calidris canutus rufa*) cross offshore WEAs during the night with clear skies and no precipitation, with three quarters of flights falling within 20 to 200 m (66 to 656 ft) (Loring et al. 2018). Common Terns (*Sterna hirundo)* and Roseate Terns (*Sterna dougallii)* crossed the WEAs under fair weather conditions and during early morning, with most of their flights falling below 25 m (82 ft) and only 4.3% and 6.4% of flights falling within 20 m to 200 m (66 ft to 656 ft), respectively (Loring et al. 2019). Piping Plovers (*Charadrius melodus*) occurred offshore during the evening, also under fair weather conditions, and primarily flew above 250 m (820 ft), with 21.3% of flights occurring within 20 to 200 m (66 to 656 ft) (Loring et al. 2019). Surf Scoters (*Melanitta perspicillata*) and Red-throated Loons (*Gavia stellata*) flew over WEAs during the migration period, remaining in coastal and inshore areas during the winter (Spiegel et al. 2017; Stenhouse et al. 2020). Northern Gannets (*Morus bassanus*) flew over a large portion of the mid-Atlantic offshore region, overlapping all the current WEAs,

[2] The following WEAs are considered to be in the mid-Atlantic region: Delaware, Maryland, New Jersey, New York, and Virginia (MARCO, 2021).

which places this species at high risk of exposure to future wind farms (Spiegel et al. 2017; Stenhouse et al. 2020).

Maps synthesizing the results of various tracking studies are available through the Northeast Ocean Data Portal, created by the Marine-Life Data and Analysis Team (MDAT) (Winship et al. 2018; Curtice et al. 2019; MDAT et al. 2021). These maps are the result of modelling the effect of various environmental parameters (i.e. turbidity, sea surface temperature, depth, and distance to land) on the predicted relative density of avian species within the Atlantic offshore region. The model was informed by multiple science-quality at-sea surveys from 1978-2016 (Curtice et al. 2019). Based on the MDAT model results, the highest relative density of avian species is inshore of the Project Area, with the density decreasing further offshore (Figure 3).

To further examine avian abundance in the Project Area, the MDAT model results were compared to the MABS study for the three most common avian families: loons (family Gaviidae), gannets (family Sulidae), and gulls and terns (family Laridae). Before combining the individual species into family groups, the MDAT model results were first normalized by dividing the values by the sum total predicted relative density, per the authors' recommendation (Winship et al. 2018). Additionally, the MABS study data were processed by tallying the number of individual observations within a 1 km by 1 km cell, creating a grid encompassing the MABS survey area. The MDAT model results and the MABS study data were further divided by season, following the MDAT definition of season (Curtice et al. 2019).

The MABS study and the MDAT model results both show that the three most common avian families rarely occur within the Project Area. Loons were most frequently observed during the MABS survey in the winter and spring, but are predicted to occur in low densities year-round based on the MDAT model results (Figure 3a). Gannets were observed the most in the winter during the MABS survey, which corresponds to a moderate predicted density during the winter in the MDAT model results, but had low predicted densities the rest of the year (Figure 3b). Gulls and terns were observed during the MABS survey consistently year-round, but their highest predicted densities occur along the shoreline or along the western boundary of the Lease area based on the MDAT model results (Figure 3c).

Figure 3 – Avian Abundance

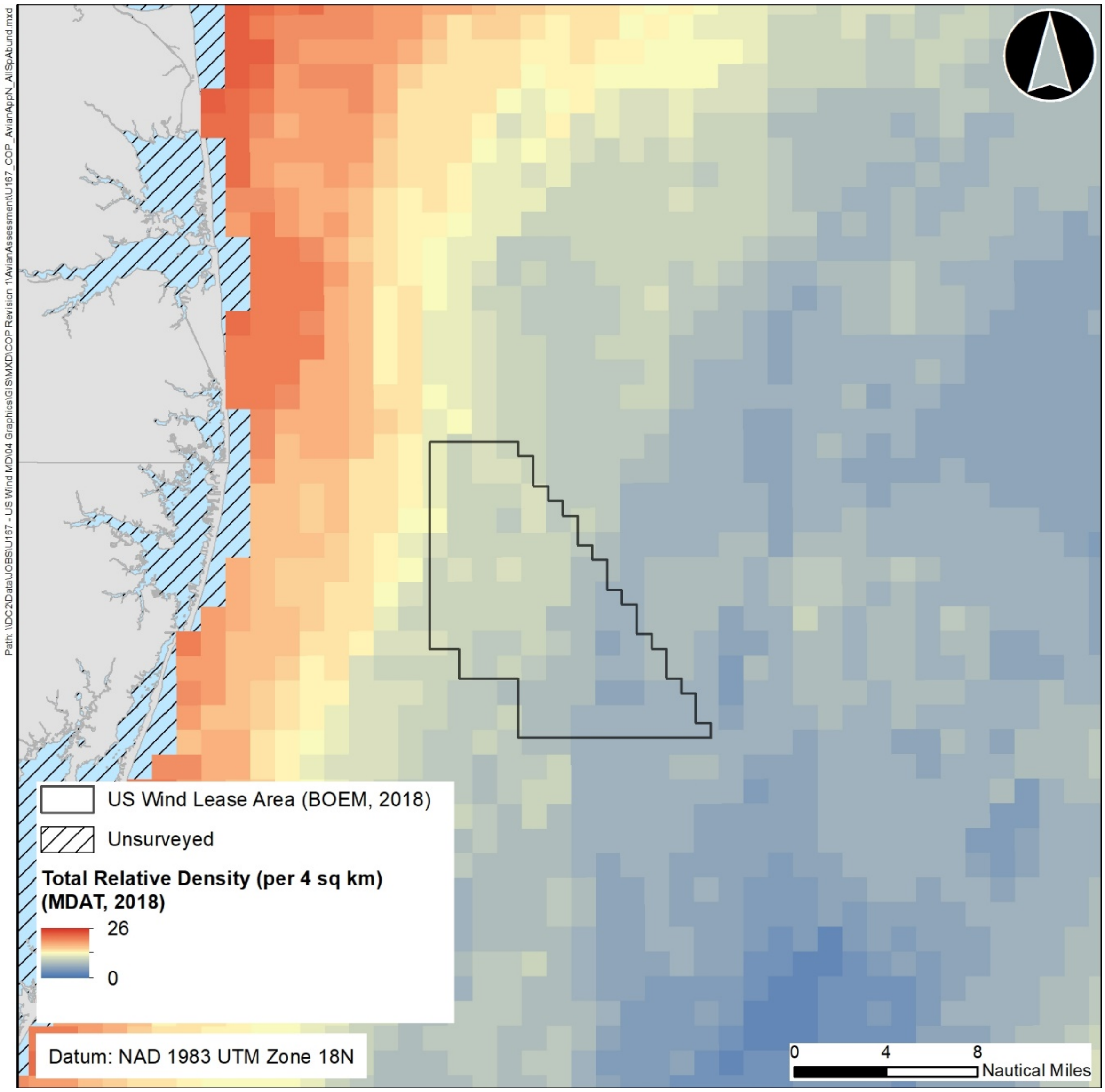


Figure 3a – Loon Abundance

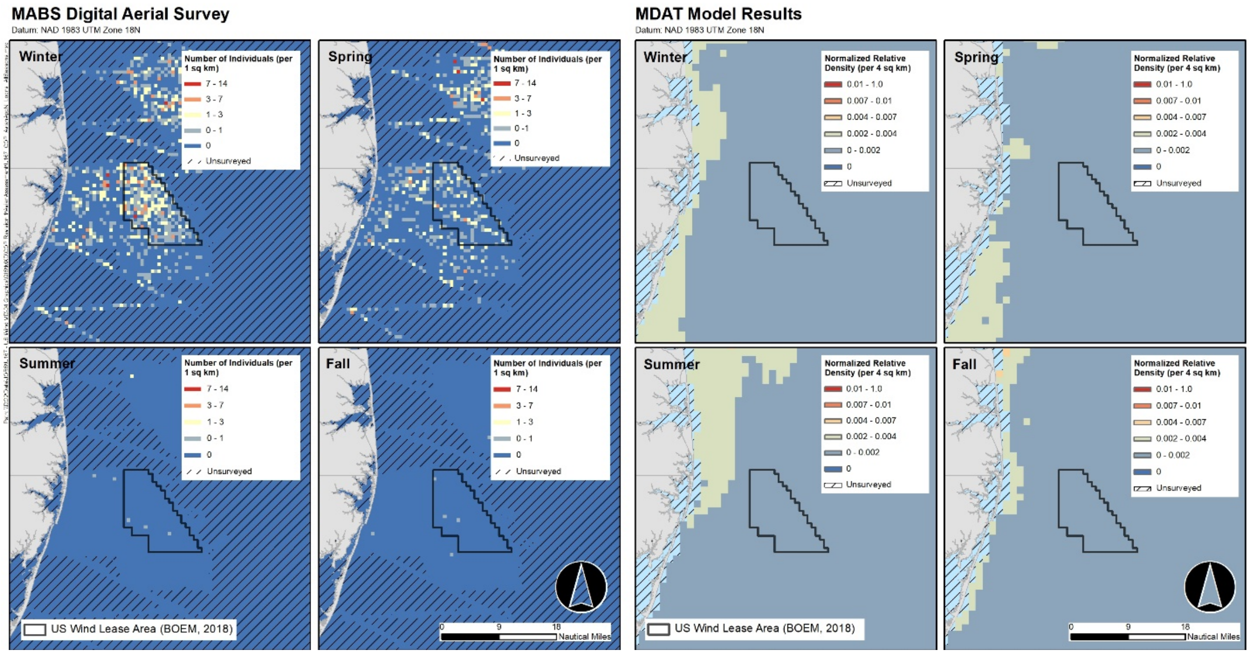


Figure 3b – Gannet Abundance

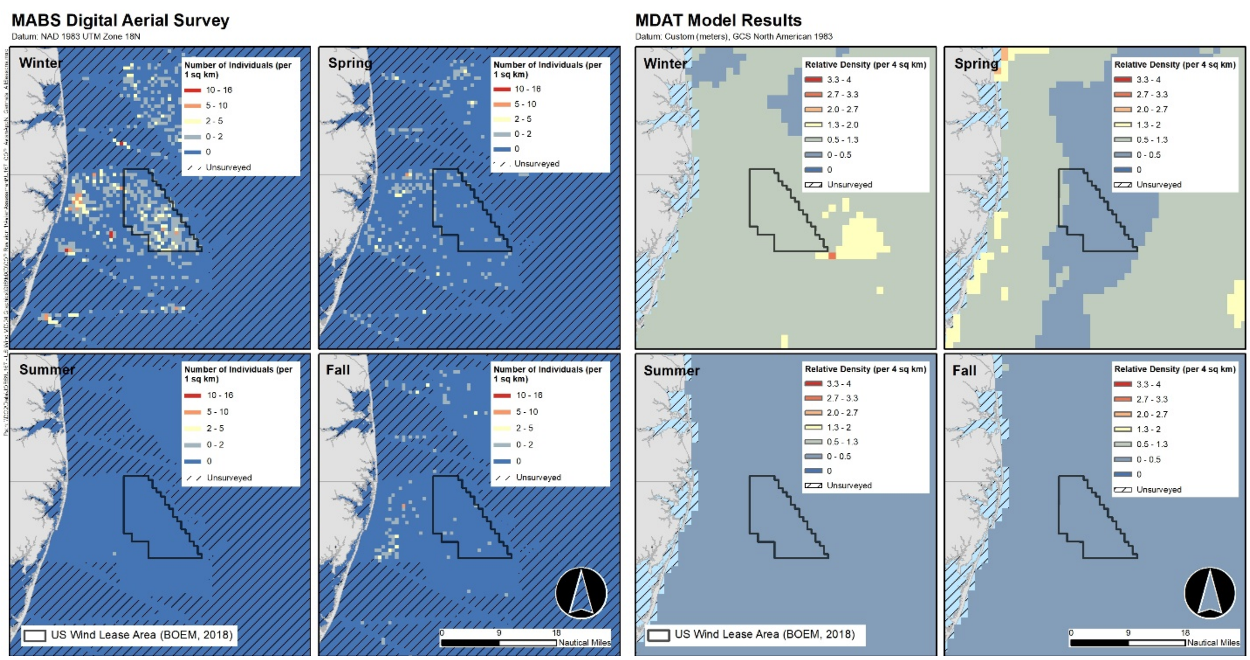
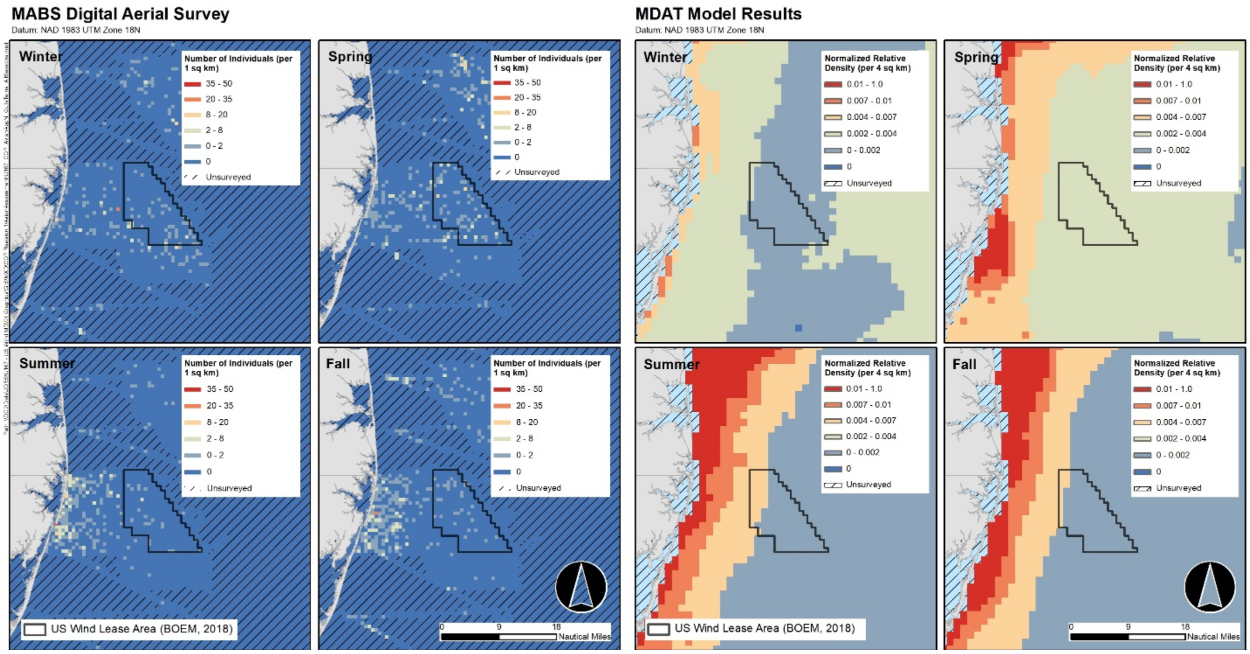


Figure 3c – Gull and Tern Abundance



3.2 Behavioral Exposure

As discussed above, behavioral exposure in the context of this assessment is defined as the relative likelihood of a species or group passing through the rotor-swept zone of the WTGs based on the average expected flight elevations of that species or group. Behavioral exposure can therefore be conceptualized as exposure to the Project on the vertical plane.

Average flight altitude – and in turn, relative behavioral exposure – for avian families was assessed using three data sources: the MABS high-resolution digital video aerial surveys (Williams et al. 2015a, 2015b), Furness *et al.* (2013), and Willmott *et al.* (2013). Average flight altitude was assessed at the family level rather than at the species level due to the lack of robust available data on average flight altitudes for all species potentially occurring in the Project area. Given the morphological and behavioral similarities between species within the same family, generalizing average flight altitudes to the family level is presumed valid.

Analysis of MABS Data

The MABS high-resolution digital video aerial survey data were used to assess average flight altitudes for the nine marine bird families potentially present in the mid-Atlantic WEAs, as the MABS boat-based surveys did not identify flight altitudes (Williams et al. 2015a, 2015b). This assessment used the data available for the entire MABS survey area in order to provide a more robust data set than would be available for the Maryland WEA alone. For a record to be included in this analysis, both of the following criteria had to be met: (1) the species identification confidence was reported as “definite” or “probable,” and (2) the flight height confidence was reported as at least 70%. Records that met both of these criteria were first examined to determine the proportion of records for each family that represented birds in flight versus birds not in flight (i.e., sitting on the water). Records that represented birds in flight and for which flight altitude could be determined were then further analyzed to determine the proportion of records that fell into each of the five classes used in the MABS study (Williams et al. 2015a, 2015b) to characterize flight altitude: 0-20 m, 20-50 m, 50-100 m, 100-200 m, and 200+ m (0-66 ft, 66-164 ft, 164-328 ft, 328-656 ft, and 656+ ft).

For the 14.7 MW WTGs, which entails a rotor-swept zone of between approximately 29 m (95 ft) and 249 m (817 ft), records that fell into the lowest (0-20 m (0-66 ft)) altitude class were presumed to represent birds flying below the rotor-swept zone of the proposed WTGs, while records that fell into the four highest altitude classes (20-50 m (66-164 ft), 50-100 m (164-328 ft), 100-200 m(328-656 ft)) and 200+ m (656+ ft)) were presumed to represent birds flying within the rotor-swept zone of the WTGs. Since the highest altitude class (200+ m (656+ ft)) includes all records of birds flying above 200 m (656 ft), it is possible that the analysis of the 14.7 MW WTG resulted in an overestimate of the number of birds flying within the rotor-swept zone. However, since this highest altitude class accounted for only 2% of all records included in the analysis, this effect is not expected to significantly change the overall conclusions

For the 18 MW WTGs, which entails a rotor-swept zone of between approximately 36 m (118 ft) and 286 m (938 ft), records that fell into the lowest (0-20 m (0-66 ft)) altitude class were presumed to represent birds flying below the rotor-swept zone, while records that fell into the four highest altitude classes (20-50 m (66-164 ft), 50-100 m (164-328 ft), 100-200 m (328-656 ft), and 200+ m (656+ ft)) were presumed to represent birds flying within the rotor-swept zone of the WTGs. Since the highest altitude class (200+ m (656+ ft)) includes all records of birds flying above 200 m (656 ft), it is possible that the analysis of the 18 MW WTG resulted in an overestimate of the number of birds flying within the rotor-swept zone. However, since this highest altitude class accounted for only 2% of all records included in the analysis, this effect is not expected to significantly change the overall conclusions.

The results of this analysis are presented in Table 9.

Table 9 – Average Flight Altitudes for Marine Bird Families in the MABS Study Area

Family	Records of Birds in Flight with Altitude Determined	Altitude Classes (meters)										Percent Inside Rotor-Swept Zone of 14.7 MW WTG	Percent Inside Rotor-Swept Zone of 18 MW WTG
		0-20		20-50		50-100		100-200		200+			
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent		
Alcids (Alcidae)	63	46	73%	3	5%	14	22%	0	0%	0	0%	27%	27%
Gannets (Sulidae)	1393	809	58%	279	20%	205	15%	77	6%	23	2%	42%	42%
Grebes (Podicipedidae)	-	-	-	-	-	-	-	-	-	-	-	-	-
Gulls and Terns (Laridae)	2094	1304	62%	365	17%	242	12%	133	6%	50	2%	38%	38%
Jaegers and Skuas (Stercorariidae)	5	4	80%	0	0%	1	20%	0	0%	0	0%	20%	20%
Loons (Gaviidae)	108	81	75%	20	19%	2	2%	2	2%	3	3%	25%	25%
Sea Ducks (Anatidae)	295	235	80%	32	11%	5	2%	8	3%	15	5%	20%	20%
Shearwaters and Fulmars (Procellariidae)	47	37	79%	5	11%	4	9%	1	2%	0	0%	21%	21%
Storm-petrels (Hydrobatidae)	53	47	89%	6	11%	0	0%	0	0%	0	0%	11%	11%

As summarized in Table 9, the avian families with the highest percentage of records of individuals flying within the rotor-swept zone of the 14.7 and 18 MW WTGs were gannets (42%), gulls and terns (38%), and alcids (27%), while the families with the lowest percentage of records of individuals flying within the rotor-swept zone of the 14.7 and 18 MW WTGs were storm-petrels (11%) and sea ducks (20%). There were no records of grebes in flight for which flight elevation was reported, and thus this family could not be evaluated in this analysis. Similarly, jaegers and skuas are represented in this analysis by only five records of birds in flight for which flight elevation was reported and the results are therefore based on a small sample size.

Comparison with Furness *et al.* (2013) and Wilmott *et al. (2013)*

Furness *et al*. (2013) summarizes data on flight altitudes for selected marine bird species based on the results of several European and North American studies. The summary data in Furness *et al*. (2013) is presented in the context of the percent of time spent in flight within the rotor-swept zone, which is defined in the analysis as between 20 m (66 ft) and 150 m (492 ft). The upper end of the rotor-swept zone elevation assumed for the Furness *et al*. (2013) analysis is lower than that used for the MABS (Williams et al. 2015a, 2015b) data analysis; therefore, the percentages presented in Furness *et al*. (2013) may underestimate the overall percent of birds flying within the rotor-swept zone compared to the analysis of the MABS data presented here. However, the analysis of the MABS data indicates relatively few records of birds flying in the 100-200 m (328-656 ft) and 200+ m (656+ ft) altitude classes; therefore, discrepancies due to the different elevations used for the upper limit of the rotor-swept zones between the two analyses are expected to be minor.

The analysis presented in Furness *et al*. (2013) includes at least one member of each of the nine marine bird families discussed in this section. As much of the source data used in the Furness *et al*. (2013) analysis is from European studies, many of the species included in the analysis are primarily eastern Atlantic species that do not regularly occur off the mid-Atlantic coast of the United States. However, as discussed above, average flight elevations for species within the same family are presumed to be similar due to morphological and behavioral similarities; therefore, the comparison of the analysis for mainly European species presented in Furness *et al*. (2013) with site-specific data for North American species provided by the MABS studies (Williams et al. 2015a, 2015b) is presumed to be valid.

Wilmott *et al.* (2013) summarizes data on the percent of time a specific marine bird, landbird, or waterfowl species is found within the rotor swept zone from European and North American studies. The summary data is used to model the relative sensitivity of these species to the impacts of collision, which used rotor-swept zone as a model metric, defined as being between 20 m (66 ft) and 200 m (656 ft). Wilmott *et al.* (2013) divides the percentage of time in the rotor-swept zone data into three broad categories: <5%, 5-20%, and >20%. Due to the limited number of studies examining flight height and the variability of height estimates, Wilmott *et al.* (2013) states that the levels of uncertainty were often high. The study uses the most conservative estimate for flight height, defined by Wilmott *et al.* (2013) as being the highest percentage of time in the rotor-swept zone.

The analysis presented by Wilmott *et al.* (2013) includes at least one member of each of the nine marine bird families described in this section. For some families, particularly Laridae (gulls and terns) and Anatidae (sea ducks), more individual species were included in the analysis than in the MABS data presented here. These species were included in the comparison between the Wilmott *et al.* (2013) analysis and the MABS data analysis.

Table 10 presents a comparison of the approximate percent of time spent in flight within the rotor-swept zone based on the MABS data analysis and the analysis presented in Furness *et al*. (2013) and Wilmott *et al.* (2013) for marine bird families.

Table 10 – Comparison of Percent of Time Spent in Flight within the Rotor-Swept Zone between MABS, Furness *et al*. (2013), and Wilmott *et al.* (2013)

Family	Percent of Time Flying within the Rotor-Swept Zone			
	MABS Data Analysis 14.7 MW WTG	MABS Data Analysis 18 MW WTG	Furness *et al.* (2013)	Wilmott *et al.* (2013)
Alcids (Alcidae)	27%	27%	1%	5 – 20%
Gannets (Sulidae)	42%	42%	16%	>20%
Grebes (Podicipedidae)	No Data	No Data	4%	5 – 20%
Gulls and Terns (Laridae)	38%	38%	17%	>20%
Jaegers and Skuas (Stercorariidae)	20%	20%	10%	>20%
Loons (Gaviidae)	25%	25%	5%	5 – 20%
Sea Ducks (Anatidae)	20%	20%	3%	>20%
Shearwaters and Fulmars (Procellariidae)	21%	21%	0%	<5%
Storm-petrels (Hydrobatidae)	11%	11%	2%	<5%

As shown in Table 10, there are large discrepancies in the estimated percent of time flying within the rotor-swept zone for nearly all marine bird families between the three analyses. This could be due to several factors, some of which are discussed above, including: differences in method of data collection, differences in the species composition of the two analyses, differences in the elevations used to define the rotor-swept zone, the time of year in which data was collected, the sample size of the various studies, whether or not the surveys were conducted near breeding colonies, and weather conditions at the time of the surveys.

The most significant difference may be the method of data collection. Nearly all of the studies used in the Furness *et al*. (2013) analysis collected data through boat-based and/or land-based visual observations. Those used in Wilmott *et al.* (2013) analysis collected data through various methods, including boat-based and land-based visual observations, radar observations, thermal imaging, acoustic observations, and aerial surveys. Both Furness *et al*. (2013) and Wilmott *et al.* (2013) consisted of studies based in both North America and Europe. In comparison, the MABS data represents an analysis of digital video collected through aerial flights over the study area in the mid-Atlantic. The MABS report acknowledges that their flight height data reflects a significantly higher percentage of birds flying within the rotor-swept zone than two recent studies of avian use of the marine environment off the Atlantic coast of the United States, and suggests that these differences may be attributable to the differing survey methods (visual observation versus digital video aerial surveys) employed (Williams et al. 2015a, 2015b).

For the purposes of this analysis, the MABS digital aerial survey results were considered the most reliable of the three datasets and were the primary source used to characterize avian behavioral exposure. The MABS digital aerial survey data were considered more reliable because the surveys produce a permanent record of each observation, allow for a more detailed and objective analysis of flight elevation, and represent data collected from the Lease area and vicinity.

Overall Assessment of Behavioral Exposure

The goal of the behavioral exposure assessment for marine birds was to determine which avian families are potentially at a higher risk of exposure to the Project (and specifically to collision with rotating turbine blades) based on average estimated flight elevations. Behavioral exposure was characterized primarily through the use of MABS digital video aerial survey data (Williams et al. 2015a, 2015b). The overall assessment of relative behavioral exposure was made by ranking the nine marine bird families potentially occurring in the Project area on the basis of their estimated percent of flight time within the rotor-swept zone of the 14.7 and 18 MW WTGs according to the analysis of the MABS data, as summarized in Table 11.

Table 11 – Relative Behavioral Exposure for Marine Bird Families

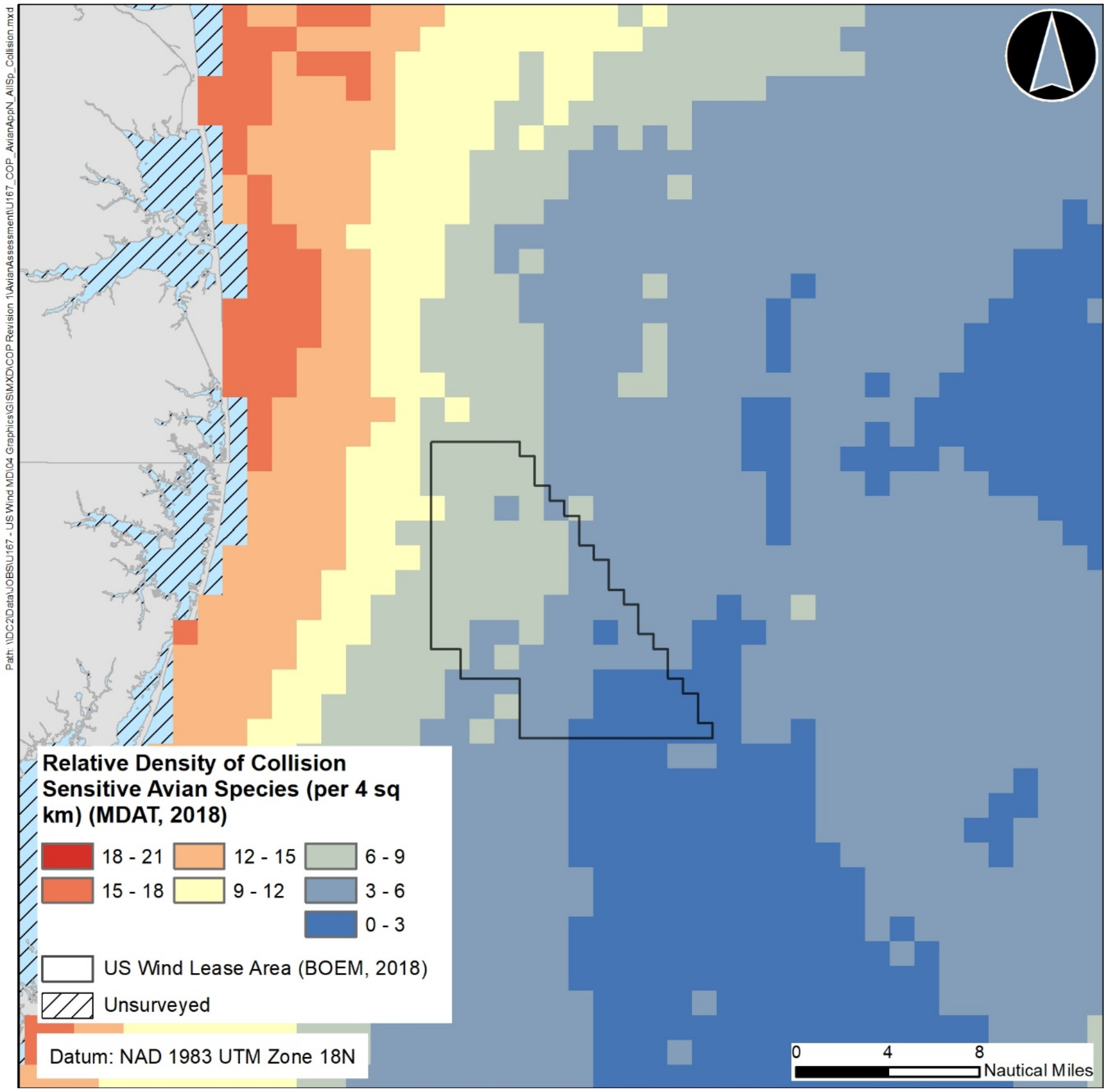
Family	Percent of Time Flying within the Rotor-Swept Zone	Behavioral Exposure Relative Rank
Gannets (Sulidae)	42%	1
Gulls and Terns (Laridae)	38%	2
Alcids (Alcidae)	27%	3
Loons (Gaviidae)	25%	4
Shearwaters and Fulmars (Procellariidae)	21%	5

Family	Percent of Time Flying within the Rotor-Swept Zone	Behavioral Exposure Relative Rank
Jaegers and Skuas (Stercorariidae)	20%	7
Sea Ducks (Anatidae)	20%	6
Storm-petrels (Hydrobatidae)	11%	8
Grebes (Podicipedidae)	No Data	

The assessment of estimated flight elevations – and in turn, relative behavioral exposure – was made using the best available data for the Lease area (Williams et al. 2015a, 2015b). The analysis presented in Furness *et al*. (2013) and Wilmott *et al.* (2013) appears to support the ranking of northern gannet (family Sulidae) and gulls and terns (family Laridae) as the marine bird families with the highest potential risk of collision with turbine blades based on the average flight elevations of these species. Similarly, the relative ranks of loons (family Gaviidae), sea ducks (family Anatidae), and storm-petrels (family Hydrobatidae) based on the MABS data is consistent with how these families would rank based on the analysis presented in Furness *et al*. (2013). The alcids (family Alcidae) and shearwaters and fulmars (family Procellariidae) show the highest difference in relative ranks between the analysis of the MABS data and the analysis presented in Furness *et al*. (2013). In terms of percentage of time flying within the rotor-swept zone, the MABS data indicate values 27 and 70 times higher for alcids and shearwaters and fulmars, respectively, than the analysis in Furness *et al*. (2013). Members of both of these families are generally understood to fly close to the surface of the water; however, the MABS data indicate these species flying higher than 20 m (66 ft) 27% and 21% of the time, respectively (Williams et al. 2015a, 2015b). Several factors can influence flight elevation of seabirds, including wind speed; whether the bird is experiencing a headwind or a tailwind; and whether the purpose of the flight is for short-distance, local movements or long-distance migrations. It is unclear whether or how any of these or other factors may have influenced flight heights of seabirds during the MABS surveys; however, based on the discrepancies between the MABS (Williams et al. 2015a, 2015b) and Furness *et al*. (2013) analyses, there is less confidence in the overall relative behavioral exposure rankings of alcids and shearwaters and fulmars given in Table 11.

The MDAT model results examined possible stressors experienced by avian species in the offshore Atlantic region. One stressor examined was collision sensitivity, based on the results of a study by Winship *et al.* (2018). These model results show the predicted relative density of avian species most sensitive to collision, shown in Figure 4. The highest densities of these collision-sensitive species occur along the shoreline, with low densities within the western half of the Lease Area.

Figure 4 – Avian Collision Sensitivity



Displacement

Displacement due to offshore wind facility construction and operation can impact marine bird species in complex and indirect ways before being noticeable (Willmott, Forcey, and Kent 2013). Some species are more sensitive than others, usually as a result of their food source. Species that feed in restricted niches (i.e. clam beds, oyster beds) would be more affected by changes in food species distribution and habitat loss (Willmott, Forcey, and Kent 2013). Being less flexible in foraging habitat and increased time over the Atlantic OCS can increase the negative effects of displacement on a population. Impacts may vary based on whether the adult is foraging to feed itself or to feed its young (Willmott, Forcey, and Kent 2013).

Wilmott *et al.* (2013) calculated displacement sensitivity as a function of annual occurrence, disturbance, macro avoidance, habitat flexibility, and if individuals were foraging to feed young. The final displacement score was calculated by multiplying this score by the population sensitivity score. Wilmott *et al.* (2013) also multiplied the upper and lower ranges of the population and displacement sensitivity scores, which would account for the overall impact of displacement. This considers environmental factors that impact displacement and the implications of displacement for a given species.

The average displacement score was calculated for each marine bird family examined in this assessment, for the lower estimate, best estimate, and upper estimate. The families were ranked by the best estimate, where having a lower numerical rank indicates a high displacement risk. This is summarized in Table 12.

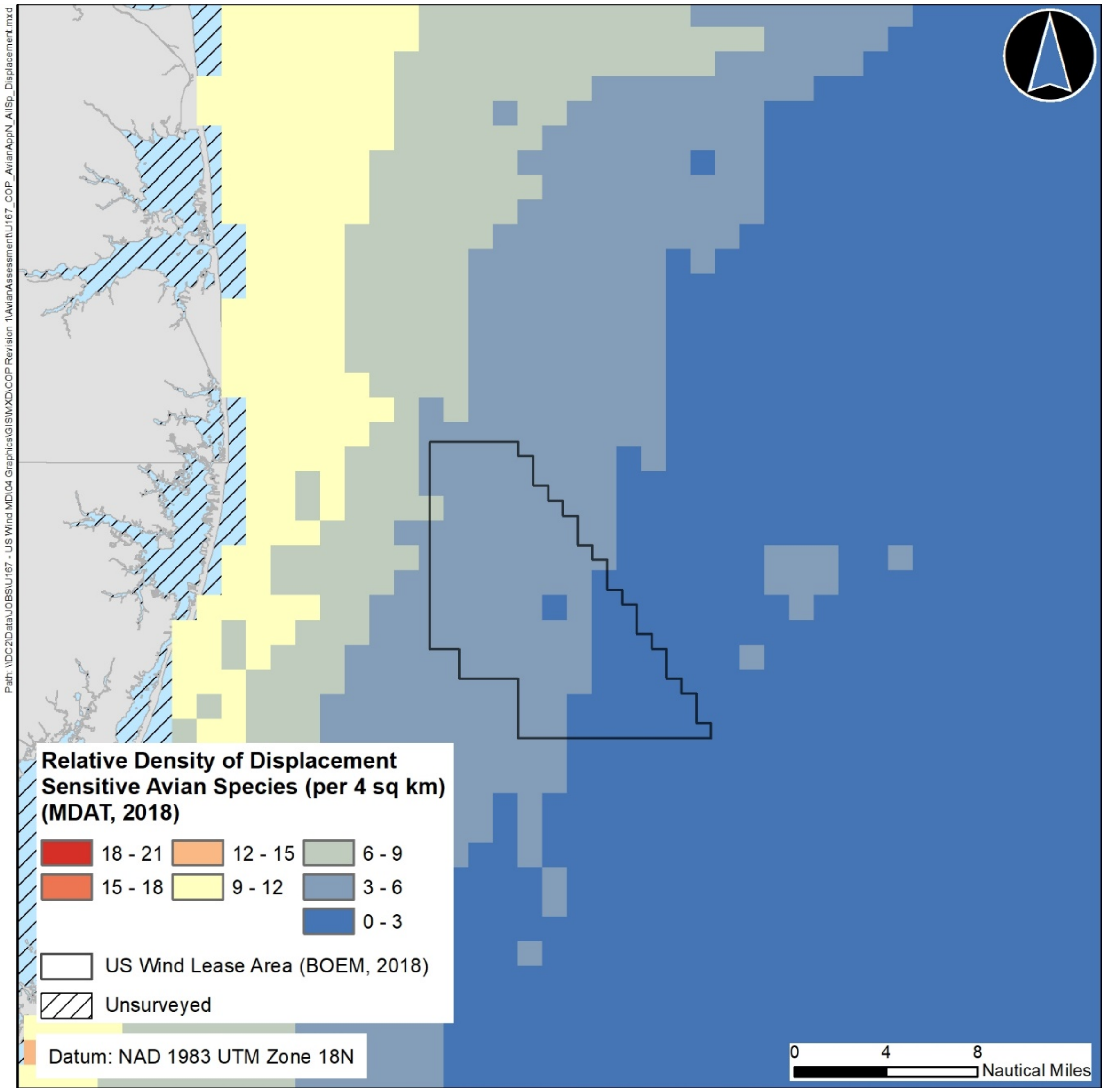
Table 12 – Displacement Sensitivity for Marine Bird Families

Family	Lower	Best Estimate	Upper	Rank
Alcids (Alcidae)	106,143.5	143,740	172,441.7	1
Gannets (Sulidae)	29,087.1	40,380	49,877.1	5
Grebes (Podicipedidae)	34,133.4	47,040	53,684.4	4
Gulls and Terns (Laridae)	16,535.9	33,796.9	43,410.3	6
Jaegers and Skuas (Stercorariidae)	6,798.2	10,944	17,954.6	9
Loons (Gaviidae)	82,134	106,200	116,820	2
Scoters, Ducks, and Geese (Anatidae)	33,495.1	73,690.1	107,931.9	3
Shearwaters and Fulmars (Procellariidae)	14,316.075	29,745	40,031.5	7
Storm-petrels (Hydrobatidae)	10,346.4	18,000	23,162.4	8

Based on this analysis, Alcids (family Alcidae) had the highest displacement sensitivity, with loons (family Gaviidae) ranked second. This is likely due to high avoidance traits and restricted prey availability (Willmott, Forcey, and Kent 2013). Jaegers and skuas (family Stercorariidae) were less sensitive to displacement, as they usually do not avoid wind farms (Willmott, Forcey, and Kent 2013).

The MDAT model results also examined displacement sensitivity, as examined by Winship *et al.* (2018), as a possible stressor to avian species, shown in Figure 5. The avian species most sensitive to displacement are predicted to occur inshore of the Project area, along the shoreline, with some predicted within the western half of the Lease area.

Figure 5 – Avian Displacement Sensitivity



4.0 SUMMARY

Geographic and behavioral exposure was assessed at the marine bird family level based primarily on analyses of MABS survey data for the Lease area (Williams et al. 2015a, 2015b). Each marine bird family was ranked numerically based on their assessed relative geographic and behavioral exposure. A family's ordinal position in each of the geographic and behavioral ranks indicates their assessed relative exposure compared to other families (i.e., the lower the numerical rank, the higher the relative exposure). Table 13 summarizes the overall relative rankings for geographic and behavioral exposure for the nine marine bird families.

Table 13 – Summary of Relative Geographic and Behavioral Exposure of Marine Bird Families to the Project

Common Name	Family	No. Species[1]	Seasonal Occurrence in WEA	Breeds in Mid-Atlantic	Geographic Exposure Relative Rank	Behavioral Exposure Relative Rank	Displacement Exposure Relative Rank
Alcids	Alcidae	2	Fall - Winter	No	4	3	1
Gannets	Sulidae	1	Fall – Winter	No	2	1	5
Grebes	Podicipedidae	1	Winter	Yes	9	N/A	4
Gulls and Terns	Laridae	11	Year-round	Yes	3	2	6
Jaegers and Skuas	Stercorariidae	2	Spring and Fall	No	8	7	9
Loons	Gaviidae	2	Fall - Spring	No	1	4	2
Sea Ducks	Anatidae	2	Fall - Winter	No	7	6	3
Shearwaters and Fulmars	Procellariidae	5	Spring	No	5	5	7
Storm-petrels	Hydrobatidae	1	Spring - Summer	No	6	8	8

[1] The approximate number of species that regularly occur in the Project area, based on MABS survey results.

With respect to geographic exposure, loons (family Gaviidae) are ranked 1, indicating that they have the highest relative annual geographic exposure to the Project among the marine birds families, while grebes (family Podicipedidae) are ranked 9, indicating that it has the lowest relative annual geographic exposure. With respect to behavioral exposure, northern gannet (family Sulidae) is ranked 1, indicating that it has the highest relative behavioral exposure to the Project among the marine bird families, while storm-petrels (family Hydrobatidae) are ranked 8, indicating that it has the lowest relative behavioral exposure (though note that grebes [family Podicipedidae] could not be ranked due to a lack of data). Alcids (family Alcidae) had the highest displacement relative risk while jaegers and skuas (family Stercorariidae) had the lowest displacement risk.

This Avian Risk Assessment ranked the relative geographic, behavioral, and displacement risk of the nine marine bird families present in the Project area. Although there are different relative risks among the marine bird families present in the Project area, based on the results of the assessment, the overall risk to marine birds from the construction and operations of the Project is considered to be minor.

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