A Geospatial Analysis of Species of Interest in US Atlantic Wind Energy Areas

By

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EXECUTIVE SUMMARY

While offshore wind energy inspires hope for a low-carbon electric grid, this climate solution may simultaneously threaten marine wildlife and ecosystems in ways that are not fully understood. In this analysis, I support the Department of Energy (DoE) and BOEM funded Wildlife and Offshore Wind (WOW) project by quantifying spatiotemporal overlap between the following species of interest and wind energy lease sites in the U.S. Atlantic: The Fin whale, Common minke whale, Humpback whale, North Atlantic right whale, Red-throated loon, Northern gannet and Great black-backed gull. Additionally, I leverage geospatial tools to assess the representativeness of marine wildlife abundance levels in project WOW field sites (Vineyard Wind and Empire Wind) relative to other wind energy areas. Results from this analysis improve our understanding of how species of interest may interact with wind energy areas in the US Atlantic, and how applicable or relevant project WOW field data will be for planning or management decisions in other wind energy lease sites.

To conduct this analysis, I acquired species-specific distribution products from the OBIS-SEAMAP model repository. After processing these distribution products to achieve equal temporal resolutions across all species of interest, I generated zonal statistics to acquire mean density values for each species, in each season, in each wind energy lease site. BOEM wind energy lease sites were buffered by 10 kilometers prior to generating zonal statistics in order to stay consistent with similar ongoing Project WOW analyses. Density values are measured in number of individuals per 100 square kilometers and are visualized in maps and tables to provide insight into: 1) where, when and to what extent do species of interest overlap with wind energy areas, and 2) how representative project WOW field sites are to other wind energy areas in terms of marine wildlife abundance.

Key findings:

1. Overlap hot spots between marine mammal (cetacean) species of interest and wind energy lease sites are typically found in northern latitudes, often in the cluster of sites just south Martha's Vineyard, Massachusetts. For Minke whales, Humpback whales and Right whales, the highest amount of overlap observed out of the entire year occurs within

this cluster, specifically in the Vineyard Northeast lease site. For all cetaceans apart from the Right whale, the greatest amount of observed overlap with wind energy sites occurs during summer months (for the Right whale the greatest amount of observed overlap occurs during winter months). Data suggest that there may be more instances of high relative overlap for Minke whales and Right whales compared to Fin whales and Humpback whales, though additional work is necessary to fully evaluate the ecological significance of these relative levels of overlap.

2. For the Northern gannet and the Red-throated loon, the greatest amount of overlap occurs during the winter in the Commonwealth of Virginia Dept of Mines, Minerals and Energy research site. For the Great black-backed gull, the greatest amount of overlap occurs during the fall in the Narragansett Electric Company right-of-way grant near Narragansett, Rhode Island. Results from this analysis suggest that there may be more instances of high relative overlap of the Northern gannet in wind energy lease sites compared to the Red-throated loon and the Great black-backed gull. As is the case with cetacean species of interest, results from this analysis do not answer the question of whether predicted overlap between seabirds and wind energy lease areas is ecologically significant.

3. In Vineyard Wind, the spatiotemporal distribution of species of interest tend to be similar to those in other sites just south of Massachusetts. In Empire Wind, the spatiotemporal distribution of species of interest tend to be similar to those in other sites in the New York Bight. Despite some inconsistencies in these levels of representativeness, these broad patterns are helpful in thinking about how inferences made from field data may be extrapolated to other sites. With that said, caution should be exercised in extrapolating inferences from field data to other sites, and all extrapolations should be made at the site-level.

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INTRODUCTION

1. Offshore Wind Energy

The global development of offshore wind energy has rapidly increased from its inception in the 1990s to its current electricity-generating capacity of over 34 GW (Bidwell et al. 2022). Although the majority of these advancements have occurred in the United Kingdom, Europe and China, the United States is projected to soon develop a strong presence in the global industry (ibid). The development of offshore wind energy in the US will play a crucial role in the effort to meet numerous climate goals such as a 40% reduction in greenhouse gas emissions by 2030 as delineated in the Inflation Reduction Act of 2022 and a 1.5°C limit to global warming as delineated in the Paris Agreement. Tapping into more sustainable energy sources will become increasingly important in the face of climate change, although the widespread industrialization of offshore wind energy must be done responsibly such that all stakeholders - human and nonhuman - are considered.

The two main types of offshore wind turbines are broadly categorized by their support structures, which either involve fixed or floating infrastructure (Asim et al. 2022). Fixed-support wind energy infrastructure, typically characterized by a monopile or braced frame structure anchored to the seafloor, is currently the most common type of wind energy infrastructure found offshore (Arshad & O'Kelly 2013). Turbines fixed with a monopile are suitable for waters up to 30 meters in depth, assuming favorable seabed geologic conditions, while turbines anchored with braced frames or multi-piles have depth limits closer to 50 meters (Li et al. 2020). The development of wind energy in waters that exceed 50 meters in depth requires the use of floating infrastructure, which first saw commercial use in 2017 in British waters. Due to engineering advancements, it is projected that the costs of floating wind energy infrastructure will be reduced by half in 2050, making this type of wind turbine more economically viable and thus more popular in the near future (ibid).

In the US, the installation of offshore wind turbines is restricted to the Outer Continental Shelf (OCS), which is defined as the seafloor and subsoil lying outside State jurisdiction and inside Federal jurisdiction. State jurisdiction extends 3 nautical miles from shore for all states except Texas and the Florida Gulf Coast (in which case the State jurisdiction extends 9 nautical miles),

and Federal jurisdiction encompasses the Exclusive Economic Zone (EEZ) which begins 12 nautical miles offshore and extends seaward to the 200 nautical mile mark. Portions of the continental shelf that exceed the US EEZ are known as the extended continental shelf (ECS) and are also included in the OCS definition; all criteria used to determine ECS boundaries are delineated in Article 76 in the Law of the Sea Convention.

Under the Energy Policy Act of 2005, The US Department of Interior's Bureau of Ocean Energy Management (BOEM) has the authority to issue wind energy leases in the OCS and to accept, reject or modify construction and operation plans submitted by developers. Collaboration between BOEM, NOAA and other relevant Federal agencies and stakeholders is mandated by the Energy Policy Act of 2005 during the following four phases of BOEM's renewable energy program: planning, leasing, site assessment and construction/operation. This regulatory framework is applicable to the entire OCS, which BOEM has divided into the following four regions: The Alaska, Pacific, Gulf of Mexico and Atlantic OCS regions.

The Atlantic OCS region, which has been identified as particularly suitable for wind energy development from a technological, commercial and environmental standpoint, is currently experiencing a rapid expansion of wind energy lease areas and planning sites (Musial et al. 2016, Stenhouse et al. 2020). In 2022 alone, six lease areas in the New York bight were auctioned to offshore wind developers and two Federal Register notices were issued by BOEM to initiate offshore wind planning and leasing procedures in the Gulf of Maine (Northeast Ocean Data Portal). BOEM also recently approved construction and operation plans for the Vineyard Wind 1 and South Fork wind farms, both of which will be located in southern New England state waters, so early stages of infrastructure implementation are underway in the Atlantic OCS as well (ibid). The figure below illustrates BOEM wind lease sites and planning areas in the Atlantic OCS region as of June 2020.

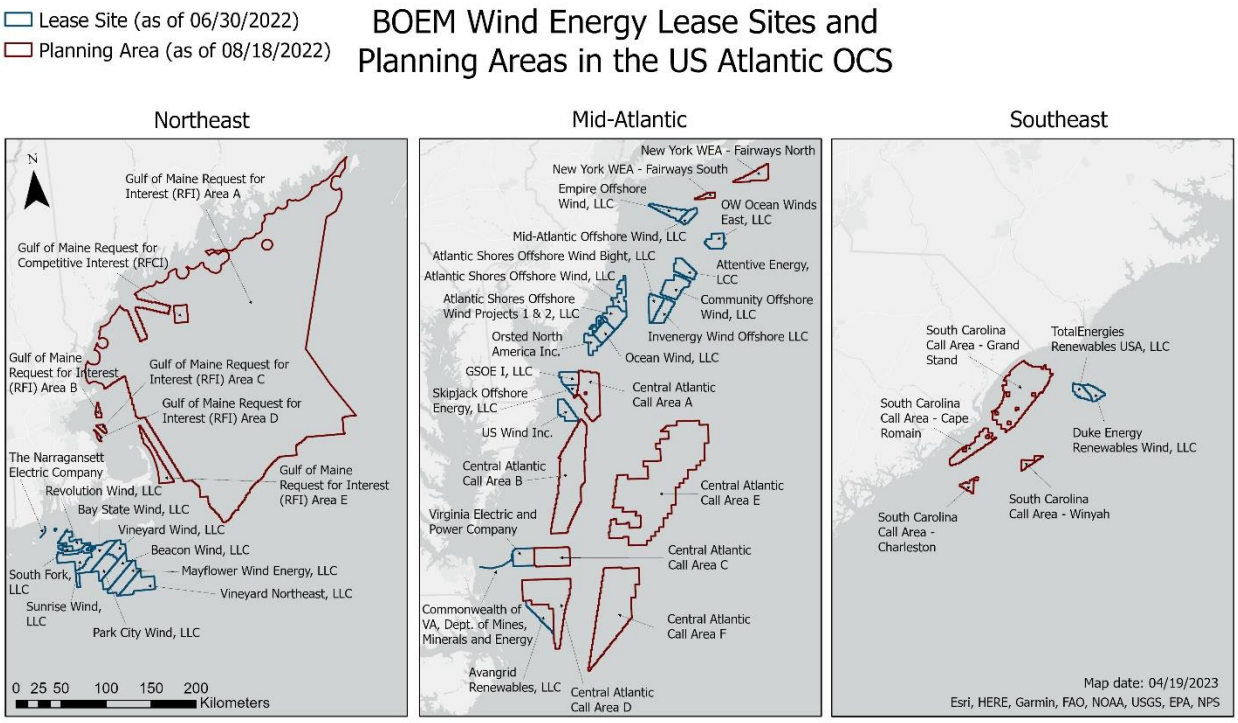

Figure 1. Bureau of Ocean Energy Management wind energy lease sites and planning areas in the US Atlantic

2. Ecological Impacts & Knowledge Gaps

Although the recent wind energy developments in the Atlantic OCS are non-trivial and inspire hope for a transition away from fossil fuels, US offshore wind energy is still in its infancy and our understanding of the ecological implications associated with domestic offshore wind activity is still developing. These ecological implications create a challenging juxtaposition between the climate crisis and the biodiversity crisis, reiterating the need for immediate and effective ocean use planning strategies and marine wildlife monitoring capabilities. NOAA is responsible for monitoring impacts of offshore wind on marine life under several laws (the Endangered Species Act, Marine Mammal Protection Act, National Environmental Policy Act, National Marine Sanctuary Act, and Energy Policy Act), although this concern must be shared by wind energy developers and shareholders alike.

One ecological impact of concern for marine mammal (cetacean) species relates to underwater noise pollution. Offshore wind energy installation generates low-frequency underwater noise

during turbine construction (a short duration of high-intensity noise) and during turbine operation (a continuous duration low-intensity noise) (Tougaard et al. 2008). Most marine mammals utilize underwater sound for communication, foraging and navigation, and it is speculated that noise pollution from wind energy development and associated anthropogenic activity may impair/impact these behaviors. Effects of turbine-generated underwater noise on marine mammals are still not fully understood and to date, the majority of research focuses on construction noise rather than operational noise. Because operational noise increases with turbine size, and because larger turbines will become increasingly popular as technology and engineering capabilities improve, a large knowledge gap still exists with respect to wind energy impacts on marine mammals (Stöber & Thomsen 2021). In addition, previous studies of wind energy development in Europe and the United Kingdom do not include many of the migratory baleen whale species found along the US Atlantic coast.

A second notable ecological concern stemming from wind energy development is seabird collision and displacement. Collision events typically occur when seabirds fly through the rotor sweep zone (any area that is momentarily occupied by a turbine's blade during one full rotation), whereas displacement events occur when seabirds avoid flying, foraging or resting within or adjacent to offshore wind farms (Furness et al. 2013). Collision vulnerability tends to have an inverse relationship with displacement vulnerability because seabirds that avoid wind farms are less at-risk of physically interacting with wind turbines and more at-risk of experiencing displacement from potentially important habitat areas (ibid). Our understanding of seabird collision and displacement risks is still developing and is challenging to study due to large spatiotemporal variability in seabird distribution (Welcker & Nehls 2016).

3. Project Wildlife and Offshore Wind

Wildlife and offshore Wind (WOW) is a project led by Duke University that aims to improve our collective ability to assess potential impacts of wind energy development on marine wildlife. More specifically, the goal of project WOW is to provide wind energy stakeholders with a framework for more effective and efficient approaches to environmental assessment in the context of wind energy development. This work is led by Duke University's Dr. Douglas Nowacek (PI), Dr. Patrick Halpin (co-PI) and Dr. Brian Murray (co-PI) and is funded by the US Department of Energy (DoE) and BOEM. A full list of other contributors and external advisors can be found on the project WOW website (offshorewind.env.duke.edu).

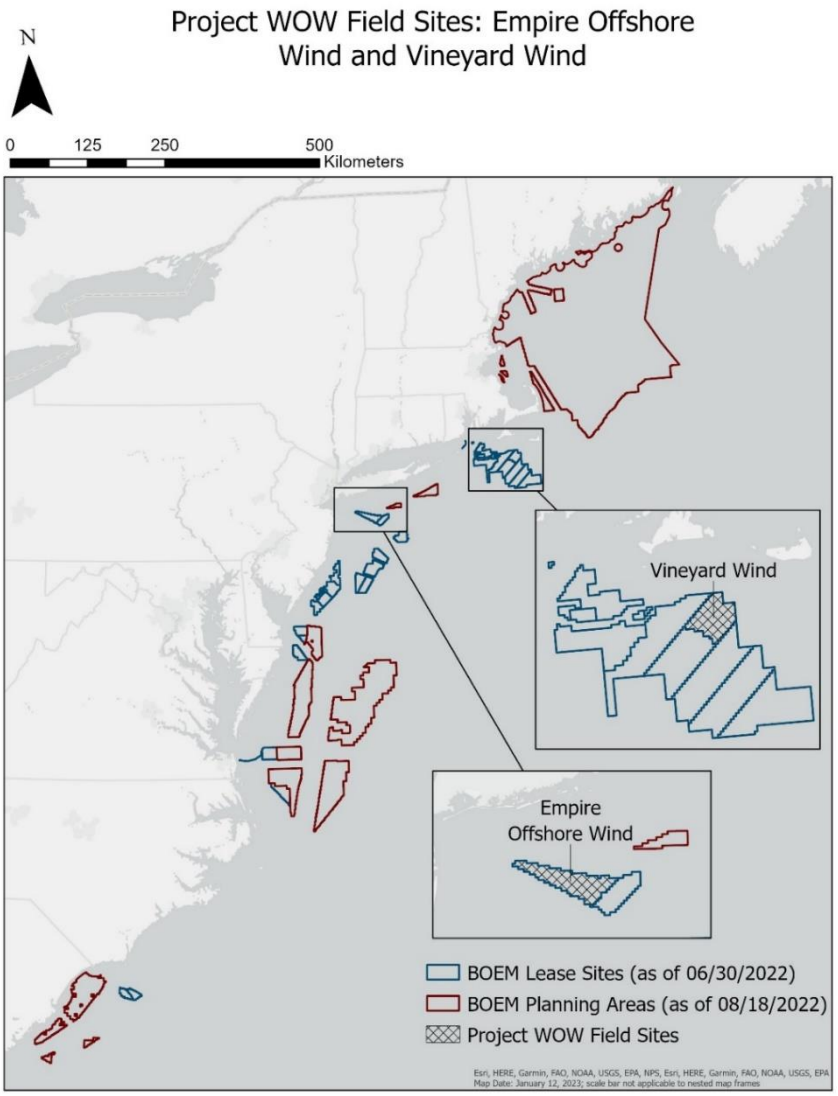

Figure 2. Project WOW field sites: Empire Offshore Wind and Vineyard Wind

Starting in June 2023, Project WOW will conduct field work to monitor marine wildlife via ship-based surveys, aerial surveys and passive acoustic monitoring recorders. These Integrated Regional Ecosystem Studies (IRES) are intended to capture pre-construction, construction and post-construction time periods in order to test for behavioral or distributional changes in marine mammal, seabird, bat and turtle species attributed to wind energy development activities. Data acquired from this field work will be used as a basis to guide future research, to validate survey methods and to improve predictive species distribution maps. The initial IRES studies will take place within the first two large-scale wind energy areas to be

developed in the Atlantic OCS: Empire Offshore Wind and Vineyard Wind. Figure 2 illustrates these two sites in relation to other wind energy lease sites and planning areas in the Atlantic OCS.

4. Species of Interest

Project WOW members have identified the following baleen whales and seabirds as species of interest, meaning they will be targeted during field data collection: The Fin whale, Common minke whale, Humpback whale, North Atlantic right whale, Red-throated loon, Northern gannet and Great black-backed gull. This group of animals are of particular interest because they are considered representative of marine wildlife at-risk of wind energy development impacts. Below are seasonal distribution maps for each species of interest utilizing non-standardized symbology (separate scale bars for each season) to illustrate distributional changes within each season. Seasonal distribution maps utilizing standardized symbology (one scale bar for all four seasons season) are helpful for visualizing distributional changes across seasons and can be found in the *Additional Maps* section in the appendix.

A) Fin Whale

The Fin whale (*Balaenoptera physalus*) is the second largest whale species on earth, with adults reaching up to 85 feet in length and 80 tons in weight (NOAA Fisheries 2022a). The distribution of the Fin whale extends to the four major ocean basins, although the Northern and Southern hemisphere stocks are assumed to be reproductively isolated (Mizroch et al. 1984). Migration patterns are generally characterized by the movement between higher latitudes in the summer months and lower latitudes in the winter months, where older individuals typically reach higher latitudes than younger individuals (ibid). NOAA Fisheries divides Fin whales in the US EEZ into four management stocks: California/Oregon/Washington, Hawaii, Alaska/Northeast Pacific, and Western North Atlantic In the Western North Atlantic stock, Fin whales are commonly found in important feeding grounds in New England and the Gulf of St. Lawrence (NOAA Fisheries 2022b). Fin whales are currently listed as endangered under the Endangered Species Act (ESA),

and are considered vulnerable to ship strikes, ocean noise, fishing gear entanglement and climate change (NOAA Fisheries 2022a).

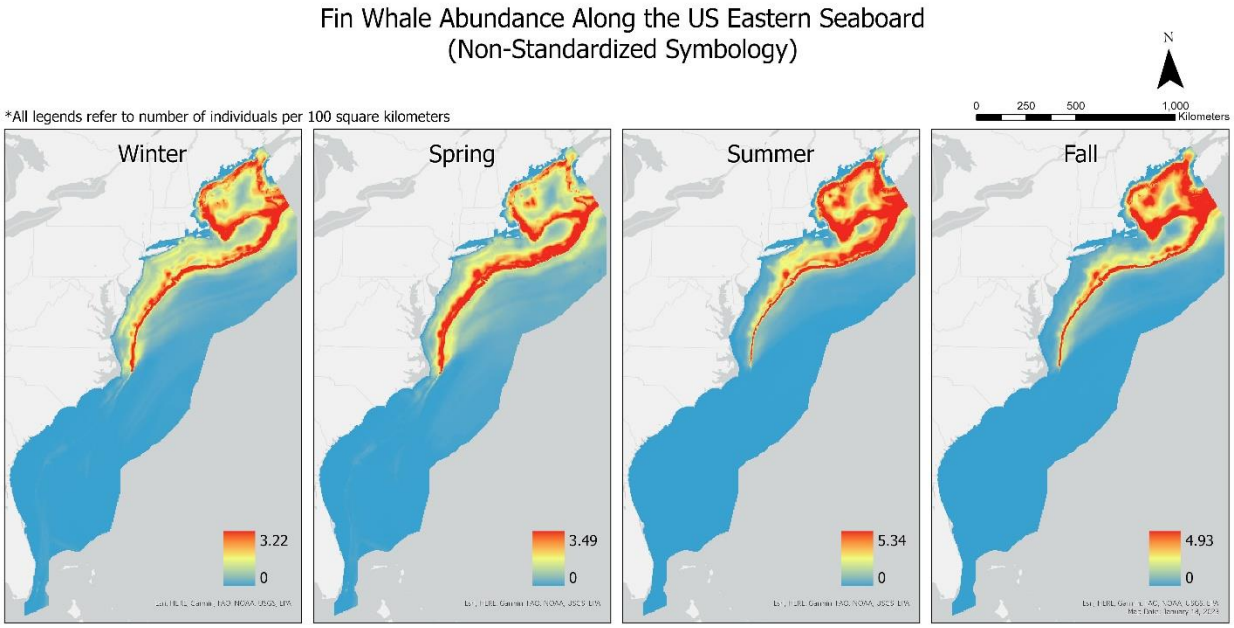

Figure 3. Fin whale abundance in the US Atlantic (non-standardized symbology)

B) Minke Whale

The Common minke whale (*Balaenoptera acutorostrata*) is the smallest baleen whale in North America and is found in coastal and offshore waters in the northern Atlantic and Pacific oceans (NOAA Fisheries 2022c). In the northern Atlantic, the distribution of the Common minke whale (hereafter Minke whale) extends to the Canadian arctic during summer months and to the Caribbean topics during winter months, although the exact whereabouts of these seasonal grounds are not fully understood (Perrin et al. 2018). NOAA Fisheries divides Minke whales in the US EEZ into four management stocks: Alaska, California/Oregon/Washington, Hawaii, and Canadian Eastern Coastal. Minke whales in the Canadian Eastern Coastal stock are abundant in New England coastal waters throughout the spring, summer and fall months and tend to move towards deeper, off-shelf waters during winter months (NOAA Fisheries 2021). Minke whales

are protected under the Marine Mammal Protection Act (MMPA), although they are not listed as threatened or endangered under the ESA.

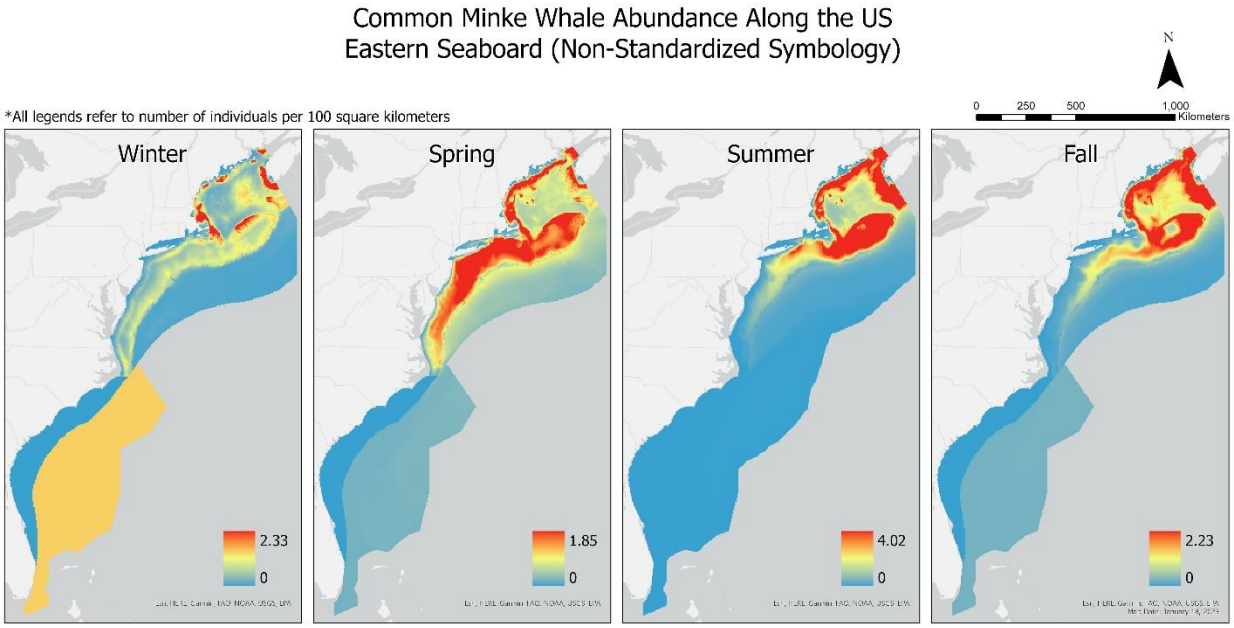

Figure 4. Minke whale abundance in the US Atlantic (non-standardized symbology)

C) Humpback Whale

The Humpback whale (*Megaptera novaeangliae)* is a highly migratory species found in all four major ocean basins (Clapham 2018). In a swim that can reach up to 5,000 miles one way, these animals typically migrate from mid to high latitude feeding grounds in the summer months to

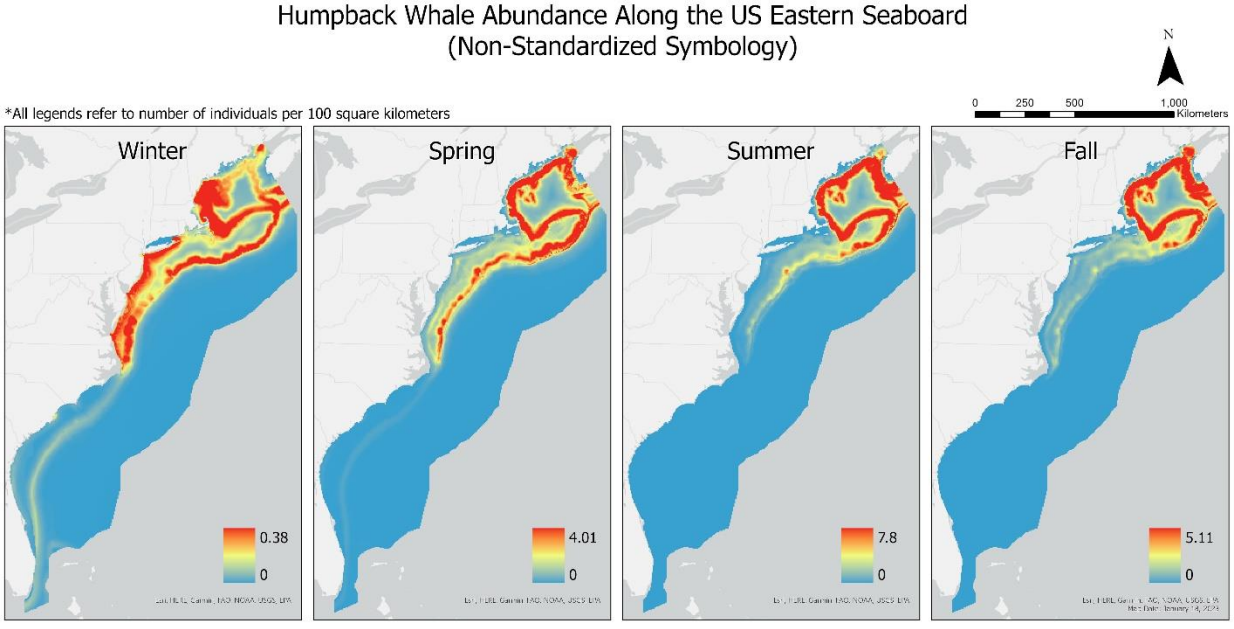

Figure 5. Humpback whale abundance in the US Atlantic (non-standardized symbology)

coastal tropical calving grounds in the winter (ibid). Management units for Humpback whales in the US EEZ include the American Samoa, California/Oregon/Washington, Central North Pacific, Western North Pacific and Gulf of Maine stocks. Humpback whales in the Gulf of Maine stock feed during the spring, summer and fall months along the US eastern seaboard and throughout the Gulf of St. Lawrence, Newfoundland and western Greenland; these whales then migrate to the West Indies or the Cape Verde Islands during winter months to breed their calves (NOAA Fisheries 2020). According to the 2019 stock assessment report, it is estimated that the Gulf of Maine Humpback whale stock is comprised of 1,396 individuals. Humpback whales are currently listed as endangered under the ESA, and are considered vulnerable to ship strikes, vessel-based harassment, fishing gear entanglement and climate change (NOAA Fisheries 2023a).

D) North Atlantic Right Whale

With only 350 individuals remaining, the North Atlantic right whale (*Eubalaena glacialis*) is one of the most endangered whale species on earth (NOAA Fisheries 2023b). Although these whales are listed as endangered under the ESA and have gained national backing for critical conservation measures, North Atlantic right whale (hereafter Right whale) populations are still struggling to stabilize. This is largely because of compounding stressors especially ship strikes and fishing entanglements (Moore et al. 2021). Right whales can be found foraging in coastal

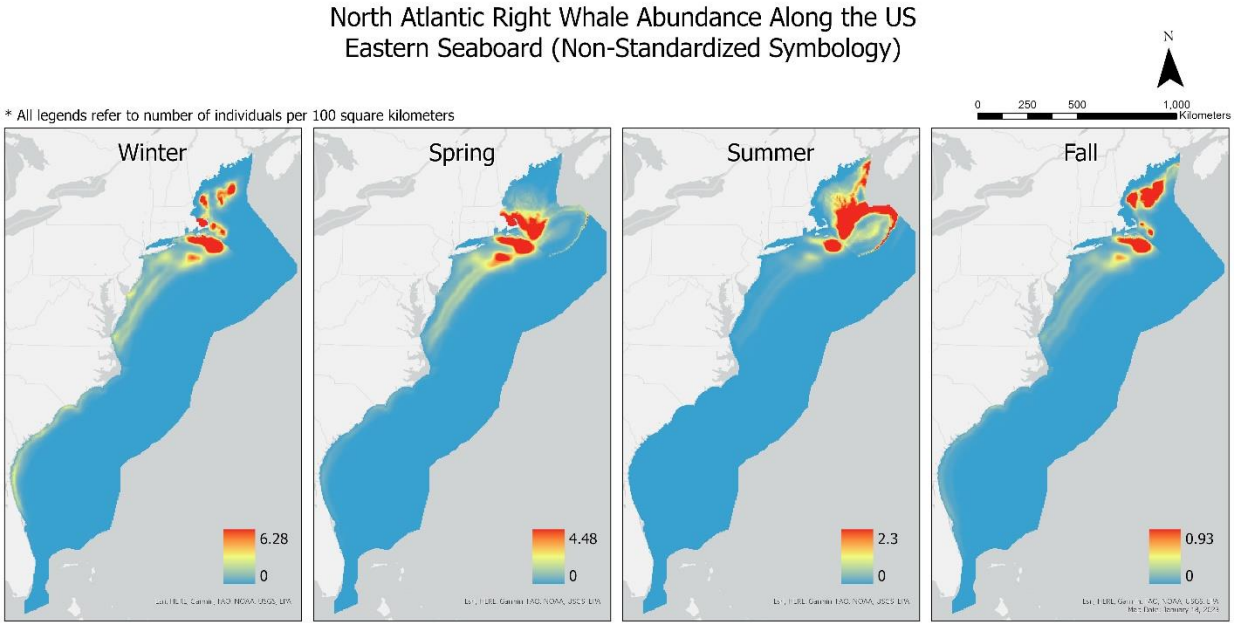

Figure 6. Right whale abundance in the US Atlantic (non-standardized symbology)

waters from New England to Nova Scotia during spring and summer months. In the fall, Right whales tend to migrate to calving grounds in South Carolina, Georgia and northeast Florida. These two areas (New England and southeast US) have been designated by NOAA Fisheries as right whale critical habitat, meaning they are prioritized in right whale conservation efforts.

E) Red-Throated Loon

Red-throated loon (*Gavia stellata*) population dynamics and migration patterns are not fully understood, although it is estimated that up to 100,000 individuals migrate to the US mid-Atlantic region during winter months and that breeding grounds occur at higher latitudes in freshwater or brackish waterbodies (Rizzolo et al. 2020). These seabirds, the smallest loon species in the world, are listed as a species of conservation concern by the US Fish and Wildlife Service (USFWS) although they also have a status of "Least Concern" according to the International Union for Conservation of Nature (IUCN). As reflected in the map below, there are no transect segments in the Atlantic OCS with Red-throated loon sightings during summer months; as a result, this study will only examine Red-throated loon data during winter, spring and fall months.

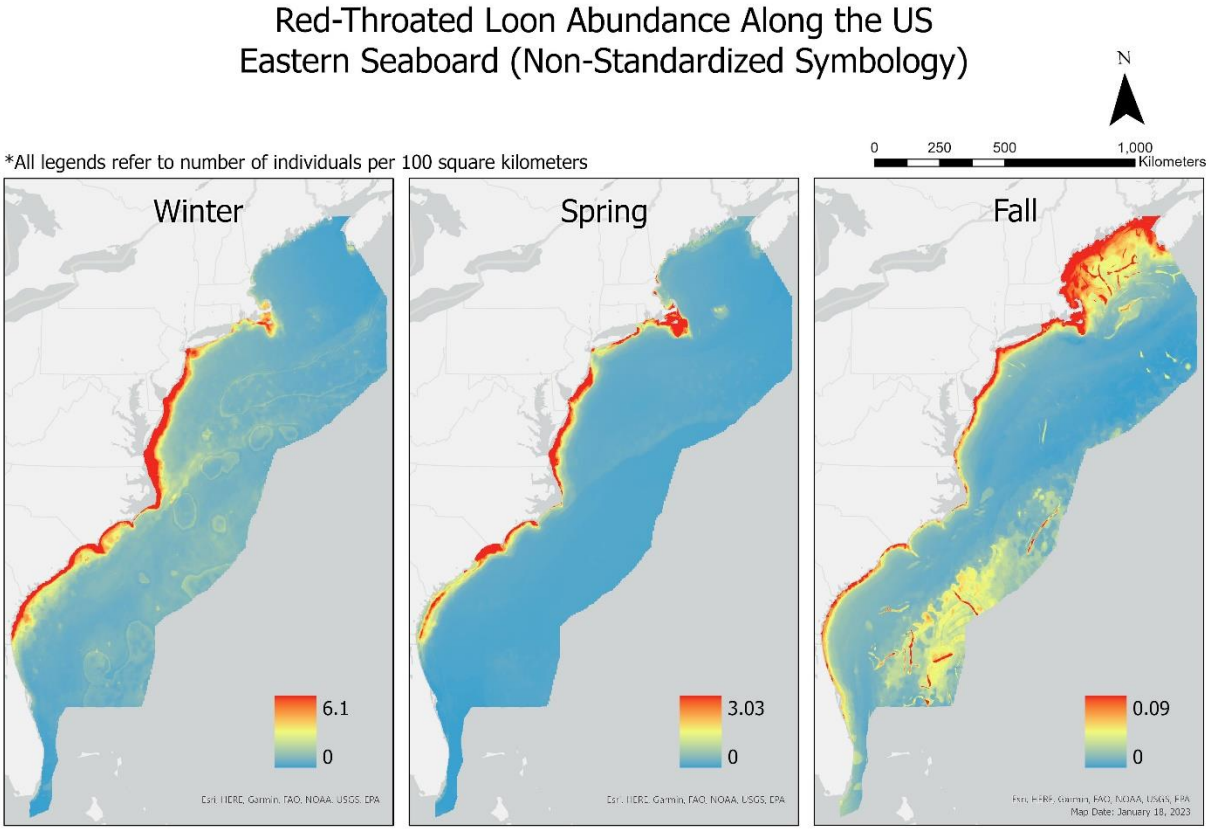

Figure 7. Red-throated loon abundance in the US Atlantic (non-standardized symbology)

F) Northern Gannet

The Northern Gannet (*Morus bassanus)* is the largest seabird in the North Atlantic and is easily identifiable by a golden-yellow head. These seabirds are found in coastal waters throughout the eastern and western Atlantic Ocean, although these populations are generally considered discrete as these birds rarely embark on ocean crossings (Garthe et al. 2016). The western Atlantic is home to less than half of the world's Northern gannet population, and the distribution of this population is extensive: wintering grounds for the western Atlantic's Northern gannets range from Maine to the Florida Gulf Coast, and breeding grounds are commonly found in subarctic Canadian waters. Northern gannets are known to stay fairly close to shore, so these wintering and breeding grounds are often within coastal waters. According to the IUCN, the Northern gannet has a conservation status of "Least Concern", and populations in North America have been increasing since the 1980s (Chardine et al. 2013).

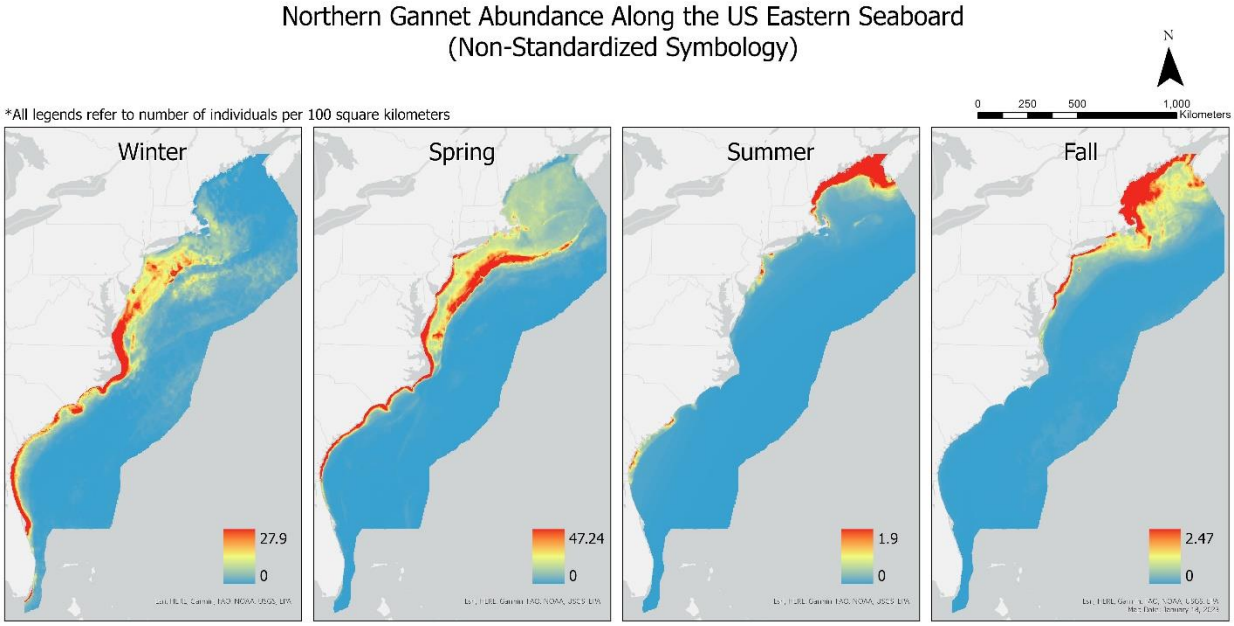

Figure 8. Northern gannet abundance in the US Atlantic (non-standardized symbology)

G) Great Black-Backed Gull

The Great black-backed gull (*Larus marinus*) is the largest gull in the world and is found in northern coastal areas on both sides of the Atlantic Ocean. In North America, the distribution of the Great-black-backed gull is centered in New England and Canada, although this range has expanded southward in the past century to include the mid-Atlantic region and inland to include the Great Lakes (Washburn et al. 2016). North American Great black-backed gulls breed in

northern Canada and are typically found in coastal waters, although they may travel far offshore in the winter months to forage. The population of this gull has grown since the 1930s largely due to increased exposure to human garbage, which is beneficial for opportunistic feeding (ibid).

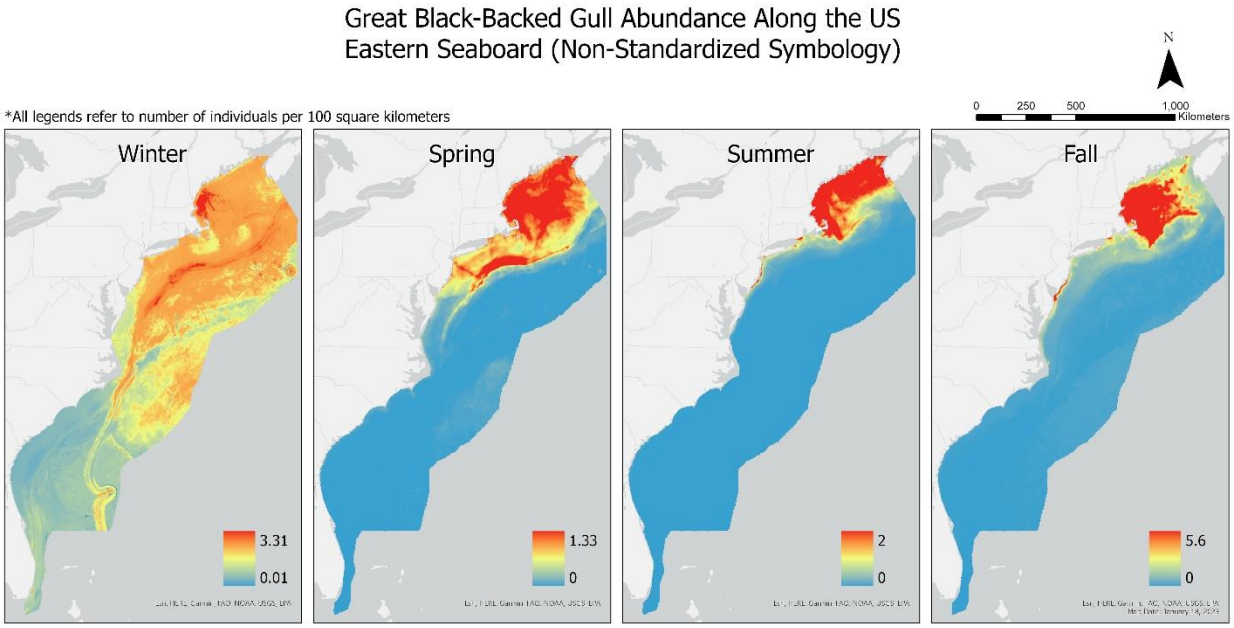

Figure 9. Great black-backed gull abundance in the US Atlantic (non-standardized symbology)

5. Study Overview & Objectives

In this project, I use geospatial analysis to achieve two objectives: first, to better understand spatiotemporal overlap between species of interest and wind energy sites in the US Atlantic, and second to better understand project WOW field site representativeness in terms of marine wildlife abundance. To achieve these objectives, I utilize an inter-species and intra-species analytic approach, where an inter-species analysis examines change within a species across seasons and an intra-species analysis examines change within a season across species. Better understanding current levels of marine wildlife abundance within wind energy sites, and how these levels compare to those within the Empire Wind and Vineyard Wind IRES study sites, could potentially inform future wind energy site planning. For example, if a wind energy lease site is characterized by a cetacean and seabird spatiotemporal distribution similar to that in a study site, field data collected this summer may be relevant or applicable to management decisions for that lease site.

METHODS

1. Acquiring & Processing BOEM Offshore Wind Energy Site Data

Data pertaining to BOEM offshore wind lease sites and planning areas were accessed via the Northeast Ocean Data Portal and downloaded via the Marine Cadaster data delivery system. The two downloaded shapefiles were merged and buffered by 10 kilometers in Jupyter Notebook using the ArcPy module (see *Script#1-Merge&BufferShapefiles.ipynb*). Although several updated versions of these shapefiles have become available since the inception of this project, all boundary updates have been made outside this projects' study area and thus have been ignored.

A 10-kilometer buffer was used to account for underwater sound traveling outside of lease site boundaries, as turbines may be built along the border of lease site boundaries. Additionally, because some sites border marine wildlife hotspots or migratory pathways while others are more isolated, a buffer allows my analysis to begin to account for these proximity differences. A 10-kilometer buffer was chosen specifically to stay consistent with similar ongoing project WOW analyses.

2. Acquiring & Processing Marine Wildlife Raster Data

Cetacean distribution products, created by Duke University's Marine Geospatial Ecology Lab using distance sampling and density surface modeling methods, were downloaded via the OBIS-SEAMAP Model Repository hosted by the Marine-Life Data and Analysis Team (MDAT). These distribution products were downloaded as monthly rasters with 25 square kilometer (5 km x 5 km) spatial resolution. The most recent versions of each cetacean model were utilized in this analysis, and are as follows: North Atlantic Right Whale (version 12); Fin Whale (version 12); Humpback Whale (version 11); and Common Minke Whale (version 10). Humpback Whale and North Atlantic Right Whale raster data were divided into three eras reflecting periods of varying population growth rates based on recent NOAA Fisheries stock assessment reports. For the Humpback Whale, these eras are: 2002-2008, 2002-2019 and 2009-2019. For the North Atlantic Right Whale, these eras are: 2003-2009, 2003-2019 and 2010-2019. Per recommendation of the metadata, both species' most recent eras were used in this analysis.

Avian distribution products, created by the Marine Spatial Ecology Division Biogeography Branch at NOAA's National Centers for Coastal Ocean Science, were also downloaded via the OBIS-SEAMAP Model Repository. The latest version of avian models (version 2) were downloaded as seasonal rasters with 4 square kilometer spatial resolution. The seasonal definitions used to create these models are: Winter (December 1st – February 28th/29th); Spring (March 1st – May 31st); Summer (June 1st – August 31st); and Fall (September 1st – November 30th).

For the sake of consistency, cetacean seasonal rasters were created using the same seasonal definitions as the avian distribution products. Consistent seasonal definitions make inter-species comparisons possible, although species-specific seasonal definitions would potentially enable a more robust look into seasonal movement and migration of cetaceans. Seasonal cetacean rasters were generated in Jupyter Notebook using the ArcPy module (see *Script#2-CreateSeasonalRasters.ipynb*) and all seasonal rasters, both avian and cetacean, were then masked to have the same extent.

3. Generating & Visualizing Zonal Statistics

Mean cetacean and avian abundances were calculated for each season within the buffered and merged offshore wind energy site shapefile. Mean abundance values were generated, as opposed to maximum abundance values, because this statistical measure is more representative of each offshore wind site as a whole. These abundance values are measured in number of individuals per 100 square kilometers and can be found in the *Raw Data* section in the appendix. Zonal statistic tables were generated in Jupyter Notebook using the ArcPy module (see *Script#3-RunZonalStatistics.ipynb*) and saved as database files. The GeoPandas module was then used in Jupyter Notebook (see *Script#4-CreateFinalShapefile.ipynb*) to add zonal statistics as attributes to the merged offshore wind energy site shapefile. Geopandas were also used in this script to add the latitude of each wind energy site's centroid as an attribute to the same shapefile. This was done to enable comparisons of zonal statistics on a latitudinal gradient. The merged offshore wind energy site shapefile was used for data visualizations, as opposed to the buffered and merged offshore wind energy site shapefile, in an effort to simplify data visuals.

Results from the intra-species analysis are visualized as maps using ArcGIS Pro, where each map illustrates the mean abundance of one species in each site in each season. Results from the inter-species analysis are visualized as tables using Microsoft Excel, where each table illustrates ratios of species-specific seasonal abundance relative to the yearly maximum. Here, the yearly maximum is the greatest amount of overlap observed between a species of interest and all wind energy areas over the entire duration of the year. Due to the large difference in spatial scale between certain wind energy planning areas and lease sites, the results below only include wind energy lease sites; results that mix wind energy lease sites with planning areas can be found in the *Additional Maps* and *Additional Tables* sections in the appendix.

RESULTS

1. Intra-species Analysis

Here I utilize an intra-species analysis to gain insight into where, when and how much spatial overlap exists between each species of interest and wind energy lease areas. By examining how the spatiotemporal distribution of each species of interest relates to wind energy lease sites, we develop a better understanding of how wind energy development may interact with marine environments. The figures below illustrate these intra-species analyses, where overlap is visualized as a mean abundance value (number of individuals per 100 square kilometers) within each lease site. Lease sites are purposely not labeled in an effort to simplify the data visuals (please reference Figure 1 for wind energy lease site labels).

A) Fin Whale

For each season, the wind energy lease site with the highest mean abundance of Fin whales is Ocean Winds East, LLC (lease number OCS-A 0537). This 290 square kiometer site is located in the New York Bight and is characterized by the following mean abundances of Fin whales during winter, spring, summer and fall months respectively: 0.27, 0.39, 0.58 and 0.35 individuals per 100 square kilometers. These values are fairly small compared to the highest overall density of Fin whales that we see along the US eastern seaboard (5.34 individuals per 100 square kilometers), which occurs in the summer along the outer edge of George's Bank. Other areas of high relative overlap can be seen in the summer months in the cluster of sites south of Martha's Vineyard in Massachusetts. Wind energy lease areas that have little to no mean abundance of Fin

whales include South Carolina during all seasons, as well as coastal sites in New Jersey, Delaware, and Maryland during summer and fall months.

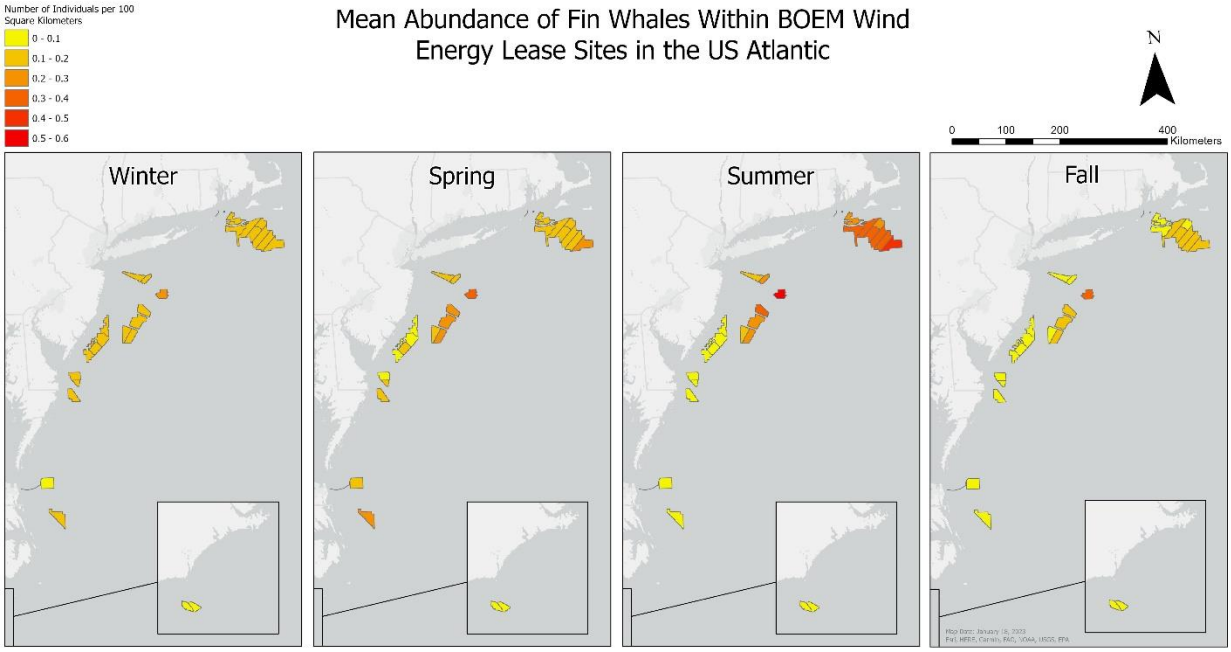

Figure 10. Mean abundance of Fin whales in US Atlantic BOEM wind energy lease sites

B) Common Minke Whale

The highest mean abundance of Minke whales within wind energy lease sites is 1.2 individuals per 100 square kilometers, and is seen in the Vineyard Northeast lease site (lease number OCS-A 0522) during summer months. Vineyard Northeast is located just south of Martha's Vineyard, Massachusetts and is a part of the cluster of wind energy lease sites that have comparable densities during summer and spring months. Vineyard Wind (lease number OCS-A 0501) is a part of this cluster and is where we observe the greatest overlap with Minke whales during spring months (with a mean abundance value of 1.01 individuals per 100 square kilometers). Outside of this cluster, wind energy lease sites in the New York Bight have high relative levels of Minke whale overlap particularly during spring months. Wind energy lease areas that consistently have little to no Minke whale overlap include South Carolina throughout the entire year, as well as coastal sites between New Jersey and Virginia during summer, fall and winter months. In the summer, the density of Minke whales can reach up to 4 individuals per 100 square kilometers along the coast of Maine and southern Nova Scotia; it is important to note that the Gulf of Maine

RFI Area A encompasses some of these areas (as seen in Figure 20 in the *Additional Maps* section in the appendix).

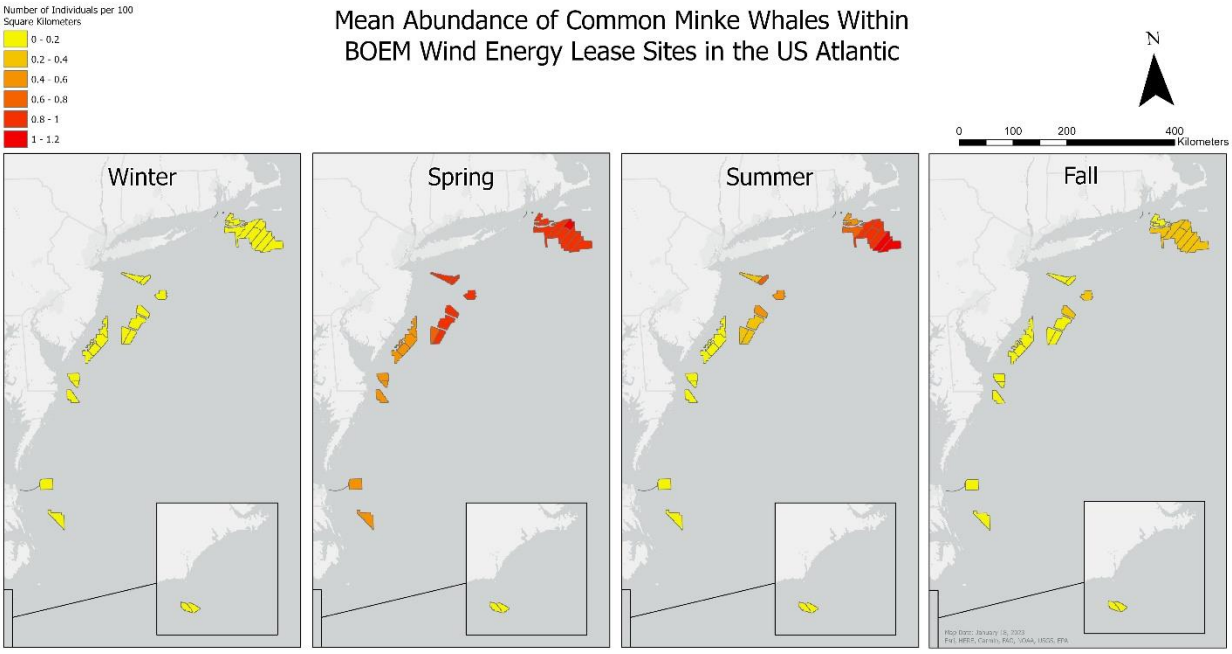

Figure 11. Mean abundance of Minke whales in US Atlantic BOEM wind energy lease sites

C) Humpback Whale

In the summer, the density of Humpback whales can reach 7.8 individuals per 100 square kilometers in the Gulf of Maine; these levels are significantly larger than the greatest overlap

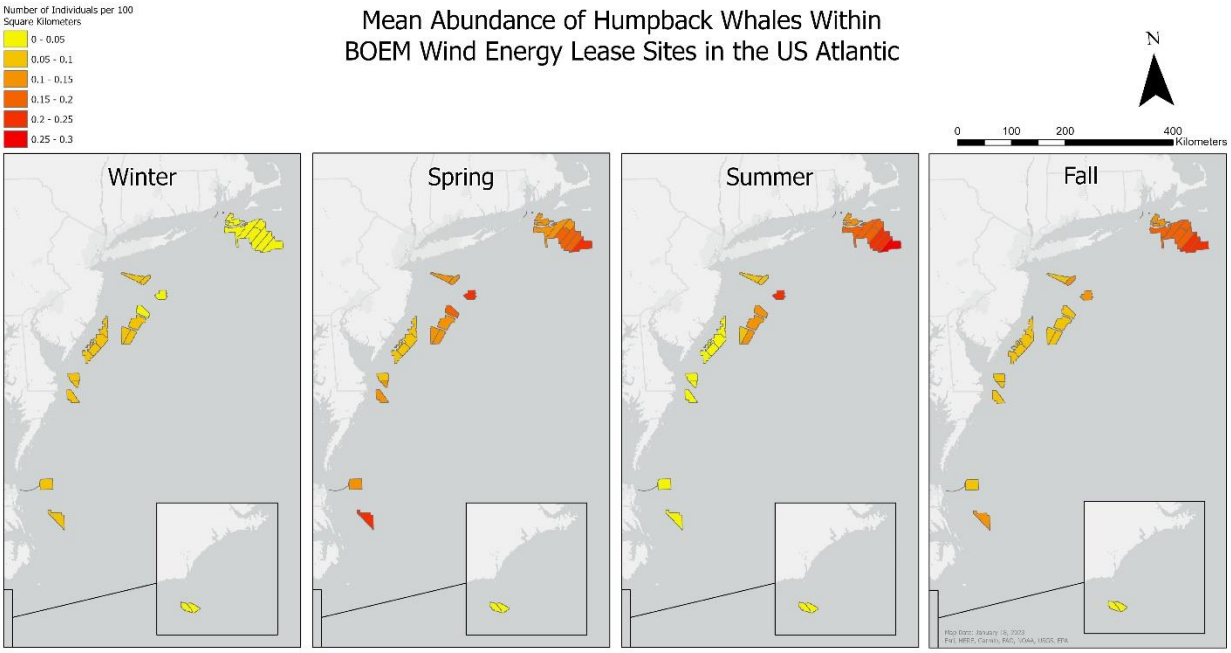

Figure 12. Mean abundance of Humpback whales in US Atlantic BOEM wind energy lease sites

observed within a lease site, which occurs in the Vineyard Northeast lease site during summer months (0.27 individuals per 100 square kilometers). This lease site is also where we observe the greatest amount of overlap during fall months, with a mean density of 0.23 individuals per 100 square kilometers. In the spring, we observe the greatest overlap with Humpback whales in Avangrid Renewables, LLC (lease number OCS-A 0508) with a mean density of 0.24 individuals per 100 square kilometers. This 495 square kilometer site is located in the northern Outer Banks near Kitty Hawk, North Carolina.

D) North Atlantic Right Whale

Overlap between Right whales and offshore wind areas is concentrated in sites around Massachusetts during winter and spring months. For each season, the wind energy lease site with the highest mean density of Right whales is Vineyard Northeast. This site is characterized by the following mean densities of Right whales during winter, spring, summer and fall months respectively: 0.96, 0.86, 0.11 and 0.14 individuals per 100 square kilometers. The maximum density of right whales observed in the US eastern seaboard (6.28 individuals per 100 square kilometers) occurs south of Nantucket Island, Massachusetts during the winter months; a 10-kilometer buffer of the Vineyard Northeast lease site abuts this area.

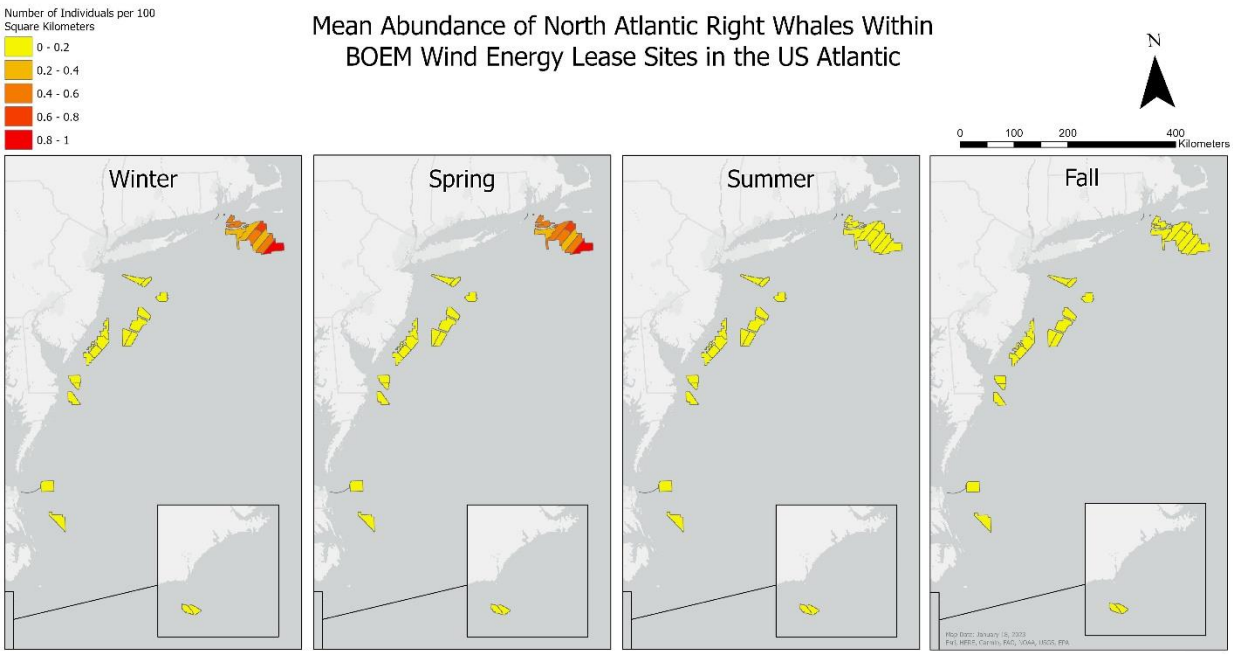

Figure 13. Mean abundance of Right whales in US Atlantic BOEM wind energy lease sites

E) Red-Throated Loon

The highest mean density of Red-throated loons found within wind energy lease sites is 0.29 individuals per 100 square kilometers, and is seen in the winter months in the Commonwealth of Virginia, Department of Mines, Minerals and Energy research site (lease number OCS-A 0497). It is important to note that the mean density of Red-throated loons is higher within this site partially because the spatial footprint of this site includes power cables that run to shore, and the Red-throated loon is typically found within coastal ocean waters during migration (Kaufman n.d.). In the summer, the density of Red-throated loons can reach over 6 individuals per 100 square kilometers along North Carolina's Outer Banks (specifically near Rodanthe, which is the northernmost village on Hatteras Island).

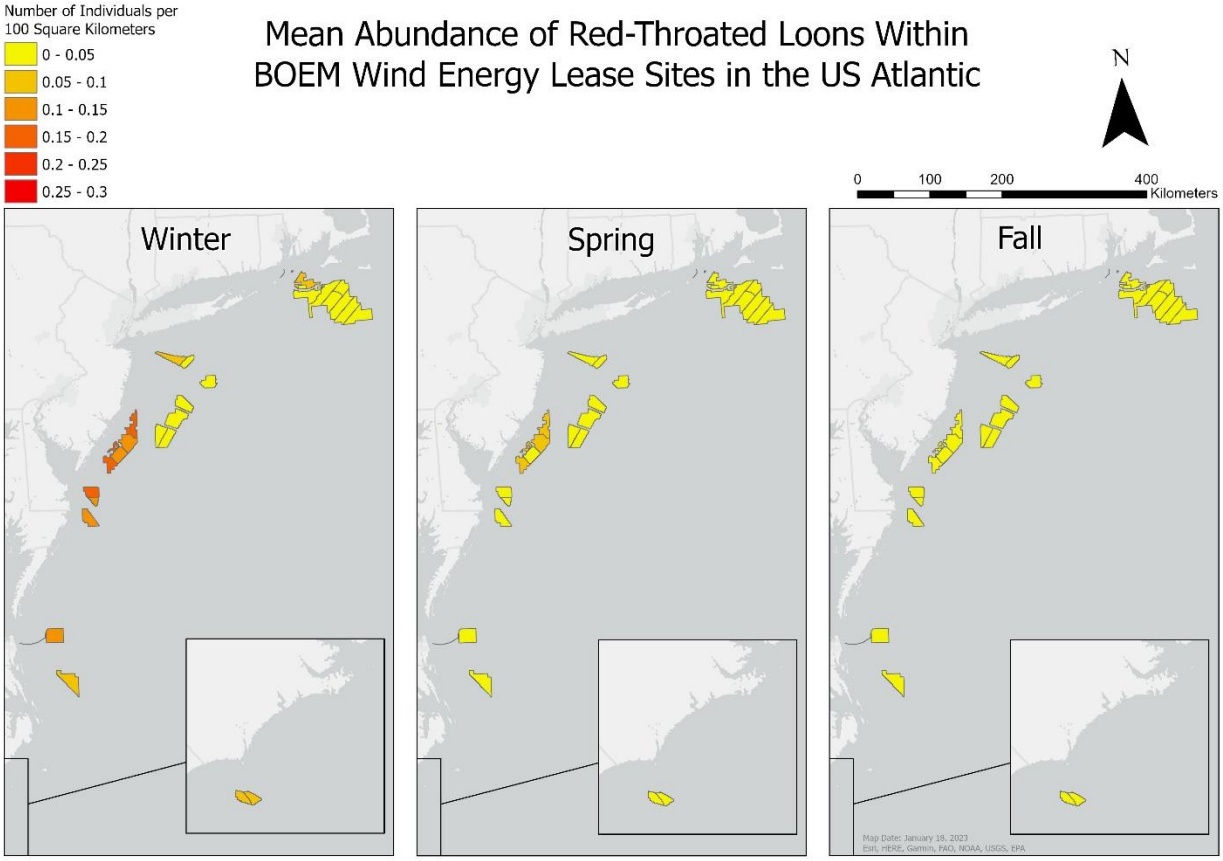

Figure 14. Mean abundance of Red-throated loons in US Atlantic BOEM wind energy lease sites

F) Northern Gannet

Similar to the Red-throated loon, the offshore wind energy site with the highest mean density of Northern gannets is the Commonwealth of Virginia, Department of Mines, Minerals and Energy

research site. Within this site, a mean density of 3.08 individuals per 100 square kilometers is observed during winter months and a mean density of 2.27 individuals per 100 square kilometers is observed during spring months. These values are small relative to the highest overall density of Northern gannets that we see along the US eastern seaboard (47.24 individuals per 100 square kilometers), which occurs in the spring near Cape Lookout, North Carolina. As seen in Fig. 8, Northern gannet populations reduce dramatically during summer and fall months due to migration which is reflected in the significant reduction of overlap in wind energy lease sites during these months.

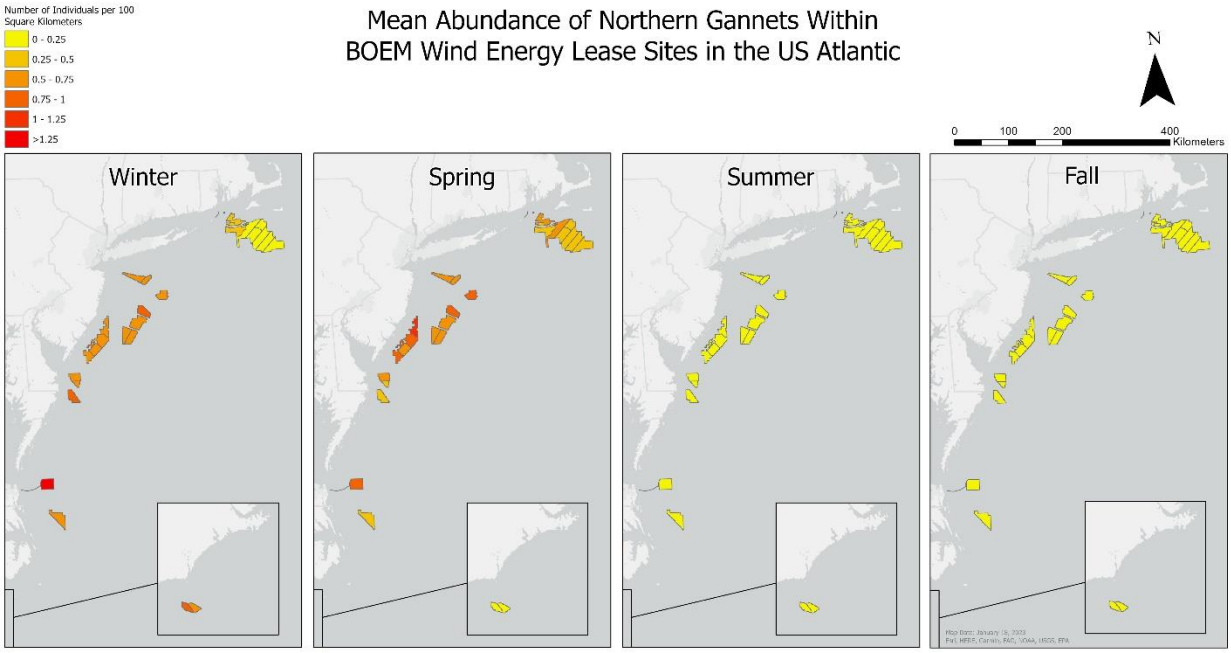

Figure 15. Mean abundance of Northern gannets in US Atlantic BOEM wind energy lease sites

G) Great Black-Backed Gull

For each season, the wind energy lease site with the highest mean density of Great black-backed gulls is owned by the Narraganset Electric Company (lease number OCS-A 0506) which was granted for the installation of a submarine transmission cable to deliver electricity from Rhode Island's Block Island wind farm to shore. Within this lease, the mean densities of Great black-backed gulls during winter, spring, summer and fall months are 0.23, 0.14, 0.15 and 0.25 individuals per 100 square kilometers respectively. These levels are fairly low compared to the

maximum density of Great black-backed gulls observed in the US eastern seaboard (5.6 individuals per 100 square kilometers) which occurs in the fall in the Gulf of Maine.

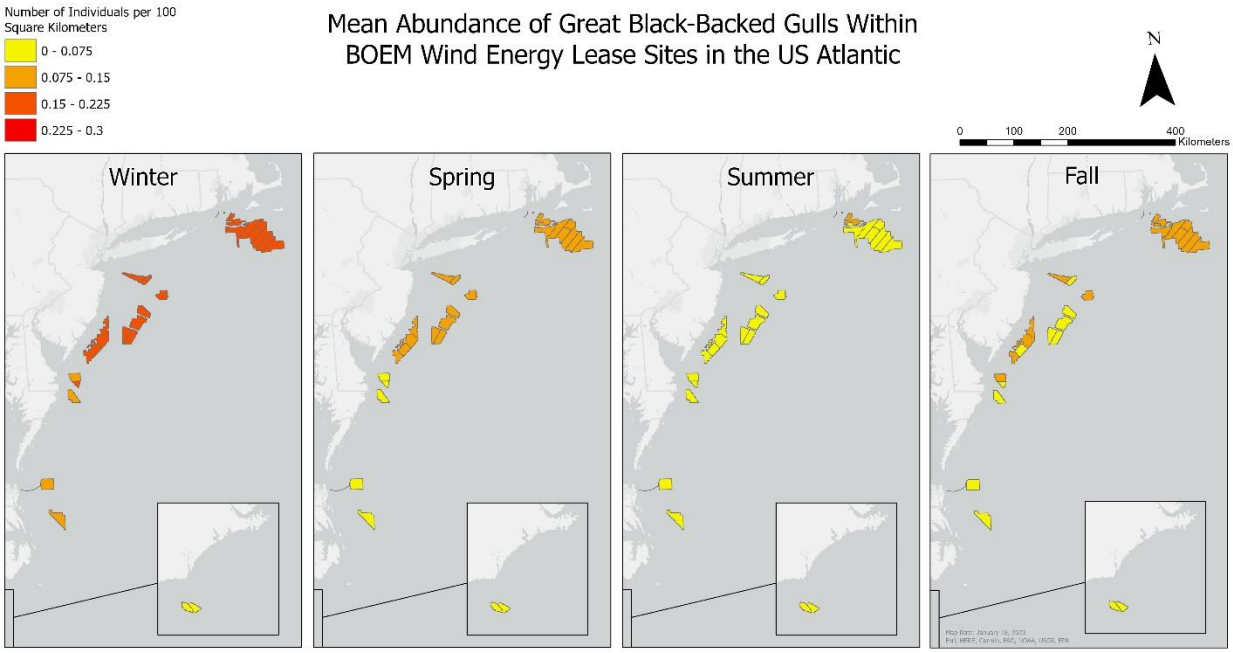

Figure 16. Mean abundance of Great black-backed gulls in US Atlantic BOEM wind energy lease sites

2. Inter-species Comparisons

Here, I conduct an inter-species analysis to provide insight into my second research question: how representative are project WOW field sites to other lease areas in terms of marine wildlife abundance? Better understanding how similar or dissimilar lease sites are in terms of wildlife abundance provides insight into how relevant or applicable project WOW field data will be in decision-making for other lease sites. For example, if the spatiotemporal distribution of marine wildlife in Vineyard Wind is found to be similar to that in Ocean Winds East (a lease site near New Jersey), then field data collected over the summer may be insightful for planning in Ocean Winds East. The tables below illustrate this inter-species analysis using ratios of seasonal abundance to the yearly maximum, where the yearly maximum represents the greatest density of each species observed within a wind energy lease site. These ratios are visualized as a heap map where a green cell suggests lower mean abundance relative to the yearly maximum and a red cell suggests greater mean abundance relative to the yearly maximum.

A) Winter Season

Results from this analysis suggest that out of all seasons, the greatest amount of overlap between the following species and wind energy lease sites occurs during winter months: Right whales, Northern gannets and Red-throated. For Right whales, this overlap occurs in Vineyard Northeast LLC (0.96 individuals per 100 square kilometers) and for Northern gannets and Red-throated loons this occurs in the Commonwealth of Virginia, Department of Mines, Minerals and Energy research site (3.08 and 0.29 individuals per 100 square kilometers respectively). Aside from Right whales, which tend to be concentrated in more northerly sites with latitudes around 41°, there is little abundance of baleen whales in the winter months relative to respective yearly maximums. In terms of seabirds, there seems to be a latitudinal gradient for Northern gannets and Red-throated loons where greater abundance levels are observed in southern sites compared to northern sites. High abundance levels of Great black-backed gulls relative to the yearly maximum are observed in all sites except for those furthest south, near the coastal border of North Carolina and South Carolina.

In Vineyard Wind, winter months may be characterized by low levels of the following species relative to respective yearly maximums: Fin whales, Minke whales, Humpback whales, Red-throated loons and Northern gannets; Vineyard Wind may also be characterized by high levels of

Winter Abundance to Yearly Maximum: Species-Specific Mean Abundance Ratios Within BOEM Wind Energy Lease Sites in the US Atlantic

Area ID	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Red-Throated Loon	Northern Gannet	Great Black-Backed Gull
OCS-A 0506 - The Narragansett Electric Company	41.27	0.26	0.04	0.18	0.17	0.27	0.09	0.89
OCS-A 0486 - Revolution Wind, LLC	41.15	0.32	0.09	0.16	0.48	0.18	0.10	0.87
OCS-A 0517 - South Fork Wind, LLC	41.09	0.32	0.10	0.16	0.44	0.15	0.11	0.86
OCS-A 0501 - Vineyard Wind LLC	41.04	0.29	0.12	0.15	0.73	0.15	0.07	0.73
OCS-A 0487 - Sunrise Wind LLC	40.99	0.31	0.08	0.13	0.31	0.12	0.10	0.81
OCS-A 0500 - Bay State Wind LLC	40.97	0.30	0.10	0.12	0.41	0.12	0.08	0.76
OCS-A 0534 - Park City Wind LLC	40.90	0.30	0.10	0.11	0.43	0.11	0.08	0.72
OCS-A 0520 - Beacon Wind LLC	40.82	0.30	0.09	0.10	0.38	0.11	0.07	0.71
OCS-A 0521 - Mayflower Wind Energy LLC	40.75	0.31	0.08	0.10	0.50	0.12	0.07	0.70
OCS-A 0522 - Vineyard Northeast LLC	40.68	0.32	0.09	0.11	1.00	0.11	0.07	0.69
OCS-A 0512 - Empire Offshore Wind, LLC	40.30	0.26	0.05	0.32	0.09	0.33	0.19	0.85
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	40.24	0.29	0.06	0.26	0.11	0.15	0.20	0.88
OCS-A 0537 - OW Ocean Winds East, LLC	39.98	0.45	0.09	0.17	0.07	0.10	0.20	0.82
OCS-A 0538 - Attentive Energy LLC	39.72	0.32	0.06	0.17	0.06	0.11	0.24	0.84
OCS-A 0539 - Community Offshore Wind, LLC	39.54	0.31	0.06	0.20	0.08	0.11	0.24	0.86
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	39.47	0.24	0.03	0.36	0.06	0.58	0.17	0.71
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	39.36	0.29	0.05	0.23	0.09	0.13	0.21	0.85
OCS-A 0542 - Invenergy Wind Offshore LLC	39.30	0.33	0.06	0.19	0.10	0.11	0.21	0.86
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	39.27	0.25	0.04	0.34	0.07	0.47	0.18	0.71
OCS-A 0498 - Ocean Wind LLC	39.12	0.27	0.04	0.34	0.06	0.42	0.17	0.70
OCS-A 0532 - Orsted North America Inc.	39.07	0.24	0.04	0.36	0.08	0.59	0.19	0.67
OCS-A 0482 - GSOE I LLC	38.67	0.24	0.04	0.32	0.10	0.54	0.18	0.58
OCS-A 0519 - Skipjack Offshore Energy LLC	38.57	0.28	0.05	0.28	0.07	0.42	0.19	0.60
OCS-A 0490 - US Wind Inc.	38.35	0.30	0.06	0.29	0.07	0.49	0.28	0.54
OCS-A 0483 - Virginia Electric and Power Company	36.91	0.17	0.04	0.29	0.10	0.39	0.46	0.55
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	36.89	0.12	0.03	0.33	0.11	1.00	1.00	0.59
OCS-A 0508 - Avangrid Renewables LLC	36.34	0.28	0.07	0.33	0.02	0.32	0.19	0.53
OCS - A 0545 - TotalEnergies Renewables USA, LLC	33.45	0.00	0.00	0.01	0.02	0.26	0.26	0.25
OCS - A 0546 - Duke Energy Renewables Wind, LLC	33.45	0.00	0.00	0.01	0.01	0.26	0.24	0.25

Table 1. Winter abundance to yearly maximum: Mean abundance ratios in US Atlantic BOEM wind energy lease sites

Right whales and Great black-backed relative to respective yearly maximums. This pattern is comparable to other wind energy lease sites in northern waters especially with centroid latitudes between 41.15° and 40.68°. In Empire Offshore Wind, winter months may be characterized by low levels of each species of interest except for the Great black-backed gull (which we observe in a high relative density). This pattern is comparable to sites in the New York Bight, with latitudes between 40.24° and 38.35°, although there is some deviation in representativeness with the Red-throated loon.

B) Spring Season

Out of the entire year, Spring is the only season when we see no instances of maximum overlap between species of interest and wind energy lease sites (in other words, there are no ratio values of 1). However, except for the Red-throated loon, there are still medium to high density levels for each species of interest. For baleen whales, this overlap seems to be spread across the map: in sites near Massachusetts, there is notable overlap of Minke, Humpback and Right whales and in sites near the New York Bight, there is notable overlap of Fin, Minke and Humpback whales. For the Red-throated loon, spring density relative to the yearly maximum is low in all sites, especially those further north. This pattern is similar to that for the Northern gannet, although there are generally more Northern gannets across the map compared to Red-throated loons.

Spring Abundance to Yearly Maximum: Species-Specific Mean Abundance Ratios Within BOEM Wind Energy Lease Sites in the US Atlantic

Area ID	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Red Throated Loon	Northern Gannet	Great Black-Backed Gull
OCS-A 0506 - The Narragansett Electric Company	41.27	0.20	0.50	0.34	0.16	0.13	0.21	0.55
OCS-A 0486 - Revolution Wind, LLC	41.15	0.30	0.72	0.42	0.49	0.08	0.17	0.47
OCS-A 0517 - South Fork Wind, LLC	41.09	0.31	0.75	0.38	0.48	0.05	0.15	0.47
OCS-A 0501 - Vineyard Wind LLC	41.04	0.29	0.83	0.51	0.74	0.08	0.15	0.44
OCS-A 0487 - Sunrise Wind LLC	40.99	0.31	0.73	0.48	0.35	0.04	0.16	0.48
OCS-A 0500 - Bay State Wind LLC	40.97	0.32	0.74	0.53	0.45	0.05	0.17	0.47
OCS-A 0534 - Park City Wind LLC	40.90	0.31	0.75	0.57	0.47	0.05	0.16	0.46
OCS-A 0520 - Beacon Wind LLC	40.82	0.32	0.70	0.62	0.41	0.05	0.16	0.45
OCS-A 0521 - Mayflower Wind Energy LLC	40.75	0.34	0.66	0.65	0.48	0.05	0.16	0.42
OCS-A 0522 - Vineyard Northeast LLC	40.68	0.37	0.67	0.75	0.90	0.05	0.15	0.38
OCS-A 0512 - Empire Offshore Wind, LLC	40.30	0.25	0.69	0.40	0.08	0.07	0.20	0.48
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	40.24	0.33	0.76	0.45	0.11	0.04	0.17	0.53
OCS-A 0537 - OW Ocean Winds East, LLC	39.98	0.68	0.71	0.80	0.11	0.02	0.24	0.47
OCS-A 0538 - Attentive Energy LLC	39.72	0.43	0.73	0.59	0.08	0.02	0.27	0.53
OCS-A 0539 - Community Offshore Wind, LLC	39.54	0.37	0.68	0.53	0.09	0.02	0.22	0.42
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	39.47	0.15	0.44	0.35	0.04	0.26	0.39	0.43
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	39.36	0.32	0.64	0.47	0.09	0.03	0.18	0.37
OCS-A 0542 - Invenergy Wind Offshore LLC	39.30	0.41	0.68	0.54	0.11	0.02	0.20	0.33
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	39.27	0.16	0.43	0.33	0.04	0.21	0.29	0.35
OCS-A 0498 - Ocean Wind LLC	39.12	0.17	0.41	0.35	0.04	0.14	0.23	0.30
OCS-A 0532 - Orsted North America Inc.	39.07	0.15	0.34	0.31	0.04	0.20	0.32	0.31
OCS-A 0482 - GSOE I LLC	38.67	0.17	0.36	0.35	0.04	0.13	0.17	0.15
OCS-A 0519 - Skipjack Offshore Energy LLC	38.57	0.18	0.41	0.44	0.04	0.09	0.12	0.08
OCS-A 0490 - US Wind Inc.	38.35	0.23	0.42	0.48	0.05	0.11	0.16	0.09
OCS-A 0483 - Virginia Electric and Power Company	36.91	0.19	0.36	0.48	0.07	0.07	0.27	0.04
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	36.89	0.11	0.20	0.32	0.04	0.25	0.74	0.08
OCS-A 0508 - Avangrid Renewables LLC	36.34	0.48	0.35	0.89	0.02	0.03	0.16	0.02
OCS - A 0545 - TotalEnergies Renewables USA, LLC	33.45	0.00	0.00	0.01	0.01	0.05	0.06	0.01
OCS - A 0546 - Duke Energy Renewables Wind, LLC	33.45	0.00	0.00	0.01	0.01	0.04	0.05	0.01

Table 2. Spring abundance to yearly maximum: Mean abundance ratios in US Atlantic BOEM wind energy lease sites

One lease site with notable Northern gannet overlap is the Commonwealth of Virginia, Department of Mines, Minerals and Energy research site, which is characterized by a density of 2.27 Northern gannets per 100 square kilometers during spring months. Contrary to trends observed with the distribution of Red-throated loons and Northern gannets, the density of Great black-backed gulls tends to be greater in sites further north and lower in sites further south.

In the spring, Vineyard Wind may be characterized by low levels of Red-throated loons, Northern Gannets and Fin whales, medium levels of Humpback whales and Great black-backed gulls and high abundance levels for Right whales and Minke whales. Again, these levels are all relative to the maximum amount of overlap observed in any site for each species of interest. These relative levels of marine wildlife are similar to those observed in other lease sites near Massachusetts and, excluding the Right Whale, to those observed in Empire Wind.

C) Summer Season

In the summer months, we observed the greatest amount of overlap between the following species and wind energy lease sites: Fin whales, Minke whales and humpback whales. For Fin whales, this overlap is observed in the Ocean Winds East lease site (lease number OCS-A 0537)

Summer Abundance to Yearly Maximum: Species-Specific Mean Abundance Ratios Within BOEM Wind Energy Lease Sites in the US Atlantic

Area ID	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Northern Gannet	Great Black-Backed Gull
OCS-A 0506 - The Narragansett Electric Company	41.27	0.15	0.23	0.26	0.01	0.00	0.58
OCS-A 0486 - Revolution Wind, LLC	41.15	0.38	0.46	0.42	0.03	0.00	0.30
OCS-A 0517 - South Fork Wind, LLC	41.09	0.49	0.55	0.41	0.03	0.00	0.27
OCS-A 0501 - Vineyard Wind LLC	41.04	0.48	0.80	0.57	0.05	0.00	0.23
OCS-A 0487 - Sunrise Wind LLC	40.99	0.61	0.64	0.56	0.02	0.00	0.21
OCS-A 0500 - Bay State Wind LLC	40.97	0.55	0.66	0.63	0.03	0.00	0.17
OCS-A 0534 - Park City Wind LLC	40.90	0.56	0.76	0.69	0.03	0.00	0.18
OCS-A 0520 - Beacon Wind LLC	40.82	0.60	0.81	0.76	0.03	0.00	0.15
OCS-A 0521 - Mayflower Wind Energy LLC	40.75	0.63	0.85	0.84	0.05	0.00	0.12
OCS-A 0522 - Vineyard Northeast LLC	40.68	0.74	1.00	1.00	0.11	0.00	0.10
OCS-A 0512 - Empire Offshore Wind, LLC	40.30	0.25	0.31	0.20	0.00	0.00	0.12
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	40.24	0.50	0.50	0.33	0.01	0.00	0.07
OCS-A 0537 - OW Ocean Winds East, LLC	39.98	1.00	0.48	0.88	0.01	0.00	0.03
OCS-A 0538 - Attentive Energy LLC	39.72	0.59	0.38	0.47	0.00	0.00	0.04
OCS-A 0539 - Community Offshore Wind, LLC	39.54	0.38	0.30	0.38	0.00	0.00	0.03
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	39.47	0.07	0.06	0.10	0.00	0.01	0.22
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	39.36	0.27	0.26	0.29	0.00	0.00	0.02
OCS-A 0542 - Invenergy Wind Offshore LLC	39.30	0.44	0.31	0.40	0.01	0.00	0.02
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	39.27	0.08	0.08	0.09	0.00	0.01	0.11
OCS-A 0498 - Ocean Wind LLC	39.12	0.09	0.08	0.10	0.00	0.00	0.05
OCS-A 0532 - Orsted North America Inc.	39.07	0.07	0.05	0.07	0.00	0.00	0.10
OCS-A 0482 - GSOE I LLC	38.67	0.07	0.05	0.10	0.00	0.00	0.05
OCS-A 0519 - Skipjack Offshore Energy LLC	38.57	0.09	0.06	0.14	0.00	0.00	0.02
OCS-A 0490 - US Wind Inc.	38.35	0.10	0.07	0.16	0.00	0.00	0.02
OCS-A 0483 - Virginia Electric and Power Company	36.91	0.07	0.02	0.09	0.00	0.00	0.01
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	36.89	0.03	0.01	0.04	0.00	0.00	0.01
OCS-A 0508 - Avangrid Renewables LLC	36.34	0.14	0.02	0.18	0.00	0.00	0.01
OCS - A 0545 - TotalEnergies Renewables USA, LLC	33.45	0.00	0.00	0.00	0.00	0.00	0.00
OCS - A 0546 - Duke Energy Renewables Wind, LLC	33.45	0.00	0.00	0.00	0.00	0.00	0.00

Table 3. Summer abundance to yearly maximum: Mean abundance ratios in US Atlantic BOEM wind energy lease sites

and for Minke and Humpback whales this overlap is observed in the Vineyard Northeast lease site. All lease sites north of the 40.68° latitude mark are characterized by high levels of overlap for these three baleen whales, although the magnitude of this overlap reduces gradually as latitude increases. The only notable overlap observed between seabirds and lease sites occurs in the northernmost sites for the Great black-backed gull. Aside from this area, there is little to no overlap in the summer months between wind energy lease sites and seabird species of interest.

Vineyard Wind during summer months may be characterized by low relative levels of Right whales, Northern gannets and Great black-backed gulls, medium levels of Fin whales and Humpback whales, and a high relative level of Minke whales. This pattern is similar to that observed in other sites north of the 40.68° latitude mark, although this becomes less true for Fin whales and Humpback whales as latitude decreases (overlap becomes greater than that observed in Vineyard Wind). Empire Wind during summer months may be characterized by low relative levels of all species of interest, although Table 3 should be referenced for species-specific comparisons as this classification may be too generalizing. This pattern is similar to other sites in the New York Bight, except for the Ocean Winds East lease site where we observe a spike in Fin whale and Humpback whale relative abundance. No overlap is observed between any species of interest and the two lease sites off the coastal border of North and South Carolina.

C) Fall Season

During the fall months, we generally observe less overlap between the following species of interest and wind energy lease areas: Fin whales, Minke whales, Right whales and Northern gannets. This trend is consistent across the map, except for Ocean Winds East where we observe a notable spike in overlap relative to the yearly maximum for Fin whales. For Humpback whales, high levels of overlap are observed in lease sites north of the 40.68° latitude mark, although the magnitude of this overlap reduces gradually as latitude increases. Medium to low levels of Humpback whale abundance are also observed in all sites south of the 40.68° latitude mark, and the two southernmost lease sites are both characterized by no Humpback whale overlap. For the Great black-backed gull, there seems to be a change in overlap along a latitudinal gradient. The northernmost site (Narragansett Electric Company) is where we observe the greatest amount of overlap observed between these gulls and lease sites out of the entire year; as latitudes decrease, relative density of Great black-backed gulls consistently decreases.

In the fall, Vineyard Wind can be characterized by medium relative levels of Humpback whales and Great black-backed gulls and low levels of all other species of interest. Except for the Narragansett Electric Company, which is where we see the greatest amount of observed overlap for the Great black-backed gull, Vineyard Wind is characterized by a spatiotemporal distribution of species of interest that is similar to that in other lease sites north of the 40.68° latitude mark. Empire Wind is characterized by mid to low levels of Humpback whales and Great black-backed gulls, and very low levels of Fin whales, Minke whales, Right whales, Red-throated loons and Northern gannets. This characterization is generally similar to that in other lease sites in the New York Bight, although the Ocean Winds East lease site is again the exception (as this is where we observe a spike in Fin whales and Humpback whales).

Fall Abundance to Yearly Maximum: Species-Specific Mean Abundance Ratios Within BOEM Wind Energy Lease Sites in the US Atlantic

Area ID	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Red Throated Loon	Norther Gannet	Great Black-Backed Gull
OCS-A 0506 - The Narragansett Electric Company	41.27	0.06	0.05	0.43	0.02	0.01	0.04	1.00
OCS-A 0486 - Revolution Wind, LLC	41.15	0.10	0.11	0.51	0.06	0.01	0.03	0.53
OCS-A 0517 - South Fork Wind, LLC	41.09	0.11	0.13	0.45	0.05	0.01	0.02	0.50
OCS-A 0501 - Vineyard Wind LLC	41.04	0.11	0.21	0.63	0.10	0.01	0.03	0.36
OCS-A 0487 - Sunrise Wind LLC	40.99	0.17	0.22	0.57	0.04	0.00	0.02	0.42
OCS-A 0500 - Bay State Wind LLC	40.97	0.18	0.24	0.63	0.05	0.00	0.02	0.38
OCS-A 0534 - Park City Wind LLC	40.90	0.17	0.26	0.70	0.06	0.00	0.02	0.36
OCS-A 0520 - Beacon Wind LLC	40.82	0.21	0.30	0.73	0.05	0.00	0.02	0.36
OCS-A 0521 - Mayflower Wind Energy LLC	40.75	0.23	0.30	0.76	0.07	0.00	0.02	0.36
OCS-A 0522 - Vineyard Northeast LLC	40.68	0.24	0.32	0.86	0.14	0.00	0.02	0.35
OCS-A 0512 - Empire Offshore Wind, LLC	40.30	0.08	0.06	0.35	0.01	0.01	0.01	0.31
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	40.24	0.11	0.09	0.37	0.01	0.00	0.01	0.28
OCS-A 0537 - OW Ocean Winds East, LLC	39.98	0.61	0.27	0.52	0.01	0.00	0.01	0.30
OCS-A 0538 - Attentive Energy LLC	39.72	0.29	0.17	0.32	0.01	0.00	0.01	0.27
OCS-A 0539 - Community Offshore Wind, LLC	39.54	0.17	0.11	0.30	0.01	0.00	0.01	0.25
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	39.47	0.06	0.03	0.25	0.01	0.01	0.02	0.39
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	39.36	0.11	0.07	0.26	0.01	0.00	0.01	0.22
OCS-A 0542 - Invenergy Wind Offshore LLC	39.30	0.18	0.11	0.30	0.01	0.00	0.01	0.22
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	39.27	0.06	0.03	0.21	0.01	0.01	0.02	0.33
OCS-A 0498 - Ocean Wind LLC	39.12	0.06	0.03	0.22	0.01	0.01	0.02	0.26
OCS-A 0532 - Orsted North America Inc.	39.07	0.05	0.02	0.19	0.01	0.01	0.03	0.41
OCS-A 0482 - GSOE I LLC	38.67	0.05	0.02	0.22	0.01	0.01	0.01	0.43
OCS-A 0519 - Skipjack Offshore Energy LLC	38.57	0.06	0.03	0.29	0.01	0.01	0.01	0.18
OCS-A 0490 - US Wind Inc.	38.35	0.07	0.02	0.32	0.01	0.01	0.01	0.24
OCS-A 0483 - Virginia Electric and Power Company	36.91	0.04	0.01	0.21	0.01	0.00	0.00	0.10
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	36.89	0.03	0.01	0.13	0.01	0.01	0.01	0.21
OCS-A 0508 - Avangrid Renewables LLC	36.34	0.13	0.02	0.37	0.00	0.00	0.00	0.08
OCS - A 0545 - TotalEnergies Renewables USA, LLC	33.45	0.00	0.00	0.00	0.00	0.00	0.00	0.04
OCS - A 0546 - Duke Energy Renewables Wind, LLC	33.45	0.00	0.00	0.00	0.00	0.00	0.00	0.04

Table 4. Fall abundance to yearly maximum: Mean abundance ratios in US Atlantic BOEM wind energy lease sites

DISCUSSION

This project utilizes geospatial tools to provide insight into two research questions: First, where when and to what extent do species of interest overlap with wind energy sites in the U.S. Atlantic? Secondly, how representative are project WOW field sites to other wind energy areas

in terms of marine wildlife abundance? To understand how the results from this analysis provide insight into these two research questions, it is helpful to contextualize these results and identify spatial and temporal patterns that serve as key takeaways. Here, I examine said spatiotemporal patterns, and evaluate what conclusions may be drawn versus what additional work is required to fully understand the ecological significance of these findings.

1. Cetaceans

Overlap hot spots between baleen whales and offshore wind lease sites are typically found in northern latitudes, often in the cluster of sites near Martha's Vineyard, Massachusetts. For Minke whales, Humpback whales and Right whales, the highest amount of overlap observed out of the entire year occurs within this cluster, specifically in the Vineyard Northeast lease site. Vineyard Northeast encompasses a 536 square kilometer swath of the Northeast US Atlantic Ocean, which is an area that is slightly smaller than the city of Chicago, Illinois. By multiplying our density values to meet the size of Vineyard Northeast, we predict the following number of baleen whales within this least site: 6.5 Minke whales (during the summer), 1.46 Humpback whales (during the summer) and 5.13 Right whales (during the winter). Again, these numbers are the greatest densities (in this case is measured by number of species per 536 square kilometers) observed for these species out of all sites and seasons.

Outside of this cluster, Ocean Winds East is another lease site characterized by notable levels of overlap especially for Fin whales and Humpback whales during summer months. At 306 square kilometers, Ocean Winds East is similar in size to Dublin, Ireland and is where we observe the greatest density for Fin whales out of all sites and seasons. By similarly multiplying our density values to meet Ocean Winds East's area, we predict 1.76 Fin whales and 0.73 Humpback whales within this lease site during summer months.

One of the most important questions left unanswered by this work is whether or not these abundance values are noteworthy or raise ecological concern. For example, the greatest density of Humpback whales predicted within wind energy lease sites is 0.27 individuals per 100 square kilometers and the greatest density of Humpback whales predicted in the US Atlantic is 7.8 individuals per 100 square kilometers. This begs the question of whether the predicted overlap is

ecologically noteworthy or worrisome? Examining this question is outside the scope of this project as it requires further analysis into topics such as endangerment status, breeding productivity and adult survival rates for each species of interest. With that said, by quantifying when, where and to what extent species of interest overlap with wind energy areas, this project provides necessary information for answering this question.

Although additional work must be done to evaluate the ecological significance of these findings, several conclusions can be drawn in the larger context of offshore wind energy development. For example, data suggest that there may be more instances of high relative overlap for Minke whales and Right whales compared to Fin whales and Humpback whales. Moreover, out of all the cetacean species of interest, the Right whale is the only species that is listed as critically endangered under the ESA and that, in certain areas and times of the year, exhibits higher levels of relative overlap with wind energy lease sites. These findings are crucial for planning appropriate mitigation measures to ensure the sustainability and long-term viability of offshore wind energy projects. Examples of mitigation measures for cetaceans may involve seasonal closures for pile driving or utilizing bubble curtains to minimize underwater noise pollution (Verfuss et al. 2016).

In addition to spatial patterns, broad temporal patterns also exist across cetacean species of interest and wind energy area overlap, especially for Fin whales, Minke whales and Humpback whales. For these three species, we predict low levels of overlap during the winter (across all sites), higher levels during the spring (mostly in northern sites), highest levels during the summer (mostly in northern sites), and then a mix of various levels during the fall. Due to differences in migration patterns, these temporal patterns are not applicable to the Right whale. Instead, for the Right whale, we predict high levels of overlap in northern sites during the winter (when we see very little overlap with other baleen species of interest), and low levels of overlap across all sites during the summer (when we see high relative levels of overlap between other baleen whales and northern sites). Examining differences in the timing of overlap is important for more responsible scheduling of pile driving and other activities that produce potentially disruptive underwater noise.

2. Seabirds

Results from this analysis suggest that the greatest densities of seabird overlap occur within the two wind energy lease sites that are the smallest, closest to shore, and that are primarily characterized by transmission cable footprints. For the Northern gannet and the Red-throated loon, the greatest amount of observed overlap occurs in the Commonwealth of Virginia Dept of Mines, Minerals and Energy research site, which is a pilot project consisting of two wind turbines and export cables running to the Virginia Beach coastline. This site, also known as the Coastal Virginia Offshore Wind (CVOW) project, has been operational since Fall 2020 and is intended to guide future development within adjacent lease areas (BOEM n.d.). During summer months, we predict a density of 3.08 Northern gannets and 0.29 Red-throated loons per 100 square kilometers within this site; as this site is 8.64 kilometers squared in size (smaller than the Los Angeles International Airport), we predict to see 0.27 Northern gannets and 0.03 Red-throated loons within this site at this time.

The Narragansett Electric Company site is a right-of-way grant near Narragansett, Rhode Island and is where we predict the greatest density of Great-black backed gulls out of all lease sites and in every season (with maximum density reaching 0.25 individuals per 100 square kilometers during summer months). When thinking about potential repercussions of this overlap, it is important to note that we will not see turbines within this lease site and that instead this area strictly indicates transmission cable routing. In other words, displacement or collision events may be less relevant to this area, because all of the development that takes place at this site occurs underwater and these phenomena typically involve the physical structure of a wind turbine (Firestone et al. 2018).

In addition to spatial patterns, the Northern gannet and Red-throated loon exhibit similar temporal patterns of overlap with wind energy areas. For both species, high levels of relative overlap are predicted in the winter (namely in CVOW), mid to low levels are predicted in the spring (in CVOW) and low levels of relative overlap are predicted in the summer and fall across all sites. The Great black-backed gull exhibits more consistent levels of overlap from both a spatial and temporal standpoint, where high relative levels are predicted in more northern sites and less in southern sites. This pattern is evident in all seasons, although overlap with northern

sites is particularly high in winter months. Results from this analysis suggest that, purely from the standpoint of seabird impact mitigation, wind turbine maintenance operations should occur during the winter months when we predict high relative densities of all seabird species of interest within wind energy lease areas. Minimizing the amount of time that turbines are operational during winter months may decrease the amount of collision events, although the risk of displacement would persist.

As is the case with cetacean species of interest, results from this analysis do not answer the question of whether predicted overlap between seabirds and wind energy lease areas is ecologically significant. Again, although answering this question is outside the scope of this work, this analysis helps facilitate a more informed conversation about ecological significance by providing insight into potential levels of exposure from a spatial and temporal standpoint. Results from this analysis suggest that there may be more instances of high density overlap for the Northern Gannet within wind energy lease sites compared to the Red-throated loon and the Great black-backed gull. Moreover, results from this analysis suggest that for seabird species of interest, greater relative levels of overlap may be more likely in lease sites that are in close proximity to the coast. These findings provide important insight into where and when seabird species of interest will likely interact with wind energy development in the US Atlantic.

3. Conclusion

This project aimed to examine spatiotemporal overlap between species of interest and wind energy sites in the U.S. Atlantic, as well as to assess the representativeness of Project WOW field sites to other wind energy areas in terms of marine wildlife abundance. Two important patterns, particularly relevant to the second research question, emerged. First, the mean densities of species of interest within Vineyard Wind tend to be similar to those in other sites just south of Massachusetts, although there are exceptions to this pattern and Tables 1 - 4 above should be referenced for site-specific comparisons of marine wildlife abundance. Secondly, mean density values within Empire Wind tend to be similar to those in other sites in the New York Bight, although there are exceptions to this pattern as well. Despite some inconsistencies in these levels of representativeness, these broad patterns are helpful in thinking about how inferences made from field data may be extrapolated to other sites. With that said, caution should be exercised in

extrapolating inferences from field data to other sites, and all extrapolations should be made at the site-level.

This caution is necessary not only because site characterization is nuanced and context specific, but also because overlap between these species and wind energy areas may change over time. In other words, the levels of marine wildlife representativeness suggested by this analysis may only be temporarily relevant or accurate. Overlap between species of interest and wind energy areas may shift as climate change impacts ocean temperatures, acidity, currents, precipitation patterns and sea levels (Gremillet & Boulinier 2009, Meyer-Gutbrod et al. 2021, NOAA 2022a). These changes in ocean conditions may shift marine wildlife distribution ranges, depending on tolerance thresholds, such that future overlap between species of interest and wind energy areas deviates from what is predicted here.

Similarly, interactions between marine wildlife and wind energy areas may change in the future as wind turbines themselves change. Floating wind energy infrastructure, which is projected to become increasingly popular in upcoming years, may be associated with different environmental impacts compared to their fixed-structure counterparts (Farr et al. 2021). For example, the installation of floating turbines will not involve traditional pile driving procedures required for fixed-structure turbines, meaning floating turbines may be associated with less underwater noise pollution than wind turbines anchored with monopiles (ibid). Additionally, floating turbines are projected to be larger than fixed-structure turbines, meaning the rotor sweep zones on floating turbines may be associated with more seabird collision events compared to smaller, fixed-structure turbines (Bailey et al. 2014).

All wind energy lease sites included in this analysis have already been auctioned to developers, but the majority of these sites have not yet received BOEM's approval for construction and operation. If site-specific levels of overlap are deemed ecologically noteworthy, this analysis could be helpful in the development of environmentally responsible construction and operation plans. In other words, the window of opportunity for forward-thinking marine wildlife impact mitigation measures in the context of wind energy development may still be open. This notion extends past the approval of construction and operation plans; initiating vessel speeding

regulations for daily maintenance crews, temporary closures during important seabird migratory periods, or installing bubble curtains that absorb underwater noise pollution are all ways to mitigate impacts even after the turbines themselves are installed and operational (Laist et al. 2006, Verfuss et al. 2016).

According to Project Drawdown, a nonprofit organization focused on the promotion of equitable climate solutions, offshore wind energy is projected to prevent up to 10 gigatons of greenhouse gas emissions by 2050. Although these numbers are inspiring, we must ensure that addressing the climate crisis does not worsen the biodiversity crisis by prioritizing the mitigation of potentially negative environmental impacts. This project illustrates the power of geospatial data analytics to contribute to the conversation of wind energy development as a responsible climate solution, and is evidenced here as a necessary tool in facilitating more informed offshore wind energy planning.

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APPENDIX

1. Raw Data

Winter Mean Abundance Raw Data (Individuals per 100 Square Kilometers)

Area ID	Status	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Red-Throated Loon	Northern Gannet	Great Black-Backed Gull
Gulf of Maine Request for Competitive Interest (RFCI)	Planning Area (08/18/2022)	43.35	0.19	0.03	0.10	0.09	0.02	0.03	0.24
Gulf of Maine Request for Interest (RFI) Area A	Planning Area (08/18/2022)	42.88	0.30	0.10	0.08	0.08	0.02	0.06	0.24
Gulf of Maine Request for Interest (RFI) Area B	Planning Area (08/18/2022)	42.44	0.10	0.26	0.05	0.00	0.03	0.15	0.28
Gulf of Maine Request for Interest (RFI) Area C	Planning Area (08/18/2022)	42.27	0.13	0.38	0.06	0.01	0.04	0.14	0.25
Gulf of Maine Request for Interest (RFI) Area D	Planning Area (08/18/2022)	42.19	0.09	0.39	0.04	0.14	0.04	0.09	0.23
Gulf of Maine Request for Interest (RFI) Area E	Planning Area (08/18/2022)	41.90	0.58	0.47	0.26	0.23	0.03	0.37	0.24
OCS-A 0506 - The Narragansett Electric Company	Lease Site (06/30/2022)	41.27	0.15	0.04	0.05	0.16	0.08	0.28	0.23
OCS-A 0486 - Revolution Wind, LLC	Lease Site (06/30/2022)	41.15	0.19	0.11	0.04	0.46	0.05	0.29	0.22
OCS-A 0517 - South Fork Wind, LLC	Lease Site (06/30/2022)	41.09	0.19	0.12	0.04	0.43	0.04	0.34	0.22
OCS-A 0501 - Vineyard Wind LLC	Lease Site (06/30/2022)	41.04	0.17	0.15	0.04	0.70	0.04	0.21	0.19
OCS-A 0487 - Sunrise Wind LLC	Lease Site (06/30/2022)	40.99	0.18	0.10	0.04	0.30	0.03	0.30	0.21
OCS-A 0500 - Bay State Wind LLC	Lease Site (06/30/2022)	40.97	0.17	0.12	0.03	0.40	0.03	0.24	0.19
OCS-A 0534 - Park City Wind LLC	Lease Site (06/30/2022)	40.90	0.17	0.12	0.03	0.42	0.03	0.25	0.18
OCS-A 0520 - Beacon Wind LLC	Lease Site (06/30/2022)	40.82	0.17	0.10	0.03	0.36	0.03	0.22	0.18
OCS-A 0521 - Mayflower Wind Energy LLC	Lease Site (06/30/2022)	40.75	0.18	0.10	0.03	0.48	0.03	0.21	0.18
OCS-A 0522 - Vineyard Northeast LLC	Lease Site (06/30/2022)	40.68	0.19	0.11	0.03	0.96	0.03	0.21	0.18
New York WEA - Fairways North	Planning Area (08/18/2022)	40.61	0.21	0.13	0.06	0.08	0.03	0.44	0.22
New York WEA - Fairways South	Planning Area (08/18/2022)	40.43	0.19	0.11	0.08	0.14	0.05	0.45	0.22
OCS-A 0512 - Empire Offshore Wind, LLC	Lease Site (06/30/2022)	40.30	0.15	0.06	0.09	0.09	0.10	0.57	0.22
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	Lease Site (06/30/2022)	40.24	0.17	0.07	0.07	0.11	0.04	0.62	0.22
OCS-A 0537 - OW Ocean Winds East, LLC	Lease Site (06/30/2022)	39.98	0.26	0.11	0.05	0.07	0.03	0.61	0.21
OCS-A 0538 - Attentive Energy LLC	Lease Site (06/30/2022)	39.72	0.18	0.08	0.05	0.06	0.03	0.75	0.21
OCS-A 0539 - Community Offshore Wind, LLC	Lease Site (06/30/2022)	39.54	0.18	0.07	0.05	0.08	0.03	0.73	0.22
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	Lease Site (06/30/2022)	39.47	0.14	0.04	0.10	0.06	0.17	0.53	0.18
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	Lease Site (06/30/2022)	39.36	0.17	0.05	0.06	0.09	0.04	0.65	0.22
OCS-A 0542 - Invenergy Wind Offshore LLC	Lease Site (06/30/2022)	39.30	0.19	0.07	0.05	0.10	0.03	0.65	0.22
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	Lease Site (06/30/2022)	39.27	0.14	0.05	0.09	0.06	0.14	0.55	0.18
OCS-A 0498 - Ocean Wind LLC	Lease Site (06/30/2022)	39.12	0.15	0.05	0.09	0.06	0.12	0.53	0.18
OCS-A 0532 - Orsted North America Inc.	Lease Site (06/30/2022)	39.07	0.14	0.05	0.10	0.08	0.17	0.58	0.17
OCS-A 0482 - GSOE I LLC	Lease Site (06/30/2022)	38.67	0.14	0.05	0.09	0.10	0.15	0.54	0.15
OCS-A 0519 - Skipjack Offshore Energy LLC	Lease Site (06/30/2022)	38.57	0.16	0.07	0.08	0.06	0.12	0.58	0.15
Central Atlantic Call Area A	Planning Area (08/18/2022)	38.52	0.17	0.07	0.06	0.08	0.06	0.83	0.19
OCS-A 0490 - US Wind Inc.	Lease Site (06/30/2022)	38.35	0.17	0.07	0.08	0.07	0.14	0.87	0.14
Central Atlantic Call Area B	Planning Area (08/18/2022)	37.66	0.23	0.10	0.10	0.08	0.05	0.67	0.16
Central Atlantic Call Area E	Planning Area (08/18/2022)	37.61	0.12	0.01	0.00	0.00	0.03	0.15	0.21
OCS-A 0483 - Virginia Electric and Power Company	Lease Site (06/30/2022)	36.91	0.10	0.05	0.08	0.09	0.11	1.42	0.14
Central Atlantic Call Area C	Planning Area (08/18/2022)	36.90	0.22	0.09	0.09	0.05	0.05	0.48	0.16
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	Lease Site (06/30/2022)	36.89	0.07	0.04	0.09	0.10	0.29	3.08	0.15
Central Atlantic Call Area D	Planning Area (08/18/2022)	36.48	0.28	0.08	0.08	0.03	0.08	0.56	0.17
Central Atlantic Call Area F	Planning Area (08/18/2022)	36.37	0.14	0.01	0.00	0.00	0.05	0.24	0.18
OCS-A 0508 - Avangrid Renewables LLC	Lease Site (06/30/2022)	36.34	0.16	0.08	0.09	0.02	0.09	0.60	0.13
OCS - A 0545 - TotalEnergies Renewables USA, LLC	Lease Site (06/30/2022)	33.45	0.00	0.00	0.00	0.02	0.07	0.81	0.06
OCS - A 0546 - Duke Energy Renewables Wind, LLC	Lease Site (06/30/2022)	33.45	0.00	0.00	0.00	0.01	0.07	0.74	0.06
South Carolina Call Area - Grand Strand	Planning Area (08/18/2022)	33.44	0.00	0.00	0.00	0.06	0.16	0.61	0.06
South Carolina Call Area - Cape Romain	Planning Area (08/18/2022)	32.89	0.00	0.00	0.01	0.06	0.16	0.68	0.06
South Carolina Call Area - Winyah	Planning Area (08/18/2022)	32.75	0.00	0.00	0.01	0.00	0.03	0.04	0.06
South Carolina Call Area - Charleston	Planning Area (08/18/2022)	32.52	0.00	0.00	0.00	0.01	0.05	0.19	0.06

Table 5. Winter mean abundance raw data

Spring Mean Abundance Raw Data (Individuals per 100 Square Kilometers)

Area ID	Status	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Red-Throated Loon	Northern Gannet	Great Black-Backed Gull
Gulf of Maine Request for Competitive Interest (RFCI)	Planning Area (08/18/2022)	43.35	0.18	0.42	0.33	0.02	0.01	0.37	0.23
Gulf of Maine Request for Interest (RFI) Area A	Planning Area (08/18/2022)	42.88	0.31	0.42	0.40	0.12	0.01	0.35	0.22
Gulf of Maine Request for Interest (RFI) Area B	Planning Area (08/18/2022)	42.44	0.11	0.79	0.12	0.18	0.01	0.40	0.24
Gulf of Maine Request for Interest (RFI) Area C	Planning Area (08/18/2022)	42.27	0.14	0.78	0.15	0.58	0.01	0.39	0.23
Gulf of Maine Request for Interest (RFI) Area D	Planning Area (08/18/2022)	42.19	0.10	0.59	0.08	1.27	0.02	0.40	0.20
Gulf of Maine Request for Interest (RFI) Area E	Planning Area (08/18/2022)	41.90	0.71	0.82	1.31	0.66	0.02	0.56	0.26
OCS-A 0506 - The Narragansett Electric Company	Lease Site (06/30/2022)	41.27	0.12	0.61	0.09	0.15	0.04	0.66	0.14
OCS-A 0486 - Revolution Wind, LLC	Lease Site (06/30/2022)	41.15	0.17	0.87	0.11	0.47	0.02	0.52	0.12
OCS-A 0517 - South Fork Wind, LLC	Lease Site (06/30/2022)	41.09	0.18	0.91	0.10	0.46	0.01	0.47	0.12
OCS-A 0501 - Vineyard Wind LLC	Lease Site (06/30/2022)	41.04	0.17	1.01	0.14	0.71	0.02	0.48	0.11
OCS-A 0487 - Sunrise Wind LLC	Lease Site (06/30/2022)	40.99	0.18	0.88	0.13	0.34	0.01	0.48	0.12
OCS-A 0500 - Bay State Wind LLC	Lease Site (06/30/2022)	40.97	0.18	0.90	0.14	0.43	0.01	0.52	0.12
OCS-A 0534 - Park City Wind LLC	Lease Site (06/30/2022)	40.90	0.18	0.91	0.16	0.45	0.01	0.48	0.12
OCS-A 0520 - Beacon Wind LLC	Lease Site (06/30/2022)	40.82	0.18	0.85	0.17	0.39	0.01	0.50	0.11
OCS-A 0521 - Mayflower Wind Energy LLC	Lease Site (06/30/2022)	40.75	0.19	0.80	0.18	0.46	0.01	0.49	0.11
OCS-A 0522 - Vineyard Northeast LLC	Lease Site (06/30/2022)	40.68	0.21	0.81	0.20	0.86	0.01	0.45	0.10
New York WEA - Fairways North	Planning Area (08/18/2022)	40.61	0.23	1.00	0.15	0.09	0.01	0.52	0.13
New York WEA - Fairways South	Planning Area (08/18/2022)	40.43	0.22	1.03	0.13	0.13	0.01	0.51	0.13
OCS-A 0512 - Empire Offshore Wind, LLC	Lease Site (06/30/2022)	40.30	0.14	0.84	0.11	0.08	0.02	0.60	0.12
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	Lease Site (06/30/2022)	40.24	0.19	0.93	0.12	0.10	0.01	0.52	0.14
OCS-A 0537 - OW Ocean Winds East, LLC	Lease Site (06/30/2022)	39.98	0.39	0.86	0.22	0.10	0.01	0.75	0.12
OCS-A 0538 - Attentive Energy LLC	Lease Site (06/30/2022)	39.72	0.25	0.88	0.16	0.07	0.01	0.82	0.13
OCS-A 0539 - Community Offshore Wind, LLC	Lease Site (06/30/2022)	39.54	0.22	0.82	0.14	0.09	0.01	0.69	0.11
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	Lease Site (06/30/2022)	39.47	0.09	0.53	0.10	0.04	0.08	1.20	0.11
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	Lease Site (06/30/2022)	39.36	0.18	0.78	0.13	0.08	0.01	0.57	0.09
OCS-A 0542 - Invenergy Wind Offshore LLC	Lease Site (06/30/2022)	39.30	0.23	0.83	0.15	0.10	0.01	0.62	0.08
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	Lease Site (06/30/2022)	39.27	0.09	0.52	0.09	0.04	0.06	0.88	0.09
OCS-A 0498 - Ocean Wind LLC	Lease Site (06/30/2022)	39.12	0.10	0.50	0.10	0.04	0.04	0.70	0.08
OCS-A 0532 - Orsted North America Inc.	Lease Site (06/30/2022)	39.07	0.09	0.41	0.08	0.04	0.06	1.00	0.08
OCS-A 0482 - GSOE I LLC	Lease Site (06/30/2022)	38.67	0.10	0.43	0.09	0.04	0.04	0.52	0.04
OCS-A 0519 - Skipjack Offshore Energy LLC	Lease Site (06/30/2022)	38.57	0.11	0.49	0.12	0.04	0.02	0.37	0.02
Central Atlantic Call Area A	Planning Area (08/18/2022)	38.52	0.17	0.58	0.14	0.07	0.01	0.57	0.02
OCS-A 0490 - US Wind Inc.	Lease Site (06/30/2022)	38.35	0.13	0.51	0.13	0.04	0.03	0.50	0.02
Central Atlantic Call Area B	Planning Area (08/18/2022)	37.66	0.38	0.59	0.29	0.08	0.01	0.67	0.01
Central Atlantic Call Area E	Planning Area (08/18/2022)	37.61	0.20	0.21	0.03	0.00	0.00	0.04	0.00
OCS-A 0483 - Virginia Electric and Power Company	Lease Site (06/30/2022)	36.91	0.11	0.43	0.13	0.07	0.02	0.84	0.01
Central Atlantic Call Area C	Planning Area (08/18/2022)	36.90	0.40	0.51	0.29	0.05	0.01	1.04	0.01
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	Lease Site (06/30/2022)	36.89	0.06	0.24	0.09	0.04	0.07	2.27	0.02
Central Atlantic Call Area D	Planning Area (08/18/2022)	36.48	0.45	0.42	0.25	0.02	0.01	0.48	0.01
Central Atlantic Call Area F	Planning Area (08/18/2022)	36.37	0.22	0.19	0.01	0.00	0.01	0.02	0.00
OCS-A 0508 - Avangrid Renewables LLC	Lease Site (06/30/2022)	36.34	0.28	0.43	0.24	0.02	0.01	0.49	0.01
OCS - A 0545 - TotalEnergies Renewables USA, LLC	Lease Site (06/30/2022)	33.45	0.00	0.00	0.00	0.01	0.01	0.18	0.00
OCS - A 0546 - Duke Energy Renewables Wind, LLC	Lease Site (06/30/2022)	33.45	0.00	0.00	0.00	0.01	0.01	0.16	0.00
South Carolina Call Area - Grand Strand	Planning Area (08/18/2022)	33.44	0.00	0.00	0.00	0.02	0.07	0.87	0.00
South Carolina Call Area - Cape Romain	Planning Area (08/18/2022)	32.89	0.00	0.00	0.01	0.02	0.03	0.87	0.00
South Carolina Call Area - Winyah	Planning Area (08/18/2022)	32.75	0.01	0.00	0.01	0.00	0.00	0.03	0.00
South Carolina Call Area - Charleston	Planning Area (08/18/2022)	32.52	0.00	0.00	0.00	0.00	0.01	0.03	0.00

Table 6. Spring mean abundance raw data

Summer Mean Abundance Raw Data (Individuals per 100 Square Kilometers)

Area ID	Status	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Northern Gannet	Great Black-Backed Gull
Gulf of Maine Request for Competitive Interest (RFCI)	Planning Area (08/18/2022)	43.35	0.65	0.78	0.75	0.03	0.02	0.37
Gulf of Maine Request for Interest (RFI) Area A	Planning Area (08/18/2022)	42.88	0.81	0.86	0.85	0.09	0.06	0.33
Gulf of Maine Request for Interest (RFI) Area B	Planning Area (08/18/2022)	42.44	0.19	0.99	0.16	0.00	0.05	0.72
Gulf of Maine Request for Interest (RFI) Area C	Planning Area (08/18/2022)	42.27	0.22	0.75	0.20	0.00	0.03	0.51
Gulf of Maine Request for Interest (RFI) Area D	Planning Area (08/18/2022)	42.19	0.08	0.36	0.09	0.00	0.05	0.50
Gulf of Maine Request for Interest (RFI) Area E	Planning Area (08/18/2022)	41.90	1.24	0.77	1.83	0.01	0.02	0.83
OCS-A 0506 - The Narragansett Electric Company	Lease Site (06/30/2022)	41.27	0.09	0.28	0.07	0.01	0.01	0.15
OCS-A 0486 - Revolution Wind, LLC	Lease Site (06/30/2022)	41.15	0.22	0.56	0.12	0.03	0.00	0.08
OCS-A 0517 - South Fork Wind, LLC	Lease Site (06/30/2022)	41.09	0.28	0.67	0.11	0.03	0.00	0.07
OCS-A 0501 - Vineyard Wind LLC	Lease Site (06/30/2022)	41.04	0.28	0.97	0.16	0.05	0.00	0.06
OCS-A 0487 - Sunrise Wind LLC	Lease Site (06/30/2022)	40.99	0.35	0.78	0.15	0.02	0.00	0.05
OCS-A 0500 - Bay State Wind LLC	Lease Site (06/30/2022)	40.97	0.32	0.80	0.17	0.03	0.00	0.04
OCS-A 0534 - Park City Wind LLC	Lease Site (06/30/2022)	40.90	0.32	0.92	0.19	0.03	0.00	0.04
OCS-A 0520 - Beacon Wind LLC	Lease Site (06/30/2022)	40.82	0.34	0.98	0.21	0.03	0.00	0.04
OCS-A 0521 - Mayflower Wind Energy LLC	Lease Site (06/30/2022)	40.75	0.37	1.03	0.23	0.05	0.00	0.03
OCS-A 0522 - Vineyard Northeast LLC	Lease Site (06/30/2022)	40.68	0.43	1.21	0.27	0.11	0.00	0.03
New York WEA - Fairways North	Planning Area (08/18/2022)	40.61	0.50	0.99	0.15	0.00	0.00	0.04
New York WEA - Fairways South	Planning Area (08/18/2022)	40.43	0.37	0.70	0.09	0.01	0.00	0.03
OCS-A 0512 - Empire Offshore Wind, LLC	Lease Site (06/30/2022)	40.30	0.14	0.37	0.06	0.00	0.01	0.03
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	Lease Site (06/30/2022)	40.24	0.29	0.61	0.09	0.00	0.00	0.02
OCS-A 0537 - OW Ocean Winds East, LLC	Lease Site (06/30/2022)	39.98	0.58	0.58	0.24	0.01	0.00	0.01
OCS-A 0538 - Attentive Energy LLC	Lease Site (06/30/2022)	39.72	0.34	0.46	0.13	0.00	0.00	0.01
OCS-A 0539 - Community Offshore Wind, LLC	Lease Site (06/30/2022)	39.54	0.22	0.37	0.10	0.00	0.00	0.01
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	Lease Site (06/30/2022)	39.47	0.04	0.07	0.03	0.00	0.03	0.06
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	Lease Site (06/30/2022)	39.36	0.15	0.31	0.08	0.00	0.00	0.00
OCS-A 0542 - Invenergy Wind Offshore LLC	Lease Site (06/30/2022)	39.30	0.25	0.38	0.11	0.01	0.00	0.00
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	Lease Site (06/30/2022)	39.27	0.05	0.10	0.03	0.00	0.02	0.03
OCS-A 0498 - Ocean Wind LLC	Lease Site (06/30/2022)	39.12	0.05	0.09	0.03	0.00	0.01	0.01
OCS-A 0532 - Orsted North America Inc.	Lease Site (06/30/2022)	39.07	0.04	0.06	0.02	0.00	0.01	0.03
OCS-A 0482 - GSOE I LLC	Lease Site (06/30/2022)	38.67	0.04	0.06	0.03	0.00	0.01	0.01
OCS-A 0519 - Skipjack Offshore Energy LLC	Lease Site (06/30/2022)	38.57	0.05	0.07	0.04	0.00	0.00	0.00
Central Atlantic Call Area A	Planning Area (08/18/2022)	38.52	0.10	0.15	0.07	0.00	0.00	0.00
OCS-A 0490 - US Wind Inc.	Lease Site (06/30/2022)	38.35	0.06	0.08	0.04	0.00	0.00	0.00
Central Atlantic Call Area B	Planning Area (08/18/2022)	37.66	0.18	0.13	0.13	0.00	0.00	0.00
Central Atlantic Call Area E	Planning Area (08/18/2022)	37.61	0.16	0.05	0.01	0.00	0.00	0.00
OCS-A 0483 - Virginia Electric and Power Company	Lease Site (06/30/2022)	36.91	0.04	0.03	0.02	0.00	0.00	0.00
Central Atlantic Call Area C	Planning Area (08/18/2022)	36.90	0.18	0.07	0.09	0.00	0.00	0.00
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	Lease Site (06/30/2022)	36.89	0.02	0.01	0.01	0.00	0.00	0.00
Central Atlantic Call Area D	Planning Area (08/18/2022)	36.48	0.24	0.04	0.06	0.00	0.00	0.00
Central Atlantic Call Area F	Planning Area (08/18/2022)	36.37	0.10	0.04	0.00	0.00	0.00	0.00
OCS-A 0508 - Avangrid Renewables LLC	Lease Site (06/30/2022)	36.34	0.08	0.03	0.05	0.00	0.00	0.00
OCS - A 0545 - TotalEnergies Renewables USA, LLC	Lease Site (06/30/2022)	33.45	0.00	0.00	0.00	0.00	0.00	0.00
OCS - A 0546 - Duke Energy Renewables Wind, LLC	Lease Site (06/30/2022)	33.45	0.00	0.00	0.00	0.00	0.00	0.00
South Carolina Call Area - Grand Strand	Planning Area (08/18/2022)	33.44	0.00	0.00	0.00	0.00	0.01	0.00
South Carolina Call Area - Cape Romain	Planning Area (08/18/2022)	32.89	0.00	0.00	0.00	0.00	0.02	0.00
South Carolina Call Area - Winyah	Planning Area (08/18/2022)	32.75	0.00	0.00	0.00	0.00	0.00	0.00
South Carolina Call Area - Charleston	Planning Area (08/18/2022)	32.52	0.00	0.00	0.00	0.00	0.00	0.00

Table 7. Summer mean abundance raw data

Fall Mean Abundance Raw Data (Individuals per 100 Square Kilometers)

Area ID	Status	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Red-Throated Loon	Northern Gannet	Great Black-Backed Gull
Gulf of Maine Request for Competitive Interest (RFCI)	Planning Area (08/18/2022)	43.35	0.47	0.63	0.55	0.10	0.00	0.26	0.69
Gulf of Maine Request for Interest (RFI) Area A	Planning Area (08/18/2022)	42.88	0.59	0.58	0.64	0.05	0.00	0.16	0.56
Gulf of Maine Request for Interest (RFI) Area B	Planning Area (08/18/2022)	42.44	0.08	0.46	0.19	0.00	0.00	0.57	1.05
Gulf of Maine Request for Interest (RFI) Area C	Planning Area (08/18/2022)	42.27	0.08	0.39	0.24	0.00	0.00	0.52	0.82
Gulf of Maine Request for Interest (RFI) Area D	Planning Area (08/18/2022)	42.19	0.04	0.23	0.11	0.00	0.00	0.48	0.64
Gulf of Maine Request for Interest (RFI) Area E	Planning Area (08/18/2022)	41.90	0.80	0.72	1.59	0.02	0.00	0.44	1.04
OCS-A 0506 - The Narragansett Electric Company	Lease Site (06/30/2022)	41.27	0.04	0.06	0.12	0.02	0.00	0.12	0.25
OCS-A 0486 - Revolution Wind, LLC	Lease Site (06/30/2022)	41.15	0.06	0.13	0.14	0.05	0.00	0.08	0.14
OCS-A 0517 - South Fork Wind, LLC	Lease Site (06/30/2022)	41.09	0.06	0.16	0.12	0.05	0.00	0.07	0.13
OCS-A 0501 - Vineyard Wind LLC	Lease Site (06/30/2022)	41.04	0.06	0.25	0.17	0.09	0.00	0.08	0.09
OCS-A 0487 - Sunrise Wind LLC	Lease Site (06/30/2022)	40.99	0.10	0.27	0.15	0.04	0.00	0.07	0.11
OCS-A 0500 - Bay State Wind LLC	Lease Site (06/30/2022)	40.97	0.10	0.30	0.17	0.05	0.00	0.07	0.10
OCS-A 0534 - Park City Wind LLC	Lease Site (06/30/2022)	40.90	0.10	0.32	0.19	0.06	0.00	0.07	0.09
OCS-A 0520 - Beacon Wind LLC	Lease Site (06/30/2022)	40.82	0.12	0.36	0.20	0.05	0.00	0.07	0.09
OCS-A 0521 - Mayflower Wind Energy LLC	Lease Site (06/30/2022)	40.75	0.13	0.36	0.21	0.07	0.00	0.07	0.09
OCS-A 0522 - Vineyard Northeast LLC	Lease Site (06/30/2022)	40.68	0.14	0.39	0.23	0.14	0.00	0.07	0.09
New York WEA - Fairways North	Planning Area (08/18/2022)	40.61	0.14	0.28	0.16	0.01	0.00	0.07	0.09
New York WEA - Fairways South	Planning Area (08/18/2022)	40.43	0.09	0.13	0.12	0.02	0.00	0.05	0.08
OCS-A 0512 - Empire Offshore Wind, LLC	Lease Site (06/30/2022)	40.30	0.04	0.07	0.10	0.01	0.00	0.04	0.08
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	Lease Site (06/30/2022)	40.24	0.07	0.11	0.10	0.01	0.00	0.04	0.07
OCS-A 0537 - OW Ocean Winds East, LLC	Lease Site (06/30/2022)	39.98	0.35	0.33	0.14	0.01	0.00	0.03	0.08
OCS-A 0538 - Attentive Energy LLC	Lease Site (06/30/2022)	39.72	0.17	0.21	0.09	0.01	0.00	0.02	0.07
OCS-A 0539 - Community Offshore Wind, LLC	Lease Site (06/30/2022)	39.54	0.10	0.13	0.08	0.01	0.00	0.02	0.06
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	Lease Site (06/30/2022)	39.47	0.03	0.03	0.07	0.01	0.00	0.07	0.10
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	Lease Site (06/30/2022)	39.36	0.06	0.09	0.07	0.01	0.00	0.02	0.06
OCS-A 0542 - Invenergy Wind Offshore LLC	Lease Site (06/30/2022)	39.30	0.11	0.14	0.08	0.01	0.00	0.02	0.06
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	Lease Site (06/30/2022)	39.27	0.03	0.03	0.06	0.01	0.00	0.07	0.08
OCS-A 0498 - Ocean Wind LLC	Lease Site (06/30/2022)	39.12	0.03	0.03	0.06	0.01	0.00	0.05	0.07
OCS-A 0532 - Orsted North America Inc.	Lease Site (06/30/2022)	39.07	0.03	0.03	0.05	0.01	0.00	0.11	0.10
OCS-A 0482 - GSOE I LLC	Lease Site (06/30/2022)	38.67	0.03	0.03	0.06	0.01	0.00	0.04	0.11
OCS-A 0519 - Skipjack Offshore Energy LLC	Lease Site (06/30/2022)	38.57	0.03	0.03	0.08	0.01	0.00	0.02	0.05
Central Atlantic Call Area A	Planning Area (08/18/2022)	38.52	0.05	0.05	0.09	0.01	0.00	0.01	0.04
OCS-A 0490 - US Wind Inc.	Lease Site (06/30/2022)	38.35	0.04	0.03	0.09	0.01	0.00	0.04	0.06
Central Atlantic Call Area B	Planning Area (08/18/2022)	37.66	0.11	0.05	0.13	0.01	0.00	0.01	0.03
Central Atlantic Call Area E	Planning Area (08/18/2022)	37.61	0.18	0.04	0.01	0.00	0.00	0.00	0.01
OCS-A 0483 - Virginia Electric and Power Company	Lease Site (06/30/2022)	36.91	0.02	0.01	0.06	0.01	0.00	0.00	0.03
Central Atlantic Call Area C	Planning Area (08/18/2022)	36.90	0.18	0.04	0.11	0.01	0.00	0.00	0.02
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	Lease Site (06/30/2022)	36.89	0.01	0.01	0.04	0.01	0.00	0.02	0.05
Central Atlantic Call Area D	Planning Area (08/18/2022)	36.48	0.25	0.03	0.10	0.00	0.00	0.00	0.02
Central Atlantic Call Area F	Planning Area (08/18/2022)	36.37	0.12	0.04	0.00	0.00	0.00	0.00	0.01
OCS-A 0508 - Avangrid Renewables LLC	Lease Site (06/30/2022)	36.34	0.08	0.02	0.10	0.00	0.00	0.00	0.02
OCS - A 0545 - TotalEnergies Renewables USA, LLC	Lease Site (06/30/2022)	33.45	0.00	0.00	0.00	0.00	0.00	0.00	0.01
OCS - A 0546 - Duke Energy Renewables Wind, LLC	Lease Site (06/30/2022)	33.45	0.00	0.00	0.00	0.00	0.00	0.00	0.01
South Carolina Call Area - Grand Strand	Planning Area (08/18/2022)	33.44	0.00	0.00	0.00	0.01	0.00	0.00	0.01
South Carolina Call Area - Cape Romain	Planning Area (08/18/2022)	32.89	0.00	0.00	0.00	0.00	0.00	0.00	0.01
South Carolina Call Area - Winyah	Planning Area (08/18/2022)	32.75	0.00	0.00	0.00	0.00	0.00	0.00	0.01
South Carolina Call Area - Charleston	Planning Area (08/18/2022)	32.52	0.00	0.00	0.00	0.00	0.00	0.00	0.01

Table 8. Fall mean abundance raw data

2. Additional Maps

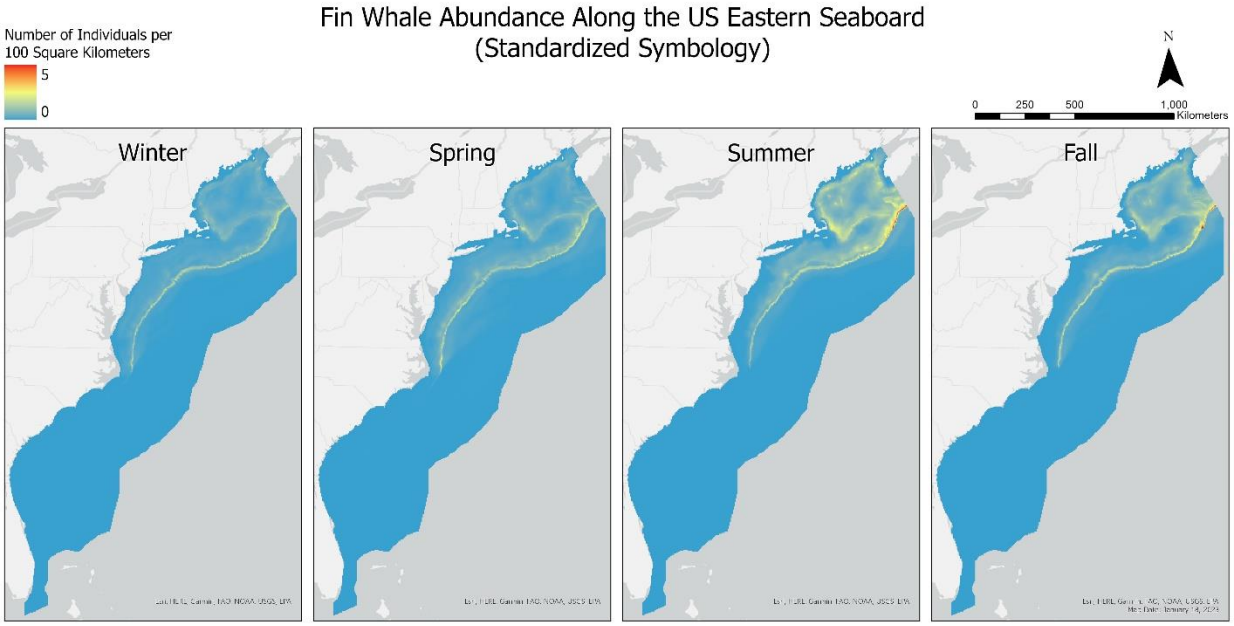

Figure 17. Fin whale abundance in the US Atlantic (standardized symbology)

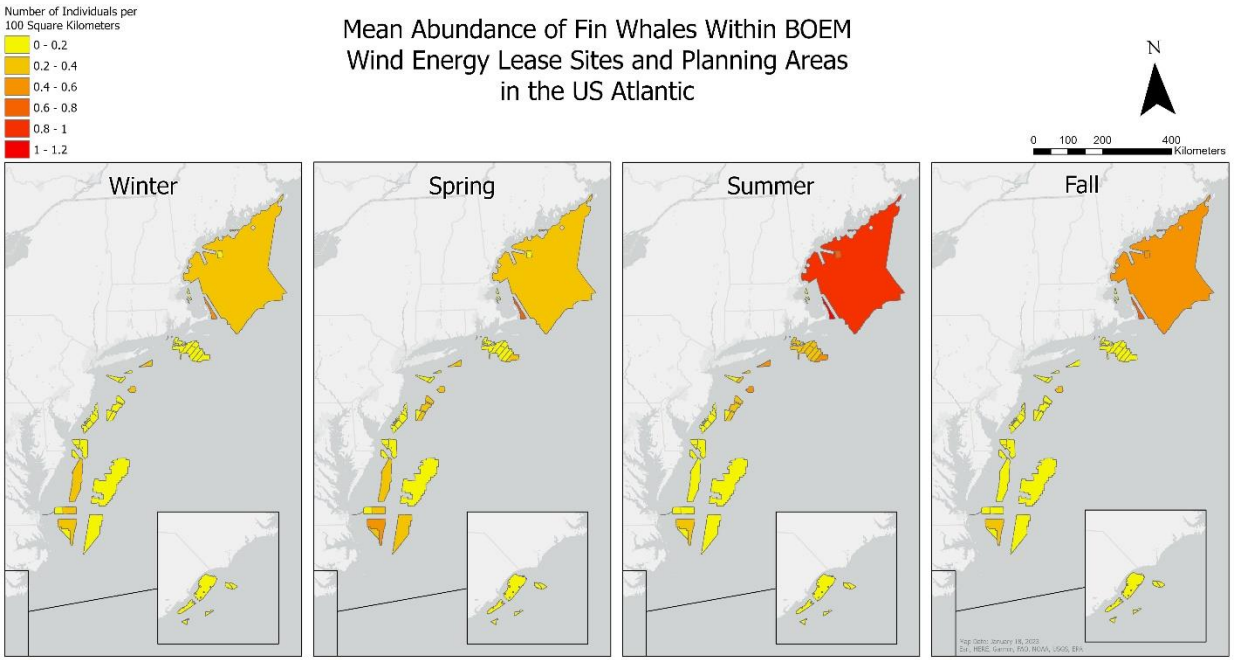

Figure 18. Mean abundance of Fin whales in US Atlantic wind energy lease sites and planning areas

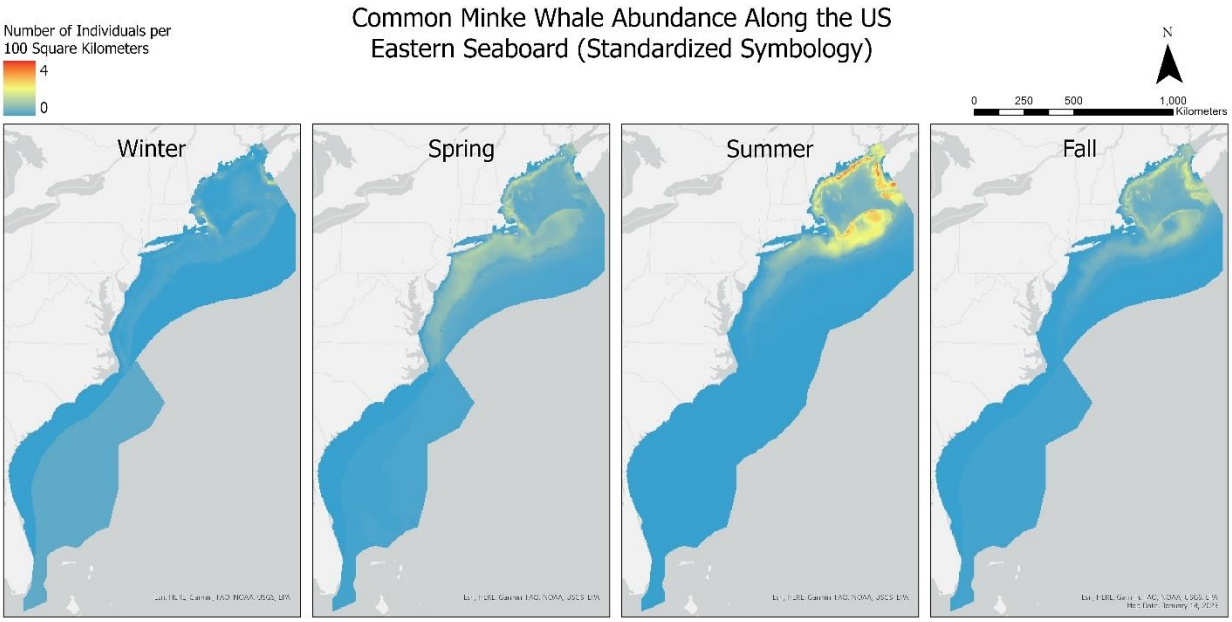

Figure 19. Minke whale abundance in the US Atlantic (standardized symbology)

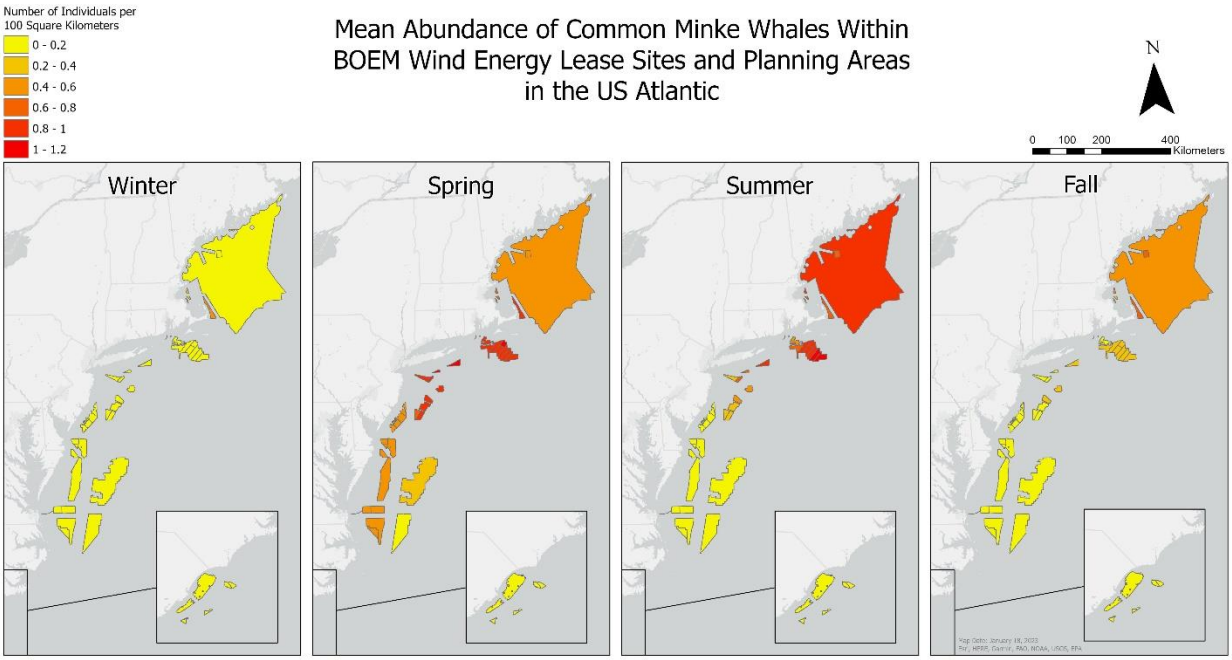

Figure 20. Mean abundance of Minke whales in US Atlantic wind energy lease sites and planning areas

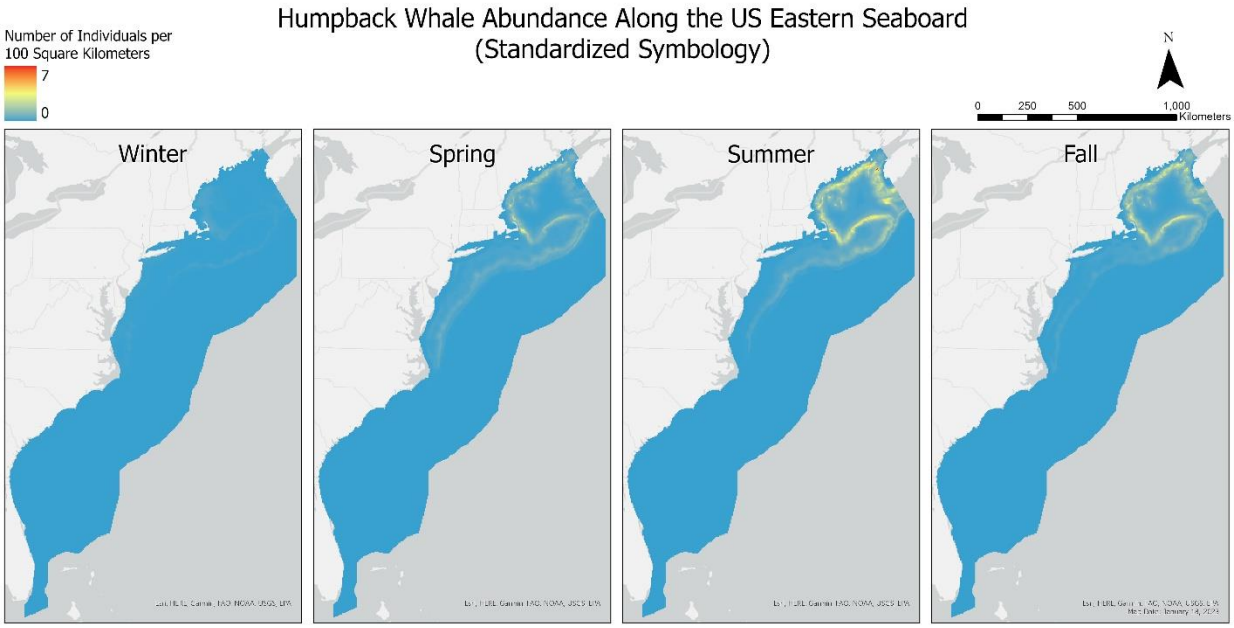

Figure 21. Humpback whale abundance in the US Atlantic (standardized symbology)

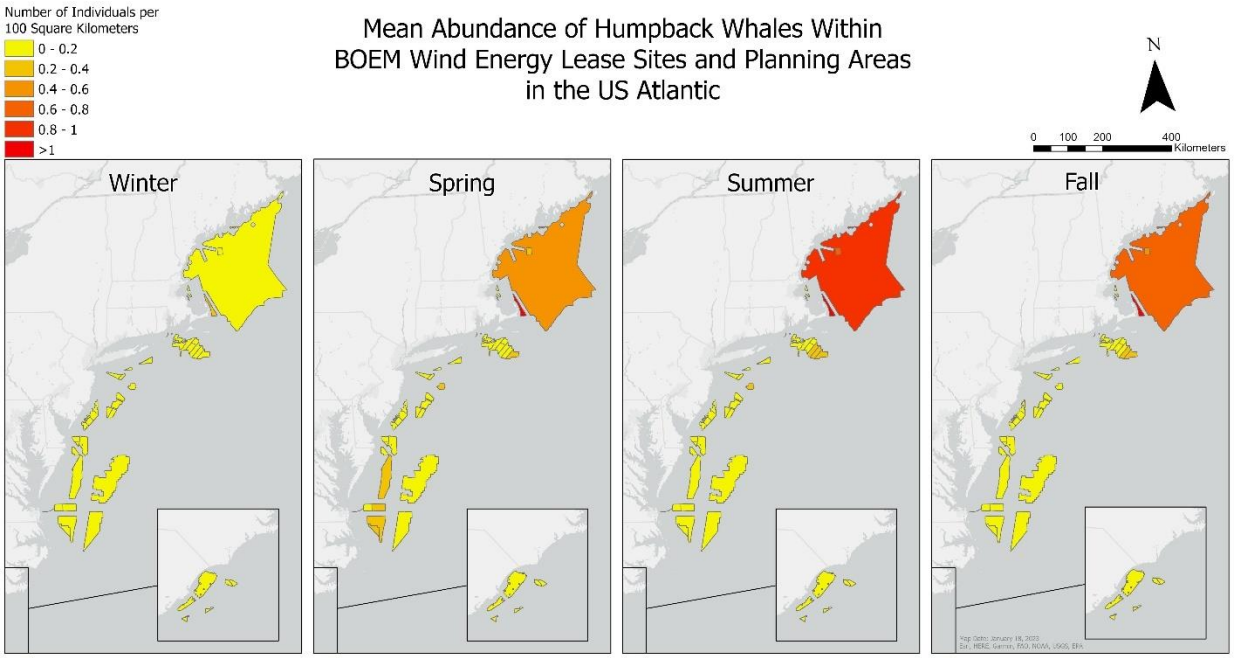

Figure 22. Mean abundance of Humpback whales in US Atlantic wind energy lease sites and planning areas

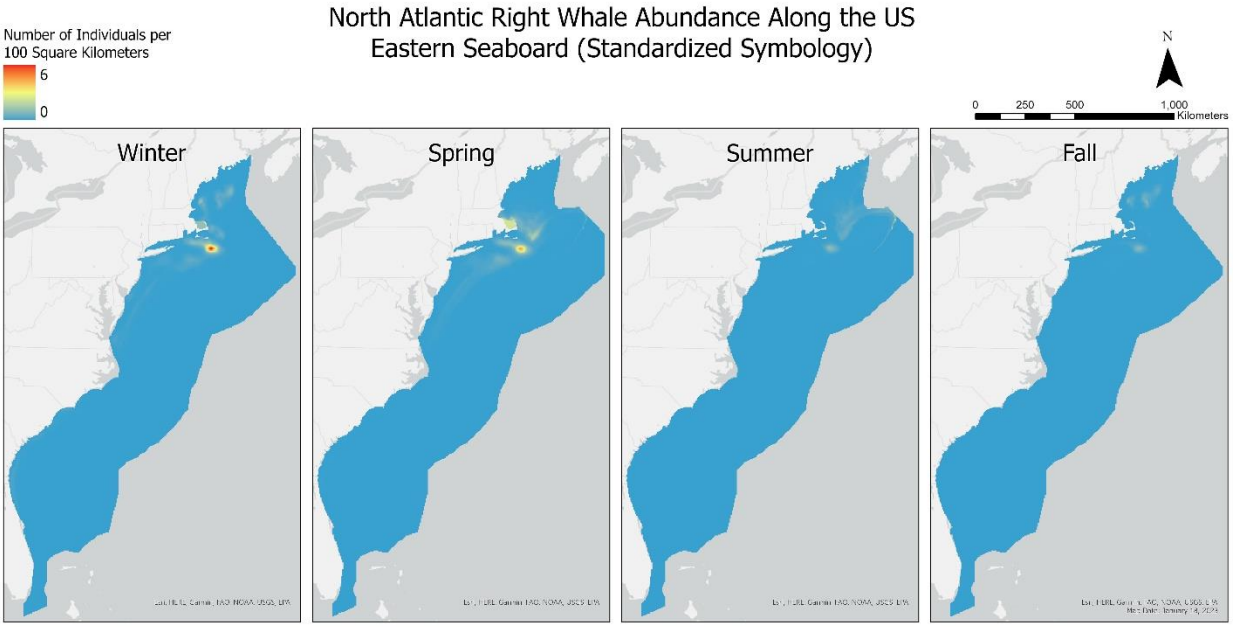

Figure 23. Right whale abundance in the US Atlantic (standardized symbology)

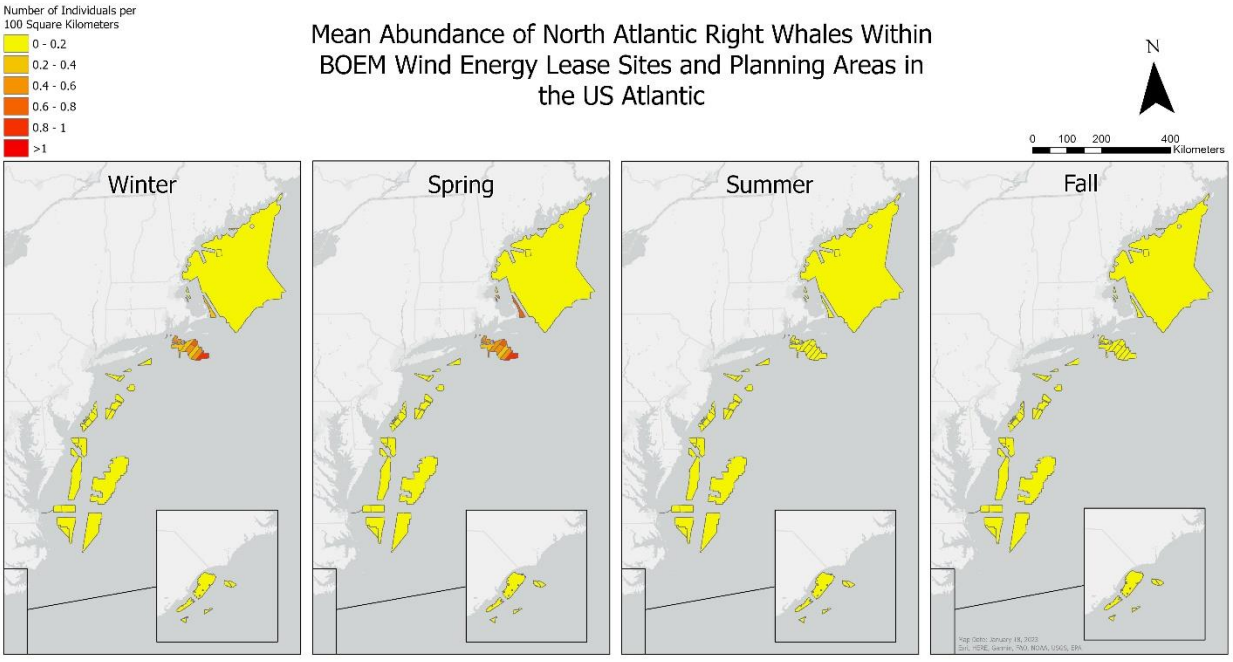

Figure 24. Mean abundance of Right whales in US Atlantic wind energy lease sites and planning areas

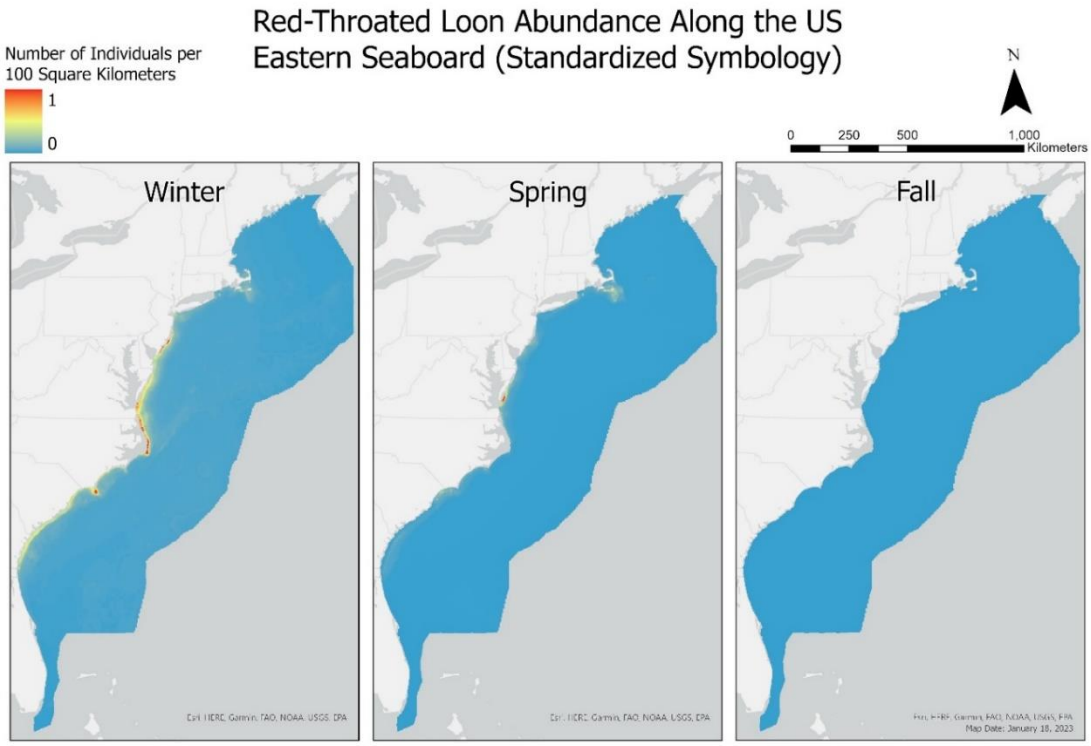

Figure 25. Red-throated loon abundance in the US Atlantic (standardized symbology)

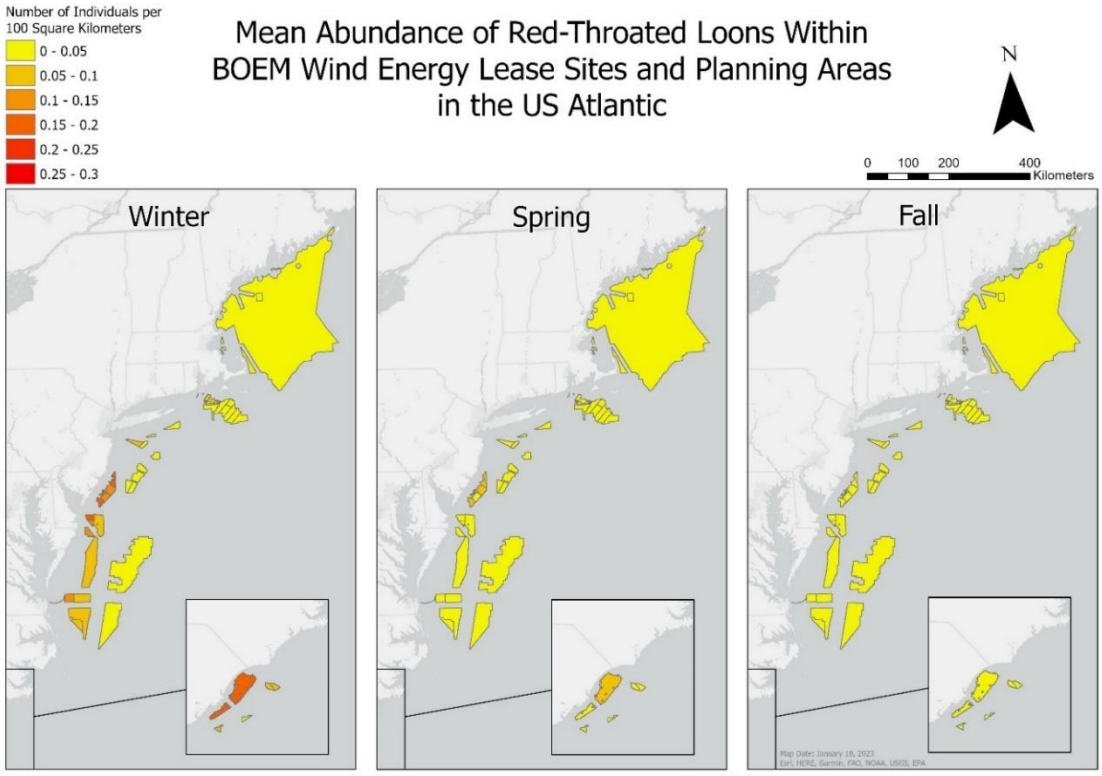

Figure 26. Mean abundance of Red-throated loons in US Atlantic wind energy lease sites and planning areas

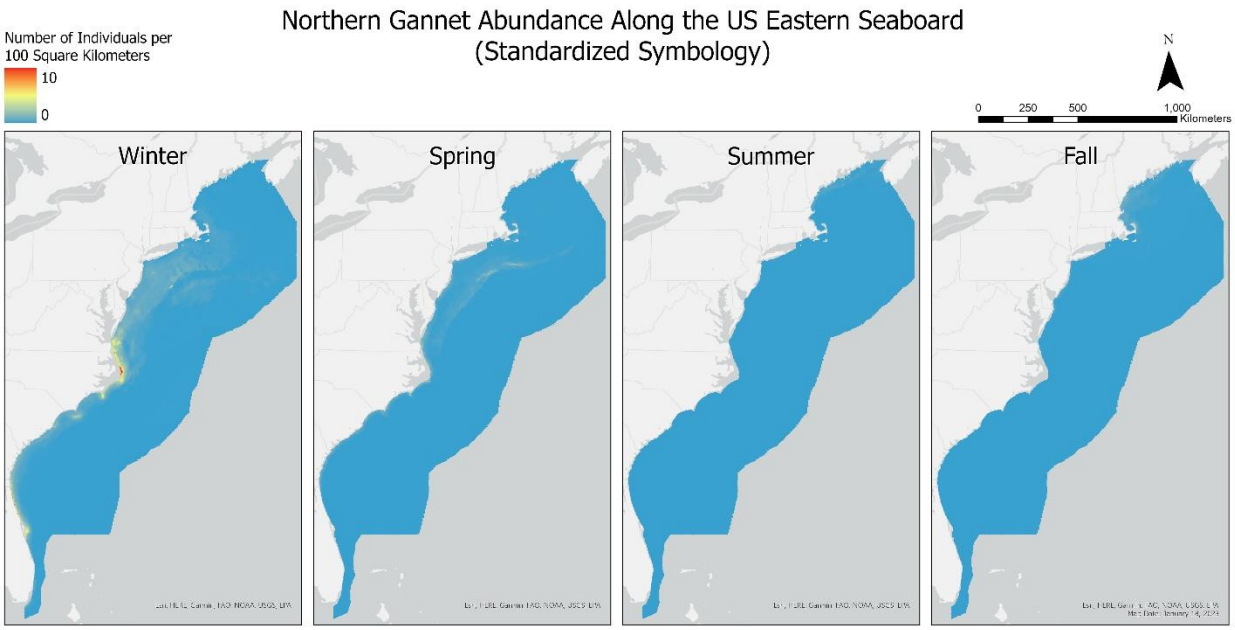

Figure 27. Northern gannet abundance in the US Atlantic (standardized symbology)

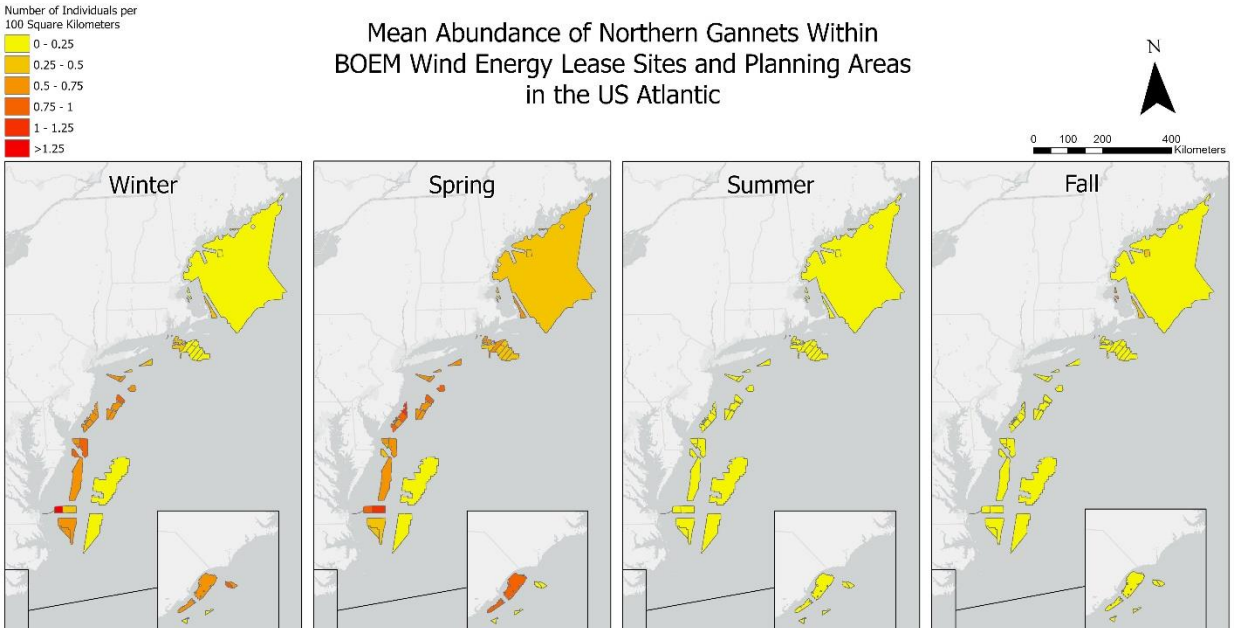

Figure 28. Mean abundance of Northern gannets in US Atlantic wind energy lease sites and planning areas

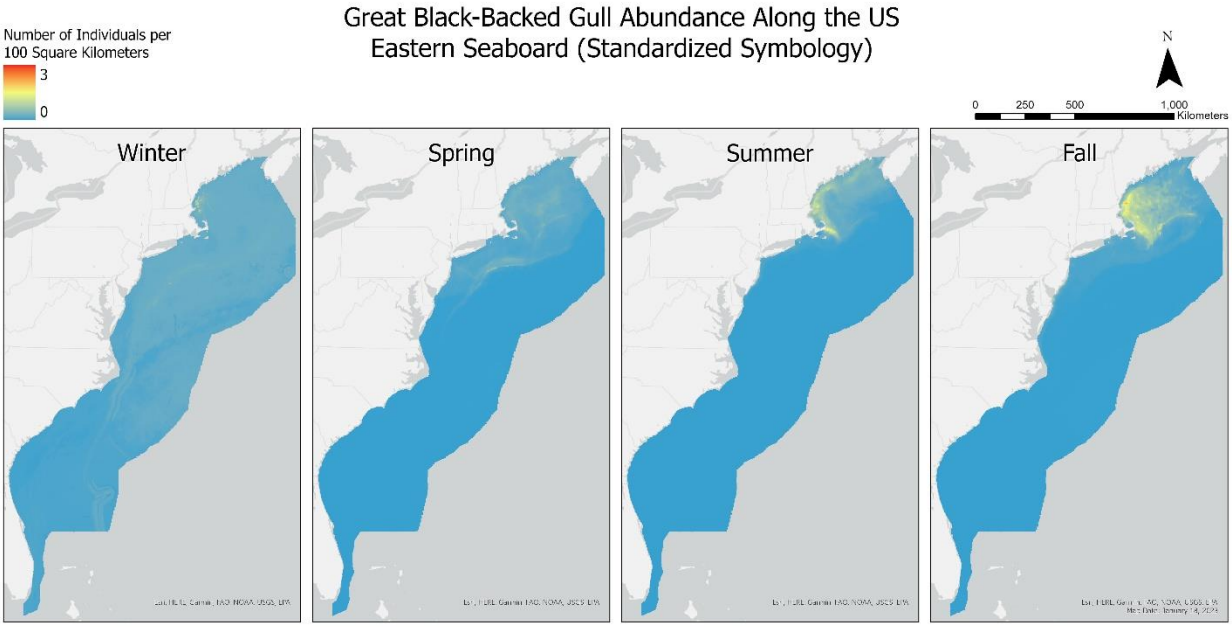

Figure 29. Great black-backed gull abundance in the US Atlantic (standardized symbology)

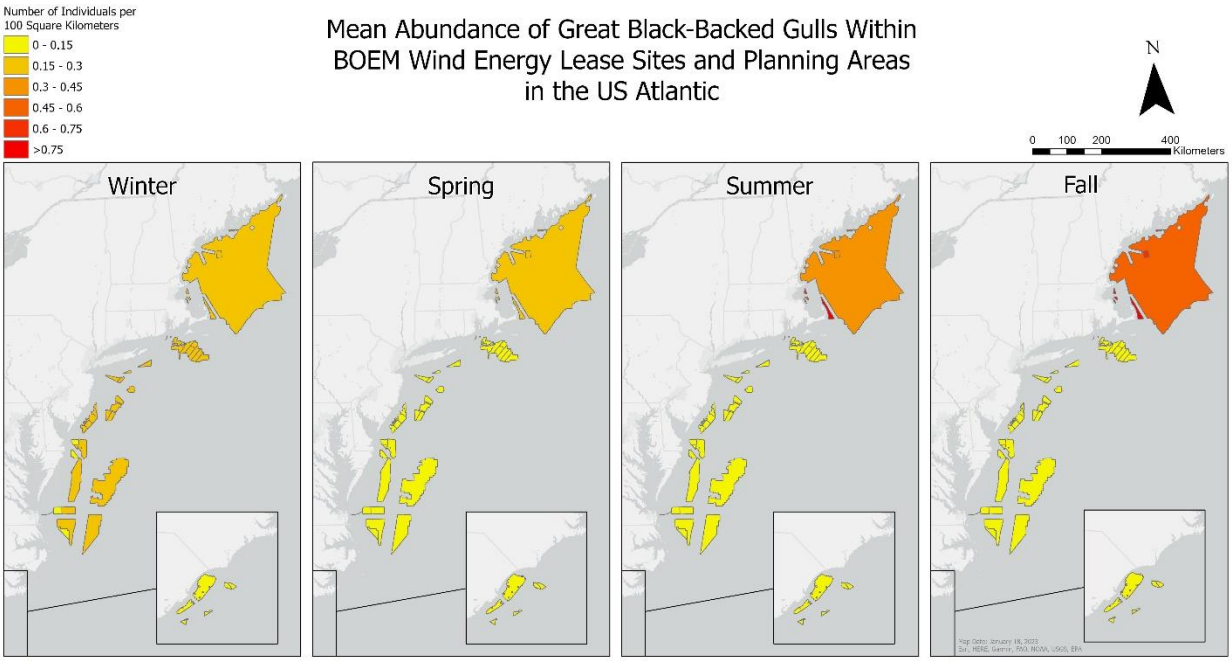

Figure 30. Mean abundance of Great black-backed gulls in US Atlantic wind energy lease sites and planning areas

3. Additional Tables

Winter Abundance to Yearly Maximum: Species-Specific Mean Abundance Ratios Within BOEM Wind Energy Lease Sites and Planning Areas in the US Atlantic

Area ID	Status	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Red-Throated Loon	Northern Gannet	Great Black-Backed Gull
Gulf of Maine Request for Competitive Interest (RFCI)	Planning Area (as of 08/18/2022)	43.35	0.15	0.02	0.06	0.07	0.06	0.01	0.22
Gulf of Maine Request for Interest (RFI) Area A	Planning Area (as of 08/18/2022)	42.88	0.24	0.08	0.05	0.06	0.06	0.02	0.23
Gulf of Maine Request for Interest (RFI) Area B	Planning Area (as of 08/18/2022)	42.44	0.08	0.21	0.03	0.00	0.11	0.05	0.27
Gulf of Maine Request for Interest (RFI) Area C	Planning Area (as of 08/18/2022)	42.27	0.10	0.31	0.03	0.01	0.12	0.05	0.24
Gulf of Maine Request for Interest (RFI) Area D	Planning Area (as of 08/18/2022)	42.19	0.07	0.32	0.02	0.11	0.15	0.03	0.22
Gulf of Maine Request for Interest (RFI) Area E	Planning Area (as of 08/18/2022)	41.90	0.47	0.38	0.14	0.18	0.10	0.12	0.23
OCS-A 0506 - The Narragansett Electric Company	Lease Site (as of 06/30/2022)	41.27	0.12	0.04	0.03	0.13	0.27	0.09	0.22
OCS-A 0486 - Revolution Wind, LLC	Lease Site (as of 06/30/2022)	41.15	0.15	0.09	0.02	0.36	0.18	0.10	0.21
OCS-A 0517 - South Fork Wind, LLC	Lease Site (as of 06/30/2022)	41.09	0.15	0.10	0.02	0.33	0.15	0.11	0.21
OCS-A 0501 - Vineyard Wind LLC	Lease Site (as of 06/30/2022)	41.04	0.14	0.12	0.02	0.55	0.15	0.07	0.18
OCS-A 0487 - Sunrise Wind LLC	Lease Site (as of 06/30/2022)	40.99	0.14	0.08	0.02	0.23	0.12	0.10	0.20
OCS-A 0500 - Bay State Wind LLC	Lease Site (as of 06/30/2022)	40.97	0.14	0.10	0.02	0.31	0.12	0.08	0.18
OCS-A 0534 - Park City Wind LLC	Lease Site (as of 06/30/2022)	40.90	0.14	0.10	0.02	0.33	0.11	0.08	0.17
OCS-A 0520 - Beacon Wind LLC	Lease Site (as of 06/30/2022)	40.82	0.14	0.09	0.01	0.29	0.11	0.07	0.17
OCS-A 0521 - Mayflower Wind Energy LLC	Lease Site (as of 06/30/2022)	40.75	0.14	0.08	0.01	0.38	0.12	0.07	0.17
OCS-A 0522 - Vineyard Northeast LLC	Lease Site (as of 06/30/2022)	40.68	0.15	0.09	0.02	0.75	0.11	0.07	0.17
New York WEA - Fairways North	Planning Area (as of 08/18/2022)	40.61	0.17	0.11	0.03	0.06	0.12	0.14	0.21
New York WEA - Fairways South	Planning Area (as of 08/18/2022)	40.43	0.16	0.09	0.04	0.11	0.17	0.14	0.21
OCS-A 0512 - Empire Offshore Wind, LLC	Lease Site (as of 06/30/2022)	40.30	0.12	0.05	0.05	0.07	0.33	0.19	0.21
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	Lease Site (as of 06/30/2022)	40.24	0.13	0.06	0.04	0.09	0.15	0.20	0.21
OCS-A 0537 - OW Ocean Winds East, LLC	Lease Site (as of 06/30/2022)	39.98	0.21	0.09	0.03	0.05	0.10	0.20	0.20
OCS-A 0538 - Attentive Energy LLC	Lease Site (as of 06/30/2022)	39.72	0.15	0.06	0.03	0.05	0.11	0.24	0.20
OCS-A 0539 - Community Offshore Wind, LLC	Lease Site (as of 06/30/2022)	39.54	0.15	0.06	0.03	0.06	0.11	0.24	0.21
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	Lease Site (as of 06/30/2022)	39.47	0.11	0.03	0.05	0.05	0.58	0.17	0.17
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	Lease Site (as of 06/30/2022)	39.36	0.13	0.05	0.03	0.07	0.13	0.21	0.21
OCS-A 0542 - Invenergy Wind Offshore LLC	Lease Site (as of 06/30/2022)	39.30	0.15	0.06	0.03	0.08	0.11	0.21	0.21
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	Lease Site (as of 06/30/2022)	39.27	0.12	0.04	0.05	0.05	0.47	0.18	0.17
OCS-A 0498 - Ocean Wind LLC	Lease Site (as of 06/30/2022)	39.12	0.12	0.04	0.05	0.05	0.42	0.17	0.17
OCS-A 0532 - Orsted North America Inc.	Lease Site (as of 06/30/2022)	39.07	0.11	0.04	0.05	0.06	0.59	0.19	0.16
OCS-A 0482 - GSOE I LLC	Lease Site (as of 06/30/2022)	38.67	0.11	0.04	0.05	0.08	0.54	0.18	0.14
OCS-A 0519 - Skipjack Offshore Energy LLC	Lease Site (as of 06/30/2022)	38.57	0.13	0.05	0.04	0.05	0.42	0.19	0.15
Central Atlantic Call Area A	Planning Area (as of 08/18/2022)	38.52	0.14	0.06	0.04	0.06	0.22	0.27	0.18
OCS-A 0490 - US Wind Inc.	Lease Site (as of 06/30/2022)	38.35	0.14	0.06	0.04	0.06	0.49	0.28	0.13
Central Atlantic Call Area B	Planning Area (as of 08/18/2022)	37.66	0.19	0.08	0.05	0.06	0.18	0.22	0.16
Central Atlantic Call Area E	Planning Area (as of 08/18/2022)	37.61	0.10	0.01	0.00	0.00	0.11	0.05	0.20
OCS-A 0483 - Virginia Electric and Power Company	Lease Site (as of 06/30/2022)	36.91	0.08	0.04	0.04	0.07	0.39	0.46	0.13
Central Atlantic Call Area C	Planning Area (as of 08/18/2022)	36.90	0.18	0.07	0.05	0.04	0.18	0.16	0.15
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	Lease Site (as of 06/30/2022)	36.89	0.05	0.03	0.05	0.08	1.00	1.00	0.14
Central Atlantic Call Area D	Planning Area (as of 08/18/2022)	36.48	0.23	0.07	0.05	0.02	0.29	0.18	0.16
Central Atlantic Call Area F	Planning Area (as of 08/18/2022)	36.37	0.11	0.01	0.00	0.00	0.16	0.08	0.17
OCS-A 0508 - Avangrid Renewables LLC	Lease Site (as of 06/30/2022)	36.34	0.13	0.07	0.05	0.02	0.32	0.19	0.13
OCS - A 0545 - TotalEnergies Renewables USA, LLC	Lease Site (as of 06/30/2022)	33.45	0.00	0.00	0.00	0.01	0.26	0.26	0.06
OCS - A 0546 - Duke Energy Renewables Wind, LLC	Lease Site (as of 06/30/2022)	33.45	0.00	0.00	0.00	0.01	0.26	0.24	0.06
South Carolina Call Area - Grand Strand	Planning Area (as of 08/18/2022)	33.44	0.00	0.00	0.00	0.04	0.54	0.20	0.06
South Carolina Call Area - Cape Romain	Planning Area (as of 08/18/2022)	32.89	0.00	0.00	0.00	0.04	0.55	0.22	0.06
South Carolina Call Area - Winyah	Planning Area (as of 08/18/2022)	32.75	0.00	0.00	0.01	0.00	0.09	0.01	0.06
South Carolina Call Area - Charleston	Planning Area (as of 08/18/2022)	32.52	0.00	0.00	0.00	0.00	0.18	0.06	0.06

Table 9. Winter abundance to yearly maximum: Mean abundance ratios in US Atlantic BOEM wind energy lease sites and planning areas

Spring Abundance to Yearly Maximum: Species-Specific Mean Abundance Ratios Within BOEM Wind Energy Lease Sites and Planning Areas in the US Atlantic

Area ID	Status	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Red-Throated Loon	Northern Gannet	Great Black-Backed Gull
Gulf of Maine Request for Competitive Interest (RFCI)	Planning Area (as of 08/18/2022)	43.35	0.23	0.35	0.39	0.02	0.02	0.12	0.33
Gulf of Maine Request for Interest (RFI) Area A	Planning Area (as of 08/18/2022)	42.88	0.39	0.36	0.49	0.15	0.02	0.11	0.32
Gulf of Maine Request for Interest (RFI) Area B	Planning Area (as of 08/18/2022)	42.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gulf of Maine Request for Interest (RFI) Area C	Planning Area (as of 08/18/2022)	42.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gulf of Maine Request for Interest (RFI) Area D	Planning Area (as of 08/18/2022)	42.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gulf of Maine Request for Interest (RFI) Area E	Planning Area (as of 08/18/2022)	41.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OCS-A 0506 - The Narragansett Electric Company	Lease Site (as of 06/30/2022)	41.27	0.15	0.50	0.11	0.16	0.13	0.21	0.20
OCS-A 0486 - Revolution Wind, LLC	Lease Site (as of 06/30/2022)	41.15	0.21	0.72	0.14	0.49	0.08	0.17	0.18
OCS-A 0517 - South Fork Wind, LLC	Lease Site (as of 06/30/2022)	41.09	0.22	0.75	0.12	0.48	0.05	0.15	0.17
OCS-A 0501 - Vineyard Wind LLC	Lease Site (as of 06/30/2022)	41.04	0.21	0.83	0.16	0.74	0.08	0.15	0.16
OCS-A 0487 - Sunrise Wind LLC	Lease Site (as of 06/30/2022)	40.99	0.22	0.73	0.15	0.35	0.04	0.16	0.18
OCS-A 0500 - Bay State Wind LLC	Lease Site (as of 06/30/2022)	40.97	0.23	0.74	0.17	0.45	0.05	0.17	0.18
OCS-A 0534 - Park City Wind LLC	Lease Site (as of 06/30/2022)	40.90	0.22	0.75	0.18	0.47	0.05	0.16	0.17
OCS-A 0520 - Beacon Wind LLC	Lease Site (as of 06/30/2022)	40.82	0.23	0.70	0.20	0.41	0.05	0.16	0.17
OCS-A 0521 - Mayflower Wind Energy LLC	Lease Site (as of 06/30/2022)	40.75	0.25	0.66	0.21	0.48	0.05	0.16	0.15
OCS-A 0522 - Vineyard Northeast LLC	Lease Site (as of 06/30/2022)	40.68	0.27	0.67	0.24	0.90	0.05	0.15	0.14
New York WEA - Fairways North	Planning Area (as of 08/18/2022)	40.61	0.30	0.83	0.18	0.09	0.04	0.17	0.19
New York WEA - Fairways South	Planning Area (as of 08/18/2022)	40.43	0.27	0.84	0.16	0.14	0.05	0.17	0.18
OCS-A 0512 - Empire Offshore Wind, LLC	Lease Site (as of 06/30/2022)	40.30	0.18	0.69	0.13	0.08	0.07	0.20	0.18
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	Lease Site (as of 06/30/2022)	40.24	0.24	0.76	0.14	0.11	0.04	0.17	0.20
OCS-A 0537 - OW Ocean Winds East, LLC	Lease Site (as of 06/30/2022)	39.98	0.49	0.71	0.26	0.11	0.02	0.24	0.17
OCS-A 0538 - Attentive Energy LLC	Lease Site (as of 06/30/2022)	39.72	0.32	0.73	0.19	0.08	0.02	0.27	0.20
OCS-A 0539 - Community Offshore Wind, LLC	Lease Site (as of 06/30/2022)	39.54	0.27	0.68	0.17	0.09	0.02	0.22	0.16
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	Lease Site (as of 06/30/2022)	39.47	0.11	0.44	0.11	0.04	0.26	0.39	0.16
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	Lease Site (as of 06/30/2022)	39.36	0.23	0.64	0.15	0.09	0.03	0.18	0.14
OCS-A 0542 - Invenergy Wind Offshore LLC	Lease Site (as of 06/30/2022)	39.30	0.29	0.68	0.17	0.11	0.02	0.20	0.12
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	Lease Site (as of 06/30/2022)	39.27	0.12	0.43	0.11	0.04	0.21	0.29	0.13
OCS-A 0498 - Ocean Wind LLC	Lease Site (as of 06/30/2022)	39.12	0.13	0.41	0.11	0.04	0.14	0.23	0.11
OCS-A 0532 - Orsted North America Inc.	Lease Site (as of 06/30/2022)	39.07	0.11	0.34	0.10	0.04	0.20	0.32	0.11
OCS-A 0482 - GSOE I LLC	Lease Site (as of 06/30/2022)	38.67	0.12	0.36	0.11	0.04	0.13	0.17	0.06
OCS-A 0519 - Skipjack Offshore Energy LLC	Lease Site (as of 06/30/2022)	38.57	0.13	0.41	0.14	0.04	0.09	0.12	0.03
Central Atlantic Call Area A	Planning Area (as of 08/18/2022)	38.52	0.22	0.48	0.17	0.07	0.05	0.18	0.03
OCS-A 0490 - US Wind Inc.	Lease Site (as of 06/30/2022)	38.35	0.17	0.42	0.15	0.05	0.11	0.16	0.03
Central Atlantic Call Area B	Planning Area (as of 08/18/2022)	37.66	0.48	0.49	0.35	0.08	0.04	0.22	0.02
Central Atlantic Call Area E	Planning Area (as of 08/18/2022)	37.61	0.25	0.18	0.04	0.01	0.02	0.01	0.01
OCS-A 0483 - Virginia Electric and Power Company	Lease Site (as of 06/30/2022)	36.91	0.14	0.36	0.16	0.07	0.07	0.27	0.01
Central Atlantic Call Area C	Planning Area (as of 08/18/2022)	36.90	0.50	0.42	0.35	0.05	0.03	0.34	0.02
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	Lease Site (as of 06/30/2022)	36.89	0.08	0.20	0.10	0.04	0.25	0.74	0.03
Central Atlantic Call Area D	Planning Area (as of 08/18/2022)	36.48	0.57	0.35	0.30	0.02	0.03	0.15	0.01
Central Atlantic Call Area F	Planning Area (as of 08/18/2022)	36.37	0.28	0.16	0.01	0.00	0.02	0.01	0.01
OCS-A 0508 - Avangrid Renewables LLC	Lease Site (as of 06/30/2022)	36.34	0.35	0.35	0.29	0.02	0.03	0.16	0.01
OCS - A 0545 - TotalEnergies Renewables USA, LLC	Lease Site (as of 06/30/2022)	33.45	0.00	0.00	0.00	0.01	0.05	0.06	0.00
OCS - A 0546 - Duke Energy Renewables Wind, LLC	Lease Site (as of 06/30/2022)	33.45	0.00	0.00	0.00	0.01	0.04	0.05	0.00
South Carolina Call Area - Grand Strand	Planning Area (as of 08/18/2022)	33.44	0.00	0.00	0.01	0.02	0.24	0.28	0.01
South Carolina Call Area - Cape Romain	Planning Area (as of 08/18/2022)	32.89	0.00	0.00	0.01	0.02	0.10	0.28	0.01
South Carolina Call Area - Winyah	Planning Area (as of 08/18/2022)	32.75	0.01	0.00	0.02	0.00	0.02	0.01	0.00
South Carolina Call Area - Charleston	Planning Area (as of 08/18/2022)	32.52	0.00	0.00	0.00	0.00	0.02	0.01	0.00

Table 10. Spring abundance to yearly maximum: Mean abundance ratios in US Atlantic BOEM wind energy lease sites and planning areas

Summer Abundance to Yearly Maximum: Species-Specific Mean Abundance Ratios Within BOEM Wind Energy Lease Sites and Planning Areas in the US Atlantic

Area ID	Status	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Northern Gannet	Great Black-Backed Gull
Gulf of Maine Request for Competitive Interest (RFCI)	Planning Area (as of 08/18/2022)	43.35	0.82	0.64	0.88	0.03	0.01	0.53
Gulf of Maine Request for Interest (RFI) Area A	Planning Area (as of 08/18/2022)	42.88	1.00	0.70	1.00	0.10	0.02	0.50
Gulf of Maine Request for Interest (RFI) Area B	Planning Area (as of 08/18/2022)	42.44	0.00	0.00	0.00	0.00	0.00	0.00
Gulf of Maine Request for Interest (RFI) Area C	Planning Area (as of 08/18/2022)	42.27	0.00	0.00	0.00	0.00	0.00	0.00
Gulf of Maine Request for Interest (RFI) Area D	Planning Area (as of 08/18/2022)	42.19	0.00	0.00	0.00	0.00	0.00	0.00
Gulf of Maine Request for Interest (RFI) Area E	Planning Area (as of 08/18/2022)	41.90	0.00	0.00	0.00	0.00	0.00	0.00
OCS-A 0506 - The Narragansett Electric Company	Lease Site (as of 06/30/2022)	41.27	0.11	0.23	0.08	0.01	0.00	0.21
OCS-A 0486 - Revolution Wind, LLC	Lease Site (as of 06/30/2022)	41.15	0.28	0.46	0.14	0.03	0.00	0.11
OCS-A 0517 - South Fork Wind, LLC	Lease Site (as of 06/30/2022)	41.09	0.35	0.55	0.13	0.03	0.00	0.10
OCS-A 0501 - Vineyard Wind LLC	Lease Site (as of 06/30/2022)	41.04	0.35	0.80	0.18	0.05	0.00	0.09
OCS-A 0487 - Sunrise Wind LLC	Lease Site (as of 06/30/2022)	40.99	0.44	0.64	0.18	0.02	0.00	0.08
OCS-A 0500 - Bay State Wind LLC	Lease Site (as of 06/30/2022)	40.97	0.40	0.66	0.20	0.03	0.00	0.06
OCS-A 0534 - Park City Wind LLC	Lease Site (as of 06/30/2022)	40.90	0.41	0.76	0.22	0.03	0.00	0.06
OCS-A 0520 - Beacon Wind LLC	Lease Site (as of 06/30/2022)	40.82	0.43	0.81	0.25	0.03	0.00	0.05
OCS-A 0521 - Mayflower Wind Energy LLC	Lease Site (as of 06/30/2022)	40.75	0.46	0.85	0.27	0.05	0.00	0.04
OCS-A 0522 - Vineyard Northeast LLC	Lease Site (as of 06/30/2022)	40.68	0.54	1.00	0.32	0.11	0.00	0.04
New York WEA - Fairways North	Planning Area (as of 08/18/2022)	40.61	0.63	0.82	0.18	0.01	0.00	0.06
New York WEA - Fairways South	Planning Area (as of 08/18/2022)	40.43	0.47	0.57	0.11	0.01	0.00	0.04
OCS-A 0512 - Empire Offshore Wind, LLC	Lease Site (as of 06/30/2022)	40.30	0.18	0.31	0.07	0.00	0.00	0.05
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	Lease Site (as of 06/30/2022)	40.24	0.36	0.50	0.11	0.01	0.00	0.03
OCS-A 0537 - OW Ocean Winds East, LLC	Lease Site (as of 06/30/2022)	39.98	0.73	0.48	0.28	0.01	0.00	0.01
OCS-A 0538 - Attentive Energy LLC	Lease Site (as of 06/30/2022)	39.72	0.43	0.38	0.15	0.00	0.00	0.01
OCS-A 0539 - Community Offshore Wind, LLC	Lease Site (as of 06/30/2022)	39.54	0.28	0.30	0.12	0.00	0.00	0.01
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	Lease Site (as of 06/30/2022)	39.47	0.05	0.06	0.03	0.00	0.01	0.08
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	Lease Site (as of 06/30/2022)	39.36	0.19	0.26	0.09	0.00	0.00	0.01
OCS-A 0542 - Invenergy Wind Offshore LLC	Lease Site (as of 06/30/2022)	39.30	0.32	0.31	0.13	0.01	0.00	0.01
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	Lease Site (as of 06/30/2022)	39.27	0.06	0.08	0.03	0.00	0.01	0.04
OCS-A 0498 - Ocean Wind LLC	Lease Site (as of 06/30/2022)	39.12	0.06	0.08	0.03	0.00	0.00	0.02
OCS-A 0532 - Orsted North America Inc.	Lease Site (as of 06/30/2022)	39.07	0.05	0.05	0.02	0.00	0.00	0.04
OCS-A 0482 - GSOE I LLC	Lease Site (as of 06/30/2022)	38.67	0.05	0.05	0.03	0.00	0.00	0.02
OCS-A 0519 - Skipjack Offshore Energy LLC	Lease Site (as of 06/30/2022)	38.57	0.07	0.06	0.05	0.00	0.00	0.01
Central Atlantic Call Area A	Planning Area (as of 08/18/2022)	38.52	0.12	0.13	0.08	0.00	0.00	0.00
OCS-A 0490 - US Wind Inc.	Lease Site (as of 06/30/2022)	38.35	0.08	0.07	0.05	0.00	0.00	0.01
Central Atlantic Call Area B	Planning Area (as of 08/18/2022)	37.66	0.23	0.10	0.15	0.00	0.00	0.00
Central Atlantic Call Area E	Planning Area (as of 08/18/2022)	37.61	0.20	0.04	0.01	0.00	0.00	0.00
OCS-A 0483 - Virginia Electric and Power Company	Lease Site (as of 06/30/2022)	36.91	0.05	0.02	0.03	0.00	0.00	0.00
Central Atlantic Call Area C	Planning Area (as of 08/18/2022)	36.90	0.23	0.06	0.11	0.00	0.00	0.00
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	Lease Site (as of 06/30/2022)	36.89	0.02	0.01	0.01	0.00	0.00	0.01
Central Atlantic Call Area D	Planning Area (as of 08/18/2022)	36.48	0.30	0.03	0.07	0.00	0.00	0.00
Central Atlantic Call Area F	Planning Area (as of 08/18/2022)	36.37	0.13	0.03	0.00	0.00	0.00	0.00
OCS-A 0508 - Avangrid Renewables LLC	Lease Site (as of 06/30/2022)	36.34	0.10	0.02	0.06	0.00	0.00	0.00
OCS - A 0545 - TotalEnergies Renewables USA, LLC	Lease Site (as of 06/30/2022)	33.45	0.00	0.00	0.00	0.00	0.00	0.00
OCS - A 0546 - Duke Energy Renewables Wind, LLC	Lease Site (as of 06/30/2022)	33.45	0.00	0.00	0.00	0.00	0.00	0.00
South Carolina Call Area - Grand Strand	Planning Area (as of 08/18/2022)	33.44	0.00	0.00	0.00	0.00	0.00	0.00
South Carolina Call Area - Cape Romain	Planning Area (as of 08/18/2022)	32.89	0.00	0.00	0.00	0.00	0.01	0.00
South Carolina Call Area - Winyah	Planning Area (as of 08/18/2022)	32.75	0.00	0.00	0.00	0.00	0.00	0.00
South Carolina Call Area - Charleston	Planning Area (as of 08/18/2022)	32.52	0.00	0.00	0.00	0.00	0.00	0.00

Table 11. Summer abundance to yearly maximum: Mean abundance ratios in US Atlantic BOEM wind energy lease sites and planning areas

Fall Abundance to Yearly Maximum: Species-Specific Mean Abundance Ratios Within BOEM Wind Energy Lease Sites and Planning Areas in the US Atlantic

Area ID	Status	Centroid Lattitude	Fin Whale	Common Minke Whale	Humpback Whale	North Atlantic Right Whale	Red-Throated Loon	Northern Gannet	Great Black-Backed Gull
Gulf of Maine Request for Competitive Interest (RFCI)	Planning Area (as of 08/18/2022)	43.35	0.59	0.52	0.65	0.10	0.01	0.09	1.00
Gulf of Maine Request for Interest (RFI) Area A	Planning Area (as of 08/18/2022)	42.88	0.73	0.47	0.76	0.05	0.01	0.06	0.83
Gulf of Maine Request for Interest (RFI) Area B	Planning Area (as of 08/18/2022)	42.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gulf of Maine Request for Interest (RFI) Area C	Planning Area (as of 08/18/2022)	42.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gulf of Maine Request for Interest (RFI) Area D	Planning Area (as of 08/18/2022)	42.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gulf of Maine Request for Interest (RFI)Area E	Planning Area (as of 08/18/2022)	41.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OCS-A 0506 - The Narragansett Electric Company	Lease Site (as of 06/30/2022)	41.27	0.05	0.05	0.14	0.02	0.01	0.04	0.37
OCS-A 0486 - Revolution Wind, LLC	Lease Site (as of 06/30/2022)	41.15	0.07	0.11	0.16	0.06	0.01	0.03	0.20
OCS-A 0517 - South Fork Wind, LLC	Lease Site (as of 06/30/2022)	41.09	0.08	0.13	0.15	0.05	0.01	0.02	0.19
OCS-A 0501 - Vineyard Wind LLC	Lease Site (as of 06/30/2022)	41.04	0.08	0.21	0.20	0.10	0.01	0.03	0.13
OCS-A 0487 - Sunrise Wind LLC	Lease Site (as of 06/30/2022)	40.99	0.12	0.22	0.18	0.04	0.00	0.02	0.16
OCS-A 0500 - Bay State Wind LLC	Lease Site (as of 06/30/2022)	40.97	0.13	0.24	0.20	0.05	0.00	0.02	0.14
OCS-A 0534 - Park City Wind LLC	Lease Site (as of 06/30/2022)	40.90	0.13	0.26	0.22	0.06	0.00	0.02	0.13
OCS-A 0520 - Beacon Wind LLC	Lease Site (as of 06/30/2022)	40.82	0.15	0.30	0.24	0.05	0.00	0.02	0.13
OCS-A 0521 - Mayflower Wind Energy LLC	Lease Site (as of 06/30/2022)	40.75	0.17	0.30	0.25	0.07	0.00	0.02	0.13
OCS-A 0522 - Vineyard Northeast LLC	Lease Site (as of 06/30/2022)	40.68	0.18	0.32	0.28	0.14	0.00	0.02	0.13
New York WEA - Fairways North	Planning Area (as of 08/18/2022)	40.61	0.18	0.23	0.18	0.01	0.00	0.02	0.13
New York WEA - Fairways South	Planning Area (as of 08/18/2022)	40.43	0.11	0.11	0.15	0.02	0.01	0.02	0.11
OCS-A 0512 - Empire Offshore Wind, LLC	Lease Site (as of 06/30/2022)	40.30	0.06	0.06	0.11	0.01	0.01	0.01	0.11
Provisional - OCS-A 0544 - Mid-Atlantic Offshore Wind LLC	Lease Site (as of 06/30/2022)	40.24	0.08	0.09	0.12	0.01	0.00	0.01	0.10
OCS-A 0537 - OW Ocean Winds East, LLC	Lease Site (as of 06/30/2022)	39.98	0.44	0.27	0.17	0.01	0.00	0.01	0.11
OCS-A 0538 - Attentive Energy LLC	Lease Site (as of 06/30/2022)	39.72	0.21	0.17	0.10	0.01	0.00	0.01	0.10
OCS-A 0539 - Community Offshore Wind, LLC	Lease Site (as of 06/30/2022)	39.54	0.13	0.11	0.10	0.01	0.00	0.01	0.09
OCS-A 0549 - Atlantic Shores Offshore Wind, LLC	Lease Site (as of 06/30/2022)	39.47	0.04	0.03	0.08	0.01	0.01	0.02	0.14
OCS-A 0541 - Atlantic Shores Offshore Wind Bight, LLC	Lease Site (as of 06/30/2022)	39.36	0.08	0.07	0.08	0.01	0.00	0.01	0.08
OCS-A 0542 - Invenergy Wind Offshore LLC	Lease Site (as of 06/30/2022)	39.30	0.13	0.11	0.10	0.01	0.00	0.01	0.08
OCS-A 0499 - Atlantic Shores Offshore Wind Projects 1 & 2, LLC's	Lease Site (as of 06/30/2022)	39.27	0.04	0.03	0.07	0.01	0.01	0.02	0.12
OCS-A 0498 - Ocean Wind LLC	Lease Site (as of 06/30/2022)	39.12	0.04	0.03	0.07	0.01	0.01	0.02	0.10
OCS-A 0532 - Orsted North America Inc.	Lease Site (as of 06/30/2022)	39.07	0.04	0.02	0.06	0.01	0.01	0.03	0.15
OCS-A 0482 - GSOE I LLC	Lease Site (as of 06/30/2022)	38.67	0.04	0.02	0.07	0.01	0.01	0.01	0.16
OCS-A 0519 - Skipjack Offshore Energy LLC	Lease Site (as of 06/30/2022)	38.57	0.04	0.03	0.09	0.01	0.01	0.01	0.07
Central Atlantic Call Area A	Planning Area (as of 08/18/2022)	38.52	0.06	0.04	0.10	0.01	0.00	0.00	0.06
OCS-A 0490 - US Wind Inc.	Lease Site (as of 06/30/2022)	38.35	0.05	0.02	0.10	0.01	0.01	0.01	0.09
Central Atlantic Call Area B	Planning Area (as of 08/18/2022)	37.66	0.14	0.04	0.15	0.01	0.00	0.00	0.04
Central Atlantic Call Area E	Planning Area (as of 08/18/2022)	37.61	0.23	0.04	0.01	0.00	0.00	0.00	0.02
OCS-A 0483 - Virginia Electric and Power Company	Lease Site (as of 06/30/2022)	36.91	0.03	0.01	0.07	0.01	0.00	0.00	0.04
Central Atlantic Call Area C	Planning Area (as of 08/18/2022)	36.90	0.22	0.03	0.13	0.01	0.00	0.00	0.03
OCS-A 0497 - Commonwealth of VA, Dept. of Mines, Minerals and Energy	Lease Site (as of 06/30/2022)	36.89	0.02	0.01	0.04	0.01	0.01	0.01	0.08
Central Atlantic Call Area D	Planning Area (as of 08/18/2022)	36.48	0.31	0.03	0.12	0.00	0.00	0.00	0.03
Central Atlantic Call Area F	Planning Area (as of 08/18/2022)	36.37	0.15	0.03	0.00	0.00	0.00	0.00	0.01
OCS-A 0508 - Avangrid Renewables LLC	Lease Site (as of 06/30/2022)	36.34	0.09	0.02	0.12	0.00	0.00	0.00	0.03
OCS - A 0545 - TotalEnergies Renewables USA, LLC	Lease Site (as of 06/30/2022)	33.45	0.00	0.00	0.00	0.00	0.00	0.00	0.01
OCS - A 0546 - Duke Energy Renewables Wind, LLC	Lease Site (as of 06/30/2022)	33.45	0.00	0.00	0.00	0.00	0.00	0.00	0.01
South Carolina Call Area - Grand Strand	Planning Area (as of 08/18/2022)	33.44	0.00	0.00	0.00	0.01	0.01	0.00	0.02
South Carolina Call Area - Cape Romain	Planning Area (as of 08/18/2022)	32.89	0.00	0.00	0.00	0.01	0.01	0.00	0.02
South Carolina Call Area - Winyah	Planning Area (as of 08/18/2022)	32.75	0.00	0.00	0.00	0.00	0.00	0.00	0.01
South Carolina Call Area - Charleston	Planning Area (as of 08/18/2022)	32.52	0.00	0.00	0.00	0.00	0.00	0.00	0.01

Table 12. Fall abundance to yearly maximum: Mean abundance ratios in US Atlantic BOEM wind energy lease sites and planning areas