MAYFLOWER WIND

Appendix I1. Avian Exposure Risk Assessment

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MAYFLOWER WIND OFFSHORE WIND PROJECT

Avian Exposure Risk Assessment

Mayflower Wind

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Abbreviations

Abbreviation	Meaning
AERA	Avian Exposure Risk Assessment
BOEM	Bureau of Ocean Energy Management
COP	Construction and Operations Plan
cm	Centimeter
CUNY	The City University of New York
CWS-ECCC	Canadian Wildlife Service, Environment and Climate Change Canada
DOI	U.S. Department of the Interior
EcoMon	Ecosystem Monitoring Program
ECSAS	Eastern Canada Seabirds at Sea
ESA	Endangered Species Act
Ft	Foot/Feet
G&G	Geophysical and Geotechnical
GPS	Global-positioning System
GSD	Ground-sampling Distance
HAT	Highest Astronomical Tide
HD	High-definition
kt	Knot(s)
m	Meter(s)
MCEC	Massachusetts Clean Energy Center
MDAT	Marine-life Data and Analysis Team
MADFW	Massachusetts Division of Fisheries and Wildlife
MESA	Massachusetts Endangered Species Act
MLLW	Mean Lower Low Water
MNWR	Monomoy National Wildlife Refuge
NAPA	BOEM North Atlantic Planning Area
NASC	Northwest Atlantic Seabird Catalog
NEFSC	Northeast Fisheries Science Center
NHESP	Natural Heritage and Endangered Species Program
NM	Nautical mile(s)
NMFS	NOAA National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NODP	Northeast Ocean Data Portal
OCS	Outer Continental Shelf
PTT	Platform Terminal (satellite) Transmitter(s)
QA	Quality Assurance
RSZ	Rotor-swept Zone
SGCN	Species of Greatest Conservation Need
TPNWR	Trustom Pond National Wildlife Refuge

Abbreviation	Meaning
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VHF	Very high frequency
WEA	Wind Energy Area

REVISION HISTORY

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EXECUTIVE SUMMARY

In accordance with Bureau of Ocean Energy Management (BOEM) guidance (BOEM 2020 a-b), an Avian Exposure Risk Assessment (AERA) was completed for the Mayflower Wind Offshore Wind Energy Project (the Project). The AERA relied on the best-available information relevant to marine avian species with potential to occur in the Outer Continental Shelf (OCS) Lease Area OCS-A 0521 (Lease Area) and considered multiple spatially-explicit, quantitative, and qualitative resources available for species occurrences at multiple scales. Specifically, the AERA incorporates baseline regional information as well as site-specific data collected during Project-sponsored high-definition aerial (Aerial HD) surveys and opportunistic ship-based surveys to evaluate marine bird occurrence in the Lease Area, with a focus on species of conservation concern (e.g., federally- or state-listed species) and potentially sensitive species (i.e., species believed to be susceptible to displacement from wind energy projects or collision with operational wind turbines). The AERA includes exposure maps for focal species, potentially sensitive species, and taxonomic groups. All species with potential to occur in the Lease Area were also scored based on occurrence levels in the Lease Area relative to local and regional observed or predicted abundance. Results indicated that tern species, including federally-endangered roseate tern and Massachusetts Species of Concern (SC) common tern, may occur in the Lease Area in low to moderate levels relative to local and regional occurrence levels, and concentrations of these species are not expected in the Lease Area based on prey base (*Ammodytes* sp.) distribution data. Federally-endangered black-capped petrel and state-endangered Leach's storm petrel are expected to rarely occur in the Lease Area based on baseline data and neither species was observed during the Aerial HD surveys or opportunistically during geophysical and geotechnical (G&G) surveys. Coastal shorebirds including federally-threatened rufa red knot and piping plover may travel through the Lease Area but available data do not indicate that such movements are common. Black-legged kittiwake, a species exhibiting population declines and potentially sensitive to collision with turbine blades, may occur at moderate levels relative to regional levels in spring, fall and winter; similar relationships were observed for surf scoter and red-throated loon, also considered potentially sensitive to displacement and collision, in spring and winter. Northern gannet, also considered vulnerable to collision or displacement from offshore wind facilities, may occur at moderate to high abundance levels in the Lease Area compared to regional levels, particularly in summer and fall. Overall, the Lease Area does not appear to contain areas where high relative abundances of species considered at risk from collision with operational turbines are expected; however, northern portions of the Lease Area may be frequented by some collision-sensitive species including razorbill, northern gannet, and gull and seaduck species in winter and spring. As a group, species believed to be sensitive to displacement from offshore wind projects are expected to be low relative to local and regional waters, with a small pocket of moderately-high recorded activity in the northern portion of the Lease Area during winter and spring; again, exposure rates are driven primarily by razorbill, northern gannet and some seaduck species.

1 INTRODUCTION

This report provides an Avian Exposure Risk Assessment (AERA) for the Mayflower Wind Offshore Wind Project (the Project). General AERA framework, methods and results are presented herein.

2 EXPOSURE ANALYSIS FRAMEWORK AND METHODS

To assess potential exposure of marine birds in the Outer Continental Shelf (OCS) Lease Area OCS-A 0521 (Lease Area), this AERA considered multiple spatially-explicit, quantitative, and qualitative data resources available for species occurrences at the Lease Area, local, and regional scales. The methodology used was modified from Epsilon Associates, Inc. (2018) and relied on the best-available information relevant to marine avian species with potential to occur offshore in the region. Exposure to operational turbine blades is a function of vertical (flight height), temporal (seasonal) and horizontal distribution. This AERA provides distributional information for species and species groups likely to occur within the Lease Area; the goal is to present information that can be integrated with additional data pertaining to the Project (e.g., number and size of turbines to be installed; See Table 2-1) and species (e.g. wing span, flight speed) to inform and parameterize collision-risk models or other tools as warranted. Focal species in the AERA are discussed in Section 2.1. The individual data sets, reports, and other sources that informed the AERA, and the methods by which these data were initially derived, are summarized in Section 2.2. The framework used to assess relative and overall exposure risk to focal species and taxonomic groups is summarized in Section 2.3.

Table 2-1 WTG Parameters[1]

WTG Parameter	Minimum	Maximum
Rotor diameter	721.7 ft (220.0 m)	918.6 ft (280.0 m)
Rotor swept area	409,168.5 ft^2 (38,013.0 m^2)	662,787.8 ft^2 (61,575.0 m^2)
Blade length	351.0 ft (107.0 m)	452.8 ft (138.0 m)
Tip height above MLLW	779.5 ft (237.6 m)	1,066.3 ft (325.0 m)
Hub height above MLLW	418.7 ft (127.6 m)	605.1 ft (184.4 m)
Tip clearance (air gap) above highest astronomical tide (HAT)	53.8 ft (16.4 m)	n/a

[1] Up to up to 147 positions in the Lease Area may be occupied by wind turbine generators (WTG); See Construction and Operations Plan (COP) Sections 3.1 and 3.3.2 for additional details.

2.1 Focal Species

For the purposes of the AERA, focal species were identified based on their conservation status including federal- or state-listing (i.e., those listed as Threatened or Endangered under the federal Endangered Species Act [ESA] or Massachusetts Endangered Species Act [MESA]), availability of supporting data, or other factors that warranted a more detailed assessment. Focal species in the AERA and justification for inclusion in the analysis are summarized in Table 2-2. Note that black-capped petrel was proposed for federal-listing as ESA Threatened in 2018 and is currently under review by the U.S. Fish and Wildlife Service (USFWS). Scientific names for all species included in the AERA are provided in Appendix A.

Table 2-2 Focal Species

Focal Species	ESA*	MESA*	Additional Justification
Roseate tern	E	E	N/A
Rufa red knot	T	T	N/A
Piping plover	T	T	N/A
Leach's storm-petrel	-	E	N/A
Black-capped petrel	P	-	N/A
Common tern	-	SC	Commonly associated with federally-listed roseate tern. Radio-tracking data available for local mixed-species breeding colonies (see Section 2.2.4.1).
Black-legged kittiwake	-	-	Identified as a concern by Non-governmental Organizations (NGO; ABC 2019) as the species has experienced large circumpolar declines over the last few decades and may be sensitive to collision.
Northern gannet	-	-	Fine-scale satellite tracking data available for the region (see Section 2.2.4.2). U.S. Fish and Wildlife Service (USFWS) species of conservation concern and considered vulnerable to collision or displacement from wind energy facilities (Kushlan et al. 2002, Spiegel et al. 2017).
Red-throated loon	-	-	Fine-scale satellite tracking data available for the region (see Section 2.2.4.2). USFWS species of conservation concern (including designation as a Bird of Conservation Concern [BCC] for the region) and considered vulnerable to collision or displacement from wind energy facilities (Kushlan et al. 2002, Spiegel et al. 2017).
Surf scoter	-	-	Fine-scale satellite tracking data available for the region (see Section 2.2.4.2). USFWS Bird of Management Concern (BMC) and considered vulnerable to collision or displacement from wind energy facilities (Spiegel et al. 2017).

* ESA = Endangered Species Act; MESA = Massachusetts Endangered Species Act; E = Endangered; T = Threatened; SC = Special Concern; P = Proposed for listing.

2.2 Exposure Mapping

Various spatial data sources were used to evaluate local and regional marine bird use. To assess regional-scale distribution and predicted abundance patterns for individual species and grouped sensitive species (i.e., collision-sensitive, displacement-sensitive) Marine-life Data and Analysis Team (MDAT) marine bird abundance and occurrence models were consulted ("MDAT data" or "MDAT modeled abundance"; Winship et al. 2018, Curtice et al., 2016, Kinlan et al. 2016) (see Section 2.2.1 for a detailed description). At the local scale, Massachusetts Clean Energy Center (MCEC) seabird survey data ("MCEC data"; Veit et al., 2016) served as the primary source for comparing avian occurrence in the Lease Area compared to distribution and abundance of marine birds off the coast of Massachusetts (see Section 2.2.2 for a detailed description). Each of the MDAT and MCEC data sets have limitations that are not discussed in detail here but are provided in Epsilon Associates, Inc. (2018), Winship et al. (2018), Curtice et al. (2016), Kinlan et al. (2016), and Veit et al. (2016). Recent (2019-2020) Project-sponsored survey data from aerial and boat-based surveys further informed likelihood of species occurrence and relative abundance within the Lease Area (see Section 2.2.3 for a detailed description). Additional data, reports, and expert feedback considered useful for assessing potential exposure to marine birds were also obtained from agencies or other monitoring sources (see Section 2.2.4 for a detailed description); these sources were used to qualitatively assess exposure likelihood but did not influence the exposure scoring method employed for individual species (see Section 2.3.2). Table 2-3 lists the primary external datasets used to inform the analysis. All species included in the exposure analysis are listed in Attachment A.

Table 2-3 Spatial Datasets used for Exposure Mapping

Dataset	Organization[1]	Temporal Coverage	Spatial Coverage	Source
MDAT models	BOEM, NOAA, USGS et al.	1978-2016[2]	Atlantic OCS and adjacent waters: FL to ME	https://www.northeastoceandata.org/data-download/
MCEC	Massachusetts Clean Energy Center	2011-2015	MA and RI OCS Wind Lease Areas	Provided by NOAA National Centers for Coastal Ocean Science. Reference: Veit et al. 2016
Modelled track densities for roseate terns and common terns	BOEM, USFWS	2014-2015 Common terns) 2015-2017 (Roseate terns)	Long Island Sound to Cape Cod Bay.	Provided by USFWS. Reference: Loring et al. 2019
Model-estimated migratory tracks of Piping Plovers	BOEM, USFWS	2015-2017	Birds tagged in Massachusetts and Rhode Island. Tracks range from MA to NC	Provided by USFWS. Reference: Loring et al. 2019
Utilization distribution (Surf scoter, northern gannet, red-throated loon)	BOEM, USFWS	2012-2016	Atlantic OCS	https://services.northeastoceandata.org/arcgis1/rest/services/MarineLifeAndHabitat/MapServer Reference: Spiegel et al. 2017
EcoMon Plankton v3.5 (Oceanography Branch Plankton Database)	NOAA NEFSC	1977-2017	Gulf of Maine to Cape Hatteras	ftp://ftp.nefsc.noaa.gov/pub/hydro/zooplankton_data/ https://www.fisheries.noaa.gov/inport/item/9286

Dataset	Organization[1]	Temporal Coverage	Spatial Coverage	Source
Bottom Trawl Surveys	NOAA NEFSC	1971-Present	Gulf of Maine to Cape Hatteras	Spring: https://www.fisheries.noaa.gov/inport/item/22561 Summer: https://www.fisheries.noaa.gov/inport/item/22562 Fall: https://www.fisheries.noaa.gov/inport/item/22560 Winter: https://www.fisheries.noaa.gov/inport/item/22563

1 Organization(s) responsible for initial data acquisition or data compilation.

2 Models based on multiple surveys conducted at various times during this period.

2.2.1 MDAT Data

The Bureau of Ocean Energy Management (BOEM), National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS) and collaborators conducted a study aimed at modeling the spatial distributions of marine bird species in the U.S. Atlantic OCS (Winship et al. 2018, Curtice et al. 2019, Curtice et al., 2016, Kinlan et al. 2016) using data from multiple long-term monitoring efforts, including aerial and boat-based visual surveys at sea. Specifically, over three decades of sighting survey data (1978-2016) contained in the U.S. Department of the Interior (DOI) Northwest Atlantic Seabird Catalog (NASC) database and Canadian Wildlife Service, Environment and Climate Change Canada (CWS-ECCC) Eastern Canada Seabirds at Sea (ECSAS) database were analyzed. Resulting maps represented modeled spatial distributions of 47 marine bird species in U.S. Atlantic OCS and adjacent waters from Florida to Maine, per season (i.e., Spring [1 March – 31 May], Summer [1 June – 31 August]), Fall [1 September – 30 November], Winter [1 December – 28/29 February]), based on multiple spatial and temporal predictor variables (Winship et al. 2018). The models were developed in 2016 (Curtice et al., 2016, Kinlan et al. 2016) and updated in 2018 (MDAT V2; Winship et al. 2018).

The MDAT-modeled abundance data provide predictions of the relative density (number of individuals per square kilometer [km^2]) in each 2 km^2 cell within the modeling space for each species and season (where relevant; Winship et al. 2018). Additionally, combined MDAT predictive maps were derived for species that are considered most likely to be sensitive to collision with or displacement from operational wind turbines (Section 2.3.1; Northeast Regional Ocean Council [NROC] 2020, Curtice et al. 2019); cells within each of these map grids represented summed predicted individuals per km^2 within each sensitivity group. The 2018 MDAT also estimated and mapped the uncertainty associated with individual species predictions, and this uncertainty is not explicitly addressed in this AERA. The estimated uncertainty in the MDAT model predictions was high in some cases, particularly for rare species and species groups in areas with lower sampling effort (see Winship et al. 2018 for detailed discussion).

Data procured for this AERA included the two combined MDAT layers (i.e., collision risk or displacement risk [annual]) and individual species layers (seasonal and annual; Curtice et al. 2019). The combined data layers were publicly available and downloaded from the Northeast Ocean Data Portal (NODP; NROC 2020, Curtice et al. 2019). The updated species-specific data from the 2018 models (Winship et al. 2018) are not public and were requested and received from NOAA, where the NASC database is currently housed, in May 2020.

In all MDAT exposure maps for the AERA (Section 3.1), data are presented in bins; low and high parenthetic values for MDAT represent the minimum relative density value and the relative density value > 3 standard deviations (SD) above the mean value for all 2 km^2 grid cells in the modeled area (i.e., U.S. Atlantic OCS and adjacent waters from Florida to Maine; see Winship et al. 2018 for details). All MDAT maps are provided at two scales: the first depicts the scale at which the MCEC data (Section 2.2.2) are presented for comparative purposes, and the second depicts Atlantic waters within the MDAT modeling space from New Jersey to Massachusetts. Annual predicted abundance maps are provided for the two sensitivity groups, and relevant seasonal maps are provided for individual focal species. Species-specific maps include only those seasons for which there is reasonable likelihood of species occurrence in the Lease Area. Note that MDAT results and associated exposure scores (Section 2.3.2) presented in this AERA should not be interpreted as a measure of the absolute number of individuals likely to be exposed, but rather as measures of occurrence relative to other surveyed areas in the region (see Section 3.3.1 for further discussion).

2.2.2 MCEC Data

Between 2011 and 2015, The City University of New York (CUNY), NOAA, and others conducted and analyzed data from 38 aerial seabird surveys that provided local coverage of the BOEM Massachusetts-Rhode Island Wind Energy Area (MA-RI WEA) south of Nantucket and Martha's Vineyard (Veit et al. 2016). Approximately 23,000 linear km of transects were surveyed during the study, during which all marine birds observed within a 100-200 m survey area along each transect line were recorded (i.e., contingent on number of surveyors [one or two]).

For this AERA, spatially-referenced MCEC data including survey date and species observed were obtained from NOAA in May 2020 and used to derive species density estimates (individuals per km^2) per season for each OCS lease block as defined by BOEM (approximately 23 km^2 each) included in the sampling effort (see Section 3.1 exposure maps for distribution of sample blocks). The OCS lease blocks serve as the legal units for offshore boundary coordinates used to define small geographic areas within the Atlantic OCS Planning Region managed by the BOEM Office of Renewable Energy Program. Density estimates for each block were corrected for survey effort and calculated for each species and survey day as:

$$\frac{\#\ Individuals\ Observed}{Transect\ length\ (m)\ within\ Block\ \times\ n\ observers\ \times\ 100\ (m)}$$

The mean density (per km^2) for each species and season was then calculated for each BOEM OCS block and served as the relative density estimate used in exposure mapping and exposure scoring (Section 2.3.2). Seasons were identical to those defined for the MDAT models. Summed means for species considered sensitive to collision or displacement were also calculated for each OCS lease block (Section 2.3.1). Individuals that were not identifiable to species (i.e., "unknown") were not included in calculations of individual species scores.

In all exposure maps (Section 3.1), MCEC values for each BOEM block are presented as quantiles; blocks with zero counts were categorized as zero (lowest quantile), and remaining blocks with observations were divided into five quantiles representing 0-20, 21-40, 41-60, 60-80 and 81-100th percentiles relative to all BOEM non-zero blocks (1st to 5th quantile bin, respectively). Low and high parenthetic values in MCEC exposure maps represent minimum and maximum individuals observed per km^2 in each BOEM lease block. Relevant seasonal maps are provided for individual species; maps do not include seasons for which no individuals were observed across the entire MCEC survey area. As with the MDAT data, results and associated exposure scores (Section 2.3.2) presented in this AERA should not be interpreted as a measure of the absolute number of individuals likely to be exposed, but rather as measures of occurrence relative to the MCEC survey coverage area (see Section 3.3.1 for further discussion).

2.2.3 Project-Sponsored Surveys (Mayflower Wind Lease Area)

2.2.3.1 High-definition Aerial Surveys (Aerial HD)

To supplement the regional (MDAT) and local (MCEC) data, Mayflower Wind collected high-definition (HD) aerial imagery from November 2019 through October 2020 (Mayflower Wind Energy LLC 2020, Normandeau Associates, 2020a-d). These data were based on images captured using a grid-based survey design with a 1.5-centimeter (cm) resolution ground sampling distance (GSD). Digital still imagery was captured during each survey, each of which employed a global positioning system (GPS)-linked camera platform using a flight management system to ensure the survey tracks were flown with a high degree of accuracy. The survey altitude was held at approximately 414.5 meters (m; 1360 feet [ft]) to optimize coverage and minimize interference from cloud cover, and the aircraft was flown at a target ground speed of approximately 120 knots (kt) to reduce motion blur and ensure high image quality. The aerial digital survey captured images along nine lines spaced approximately 2 km across-track within the Lease Area and 1 nautical mile (NM) buffer (Figure 2-1). During each survey, abutting digital still images were collected along each of the survey lines, with a sampling swath width of 384 m (192 m on each side of the center line; total transect area = approximately 15,583 ha [38,508 ac]). The captured images covered a minimum of 40% of the transect area per survey (i.e., approximately 6,233 ha [15,403 ac]; sample area). Surveys were conducted monthly and sampling effort was increased during the migratory period for terns and other species of concern in coordination with the Massachusetts Division of Fisheries and Wildlife (MADFW) Natural Heritage and Endangered Species Program (NHESP). One survey per month was completed from November 2019 through March 2020, two surveys were flown in April[1] and May 2020, one survey per month was completed from June through July 2020, two surveys were flown in August, and one survey per month was completed from September[2] through October 2020.

[1] Includes survey on 2 May 2020, in accordance with BOEM guidance which allows surveys within three days of month's end to be attributed to the previous month.

[2] Mayflower Wind attempted a second survey in September but was unable to complete one due to adverse weather conditions at the end of the month.

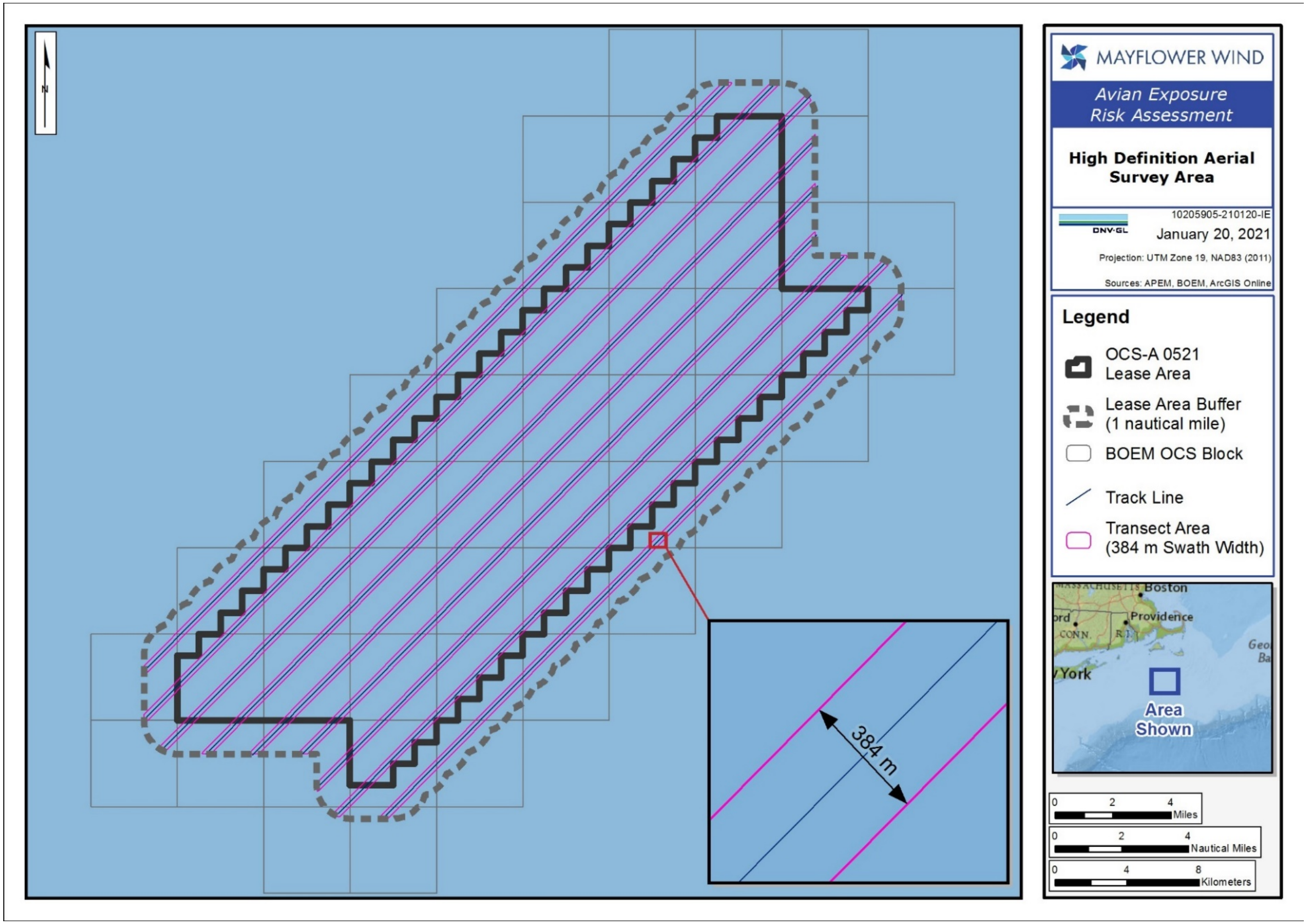

Figure 2-1 High Definition Aerial Survey Tracks

Tracks depicted represent center line plus transect area (i.e., strip transect spanning 192 m on each side of the track line within which images were collected; see text for details).

Third-party experts analyzed the images to enumerate birds and a second, third-party reviewer provided quality assurance (QA) of the data to identify any missed individuals. In general, using the methods employed, a GSD of 1.5- cm resolution is considered sufficiently high to positively identify smaller species, such as terns, to species. For instance, the third-party experts were able in most cases to discern among tern species (e.g., roseate tern vs. common tern) based on tail length, wing structure, and plumage. The Aerial HD study plan was developed in coordination with BOEM in 2019 and 2020 (Mayflower Wind Energy LLC 2020a).

The Aerial HD data are presented in exposure maps (Section 3.1) as raw observations and as mean seasonal densities within BOEM OCS blocks; densities were effort-adjusted and calculated for each season and species using a method similar to that used for the MCEC density estimates. The Aerial HD data were also used to supplement seasonal exposure scores for each species based on maximum counts observed across surveys (Section 2.3.2). Finally, Aerial HD data were evaluated to identify flight heights exhibited by species observed within the Lease Area (Section 3.2.1). For each species for which flight height data were recorded, average, standard deviation, and proportion of individuals observed within elevation bins: <20 m, 21–50 m, 51-100 m, 101–240 m, 241-325 m, and >325 m are reported. Bin classifications were assigned to capture rotor swept zone (RSZ) parameters in the Project Design Envelope (see Section 3 of the Construction and Operations Plan [COP]); potential RSZ bounds range from approximately 16.5 m above highest astronomical tide (HAT) to approximately 325 m above mean lower low water (MLLW).

2.2.3.2 Boat Observers – Geophysical and Geotechnical Surveys

A series of geophysical and geotechnical (G&G) vessel surveys completed in the Lease Area between September and November 2019 included an onboard professional avian observer who recorded all birds observed during the surveys (RPS Group 2019, 2020). G&G surveys were completed between 9 September and 17 September, during which 2270 individuals representing 12 species were recorded, and between 30 October and 7 November 2019, during which 1,407 individuals representing 27 species were observed. Most individuals were identified to species. The September observations were primarily comprised of great shearwater (*Puffinus gravis*; 266 observations representing 1,981 individuals), and the October-November observations were dominated by herring gull (*Larus argentatus*; 59 observations representing 572 individuals), northern gannet (*Morus bassanus*; 241 observations representing 402 individuals), and great shearwater (92 observations representing 199 individuals). Because these data were not collected according to a systematic survey design they are treated as qualitative and supplemental in this AERA.

2.2.4 Additional Data Sets

2.2.4.1 Very High Frequency Tracking Data (USFWS)

From 2014 to 2017, the USFWS captured adult roseate terns (n=150), common terns (n=266), and piping plovers (n=150) at select nesting areas on the U.S. Atlantic coast and fitted each with a digital very high frequency (VHF) transmitter (Loring et al. 2019). During the study, tagged individuals were tracked using an array of automated VHF telemetry stations within a study area encompassing a portion of the U.S. Atlantic OCS, extending from Cape Cod, Massachusetts to southern Virginia. Tracking stations included those in the collaborative Motus Wildlife Tracking System of automated telemetry stations (Motus; Bird Studies Canada 2020), which are able to track the movements of passing tagged individuals from the Canadian High Arctic to South America (Taylor et al. 2017). All tagging was conducted during the breeding period and tracking continued through post-breeding dispersal and migratory departure. Piping plovers were tagged at breeding areas on Cape Cod and in Rhode Island, including on Monomoy National Wildlife Refuge (MNWR) and South Beach in Chatham, MA, and Trustom Pond National Wildlife Refuge (TPNWR) in South Kingstown, RI. Common and roseate terns were tagged at their largest nesting colonies within the U.S. Atlantic, with the roseate tern sites collectively representing over 90% of the northeastern U.S. breeding population (Loring et al. 2019, Nisbet et al. 2014). Roseate tern tagging areas included Great Gull Island, Bird Island, Ram Island, and Penikese Island, the latter three of which are located in Buzzard's Bay. Common terns were tagged at the roseate tern sites as well as at a breeding colony on MNWR.

Locations of tagged individuals were used to build spatially-explicit models to estimate movements of the three target species in the Atlantic OCS during the breeding period, post-breeding dispersal, and fall migration. The models accounted for observation error including uncertainty related to variability in the relationship between predicted signal strength and flight altitude (Loring et al. 2019). Limitations of the VHF tracking data are fully discussed in Loring et al. (2019). Although detection probability varies according to species, flight height, and other factors, tagged birds are generally detectable within approximately 5-20 km. The USFWS data were not publicly available and were obtained from USFWS in August 2020. Layers received represented interpolated (model generated) flight paths from detections of land-based towers for each species (Loring et al. 2019). It should be noted that not every VHF station was active during each year of study; for instance, the array in 2015 was limited to the Cape Cod, MA to Long Island, NY region. For the purpose of this AERA, DNV GL relied on a simplified interpretation of the data that does not address interannual differences in station effort; tagged individuals were considered detectable within a range of 20 km from VHF monitoring stations. These data were considered during exposure mapping and overall assessment but did not factor into exposure scoring (Section 2.3.2). Exposure maps represent interpolated (modeled) track densities for roseate and common tern (density of 10-minute line segments per 1 km^2 pixel); piping plover exposure maps depict raw path data only (Loring et al. 2019). Loring et al. (2019) also calculated estimates of species exposure probability to BOEM WEAs; these probability surfaces were not available for exposure mapping but were consulted to inform interpretation of the VHF tracking maps.

2.2.4.2 GPS Tracking Data (USFWS)

USFWS, USGS, and others conducted a study to determine the fine-scale use and movement patterns of three species of diving marine birds, including red-throated loon, surf scoter, and northern gannet in Federal waters of the U.S. during fall migration (approximately October through November; patterns varied among species), spring migration (approximately April through May) and winter (approximately December through March) (Spiegel et al. 2017). The analysis incorporated data from 239 adult birds tagged between New Jersey and North Carolina between 2012 and 2015, and an additional 109 surf scoters and 38 northern gannets tagged as part of prior field efforts. All individuals were tracked via Platform Terminal (satellite) Transmitters (PTTs). The tracking data were then analyzed using dynamic Brownian bridge movement models to develop spatial-utilization distributions for each species. Although all tagging occurred in the mid-Atlantic region, movement paths were recorded as far north as Newfoundland. Limitations of the models, including the effects of small sample bias, are discussed in detail in Spiegel et al. (2017). Results of the study are depicted spatially as utilization-distribution maps, wherein the 50%, 75%, and 95% boundaries represent isopleths (i.e., percent of total use occurring within each band) of the composite movement surface for each season. Species core use areas are defined as those occurring within the 50% isopleth, and species overall use areas defined as those occurring within the 95% isopleth (Spiegel et al. 2017). These data were recently uploaded to the NODP and included in the AERA exposure mapping. They were not factored into the exposure scoring process because they were available only for these three species and unlike the scoring criteria used, did not represent results from standardized, multispecies surveys (see Section 2.3.2).

2.2.4.3 *Ammodytes* (Sand Lance) Data

State wildlife management agencies in New England have recently identified 11 Species of Greatest Conservation Need (SGCN) in the Northwest Atlantic that consume and to various degrees rely on *Ammodytes* sp. (e.g., American sand lance [*Ammodytes americanus*] and the Northern sand lance [*A. dubius*]), including roseate tern, Arctic tern, Atlantic puffin, razorbill, common murre, great cormorant, great shearwater, Cory's shearwater, sooty shearwater, northern gannet, and red-throated loon (Staudinger et al. 2020, Nisbet et al. 2014). Therefore, two long-term data sets maintained by the Northeast Fisheries Science Center (NEFSC) of the NOAA National Marine Fisheries Service (NMFS) were consulted to identify any high-use areas for these prey species in or adjacent to the Lease Area. Both data sets were obtained from NEFSC public data portals and are considered in the AERA exposure mapping but not factored into the exposure scoring process because not all avian species in this assessment feed on *Ammodytes,* and because the scoring criteria used represented only results from standardized, multispecies avian surveys (Section 2.3.2). Summaries of the two NEFSC data sets are provided below.

Bottom Trawl Surveys (NOAA NEFSC)

Bottom trawl survey data collected from 2009 through 2019 were obtained from the NEFSC data library (NEFSC 2020a). The bottom trawl surveys were initiated in 1963 and standardized protocols were updated in 2004 (Johnston and Sosebee 2014, Stauffer 2004). Overall coverage of the surveys extends from Nova Scotia to Florida waters. Surveys have typically focused on fisheries stocks and have involved data collection by numerous vessels using varied gear methods, and overall sampling effort has varied by season and year (Johnston and Sosebee 2014). Limitations associated with difficulties in the standardization of trawl survey methods are discussed further in Johnston and Sosebee (2014) and Smith (2002). *Ammodytes* are not consistently caught in bottom trawl surveys due to the mesh sizes typically used and species' behavior (e.g., avoidance, burrowing) but may be captured incidentally (Staudinger et al. 2020).

Ichthyoplankton Surveys (NOAA NEFSC)

The NEFSC currently houses long-term ichthyoplankton survey data, collected during the Ecosystem Monitoring (EcoMon) Program (1999—present; NEFSC 2020b). The EcoMon program was designed for multi-species plankton surveys, and sampling effort has covered the Northeast U.S. continental shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia, four to eight times per year. Sampling effort has varied by year, ranging from approximately 100 to 200 days of sampling per year, primarily due to ship availability and weather conditions during cruises (Walsh et al. 2015, Kane 2007). NEFSC has developed correction factors to adjust for these and other inconsistencies and employs various statistical tools to generate population estimates; each species estimate represents an index of abundance (over time or space; NEFSC 2020b). The data refer to a standard tow or sample and are not normalized to a unit area. In interpreting the zooplankton survey maps, it is important to note that Northwest Atlantic *Ammodytes* spawn in winter, and data availability for these species generally coincided with the months when larvae were present in the water column but before they attained body sizes at which they could evade survey gear (i.e., (typically in spring; Staudinger et al. 2020). EcoMon data from 2009-2017 were included in the AERA exposure mapping (NEFSC 2020b); data from 2018 to present were not available for inclusion.

2.3 Exposure Assessment

2.3.1 Species Sensitivity

Potential exposure of species that are considered sensitive to collision (i.e., at risk of colliding with moving blades) or displacement (i.e., may experience habitat loss as a result of avoidance of wind turbines) was assessed collectively by grouping species known to be "collision-sensitive" or "displacement-sensitive" (Table 2-4). The species listed in Table are based on categories defined in Robinson Willmott et al. (2013) and applied by MDAT to generate density maps for sensitive species (Curtice et al. 2019). The MDAT layers represent total predicted relative density of all individuals (of the included species) in that cell and were developed by stacking each individual species' predicted annual relative density layers (normalized) and summing the values of the pixels in each resulting column (Curtice et al. 2019). MDAT sensitivity-group modeled layers were only available at the annual scale. For the MCEC and Aerial HD data sets, values for each BOEM lease block represent summed means across all species in each category. The MDAT, MCEC, and Aerial HD values were assessed for each sensitivity group during AERA exposure mapping (Section 3.1) but were not factored into exposure scores (see Section 2.3.2).

Table 2-4 Species included in Collision- and Displacement-sensitive Exposure Mapping Categories

(Curtice et al. 2019, Robinson Willmott et al. 2013)

Species	Collision-sensitive Species	Displacement-sensitive Species
Arctic tern	X	X
Atlantic puffin	X	X
Audubon's shearwater	X	-
Black guillemot	X	X
Black scoter	X	X
Black-legged kittiwake	X	-
Bridled tern	X	X
Common eider	X	X
Common loon	X	X
Common murre	X	X
Common tern	X	X
Cory's shearwater	X	-
Double-crested cormorant	X	-
Great black-backed gull	X	X
Great shearwater	X	-
Great skua	X	-
Herring gull	X	-
Horned grebe	X	-
Laughing gull	X	-
Leach's storm-petrel	X	-
Long-tailed duck	X	X

Species	Collision-sensitive Species	Displacement-sensitive Species
Manx shearwater	X	X
Northern fulmar	X	-
Northern gannet	X	X
Parasitic jaeger	X	-
Pomarine jaeger	X	-
Razorbill	X	X
Red phalarope	X	-
Red-breasted merganser	X	-
Red-necked phalarope	X	-
Red-throated loon	X	X
Roseate tern	X	-
Sooty shearwater	X	-
Sooty tern	X	X
South polar skua	X	-
Surf scoter	X	X
Thick-billed murre	X	X
White-winged scoter	X	X
Wilson's storm-petrel	X	-

2.3.2 Exposure Scoring

Exposure scoring methods used were modified from AERA prepared for other regional BOEM lease areas (e.g., Epsilon Associates, Inc. 2018) and were informed by three primary data sets: the MDAT, MCEC, and Aerial HD data sets. Scores ranged from 0 to 3 for each data set, based on the approach summarized below.

2.3.2.1 MDAT (Regional Score)

To generate potential exposure within the Lease Area relative to seasonal regional use for each species, the most current MDAT predictive spatial models were used to generate exposure scores (Winship et al. 2018). First, the BOEM North Atlantic Planning Area (NAPA; https://www.boem.gov/regions/atlantic-ocs-region) was gridded into rectangles approximating the size of the Lease Area (approximately 515 km^2), resulting in 724 representative polygons that overlapped the MDAT model extent. Predicted values were then summed for each species within each polygon and adjusted so that values for each polygon represented the proportion of total predicted abundance across the study area for each species-season combination. Based on the distribution of proportional values across all polygons, the 25^{th}, 50^{th} and 75^{th} percentile values were calculated for each species per season. Exposure scores were then assigned for the Lease Area such that: values less than or equal to the 25^{th} percentile break were scored as zero; those between the 25^{th} and 50^{th} percentile breaks as 1; those between the 50^{th} and 75^{th} percentile breaks as 2; and those above the 75^{th} percentile break as 3. If a species-season combination was not available from the MDAT regional models, then the score from the local, MCEC surveys was assigned to the regional score (Section 2.3.2.2; Epsilon Associates, Inc. 2018).

2.3.2.2 MCEC (Local Score)

The process for scoring the Lease Area relative to the local area that was surveyed during the MCEC surveys was similar to that used for the regional scoring. The mean, effort-adjusted relative density for the Lease Area was comprised of 16 surveyed lease blocks. To compare the Lease Area to other similarly sized locations, we identified the nearest 13-15 lease blocks to each lease block surveyed in each season; 13 for summer and 15 for spring, winter, and fall, to align with survey effort within the Lease Area. These represented all Lease Area-sized areas within the MCEC survey area; mean relative density of each species (within season) was calculated for each of the areas. Mean density percentile thresholds were then defined and the Lease Area was scored using the same process as for the MDAT modeled data (Section 2.3.2.1). If MCEC data were not available for a species-season combination, the local score was assigned a zero.

2.3.2.3 Aerial HD Score

To further inform exposure risk, the Aerial HD survey data were examined to explore the potential proportion of each species' population, estimated at various scales, that may occur in the Lease Area within each season. Regional or continental-scale population estimates for each species (when available) were procured from the following sources:

- The North American Waterbird Conservation Plan (Kushlan et al. 2002): Provides population estimates (breeding, non-breeding, or combined) for waterbirds in the Americas. Estimates for each species represent individuals estimated to occur in North America, Central America, the islands and pelagic waters of the Caribbean Sea and western Atlantic, the U.S.-associated Pacific Islands, and pelagic waters of the Pacific. Estimates were based on multiple data sets and literature published between 1970 and 2002 and expert elicitation.
- Nisbet et al. (2013): Provides population estimate ranges for marine birds in the Eastern U.S. (Florida to Maine) and the Bay of Fundy, based on multiple breeding and non-breeding data sets collected between 1994 and 2005.
- MDAT (Winship et al. 2018): The number of individuals of each species predicted to occur in the BOEM NAPA were estimated for each season using the MDAT models. For each season, MDAT predictive models depict a predicted distribution based on a representative average year (Winship et al. 2018; spring [2002], summer [2003], fall [2004], and winter [2006]) and were therefore considered a "snapshot" in time of estimated abundance for that season. To generate predicted estimates for the region, totals were summed within each 4-km^2 pixel (i.e., value [km^2] x 4) and summed for all pixels in the NAPA for each season.

As a conservative approach, the maximum count per species recorded during each season of the Aerial HD surveys was spatially adjusted to generate seasonal abundance estimate for the Lease Area (i.e., extrapolated to un-surveyed portions of the Lease Area). Estimates for each species were then compared to the low-end population estimates available at the continental (Kushlan et al. 2002) Eastern Seaboard (Nisbet et al. 2013) and regional (MDAT NAPA estimates; Winship et al. 2018) spatial scales. An Aerial HD score of 0 was assigned if the spatially-adjusted maximum count in the Lease Area represented less than 1% of the minimum estimate from any source, and a 3 if it represented 1% or greater of the minimum estimate from any source.

2.3.2.4 Exposure Categorization Framework

Table 2-5 depicts the framework adopted for identifying species as likely having Insignificant, Very Low, Low, Moderate, or High seasonal exposure levels in the Lease Area. Seasonal scores include Local and Regional scores as well as Aerial HD survey scores with each score ranging between 0 and 3 (Sections 2.3.2.1-2.3.2.2).

Annual scores for each species were then assigned via a multi-step process. First, the seasonal exposure categories for each species-season combination (Insignificant, Very Low, Low, Moderate, and High) were re-scored from 0-4 (Insignificant=0, Very Low=1, Low=2, Moderate=3, and High=4). These scores were then summed across seasons for each species, resulting in potential annual scores ranging from 0 to 16. Summed scores were then recategorized and scored as depicted in Table 2-6.

Table 2-5 Exposure Scoring Framework - Seasonal

Exposure Level	Definition	Seasonal Scores		
		Regional Score (MDAT NAPA)	Local Score (MCEC)	Aerial HD Surveys Score
Insignificant	Lease Area densities at local and regional scales are below the 25th percentile and Project-sponsored survey results represent <1% of regional population[a].	0	0	0
Very Low	Lease Area local density is between the 25th and 50th percentiles and regional density is below the 25th percentile, or vice versa, and Project-sponsored survey results represent <1% of regional population.	0	1	0
		1	0	0
Low	Lease Area local and regional densities are between the 25th and 50th percentiles, and Project-sponsored survey results represent <1% of regional population.	1	1	0
	OR			
	Lease Area local density is between the 50th and 75th percentiles and regional density is below the 25th percentile, or vice versa, and Project-sponsored survey results represent <1% of regional population.	0	2	0
		2	0	0
Moderate	Lease Area local and regional density are between the 50th and 75th percentiles, and Project-sponsored survey results represent <1% of regional population.	2	2	0

Exposure Level	Definition	Seasonal Scores		
		Regional Score (MDAT NAPA)	Local Score (MCEC)	Aerial HD Surveys Score
	OR			
	Lease Area local density is between the 50th and 75th percentiles and regional density between the 25th and 50th percentiles, or vice versa, and Project-sponsored survey results represent <1% of regional population.	1	2	0
		2	1	0
	OR			
	Lease Area local density is greater than the 75th percentile and regional density is below the 25th percentile, or vice versa, and Project-sponsored survey results represent <1% of regional population.	0	3	0
		3	0	0
	OR			
	Lease Area local density is greater than the 75th percentile of all densities and regional density is between the 25th and 50th percentiles of all densities, or vice versa, and Project-sponsored survey results represent <1% of regional population.	1	3	0
		3	1	0
High	Lease Area densities at both local and regional scales are above the 75th percentile.	3	3	Any[b]
	OR			
	Lease Area local densities are greater than the 75th percentile and regional densities are between the 50th and 75th percentiles, or vice versa.	2	3	Any [b]
		3	2	Any [b]
	OR			
	Project-sponsored survey results represent ≥1% of regional population.	Any [b]	Any [b]	3

[a] Regional population defined as the low-end estimate from any of the following: BOEM North Atlantic Ocean (NAO) seasonal estimate (Winship et al. 2018 [MDAT]), continental estimate from Kushlan et al. (2003), or Nisbet et al. (2013) estimate for the eastern United States and Bay of Fundy. See text and Table 3-3 for details.

[b] "Any" score indicates that final categorization was driven by other datasets; score could range from 0-3 without influencing categorization.

Table 2-6 Exposure Scoring Framework - Annual

Summed Seasonal Score[a]	Annual Exposure Level	Annual Exposure Score
0-3	Insignificant	0
4-7	Low	1
8-11	Moderate	2
≥ 12	High	3

[a] Summed seasonal scores per species (potential range = 0-16; see text for details).

3 RESULTS

3.1 Exposure Mapping

3.1.1 Focal Species

3.1.1.1 Federally-listed (including proposed)

Roseate tern

Predicted abundance of roseate tern is very low in fall and summer, and low relative to regional waters in spring (Figure 3-1 - Figure 3-3). Roseate tern was observed in one BOEM block during the MCEC summer surveys (Figure 3-3), and in three BOEM blocks during the Aerial HD spring surveys (Figure 3-4). Estimated VHF post-breeding track densities indicate that most tagged roseate tern movements occurred close to shore (Figure 3-5). A limited number of movement tracks indicated southward movement from Muskeget Island before individuals moved beyond tracking range, and travel through the Lease Area thus may have occurred; however, estimated probability of roseate tern exposure in the Lease Area based on these data is very low (Loring et al. 2019). No roseate terns were observed during Project G&G surveys.

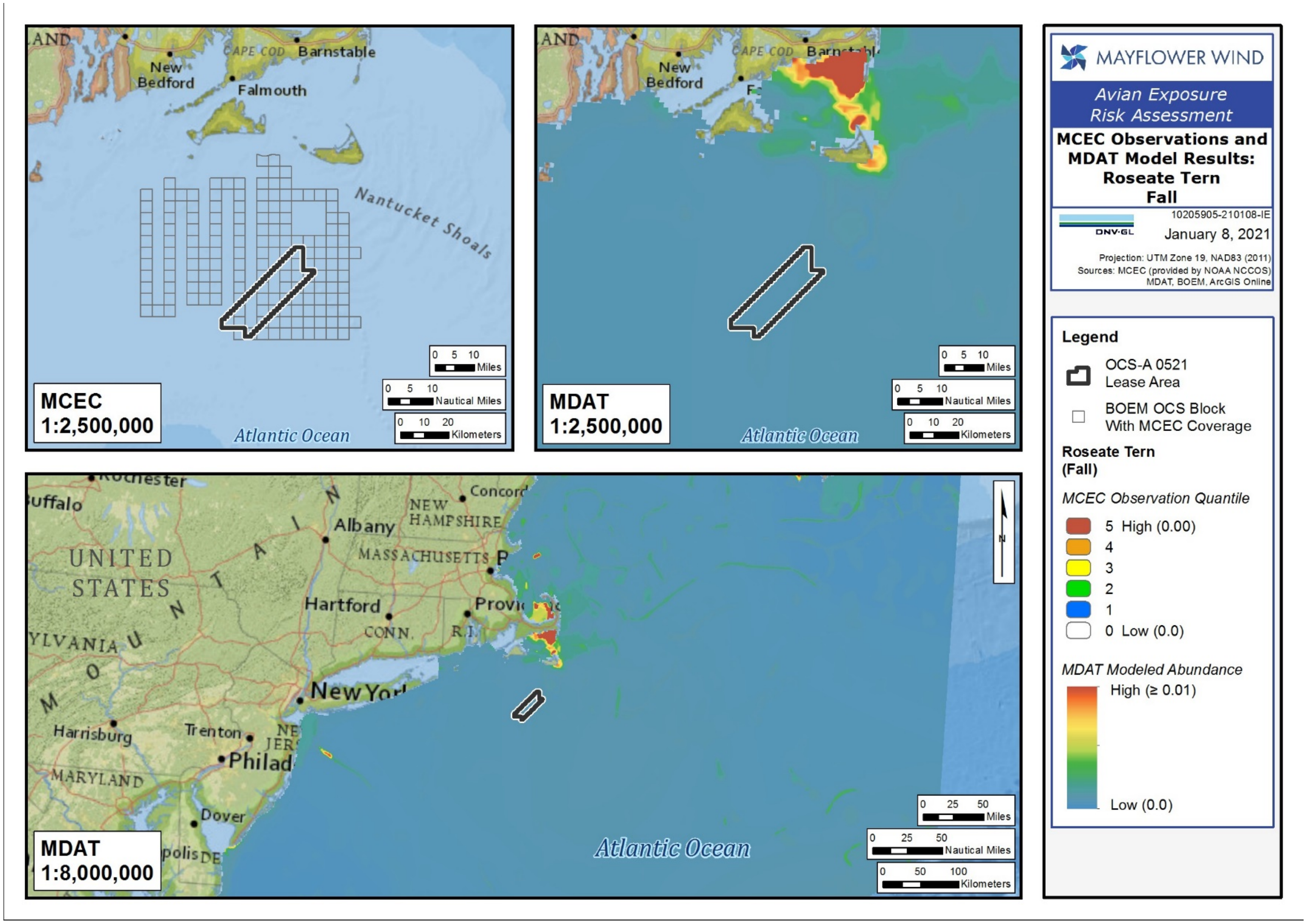

Figure 3-1 Fall roseate tern relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

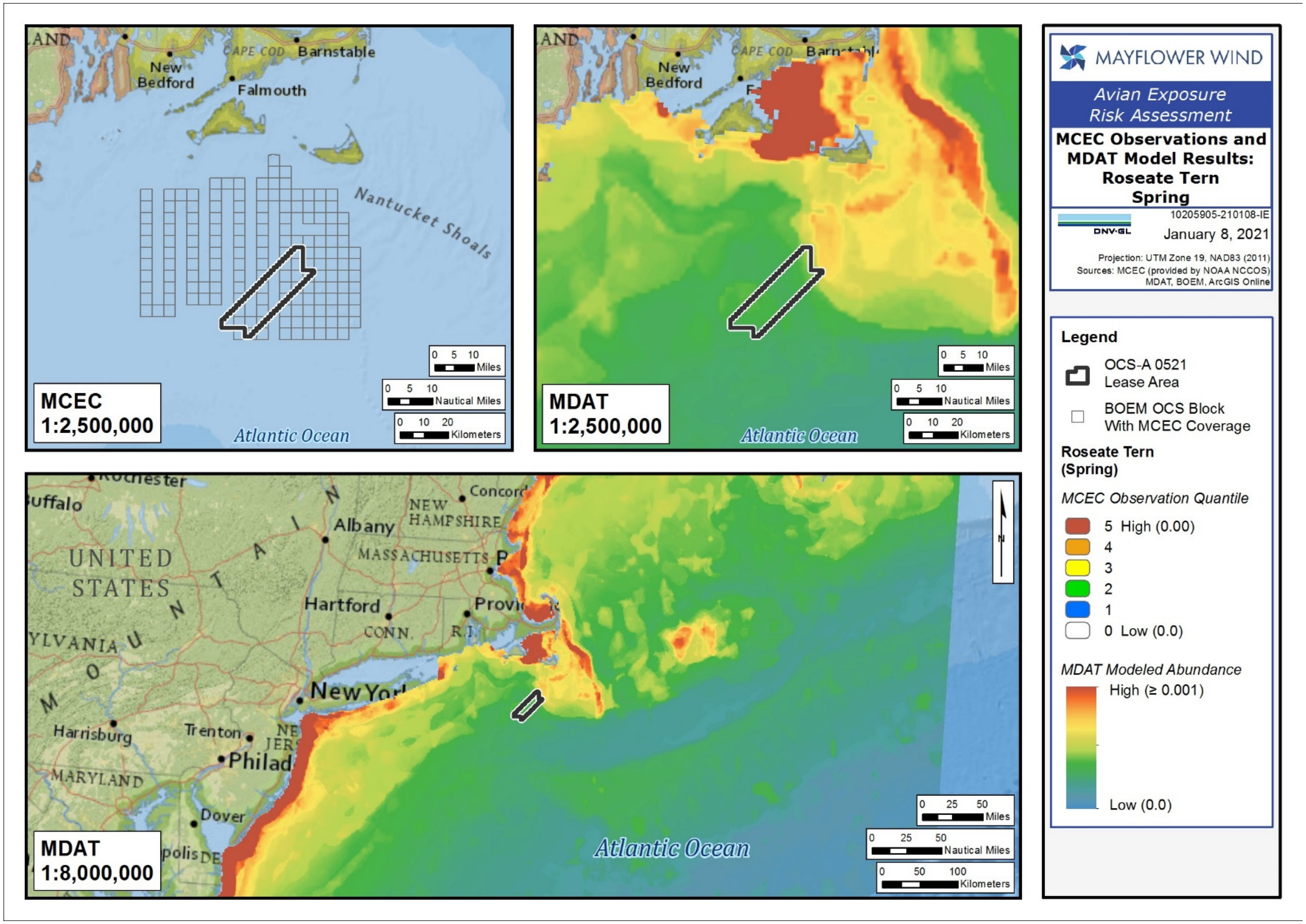

Figure 3-2 Spring roseate tern relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted.

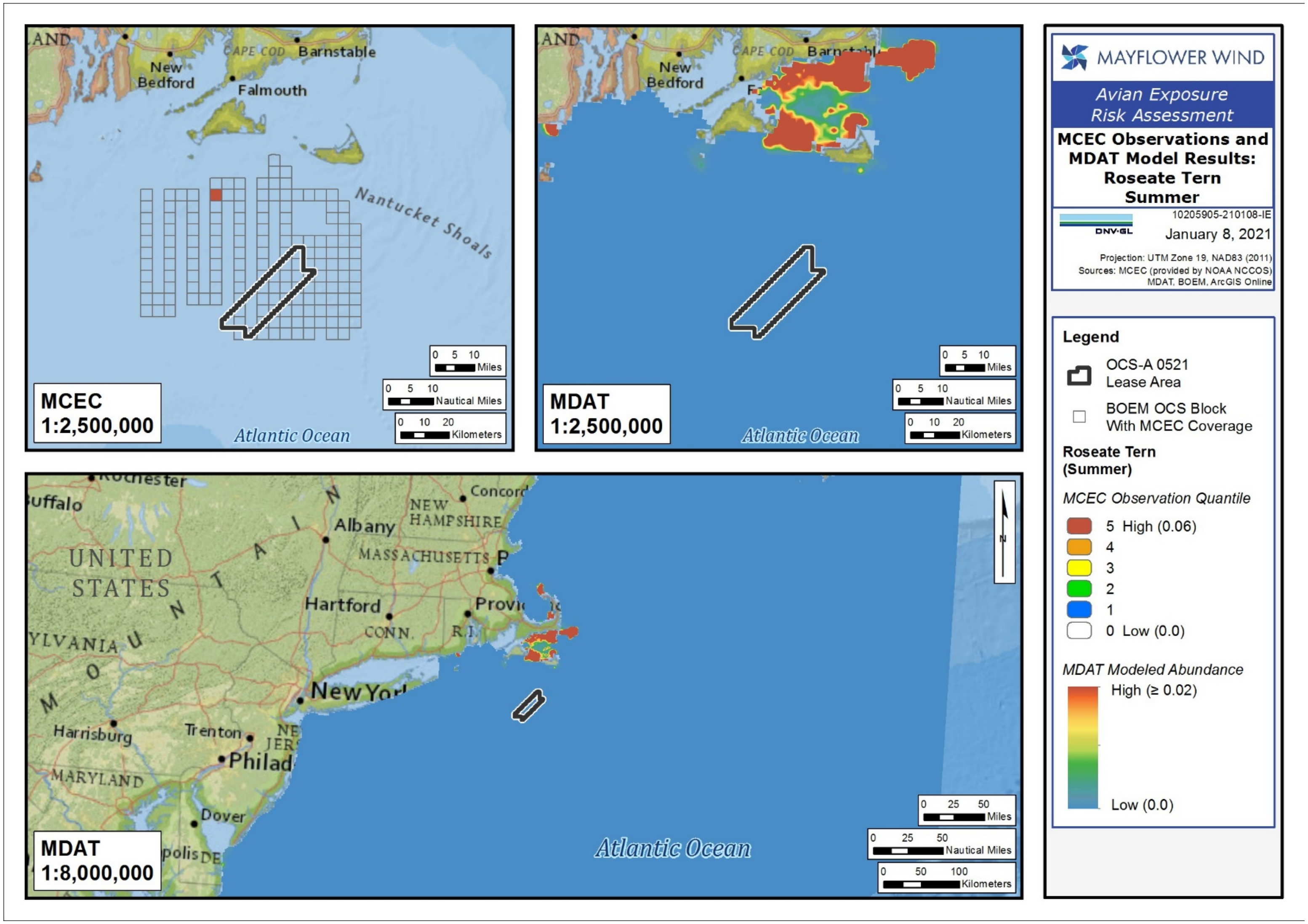

Figure 3-3 Summer roseate tern relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted.

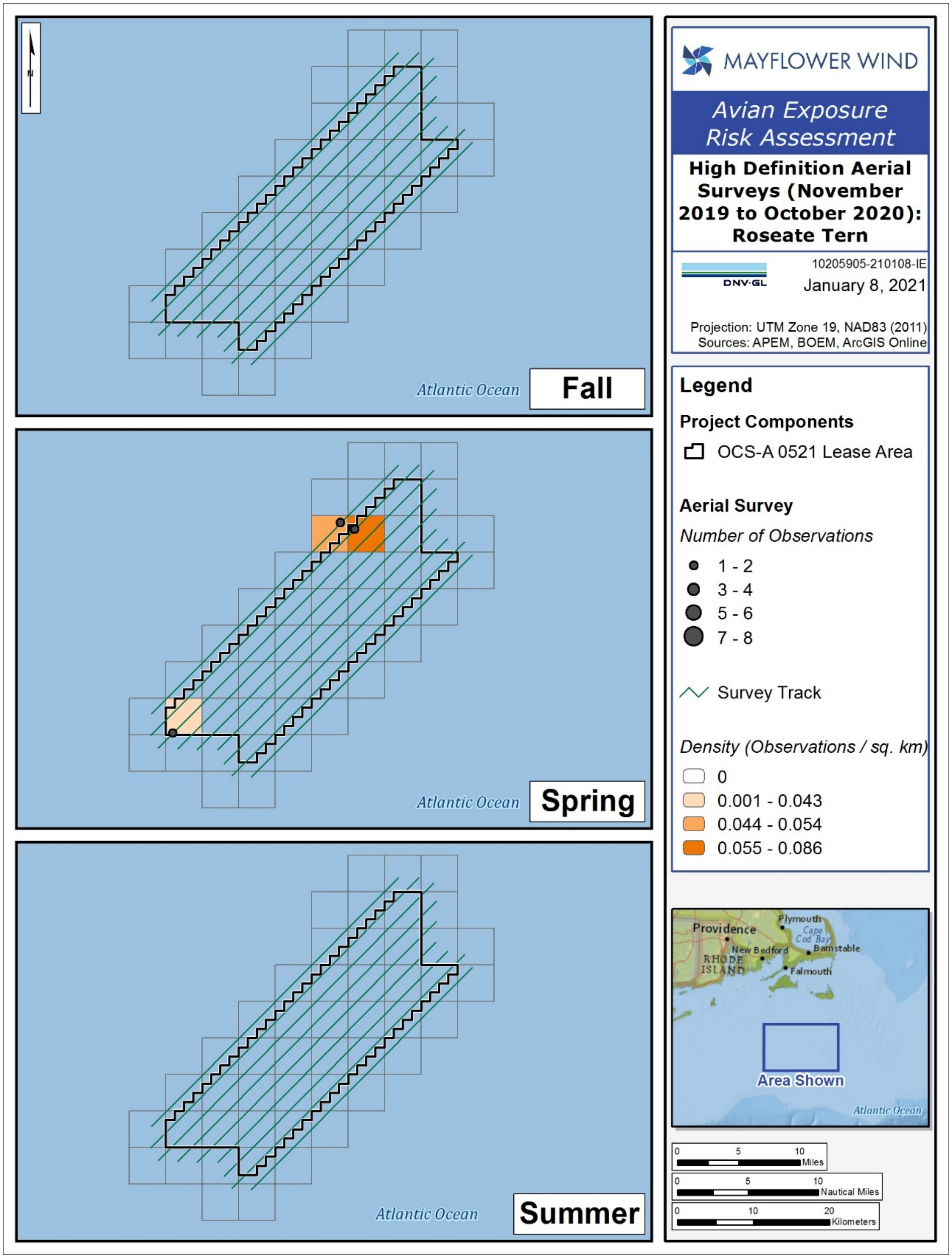

Figure 3-4 Raw observations and effort-adjusted seasonal density estimates for roseate tern

Based on Mayflower Wind high-definition aerial surveys (Aerial HD). Note that survey effort differed among seasons (fall, n=3; spring, n=5; and summer, n=3); raw observations are presented to assess within-season spatial patterns only. Density estimates represent total individuals observed per survey per km^2 within each season.

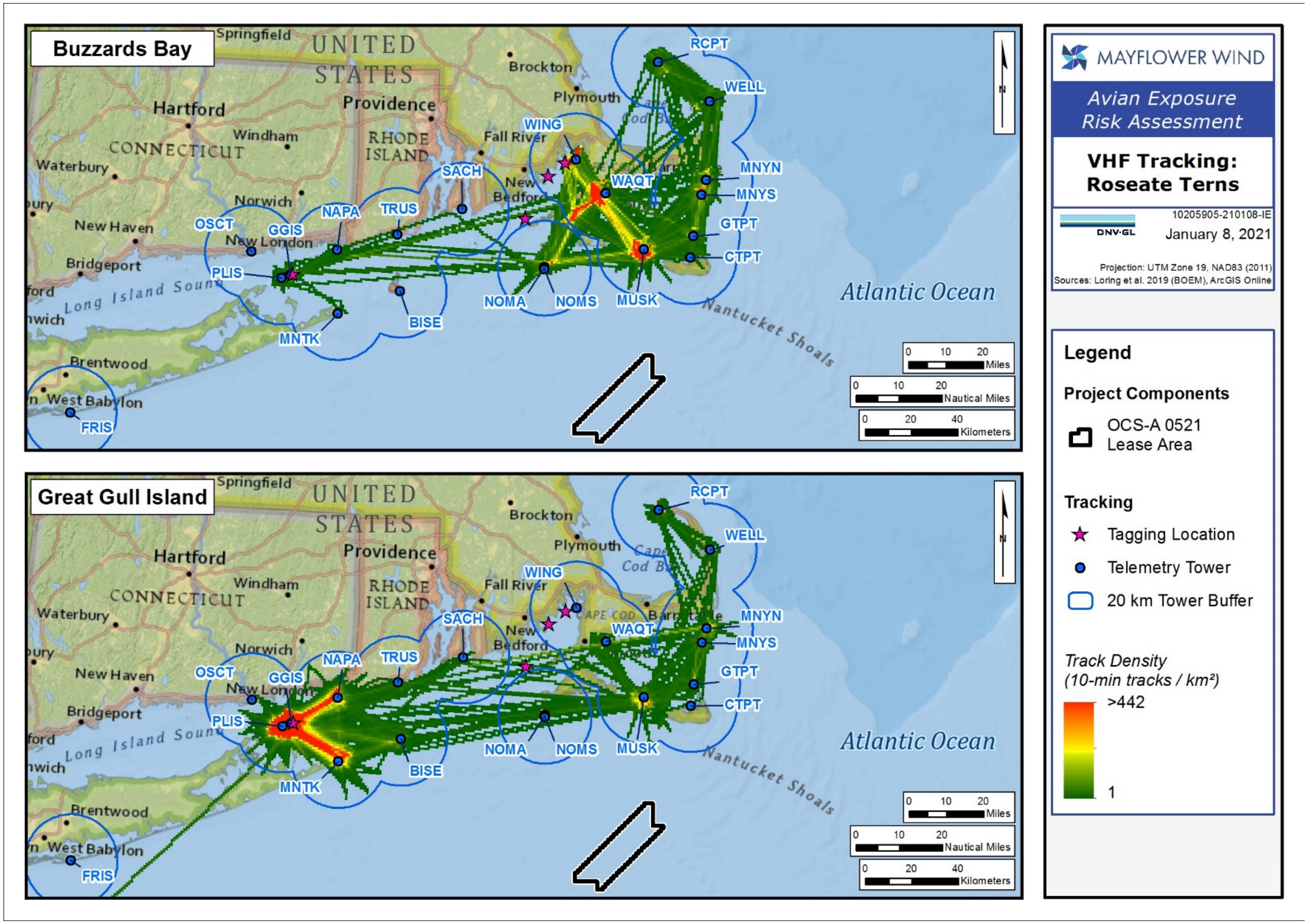

Figure 3-5 Interpolated (model generated) flight path densities of roseate terns

Tagged at breeding colonies tagged on Great Gull Island, Bird Island, Ram Island, and Penikese Island based on detections from land-based VHF tracking towers (~20-km detection range; Loring et al. 2019).

Rufa red knot

Red knot was not observed at the local scale during MCEC surveys, Aerial HD surveys, or G&G surveys and predicted abundance for the species was not modeled by MDAT. Although tracking data were not available for exposure mapping, 388 red knots were tagged with VHF transmitters by USFWS, Conserve Wildlife Foundation of New Jersey and partners across three geographic regions (i.e., Canada, Massachusetts, New Jersey) and tracked via the Motus network (Loring et al. 2018). Spatially-explicit, three-dimensional movement models were developed based on these tracking results and used to inform potential exposure within BOEM planning areas. Results indicated that most individuals followed a coastal migratory route and that probability of exposure in the Lease Area is low (Loring et al. 2018).

Piping plover

Piping plover was not observed at the local scale during MCEC surveys, Aerial HD surveys, or G&G surveys and predicted abundance for the species was not modeled by MDAT. Although no VHF-tagged individuals were tracked in the Lease Area, some tracks originating on Monomoy Island, Muskeget Island, and Nantucket Island indicated southward movement and movement through the Lease Area may have occurred. However, estimated probability of piping plover exposure in the Lease Area based on these data is low (Loring et al. 2019).

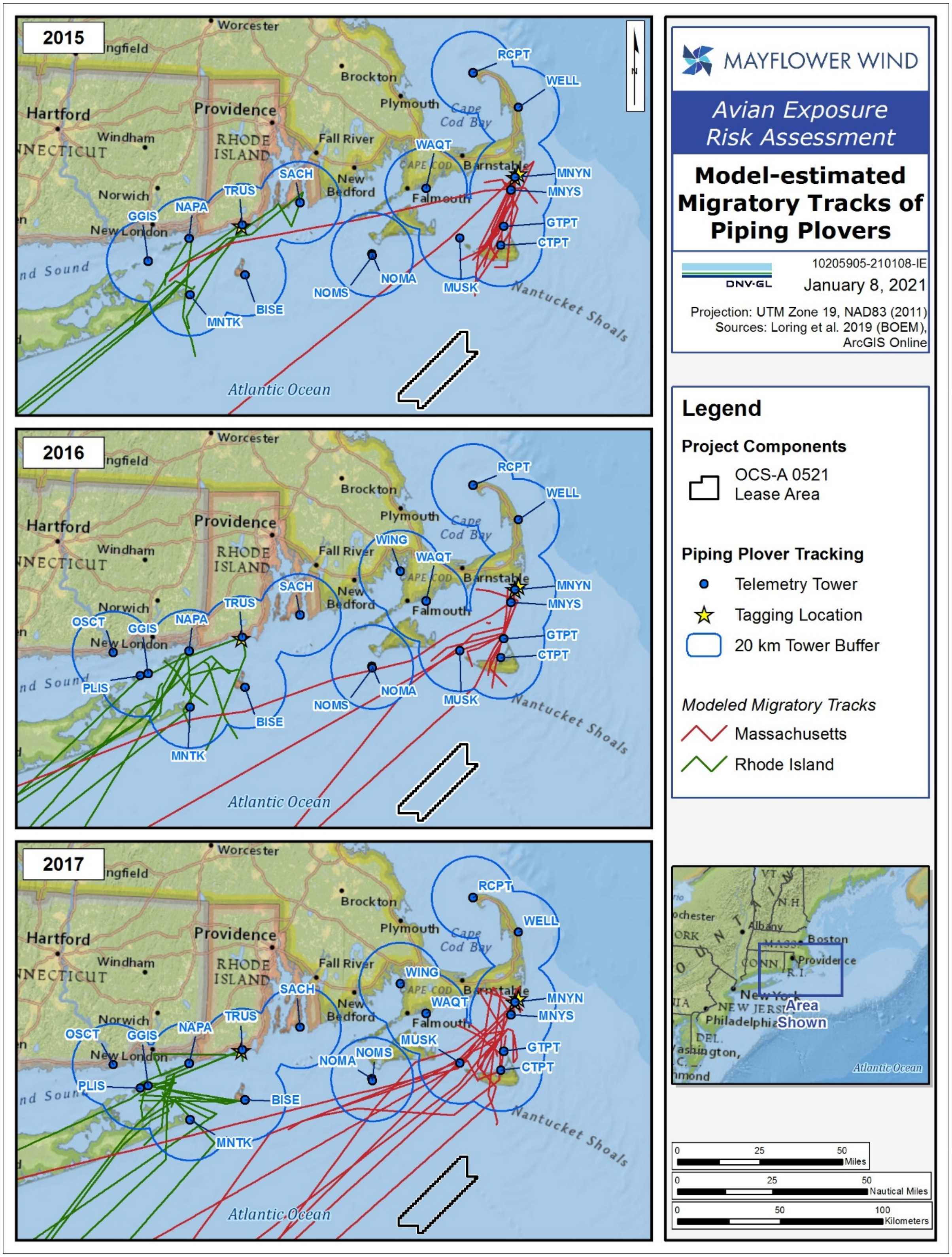

Figure 3-6 Estimated flight paths of piping plovers

Tagged at breeding areas in Massachusetts and Rhode Island based on detections from land-based VHF tracking towers (~20-km detection range; Loring et al. 2019).

Black-capped petrel

Black-capped petrel was not observed at the local scale during MCEC surveys, Aerial HD surveys, or G&G surveys and predicted abundance for the species was very low for all seasons modeled by MDAT (Figure 3-7-Figure 3-9).

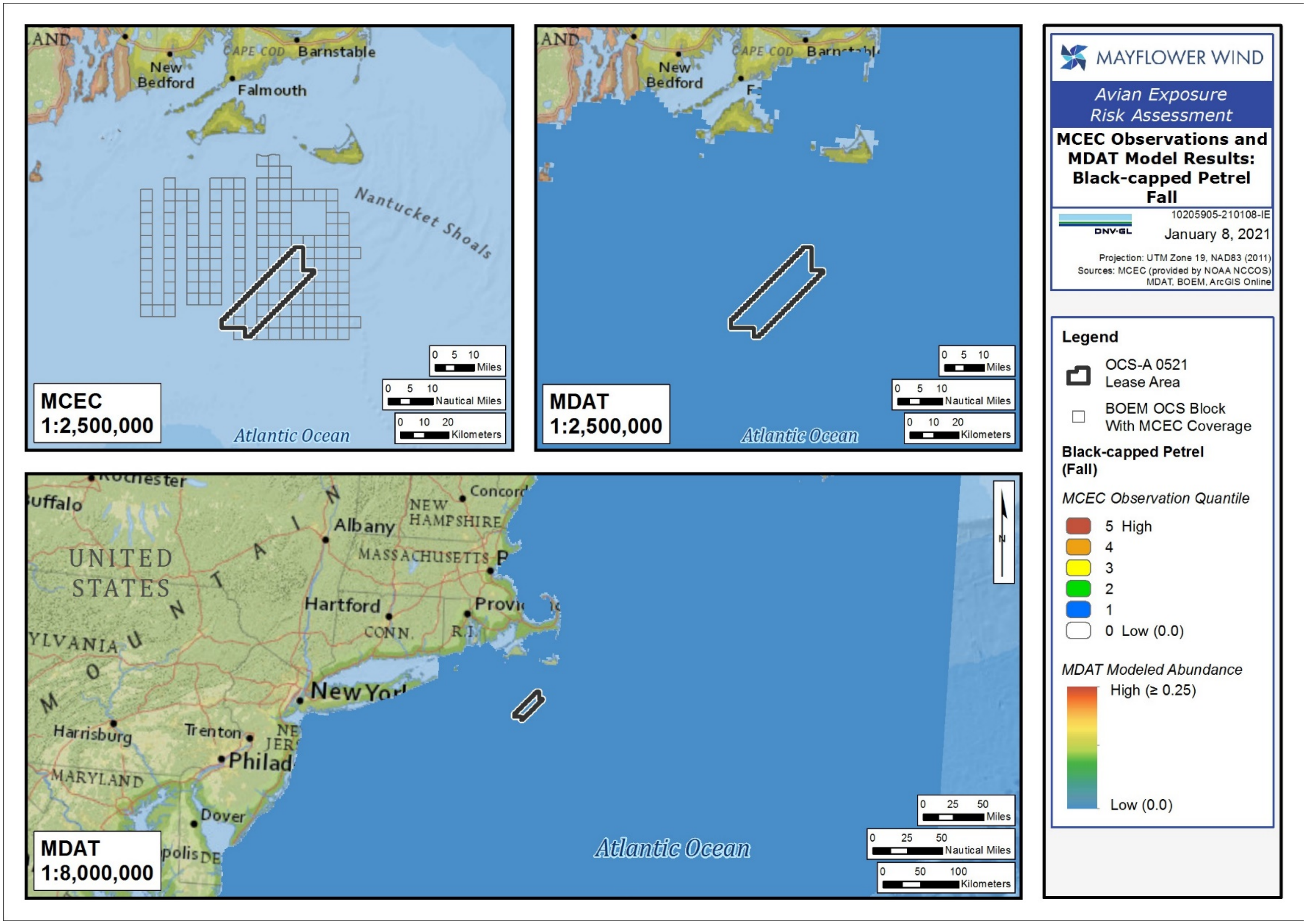

Figure 3-7 Fall black-capped petrel relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted.

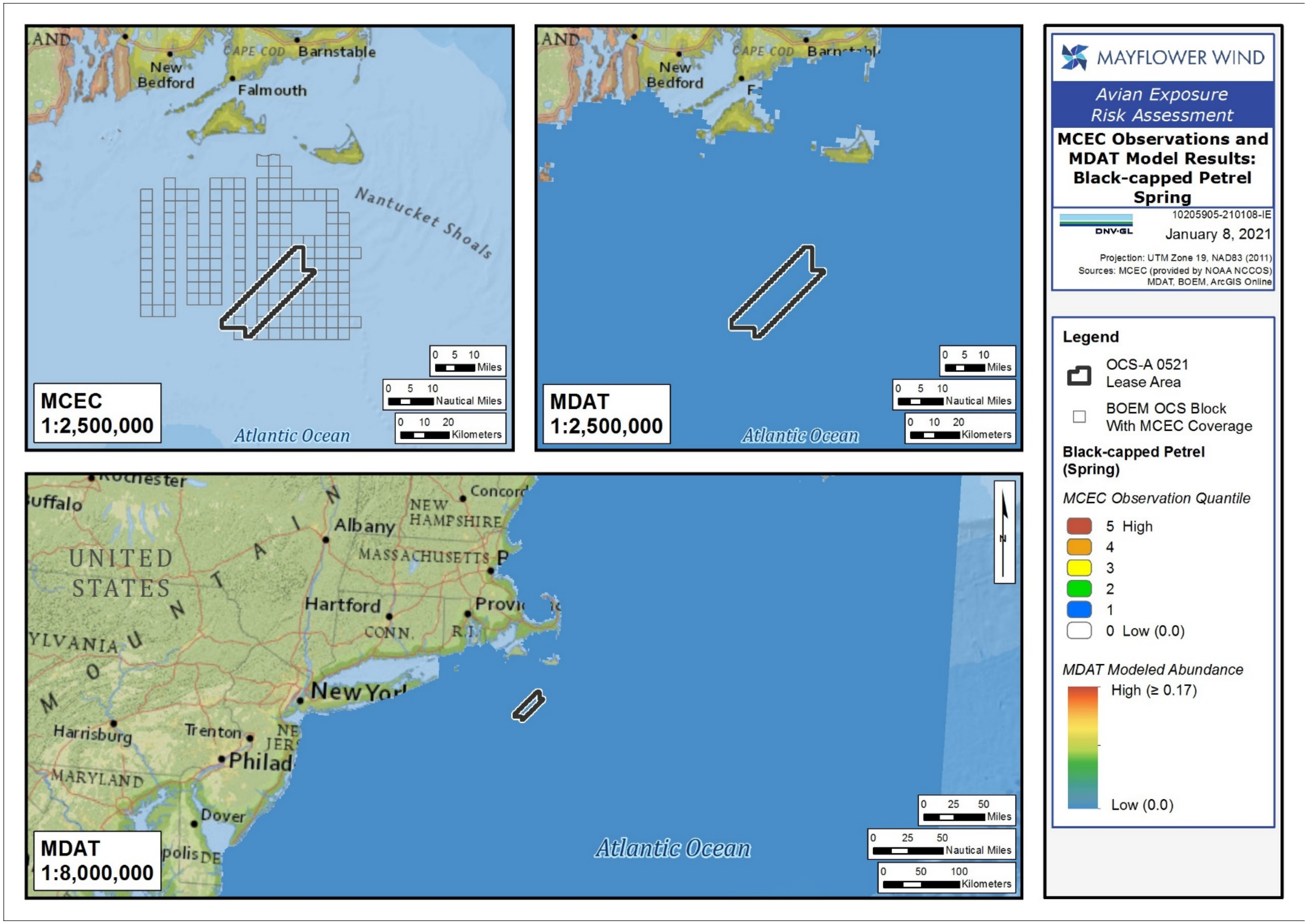

Figure 3-8 Spring black-capped petrel relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted.

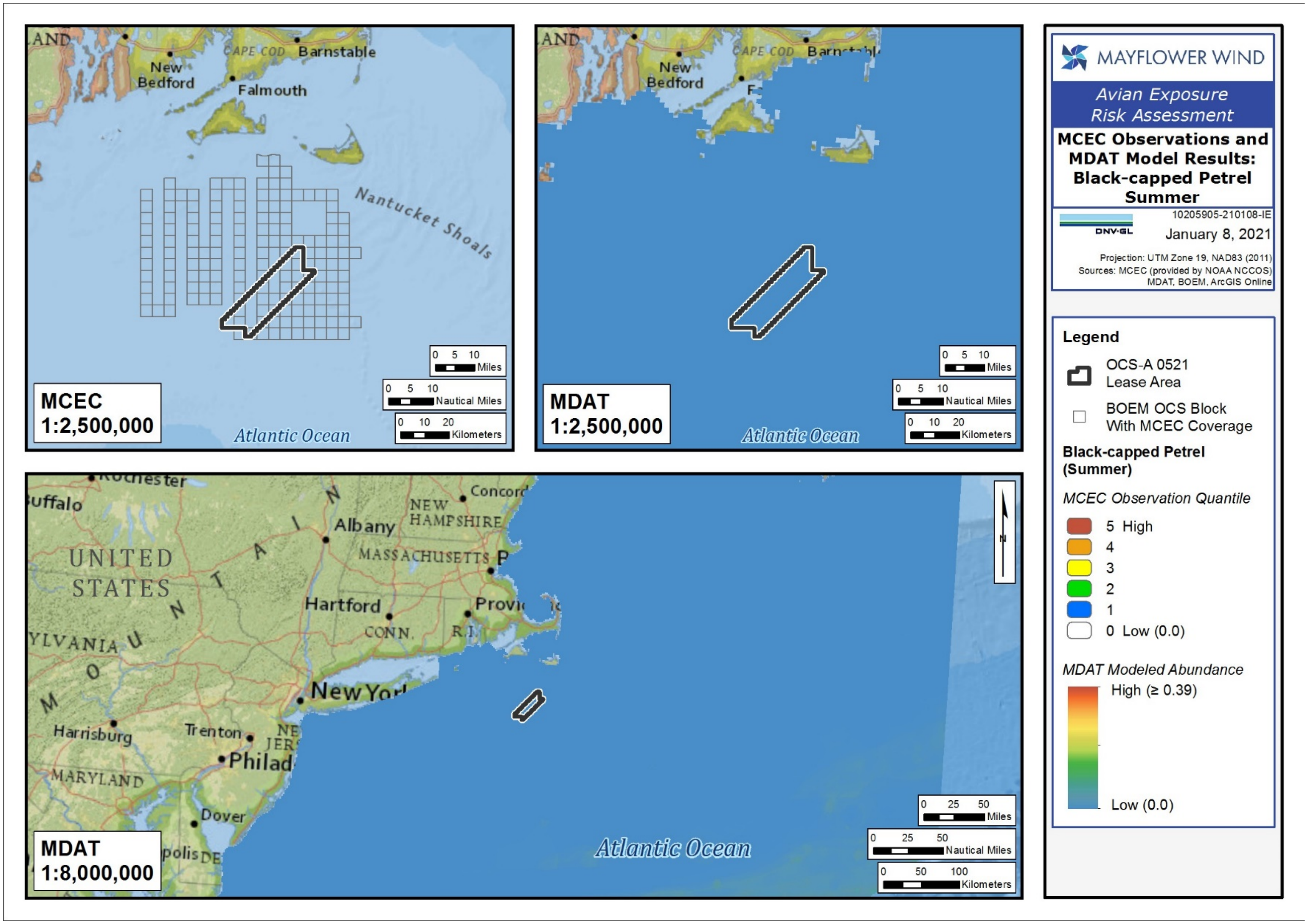

Figure 3-9 Summer black-capped petrel relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted.

3.1.1.2 State-listed

Leach’s storm-petrel

Leach’s storm-petrel was not observed at the local scale during MCEC surveys (Figure 3-10-Figure 3-12) or during Aerial HD surveys or G&G surveys. Predicted abundance was low for all seasons modeled by MDAT for the species (i.e., fall, spring, and summer; Figure 3-10-Figure 3-12), as the Leach’s storm-petrel is predicted to primarily occur further offshore than the Lease Area.

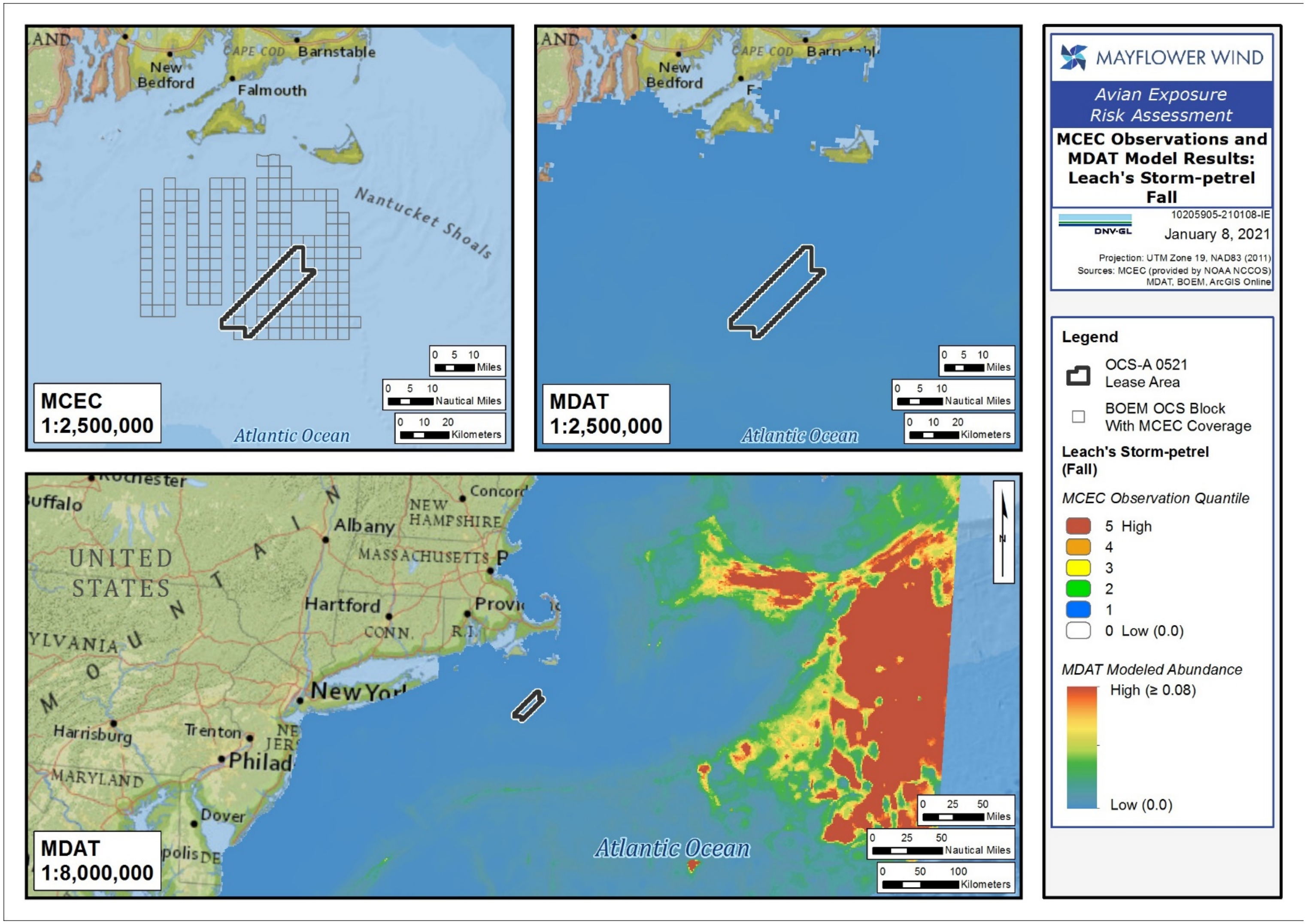

Figure 3-10 Fall Leach's storm petrel relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

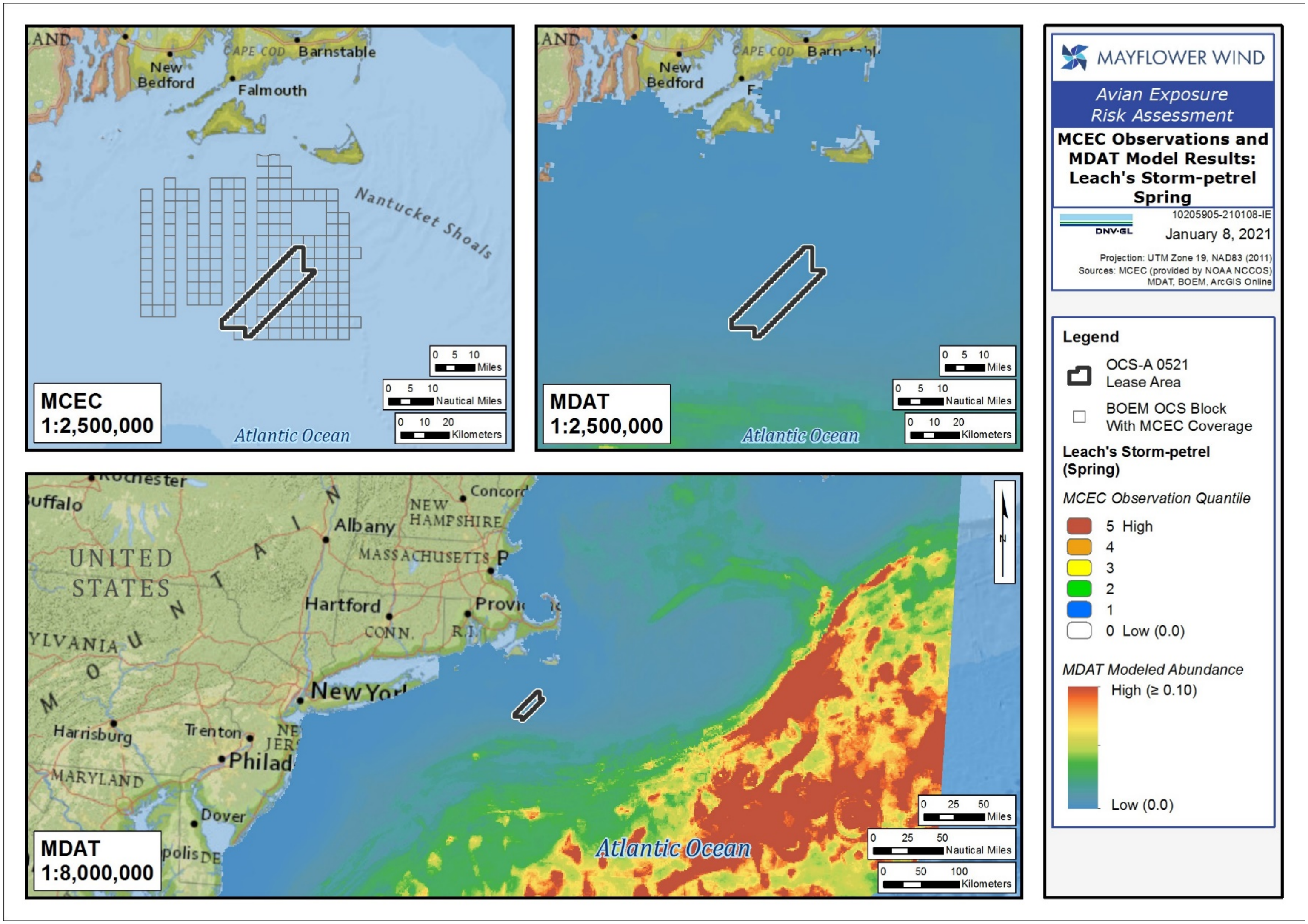

Figure 3-11 Spring Leach's storm petrel relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

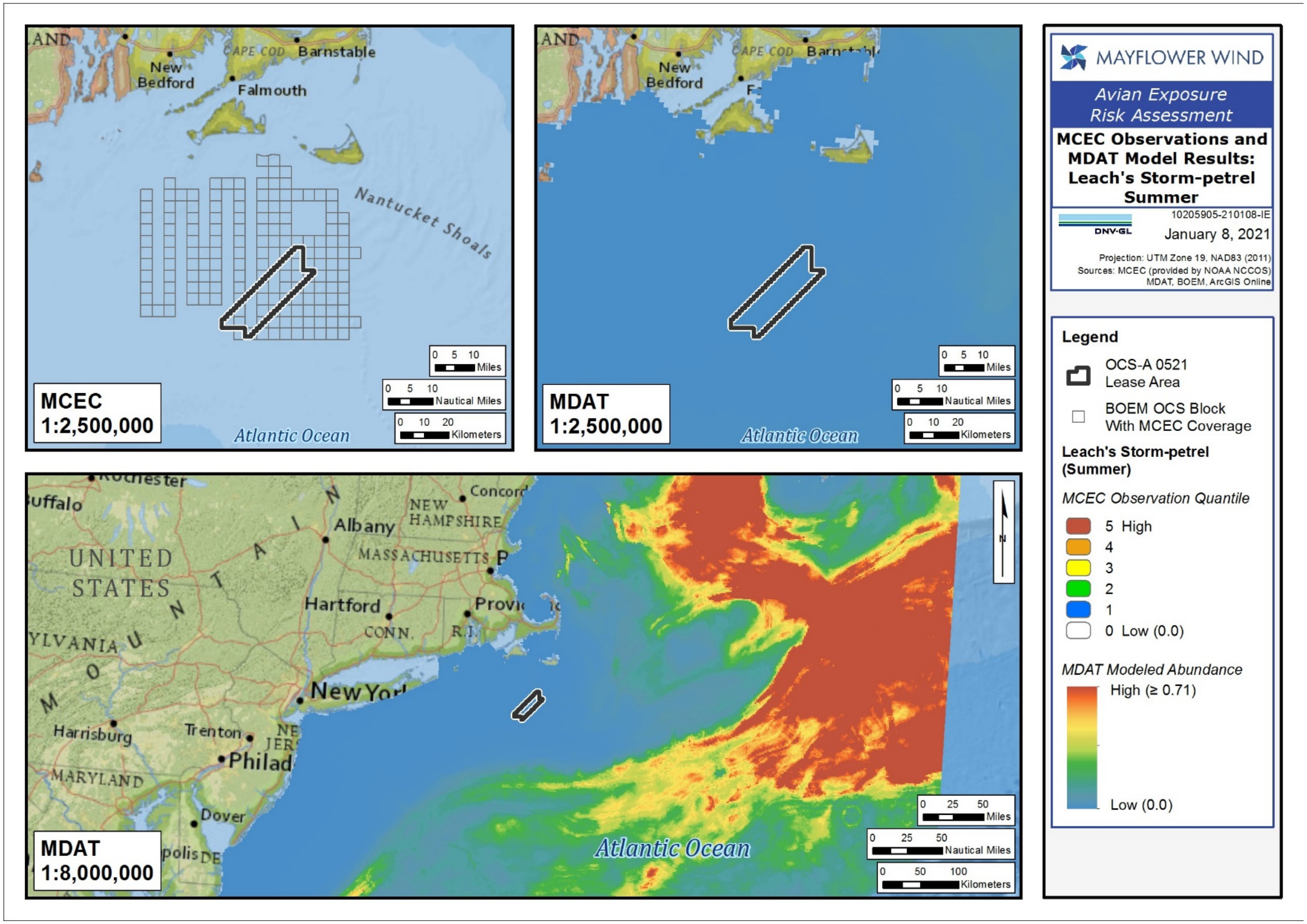

Figure 3-12 Summer Leach's storm petrel relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

3.1.1.3 Other Focal Species

Common tern

Predicted abundance of common tern is low in spring and summer, and moderate in fall relative to regional waters (Figure 3-13-Figure 3-15). Common tern was observed in relatively low densities in two BOEM blocks adjacent to the Lease Area during the MCEC summer surveys (Figure 3-15), and in five BOEM blocks in the Lease Area during the Aerial HD spring surveys (Figure 3-16). Estimated VHF post-breeding tracks indicate that most tagged common tern movements occurred close to shore (Figure 3-17). A limited number of movement tracks indicated southward movement from Muskeget Island and vicinity before individuals moved beyond tracking range, and travel through the Lease Area thus may have occurred; however, estimated probability of common tern exposure in the Lease Area based on these data is very low (Loring et al. 2019). No common terns were observed during Project G&G surveys.

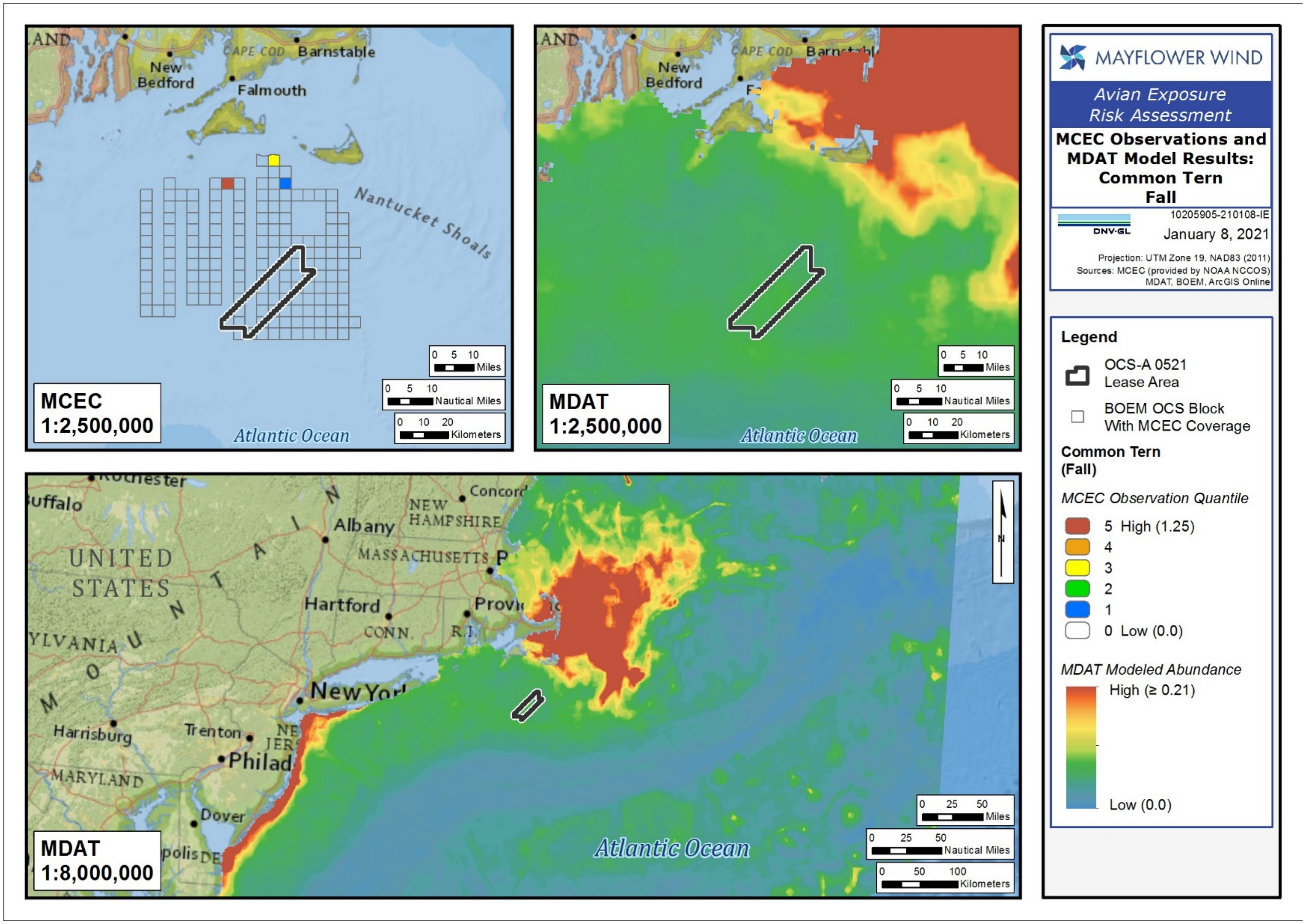

Figure 3-13 Fall common tern relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

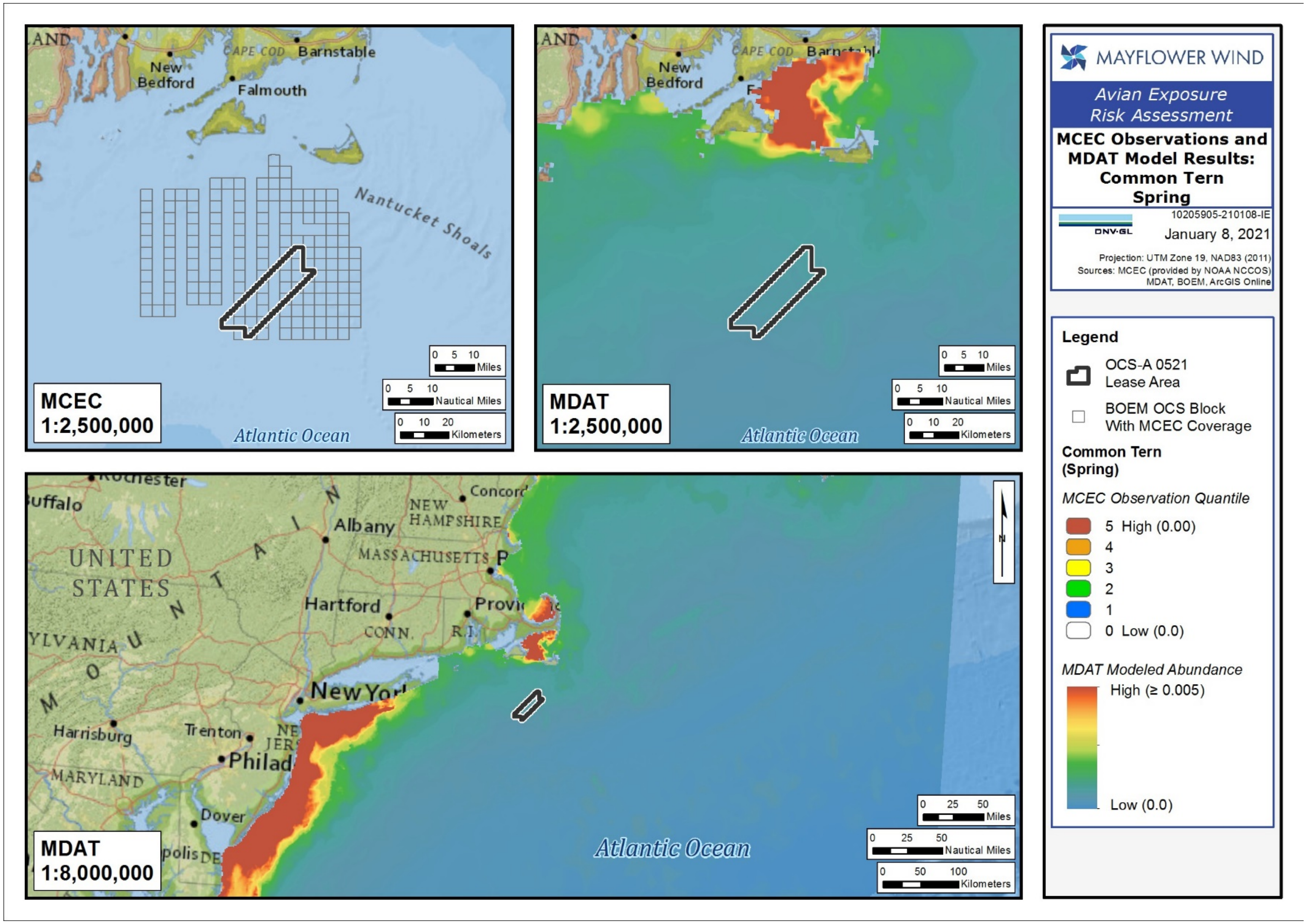

Figure 3-14 Spring common tern relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

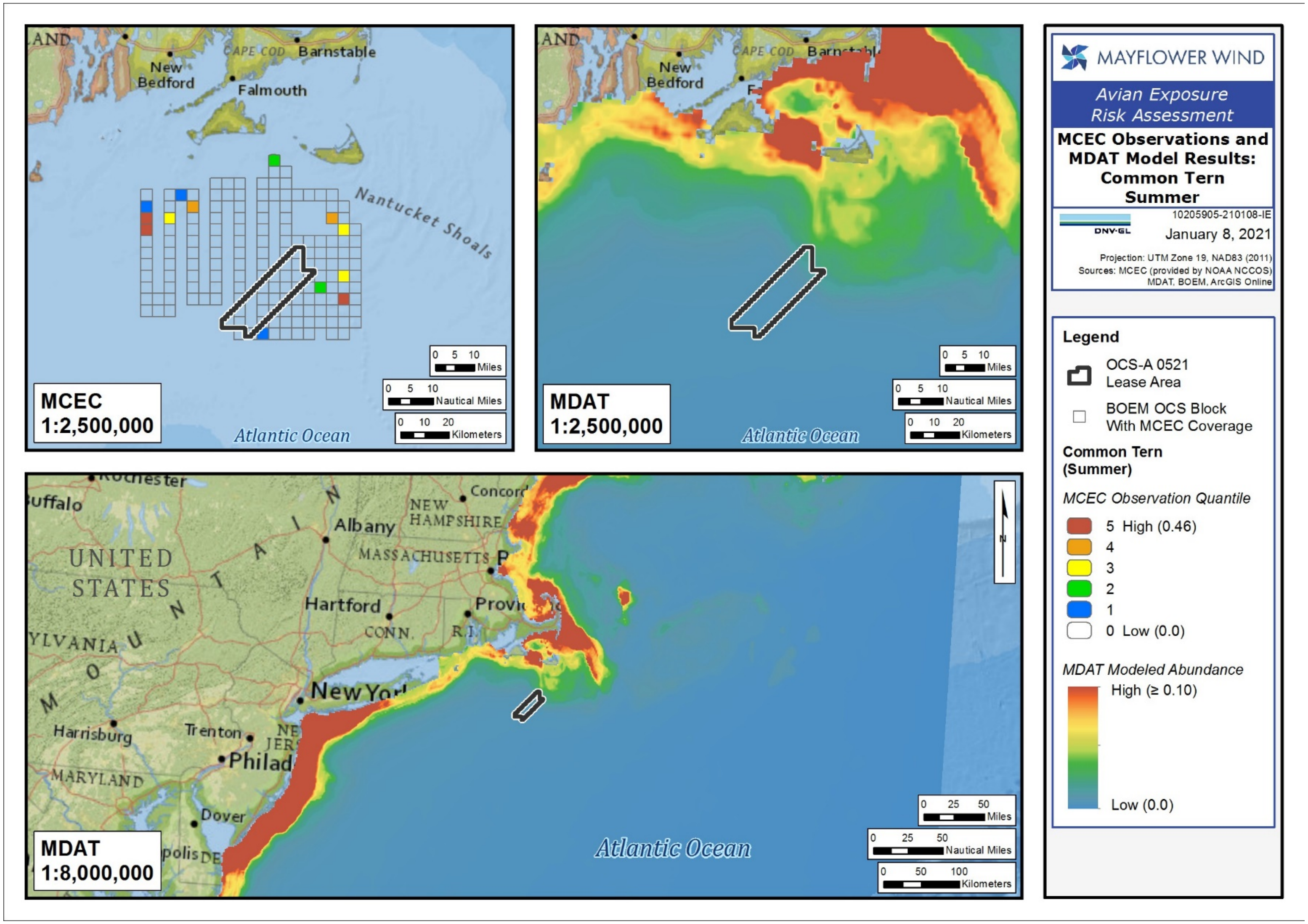

Figure 3-15 Summer common tern relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

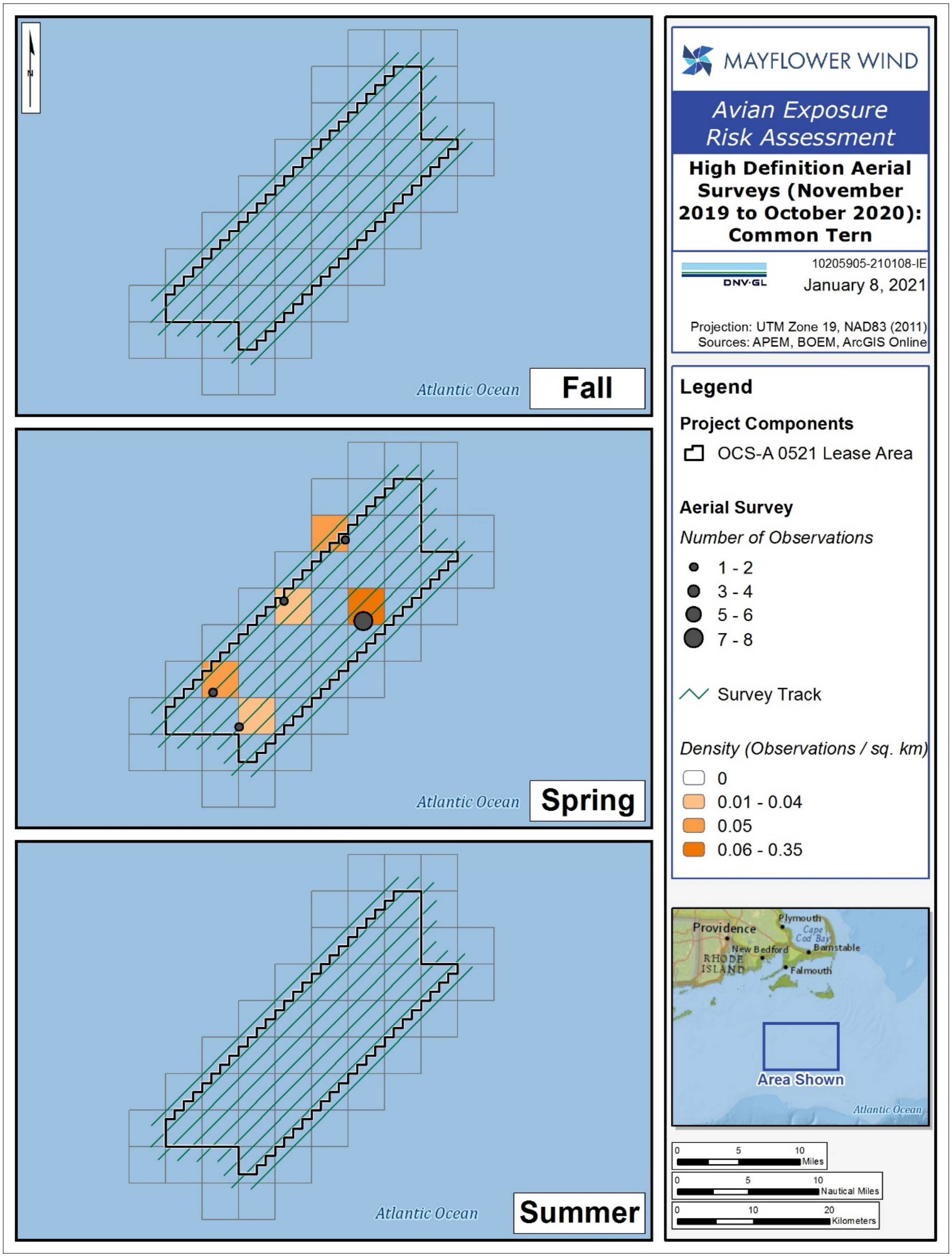

Figure 3-16 Raw observations and effort-adjusted seasonal density estimates for common tern

Note that survey effort differed among seasons (fall, n=3; spring, n=5; and summer, n=3); raw observations are presented to assess within-season spatial patterns only. Density estimates represent total individuals observed per survey per km^2 within each season.

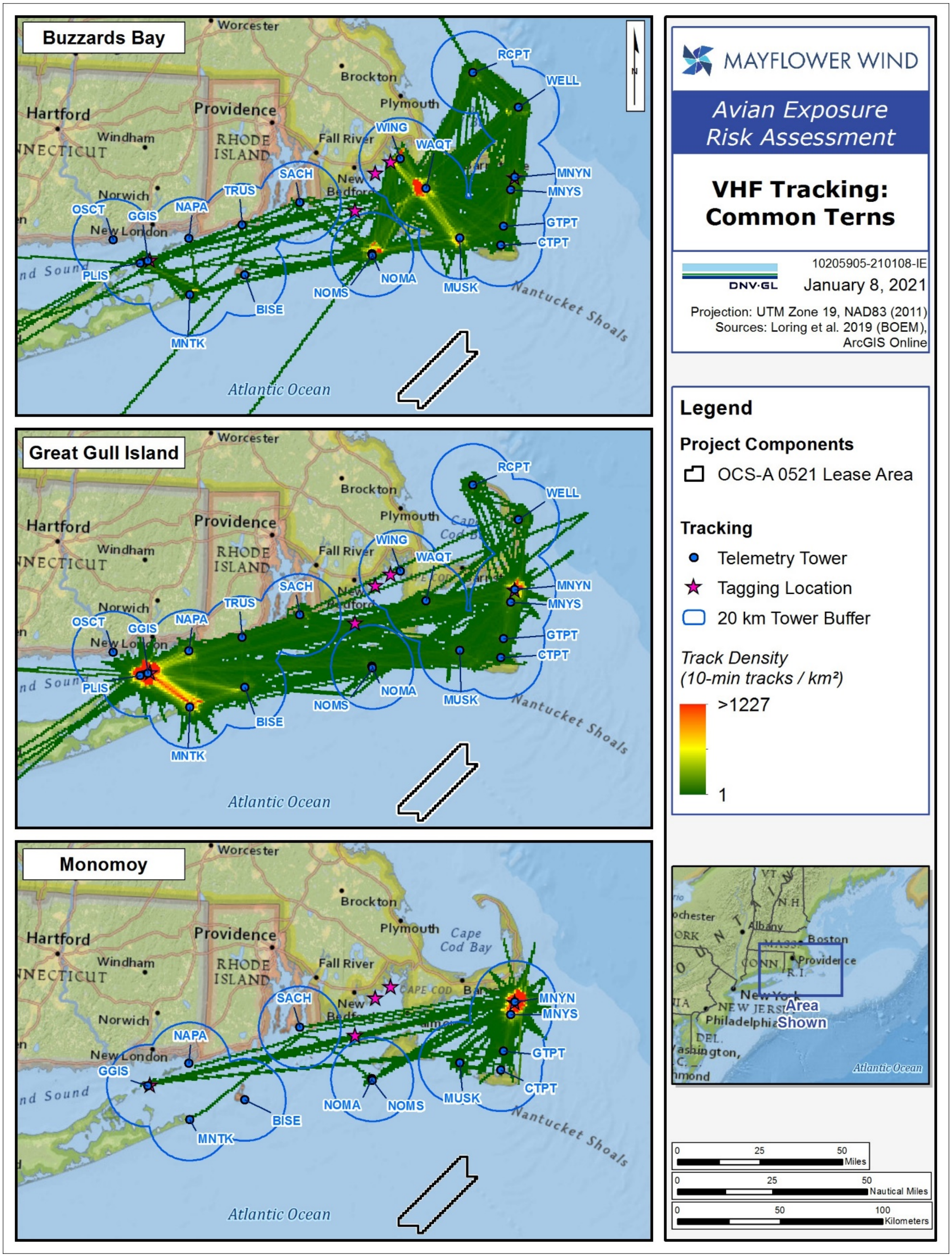

Figure 3-17 Interpolated (model generated) flight path densities of common terns

Tagged at breeding colonies tagged on Great Gull Island, Bird Island, Ram Island, Penikese Island, and Monomoy National Wildlife Refuge based on detections from land-based VHF tracking towers (~20-km detection range; Loring et al. 2019).

Black-legged kittiwake

Predicted abundance of black-legged kittiwake is low in fall, moderate in winter, and moderate to high in spring relative to regional waters (Figure 3-18-Figure 3-20). Black-legged kittiwake was observed in low to moderate densities in the Lease Area during the MCEC fall (Figure 3-18) and spring (Figure 3-20) surveys, and moderate to high densities during the winter surveys (Figure 3-19). Black-legged kittiwake was observed in the Lease Area during the fall Aerial HD surveys, and to a lesser extent during the winter and spring surveys (Figure 3-21). Eight black-legged kittiwake were observed during the October-November Project G&G surveys.

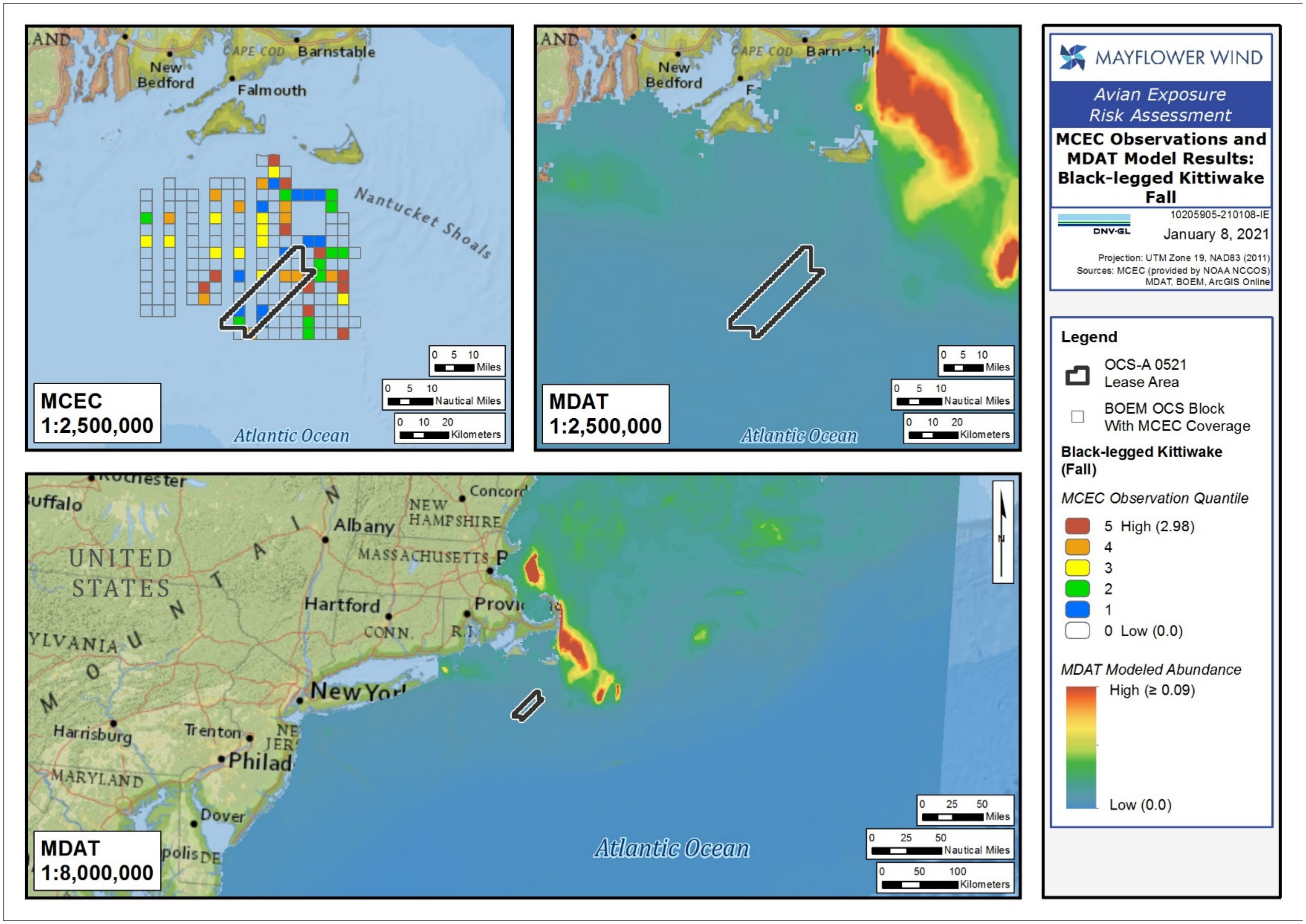

Figure 3-18 Fall black-legged kittiwake relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

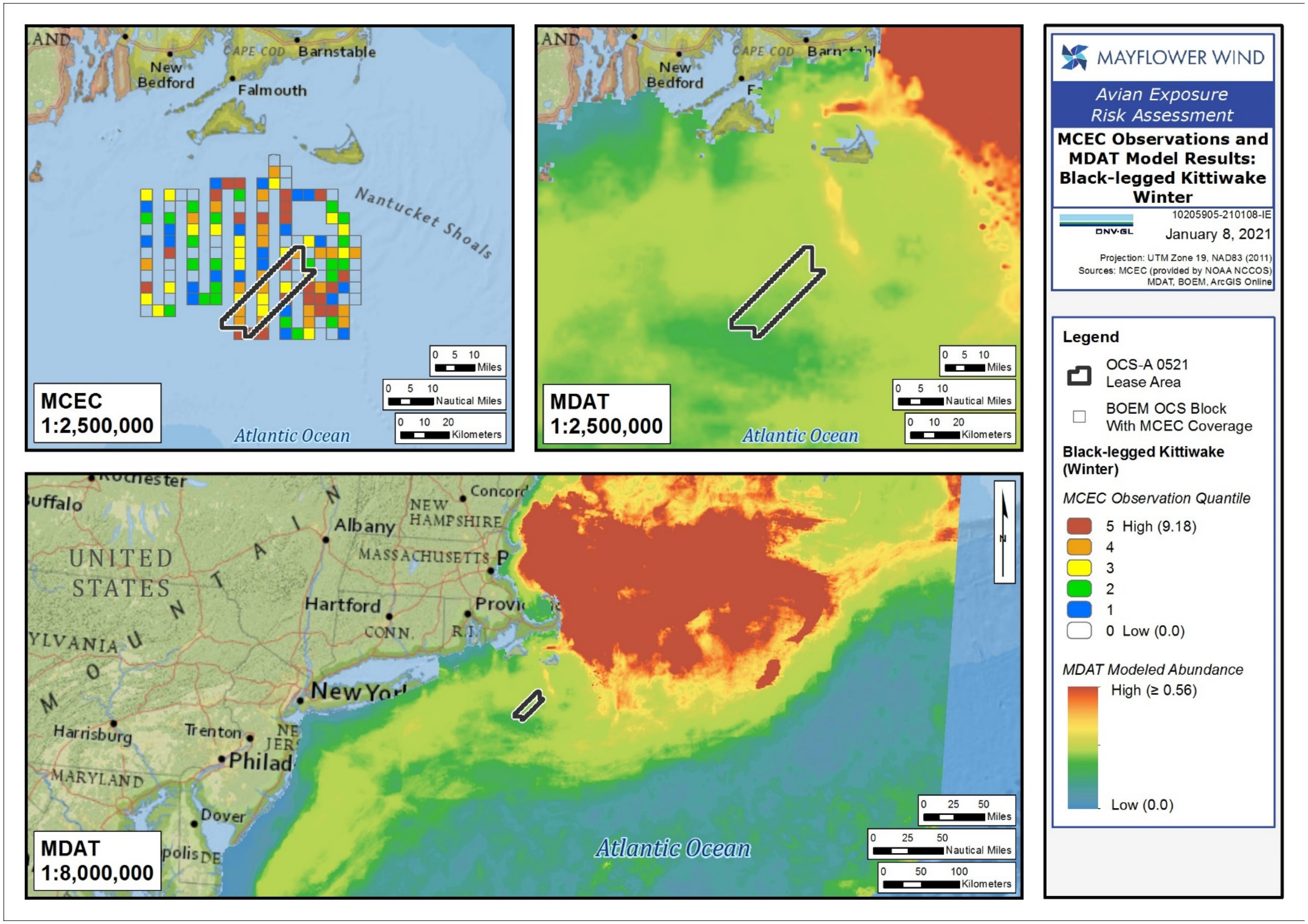

Figure 3-19 Winter black-legged kittiwake relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

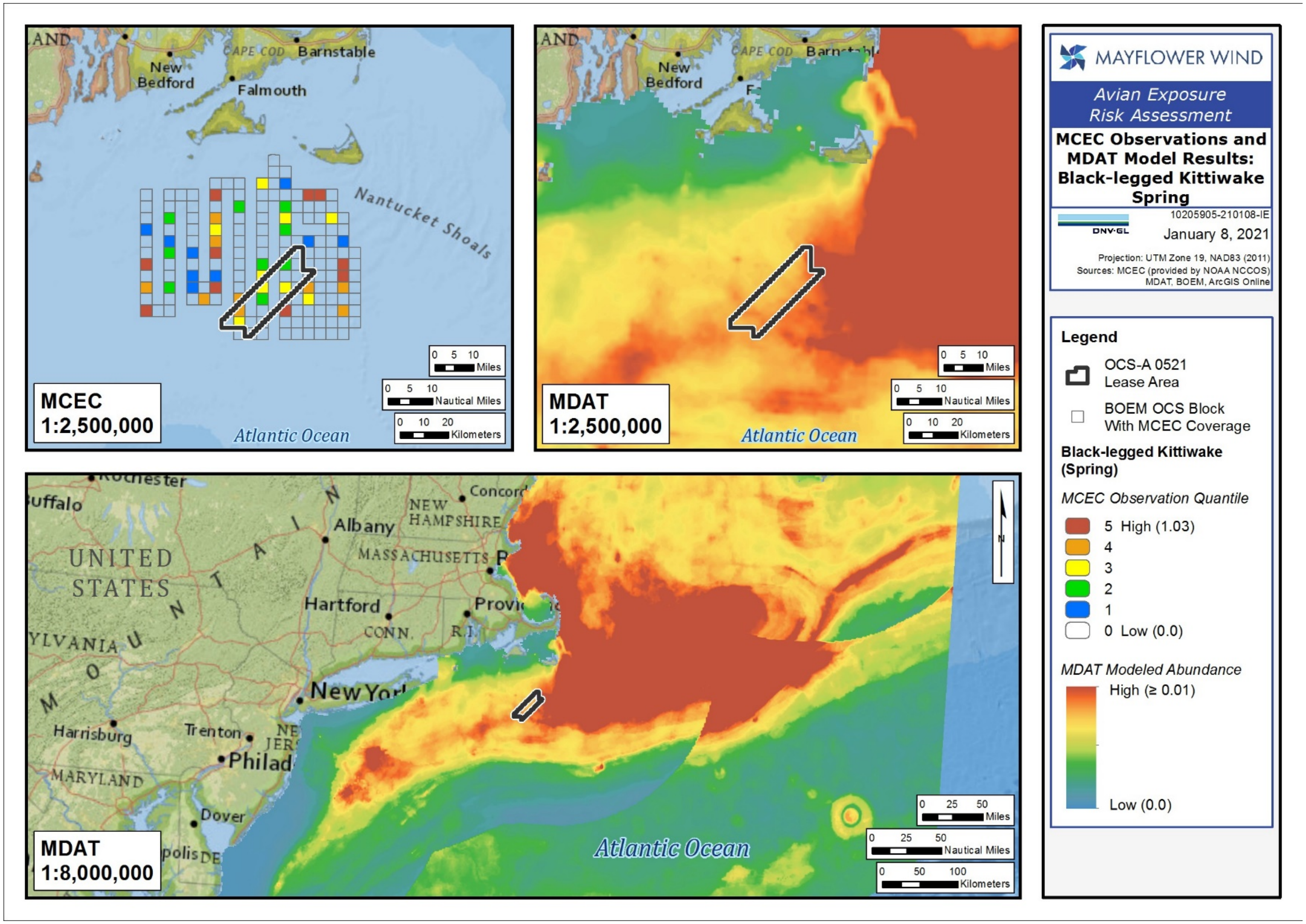

Figure 3-20 Spring black-legged kittiwake relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

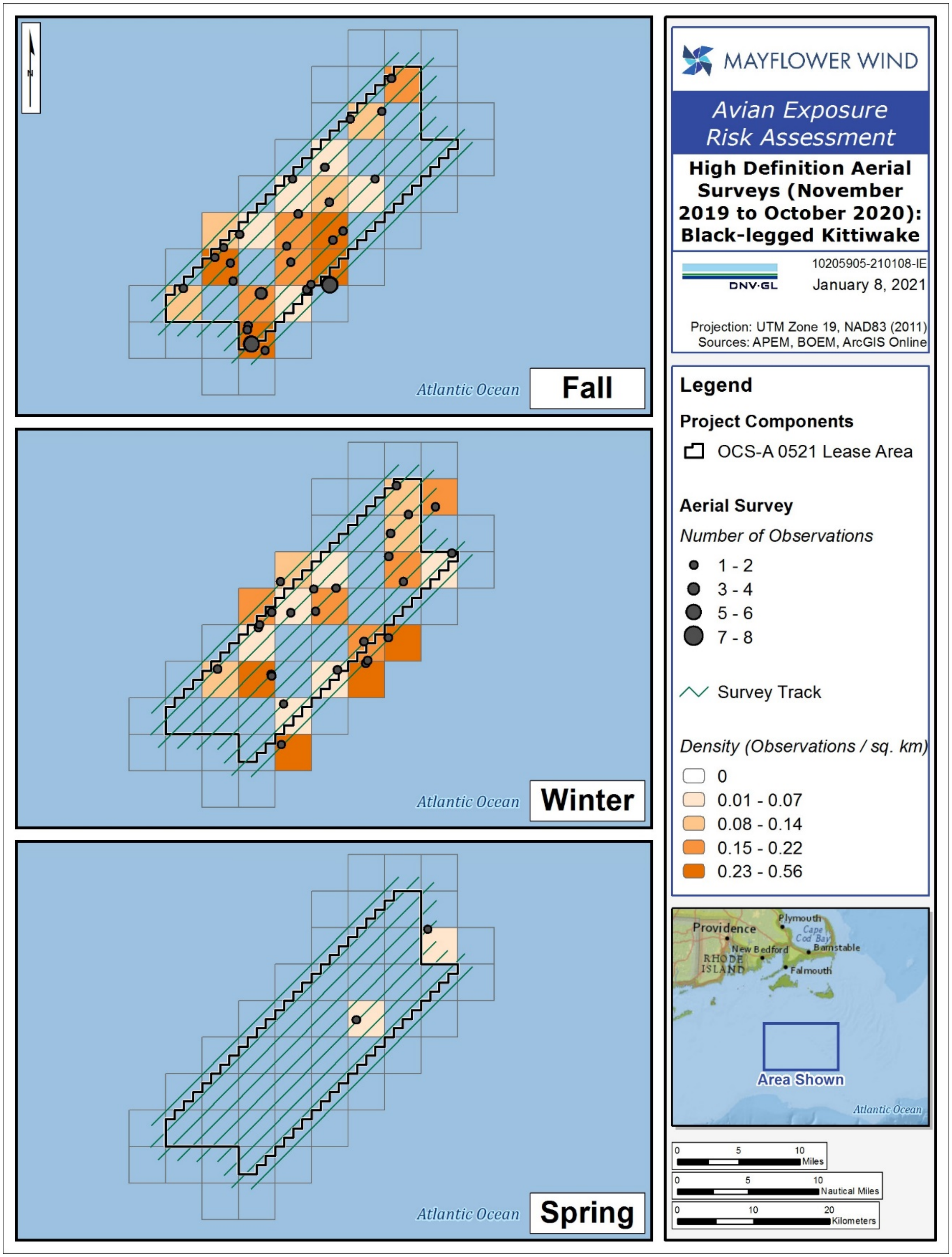

Figure 3-21 Raw observations and effort-adjusted seasonal density estimates for black-legged kittiwake

Note that survey effort differed among seasons (fall, n=3; spring, n=5; and summer, n=3); raw observations are presented to assess within-season spatial patterns only. Density estimates represent total individuals observed per survey per km^2 within each season.

Northern gannet

Predicted abundance of northern gannet is moderate in fall and spring, low to moderate in winter, and low in summer relative to regional waters (Figure 3-22 - Figure 3-25). Northern gannet was generally observed in low to moderate densities in the Lease Area during the MCEC fall (Figure 3-22) and spring (Figure 3-24) and summer (Figure 3-25) surveys, and moderate to high densities during the winter surveys (Figure 3-19). Six northern gannets were observed during the Project G&G surveys in September 2019, and 402 were observed during the October-November surveys. The species was observed in the Lease Area during the fall and spring Aerial HD surveys, and rarely during the winter surveys (Figure 3-26); none were observed during the summer surveys. Utilization distribution models based on GPS tracking data did not indicate that northern gannet core use areas occur in the Lease Area (Figure 3-27), but portions of the 75% and 95% isopleths overlap the Lease Area.

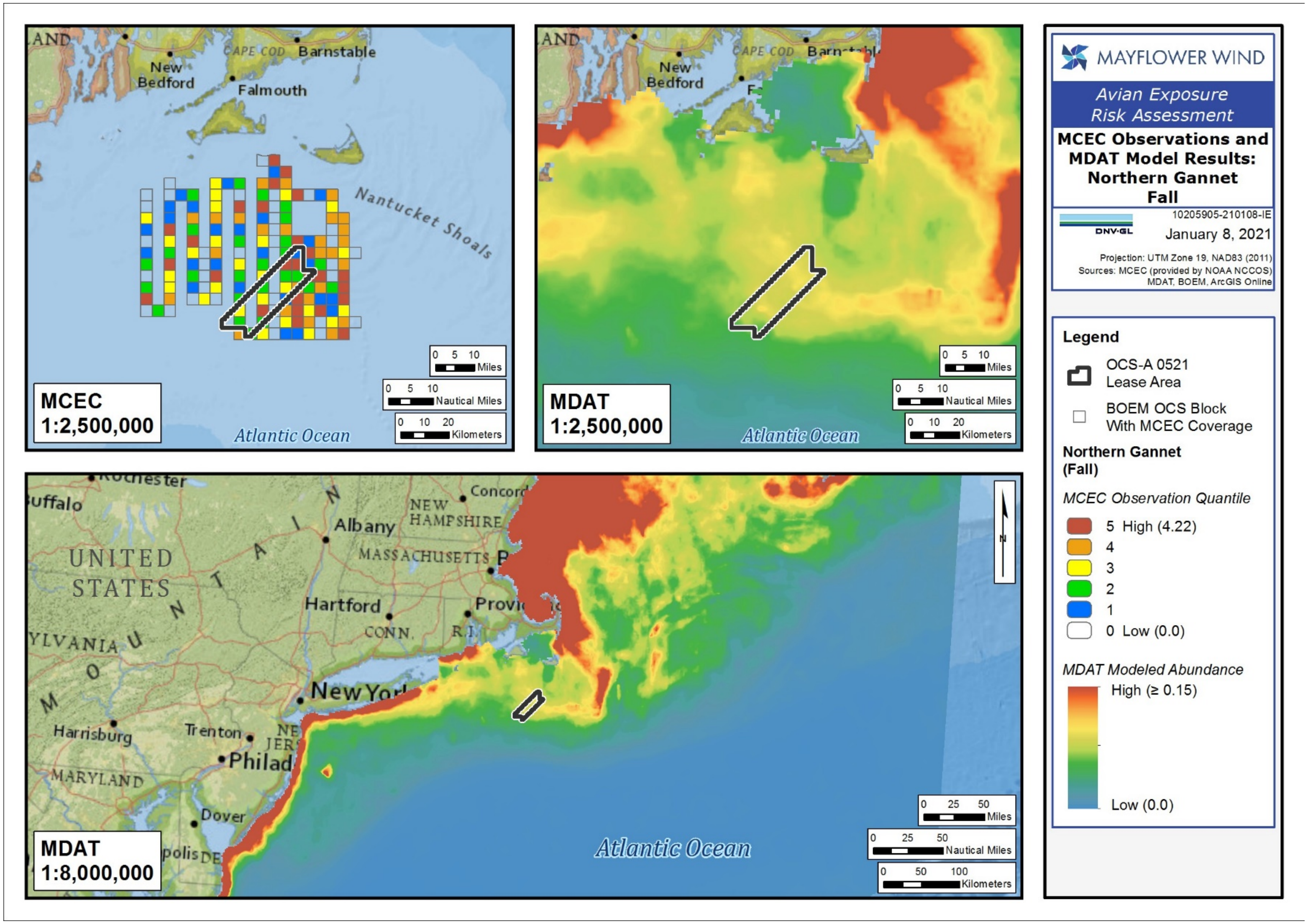

Figure 3-22 Fall northern gannet relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

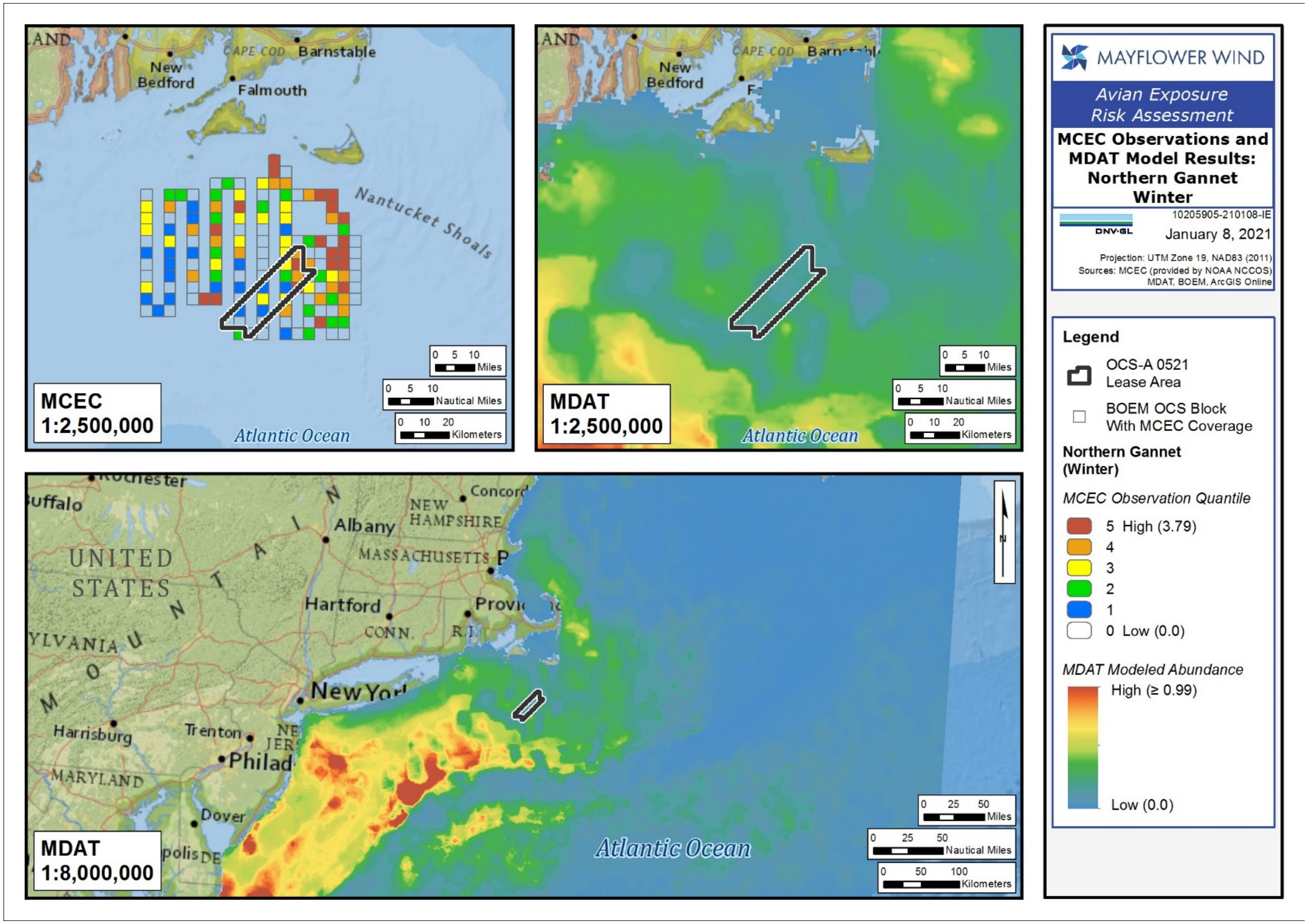

Figure 3-23 Winter northern gannet relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

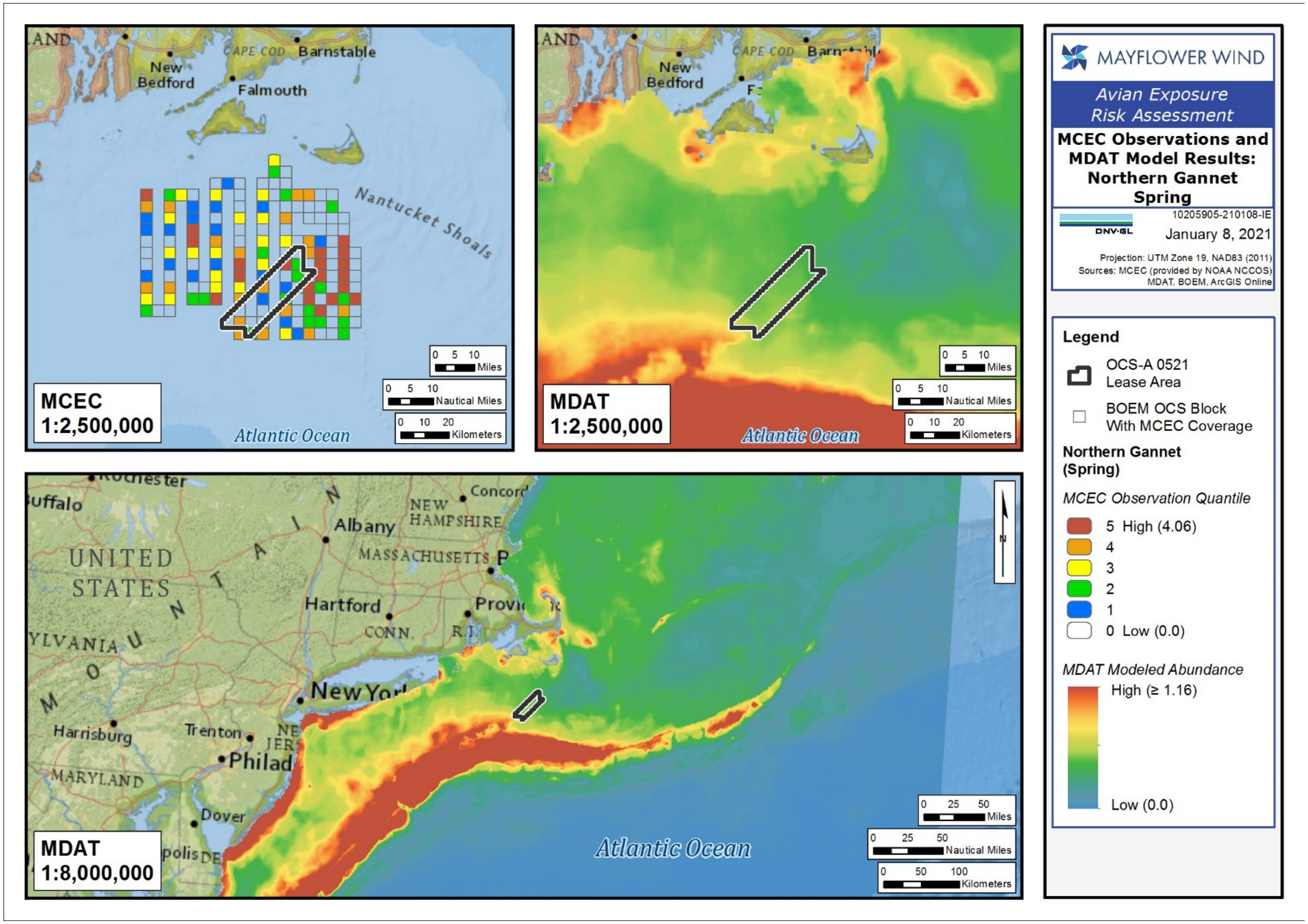

Figure 3-24 Spring northern gannet relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

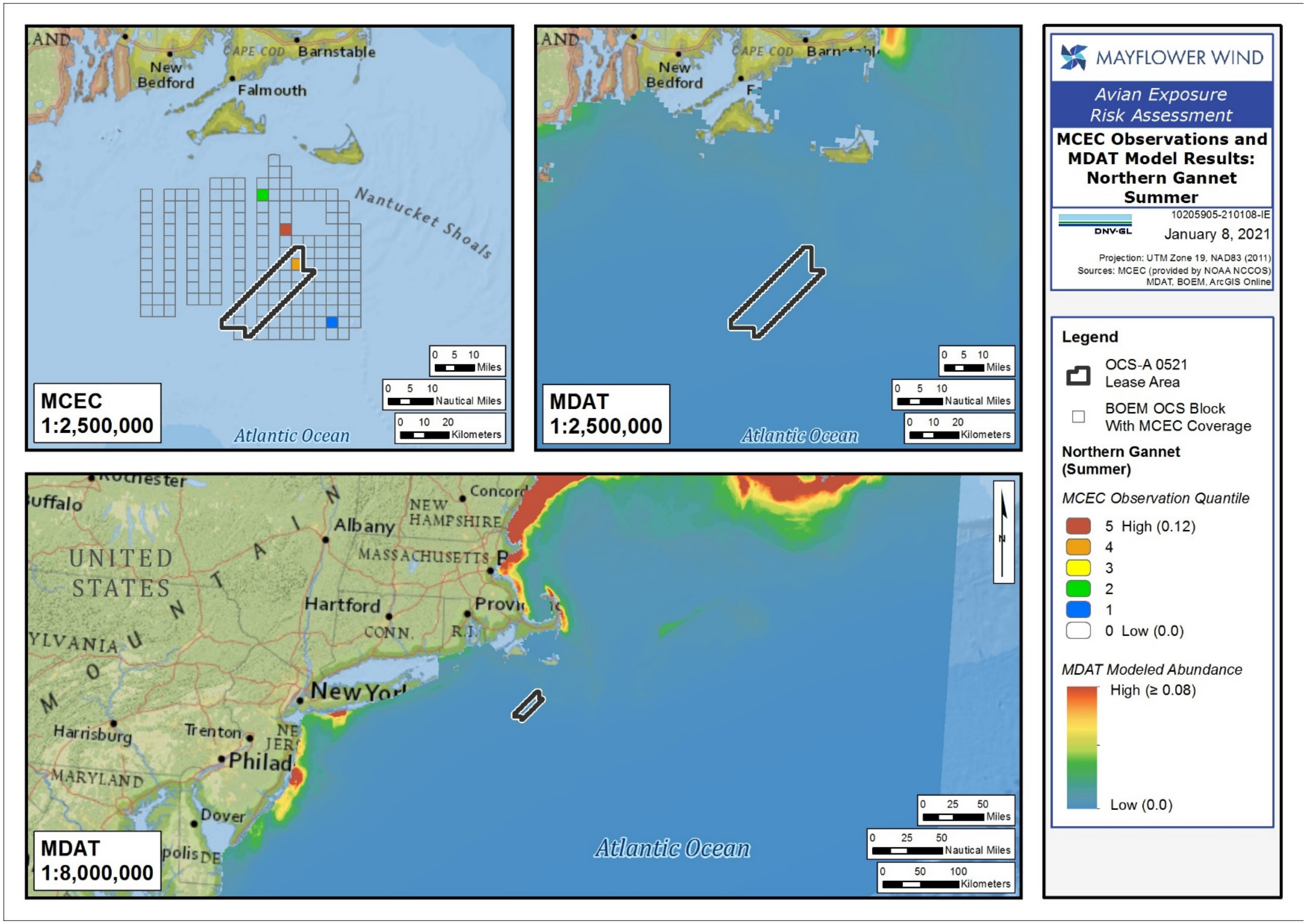

Figure 3-25 Summer northern gannet relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

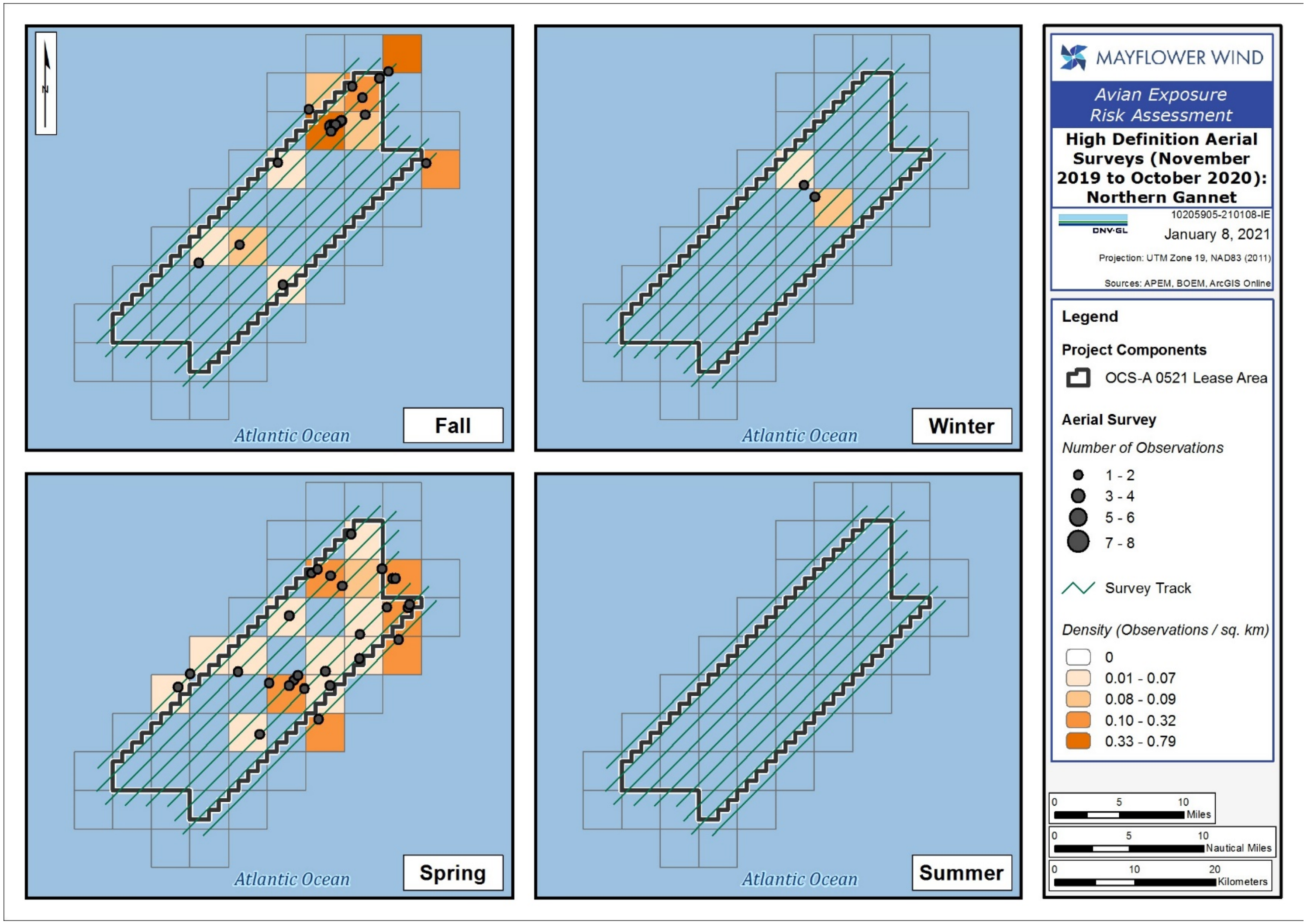

Figure 3-26 Raw observations and effort-adjusted seasonal density estimates for northern gannet

Note that survey effort differed among seasons (fall, n=3; spring, n=5; and summer, n=3); raw observations are presented to assess within-season spatial patterns only. Density estimates represent total individuals observed per survey per km^2 within each season.

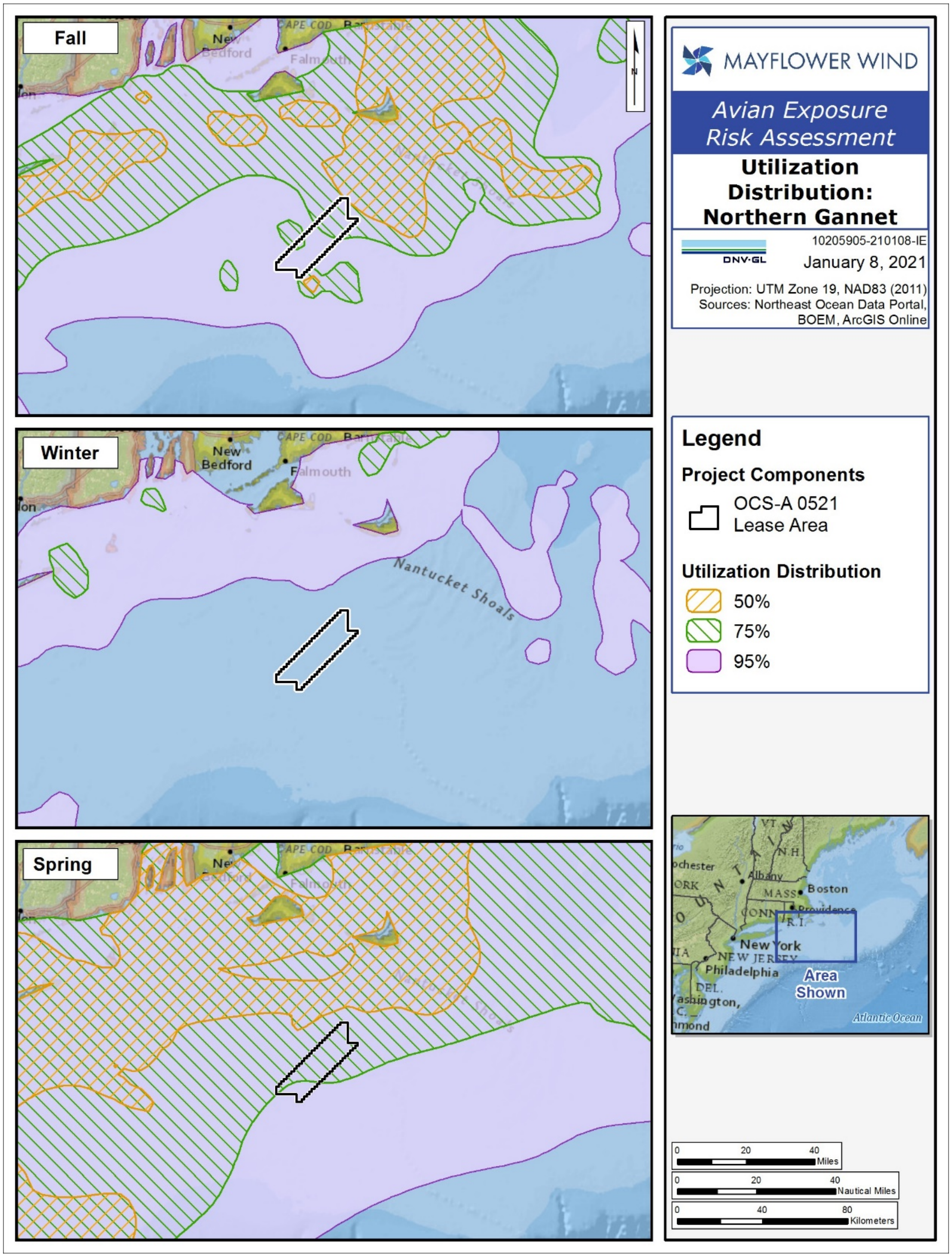

Figure 3-27 Northern gannet utilization distribution

Based on GPS tracking data (Speigel et. al 2017). Distribution contours represent 50% (core use area), 75% and 95% (regional use area) isopleths. See Section 2.2.4.2 for details.

Red-throated loon

Predicted abundance of red-throated loon is low in fall, winter, and spring relative to regional waters, with potential for occurrence estimated to be higher in the northern portion of the Lease Area (Figure 3-28 - Figure 3-30). Red-throated loon was observed in low densities in the Lease Area during the MCEC spring surveys (Figure 3-30) but the species was not observed in the Lease Area during fall or winter surveys. Several individuals were observed in the Lease Area during the Aerial HD spring surveys (Figure 3-31). Utilization distribution models based on GPS tracking data did not indicate that red-throated loon core use areas occur in the Lease Area (Figure 3-32), but portions of the 75% and 95% isopleths overlap the Lease Area. No red-throated loons were observed during Project G&G surveys.

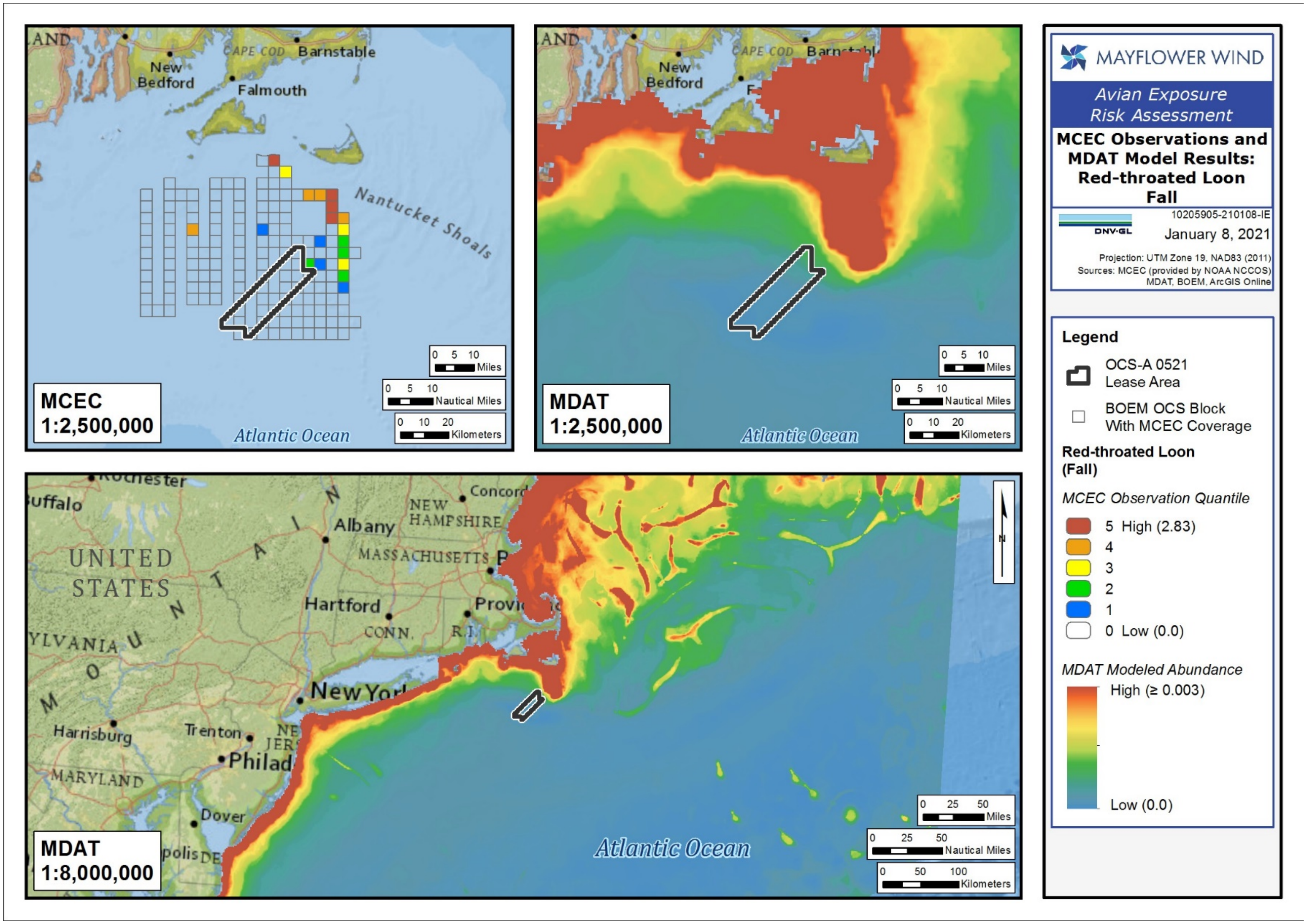

Figure 3-28 Fall red-throated loon relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

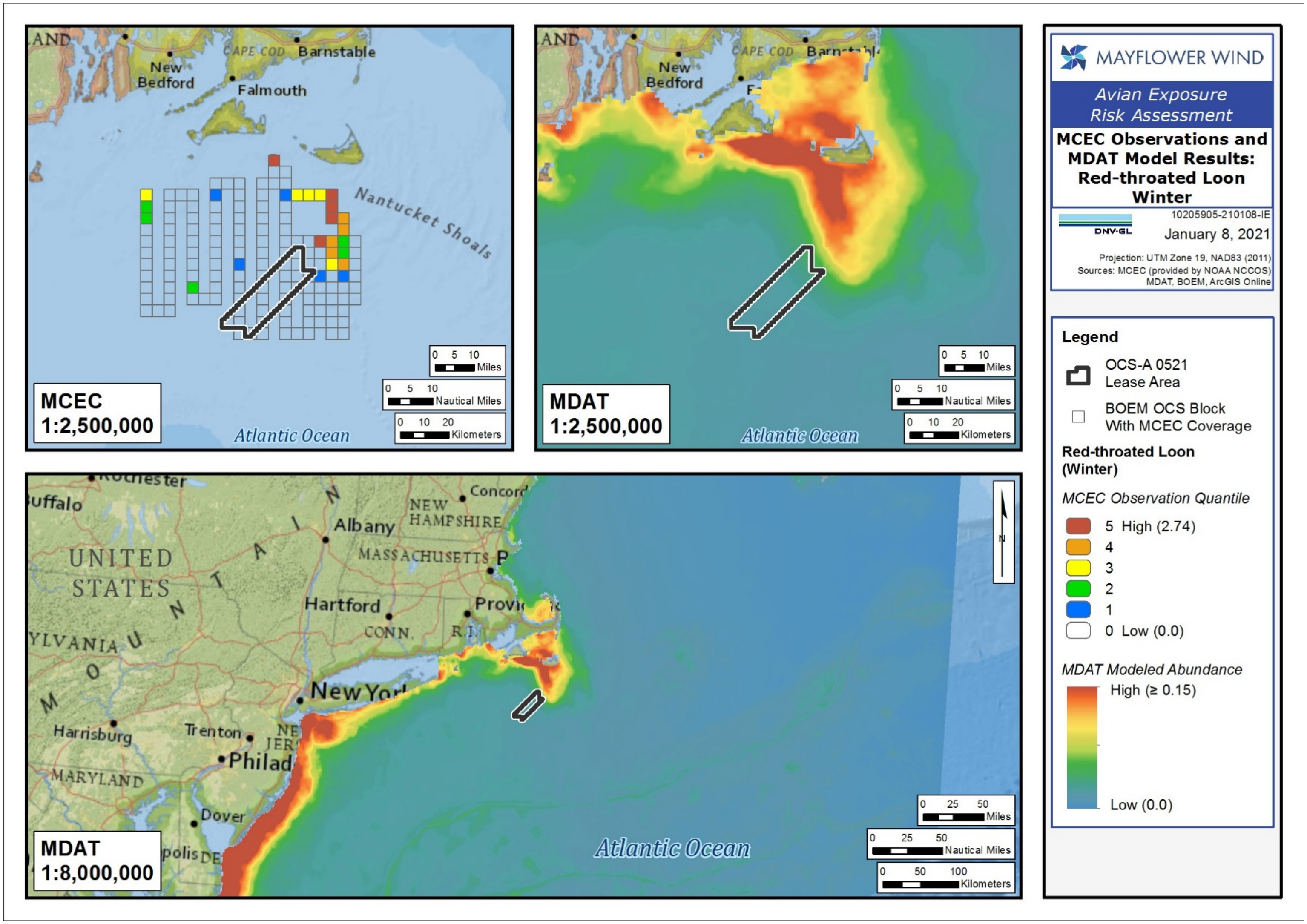

Figure 3-29 Winter red-throated loon relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

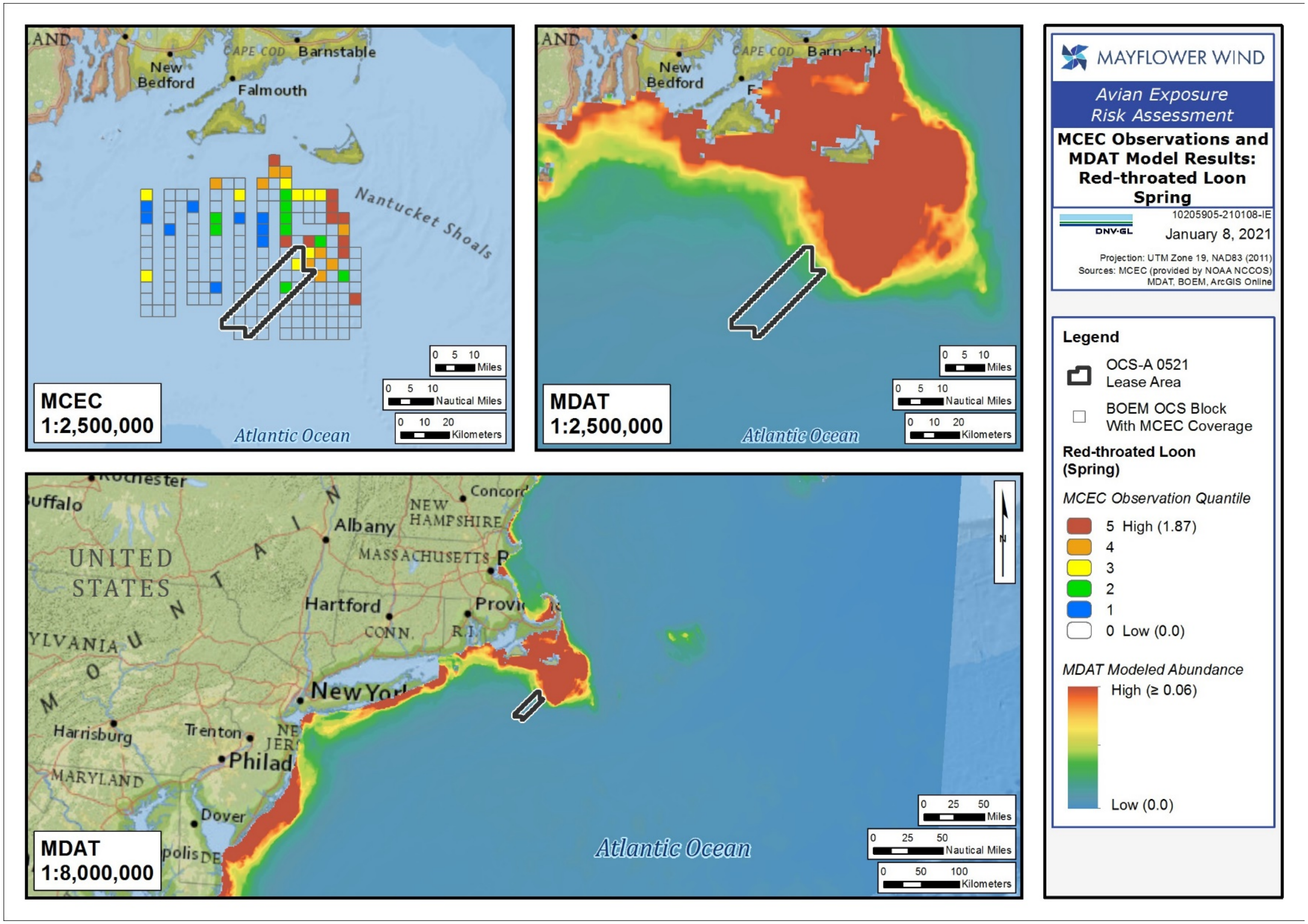

Figure 3-30 Spring red-throated loon relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

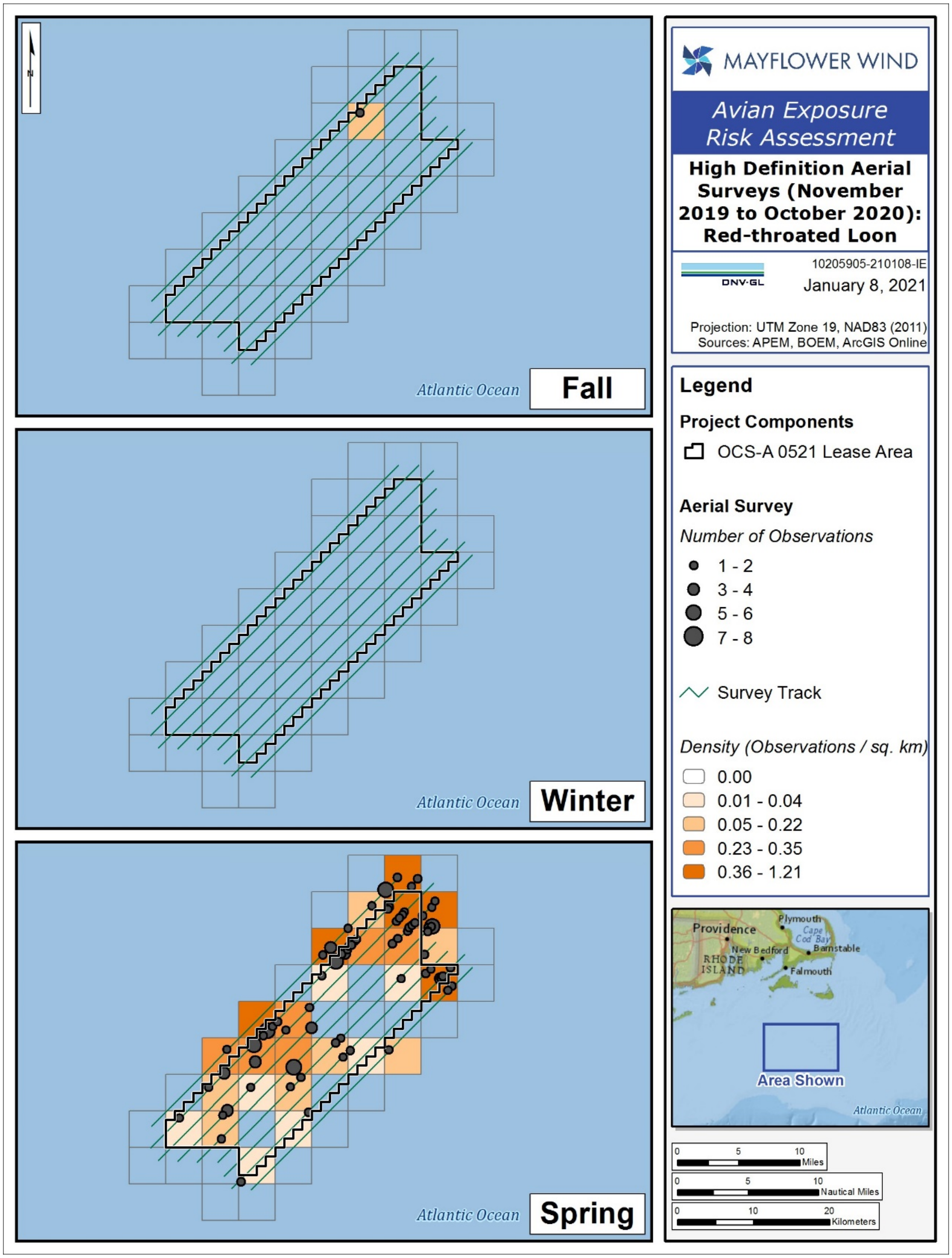

Figure 3-31 Raw observations and effort-adjusted seasonal density estimates for red-throated loon

Note that survey effort differed among seasons (fall, n=3; spring, n=5; and summer, n=3); raw observations are presented to assess within-season spatial patterns only. Density estimates represent total individuals observed per survey per km^2 within each season.

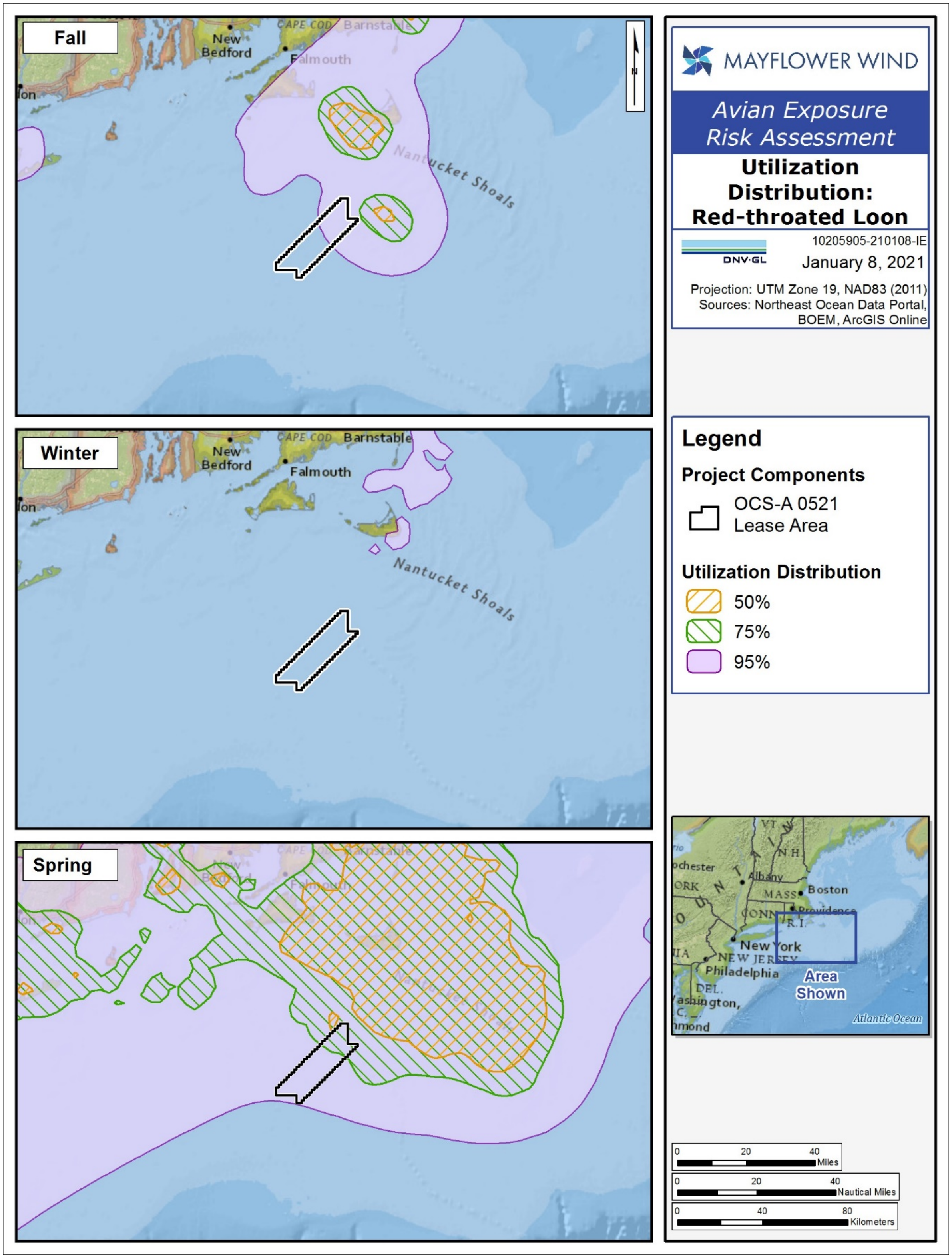

Figure 3-32 Red-throated loon utilization distribution

Based on GPS tracking data (Speigel et. Al 2017). Distribution contours represent 50% (core use area), 75% and 95% (regional use area) isopleths. See Section 2.2.4.2 for details.

Surf scoter

Predicted abundance of surf scoter is low in fall, winter, and spring relative to regional waters (Figure 3-33-Figure 3-35). Surf scoter was observed adjacent to but not within the Lease Area during the MCEC (Figure 3-33-Figure 3-35) and Aerial HD surveys (Figure 3-36). Utilization distribution models based on GPS tracking data did not indicate that surf scoter use areas occur in the Lease Area (Figure 3-37). No surf scoters were observed during Project G&G surveys.

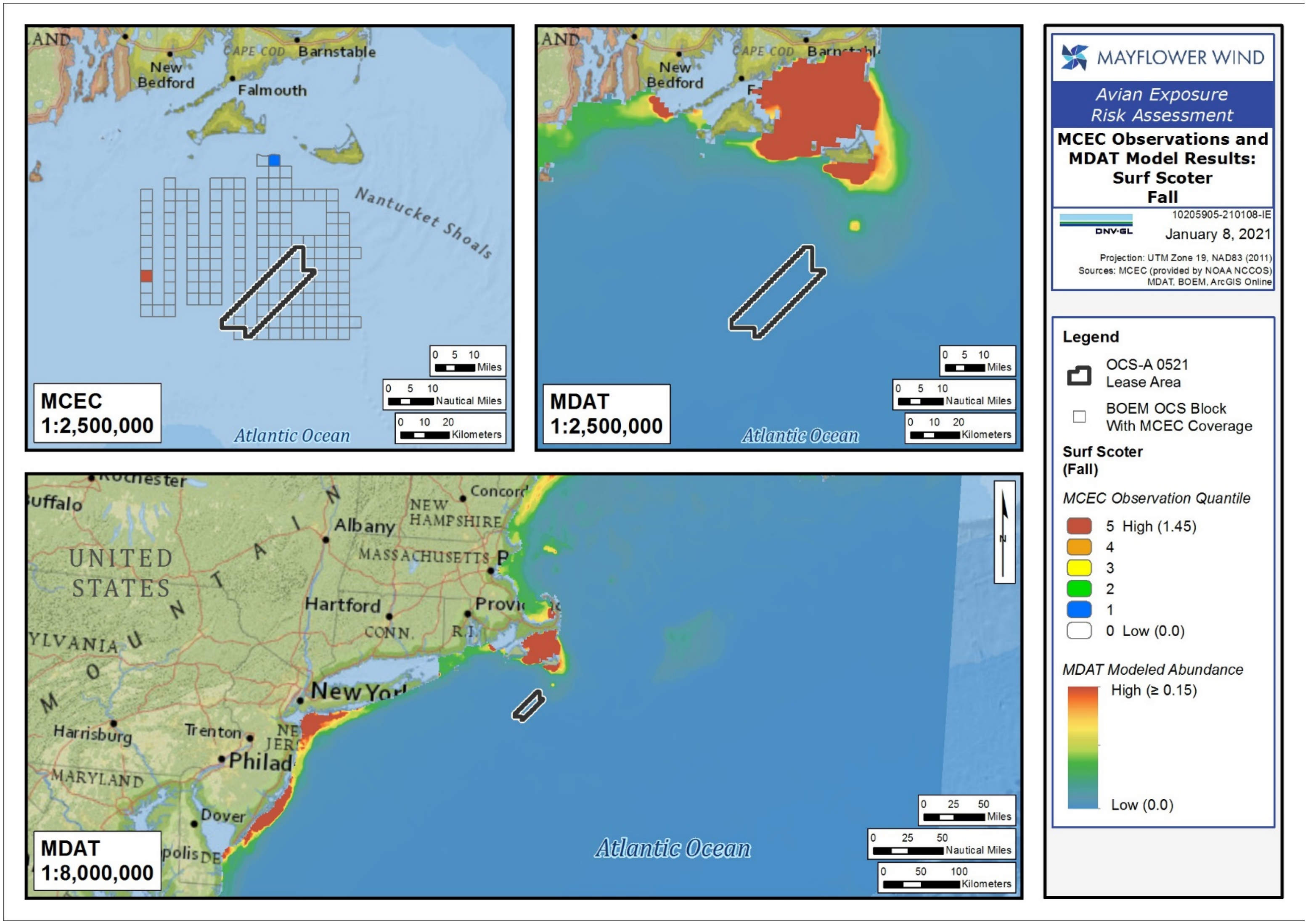

Figure 3-33 Fall surf scoter relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

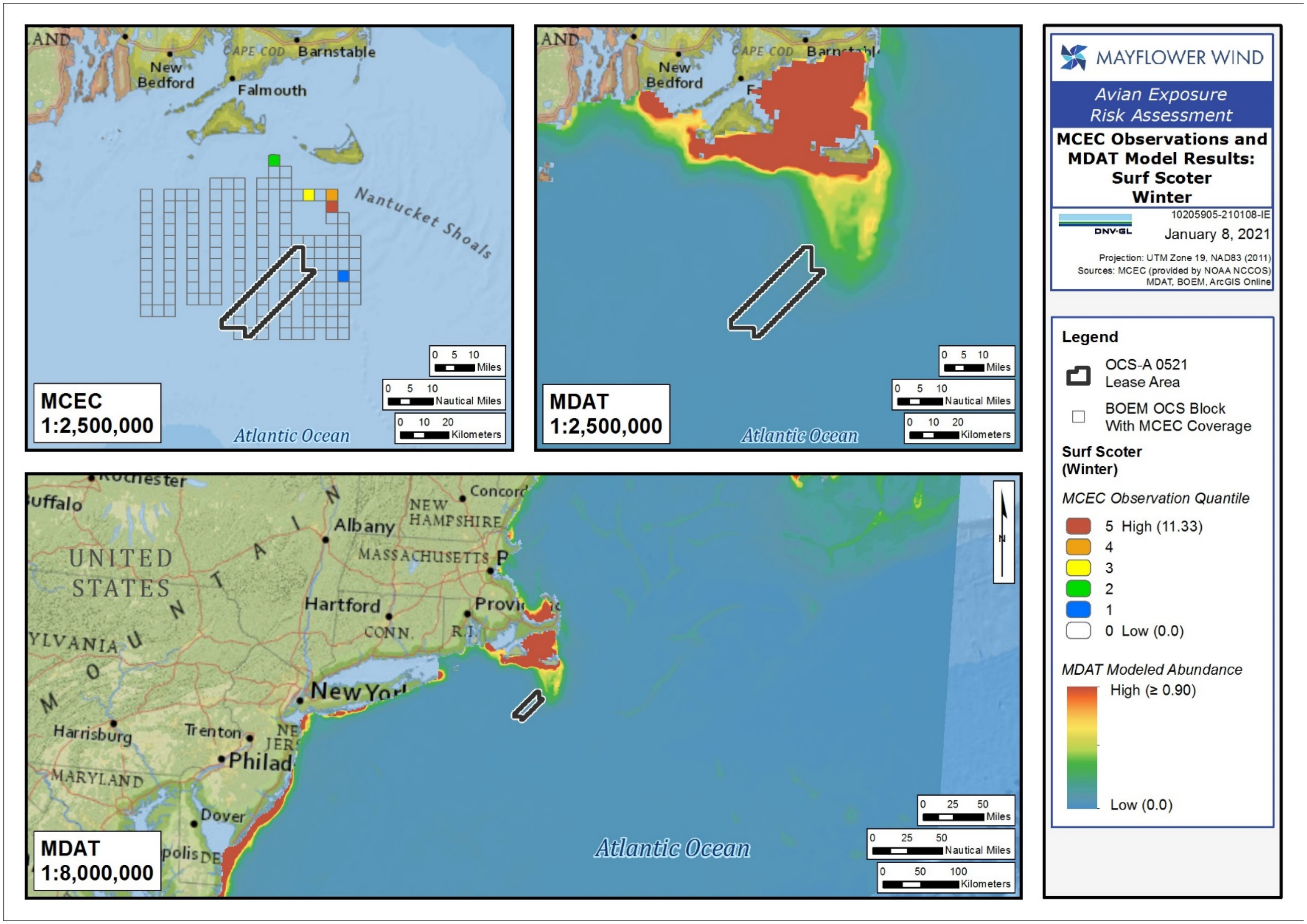

Figure 3-34 Winter surf scoter relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

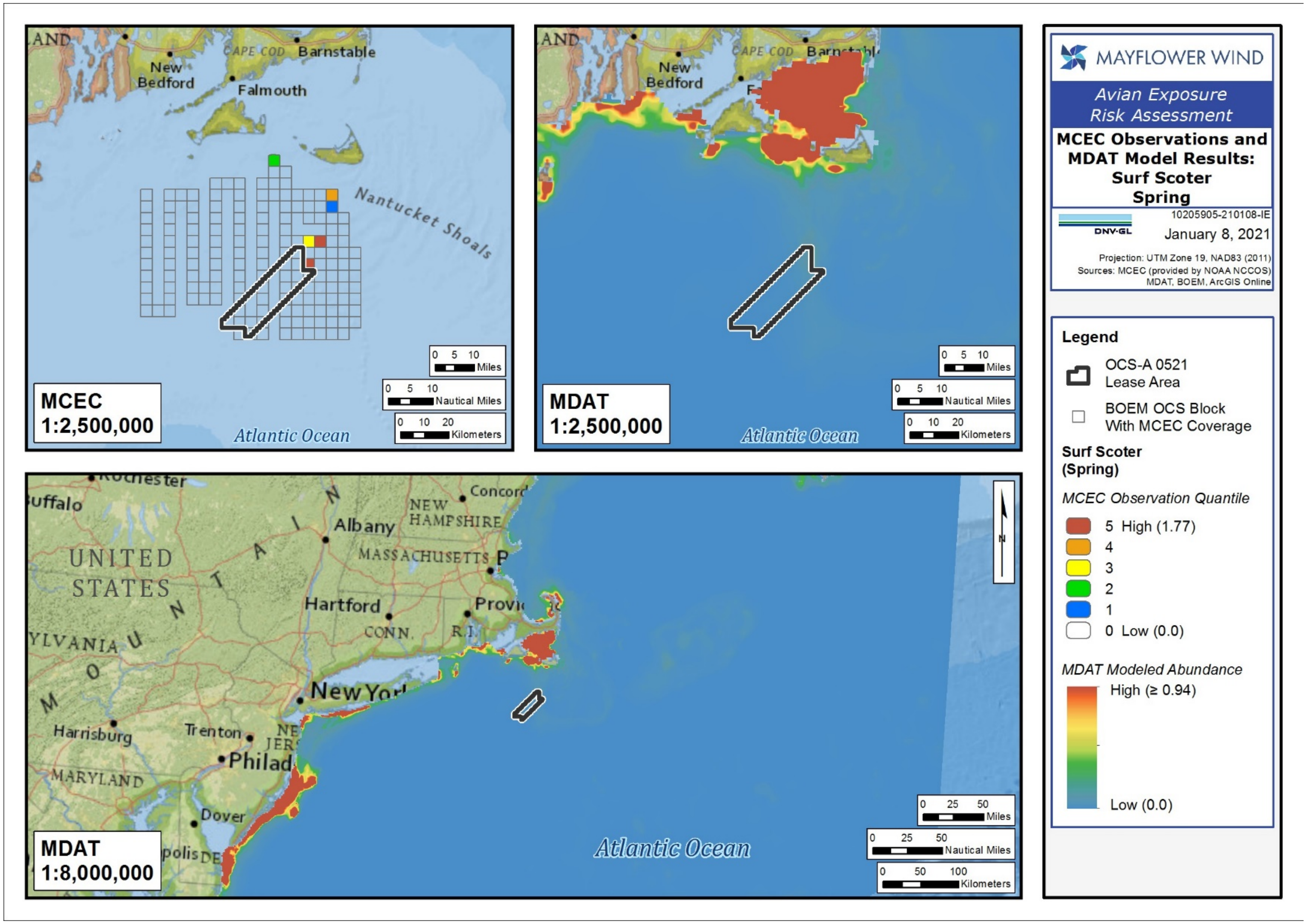

Figure 3-35 Spring surf scoter relative abundance

Predicted by the Marine-life Data and Analysis Team (MDAT V.2) spatial models (Winship et al. 2018) and density proportions observed during the local-scale Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). See text for details regarding MCEC and MDAT values depicted (Sections 2.2.1 - 2.2.2).

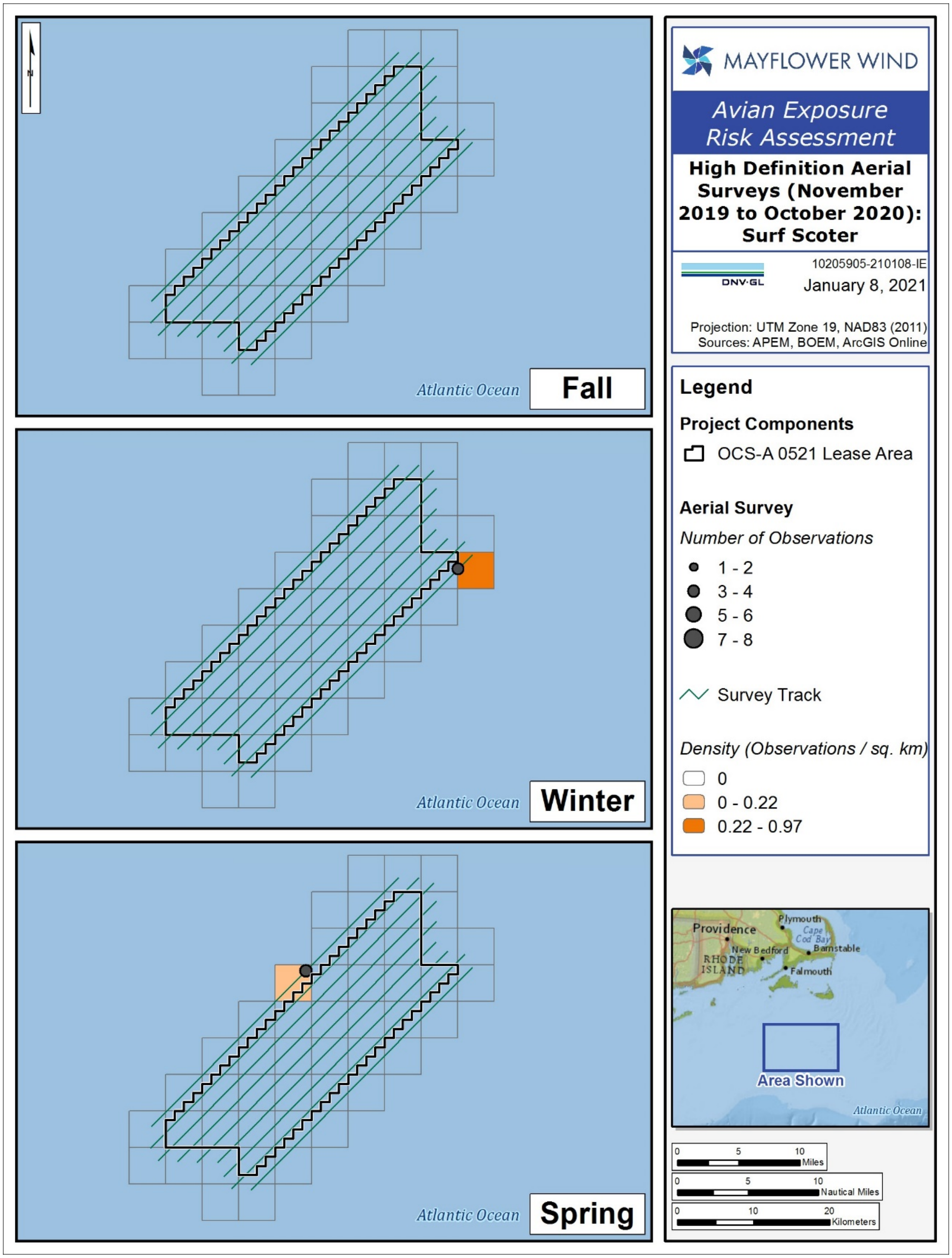

Figure 3-36 Raw observations and effort-adjusted seasonal density estimates for surf scoter

Note that survey effort differed among seasons (fall, n=3; spring, n=5; and summer, n=3); raw observations are presented to assess within-season spatial patterns only. Density estimates represent total individuals observed per survey per km^2 within each season.

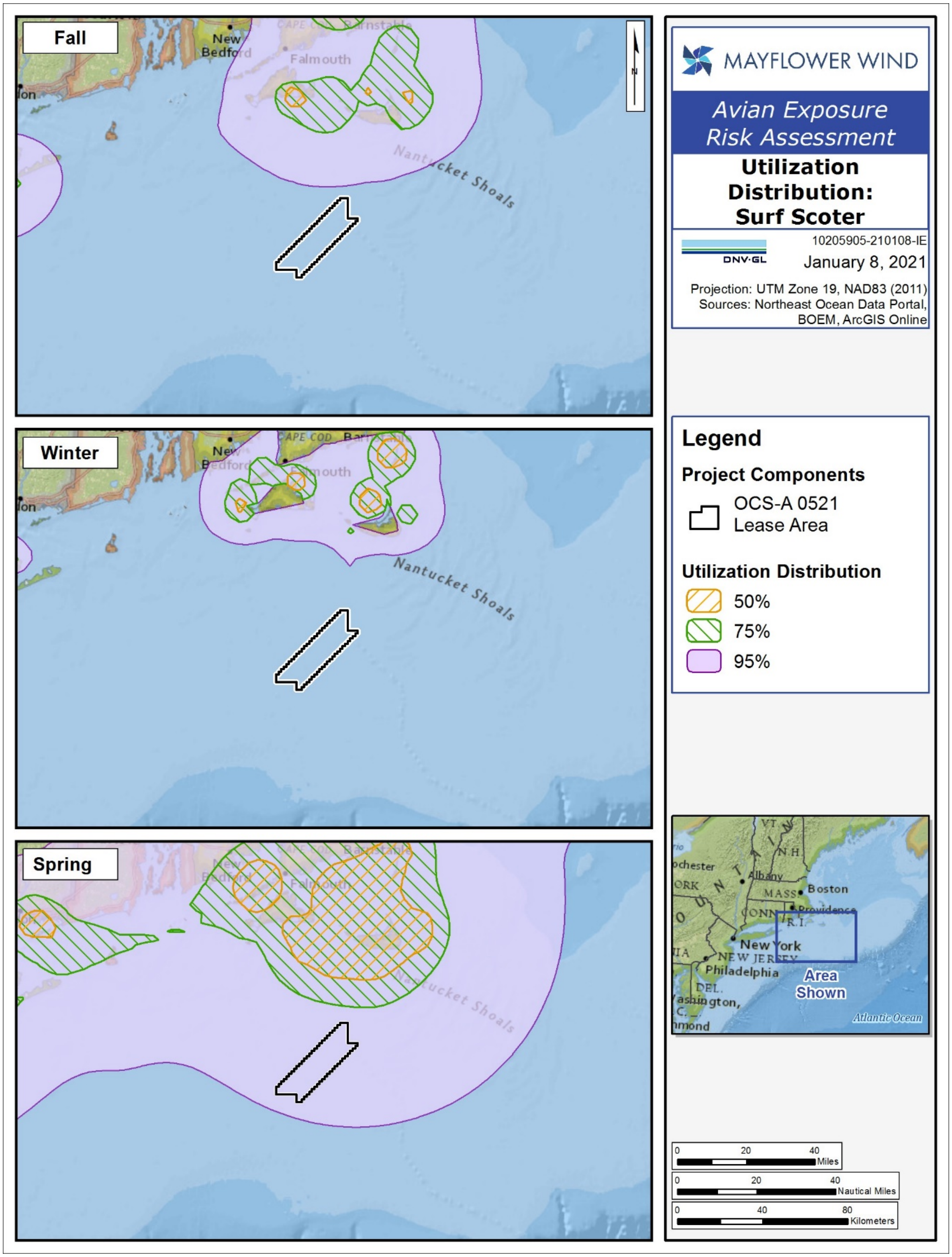

Figure 3-37 Surf scoter utilization distribution

Based on GPS tracking data (Speigel et. Al 2017). Distribution contours represent 50% (core use area), 75% and 95% (regional use area) isopleths. See Section 2.2.4.2 for details.

3.1.2 Collision-sensitive species

At the regional, annual scale, MDAT models indicate that the abundance of species sensitive to collision is likely to be low relative to other waters in the MDAT modeling space (Figure 3-38). The MCEC data indicated that in some areas of the southern portion of the Lease Area, mean densities of collision-sensitive species observed in fall were in the highest quantile recorded at the local scale (Figure 3-39); however, densities recorded in fall were generally low overall. In the northern portion of the Lease Area, densities observed were in the moderately-high range (4^{th} quantile) but lower than adjacent waters to the north and east. Combined densities were generally low relative to local waters in spring and summer. Collision-sensitive species observed in the Lease Area during the 2019-2020 Aerial HD surveys consisted primarily of white-winged scoter, long-tailed duck, Atlantic puffin, Cory's shearwater, and red-throated loon (see Attachment C). Activity of collision-sensitive species observed during the Aerial HD surveys also tended to be clustered at the northern edge of the Lease Area, particularly during winter and spring (see Section 3.1.5). Overall exposure patterns appear to be driven by the moderate to high relative exposure rates (to local and/or regional waters) that may be expected for razorbill, northern gannet, and some gull and seaduck species during some seasons (see Section 3.2).

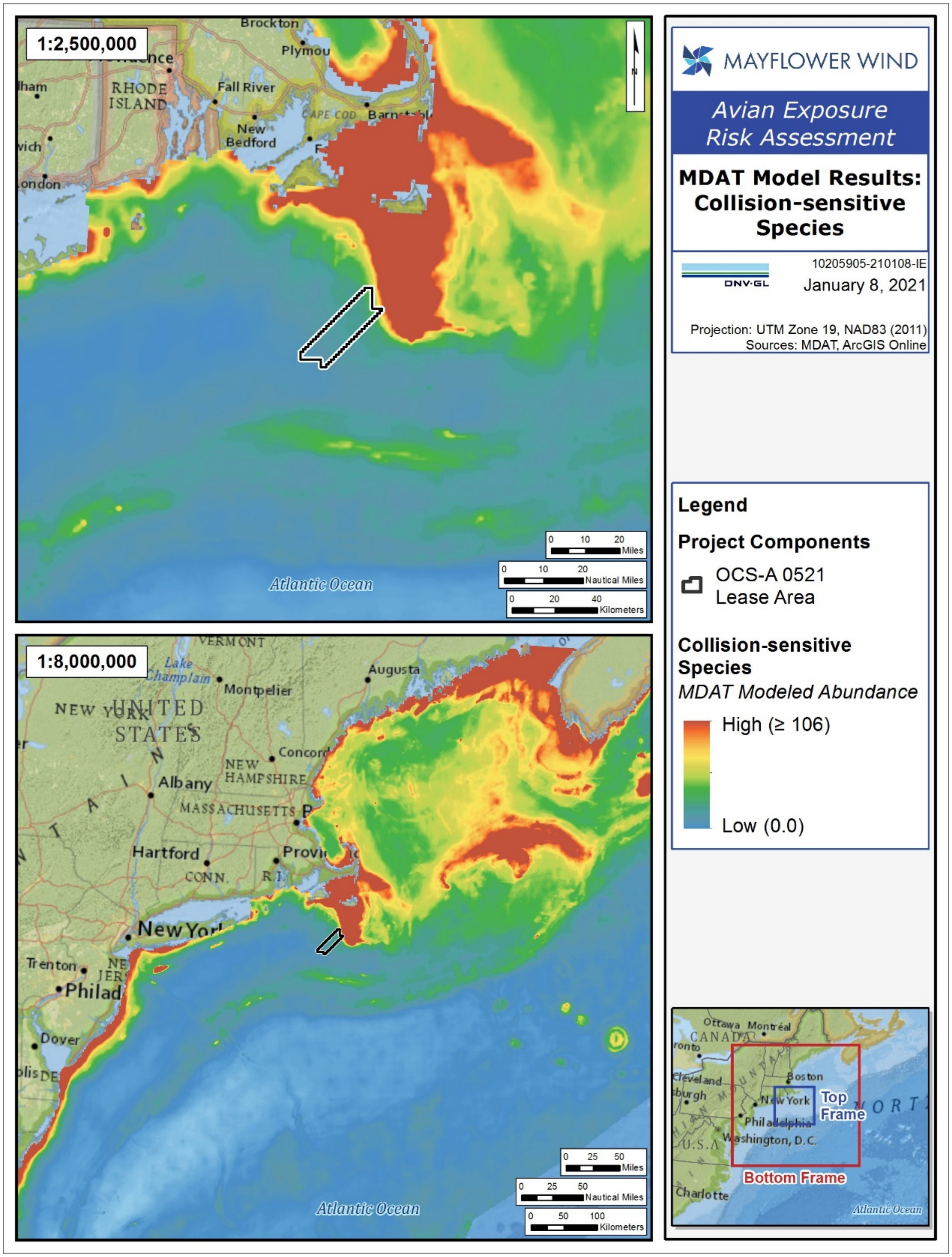

Figure 3-38 Relative abundance of collision-sensitive species

Modeled by the Marine-life Data and Analysis Team (MDAT V.2; Curtice et al. 2019). See text for cell value details (Section 2.2.1).

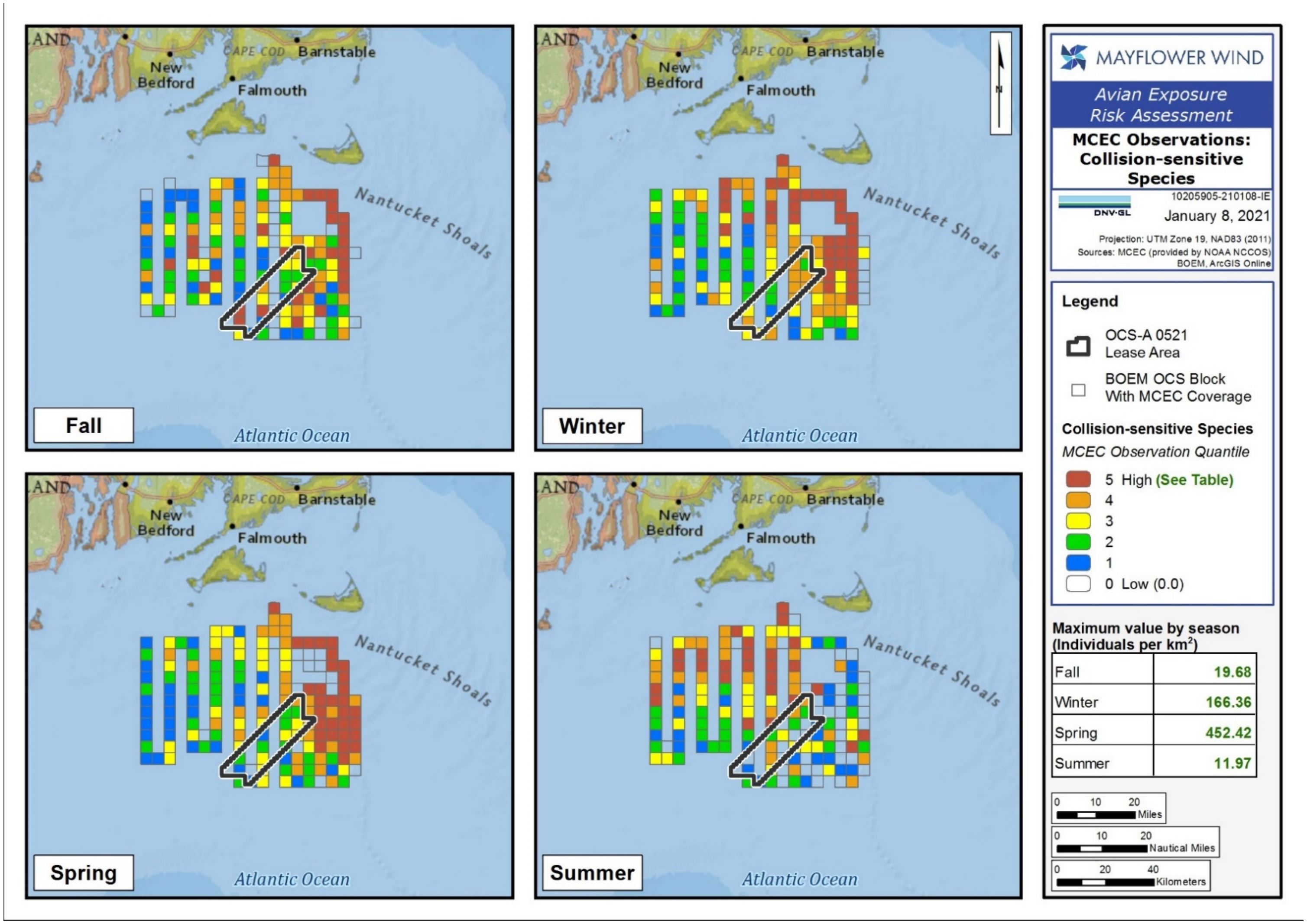

Figure 3-39 Density proportions of collision-sensitive species

Observed during Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). Table values represent effort-adjusted means (summed across species). See text for details regarding species represented and quantile assignment (Section 2.2.2).

3.1.3 Displacement-sensitive species

The MDAT models predict that the abundance of species sensitive to displacement is likely to be low overall relative to other waters in the MDAT modeling space (Figure 3-40). The MCEC data indicated mean densities of displacement-sensitive species were generally low in all seasons, with a small pocket of moderately-high activity (4th quantile) in the northern portion of the Lease Area during winter (Figure 3-41). The 2019-2020 Aerial HD surveys also indicated that activity was clustered at the northern edge of the Lease Area during winter and spring, with activity primarily represented by observations of white-winged scoter, long-tailed duck, Atlantic puffin, red-throated loon, and razorbill (see Section 3.1.5 and Attachment C). Overall patterns appear to be driven by the moderate to high relative exposure rates (to local and/or regional waters) that may be expected for razorbill, northern gannet, and some seaduck species during some seasons (see Section 3.2).

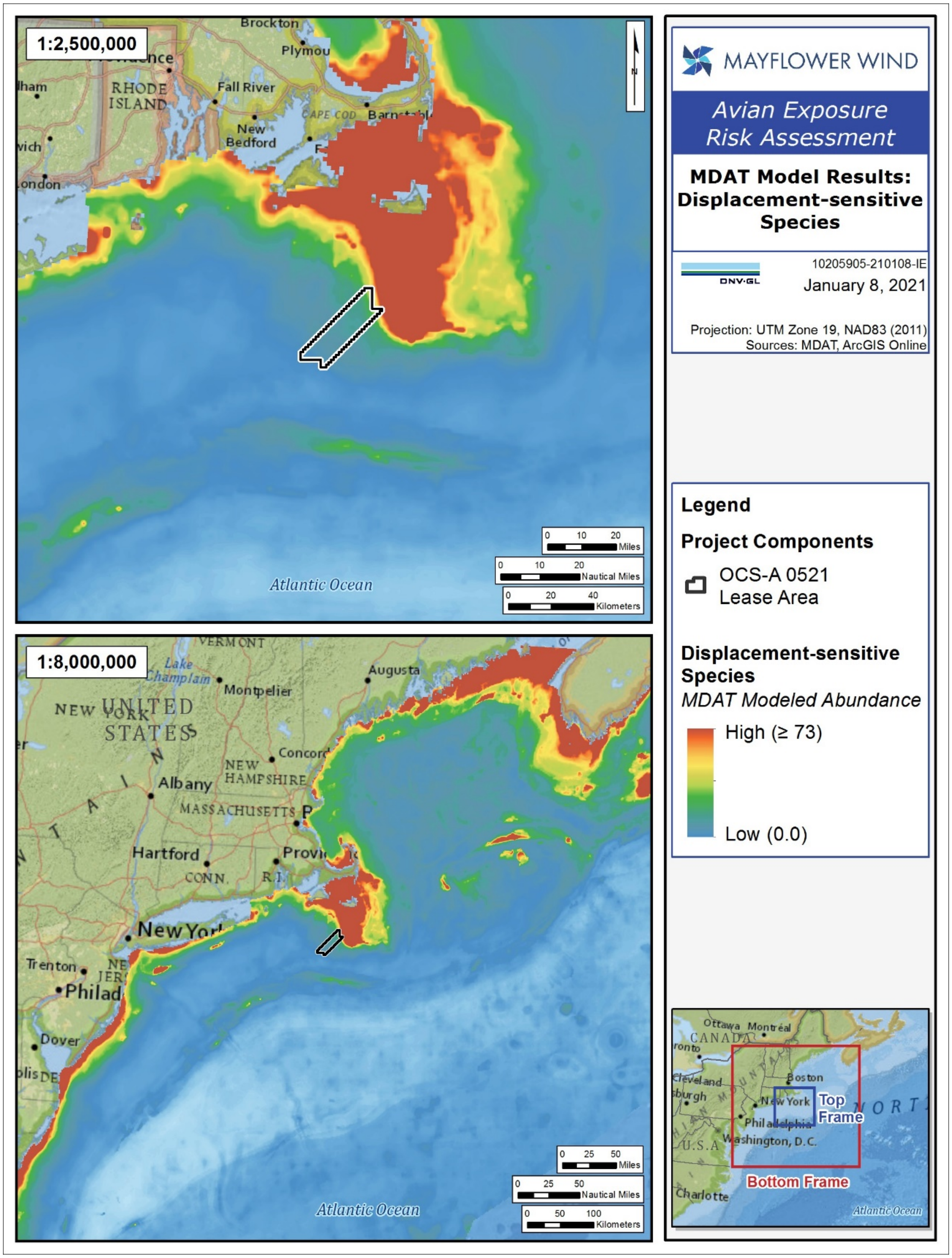

Figure 3-40 Relative abundance of displacement-sensitive species

Modeled by the Marine-life Data and Analysis Team (MDAT V.2; Curtice et al. 2019). See text for cell value details (Section 2.2.1).

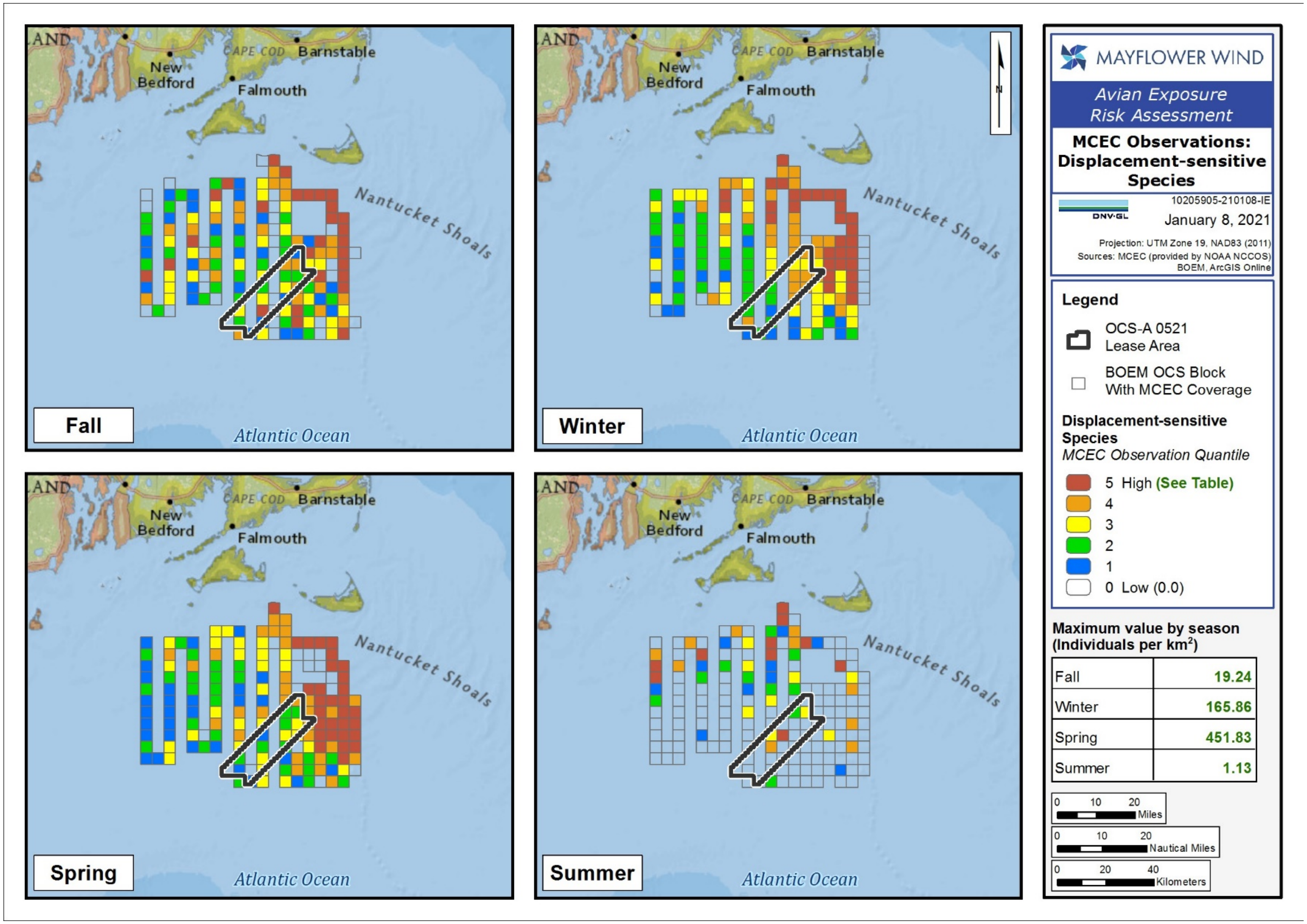

Figure 3-41 Density proportions of species sensitive to displacement

Observed during Massachusetts Clean Energy Center (MCEC) surveys (Viet et al. 2016). Table values represent effort-adjusted means (summed across species). See text for details regarding species represented and quantile assignment (Section 2.2.2).

3.1.4 *Ammodytes* (Sand Lance)

No *Ammodytes* were captured in the Lease Area or vicinity during fall and summer trawl surveys or ichthyoplankton surveys (Figure 3-42). Capture rates were higher in the region during spring surveys but were very low in the Lease Area relative to adjacent waters.

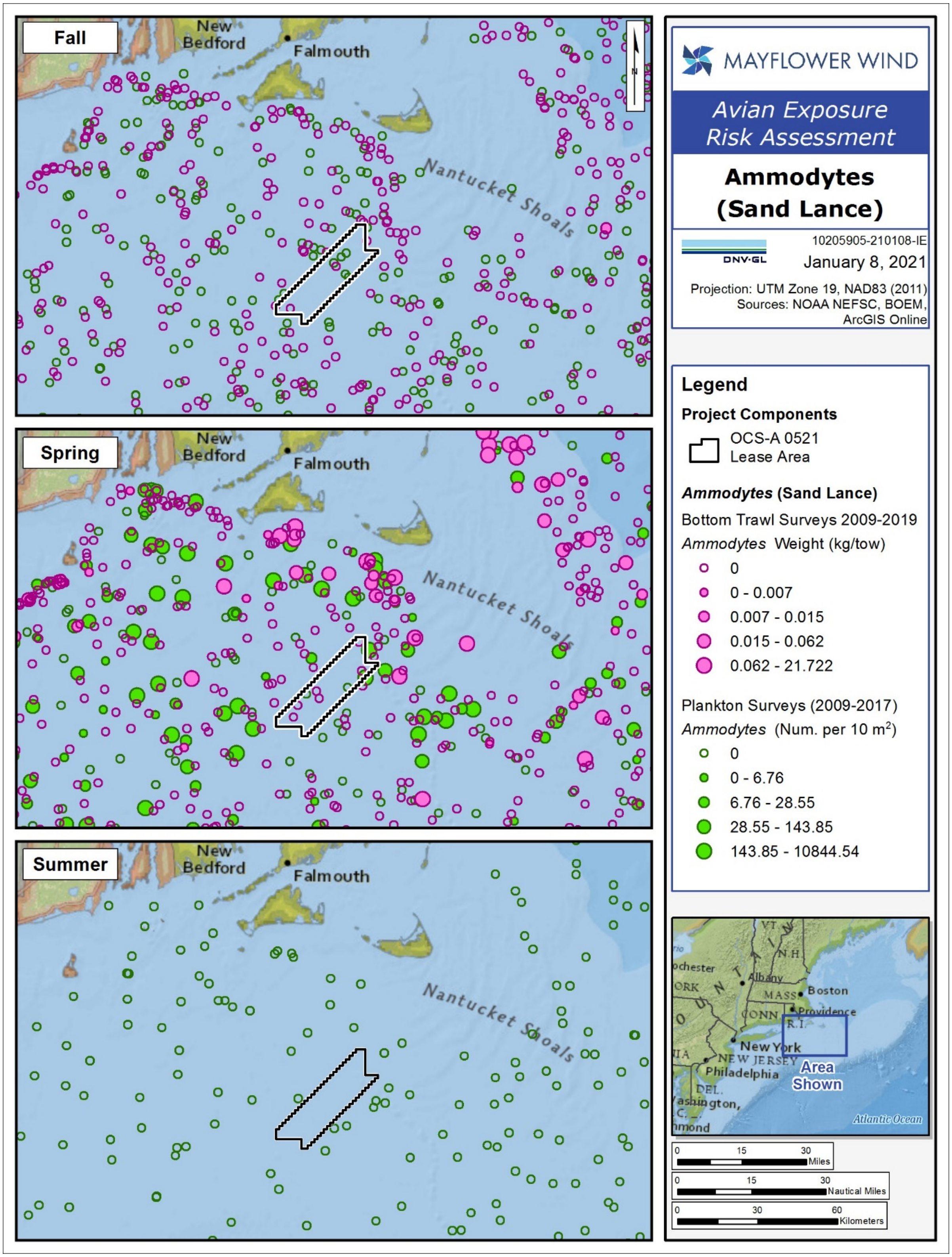

Figure 3-42 *Ammodytes* observations

Recorded during long-term bottom trawl (NEFSC 2020a) and ichthyoplankton (NEFSC 2020b) surveys. See text for methodology details (Section 2.2.4.3).

3.1.5 Taxonomic Groups Observed in the Lease Area, 2019-2020

Avian species observed during the Aerial HD surveys are displayed in Figure 3-43 - Figure 3-50. Species are grouped by taxonomic groupings as follows: alcids (auks); shearwaters, fulmars, and storm-petrels; sea ducks; loons; gannets and cormorants; gulls, skuas and jaegers; terns; and phalaropes. Mean densities of all species observed during the surveys are provided in Attachment C.

3.1.5.1 Alcids

Alcid species observed during the Aerial HD surveys included Atlantic puffin, black guillemot, dovekie, and razorbill. Density estimates depicted in Figure 3-43 also include observations that were not identifiable to species: "unknown murre" (i.e., common or thick-billed), "murre/razorbill", and "unknown auk species."

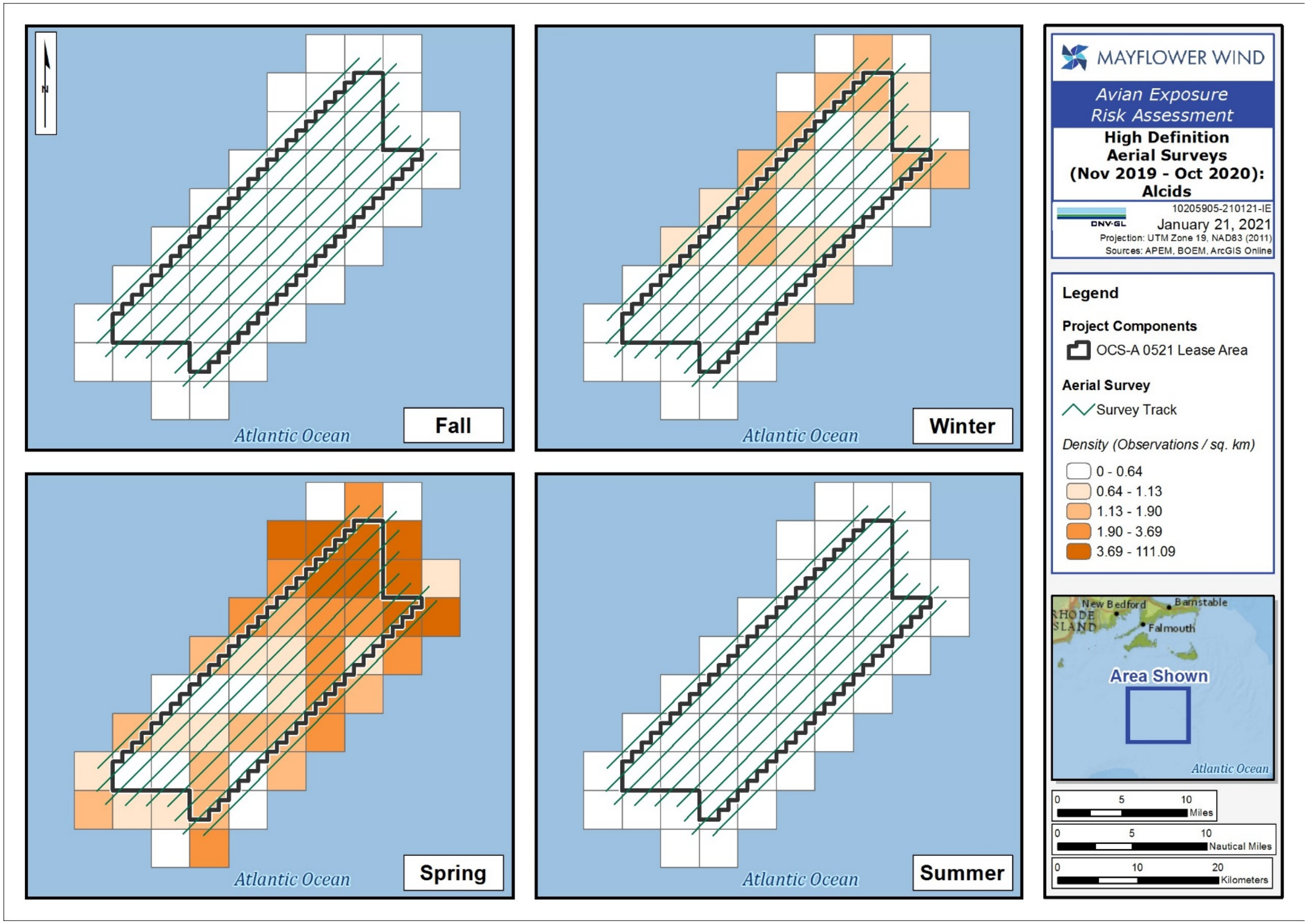

Figure 3-43 Density distribution of all alcid species

Observed in the Lease Area during high-definition aerial surveys (Aerial HD). See text for species list. Density estimates represent total individuals observed per survey per km^2 within each season.

3.1.5.2 Shearwaters, storm-petrels and fulmars

Shearwater, storm-petrel and fulmar species observed during the Aerial HD surveys included Cory's shearwater, greater shearwater, sooty shearwater, and northern fulmar. Density estimates depicted in Figure 3-44 also include observations that were not identifiable to species including "unknown storm-petrel" and "unknown shearwater."

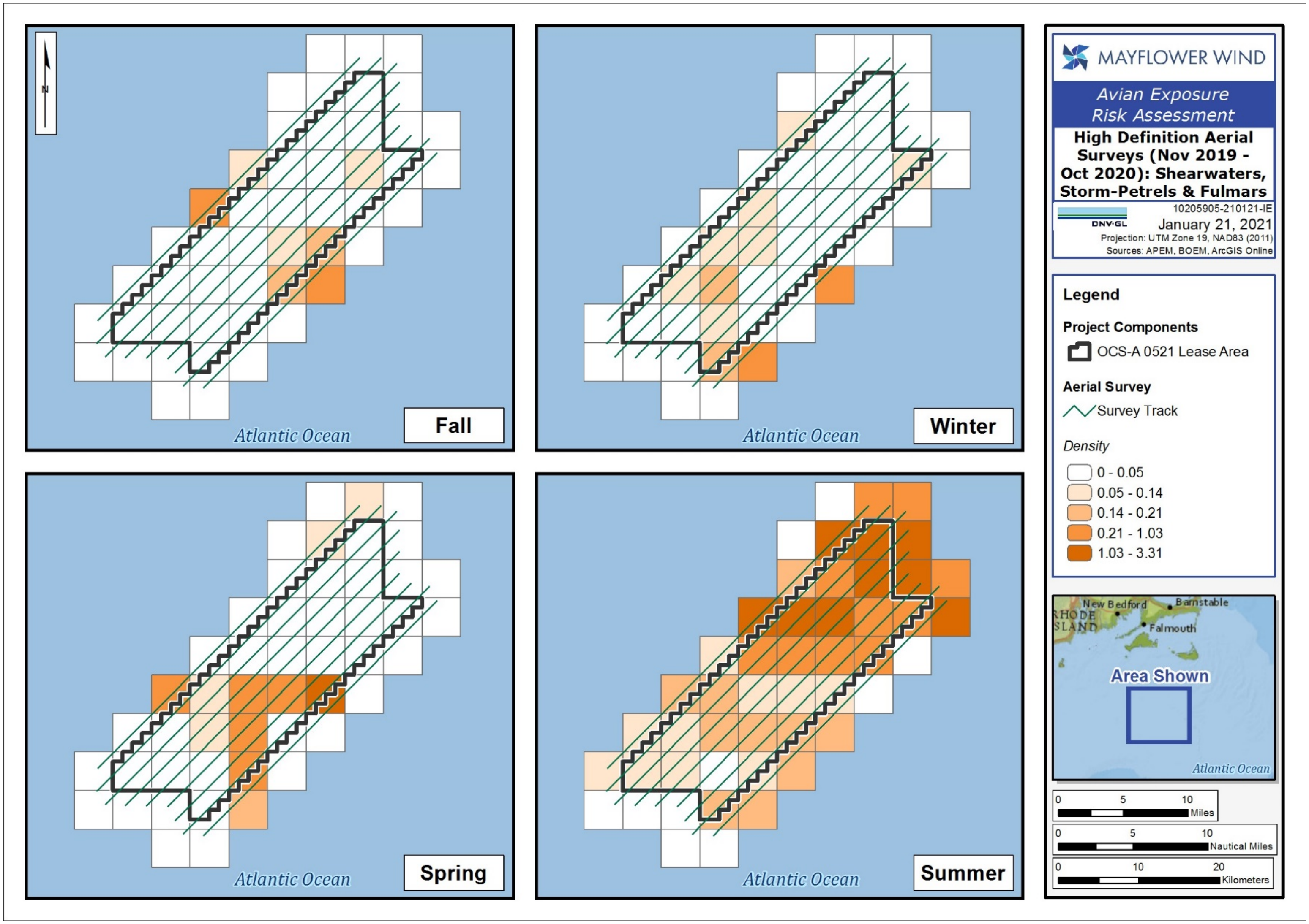

Figure 3-44 Density distribution of all shearwater, storm-petrel and fulmar species

Observed during high-definition aerial surveys (Aerial HD). See text for species list. Density estimates represent total individuals observed per survey per km^2 within each season.

3.1.5.3 Sea ducks

Sea duck species observed during the Aerial HD surveys included black scoter, common eider, long-tailed duck, surf scoter and white-winged scoter. Density estimates depicted in Figure 3-45 also include observations that were not identifiable to species including "unknown scoter" and "unknown duck."

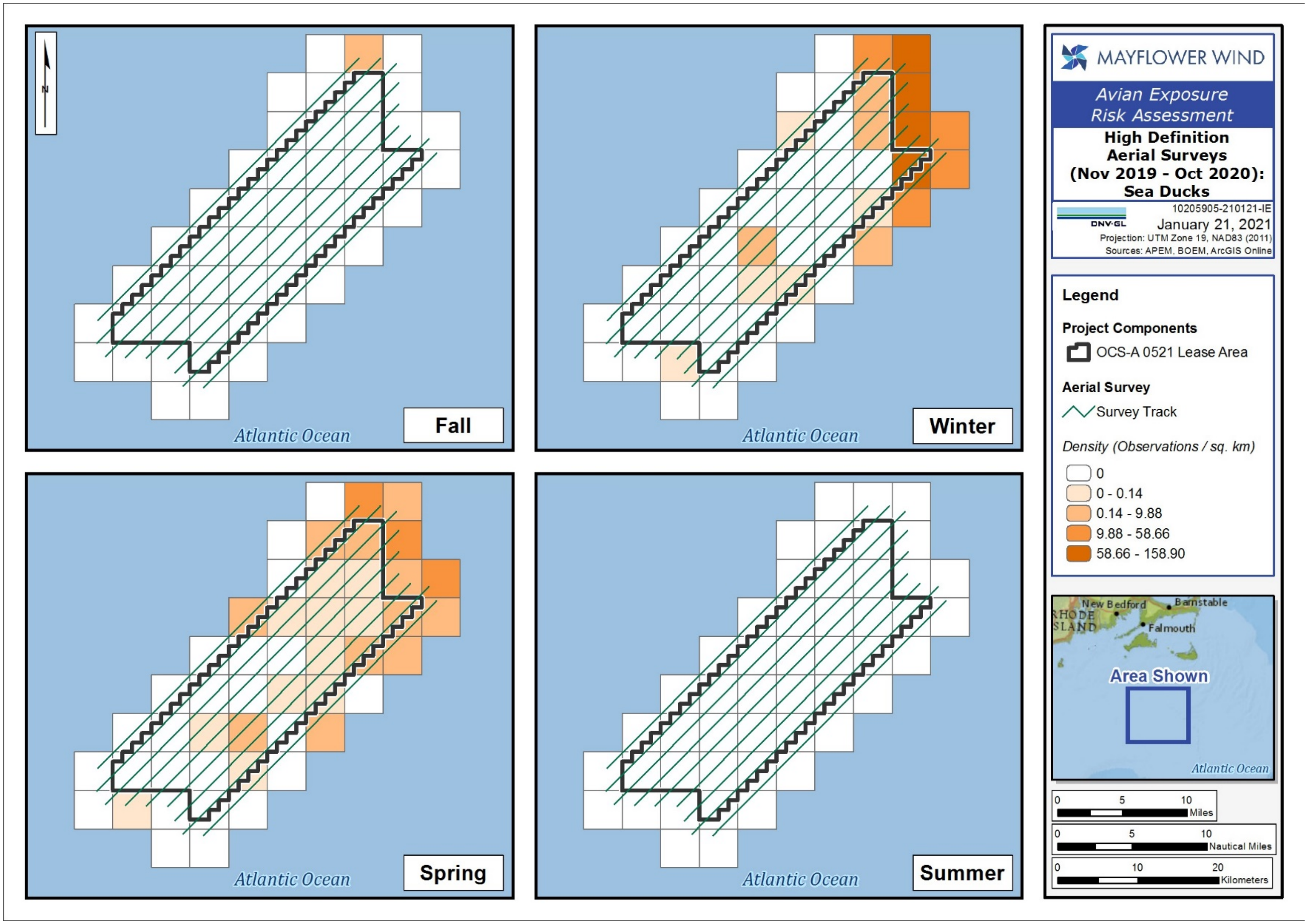

Figure 3-45 Density distribution of all sea duck species

Observed during high-definition aerial surveys (Aerial HD). See text for species list. Density estimates represent total individuals observed per survey per km^2 within each season.

3.1.5.4 Loons

Loon species observed during the Aerial HD surveys included common loon and red-throated loon. Density estimates depicted in Figure 3-46 also include “unknown loon” observations that were not identifiable to species.

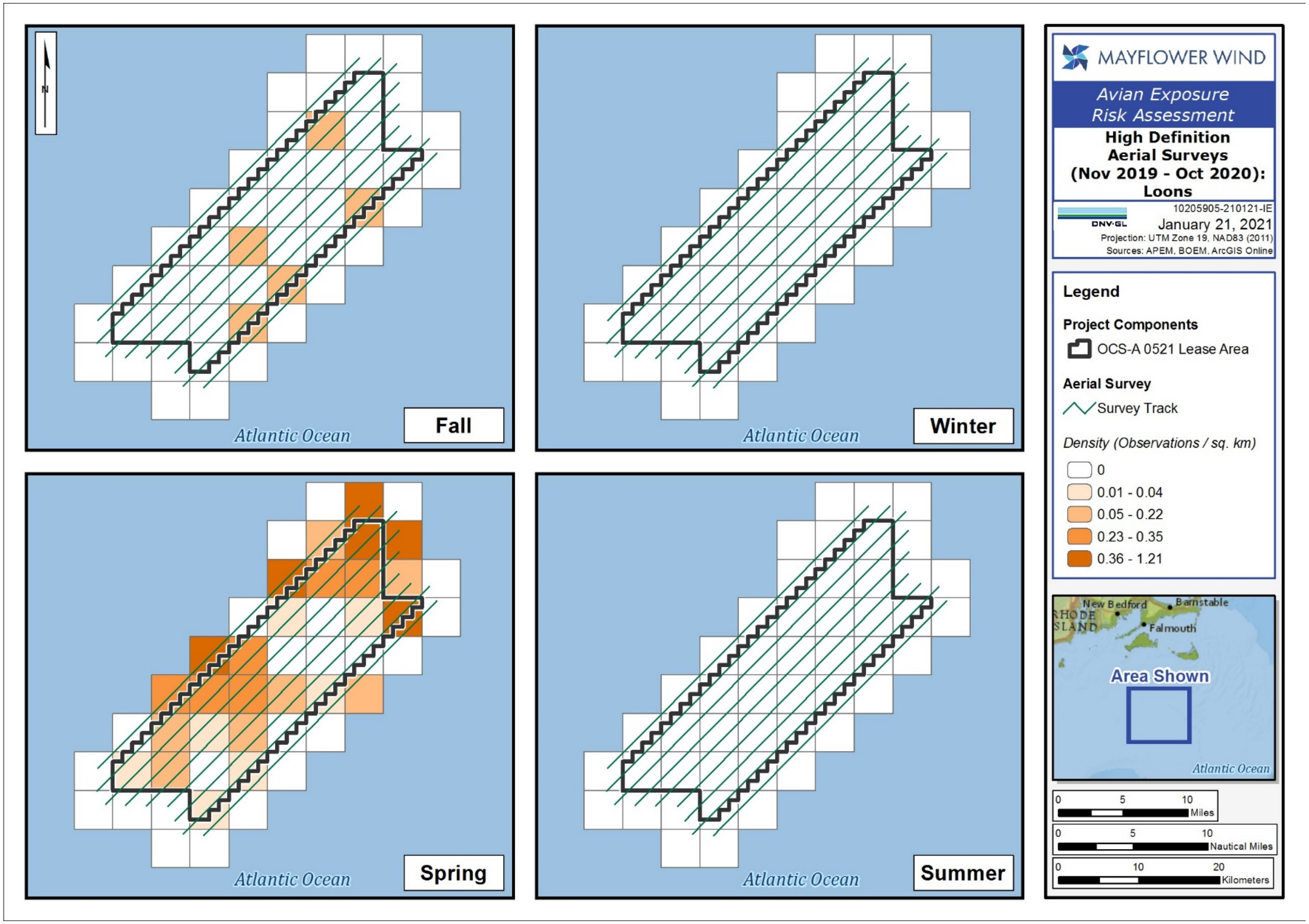

Figure 3-46 Density distribution of all loon species

Observed during high-definition aerial surveys (Aerial HD). See text for species list. Density estimates represent total individuals observed per survey per km^2 within each season.

3.1.5.5 Gannets and Cormorants

Gannet and cormorant species observed during the Aerial HD surveys included northern gannet. Density estimates depicted in Figure 3-47 also include "unknown cormorant" observations that were not identifiable to species.

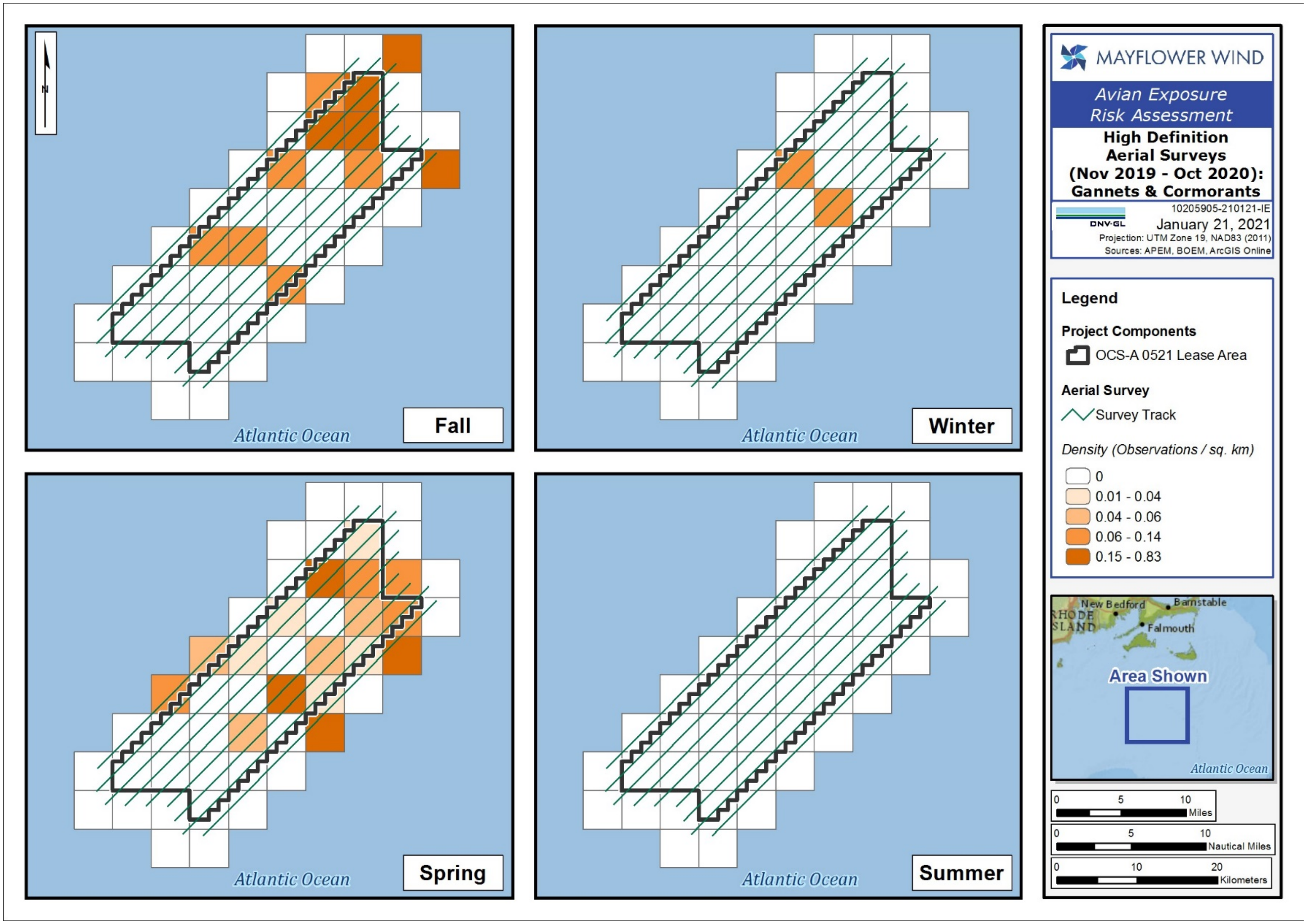

Figure 3-47 Density distribution of all gannet and cormorant species

Observed during high-definition aerial surveys (Aerial HD). See text for species list. Density estimates represent total individuals observed per survey per km^2 within each season.

3.1.5.6 Gulls, Skuas and Jaegers

Gull, skua and jaeger species observed during the Aerial HD surveys included black-legged kittiwake, Bonaparte’s gull, great black-backed gull, herring gull, lesser black-backed gull, parasitic jaeger, and pomarine jaeger. Density estimates depicted in Figure 3-48 also include observations that were not identifiable to species including “unknown gull” and “unknown skua.”

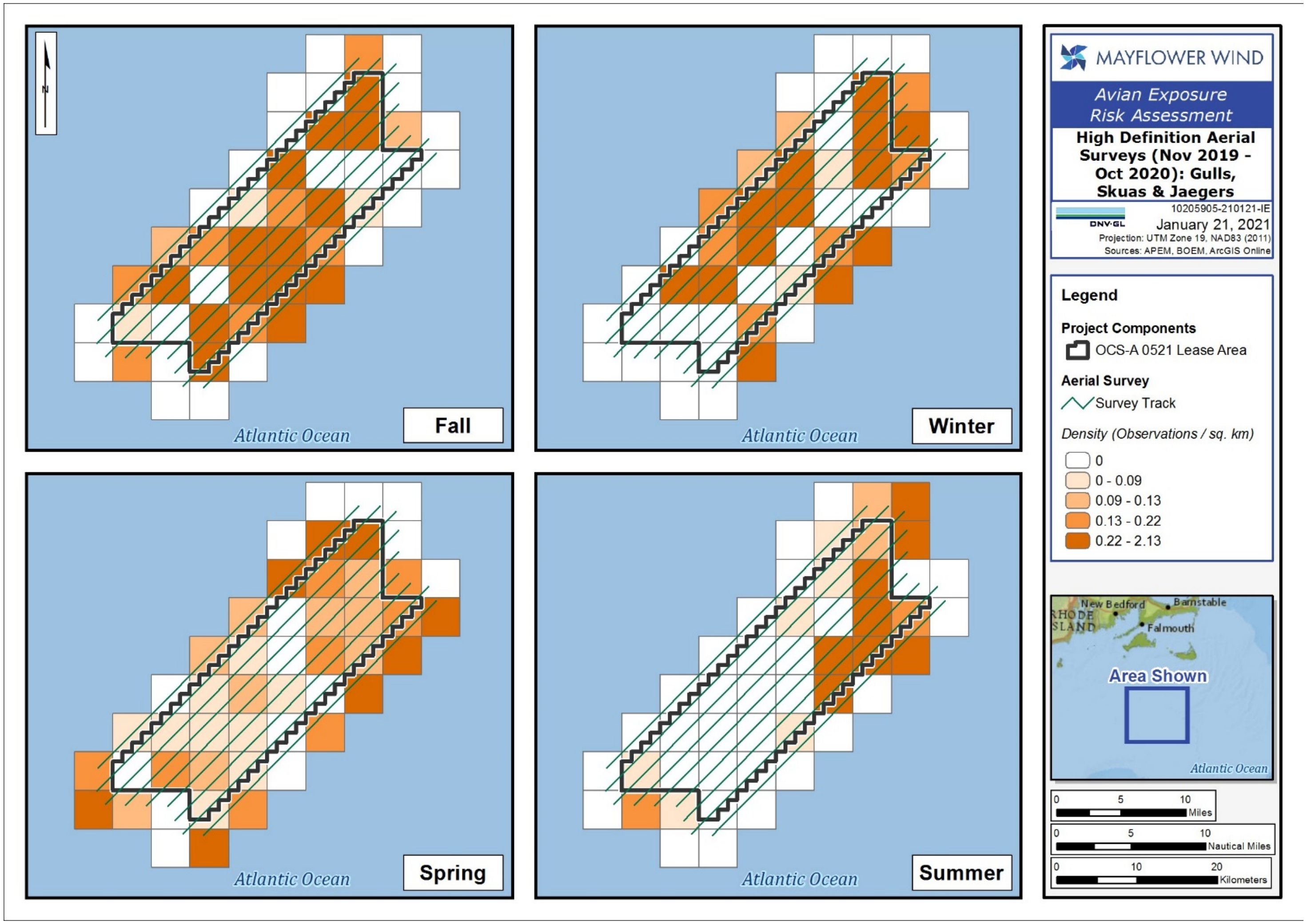

Figure 3-48 Density distribution of all gull, skua and jaeger species

Observed during high-definition aerial surveys (Aerial HD). See Table 2-3 for species list. Density estimates represent total individuals observed per survey per km^2 within each season.

3.1.5.7 Terns

Tern species observed during the Aerial HD surveys included common tern and roseate tern. Density estimates depicted in Figure 3-49 also include observations that were not identifiable to species including "commic/Forster's tern" (i.e., Arctic, common, roseate or Forster's tern) and "unknown tern."

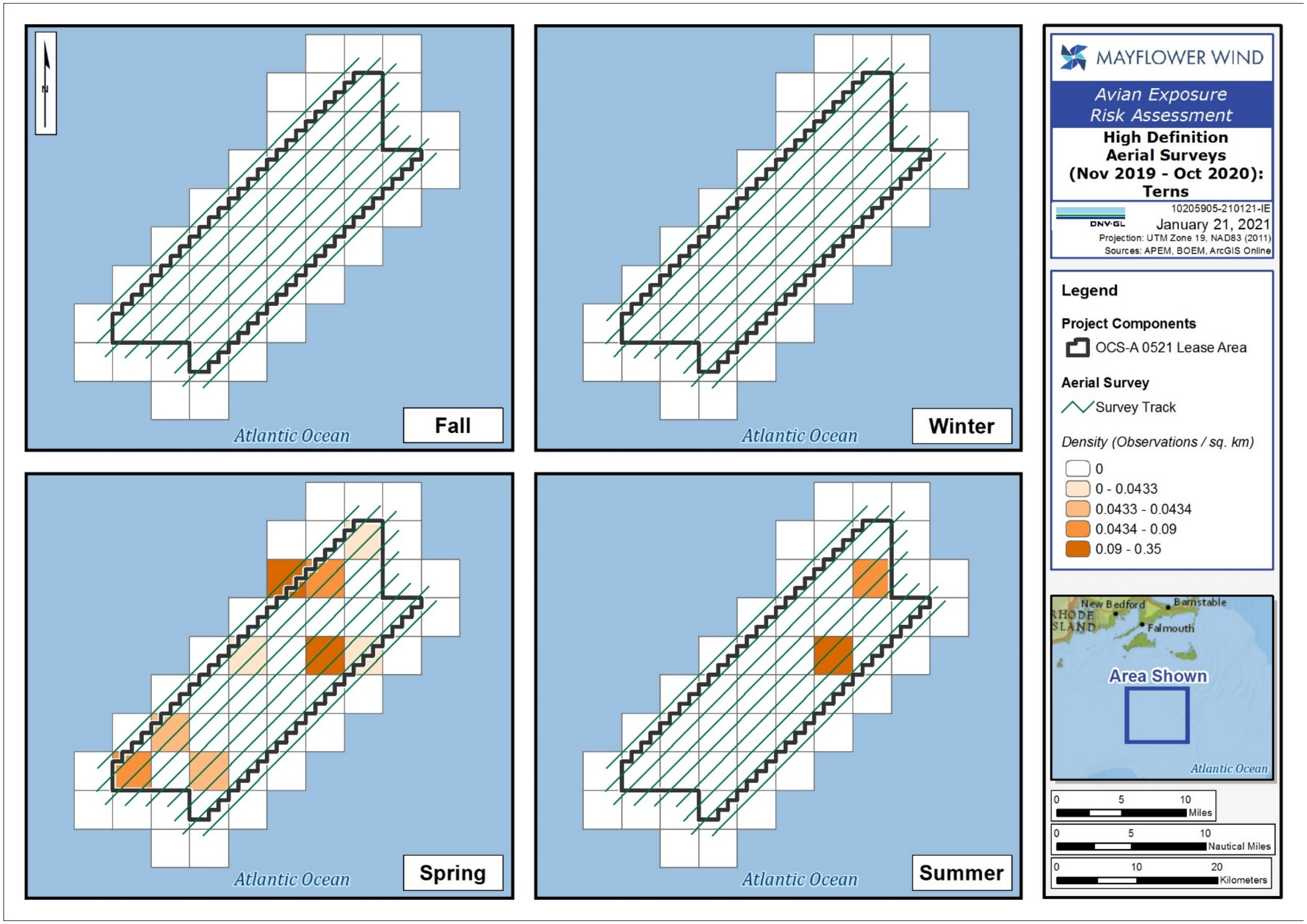

Figure 3-49 Density distribution of all tern species

Observed during high-definition aerial surveys (Aerial HD). See text for species list. Density estimates represent total individuals observed per survey per km^2 within each season.

3.1.5.8 Phalaropes

Phalarope species observed during the Aerial HD surveys included red phalarope and red-necked phalarope; all observations were identifiable to species and density estimates are depicted in Figure 3-50.

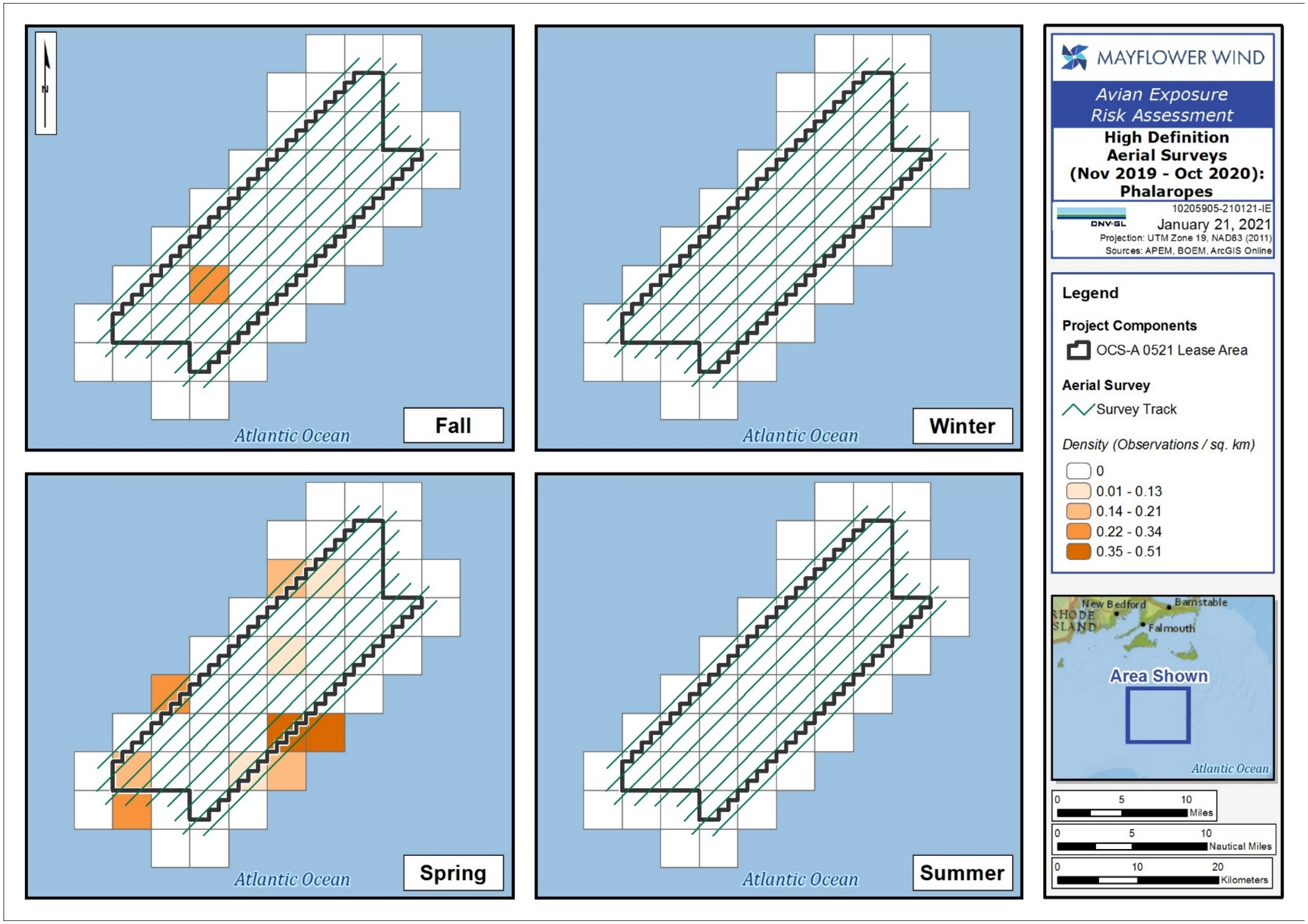

Figure 3-50 Density distribution of all phalarope species

Observed during high-definition aerial surveys (Aerial HD). See text for species list. Density estimates represent total individuals observed per survey per km^2 within each season.

3.2 Exposure Assessment

Seasonal exposure scores for all species occurring in the MDAT, MCEC, and/or Aerial HD data sets are summarized in Attachment B. Annual exposure scores for each species group are presented in Table 3-1, and number of species within each seasonal exposure category for each taxonomic group are summarized in Table 3-2. Information used for assigning Aerial HD scores is depicted in Table 3-3.

Table 3-1 Annual Exposure Scores for all Species

Based on MCEC and MDAT (modeled) Data. See Section 2.3.2 for scoring framework.

Taxonomic Group	Average Annual Exposure Score for the Taxonomic Group	Species	Annual Species Exposure Score	Annual Species Exposure Category[a]
Alcids	1.00	Atlantic puffin	1	Low
		Black guillemot	0	Insignificant
		Common murre	1	Low
		Dovekie	1	Low
		Razorbill	3	High
		Thick-billed murre	0	Insignificant
Gannets and Cormorants	2.00	Double-crested cormorant	1	Low
		Northern gannet	3	High
Gulls, Skuas, and Jaegers	1.20	Black-legged kittiwake	2	Moderate
		Bonaparte's gull	1	Low
		Great black-backed gull	2	Moderate
		Great skua	0	Insignificant
		Herring gull	3	High
		Laughing gull	2	Moderate
		Parasitic jaeger	0	Insignificant
		Pomarine jaeger	0	Insignificant
		Ring-billed gull	2	Moderate
		South polar skua	0	Insignificant
Loons and Grebes	1.33	Common loon	2	Moderate
		Horned grebe	0	Insignificant
		Red-throated loon	2	Moderate
Pelicans	1.00	Brown pelican	1	Low
Seaducks	1.57	Black scoter	2	Moderate
		Brant	0	Insignificant
		Common eider	2	Moderate
		Long-tailed duck	2	Moderate
		Red-breasted merganser	1	Low
		Surf scoter	2	Moderate

Taxonomic Group	Average Annual Exposure Score for the Taxonomic Group	Species	Annual Species Exposure Score	Annual Species Exposure Category[a]
		White-winged scoter	2	Moderate
Shearwaters, Petrels, and Storm-Petrels	1.00	Audubon's shearwater	0	Insignificant
		Band-rumped storm-petrel	0	Insignificant
		Black-capped petrel	1	Low
		Cory's shearwater	2	Moderate
		Great shearwater	1	Low
		Leach's storm-petrel	0	Insignificant
		Manx shearwater	1	Low
		Northern fulmar	3	High
		Sooty shearwater	1	Low
		Wilson's storm-petrel	1	Low
Shorebirds	0.00	Red phalarope	0	Insignificant
		Red-necked phalarope	0	Insignificant
Terns	0.43	Arctic tern	0	Insignificant
		Bridled tern	0	Insignificant
		Common tern	2	Moderate
		Least tern	0	Insignificant
		Roseate tern	1	Low
		Royal tern	0	Insignificant
		Sooty tern	0	Insignificant

[a] Based on MDAT and MCEC scores. See text for details.

Table 3-2 Number of Species in each Exposure Category by Taxonomic Group[a]

Taxonomic Group	Season	Exposure Category				
		Insignificant	*Very Low*	*Low*	*Moderate*	*High*
Alcids	Spring	1	0	1	0	3
	Summer	1	0	4	0	0
	Fall	3	0	0	0	1
	Winter	1	2	0	1	1
Gannets and Cormorants	Spring	0	0	1	1	0
	Summer	0	0	1	0	1
	Fall	0	0	1	0	1
	Winter	1	0	0	1	0
Gulls, Skuas, and Jaegers	Spring	2	2	1	2	1
	Summer	2	2	1	4	0
	Fall	3	0	3	4	0
	Winter	1	2	2	2	0
Loons and Grebes	Spring	0	0	0	2	0
	Summer	1	0	0	1	0
	Fall	0	0	2	0	0
	Winter	1	0	0	2	0
Pelicans	Spring	0	1	0	0	0
	Summer	0	0	1	0	0
	Fall	0	0	1	0	0
	Winter	0	1	0	0	0
Seaducks	Spring	1	1	0	4	1
	Summer	6	0	1	0	0
	Fall	2	0	5	0	0
	Winter	1	0	0	4	2
Shearwaters, Petrels, and Storm-Petrels	Spring	3	3	1	0	2
	Summer	2	2	4	2	0
	Fall	2	1	3	1	2
	Winter	5	2	0	1	0
Shorebirds	Spring	1	1	0	0	0
	Summer	0	1	1	0	0
	Fall	2	0	0	0	0
	Winter	1	0	0	0	0
Terns	Spring	1	0	2	0	1
	Summer	0	3	3	1	0
	Fall	0	3	2	0	0
	Winter	2	0	0	0	0

[a] Seasonal Categories based on MDAT, MCEC and Aerial HD scores (Table 3-1).

Table 3-3 Maximum one-day counts in the Lease Area

Relative to regional and continental population estimates

Species	Lease Area Estimates								Regional, National and Hemispheric Estimates (see Section 2.3.2 for scale details)						SCORE[e]
	Lease Area (Aerial HD)[a]				Lease Area Adjusted (Aerial HD)[b]				NAPA (MDAT)[c]				Kushlan et al.	Nisbet et al.[d]	
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter			
Alcids															
Atlantic puffin	247	0	2	49	815	0	7	162	3,586	1,621	486	3,986	750,000-760,000	1,000-10,000	3
Black guillemot	0	0	0	3	0	0	0	10	-	226	-	-	100,000-200,000	10,000-100,000	0
Common murre	0	0	0	0	0	0	0	0	757	-	-	1,515	4,250,000**	100-1,000 (B), 1,000-10,000 (NB)	0
Dovekie	36	0	0	10	119	0	0	33	7,798	41	6,906	116,644	1,000	10,000-100,000	3
Razorbill	81	0	44	17	267	0	145	56	12,770	824	755	31,566	76,000	1,000-10,000 (B), 10,000-1000,000 (NB)	3
Thick-billed murre	0	0	0	0	0	0	0	0	4,730	-	-	1,512	8,000,000	1,000-10,000	0
Gannets and Cormorants															
Double-crested cormorant[f]	12	0	2	0	40	0	7	0	4,316	2,331	11,479	1,668	740,000	30,000-300,000 (B), 100,000-1,000,000 (NB)	0
Northern gannet	14	0	19	1	46	0	63	3	122,331	3,262	15,638	67,114	155,456	100,000-1,000,000	0
Gulls, Skuas, and Jaegers															
Black-legged kittiwake	2	0	42	16	7	0	139	53	2,877	-	2,593	104,563	3,126,000	100-1,000 (B), 100,000-1,000,000 (NB)	0
Bonaparte's gull	35	0	1	0	115	0	3	0	19,002	-	1,660	20,403	*	30,000-300,000	0
Great black-backed gull	13	18	4	13	43	59	13	43	30,407	25,835	52,253	78,761	121,430	30,000-300,000 (B), 100,000-1,000,000 (NB)	0
Great skua	0	0	0	0	0	0	0	0	-	-	1,532	-	*	*	0
Herring gull	7	21	12	3	23	69	40	10	86,227	16,732	91,057	128,586	246,000	1,000,000-10,000,000	0
Laughing gull	0	0	0	0	0	0	0	0	804	4,165	1,831	64	528,000-538,000	1,000,000-10,000,000	0
Lesser black-backed gull	0	2	1	0	0	7	3	0	-	-	-	-	*	1-10 (B), 1,000-10,000 (NB)	0
Parasitic jaeger	1	0	0	0	3	0	0	0	261	321	1,293	-	*	1,000-10,000	0
Pomarine jaeger	0	0	1	0	0	0	3	0	1,961	436	3,285	-	20,000-40,000	10,000-100,000	0
Ring-billed gull	0	0	0	0	0	0	0	0	745	157	1,105	5,597	17,000,000	10-100 (B), 1,000,000-10,000,000 (NB)	0
South polar skua	0	0	0	0	0	0	0	0	-	583	2,142	-	-	1-10	0
Loons and Grebes															
Common loon	3	0	4	0	10	0	13	0	12,132	203	1,778	7,733	-	100,000-1,000,000	0
Horned grebe	0	0	0	0	0	0	0	0	-	-	-	387	-	30,000-300,000	0
Red-throated loon	71	0	1	0	234	0	3	0	2,864	-	427	9,541	-	300,000-3,000,000	0
Pelicans															
Brown pelican	0	0	0	0	0	0	0	0	612	0	73	132	191,600-193,7000	10,000-100,000	3
Seaducks															
Black scoter	4	0	2	0	13	0	7	0	4,293	-	9,865	26,817	-	100,000-1,000,000	0
Brant	0	0	0	0	0	0	0	0	-	-	-	-	-	-	0

Species	Lease Area Estimates								Regional, National and Hemispheric Estimates (see Section 2.3.2 for scale details)						SCORE[e]
	Lease Area (Aerial HD)[a]				Lease Area Adjusted (Aerial HD)[b]				NAPA (MDAT)[c]				Kushlan et al.	Nisbet et al.[d]	
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter			
Common eider	0	0	0	34	0	0	0	112	1,413,255	762	5	1,911,759	-	10,000-100,000 (B), 100,000-1,000,000 (NB)	0
Long-tailed duck	254	0	0	247	838	0	0	815	18,174	-	3,417	73,142	-	10,000-100,000	0
Red-breasted merganser	0	0	0	0	0	0	0	0	576	-	-	2,951	-	10-100 (B), 30,000-300,000 (NB)	0
Surf scoter	4	0	0	3	13	0	0	10	11,647	-	4,967	51,271	-	100,000-1,000,000	0
White-winged scoter	247	0	0	2,486	815	0	0	8,199	24,019	-	3,847	22,833	-	10,000-100,000	3
Shearwaters, Petrels, and Storm-Petrels															
Audubon's shearwater	0	0	0	0	0	0	0	0	2,020	24,920	20,229	1,724	6,000-10,000	3,000-30,000	0
Band-rumped storm-petrel	0	0	0	0	0	0	0	0	-	2,578	-	-	200	1,000-10,000	0
Black-capped petrel	0	0	0	0	0	0	0	0	258	2,297	420	262	4,000-10,000	1,000-10,000	0
Cory's shearwater	20	53	0	0	66	175	0	0	214	21,713	17,109	-	*	10,000-100,000	3
Great shearwater	5	21	4	0	16	69	13	0	552	366,795	162,972	355	*	1,000,000-10,000,000	0
Leach's storm-petrel	0	0	0	0	0	0	0	0	15,571	67,072	3,685	-	15,275,000	10,000-100,000 (B), 100,000-1,000,000 (NB)	0
Manx shearwater	0	0	0	0	0	0	0	0	20,633	2,184	4,351	-	360	1,000-10,000	0
Northern fulmar	12	0	8	10	40	0	26	33	17,384	1,434	11,374	185,927	2,100,000	300,000-3,000,000	0
Sooty shearwater	0	7	0	0	0	23	0	0	5,328	9,689	973	-	2,800,000**	100,000-1,000,000	0
Wilson's storm-petrel	0	0	0	0	0	0	0	0	5,646	140,141	8,165	-	50,000-100,000**	1,000,000-10,000,000	0
Shorebirds															
Red phalarope	1	0	4	0	3	0	13	0	406,491	39,617	6,918	-	-	1,000,000-10,000,000	0
Red-necked phalarope	0	0	0	0	0	0	0	0	8,917	2,029	4,565	-	-	100,000-1,000,000	0
Terns															
Arctic tern	0	0	0	0	0	0	0	0	-	491	-	-	*	3,000-30,000	0
Bridled tern	0	0	0	0	0	0	0	0	-	211	723	-	8,700-14,700	10,000-100,000	0
Common tern	8	0	0	0	26	0	0	0	297	7,523	32,116	-	300,000	100,000-1,000,000 (B), 100-1,000 (NB)	3
Least tern	0	0	0	0	0	0	0	0	-	356	5	-	60,000-100,000	10,000-100,000	0
Roseate tern	3	0	0	0	10	0	0	0	148	46	1,931	-	16,000	3,000-30,000	0
Royal tern	0	0	0	0	0	0	0	0	70	63	165	-	100,000-150,000	30,000-300,000 (B), 10,000-100,000 (NB)	0
Sooty tern	0	0	0	0	0	0	0	0	2	123	-	-	3,360,000-4,380,000	300-3,000	0

* = Insufficient information.

** = Includes non-breeders.

Dash "-" = Species not modeled.

[a] Maximum count per season.

[b] Area-adjusted maximum count per season (i.e., adjusted to represent potential occurrence in Lease Area; see Section 2.3.2.3 for details).

[c] Predicted density, summed across all 2 km^2 grid cells in the North Atlantic Planning Area (NAPA; 373,712 km^2 modeling space), within each season; see Section 2.2.1 and Winship et al. 2018 for details.

[d] (B) Breeding, (NB) Non-breeding; all other estimates represent total breeding and non-breeding population.

[e] Maximum score for any season (Lease Area estimate $\geq$ 1% of lowest regional estimate; Scores can be "0" or "3" only [see Section 2.3.2.3 for detailed description of scoring]).

[f] Includes "unknown" cormorant species.

3.2.1 Flight Heights

Flight heights of individuals observed in the Lease Area during the Aerial HD surveys are summarized in Table 3-4. Only values for individuals that were identifiable to species or to one of closely-related species (e.g., common or thick-billed murre) are included. Average flight heights are presented to allow for comparison with ranges reported from other regional surveys (Metheny and Davis 2017, Palka et al. 2017, Winiarski et al. 2011, NOAA 2004; Attachment D). Note that measures of variance (i.e., standard deviation [SD]) do not account for uncertainty associated with individual observations.

Table 3-4 Flight heights for individual species observed during high-definition aerial surveys, 2019-2020

Species	Count	Mean Height (m)	SD Height (m)	Height bin (m) (proportion of individuals)					
				< 20	21 - 50	51 - 100	101 - 240	241 - 325	> 325
Atlantic puffin	2	40.29	5.02	-	1.00	-	-	-	-
Black-legged kittiwake	46	39.77	23.85	0.22	0.41	0.37	-	-	-
Common eider	9	6.28	5.22	1.00	-	-	-	-	-
Common/Thick-billed murre	5	16.94	16.84	0.60	0.40	-	-	-	-
Dovekie	1	25.01	-	-	1.00	-	-	-	-
Duck species	2	16.69	9.22	0.50	0.50	-	-	-	-
Great black-backed gull	15	47.52	33.07	0.20	0.40	0.27	0.13	-	-
Herring gull	18	61.63	48.38	0.22	0.28	0.33	0.17	-	-
Lesser black-backed gull	1	123.44	-	-	-	-	1.00	-	-
Long-tailed duck	22	30.73	27.54	0.41	0.36	0.23	-	-	-
Murre/Razorbill	5	29.13	22.10	0.40	0.40	0.20	-	-	-
Northern fulmar	17	38.01	28.64	0.41	0.24	0.35	-	-	-
Northern gannet	15	24.27	22.92	0.47	0.40	0.13	-	-	-
Razorbill	2	3.30	1.47	1.00	-	-	-	-	-
Red phalarope	1	54.27	-	-	-	1.00	-	-	-
Red/Red-necked phalarope	4	26.71	27.60	0.50	0.25	0.25	-	-	-
Red-throated loon	15	87.82	26.03	-	-	0.73	0.27	-	-
White-winged scoter	27	32.84	21.39	0.33	0.41	0.26	-	-	-

For all individuals combined, including those that could not be identified to species, approximately 23% (of a total of 349 individuals) were estimated to occur within each of the four lower bins (i.e., < 20 m, 21-50 m, 51-100 m, and 101-240 m). Approximately 9% were observed flying between 241 and 325 m, and approximately 2% were observed above 325 m.

3.3 Discussion

3.3.1 Interpretation of Scores

As noted in Epsilon Associates (2018), each seasonal exposure score derived from this AERA process should be interpreted primarily as a measure of the seasonal importance of the Lease Area to each species *relative to other surveyed (or modeled) areas in the region*, and should not be interpreted as a measure of the absolute number of individuals likely to be exposed. This is because the MDAT and MCEC scores, which comprised 2/3 of each seasonal score, were assigned solely on the relative comparisons of predicted (MDAT) or observed (MCEC) densities in the Lease Area versus local or regional values. The annual scores presented herein were assigned based on a process that weighted all seasonal scores equally and should be interpreted as the relative importance of the Lease Area for a species or species group aggregated across an entire annual cycle. The process used in this AERA differed somewhat from that proposed by Epsilon Associates (2018) in that a third (Aerial HD) score was derived based on observations in the Lease Area relative to species population estimates, to further inform each seasonal and annual score. The intent of calculating this score was to use the more recent, intensively collected data available for the Lease Area to account in part for differences in exposure risk between species with very large versus small population sizes. However, there is considerable uncertainty in population estimates available at the regional and continental scales as well as with estimating the actual number of individuals of a species likely to occur in the Lease Area during any one season; therefore, the Aerial HD scores should be considered a very coarse estimate of potential exposure risk at the population scale.

Because the scores presented in this AERA represent relative values, caution should be employed when making inferences about, for instance, “high” or “low” exposure scores for individual species, as equivalent scores often may be interpreted differently for common versus rare species. High exposure scores indicate that observed and predicted densities of a species in the Lease Area were high relative to other surveyed or modeled areas, but do not provide an indication of overall abundance, likelihood of occurrence in the Lease Area or likelihood of collision or displacement. Conversely, low or insignificant scores indicate that densities in the Lease Area are lower than those in the region, but regionally-abundant species may still have a high likelihood of collision or displacement (at the individual level). Additional context for informing interpretation of the scores can be gained by examining estimates of count density from the MCEC (Attachment B), predicted density from MDAT (Attachment B), count density from the Aerial HD surveys (Table 3-3, Attachment C) and regional and continental population estimates (Table 3-3).

3.3.2 Avian Exposure

Focal species summaries are provided in Table 3-5. As acknowledged in Section 3.3.1, species with moderate or high relative scores may represent those from less abundant populations and should not be interpreted as having high overall abundance in the Lease Area. See Attachment B for abundance estimates.

Table 3-5 Focal[1] Species Results Summaries

Species	Summary
Roseate tern	Low exposure scores in spring and summer, moderate exposure score in fall. Species was observed in the Lease Area during Aerial HD surveys in spring only. VHF tracking data do not provide coverage of the Lease Area, but track vectors and movement models do not indicate extensive use of the Lease Area. Ichthyoplankton and trawl surveys do not indicate *Ammodytes* concentration areas occur in the Lease Area.
Rufa red knot	Exposure scores not calculated as the species was not represented in the MDAT, MCEC, or Aerial HD data sets. VHF tracking data were not available for mapping but external reports indicate that exposure level in the Lease Area is likely to be low.
Piping plover	Exposure scores not calculated as the species was not represented in the MDAT, MCEC, or Aerial HD data sets. VHF tracking data do not provide coverage of the Lease Area, but track vectors do not indicate extensive use of the Lease Area.
Black-capped petrel	Low exposure score in fall, Very Low exposure scores in spring, summer, and winter. Species was not observed in the Lease Area during MCEC or Aerial HD surveys.
Leach's storm-petrel	Insignificant exposure score in spring, summer, and fall. Species was not observed in the Lease Area during MCEC or Aerial HD surveys.
Common tern	Moderate scores in summer and fall, Insignificant in winter. High exposure score in spring driven by area-adjusted maximum Aerial HD count relative to predicted spring regional abundance (MDAT); however, few individuals (n=9) were observed during the Aerial HD surveys and predicted spring abundance is very low for the region (see Table 3-3). No observations in the Lease Area recorded during MCEC surveys. Species was not observed in the Lease Area during fall, winter, or summer Aerial HD surveys. VHF tracking data do not provide coverage of the Lease Area, but track vectors and movement models do not indicate extensive use of the Lease Area. Ichthyoplankton and trawl surveys do not indicate *Ammodytes* concentration areas occur in the Lease Area.
Black-legged kittiwake	Moderate exposure scores in spring, fall and winter, Insignificant in summer. Species was observed in the Lease Area during spring, fall, and winter surveys (MCEC and Aerial HD), and during the October-November G&G surveys.
Northern gannet	High exposure scores in summer and fall, Moderate scores in spring and winter. Species was observed in the Lease Area in all seasons during MCEC surveys, and in spring, summer, and fall during Aerial HD surveys. Lease Area overlaps with estimated fall and spring use areas, but not with core use areas. Over 400 individuals observed in the Lease Area during October-November G&G surveys.

Species	Summary
Red-throated loon	Moderate exposure scores in spring and winter, Low in fall, and Insignificant in summer. Species was observed in the Lease Area in all fall, winter, and spring during MCEC surveys, fall and spring during Aerial HD surveys. Lease Area overlaps with estimated fall and spring use areas, but not with core use areas.
Surf scoter	Moderate exposure scores in spring and winter, Low in fall, and Insignificant in summer. Species was not observed in the Lease Area during MCEC surveys or Aerial HD surveys. Lease Area overlaps with estimated spring use area, but not with core use area.

[1] Focal species were identified based on their conservation status including federal- or state-listing (i.e., those protected under the federal Endangered Species Act [ESA] or Massachusetts Endangered Species Act [MESA]), availability of supporting data, or other factors that warranted a more detailed assessment. See Section 2.1 for details.

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ATTACHMENT A – SPECIES INCLUDED IN THE AVIAN EXPOSURE RISK ASSESSMENT

Species common name	Scientific name
Alcids	
Atlantic puffin	*Fratercula artica*
Black guillemot	*Cepphus grille*
Common murre	*Uria aalge*
Dovekie	*Alle alle*
Razorbill	*Alca torda*
Thick-billed murre	*Uria lomvia*
Gannets and Cormorants	
Double-crested cormorant	*Phalacrocorax auratus*
Northern gannet	*Morus bassanus*
Gulls, Skuas, and Jaegers	
Black-legged kittiwake	*Rissa tridactyla*
Bonaparte’s gull	*Larus philadelphia*
Great black-backed gull	*Larus marinus*
Great skua	*Stercorarius skua*
Herring gull	*Larus argentatus*
Laughing gull	*Larus atricilla*
Parasitic jaeger	*Stercorarius parasiticus*
Pomarine jaeger	*Stercorarius pomarinus*
Ring-billed gull	*Larus delawarensis*
South polar skua	*Stercorarius maccormicki*
Loons and Grebes	
Common loon	*Gavia immer*
Horned grebe	*Podiceps auratus*
Pied-billed grebe	*Podilymbus podiceps*
Red-throated loon	*Gavia stellate*
Seaducks	
Black scoter	*Melanitta nigra*
Brant	*Branta bernicla*
Common eider	*Somateria mollissima*
Long-tailed duck	*Clangula hyemalis*
Red-breasted merganser	*Mergus serrator*
Surf scoter	*Melanitta perspicillata*
White-winged scoter	*Melanitta fusca*
Shearwaters, Petrels, Fulmars, and Storm-Petrels	
Audubon’s shearwater	*Puffinus lherminieri*
Band-rumped storm-petrel	*Oceanodroma castro*

Species common name	Scientific name
Black-capped petrel	*Pterodroma hasitata*
Cory's shearwater	*Calonectris diomedea*
Great shearwater	*Puffinus gravis*
Leach's storm-petrel	*Oceanodroma leucorhoa*
Manx shearwater	*Puffinus puffinus*
Northern fulmar	*Fulmarus glacialis*
Sooty shearwater	*Puffinus griseus*
Wilson's storm-petrel	*Oceanites oceanicus*
Shorebirds	
Piping plover	*Charadrius melodus*
Red phalarope	*Phalaropus fulicarius*
Red-necked phalarope	*Phalaropus lobatus*
Rufa red knot	*Calidris canutus rufa*
Terns	
Arctic tern	*Sterna paradisae*
Bridled tern	*Onychoprion anaethetus*
Common tern	*Sterna hirundo*
Least tern	*Sternula antillarum*
Roseate tern	*Sterna dougalli*
Royal tern	*Sterna maxima*
Sooty tern	*Onychoprion fuscatus*

ATTACHMENT B – SPECIES ESTIMATES AND SCORES

Species	Season	MCEC (count/km²)			MDAT (predicted abundance/km²)			Aerial HD Surveys Score[a]	Exposure Category[b]
		Lease	MCEC Survey Area	Score	Lease	NAPA	Score		
Alcids									
Atlantic puffin	Spring	0.0000	0.0000	0	0.0026	0.0095	2	3	H
	Summer	0.0000	0.0000	0	0.0009	0.0050	2	0	L
	Fall	0.0000	0.0000	0	0.0004	0.0012	0	0	I
	Winter	0.0000	0.0000	0	0.0037	0.0106	1	0	VL
Black guillemot	Summer	0.0000	0.0000	0	0.0005	0.0009	2	0	L
Common murre	Spring	0.0000	0.0015	0	0.0023	0.0020	2	0	L
	Summer	0.0000	0.0000	0	-	-	0	0	I
	Fall	0.0000	0.0000	0	-	-	0	0	I
	Winter	0.0038	0.0081	1	0.0034	0.0040	2	0	M
Dovekie	Spring	0.0038	0.0026	3	0.0049	0.0208	0	3	H
	Summer	0.0000	0.0000	0	0.0000	0.0001	2	0	L
	Fall	0.0000	0.0000	0	0.0119	0.0185	0	0	I
	Winter	0.0038	0.0057	1	0.0705	0.3114	0	0	VL
Razorbill	Spring	0.9733	1.3561	1	0.4327	0.0345	3	3	H
	Summer	0.0000	0.0000	0	0.0010	0.0023	2	0	L
	Fall	0.0058	0.0160	1	0.0016	0.0020	1	3	H
	Winter	1.6556	2.0867	2	0.3991	0.0863	3	0	H
Thick-billed murre	Spring	0.0000	0.0000	0	0.0031	0.0134	0	0	I
	Winter	0.0000	0.0000	0	0.0013	0.0040	0	0	I
Gannets and Cormorants									
Double-crested cormorant	Spring	0.0000	0.0000	0	0.0079	0.0117	2	0	L
	Summer	0.0000	0.0000	0	0.0067	0.0065	2	0	L
	Fall	0.0000	0.0019	0	0.0190	0.0308	2	0	L
	Winter	0.0000	0.0000	0	0.0035	0.0045	0	0	I
Northern gannet	Spring	0.1003	0.1894	1	0.4799	0.3262	3	0	M
	Summer	0.0039	0.0019	3	0.0020	0.0084	2	0	H
	Fall	0.4364	0.3556	3	0.0786	0.0413	3	0	H
	Winter	0.1768	0.2149	2	0.1781	0.1785	2	0	M
Gulls, Skuas, and Jaegers									
Black-legged kittiwake	Spring	0.0306	0.0495	1	0.0109	0.0077	3	0	M
	Summer	0.0000	0.0000	0	-	-	0	0	I
	Fall	0.0535	0.0746	2	0.0071	0.0070	2	0	M
	Winter	0.5356	0.5181	2	0.2549	0.2790	2	0	M
Bonaparte's gull	Spring	0.0000	0.0170	0	0.0185	0.0509	1	0	VL

Species	Season	MCEC (count/km²)			MDAT (predicted abundance/km²)			Aerial HD Surveys Score[a]	Exposure Category[b]
		Lease	MCEC Survey Area	Score	Lease	NAPA	Score		
	Summer	0.0000	0.0000	0	-	-	0	0	I
	Fall	0.0029	0.0065	2	0.0043	0.0045	2	0	M
	Winter	0.1098	0.1226	2	0.0291	0.0548	1	0	M
Great black-backed gull	Spring	0.0349	0.0323	2	0.1018	0.0817	2	0	M
	Summer	0.0434	0.0293	2	0.0291	0.0696	2	0	M
	Fall	0.0000	0.0145	0	0.0884	0.1401	2	0	L
	Winter	0.0240	0.0551	1	0.1774	0.2106	0	0	VL
Great skua	Fall	0.0000	0.0000	0	0.0010	0.0041	0	0	I
Herring gull	Spring	0.2763	0.1610	3	0.1896	0.2315	2	0	H
	Summer	0.0029	0.0422	1	0.0410	0.0463	3	0	M
	Fall	0.0360	0.0433	1	0.2293	0.2469	2	0	M
	Winter	0.0306	0.1822	1	0.2197	0.3458	1	0	L
Laughing gull	Spring	0.0000	0.0000	0	0.0007	0.0020	1	0	VL
	Summer	0.0000	0.0004	0	0.0019	0.0108	3	0	M
	Fall	0.0000	0.0007	0	0.0037	0.0047	3	0	M
	Winter	0.0000	0.0000	0	0.0001	0.0002	1	0	VL
Parasitic jaeger	Spring	0.0000	0.0000	0	0.0005	0.0007	0	0	I
	Summer	0.0000	0.0000	0	0.0010	0.0009	3	0	M
	Fall	0.0000	0.0000	0	0.0021	0.0034	0	0	I
Pomarine jaeger	Spring	0.0000	0.0000	0	0.0008	0.0052	0	0	I
	Summer	0.0000	0.0000	0	0.0008	0.0012	1	0	VL
	Fall	0.0000	0.0003	0	0.0050	0.0088	2	0	L
	Winter	0.0000	0.0000	0	-	-	0	0	I
Ring-billed gull	Spring	0.0000	0.0000	0	0.0016	0.0020	2	0	L
	Summer	0.0000	0.0000	0	0.0004	0.0004	2	0	L
	Fall	0.0000	0.0000	0	0.0027	0.0031	2	0	L
	Winter	0.0000	0.0000	0	0.0155	0.0151	2	0	L
South polar skua	Summer	0.0000	0.0000	0	0.0006	0.0016	1	0	VL
	Fall	0.0000	0.0000	0	0.0009	0.0057	0	0	I
Loons and Grebes									
Common loon	Spring	0.0098	0.0286	1	0.0236	0.0333	2	0	M
	Summer	0.0000	0.0013	0	0.0004	0.0006	3	0	M
	Fall	0.0000	0.0306	0	0.0023	0.0049	2	0	L
	Winter	0.0421	0.0394	1	0.0229	0.0216	3	0	M
Horned grebe	Winter	0.0000	0.0000	0	0.0008	0.0010	0	0	I
Red-throated loon	Spring	0.0208	0.0963	1	0.0089	0.0081	3	0	M

Species	Season	MCEC (count/km²)			MDAT (predicted abundance/km²)			Aerial HD Surveys Score[a]	Exposure Category[b]
		Lease	MCEC Survey Area	Score	Lease	NAPA	Score		
	Summer	0.0000	0.0000	0	-	-	0	0	I
	Fall	0.0000	0.0586	0	0.0008	0.0012	2	0	L
	Winter	0.0000	0.0703	0	0.0277	0.0258	3	0	M
Pelicans									
Brown pelican	Spring	0.0000	0.0000	0	0.0013	0.0016	1	0	VL
	Summer	0.0000	0.0000	0	0.0000	0.0000	2	0	L
	Fall	0.0000	0.0000	0	0.0002	0.0002	2	0	L
	Winter	0.0000	0.0000	0	0.0000	0.0004	1	0	VL
Seaducks									
Black scoter	Spring	0.0000	0.0000	0	0.0066	0.0122	3	0	M
	Summer	0.0000	0.0000	0	-	-	0	0	I
	Fall	0.0000	0.0057	0	0.0212	0.0266	2	0	L
	Winter	0.0000	0.0439	0	0.1095	0.0730	3	0	M
Brant	Spring	0.0000	0.0000	0	-	-	0	0	I
	Summer	0.0000	0.0000	0	-	-	0	0	I
	Fall	0.0000	0.0010	0	-	-	0	0	I
	Winter	0.0000	0.0000	0	-	-	0	0	I
Common eider	Spring	0.0000	0.0035	0	2.9053	3.8004	1	0	VL
	Summer	0.0000	0.0000	0	0.0010	0.0034	2	0	L
	Fall	0.0000	0.0003	0	0.0000	0.0000	2	0	L
	Winter	0.0153	0.0184	2	5.3078	5.1790	1	0	M
Long-tailed duck	Spring	0.0060	4.1626	0	0.0248	0.0554	3	0	M
	Summer	0.0000	0.0000	0	-	-	0	0	I
	Fall	0.0000	0.0007	0	0.0071	0.0092	2	0	L
	Winter	0.1913	1.9556	2	0.2159	0.2335	3	0	H
Red-breasted merganser	Spring	0.0000	0.0000	0	0.0019	0.0018	3	0	M
	Summer	0.0000	0.0000	0	-	-	0	0	I
	Fall	0.0000	0.0000	0	-	-	0	0	I
	Winter	0.0000	0.0006	0	0.0110	0.0080	3	0	M
Surf scoter	Spring	0.0000	0.0323	0	0.0304	0.0313	3	0	M
	Summer	0.0000	0.0000	0	-	-	0	0	I
	Fall	0.0000	0.0088	0	0.0086	0.0135	2	0	L
	Winter	0.0000	0.0811	0	0.1349	0.1339	3	0	M
White-winged scoter	Spring	0.2622	9.6015	2	0.0831	0.0652	3	3	H
	Summer	0.0000	0.0000	0	-	-	0	0	I
	Fall	0.0000	0.2397	0	0.0045	0.0120	2	0	L

Species	Season	MCEC (count/km^2)			MDAT (predicted abundance/km^2)			Aerial HD Surveys Score[a]	Exposure Category[b]
		Lease	MCEC Survey Area	Score	Lease	NAPA	Score		
	Winter	0.0153	2.4390	1	0.1778	0.0639	3	3	H
Shearwaters, Petrels, Fulmars, and Storm-Petrels									
Audubon's shearwater	Spring	0.0000	0.0000	0	0.0010	0.0053	1	0	VL
	Summer	0.0000	0.0000	0	0.0019	0.0673	1	0	VL
	Fall	0.0000	0.0000	0	0.0017	0.0543	0	0	I
	Winter	0.0000	0.0000	0	0.0000	0.0043	1	0	VL
Band-rumped storm-petrel	Summer	0.0000	0.0000	0	0.0003	0.0073	0	0	I
Black-capped petrel	Spring	0.0000	0.0000	0	0.0000	0.0007	1	0	VL
	Summer	0.0000	0.0000	0	0.0000	0.0061	1	0	VL
	Fall	0.0000	0.0000	0	0.0000	0.0009	2	0	L
	Winter	0.0000	0.0000	0	0.0000	0.0007	1	0	VL
Cory's shearwater	Spring	0.0000	0.0000	0	0.0002	0.0006	0	3	H
	Summer	0.1146	0.3674	1	0.1333	0.0579	3	0	M
	Fall	0.0219	0.1594	0	0.0722	0.0456	3	0	M
	Winter	0.0000	0.0002	0	-	-	0	0	I
Great shearwater	Spring	0.0000	0.0000	0	0.0004	0.0015	0	0	I
	Summer	0.0126	0.0567	0	0.5817	0.9788	2	0	L
	Fall	0.1387	0.0664	3	0.3279	0.4375	2	0	H
	Winter	0.0000	0.0000	0	0.0002	0.0009	0	0	I
Leach's storm-petrel	Spring	0.0000	0.0000	0	0.0052	0.0417	0	0	I
	Summer	0.0000	0.0000	0	0.0059	0.1824	0	0	I
	Fall	0.0000	0.0000	0	0.0009	0.0099	0	0	I
Manx shearwater	Spring	0.0000	0.0000	0	0.0010	0.0548	1	0	VL
	Summer	0.0000	0.0008	0	0.0058	0.0058	2	0	L
	Fall	0.0040	0.0113	2	0.0029	0.0116	0	0	L
	Winter	0.0000	0.0000	0	-	-	0	0	I
Northern fulmar	Spring	0.0380	0.0179	3	0.0129	0.0467	2	0	H
	Summer	0.0000	0.0000	0	0.0014	0.0039	2	0	L
	Fall	0.1466	0.0882	3	0.0058	0.0303	2	0	H
	Winter	0.0655	0.1156	1	0.2137	0.4958	2	0	M
Sooty shearwater	Spring	0.0000	0.0000	0	0.0096	0.0142	2	0	L
	Summer	0.0000	0.0009	0	0.0198	0.0258	2	0	L
	Fall	0.0000	0.0003	0	0.0013	0.0026	2	0	L
	Winter	0.0000	0.0000	0	-	-	0	0	I
Wilson's storm-petrel	Spring	0.0000	0.0009	0	0.0050	0.0151	0	0	I

Species	Season	MCEC (count/km^2)			MDAT (predicted abundance/km^2)			Aerial HD Surveys Score[a]	Exposure Category[b]
		Lease	MCEC Survey Area	Score	Lease	NAPA	Score		
	Summer	0.0811	0.1412	1	0.3984	0.3745	2	0	M
	Fall	0.0000	0.0000	0	0.0051	0.0216	1	0	VL
	Winter	0.0000	0.0005	0	-	-	0	0	I
Shorebirds									
Red phalarope	Spring	0.0000	0.0233	0	0.9100	1.0872	1	0	VL
	Summer	0.0000	0.0000	0	0.0920	0.1058	1	0	VL
	Fall	0.0000	0.0004	0	0.0093	0.0184	0	0	I
	Winter	0.0000	0.0000	0	-	-	0	0	I
Red-necked phalarope	Spring	0.0000	0.0000	0	0.0155	0.0238	0	0	I
	Summer	0.0000	0.0000	0	0.0031	0.0053	2	0	L
	Fall	0.0000	0.0000	0	0.0065	0.0122	0	0	I
Terns									
Arctic tern	Summer	0.0000	0.0000	0	0.0005	0.0014	2	0	L
Bridled tern	Summer	0.0000	0.0000	0	0.0003	0.0006	1	0	VL
	Fall	0.0000	0.0000	0	0.0006	0.0019	1	0	VL
Common tern	Spring	0.0000	0.0000	0	0.0007	0.0008	2	3	H
	Summer	0.0000	0.0111	0	0.0105	0.0205	3	0	M
	Fall	0.0000	0.0054	0	0.0946	0.0860	3	0	M
	Winter	0.0000	0.0000	0	-	-	0	0	I
Least tern	Summer	0.0000	0.0000	0	0.0010	0.0010	2	0	L
	Fall	0.0000	0.0000	0	0.0000	0.0000	1	0	VL
Roseate tern	Spring	0.0000	0.0000	0	0.0004	0.0004	2	0	L
	Summer	0.0000	0.0003	0	0.0000	0.0002	2	0	L
	Fall	0.0000	0.0000	0	0.0052	0.0052	3	0	M
	Winter	0.0000	0.0000	0	-	-	0	0	I
Royal tern	Spring	0.0000	0.0000	0	0.0000	0.0002	0	0	I
	Summer	0.0000	0.0000	0	0.0000	0.0001	1	0	VL
	Fall	0.0000	0.0000	0	0.0003	0.0004	1	0	VL
Sooty tern	Spring	0.0000	0.0000	0	0.0000	0.0000	2	0	L
	Summer	0.0000	0.0000	0	0.0002	0.0003	1	0	VL

[a] Score based on maximum count of individuals observed during aerial HD surveys as a proportion of regional population estimates. See Section 2.2.3.2 for details.

[b] I = Insignificant; VL = Very Low; L = Low; M = Moderate; H = High.

ATTACHMENT C – DENSITY ESTIMATES BASED ON HIGH-DEFINITION AERIAL SURVEYS

Species	Spring		Summer		Fall		Winter	
	Mean[a]	SD	Mean	SD	Mean	SD	Mean	SD
Atlantic puffin	0.457	0.437	-	-	0.014	0.090	0.080	0.123
Auk[b]	0.043	0.069	-	-	0.007	0.034	-	-
Black guillemot	-	-	-	-	-	-	0.009	0.031
Black-legged kittiwake	0.002	0.011	-	-	0.062	0.119	0.055	0.082
Black scoter	0.004	0.025	-	-	0.007	0.048	-	-
Bonaparte's gull	0.068	0.315	-	-	0.001	0.010	-	-
Commic[c]/Forster's tern[b]	0.004	0.017	0.002	0.011	-	-	-	-
Common eider	-	-	-	-	-	-	0.050	0.349
Common loon	0.003	0.011	-	-	0.006	0.020	-	-
Common tern	0.011	0.050	-	-	-	-	-	-
Common/Thick-billed murre[b]	0.083	0.144	-	-	-	-	-	-
Cormorant[b]	0.011	0.074	-	-	0.003	0.014	-	-
Cory's shearwater	0.018	0.045	0.207	0.326	-	-	-	-
Dovekie	0.049	0.087	-	-	-	-	0.016	0.044
Duck[b]	0.027	0.093	-	-	-	-	0.012	0.053
Great black-backed gull	0.057	0.104	0.040	0.105	0.009	0.029	0.036	0.071
Great shearwater	0.005	0.018	0.107	0.223	0.014	0.075	-	-
Gull[b]	0.003	0.011	0.002	0.011	-	-	-	-
Large Gull[b]	0.004	0.015	-	-	0.021	0.147	-	-
Small Gull[b]	0.003	0.010	0.002	0.011	0.006	0.019	-	-
Herring Gull	0.019	0.034	0.060	0.129	0.032	0.065	0.005	0.019
Lesser black-backed gull	-	-	0.002	0.015	0.002	0.016	-	-
Long-tailed duck	0.692	1.814	-	-	-	-	2.046	11.414
Loon[b]	-	-	-	-	0.001	0.010	-	-
Murre/Razorbill[b]	3.808	15.670	-	-	-	-	0.430	0.391
Northern fulmar	0.011	0.060	-	-	0.020	0.068	0.028	0.063
Northern gannet	0.033	0.061	-	-	0.047	0.142	0.003	0.014

Species	Spring		Summer		Fall		Winter	
	Mean[a]	SD	Mean	SD	Mean	SD	Mean	SD
Parasitic jaeger	0.002	0.014	-	-	-	-	-	-
Pomarine jaeger	-	-	-	-	0.003	0.024	-	-
Razorbill	0.090	0.231	-	-	0.072	0.151	0.048	0.168
Red phalarope	0.003	0.022	-	-	0.006	0.041	-	-
Red/Red-necked phalarope[b]	0.047	0.120	-	-	-	-	-	-
Red-throated Loon	0.152	0.259	-	-	0.001	0.010	-	-
Roseate tern	0.004	0.015	-	-	-	-	-	-
Scoter[b]	0.002	0.012	-	-	-	-	0.789	2.050
Shearwater[b]	-	-	0.045	0.258	-	-	-	-
Large shearwater[b]	0.089	0.377	0.090	0.203	-	-	-	-
Small shearwater[b]	0.001	0.008	-	-	-	-	-	-
Shorebird [b]	-	-	0.004	0.028	0.004	0.025		
Skua[b]	0.002	0.009	-	-	-	-	-	-
Sooty shearwater	-	-	0.008	0.028	-	-	-	-
Tern[b]	-	-	0.001	0.008	-	-	-	-
Storm-petrel	-	-	0.080	0.343	-	-	-	-
Surf scoter	0.004	0.031	-	-	-	-	0.020	0.137
White-winged scoter	1.074	2.858	-	-	0.014	0.090	11.264	31.167

[a] Observed individuals per BOEM lease block (per km^2) per survey, within season (Spring, March-May; Summer, June-August; Fall, September-November; Winter, December-February).
[b] Individual could not be identified to species.
[c] Common, Roseate, or Arctic tern.

ATTACHMENT D – FLIGHT HEIGHT ESTIMATES FROM EXTERNAL DATASETS

Species	AMAPPS[a]							EcoMon[b]								RISAMP[c]				
	Observations[d]	Flight Heights[e]						Observations[d]	Flight Heights[e]							Observations[d]	Flight Heights[e]			
		0-2 m	2-10 m	10-25 m	25-50 m	50-100 m	> 200 m		0 m	0-2 m	2-10 m	10-25 m	25-50 m	50-100 m	100-200 m		0-10 m	10-25 m	25-125 m	> 125 m
Arctic tern	4	0.25	0.25	0.25	0.00	0.25	0.00	25	0.04	0.08	0.76	0.12	0.00	0.00	0.00	-	-	-	-	-
Atlantic puffin	147	0.97	0.03	0.01	0.00	0.00	0.00	38	0.45	0.50	0.05	0.00	0.00	0.00	0.00	5	1.00	0.00	0.00	0.00
Audubon's shearwater	270	0.91	0.09	0.00	0.00	0.00	0.00	3	0.00	0.7	0.33	0.00	0.00	0.00	0.00	-	-	-	-	-
Band-rumped storm-petrel	100	0.97	0.03	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-capped petrel	36	0.56	0.36	0.08	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-legged kittiwake	1	0.00	0.00	0.00	1.00	0.00	0.00	1	0.00	0.00	1.00	0.00	0.00	0.00	0.00	48	0.38	0.48	0.15	0.00
Black scoter	22	0.27	0.32	0.36	0.00	0.05	0.00	-	-	-	-	-	-	-	-	25	0.60	0.36	0.04	0.00
Bonaparte's gull	80	0.50	0.25	0.21	0.04	0.00	0.00	-	-	-	-	-	-	-	-	11	0.64	0.36	0.00	0.00
Brant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1.00	0.00	0.00	0.00
Bridled tern	9	0.56	0.44	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Common eider	5	0.00	1.00	0.00	0.00	0.00	0.00	3	0.00	0.67	0.33	0.00	0.00	0.00	0.00	78	0.95	0.01	0.04	0.00
Common loon	49	0.61	0.10	0.12	0.12	0.04	0.00	65	0.05	0.54	0.09	0.26	0.06	0.00	0.00	396	0.89	0.06	0.05	0.00
Common murre	24	0.79	0.17	0.04	0.00	0.00	0.00	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	73	0.99	0.01	0.00	0.00
Common tern	23	0.04	0.70	0.26	0.00	0.00	0.00	87	0.01	0.15	0.61	0.23	0.00	0.00	0.00	57	0.46	0.49	0.05	0.00
Cory's shearwater	652	0.90	0.10	0.00	0.00	0.00	0.00	68	0.10	0.63	0.26	0.00	0.00	0.00	0.00	379	1.00	0.00	0.00	0.00
Double-crested cormorant	6	0.17	0.33	0.50	0.00	0.00	0.00	25	0.00	0.52	0.16	0.16	0.16	0.00	0.00	27	0.81	0.04	0.15	0.00
Dovekie	199	0.88	0.12	0.00	0.00	0.00	0.00	34	0.71	0.29	0.00	0.00	0.00	0.00	0.00	26	1.00	0.00	0.00	0.00
Great black-backed gull	221	0.24	0.25	0.41	0.08	0.01	0.00	328	0.08	0.20	0.34	0.28	0.10	0.00	0.00	384	0.52	0.23	0.24	0.01
Great shearwater	950	0.92	0.08	0.00	0.00	0.00	0.00	626	0.08	0.65	0.23	0.03	0.00	0.00	0.00	221	1.00	0.00	0.00	0.00

Species	AMAPPS[a]							EcoMon[b]								RISAMP[c]				
	Observations[d]	Flight Heights[e]						Observations[d]	Flight Heights[e]							Observations[d]	Flight Heights[e]			
		0-2 m	2-10 m	10-25 m	25-50 m	50-100 m	> 200 m		0 m	0-2 m	2-10 m	10-25 m	25-50 m	50-100 m	100-200 m		0-10 m	10-25 m	25-125 m	> 125 m
Great skua	2	0.00	0.50	0.50	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Herring gull	547	0.18	0.21	0.43	0.16	0.02	0.00	238	0.03	0.18	0.38	0.34	0.06	0.00	0.00	737	0.34	0.31	0.33	0.01
Laughing gull	40	0.10	0.53	0.35	0.00	0.00	0.03	72	0.06	0.17	0.60	0.17	0.00	0.01	0.00	99	0.59	0.33	0.08	0.00
Leach's storm-petrel	1092	0.98	0.02	0.00	0.00	0.00	0.00	293	0.01	0.97	0.02	0.00	0.00	0.00	0.00	-	-	-	-	-
Least tern	1	0.00	1.00	0.00	0.00	0.00	0.00	7	0.00	0.29	0.43	0.29	0.00	0.00	0.00	-	-	-	-	-
Long-tailed duck	9	0.44	0.22	0.22	0.00	0.00	0.11	-	-	-	-	-	-	-	-	13	0.69	0.31	0.00	0.00
Manx shearwater	97	0.79	0.14	0.06	0.00	0.00	0.00	31	0.06	0.81	0.13	0.00	0.00	0.00	0.00	5	1.00	0.00	0.00	0.00
Northern fulmar	144	0.57	0.35	0.08	0.00	0.00	0.00	302	0.09	0.69	0.20	0.03	0.00	0.00	0.00	3	1.00	0.00	0.00	0.00
Northern gannet	483	0.25	0.38	0.28	0.07	0.02	0.00	291	0.02	0.36	0.27	0.29	0.05	0.00	0.00	515	0.53	0.32	0.16	0.00
Parasitic jaeger	16	0.25	0.25	0.38	0.06	0.06	0.00	5	0.00	0.20	0.20	0.60	0.00	0.00	0.00	1	1.00	0.00	0.00	0.00
Pomarine jaeger	43	0.30	0.26	0.28	0.09	0.07	0.00	8	0.00	0.00	0.50	0.38	0.13	0.00	0.00	2	0.50	0.00	0.50	0.00
Razorbill	80	0.75	0.20	0.05	0.00	0.00	0.00	6	0.00	0.83	0.17	0.00	0.00	0.00	0.00	106	0.93	0.06	0.01	0.00
Red-breasted merganser	1	1.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	4	0.25	0.75	0.00	0.00
Red-necked phalarope	-	-	-	-	-	-	-	6	0.00	0.83	0.17	0.00	0.00	0.00	0.00	3	1.00	0.00	0.00	0.00
Red phalarope	124	0.92	0.06	0.02	0.00	0.00	0.00	28	0.54	0.25	0.14	0.07	0.00	0.00	0.00	2	1.00	0.00	0.00	0.00
Red-throated loon	17	0.18	0.53	0.12	0.18	0.00	0.00	5	0.60	0.40	0.00	0.00	0.00	0.00	0.00	109	0.50	0.35	0.14	0.01
Ring-billed gull	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	0.31	0.42	0.23	0.04
Roseate tern	-	-	-	-	-	-	-	13	0.00	0.08	0.69	0.23	0.00	0.00	0.00	4	0.25	0.50	0.25	0.00
Royal tern	3	0.00	0.33	0.67	0.00	0.00	0.00	7	0.00	0.29	0.14	0.43	0.14	0.00	0.00	-	-	-	-	-
Sooty shearwater	142	0.82	0.15	0.03	0.00	0.00	0.01	456	0.10	0.61	0.25	0.04	0.00	0.00	0.00	27	1.00	0.00	0.00	0.00

Species	AMAPPS[a]							EcoMon[b]								RISAMP[c]				
	Observations[d]	Flight Heights[e]						Observations[d]	Flight Heights[e]							Observations[d]	Flight Heights[e]			
		0-2 m	2-10 m	10-25 m	25-50 m	50-100 m	> 200 m		0 m	0-2 m	2-10 m	10-25 m	25-50 m	50-100 m	100-200 m		0-10 m	10-25 m	25-125 m	> 125 m
Sooty tern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South polar skua	16	0.25	0.44	0.19	0.06	0.06	0.00	17	0.00	0.12	0.35	0.47	0.06	0.00	0.00	-	-	-	-	-
Surf scoter	8	0.38	0.00	0.25	0.25	0.13	0.00	-	-	-	-	-	-	-	-	30	0.63	0.37	0.00	0.00
Thick-billed murre	29	0.90	0.10	0.00	0.00	0.00	0.00	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1	1.00	0.00	0.00	0.00
White-winged scoter	48	0.65	0.15	0.19	0.02	0.00	0.00	-	-	-	-	-	-	-	-	80	0.73	0.21	0.06	0.00
Wilson's storm-petrel	1026	1.00	0.00	0.00	0.00	0.00	0.00	848	0.02	0.97	0.01	0.00	0.00	0.00	0.00	358	1.00	0.00	0.00	0.00

[a] Data collected during Atlantic Marine Assessment Program for Protected Species (AMAPPS) surveys conducted in 2011, 2013 and 2014 and included in the Northwest Atlantic Seabird Catalog database. Data obtained from NOAA December 2020; additional details provided in Palka et al. 2017 and NOAA 2004.

[b] Data collected during Ecosystem Monitoring Program (EcoMon) surveys conducted in 2010 and 2017 and included in the Northwest Atlantic Seabird Catalog database. Data obtained from NOAA December 2020; additional details provided in Metheny and Davis 2017.

[c] Data collected during Rhode Island Ocean Special Area Management Plan (RISAMP) surveys conducted in 2009 and 2010 and included in the Northwest Atlantic Seabird Catalog database. Data obtained from NOAA December 2020; additional details provided in Winiarski et al. 2011.

[d] Total number of observations during surveys; each observation represents one or more (e.g. pair, flock) individuals for which flight height was estimated.

[e] Proportion of observations within each estimated flight-height bin; note that reporting bins differed among datasets.

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