VINEYARD NORTHEAST

CONSTRUCTION AND OPERATIONS PLAN
VOLUME II APPENDIX

MARCH 2024

PREPARED BY:

Epsilon
ASSOCIATES INC.

SUBMITTED BY:

VINEYARD NORTHEAST LLC

VINEYARD OFFSHORE

PUBLIC VERSION

Vineyard Northeast COP

Appendix II-C Lease Area OCS-A 0522 Avian Assessment

Prepared by:
Biodiversity Research Institute

Prepared for:
Vineyard Northeast LLC

March 2024

Revision	Date	Description
0	July 2022	Initial submission.
1	March 2023	Updated to include a discussion of confidence in the exposure assessment data and make minor corrections.
2	November 2023	Updated to reflect revisions to the onshore Project Design Envelope.
2	March 2024	Resubmitted without revisions.

Appendix II-C

Lease Area OCS-A 0522 Avian Assessment

July 2022

Revised March 2023

Revised November 2023

Prepared by:

Biodiversity Research Institute

276 Canco Road

Portland, ME 04103

Table of Contents

List of Figures

List of Tables

List of Acronyms and Abbreviations

AI	automated
AS	adult survival score
AWWI	American Wind Wildlife Institute
BOEM	Bureau of Ocean Energy Management
CCSmax	continental combined score
COP	Construction and Operations Plan
CT DEEP	Connecticut Department of Energy and Environmental Protection
CV	collision vulnerability
dBBMM	dynamic Brownian-bridge movement model
DFA	diurnal flight activity
DV	displacement vulnerability
ESA	Endangered Species Act
ESP	electrical service platform
FEIS	Final Environmental Impact Statement
ft	feet
GF	Gaussian Field
GMRF	Gaussian Markov Random Field
GPS	Global Positioning System
GSD	ground survey distance
HVAC	high voltage alternating cable
INLA	integrated nested Laplace approximation
IPaC	Information for Planning and Consultation
IPF	impact producing factors
km	kilometer
LGCP	log Gaussian Cox Poisson
m	meter
MassCEC	Massachusetts Clean Energy Center
MDAT	Marine-life Data and Analysis Team
MDIFW	Maine Department of Inland Fisheries and Wildlife
mi	mile
MLLW	Mean Lower Low Water
MW	megawatt
NCCOS	National Center for Coastal Ocean Science
NFA	nocturnal flight activity
NLCD	National Land Cover Database
NM	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NYSERDA	New York State Energy Research and Development Authority
OCS	Outer Continental Shelf
OECC	offshore export cable corridor
OPD	Official Protraction Diagram

PC	penalized complexity
PiF	Partners in Flight
PTT	Argos platform terminal transmitter
PV	population vulnerability
QC	quality control
RSZ	rotor swept zone
SGCN	species of greatest conservation need
SPDE	stochastic partical differential equation
SSmax	state status
SDJV	Sea Duck Joint Venture
SWAP	State Wildlife Action Plan
UD	Utilization distribution
USFWS	United States Fish and Wildlife Service
VHF	very high frequency
WEA	Wind Energy Area
WTG	Wind Turbine Generator

1. Summary

Vineyard Northeast LLC (the "Proponent") proposes to develop, construct, and operate offshore renewable wind energy facilities in Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0522 (the "Lease Area") along with associated offshore and onshore transmission systems. This proposed development is referred to as "Vineyard Northeast." Vineyard Northeast includes 160 total wind turbine generator (WTG) and electrical service platform (ESP) positions within the Lease Area. Up to three of those positions will be occupied by ESPs and the remaining positions will be occupied by WTGs. Two offshore export cable corridors (OECCs) – the Massachusetts OECC and the Connecticut OECC - will connect the renewable wind energy facilities to onshore transmission systems in Massachusetts and Connecticut.

This appendix to the Construction and Operations Plan (COP) assesses the potential effects on birds from onshore and offshore components of Vineyard Northeast. Onshore, the potential effects on birds from activities in the Onshore Development Area was evaluated in a desktop study by assessing the degree that Vineyard Northeast components were co-occurring with existing development, the habitat that has the potential to be disturbed, and the birds that may occupy the habitat. Offshore, for each development phase, the assessment first describes impact-producing factors, the species that would potentially be exposed to impact-producing factors, and the vulnerability of the species exposed. Exposure and vulnerability were evaluated using multiple data sources, including: digital aerial surveys of the Lease Area, Massachusetts Clean Energy Center (MassCEC) aerial surveys, National Oceanic and Atmospheric Administration (NOAA) Marine Bird Distribution Models, individual tracking data, and relevant current literature.

Offshore, the Lease Area is west of the Nantucket Shoals, a shallow, sunlit area supporting a high abundance of benthic mollusks and amphipods that is known to provide important foraging areas for sea ducks and other marine birds throughout much of the year. During construction, operations, and decommissioning, coastal birds are expected to be ephemerally exposed during migration, and marine birds are expected to be exposed during all seasons. Of the coastal birds, shorebirds, wading birds, peregrine falcons, and songbirds are expected to generally have low exposure to the Lease Area, which will be limited to migration. Eagles are not expected in the Lease Area due to the distance from shore. Depending on the species, marine birds are expected to have a range of behavioral vulnerability with sea ducks, auks, terns, and loons having higher vulnerability to displacement, and gulls and cormorants having higher vulnerability to collision. Of the marine birds, Razorbill, Black-legged Kittiwake, and Cory's Shearwater had medium exposure while other species had minimal to low exposure. Sea ducks use the northeast section of the Lease Area, closest to the Nantucket Shoals, heavily in winter and spring.

Exposure of federally listed species is expected to be minimal to low and would largely be restricted to migration. Roseate Terns are expected to have minimal to low exposure, low vulnerability to collision, and medium to high vulnerability to displacement. Piping Plovers and Red Knots are expected to have minimal to low exposure and minimal to low vulnerability. These shorebird species may be exposed during migration periods, though flight heights during migration are thought to be generally well above rotor swept zones (RSZs). There was one detection of Black-capped Petrel in digital aerial surveys, but this species likely flies below the RSZ most of the time and generally remains well offshore along the shelf edge.

2. Introduction

This Appendix provides support for the avian assessment summary provided in Section 4.2 of COP Volume II. Section 3 provides supporting material for the onshore bird COP assessment; Section 4 focuses on birds in the offshore environment and includes details on seasonal densities of all birds exposed to the Lease Area OCS-A 0522 (referred to throughout as the Lease Area); Section 5 provides an overview of data sources and assessment methods; Section 6 lists literature cited; and Attachment A provides seasonal exposure maps for marine birds.

2.1. Project Description

Vineyard Northeast LLC (the "Proponent") proposes to develop, construct, and operate offshore renewable wind energy facilities in Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0522 (the "Lease Area") along with associated offshore and onshore transmission systems. This proposed development is referred to as "Vineyard Northeast." Vineyard Northeast includes 160 total wind turbine generator (WTG) and electrical service platform (ESP) positions within the Lease Area. Up to three of those positions will be occupied by ESPs and the remaining positions will be occupied by WTGs. Two offshore export cable corridors (OECCs) – the Massachusetts OECC and the Connecticut OECC – will connect the renewable wind energy facilities to onshore transmission systems in Massachusetts and Connecticut (Figure 2-1).

The WTGs, ESP(s), and their foundations as well as the inter-array cables, inter-link cables (if used), and a portion of the offshore export cables will be located in the Lease Area. The Lease Area is 536 km^2 (132,370 acres) in size and is located entirely in federal waters. At its closest point, the Lease Area is approximately 46 km (29 miles) from Nantucket and just over 64 km (40 mi) from Martha's Vineyard. Water depths in the Lease Area range from approximately 36–64 m (118–177 ft).

Between the Lease Area and shore, the offshore export cables will be installed within OECCs that connect to onshore transmission systems in Massachusetts and Connecticut. The OECCs traverse federal and state waters. The Massachusetts OECC includes a variation that connects to a booster station located in the northwestern aliquot of Lease Area OCS-A 0534 if high voltage alternating current (HVAC) offshore export cables are used in the Massachusetts OECC to boost the electricity's voltage level, reduce transmission losses, and enhance grid capacity. The potential booster station is located approximately 23 km (15 mi) from Martha's Vineyard and 27 km (17 mi) from Nantucket.

Vineyard Northeast will include onshore transmission systems in Massachusetts and Connecticut. Each onshore transmission system will ultimately include one landfall site, one onshore export cable route, one onshore substation site, and one grid interconnection cable route.

2.2. Methods Overview

2.2.1. Onshore

The potential effects on birds from activities in the Onshore Development Area was evaluated in a desktop study by assessing the degree that Vineyard Northeast components were co-occurring with existing development, the habitat that has the potential to be disturbed, and the birds that may occupy the habitat. Co-occurrence of the onshore cable route options with existing linear infrastructure was assessed in ArcGIS by calculating the percentage of the onshore cable routes that aligned with existing roads and transmissions lines. The habitat potentially to be disturbed in the Onshore Development Area was assessed by calculating the overlap of the onshore cable routes, with a 50 m (164 ft) buffer, with local habitat types. Species that may occur around the Onshore Development Area were predicted using the eBird database (Sullivan et al. 2009).

2.2.2. Offshore

For each group addressed under this assessment, species occurrence and area use were identified and evaluated using multiple data sources, including but not limited to: APEM digital aerial surveys of the Lease Area, MassCEC visual aerial surveys, integrated density models, National Oceanic and Atmospheric Administration (NOAA) Marine Bird Distribution Models, occurrence data, individual tracking data, relevant current literature, and species accounts. The results section of this Appendix addresses exposure and vulnerability of coastal birds and marine birds separately and includes maps, tables, and figures for each major taxonomic group.

Most species were assessed within general taxonomic groups (e.g., wading birds), however, species with federal listing status were individually assessed. Listed species, or candidate species, are Piping Plover (*Charadrius m. melodus*), Red Knot (*Calidris canutus rufa*), Roseate Tern (*Sterna dougallii*), and Black-capped Petrel (*Pterodroma hasitata*).

For the offshore assessment, a semi-quantitative approach was taken that first describes the species that would potentially be exposed to the Lease Area, the vulnerability of the species exposed, and then a final risk assessment (Figure 2-2). The assessment process was as follows (details provided in Section 5):

- *Exposure* – Exposure was assessed for each species and each taxonomic group, where 'exposure' is defined as the extent of overlap between a species' seasonal or annual distribution and the Lease Area. For species where site-specific data was available, a semi-quantitative exposure assessment was conducted. This exposure assessment was focused exclusively on the horizontal, or two-dimensional, likelihood that a bird would use the Lease Area. Exposure was evaluated by comparing the estimated bird density within the Lease Area to surrounding areas, on a local and regional scale, to provide a categorical exposure score of minimal, low, medium, or high. The local data came from the MassCEC aerial surveys, which cover the Massachusetts Wind Energy Area (MA WEA; Veit et al. 2016) and the regional data came from the version 2 of the Marine-life Data and Analysis Team (MDAT) marine bird relative density and distribution models (hereafter MDAT models; Curtice et al. 2016). Thirty-two Vineyard Northeast-specific digital aerial surveys, conducted from June 2019 to July 2021, provide data on tern use of the Lease Area, seasonal density estimates, and combined with the MassCEC aerial survey data, integrated taxonomic group distribution models. Analysis of individual tracking studies and records in the Northwest Atlantic Seabird Catalog were used to augment the exposure analysis. Details on each of the data sets and detailed methods used in the exposure assessment are found in Section 5. Due to gaps in knowledge on the relationship between the number of turbines and risk, this assessment analyzes the exposure of birds to the total area of development rather than to a specific number of turbines.[1]

- *Relative Vulnerability* – Vulnerability was then assessed for marine birds using a scoring process. For the purposes of this analysis, vulnerability is defined as the degree to which a species is expected to be affected by WTGs in the Lease Area, based on known behavioral responses to similar offshore developments. The relative collision vulnerability score (CV) includes proportion of time within the RSZ, a measure of avoidance, and flight activity, and the displacement vulnerability score (DV) includes two factors—disturbance and habitat flexibility. Flight heights used in the assessment were gathered from the OCS-A 0534 boat-based surveys (local) and non-digital aerial survey datasets in the Northwest Atlantic Seabird Catalog (regional). For each score, the factors were combined to create a score that was translated into four vulnerability categories: minimal, low, medium, and high (see Section 5 for details). The results provide a relative categorical vulnerability score among the species exposed to Vineyard Northeast—e.g., the species that are least likely to collide with turbines receive a minimal collision score—and are not intended to provide an absolute likelihood of collision or displacement.

- *Risk* – The likelihood that Vineyard Northeast would impact birds was then evaluated using a weight-of-evidence approach, by combining the exposure and vulnerability assessments (Table 2-1). Population vulnerability (PV) was considered in assigning a final risk category, where a risk score was adjusted up or down based on the overall conservation status of the population (discussed in detail in Section 5). For non-listed species, the assessment provides information for BOEM to make its impact determination at a population level, as has been done for assessments of Wind E nergy Areas (WEA; BOEM 2016) and the Vineyard Wind 1 Final Environmental Impact Statement (FEIS; BOEM 2021). For federally listed species, this assessment provides information on an individual level because the loss of one individual from the breeding population has a greater likelihood of affecting a population than for non-listed species.

---

[1] Risk may not increase in a linear manner as the number of turbines increases because birds' avoidance response may change as the numbers of turbines increases. Risk is also likely affected by the size and spacing of turbines: larger turbines have fewer revolutions than smaller turbines, may have a greater airgap between the water and the lowest blade position, and may be spaced much further apart. Thus, fewer larger turbines may pose a lower risk than many smaller turbines (Johnston et al. 2014).

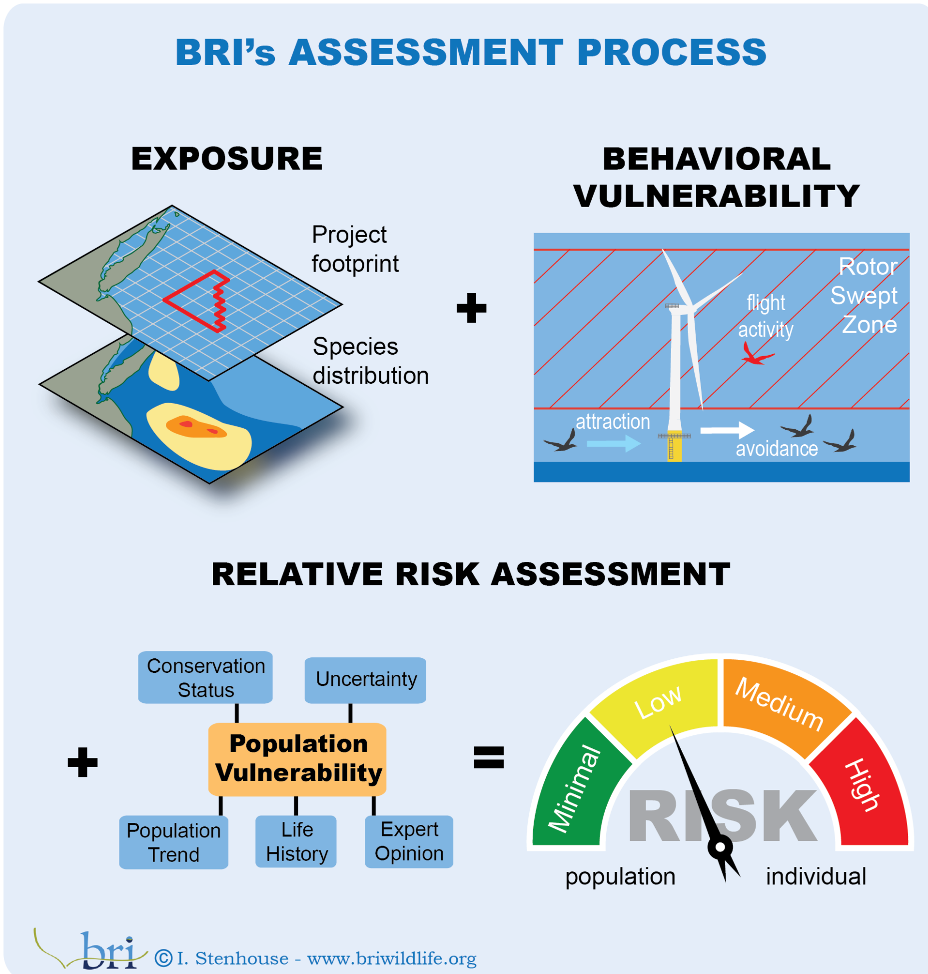


Figure 2-2: BRI's risk assessment process overview. An exposure and behavioral vulnerability assessment are combined using expert opinion to estimate relative risk.

Table 2-1: Final risk evaluation matrix. An initial risk determination is made based on vulnerability and exposure, and then the PV score is used to either keep the score the same, adjust the score up or down, or with a risk range eliminate the lower or upper portion of the range.

Exposure	Vulnerability (CV & DV)				*PV*
	Minimal	*Low*	*Medium*	*High*	
Minimal	Minimal	Minimal	Minimal	Minimal	
Low	Minimal	Low	Low	Low	
Medium	Minimal	Low	Medium	Medium	
High	Minimal	Low	Medium	High	
PV					

3. Onshore

Vineyard Northeast will include onshore transmission systems in Massachusetts and Connecticut. Each onshore transmission system will ultimately include one landfall site, one onshore export cable route, one onshore substation site, and one grid interconnection route. The potential locations of Vineyard Northeast's onshore facilities in Massachusetts and Connecticut are depicted Figure 3-1 and Figure 3-2, respectively.

The section includes supporting tables, maps, and figures for the assessment detailed in the COP for the Onshore Development Area (in both Massachusetts and Connecticut). This desktop study includes an assessment of the degree that Vineyard Northeast components are co-occurring with existing development, the habitat that has the potential to be disturbed, and the birds that may occupy the habitat. Additional information is provided on federally listed species.

3.1. Methods

3.1.1. Co-occurrence of Development and Habitat Assessment

Co-occurrence of the onshore cable routes with existing linear infrastructure was assessed in ArcGIS Pro (ESRI v2.9.3). Road centerlines for the State of Massachusetts were downloaded from MassGIS (Bureau of Geographic Information) and Connecticut road centerlines were downloaded from the CT DEEP GIS Open Data Website. The centerlines were then clipped to the buffered cable route layers. All road features that ran parallel to the cable route were manually selected and summed for total road length and percentage of total route length. These same methods were used to assess total and percentage co-occurrence with existing transmission line corridors using the Electrical Power Transmission Lines layer developed for the Homeland Infrastructure Foundation-Level Data[2] (See Table 3-1 and Table 3-6).

The habitat potentially to be disturbed by the onshore Vineyard Northeast components was assessed by calculating the overlap of the interconnection cable routes with local habitat types, and then by calculating the percentage each route was co-located with existing development as well as overlapping other landcover (habitat) types. The habitat types were determined for each cable route using the National Land Cover Database (NLCD).[3] A 50 m buffer was applied to either side of each proposed cable route. This buffer width was expected to account for potential disturbance across the construction right-of-way. The area of each landscape type within each buffered cable route was calculated by first intersecting the NLCD raster with buffered cable route using the crop function from package “Raster” (Hijmans 2020) in R version 4.1.1 (R Core Team 2021) and then summarizing the area covered by each landcover type in each route (See Table 3-2 and Table 3-7)

3.1.2. Avian Data Sources and Methods

Data on possible bird species present, including Red Knot and Piping Plover, were primarily compiled from eBird citizen science data (Sullivan et al. 2009) from within a 15 km (9.3 mi) buffer of the centroid of the Massachusetts Onshore Development Area and Connecticut Onshore Development Area, and were temporally constrained to the prior 10 years of data (2012-2022). In addition, the USFWS IPaC database (USFWS 2022) was queried using a polygon encompassing the entire Onshore Development Area.

3.1.3. Birds Likely to Occupy Existing Habitat

Due to the mobility of birds, a variety of species have the potential to pass through the habitats within or adjacent to the Onshore Development Area. Below, we provide species habitat associations obtained from species fact sheets from the BirdLife International Data Zone.[4] Table 3-3 includes species potentially present within the Horseneck BeachLandfall Site. Table 3-4 and Table 3-9 list all species detected at least 30 days over the last ten years (2012–2022) within 15 km (9.3 mi) of the centroid of the Onshore Development Area in the eBird database. Additionally, Table 3-6 and Table 3-10 respectively list species of greatest conservation need (SGCN) identified in the Massachusetts State Wildlife Action Plan (SWAP)[5] and the Connecticut SWAP[6] in 2015 for species detected at least 30 days over the last ten years within 15 km (9.3

---

[2] https://gii.dhs.gov/HIFLD
[3] https://www.mrlc.gov/data/nlcd-2016-land-cover-conus
[4] http://datazone.birdlife.org/species/search
[5] https://www.mass.gov/info-details/massachusetts-species-of-greatest-conservation-need-sgcn#birds
[6] https://portal.ct.gov/DEEP/Wildlife/CT-Wildlife-Action-Plan/CT-WAP-Current-Status#Review

mi)) of the centroid of the Onshore Development Area in the eBird database. State listed species for Massachusetts and Connecticut were found on each state’s Wildlife Action Plan webpage.

3.2. Results

3.2.1. Massachusetts

3.2.1.1. Co-occurrence with Existing Development and Habitat

Table 3-1: Road and transmission line co-occurrence with onshore cable route options.

Route Name	Co-occurrence[1] with Existing Roads and Transmission Lines		
	Total Length (km)	Co-located (km)	% of Total Length
Horseneck Beach Eastern Onshore Cable Route	28.65	28.65	100
Horseneck Beach Western Onshore Cable Route	30.69	30.69	100
Horseneck Beach Western Onshore Cable Route Variants	77.53	77.31	99.6

[1]Co-occurrance excludes areas of open water.

[2]Includes all five Horseneck Beach Western Onshore Cable Route Variants and portion of Horseneck Beach Western Onshore Cable Route from Horseneck Beach Landfall Site northwards to point where Variants branch off (near the intersection of Route 6 and Old Bedford Road).

Table 3-2: Habitat associations of onshore cable route options.

Route Name	Total Area (km^2)	Habitat Type (% of Total Area)							
		Open Water	Devel-oped	Barren Land[1]	Forested	Shrub	Grassland	Agricul-tural	Wetland
Horseneck Beach Eastern Onshore Cable Route	2.8665	1.7	51.21	1.57	30.92	0.41	0.57	0.34	13.28
Horseneck Beach Western Onshore Cable Route	3.0807	0.88	49.31	2.02	29.5	1.05	3.59	2.86	10.78
Horseneck Beach Western Onshore Cable Route Variants	8.1954	2.35	76.58	1.17	12.78	0.49	2.69	2.01	1.92

[1] Barren Land includes classifications of Dry Salt Flats, Beaches, Sandy Areas other than Beaches, Bare Exposed Rock, Strip Mines, Quarries, Gravel Pits, Transitional Areas, and Mixed Barren Land.

Table 3-3: Federally protected species eBird observations within the Horseneck Beach Landfall Site 2012-2022.

Landfall Site	Piping Plover	Roseate Tern	Red Knot
Horseneck Beach Landfall Site	606	15	0

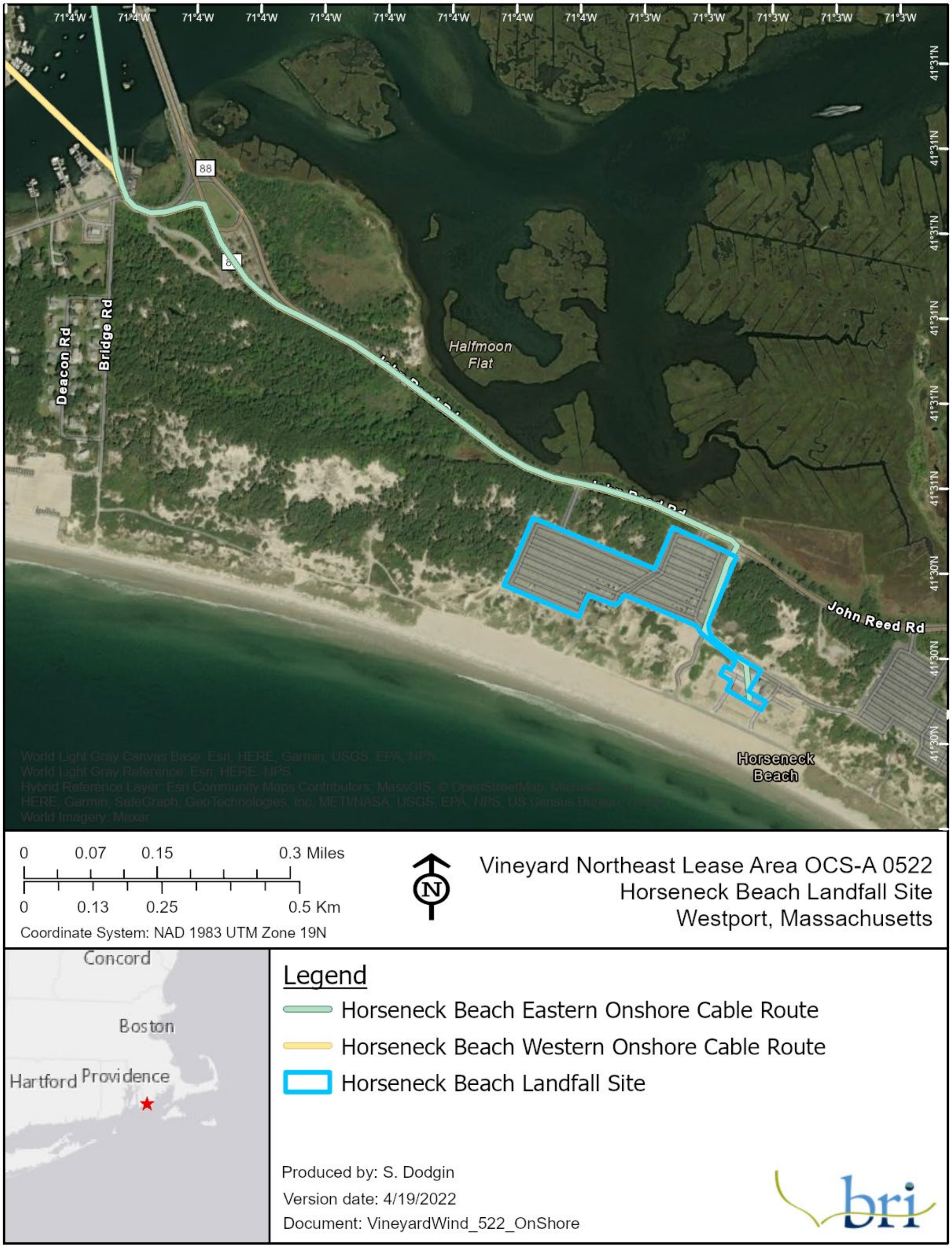


Figure 3-3: Potential Horseneck Beach Landfall Site

3.2.1.2. Threatened and Endangered Species

The analysis of Threatened and Endangered species focuses on the Red Knot (*Calidris canutus rufa*) and Piping Plover (*Charadrius melodus*), as beaches provide a key habitat for these species during breeding and/or migration. While Red Knot was not identified within the Horseneck Beach Landfall Site, based on eBird data, suitable habitat is present there and therefore discussion about this species has been included below. Based on the historical record, the Roseate Tern (*Sterna dougallii*) may occur infrequently in the area. However, although Roseate Terns breed on beaches, the specific beaches associated with proposed landfall locations are not integral to the life history of Roseate Terns, thus, this species is not included in the analysis.

3.2.1.2.1. Red Knot

In 2014, USFWS listed the North Atlantic subspecies of Red Knot as *Threatened* under the Endangered Species Act of 1973 (USFWS 2015). The *rufa* subspecies breeds in the Arctic and winters at sites as far south as Tierra del Fuego, Argentina. During both migrations, Red Knots use key staging and stopover areas to rest and feed where they utilize habitats including sandy coastal beaches, at or near tidal inlets, or the mouths of bays and estuaries, salt marshes, tidal mudflats, and sandy/gravel beaches where they feed on clams, crustaceans, and invertebrates. The highest numbers of Red Knots were detected in Massachusetts during fall migration (Figure 3-5). There is no mapped proposed critical habitat for Red Knots in the Massachusetts landfall site.

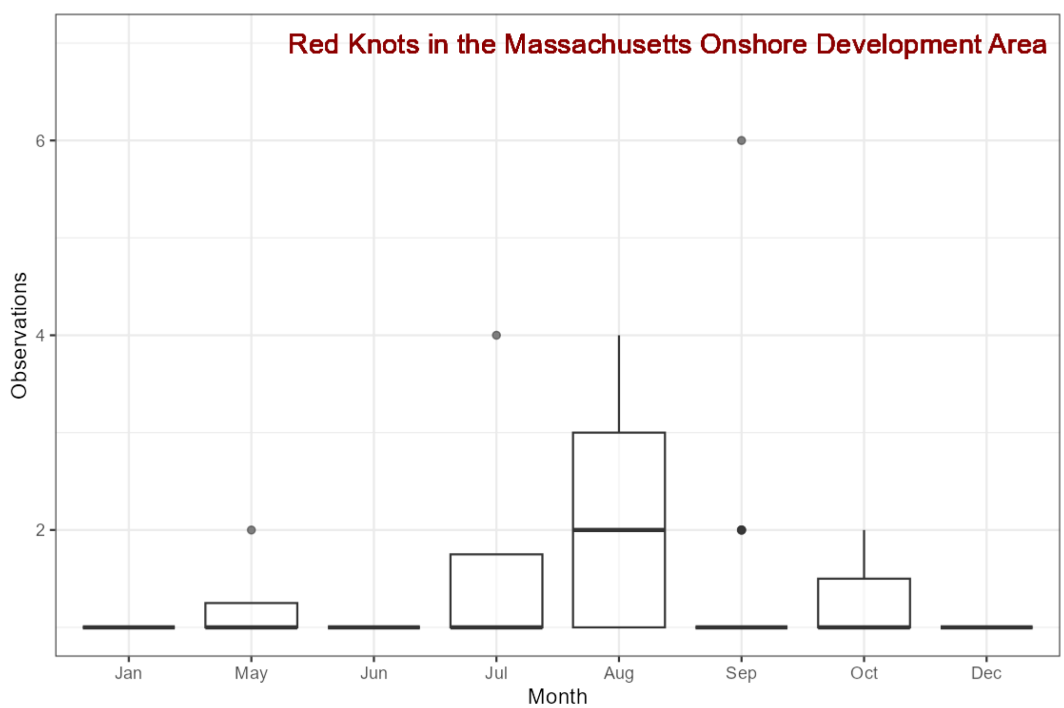


Figure 3-5: 10-year monthly total number of unique encounters (total detections) by eBird list (duplicate list postings removed) of Red Knots in coastal Massachusetts derived from the eBird database.

3.2.1.2.2. Piping Plover

The Atlantic Coast population of the Piping Plover was federally listed as Threatened in 1986 and is also listed by the State of Massachusetts. Piping Plovers nest on coastal beaches, sandflats at the ends of sand spits and barrier islands, gently sloped foredunes, sparsely vegetated dunes, and washover areas cut into or between dunes. Breeding Piping Plovers feed on exposed wet sand in wash zones, intertidal ocean beach, wrack lines, washover passes, mud, sand, and algal flats, and shorelines of streams, ephemeral ponds, lagoons, and salt marshes by probing for invertebrates at or just below the surface. They use beaches adjacent to foraging areas for roosting and preening. Small sand dunes, debris, and sparse vegetation within adjacent beaches provide shelter from wind and extreme temperatures. Most Piping Plovers arrive in Massachusetts in March and leave by October (Figure 3-6). The cable landfall sites overlap with Priority Habitat areas mapped by MassWildlife's Natural Heritage and Endangered Species Program, which may include Piping Plover nesting locations (Figure 3-7).

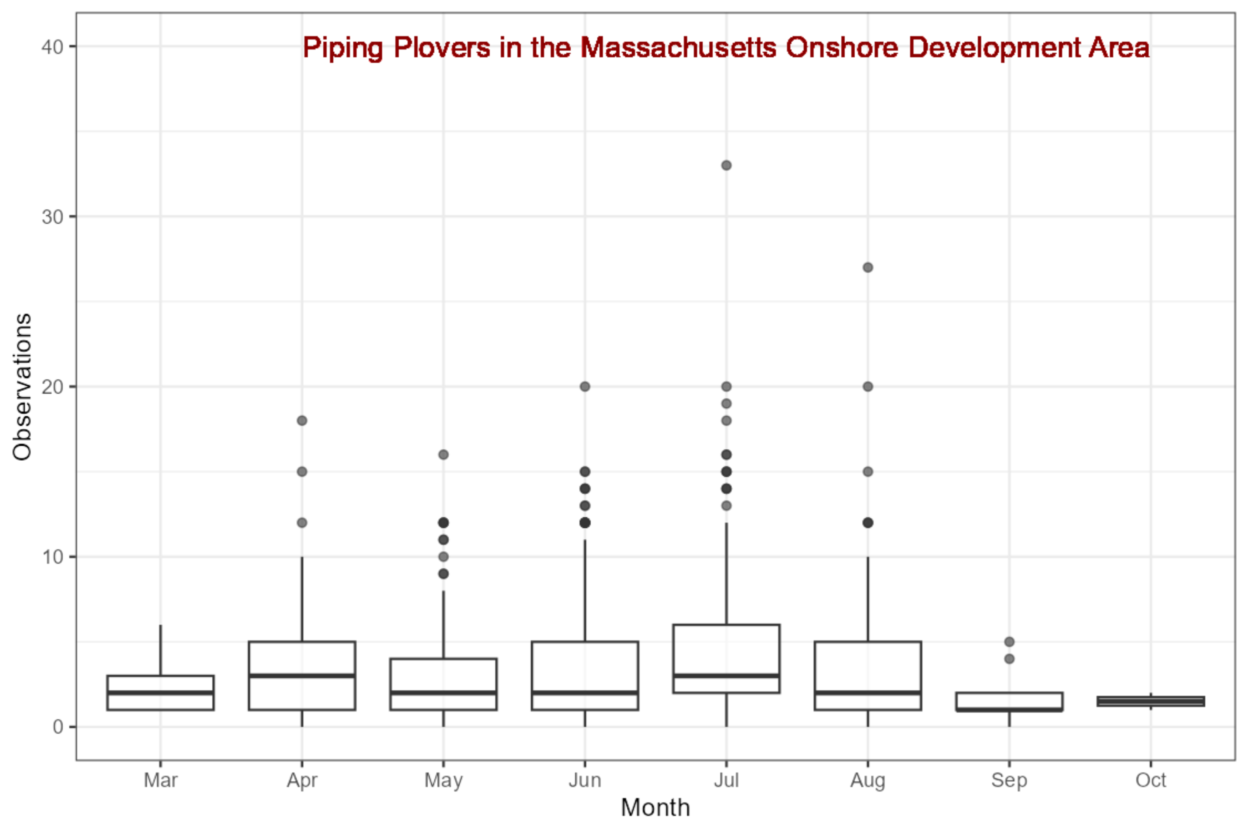


Figure 3-6: 10-year monthly total number of unique encounters (total detections) by eBird list (duplicate list postings removed) of Piping Plovers in coastal Massachusetts derived from the eBird database.

3.2.1.3. Species potentially present in the Massachusetts Onshore Development Area

Table 3-4: List of species observed by eBird users in the general Massachusetts Onshore Development Area, their primary and general breeding habitats, and presence.

Common Name	*Latin Name*	Primary Habitat	General Breeding Habitat
Snow Goose	*Anser caerulescens*	Terrestrial	Grassland
Pink-footed Goose	*Anser brachyrhynchus*	Artificial, Terrestrial	Arable Land
Brant	*Branta bernicla*	Terrestrial	Grassland
Cackling Goose	*Branta hutchinsii*	Terrestrial	Grassland
Canada Goose	*Branta canadensis*	Terrestrial, Aquatic	Grassland, Wetland
Mute Swan	*Cygnus olor*	Aquatic	Coastal/Supratidal, Wetland
Tundra Swan	*Cygnus columbianus*	Artificial, Terrestrial	Arable Land
Wood Duck	*Aix sponsa*	Terrestrial, Aquatic	Forest, Wetland
Blue-winged Teal	*Spatula discors*	Aquatic	Marine, Wetland
Northern Shoveler	*Spatula clypeata*	Freshwater	Wetland
Gadwall	*Mareca strepera*	Freshwater	Wetland
Eurasian Wigeon	*Mareca penelope*	Freshwater	Wetland
American Wigeon	*Mareca americana*	Freshwater	Wetland
Mallard	*Anas platyrhynchos*	Aquatic	Marine, Wetland
American Black Duck	*Anas rubripes*	Freshwater	Wetland
Northern Pintail	*Anas acuta*	Freshwater	Wetland
Green-winged Teal	*Anas crecca*	Freshwater	Wetland
Canvasback	*Aythya valisineria*	Freshwater	Wetland
Ring-necked Duck	*Aythya collaris*	Freshwater	Wetland
Greater Scaup	*Aythya marila*	Marine	Marine
Lesser Scaup	*Aythya affinis*	Freshwater	Wetland
King Eider	*Somateria spectabilis*	Freshwater, Marine	Marine, Wetland
Common Eider	*Somateria mollissima*	Marine	Intertidal
Harlequin Duck	*Histrionicus histrionicus*	Freshwater	Wetland
Surf Scoter	*Melanitta perspicillata*	Freshwater	Wetland
White-winged Scoter	*Melanitta deglandi*	Freshwater	Wetland
Black Scoter	*Melanitta americana*	Freshwater	Wetland
Long-tailed Duck	*Clangula hyemalis*	Terrestrial	Grassland
Bufflehead	*Bucephala albeola*	Terrestrial, Aquatic	Forest, Wetland
Common Goldeneye	*Bucephala clangula*	Terrestrial	Forest
Hooded Merganser	*Lophodytes cucullatus*	Terrestrial, Aquatic	Forest, Wetland
Common Merganser	*Mergus merganser*	Freshwater	Wetland
Red-breasted Merganser	*Mergus serrator*	Freshwater	Wetland
Ruddy Duck	*Oxyura jamaicensis*	Freshwater	Wetland
Wild Turkey	*Meleagris gallopavo*	Terrestrial	Forest, Grassland, Shrubland
Ring-necked Pheasant	*Phasianus colchicus*	Terrestrial	Forest, Grassland, Shrubland
Pied-billed Grebe	*Podilymbus podiceps*	Freshwater	Wetland
Horned Grebe	*Podiceps auritus*	Freshwater	Wetland
Red-necked Grebe	*Podiceps grisegena*	Freshwater	Wetland
Rock Pigeon	*Columba livia*	Terrestrial	Artificial
Mourning Dove	*Zenaida macroura*	Terrestrial	Forest, Grassland, Shrubland l
Yellow-billed Cuckoo	*Coccyzus americanus*	Terrestrial	Forest

Common Name	*Latin Name*	Primary Habitat	General Breeding Habitat
Black-billed Cuckoo	*Coccyzus erythropthalmus*	Terrestrial	Forest, Shrubland
Common Nighthawk	*Chordeiles minor*	Terrestrial	Grassland
Eastern Whip-poor-will	*Antrostomus vociferus*	Terrestrial	Forest
Chimney Swift	*Chaetura pelagica*	Terrestrial	Artificial, Forest
Ruby-throated Hummingbird	*Archilochus colubris*	Terrestrial	Forest
Clapper Rail	*Rallus crepitans*	Marine Intertidal	Intertidal
Virginia Rail	*Rallus limicola*	Freshwater	Wetland
American Coot	*Fulica americana*	Freshwater	Wetland
American Oystercatcher	*Haematopus palliatus*	Marine Intertidal	Intertidal
Black-bellied Plover	*Pluvialis squatarola*	Terrestrial	Grassland
American Golden-Plover	*Pluvialis dominica*	Terrestrial	Grassland, Marine Intertidal
Semipalmated Plover	*Charadrius semipalmatus*	Marine Intertidal	Intertidal
Piping Plover	*Charadrius melodus*	Coastal	Coastal/Supratidal, Wetland
Killdeer	*Charadrius vociferus*	Freshwater	Wetland
Whimbrel	*Numenius phaeopus*	Terrestrial	Forest, Grassland, Shrubland
Ruddy Turnstone	*Arenaria interpres*	Terrestrial, Aquatic	Grassland, Wetland
Red Knot	*Calidris canutus*	Marine Intertidal	Tundra
Sanderling	*Calidris alba*	Terrestrial	Grassland
Dunlin	*Calidris alpina*	Intertidal, Freshwater	Intertidal, Wetland
Purple Sandpiper	*Calidris maritima*	Intertidal, Freshwater	Grassland, Marine, Wetland
Least Sandpiper	*Calidris minutilla*	Terrestrial, Freshwater	Forest, Grassland, Shrubland, Wetland
White-rumped Sandpiper	*Calidris fuscicollis*	Freshwater	Wetland
Pectoral Sandpiper	*Calidris melanotos*	Terrestrial, Aquatic	Grassland, Wetland
Semipalmated Sandpiper	*Calidris pusilla*	Terrestrial, Aquatic	Grassland, Wetland
Short-billed Dowitcher	*Limnodromus griseus*	Intertidal	Intertidal
American Woodcock	*Scolopax minor*	Terrestrial	Forest
Wilson's Snipe	*Gallinago delicata*	Terrestrial, Aquatic	Forest, Wetland
Spotted Sandpiper	*Actitis macularius*	Freshwater	Wetland
Solitary Sandpiper	*Tringa solitaria*	Terrestrial	Grassland
Greater Yellowlegs	*Tringa melanoleuca*	Terrestrial, Aquatic	Forest, Shrubland, Wetland
Willet	*Tringa semipalmata*	Coastal	Intertidal, Wetland
Lesser Yellowlegs	*Tringa flavipes*	Terrestrial, Aquatic	Shrubland, Wetland
Bonaparte's Gull	*Chroicocephalus philadelphia*	Terrestrial, Aquatic	Forest, Wetland
Razorbill	*Alca torda*	Marine	Intertidal
Laughing Gull	*Leucophaeus atricilla*	Marine	Intertidal
Ring-billed Gull	*Larus delawarensis*	Terrestrial, Aquatic	Grassland, Wetland
Herring Gull	*Larus argentatus*	Terrestrial, Aquatic	Coastal, Intertidal
Iceland Gull	*Larus glaucoides*	Coastal	Coastal, Intertidal
Lesser Black-backed Gull	*Larus fuscus*	Coastal	Coastal, Intertidal
Glaucous Gull	*Larus hyperboreus*	Coastal	Coastal, Intertidal
Great Black-backed Gull	*Larus marinus*	Coastal	Coastal, Marine
Least Tern	*Sternula antillarum*	Marine	Marine
Caspian Tern	*Hydroprogne caspia*	Marine	Marine
Black Tern	*Chlidonias niger*	Artificial, Marine	Coastal, Supratidal
Roseate Tern	*Sterna dougallii*	Marine	Marine
Common Tern	*Sterna hirundo*	Marine	Marine

Common Name	*Latin Name*	Primary Habitat	General Breeding Habitat
Forster's Tern	*Sterna forsteri*	Marine	Marine
Red-throated Loon	*Gavia stellata*	Freshwater	Marine, Wetland
Common Loon	*Gavia immer*	Freshwater	Marine, Wetland
Cory's Shearwater	*Calonectris diomedea*	Marine	Coastal, Marine, Oceanic
Great Shearwater	*Ardenna gravis*	Marine	Coastal, Marine, Oceanic
Northern Gannet	*Morus bassanus*	Marine	Coastal, Marine, Oceanic
Great Cormorant	*Phalacrocorax carbo*	Aquatic	Forest, Marine, Wetland
Double-crested Cormorant	*Nannopterum auritum*	Marine	Marine
American Bittern	*Botaurus lentiginosus*	Freshwater	Wetland
Great Blue Heron	*Ardea herodias*	Freshwater	Wetland
Great Egret	*Ardea alba*	Terrestrial, Aquatic	Grassland, Wetland
Snowy Egret	*Egretta thula*	Freshwater	Wetland
Green Heron	*Butorides virescens*	Freshwater	Wetland
Black-crowned Night-Heron	*Nycticorax nycticorax*	Terrestrial, Aquatic	Forest, Intertidal, Wetland
Yellow-crowned Night-Heron	*Nyctanassa violacea*	Terrestrial, Aquatic	Forest, Intertidal, Wetland
Glossy Ibis	*Plegadis falcinellus*	Freshwater	Wetland
Black Vulture	*Coragyps atratus*	Terrestrial	Artificial
Turkey Vulture	*Cathartes aura*	Terrestrial	Forest, Grassland, Shrubland
Osprey	*Pandion haliaetus*	Terrestrial, Aquatic	Forest, Coastal, Wetland
Northern Harrier	*Circus hudsonius*	Terrestrial	Forest, Grassland, Shrubland
Sharp-shinned Hawk	*Accipiter striatus*	Terrestrial	Forest, Grassland, Shrubland
Cooper's Hawk	*Accipiter cooperii*	Terrestrial	Forest
Bald Eagle	*Haliaeetus leucocephalus*	Freshwater	Wetland
Red-shouldered Hawk	*Buteo lineatus*	Terrestrial	Forest
Broad-winged Hawk	*Buteo platypterus*	Terrestrial	Forest
Red-tailed Hawk	*Buteo jamaicensis*	Terrestrial	Forest, Grassland, Shrubland
Eastern Screech-Owl	*Megascops asio*	Terrestrial	Forest
Great Horned Owl	*Bubo virginianus*	Terrestrial	Forest, Shrubland
Snowy Owl	*Bubo scandiacus*	Terrestrial	Coastal/Supratidal
Barred Owl	*Strix varia*	Terrestrial	Forest
Northern Saw-whet Owl	*Aegolius acadicus*	Artificial, Terrestrial	Forest
Belted Kingfisher	*Megaceryle alcyon*	Freshwater	Wetland
Yellow-bellied Sapsucker	*Sphyrapicus varius*	Terrestrial	Forest
Red-bellied Woodpecker	*Melanerpes carolinus*	Terrestrial	Forest
Downy Woodpecker	*Dryobates pubescens*	Terrestrial	Forest
Hairy Woodpecker	*Dryobates villosus*	Terrestrial	Forest
Pileated Woodpecker	*Dryocopus pileatus*	Terrestrial	Forest
Northern Flicker	*Colaptes auratus*	Terrestrial	Forest
American Kestrel	*Falco sparverius*	Terrestrial	Forest, Grassland, Shrubland
Merlin	*Falco columbarius*	Terrestrial	Forest, Grassland, Shrubland
Peregrine Falcon	*Falco peregrinus*	Terrestrial	Rocky Cliffs
Eastern Wood-Pewee	*Contopus virens*	Terrestrial	Forest
Acadian Flycatcher	*Empidonax virescens*	Terrestrial	Forest
Willow Flycatcher	*Empidonax traillii*	Terrestrial	Shrubland
Least Flycatcher	*Empidonax minimus*	Terrestrial	Forest
Eastern Phoebe	*Sayornis phoebe*	Terrestrial	Forest
Great Crested Flycatcher	*Myiarchus crinitus*	Terrestrial	Forest
Eastern Kingbird	*Tyrannus tyrannus*	Terrestrial, Terrestrial	Forest, Shrubland

Common Name	*Latin Name*	Primary Habitat	General Breeding Habitat
White-eyed Vireo	*Vireo griseus*	Terrestrial	Shrubland
Yellow-throated Vireo	*Vireo flavifrons*	Terrestrial	Forest
Blue-headed Vireo	*Vireo solitarius*	Terrestrial	Forest
Philadelphia Vireo	*Vireo philadelphicus*	Terrestrial	Forest
Warbling Vireo	*Vireo gilvus*	Terrestrial, Aquatic	Forest, Wetland
Red-eyed Vireo	*Vireo olivaceus*	Terrestrial	Forest
Northern Shrike	*Lanius borealis*	Desert	Forest
Blue Jay	*Cyanocitta cristata*	Terrestrial	Forest
American Crow	*Corvus brachyrhynchos*	Terrestrial	Forest, Grassland, Shrubland
Fish Crow	*Corvus ossifragus*	Terrestrial, Aquatic	Grassland, Wetland
Common Raven	*Corvus corax*	Terrestrial	Forest, Rocky Cliffs
Black-capped Chickadee	*Poecile atricapillus*	Terrestrial	Forest
Tufted Titmouse	*Baeolophus bicolor*	Terrestrial	Forest
Horned Lark	*Eremophila alpestris*	Terrestrial	Grassland, Shrubland
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Terrestrial	Rocky Cliffs, Wetland
Purple Martin	*Progne subis*	Terrestrial	Forest
Tree Swallow	*Tachycineta bicolor*	Freshwater	Wetland
Bank Swallow	*Riparia riparia*	Terrestrial, Aquatic	Grassland, Wetland
Barn Swallow	*Hirundo rustica*	Terrestrial, Aquatic	Grassland, Wetland
Cliff Swallow	*Petrochelidon pyrrhonota*	Artificial, Terrestrial	Arable Land
Ruby-crowned Kinglet	*Corthylio calendula*	Terrestrial	Forest
Golden-crowned Kinglet	*Regulus satrapa*	Terrestrial	Forest
Red-breasted Nuthatch	*Sitta canadensis*	Terrestrial	Forest
White-breasted Nuthatch	*Sitta carolinensis*	Terrestrial	Forest
Brown Creeper	*Certhia americana*	Terrestrial	Forest
Blue-gray Gnatcatcher	*Polioptila caerulea*	Terrestrial	Forest
House Wren	*Troglodytes aedon*	Terrestrial	Forest, Shrubland
Winter Wren	*Troglodytes hiemalis*	Terrestrial	Forest
Marsh Wren	*Cistothorus palustris*	Freshwater	Wetland
Carolina Wren	*Thryothorus ludovicianus*	Terrestrial	Forest
European Starling	*Sturnus vulgaris*	Terrestrial	Forest, Grassland, Shrubland
Gray Catbird	*Dumetella carolinensis*	Terrestrial	Shrubland
Brown Thrasher	*Toxostoma rufum*	Terrestrial	Shrubland
Northern Mockingbird	*Mimus polyglottos*	Terrestrial	Shrubland
Eastern Bluebird	*Sialia sialis*	Terrestrial	Forest
Townsend's Solitaire	*Myadestes townsendi*	Terrestrial	Forest
Veery	*Catharus fuscescens*	Terrestrial	Forest
Swainson's Thrush	*Catharus ustulatus*	Terrestrial	Forest
Hermit Thrush	*Catharus guttatus*	Terrestrial	Forest
Wood Thrush	*Hylocichla mustelina*	Terrestrial	Forest
American Robin	*Turdus migratorius*	Terrestrial	Forest
Cedar Waxwing	*Bombycilla cedrorum*	Terrestrial	Forest
House Sparrow	*Passer domesticus*	Terrestrial	Forest, Grassland, Shrubland
American Pipit	*Anthus rubescens*	Terrestrial	Grassland, Rocky Cliffs
Evening Grosbeak	*Coccothraustes vespertinus*	Terrestrial	Forest
House Finch	*Haemorhous mexicanus*	Terrestrial	Shrubland
Purple Finch	*Haemorhous purpureus*	Terrestrial	Forest
Common Redpoll	*Acanthis flammea*	Terrestrial	Forest

Common Name	*Latin Name*	Primary Habitat	General Breeding Habitat
Red Crossbill	*Loxia curvirostra*	Terrestrial	Forest
Pine Siskin	*Spinus pinus*	Terrestrial	Forest
American Goldfinch	*Spinus tristis*	Terrestrial	Forest, Grassland, Shrubland
Snow Bunting	*Plectrophenax nivalis*	Terrestrial	Grassland
Chipping Sparrow	*Spizella passerina*	Terrestrial	Forest, Grassland, Shrubland
Clay-colored Sparrow	*Spizella pallida*	Terrestrial	Temperate, Grassland
Field Sparrow	*Spizella pusilla*	Terrestrial	Forest, Grassland, Shrubland
American Tree Sparrow	*Spizelloides arborea*	Terrestrial, Aquatic	Grassland, Shrubland, Wetland
Fox Sparrow	*Passerella iliaca*	Terrestrial	Forest
Dark-eyed Junco	*Junco hyemalis*	Terrestrial	Forest
White-crowned Sparrow	*Zonotrichia leucophrys*	Terrestrial	Forest, Grassland, Shrubland
White-throated Sparrow	*Zonotrichia albicollis*	Terrestrial	Forest, Shrubland
Seaside Sparrow	*Ammospiza maritima*	Coastal	Intertidal
Saltmarsh Sparrow	*Ammospiza caudacuta*	Coastal	Intertidal
Savannah Sparrow	*Passerculus sandwichensis*	Coastal	Coastal/Supratidal
Song Sparrow	*Melospiza melodia*	Coastal	Intertidal
Lincoln's Sparrow	*Melospiza lincolnii*	Terrestrial, Aquatic	Grassland, Shrubland, Wetland
Swamp Sparrow	*Melospiza georgiana*	Freshwater	Wetland
Eastern Towhee	*Pipilo erythrophthalmus*	Terrestrial	Forest
Yellow-breasted Chat	*Icteria virens*	Terrestrial	Forest
Bobolink	*Dolichonyx oryzivorus*	Terrestrial	Grassland
Eastern Meadowlark	*Sturnella magna*	Terrestrial	Grassland, Shrubland
Orchard Oriole	*Icterus spurius*	Terrestrial	Forest, Savanna
Baltimore Oriole	*Icterus galbula*	Terrestrial	Forest, Grassland
Red-winged Blackbird	*Agelaius phoeniceus*	Freshwater	Wetland
Brown-headed Cowbird	*Molothrus ater*	Terrestrial	Forest, Grassland
Rusty Blackbird	*Euphagus carolinus*	Freshwater	Wetland
Common Grackle	*Quiscalus quiscula*	Terrestrial	Forest, Shrubland, Wetland
Ovenbird	*Seiurus aurocapilla*	Terrestrial	Forest
Worm-eating Warbler	*Helmitheros vermivorum*	Terrestrial	Forest
Northern Waterthrush	*Parkesia noveboracensis*	Freshwater	Wetland
Blue-winged Warbler	*Vermivora cyanoptera*	Terrestrial	Grassland
Black-and-white Warbler	*Mniotilta varia*	Terrestrial	Forest
Tennessee Warbler	*Leiothlypis peregrina*	Terrestrial	Forest, Shrubland
Orange-crowned Warbler	*Leiothlypis celata*	Terrestrial	Shrubland
Nashville Warbler	*Leiothlypis ruficapilla*	Terrestrial	Forest
Common Yellowthroat	*Geothlypis trichas*	Freshwater	Wetland
Hooded Warbler	*Setophaga citrina*	Terrestrial	Forest
American Redstart	*Setophaga ruticilla*	Terrestrial	Forest
Cape May Warbler	*Setophaga tigrina*	Terrestrial	Forest
Northern Parula	*Setophaga americana*	Terrestrial	Forest
Magnolia Warbler	*Setophaga magnolia*	Terrestrial	Forest
Bay-breasted Warbler	*Setophaga castanea*	Terrestrial	Forest
Blackburnian Warbler	*Setophaga fusca*	Terrestrial	Forest
Yellow Warbler	*Setophaga petechia*	Terrestrial	Forest, Shrubland
Chestnut-sided Warbler	*Setophaga pensylvanica*	Terrestrial	Forest, Shrubland
Blackpoll Warbler	*Setophaga striata*	Terrestrial	Forest
Black-throated Blue Warbler	*Setophaga caerulescens*	Terrestrial	Forest

Common Name	*Latin Name*	Primary Habitat	General Breeding Habitat
Palm Warbler	*Setophaga palmarum*	Freshwater	Wetland
Pine Warbler	*Setophaga pinus*	Terrestrial	Forest
Yellow-rumped Warbler	*Setophaga coronata*	Terrestrial	Forest
Prairie Warbler	*Setophaga discolor*	Terrestrial	Shrubland
Black-throated Green Warbler	*Setophaga virens*	Terrestrial	Forest
Canada Warbler	*Cardellina canadensis*	Terrestrial	Forest
Wilson's Warbler	*Cardellina pusilla*	Terrestrial	Forest, Grassland, Shrubland
Scarlet Tanager	*Piranga olivacea*	Terrestrial	Forest
Northern Cardinal	*Cardinalis cardinalis*	Terrestrial	Shrubland
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Terrestrial	Forest
Indigo Bunting	*Passerina cyanea*	Terrestrial	Forest
Dickcissel	*Spiza americana*	Terrestrial	Grassland

Table 3-5: List of species of conservation concern observed by eBird users in the general Massachusetts Onshore Development Area.

Common Name	*Latin Name*	Federal	State	IPaC
Ducks, Geese, and Swans				
Common Eider	*Somateria mollissima*			•
Surf Scoter	*Melanitta perspicillata*			•
White-winged Scoter	*Melanitta deglandi*			•
Black Scoter	*Melanitta americana*			•
Long-tailed Duck	*Clangula hyemalis*			•
Red-breasted Merganser	*Mergus serrator*			•
Grebes				
Pied-billed Grebe	*Podilymbus podiceps*	None	Endangered	
Cuckoos				
Black-billed Cuckoo	*Coccyzus erythropthalmus*			•
Nightjars				
Common Nighthawk	*Chordeiles minor*	None	Endangered	
Shorebirds				
American Oystercatcher	*Haematopus palliatus*			•
Piping Plover	*Charadrius melodus*	Threatened	Threatened	•
Ruddy Turnstone	*Arenaria interpres*			•
Purple Sandpiper	*Calidris maritima*			•
Short-billed Dowitcher	*Limnodromus griseus*			•
Willet	*Tringa semipalmata*			•
Lesser Yellowlegs	*Tringa flavipes*			•
Auks				
Razorbill	*Alca torda*			•
Gulls and Terns				
Ring-billed Gull	*Larus delawarensis*			•
Least Tern	*Sternula antillarum*	None	Threatened	

Common Name	*Latin Name*	Federal	State	IPaC
Roseate Tern	*Sterna dougallii*	Endangered	Endangered	•
Common Tern	*Sterna hirundo*	None	Special Concern	
Loons				
Red-throated Loon	*Gavia stellata*			•
Common Loon	*Gavia immer*	None	Special Concern	•
Cormorants				
Double-crested Cormorant	*Nannopterum auritum*			•
Herons, Egrets, and Bitterns				
Great Egret	*Ardea alba*	None	Threatened	
Snowy Egret	*Egretta thula*	None	Threatened	
Little Blue Heron	*Egretta caerulea*	None	Special Concern	
Raptors				
Northern Harrier	*Circus hudsonius*	None	Endangered	
Sharp-shinned Hawk	*Accipiter striatus*	None	Endangered	
Bald Eagle	*Haliaeetus leucocephalus*	Bald and Golden Eagle Protection Act	Threatened	•
American Kestrel	*Falco sparverius*	None	Special Concern	
Peregrine Falcon	*Falco peregrinus*	None	Threatened	
Passerines				
Horned Lark	*Eremophila alpestris*	None	Endangered	
Wood Thrush	*Hylocichla mustelina*			•
Saltmarsh Sparrow	*Ammospiza caudacuta*	None	Special Concern	
Savannah Sparrow (Ipswich Sparrow)	*Passerculus sandwichensis*	None	Special Concern	
Swamp Sparrow (Coastal Plain Swamp Sparrow)	*Melospiza georgiana*	None	Special Concern	
Yellow-breasted Chat	*Icteria virens*	None	Endangered	
Bobolink	*Dolichonyx oryzivorus*	None	Special Concern	•
Rusty Blackbird	*Euphagus carolinus*			•
Blue-winged Warbler	*Vermivora cyanoptera*			•
Prairie Warbler	*Setophaga discolor*			•
Canada Warbler	*Cardellina canadensis*			•

3.2.2. Connecticut

3.2.2.1. Co-occurrence with existing development and habitat

Table 3-6: Road and transmission line co-occurrence with onshore cable route options.

Route Name	Co-occurrence with Existing Roads and Transmission Lines		
	Total Length (km)	Co-located (km)	% of Total Length
Eastern Point Beach Onshore Cable Route	22.27	22.27	100
Ocean Beach Onshore Cable Route	20.07	20.07	100
Niantic Beach Onshore Cable Route	19.7	19.7	100

Table 3-7: Habitat associations of onshore cable options.

Route Name	Total Area (km^2)	Habitat Type (% of Total Area)							
		Open Water	Devel-oped	Barren Land[1]	Forested	Shrub	Grassland	Agricul-tural	Wetland
Eastern Point Beach Onshore Cable Route	2.230	3.87	37.4	0.08	53.9	0.52	1.13	0.28	2.74
Ocean Beac Onshore Cable Routeh	2.003	0.22	90.5	0.18	7.27	0.49	0.36	0.08	0.9
Niantic Beach Onshore Cable Route	1.970	0.91	86.0	0.41	10.3	0.5	0.37	0.1	1.41

[1] Barren Land includes classifications of Dry Salt Flats, Beaches, Sandy Areas other than Beaches, Bare Exposed Rock, Strip Mines, Quarries, Gravel Pits, Transitional Areas, and Mixed Barren Land.

Table 3-8: Federally protected species eBird observations within the landfall sites 2012-2022.

Route Name	Piping Plover	Roseate Tern	Red Knot
Eastern Point Beach Landfall Site	2	0	0
Ocean Beach Landfall Site	9	1	0
Niantic Beach Landfall Site	2	32	0

Figure 3-8: Potential Eastern Point Beach Landfall Site.

Figure 3-9: Potential Niantic Beach Landfall Site.

Figure 3-10: Potential Ocean Beach Landfall Site.

3.2.2.2. Threatened and Endangered Species

The analysis of Threatened and Endangered species focuses on the Red Knot (*Calidris canutus rufa*) and Piping Plover (*Charadrius melodus*), as beaches provide a key habitat for these species during breeding and/or migration. While Red Knot was not identified within the three landfall site options, based on eBird data, suitable habitat is present there and therefore discussion about this species has been included below. Based on the historical record, the Roseate Tern (*Sterna dougallii*) may occur infrequently in the area. However, although Roseate Terns breed on beaches, the specific beaches associated with proposed landfall locations are not integral to the life history of Roseate Terns, thus, this species is not included in the analysis.

3.2.2.2.1. Red Knot

The highest numbers of Red Knots are detected during spring and fall migration (Figure 3-12). There is no mapped proposed critical habitat for Red Knots in the Connecticut cable landfall sites.

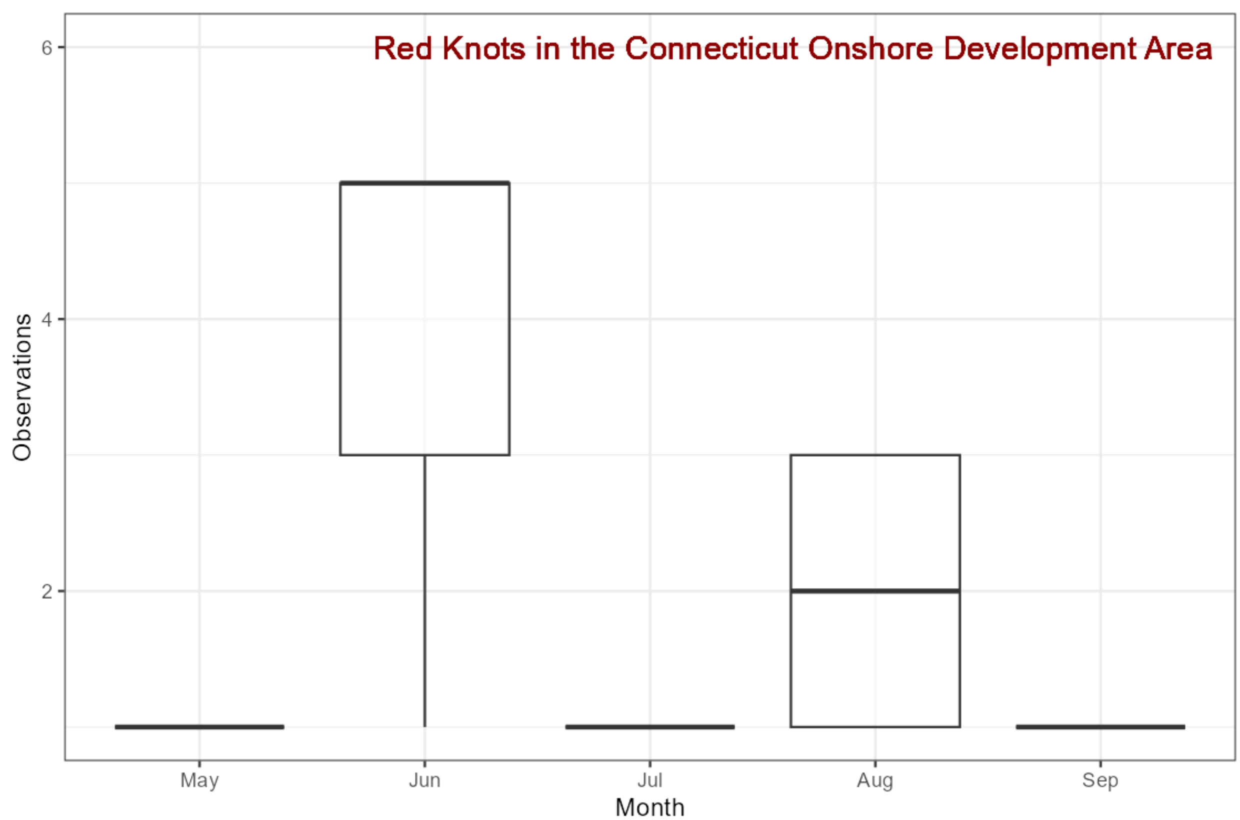


Figure 3-12: 10-year monthly total number of unique encounters (total detections) by eBird list (duplicate list postings removed) of Red Knots in coastal Connecticut derived from the eBird database.

3.2.2.2.2. Piping Plover

Piping Plovers arrive in Connecticut in March and leave by September (Figure 3-13). The cable landfall sites overlap with Critical Habitat areas mapped by the Connecticut Department of Energy and Environmental Protection (Figure 3-14). The area around Ocean Beach Park includes sand beaches, which could potentially be used by Piping Plovers.

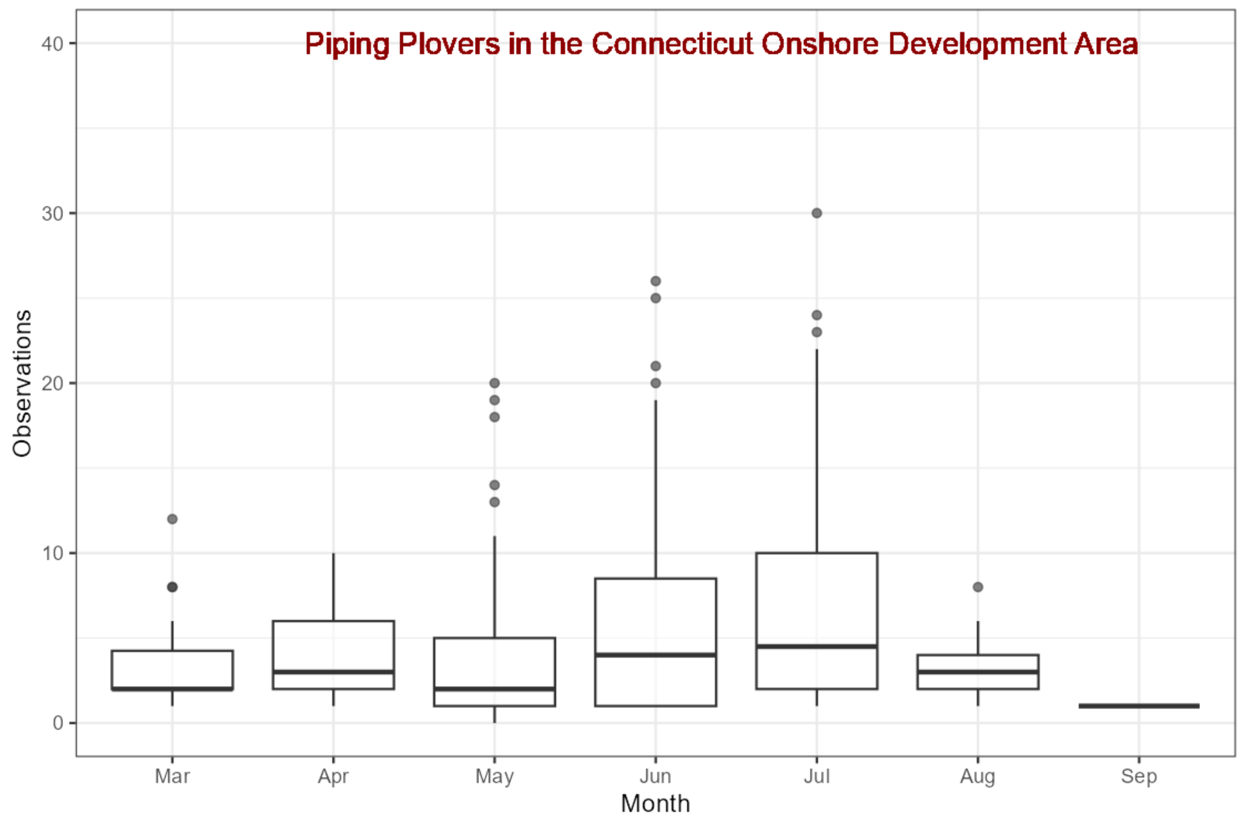


Figure 3-13: 10-year monthly total number of unique encounters (total detections) by eBird list (duplicate list postings removed) of Piping Plovers in coastal Connecticut derived from the eBird database.

3.2.2.3. *Species potentially present in the Connecticut Onshore Development Area*

Table 3-9: List of species observed by eBird users in the general Connecticut Onshore Development Area, their primary and general breeding habitats, and presence.

Common Name	*Scientific Name*	Primary Habitat	General Breeding Habitat
Snow Goose	*Anser caerulescens*	Terrestrial	Grassland
Brant	*Branta bernicla*	Terrestrial	Grassland
Canada Goose	*Branta canadensis*	Terrestrial, Aquatic	Grassland, Wetland
Mute Swan	*Cygnus olor*	Aquatic	Coastal, Wetland
Wood Duck	*Aix sponsa*	Terrestrial, Aquatic	Forest, Wetland
Blue-winged Teal	*Spatula discors*	Aquatic	Marine, Wetland
Northern Shoveler	*Spatula clypeata*	Freshwater	Wetland
Gadwall	*Mareca strepera*	Freshwater	Wetland
Eurasian Wigeon	*Mareca penelope*	Freshwater	Wetland
American Wigeon	*Mareca americana*	Freshwater	Wetland
Mallard	*Anas platyrhynchos*	Aquatic	Marine, Wetland
American Black Duck	*Anas rubripes*	Freshwater	Wetland
Northern Pintail	*Anas acuta*	Freshwater	Wetland
Green-winged Teal	*Anas crecca*	Freshwater	Wetland
Canvasback	*Aythya valisineria*	Freshwater	Wetland
Redhead	*Aythya americana*	Freshwater	Wetland
Ring-necked Duck	*Aythya collaris*	Freshwater	Wetland
Greater Scaup	*Aythya marila*	Marine	Marine
Lesser Scaup	*Aythya affinis*	Freshwater	Wetland
Common Eider	*Somateria mollissima*	Marine	Intertidal
Harlequin Duck	*Histrionicus histrionicus*	Freshwater	Wetland
Surf Scoter	*Melanitta perspicillata*	Freshwater	Wetland
White-winged Scoter	*Melanitta deglandi*	Freshwater	Wetland
Black Scoter	*Melanitta americana*	Freshwater	Wetland
Long-tailed Duck	*Clangula hyemalis*	Terrestrial	Grassland
Bufflehead	*Bucephala albeola*	Terrestrial, Aquatic	Forest, Wetland
Common Goldeneye	*Bucephala clangula*	Terrestrial	Forest
Hooded Merganser	*Lophodytes cucullatus*	Terrestrial, Aquatic	Forest, Wetland
Common Merganser	*Mergus merganser*	Freshwater	Wetland
Red-breasted Merganser	*Mergus serrator*	Freshwater	Wetland
Ruddy Duck	*Oxyura jamaicensis*	Freshwater	Wetland
Wild Turkey	*Meleagris gallopavo*	Terrestrial	Forest, Grassland, Shrubland
Ring-necked Pheasant	*Phasianus colchicus*	Terrestrial	Forest, Grassland, Shrubland
Pied-billed Grebe	*Podilymbus podiceps*	Freshwater	Wetland
Horned Grebe	*Podiceps auritus*	Freshwater	Wetland
Red-necked Grebe	*Podiceps grisegena*	Freshwater	Wetland
Rock Pigeon	*Columba livia*	Terrestrial	Artificial
Mourning Dove	*Zenaida macroura*	Terrestrial	Forest, Grassland, Shrubland
Yellow-billed Cuckoo	*Coccyzus americanus*	Terrestrial	Forest
Black-billed Cuckoo	*Coccyzus erythropthalmus*	Terrestrial	Forest, Shrubland
Common Nighthawk	*Chordeiles minor*	Terrestrial	Grassland
Eastern Whip-poor-will	*Antrostomus vociferus*	Terrestrial	Forest
Chimney Swift	*Chaetura pelagica*	Terrestrial	Artificial, Forest

Common Name	*Scientific Name*	Primary Habitat	General Breeding Habitat
Ruby-throated Hummingbird	*Archilochus colubris*	Terrestrial	Forest
Clapper Rail	*Rallus crepitans*	Marine Intertidal	Intertidal
Virginia Rail	*Rallus limicola*	Freshwater	Wetland
American Coot	*Fulica americana*	Freshwater	Wetland
Sandhill Crane	*Antigone canadensis*	Freshwater	Wetland
American Oystercatcher	*Haematopus palliatus*	Intertidal	Intertidal
Black-bellied Plover	*Pluvialis squatarola*	Terrestrial	Grassland
Semipalmated Plover	*Charadrius semipalmatus*	Intertidal	Intertidal
Piping Plover	*Charadrius melodus*	Coastal	Coastal, Wetland
Killdeer	*Charadrius vociferus*	Freshwater	Wetland
Whimbrel	*Numenius phaeopus*	Terrestrial	Forest, Grassland, Shrubland
Ruddy Turnstone	*Arenaria interpres*	Terrestrial, Aquatic	Grassland, Wetland
Sanderling	*Calidris alba*	Terrestrial	Grassland
Dunlin	*Calidris alpina*	Intertidal, Freshwater	Intertidal, Wetland
Purple Sandpiper	*Calidris maritima*	Terrestrial, Intertidal, Freshwater	Grassland, Marine, Wetland
Least Sandpiper	*Calidris minutilla*	Terrestrial, Freshwater	Forest, Grassland, Shrubland, Wetland
White-rumped Sandpiper	*Calidris fuscicollis*	Freshwater	Wetland
Pectoral Sandpiper	*Calidris melanotos*	Terrestrial, Aquatic	Grassland, Wetland
Semipalmated Sandpiper	*Calidris pusilla*	Terrestrial, Aquatic	Grassland, Wetland
Short-billed Dowitcher	*Limnodromus griseus*	Marine Intertidal	Intertidal
American Woodcock	*Scolopax minor*	Terrestrial	Forest
Wilson's Snipe	*Gallinago delicata*	Terrestrial, Aquatic	Forest, Wetland
Spotted Sandpiper	*Actitis macularius*	Freshwater	Wetland
Solitary Sandpiper	*Tringa solitaria*	Terrestrial	Grassland
Greater Yellowlegs	*Tringa melanoleuca*	Terrestrial, Aquatic	Forest, Shrubland, Wetland
Willet	*Tringa semipalmata*	Coastal	Intertidal, Wetland
Lesser Yellowlegs	*Tringa flavipes*	Terrestrial, Aquatic	Shrubland, Wetland
Bonaparte's Gull	*Chroicocephalus philadelphia*	Terrestrial, Aquatic	Forest, Wetland
Laughing Gull	*Leucophaeus atricilla*	Marine	Intertidal
Ring-billed Gull	*Larus delawarensis*	Terrestrial, Aquatic	Grassland, Wetland
Herring Gull	*Larus argentatus*	Terrestrial, Aquatic	Coastal, Intertidal
Iceland Gull	*Larus glaucoides*	Coastal	Coastal, Intertidal
Lesser Black-backed Gull	*Larus fuscus*	Coastal	Coastal, Intertidal
Great Black-backed Gull	*Larus marinus*	Coastal	Coastal/Supratidal
Least Tern	*Sternula antillarum*	Marine	Marine
Roseate Tern	*Sterna dougallii*	Marine	Marine
Common Tern	*Sterna hirundo*	Marine	Marine
Forster's Tern	*Sterna forsteri*	Marine	Marine
Red-throated Loon	*Gavia stellata*	Freshwater	Marine, Wetland
Common Loon	*Gavia immer*	Freshwater	Marine, Wetland
Northern Gannet	*Morus bassanus*	Marine	Coastal, Marine, Oceanic
Great Cormorant	*Phalacrocorax carbo*	Aquatic	Forest, Marine, Wetland
Double-crested Cormorant	*Nannopterum auritum*	Marine	Marine
American Bittern	*Botaurus lentiginosus*	Freshwater	Wetland
Great Blue Heron	*Ardea herodias*	Freshwater	Wetland
Great Egret	*Ardea alba*	Terrestrial, Aquatic	Grassland, Wetland

Common Name	*Scientific Name*	Primary Habitat	General Breeding Habitat
Snowy Egret	*Egretta thula*	Freshwater	Wetland
Green Heron	*Butorides virescens*	Freshwater	Wetland
Black-crowned Night-Heron	*Nycticorax nycticorax*	Terrestrial, Aquatic	Forest, Intertidal, Wetland
Yellow-crowned Night-Heron	*Nyctanassa violacea*	Terrestrial, Aquatic	Forest, Intertidal, Wetland
Glossy Ibis	*Plegadis falcinellus*	Freshwater	Wetland
Black Vulture	*Coragyps atratus*	Terrestrial	Forest, Grassland, Shrubland
Turkey Vulture	*Cathartes aura*	Terrestrial	Forest, Grassland, Shrubland
Osprey	*Pandion haliaetus*	Terrestrial, Aquatic	Forest, Coastal, Wetland
Northern Harrier	*Circus hudsonius*	Terrestrial	Forest, Grassland, Shrubland
Sharp-shinned Hawk	*Accipiter striatus*	Terrestrial	Forest, Grassland, Shrubland
Cooper's Hawk	*Accipiter cooperii*	Terrestrial	Forest
Bald Eagle	*Haliaeetus leucocephalus*	Freshwater	Wetland
Red-shouldered Hawk	*Buteo lineatus*	Terrestrial	Artificial, Forest
Broad-winged Hawk	*Buteo platypterus*	Terrestrial	Forest
Red-tailed Hawk	*Buteo jamaicensis*	Terrestrial	Forest, Grassland, Shrubland
Eastern Screech-Owl	*Megascops asio*	Terrestrial	Forest
Great Horned Owl	*Bubo virginianus*	Terrestrial	Forest, Shrubland
Snowy Owl	*Bubo scandiacus*	Terrestrial	Coastal
Barred Owl	*Strix varia*	Terrestrial	Forest
Belted Kingfisher	*Megaceryle alcyon*	Freshwater	Wetland
Yellow-bellied Sapsucker	*Sphyrapicus varius*	Terrestrial	Forest
Red-bellied Woodpecker	*Melanerpes carolinus*	Terrestrial	Forest
Downy Woodpecker	*Dryobates pubescens*	Terrestrial	Artificial, Forest
Hairy Woodpecker	*Dryobates villosus*	Terrestrial	Forest
Pileated Woodpecker	*Dryocopus pileatus*	Terrestrial	Forest
Northern Flicker	*Colaptes auratus*	Terrestrial	Forest
American Kestrel	*Falco sparverius*	Terrestrial	Forest, Grassland, Shrubland
Merlin	*Falco columbarius*	Terrestrial	Forest, Grassland, Shrubland
Peregrine Falcon	*Falco peregrinus*	Terrestrial	Rocky Cliffs
Eastern Wood-Pewee	*Contopus virens*	Terrestrial	Forest
Acadian Flycatcher	*Empidonax virescens*	Terrestrial	Forest
Willow Flycatcher	*Empidonax traillii*	Terrestrial	Shrubland
Least Flycatcher	*Empidonax minimus*	Terrestrial	Forest
Eastern Phoebe	*Sayornis phoebe*	Terrestrial	Forest
Great Crested Flycatcher	*Myiarchus crinitus*	Terrestrial	Forest
Eastern Kingbird	*Tyrannus tyrannus*	Terrestrial, Terrestrial	Forest, Shrubland
White-eyed Vireo	*Vireo griseus*	Terrestrial	Shrubland
Yellow-throated Vireo	*Vireo flavifrons*	Terrestrial	Forest
Blue-headed Vireo	*Vireo solitarius*	Terrestrial	Forest
Warbling Vireo	*Vireo gilvus*	Terrestrial, Aquatic	Forest, Wetland
Red-eyed Vireo	*Vireo olivaceus*	Terrestrial	Forest
Blue Jay	*Cyanocitta cristata*	Terrestrial	Forest
American Crow	*Corvus brachyrhynchos*	Terrestrial	Forest, Grassland, Shrubland
Fish Crow	*Corvus ossifragus*	Terrestrial, Aquatic	Grassland, Wetland
Common Raven	*Corvus corax*	Terrestrial	Forest, Rocky Cliffs
Black-capped Chickadee	*Poecile atricapillus*	Terrestrial	Forest
Tufted Titmouse	*Baeolophus bicolor*	Terrestrial	Forest
Horned Lark	*Eremophila alpestris*	Terrestrial, Terrestrial	Grassland, Shrubland

Common Name	*Scientific Name*	Primary Habitat	General Breeding Habitat
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Terrestrial	Rocky Cliffs, Wetland
Purple Martin	*Progne subis*	Terrestrial	Forest
Tree Swallow	*Tachycineta bicolor*	Freshwater	Wetland
Bank Swallow	*Riparia riparia*	Terrestrial, Aquatic	Grassland, Wetland
Barn Swallow	*Hirundo rustica*	Terrestrial, Aquatic	Marine, Grassland, Wetland
Ruby-crowned Kinglet	*Corthylio calendula*	Terrestrial	Forest
Golden-crowned Kinglet	*Regulus satrapa*	Terrestrial	Forest
Red-breasted Nuthatch	*Sitta canadensis*	Terrestrial	Forest
White-breasted Nuthatch	*Sitta carolinensis*	Terrestrial	Forest
Brown Creeper	*Certhia americana*	Terrestrial	Forest
Blue-gray Gnatcatcher	*Polioptila caerulea*	Terrestrial	Forest
House Wren	*Troglodytes aedon*	Terrestrial	Forest, Shrubland
Winter Wren	*Troglodytes hiemalis*	Terrestrial	Forest
Marsh Wren	*Cistothorus palustris*	Freshwater	Wetland
Carolina Wren	*Thryothorus ludovicianus*	Terrestrial	Forest
European Starling	*Sturnus vulgaris*	Terrestrial	Forest, Grassland, Shrubland
Gray Catbird	*Dumetella carolinensis*	Terrestrial	Shrubland
Brown Thrasher	*Toxostoma rufum*	Terrestrial	Shrubland
Northern Mockingbird	*Mimus polyglottos*	Terrestrial	Shrubland
Eastern Bluebird	*Sialia sialis*	Terrestrial	Forest
Townsend's Solitaire	*Myadestes townsendi*	Terrestrial	Forest
Veery	*Catharus fuscescens*	Terrestrial	Forest
Hermit Thrush	*Catharus guttatus*	Terrestrial	Forest
Wood Thrush	*Hylocichla mustelina*	Terrestrial	Forest
American Robin	*Turdus migratorius*	Terrestrial	Forest
Cedar Waxwing	*Bombycilla cedrorum*	Terrestrial	Forest
House Sparrow	*Passer domesticus*	Terrestrial	Forest, Grassland, Shrubland
American Pipit	*Anthus rubescens*	Terrestrial	Grassland, Rocky Cliffs
House Finch	*Haemorhous mexicanus*	Terrestrial	Shrubland
Purple Finch	*Haemorhous purpureus*	Terrestrial	Forest
Common Redpoll	*Acanthis flammea*	Terrestrial	Forest
Red Crossbill	*Loxia curvirostra*	Terrestrial	Forest
Pine Siskin	*Spinus pinus*	Terrestrial	Forest
American Goldfinch	*Spinus tristis*	Terrestrial	Forest, Grassland, Shrubland
Snow Bunting	*Plectrophenax nivalis*	Terrestrial	Grassland
Chipping Sparrow	*Spizella passerina*	Terrestrial	Forest, Grassland, Shrubland
Field Sparrow	*Spizella pusilla*	Terrestrial	Forest, Grassland, Shrubland
American Tree Sparrow	*Spizelloides arborea*	Terrestrial, Aquatic	Grassland, Shrubland
Fox Sparrow	*Passerella iliaca*	Terrestrial	Forest
Dark-eyed Junco	*Junco hyemalis*	Terrestrial	Forest
White-crowned Sparrow	*Zonotrichia leucophrys*	Terrestrial	Forest, Grassland, Shrubland
White-throated Sparrow	*Zonotrichia albicollis*	Terrestrial	Forest, Shrubland
Vesper Sparrow	*Pooecetes gramineus*	Terrestrial	Grassland
Seaside Sparrow	*Ammospiza maritima*	Coastal	Intertidal
Saltmarsh Sparrow	*Ammospiza caudacuta*	Coastal	Intertidal
Savannah Sparrow	*Passerculus sandwichensis*	Coastal	Coastal/Supratidal
Song Sparrow	*Melospiza melodia*	Coastal	Intertidal
Swamp Sparrow	*Melospiza georgiana*	Freshwater	Wetland

Common Name	*Scientific Name*	Primary Habitat	General Breeding Habitat
Eastern Towhee	*Pipilo erythrophthalmus*	Terrestrial	Forest
Yellow-breasted Chat	*Icteria virens*	Terrestrial	Forest
Bobolink	*Dolichonyx oryzivorus*	Terrestrial	Grassland
Eastern Meadowlark	*Sturnella magna*	Terrestrial	Grassland, Shrubland
Orchard Oriole	*Icterus spurius*	Terrestrial	Forest, Savanna
Baltimore Oriole	*Icterus galbula*	Terrestrial	Forest, Grassland
Red-winged Blackbird	*Agelaius phoeniceus*	Freshwater	Wetland
Brown-headed Cowbird	*Molothrus ater*	Terrestrial	Forest, Grassland
Rusty Blackbird	*Euphagus carolinus*	Freshwater	Wetland
Common Grackle	*Quiscalus quiscula*	Terrestrial	Forest, Shrubland, Wetland
Ovenbird	*Seiurus aurocapilla*	Terrestrial	Forest
Worm-eating Warbler	*Helmitheros vermivorum*	Terrestrial	Forest
Northern Waterthrush	*Parkesia noveboracensis*	Freshwater	Wetland
Blue-winged Warbler	*Vermivora cyanoptera*	Terrestrial	Grassland
Black-and-white Warbler	*Mniotilta varia*	Terrestrial	Forest
Tennessee Warbler	*Leiothlypis peregrina*	Terrestrial	Forest, Shrubland
Orange-crowned Warbler	*Leiothlypis celata*	Terrestrial	Shrubland
Nashville Warbler	*Leiothlypis ruficapilla*	Terrestrial	Forest
Common Yellowthroat	*Geothlypis trichas*	Freshwater	Wetland
Hooded Warbler	*Setophaga citrina*	Terrestrial	Forest
American Redstart	*Setophaga ruticilla*	Terrestrial	Forest
Northern Parula	*Setophaga americana*	Terrestrial	Forest
Magnolia Warbler	*Setophaga magnolia*	Terrestrial	Forest
Yellow Warbler	*Setophaga petechia*	Terrestrial	Forest, Shrubland
Chestnut-sided Warbler	*Setophaga pensylvanica*	Terrestrial	Forest, Shrubland
Blackpoll Warbler	*Setophaga striata*	Terrestrial	Forest
Black-throated Blue Warbler	*Setophaga caerulescens*	Terrestrial	Forest
Palm Warbler	*Setophaga palmarum*	Freshwater	Wetland
Pine Warbler	*Setophaga pinus*	Terrestrial	Forest
Yellow-rumped Warbler	*Setophaga coronata*	Terrestrial	Forest
Prairie Warbler	*Setophaga discolor*	Terrestrial	Shrubland
Black-throated Green Warbler	*Setophaga virens*	Terrestrial	Forest
Canada Warbler	*Cardellina canadensis*	Terrestrial	Forest
Scarlet Tanager	*Piranga olivacea*	Terrestrial	Forest
Northern Cardinal	*Cardinalis cardinalis*	Terrestrial	Shrubland
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Terrestrial	Forest
Indigo Bunting	*Passerina cyanea*	Terrestrial	Forest

Table 3-10: List of species of conservation concern observed by eBird users in the general Connecticut Onshore Development Area.

Common Name	*Latin Name*	Federal	State	IPaC
Ducks, Geese, and Swans				
Common Eider	*Somateria mollissima*			•
Surf Scoter	*Melanitta perspicillata*			•
White-winged Scoter	*Melanitta deglandi*			•
Black Scoter	*Melanitta americana*			•
Long-tailed Duck	*Clangula hyemalis*			•
Red-breasted Merganser	*Mergus serrator*			•
Grebes				
Pied-billed Grebe	*Podilymbus podiceps*	None	Endangered	
Cuckoos				
Black-billed Cuckoo	*Coccyzus erythropthalmus*			•
Nightjars				
Common Nighthawk	*Chordeiles minor*	None	Endangered	
Shorebirds				
American Oystercatcher	*Haematopus palliatus*			•
Piping Plover	*Charadrius melodus*	Threatened	Threatened	•
Ruddy Turnstone	*Arenaria interpres*			•
Purple Sandpiper	*Calidris maritima*			•
Short-billed Dowitcher	*Limnodromus griseus*			•
Willet	*Tringa semipalmata*			•
Lesser Yellowlegs	*Tringa flavipes*			•
Red Knot	*Calidris canutus rufa*	Threatened	Special Concern	
Auks				
Razorbill	*Alca torda*			•
Gulls and Terns				
Ring-billed Gull	*Larus delawarensis*			•
Least Tern	*Sternula antillarum*	None	Threatened	
Roseate Tern	*Sterna dougallii*	Endangered	Endangered	•
Common Tern	*Sterna hirundo*	None	Special Concern	
Loons				
Red-throated Loon	*Gavia stellata*			•
Common Loon	*Gavia immer*	None	Special Concern	•
Cormorants				
Double-crested Cormorant	*Nannopterum auritum*			•
Herons, Egrets, and Bitterns				
Great Egret	*Ardea alba*	None	Threatened	
Snowy Egret	*Egretta thula*	None	Threatened	
Little Blue Heron	*Egretta caerulea*	None	Special Concern	
Raptors				

Common Name	*Latin Name*	Federal	State	IPaC
Northern Harrier	*Circus hudsonius*	None	Endangered	
Sharp-shinned Hawk	*Accipiter striatus*	None	Endangered	
Bald Eagle	*Haliaeetus leucocephalus*	Bald and Golden Eagle Protection Act	Threatened	•
American Kestrel	*Falco sparverius*	None	Special Concern	
Peregrine Falcon	*Falco peregrinus*	None	Threatened	
Passerines				
Horned Lark	*Eremophila alpestris*	None	Endangered	
Wood Thrush	*Hylocichla mustelina*			•
Saltmarsh Sparrow	*Ammospiza caudacuta*	None	Special Concern	
Savannah Sparrow (Ipswich Sparrow)	*Passerculus sandwichensis*	None	Special Concern	
Swamp Sparrow (Coastal Plain Swamp Sparrow)	*Melospiza georgiana*	None	Special Concern	
Yellow-breasted Chat	*Icteria virens*	None	Endangered	
Bobolink	*Dolichonyx oryzivorus*	None	Special Concern	•
Rusty Blackbird	*Euphagus carolinus*			•
Blue-winged Warbler	*Vermivora cyanoptera*			•
Prairie Warbler	*Setophaga discolor*			•
Canada Warbler	*Cardellina canadensis*			•

4. Offshore: Results

Summary interpretation of our risk assessment results are presented in the body of the COP (Section 4.2 of COP Volume II). The complete results, described here in greater detail, are organized by sections addressing the exposure and vulnerability of coastal birds and marine birds separately, and include maps, tables, and figures for each species or species group. ESA-listed and candidate species are assessed individually, and their risk assessments described in depth. This assessment follows the taxonomic order presented in the most recent checklist produced by the North American Classification and Nomenclature Committee of the American Ornithological Society (Chesser et al. 2019).

Exposure assessments are based on numerous data sets and other references, including, but not limited to, the digital aerial surveys, MassCEC aerial surveys, integrated models (INLA—see Section 5 for detailed description), Northwest Atlantic Seabird Catalog data, occurrence data, individual tracking data, relevant literature, and published species accounts. The species that were detected in the Lease Area are listed in Table 4-1. Where data is sparse, however, the relative behavioral vulnerability assessment is based on the literature and expert opinion.

Table 4-1: Avian species recorded in each season in the MassCEC aerial surveys and OCS-A 0522 digital aerial surveys and cross-referenced with USFWS IPaC database (http://ecos.fws.gov/ipac/).

Species	*Scientific name*	Winter	Spring	Summer	Fall	IPaC
Ducks, geese, and swans						
Brant	*Branta bernicla*				•	
Canada Goose	*Branta canadensis*	•				
Sea ducks						
Black Scoter	*Melanitta nigra*	•	•		•	•
Common Eider	*Somateria mollissima*	•	•		•	•
King Eider	*Somateria spectabilis*	•				
Long-tailed Duck	*Clangula hyemalis*	•	•		•	•
Red-breasted Merganser	*Mergus serrator*	•	•			
Surf Scoter	*Melanitta perspicillata*	•	•		•	•
White-winged Scoter	*Melanitta fusca*	•	•		•	•
Shorebirds						
Greater Yellowlegs	*Tringa melanoleuca*				•	
Phalaropes						
Red Phalarope	*Phalaropus fulicaria*	•	•		•	
Skuas and Jaegers						
Great Skua	*Stercorarius skua*				•	
Long-tailed Jaeger	*Stercorarius longicaudus*				•	
Parasitic Jaeger	*Stercorarius parasiticus*				•	
Pomarine Jaeger	*Stercorarius pomarinus*				•	•
South Polar Skua	*Stercorarius maccormicki*				•	
Auks						
Atlantic Puffin	*Fratercula arctica*	•	•	•	•	•
Common Murre	*Uria aalge*	•	•			•
Dovekie	*Alle alle*	•	•			•
Razorbill	*Alca torda*	•	•		•	•
Small gulls						

Species	*Scientific name*	Winter	Spring	Summer	Fall	IPaC
Bonaparte's Gull	*Larus philadelphia*	•	•		•	
Medium gulls						
Black-legged Kittiwake	*Rissa tridactyla*	•	•		•	•
Laughing Gull	*Larus atricilla*	•		•	•	
Ring-billed Gull	*Larus delawarensis*		•			
Large gulls						
Great Black-backed Gull	*Larus marinus*	•	•	•	•	
Herring Gull	*Larus argentatus*	•	•	•	•	
Lesser Black-backed Gull	*Larus fuscus*		•		•	
Medium terns						
Common Tern	*Sterna hirundo*		•	•	•	
Forster's Tern	*Sterna forsteri*				•	
Roseate Tern	*Sterna dougallii*		•	•		•
Royal Tern	*Sterna maxima*			•		
Loons						
Common Loon	*Gavia immer*	•	•	•	•	•
Red-throated Loon	*Gavia stellata*	•	•		•	•
Storm-Petrels						
Wilson's Storm-Petrel	*Oceanites oceanicus*	•	•	•		•
Shearwaters and Petrels						
Black-capped Petrel	*Pterodroma hasitata*			•		
Cory's Shearwater	*Calonectris diomedea*	•		•	•	•
Great Shearwater	*Puffinus gravis*			•	•	•
Manx Shearwater	*Puffinus puffinus*			•	•	•
Northern Fulmar	*Fulmarus glacialis*	•	•	•	•	
Sooty Shearwater	*Puffinus griseus*		•	•	•	
Gannet						
Northern Gannet	*Morus bassanus*	•	•	•	•	
Cormorants						
Double-crested Cormorant	*Phalacrocorax auritus*				•	
Heron and Egrets						
Great Blue Heron	*Ardea herodias*	•			•	
Raptors						
Osprey	*Pandion haliaetus*		•			

4.1. Coastal Birds

The Lease Area is far enough offshore to be beyond the range of most terrestrial or coastal bird species. Coastal birds that may forage in the Lease Area occasionally, visit the area sporadically, or pass through on their spring or fall migrations, include shorebirds (e.g., sandpipers, plovers), waterbirds (e.g., cormorants, grebes), waterfowl (e.g., scoters, mergansers), wading birds (e.g., herons, egrets), raptors (e.g., falcons, eagles), and songbirds (e.g., warblers, sparrows). Exposure is considered by calendar season (defined as Spring [March, April, May], Summer [June, July, August], Fall [September, October, November], and Winter [December, January, February]). As birds using the region may vary by life stage in a given season (i.e., terns in summer will be breeding, while southern hemisphere breeders, such as shearwaters, are technically in their wintering season while in the area), these seasonal breakpoints are the most generalized way to describe exposure.

4.1.1. Coastal Waterbirds and Waterfowl

4.1.1.1. Spatiotemporal Context

Waterbirds is a general term used for species associated with all manner of aquatic habitats. For the purposes of this assessment, this group includes species that are generally restricted to freshwater or use saltmarshes, beaches, and other strictly coastal habitats, and that are not captured in other broad groupings. Some grebe species migrate to and winter on saltwater, where they generally stay inshore in relatively shallow and/or sheltered coastal waters, but may also be found offshore in shallower regions or over shoals (Stout and Nuechterlein 2020). Waterfowl comprises a broad group of geese and ducks, most of which spend much of the year in terrestrial or coastal wetland habitats (Baldassarre and Bolen 2006). The diving ducks generally winter on open freshwater, as well as brackish or saltwater. Species that regularly winter on saltwater, including mergansers, scaup, and goldeneyes, usually restrict their distributions to shallow, very nearshore waters (Owen and Black 1990). Waterbirds that are listed in Massachusetts are detailed in Table 4-2.

A subset of the diving ducks, however, have an exceptionally strong affinity for saltwater either year-round or outside of the breeding season. These species are known as sea ducks and are described separately in Section 4.2.3 below.

Table 4-2: Waterbirds listed in Massachusetts and their federal status.

Common Name	Scientific Name	MA Status	Federal Status
American Bittern	*Botaurus lentiginosus*	E	
Least Bittern	*Ixobrychus exilis*	E	
King Rail	*Rallus elegans*	T	
Common Moorhen	*Gallinula chloropus*	SC	

E = Endangered; T = Threatened; SC = Special Concern.

4.1.1.2. Exposure Assessment

Exposure for coastal waterbirds was assessed using species accounts, baseline survey data, and literature. Given that these species spend most of their life in freshwater aquatic and associated terrestrial habitats, that few were observed during the digital aerial surveys (Figure 4-1, Figure 4-2, Figure 4-3, and Figure 4-4; note, a majority of the detections in Figure 4-3 were “unidentified duck” and were likely sea ducks, rather than coastal species), that they were not identified in the IPaC data, and that there is little or no evidence of offshore migration in the literature or in the MassCEC aerial survey data, overall exposure of this group to the Lease Area is expected to be **minimal**.

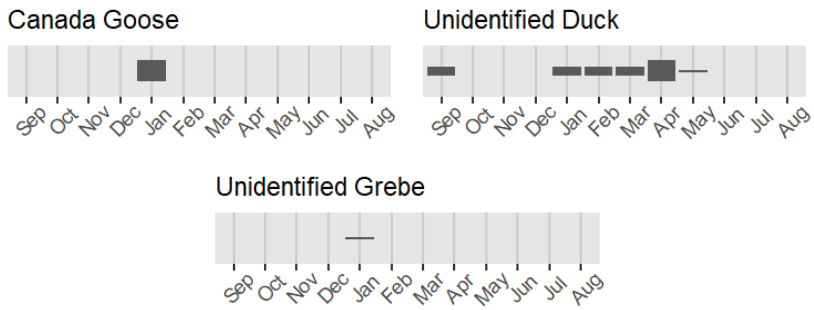


Figure 4-1. Monthly relative densities of grebes, ducks, geese, and swans in the survey area from digital aerial surveys.

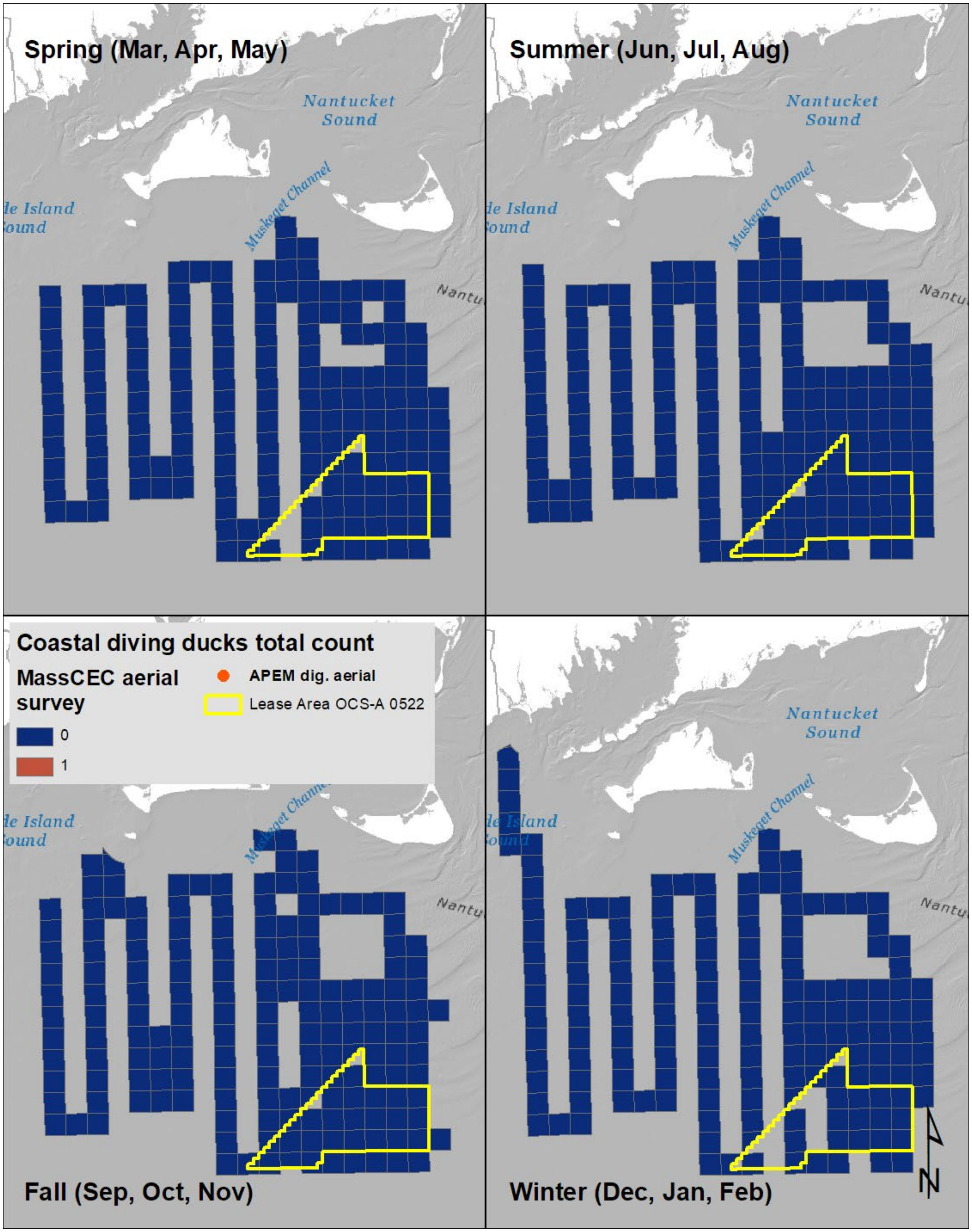


Figure 4-2: Coastal diving ducks observed, by season, during the digital aerial surveys and MassCEC aerial surveys.

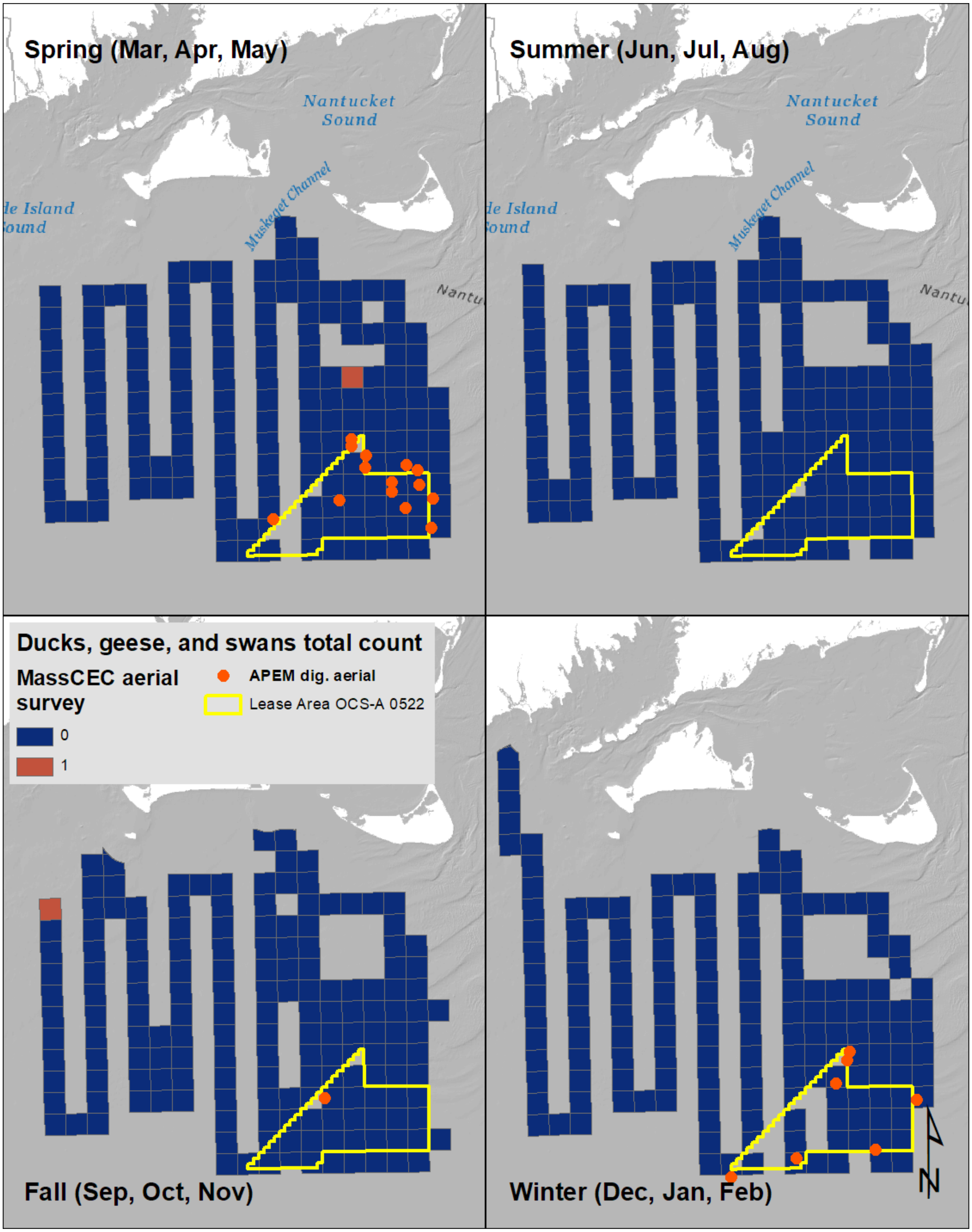


Figure 4-3: Ducks, geese, and swans observed, by season, during the digital aerial surveys and MassCEC aerial surveys. NOTE: a majority of these detections were "unidentified duck" and likely were sea ducks, rather than coastal species.

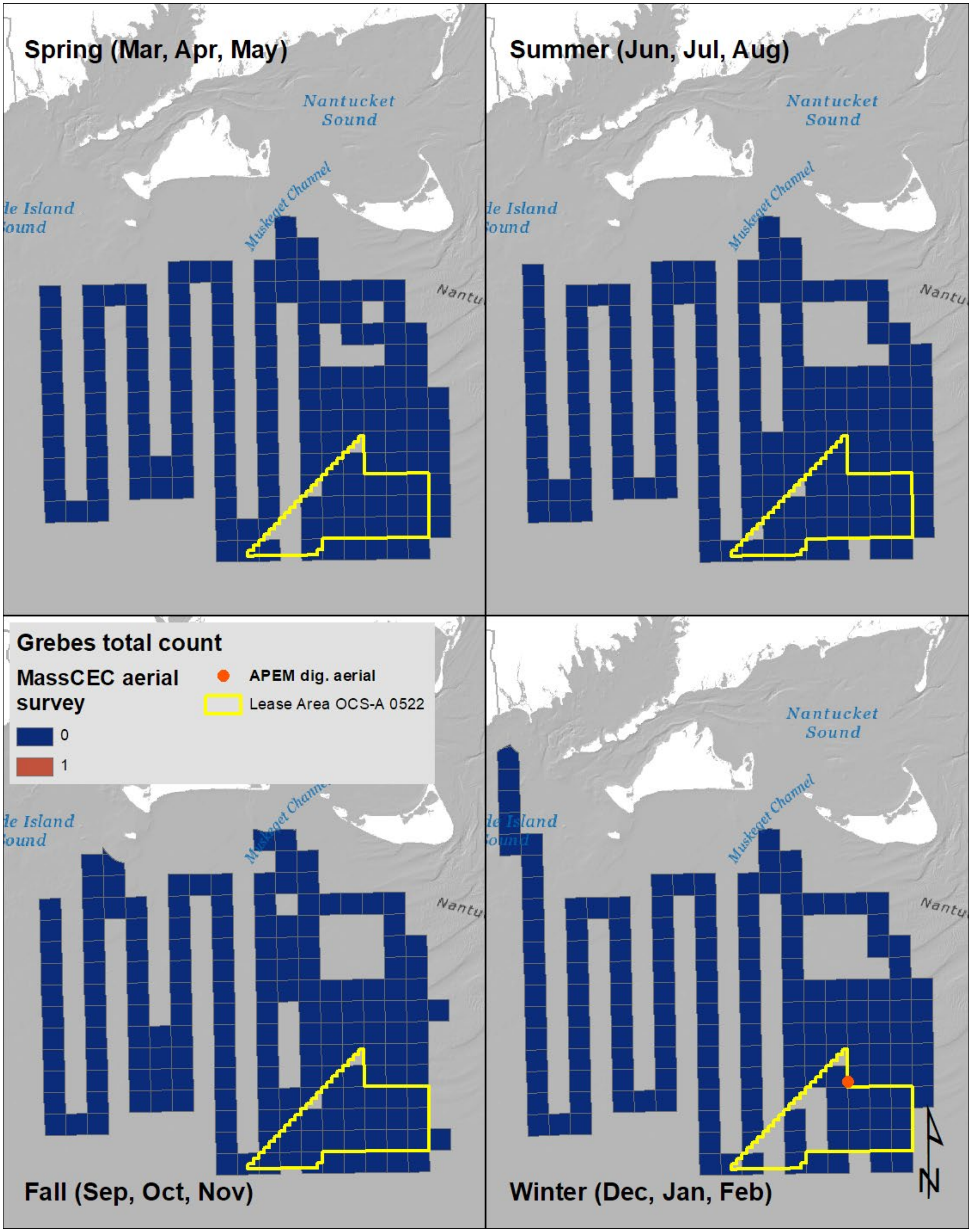


Figure 4-4: Grebes observed, by season, during the digital aerial surveys and MassCEC aerial surveys.

4.1.2. Shorebirds

4.1.2.1. Spatiotemporal Context

Shorebirds are coastal breeders and foragers that generally avoid straying out over deep waters during breeding. Few shorebird species breed locally on the U.S. Atlantic coast. Most of the shorebirds that pass through the region are northern or Arctic breeders that migrate along the U.S. Atlantic coast on their way to and from wintering areas in the Caribbean islands, Central America, and South America. Some species are capable of crossing vast areas of ocean and may traverse the Lease Area during migration. Only Phalaropes are truly marine species during the non-breeding season and are discussed below along with the other marine birds (see Section 4.2.4).

Recent tracking studies provide insight into distinct fall migratory patterns of shorebirds. More than 50% of 109 Semipalmated Sandpipers (*Calidris pusilla*) tagged in fall in the mid-coast and southern Maine were subsequently detected in southern New England (Cape Cod and islands, Rhode Island, Long Island Sound), with some as far south as Delaware Bay, the Carolinas, and Virginia. All 71 sandpipers tagged in northeastern Maine, however, remained undetected at other sites, suggesting they initiated their trans-oceanic migratory flight to South America directly from that location (Holberton et al. 2019). Some other shorebird species, such as Upland Sandpipers (*Bartramia longicauda*) and Whimbrels (*Numenius phaeopus hudsonicus*), have also been found to take long distance oceanic migration paths over the Atlantic to wintering areas in South America (Hill et al. 2019; Watts et al. 2021).

The Atlantic population of the Piping Plover and the *rufa* subspecies of the Red Knot are both federally-protected under the ESA (Table 4-3), and are thus addressed separately, below.

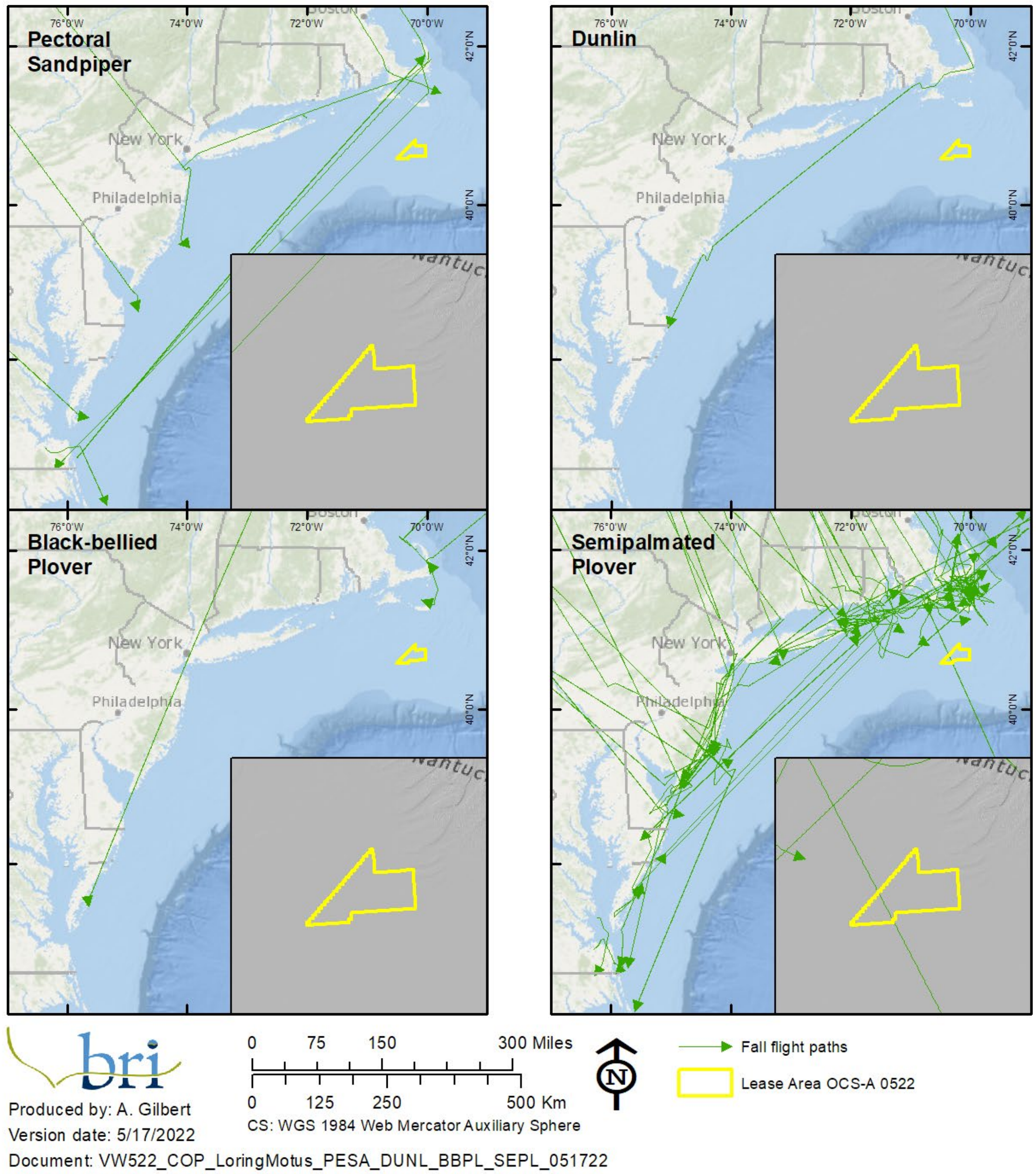
Table 4-3: Shorebirds listed in Massachusetts and their federal status.

Common Name	Scientific Name	MA Status	Federal Status
Red Knot	*Calidris canutus rufa*	T	T
Piping Plover	*Charadrius m. melodus*	T	T
Upland Sandpiper	*Bartramia longicauda*	E	

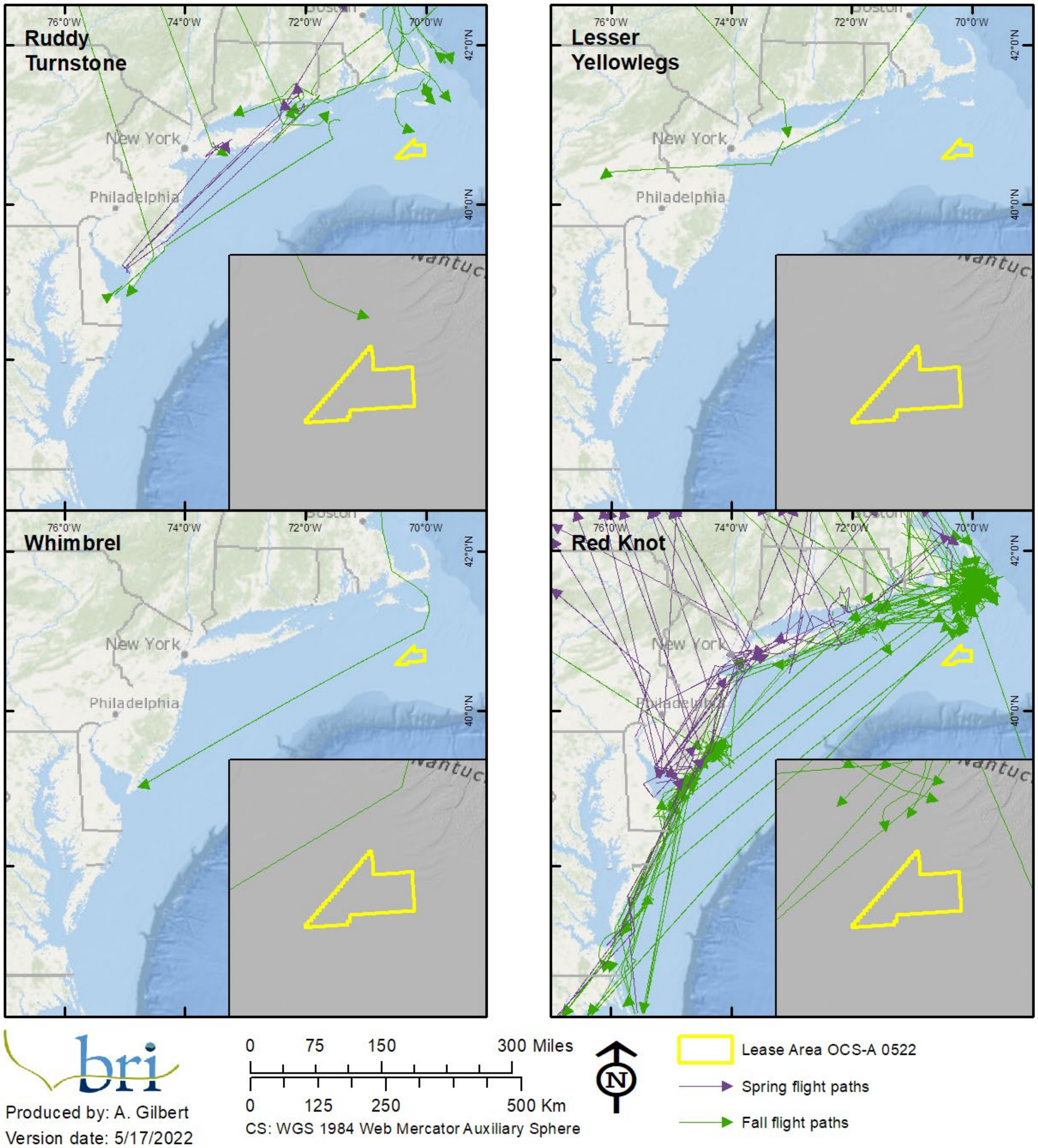
E = Endangered; T = Threatened; SC = Special Concern.

4.1.2.2. Exposure Assessment

Exposure was assessed using species accounts, tracking studies, and baseline survey data. The digital aerial surveys detected a few small flocks of shorebirds in the summer, fall, and winter (Figure 4-6). It should be noted that since shorebirds often migrate at night, their movements may not be captured in diurnal survey efforts, and uncertainty remains on shorebird offshore migratory patterns. A Motus tag study tracked shorebirds with land-based receiver towers, which were unlikely to provide detections within the Lease Area. Modeled flight paths indicated both coastal and potential offshore movements, some of which were heading in the direction of the Lease Area during the fall (Figure 4-5). Given that shorebird exposure will be primarily limited to migration and there were few detections of shorebirds in the Lease Area, exposure is expected to be **minimal** to **low**.



Pectoral Sandpiper
Dunlin
Black-bellied Plover
Semipalmated Plover
76°0'W
74°0'W
72°0'W
70°0'W
42°0'N
40°0'N
New York
Philadelphia
0 75 150 300 Miles
0 125 250 500 Km
CS: WGS 1984 Web Mercator Auxiliary Sphere
N
Fall flight paths
Lease Area OCS-A 0522
Produced by: A. Gilbert
Version date: 5/17/2022
Document: VW522_COP_LoringMotus_PESA_DUNL_BBPL_SEPL_051722



Produced by: A. Gilbert
Version date: 5/17/2022
Document: VW522_COP_LoringMotus_RUTU_LEYE_WHIM_REKN_051722

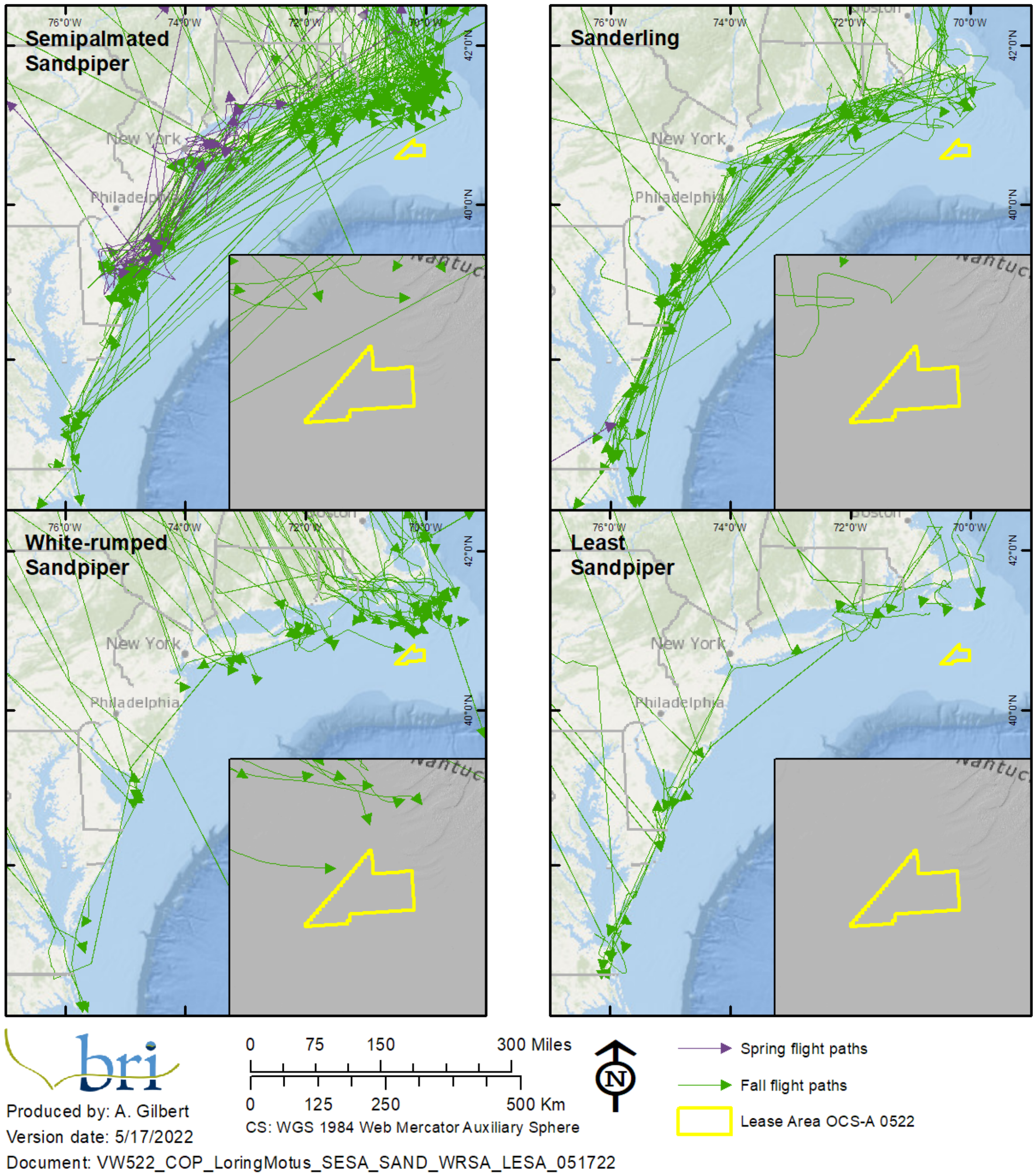


Figure 4-5: Modeled flight paths of migratory shorebirds equipped with nanotags (Loring et al. 2020). All data are not actual flight paths but interpolated (model generated) flight paths. Flight paths were modeled by detections of movements between land-based towers. Towers had a typical detection range <15 km, so birds were only detected when flying within approximately 15 km of one of the towers. (See Figure 5 [tower locations] in Loring et al. [2019] and Appendix K [detection probability] for details. Appendices are found at https://espis.boem.gov/final%20reports/BOEM_2019-018a.pdf. Data provided by USFWS and used with permission.

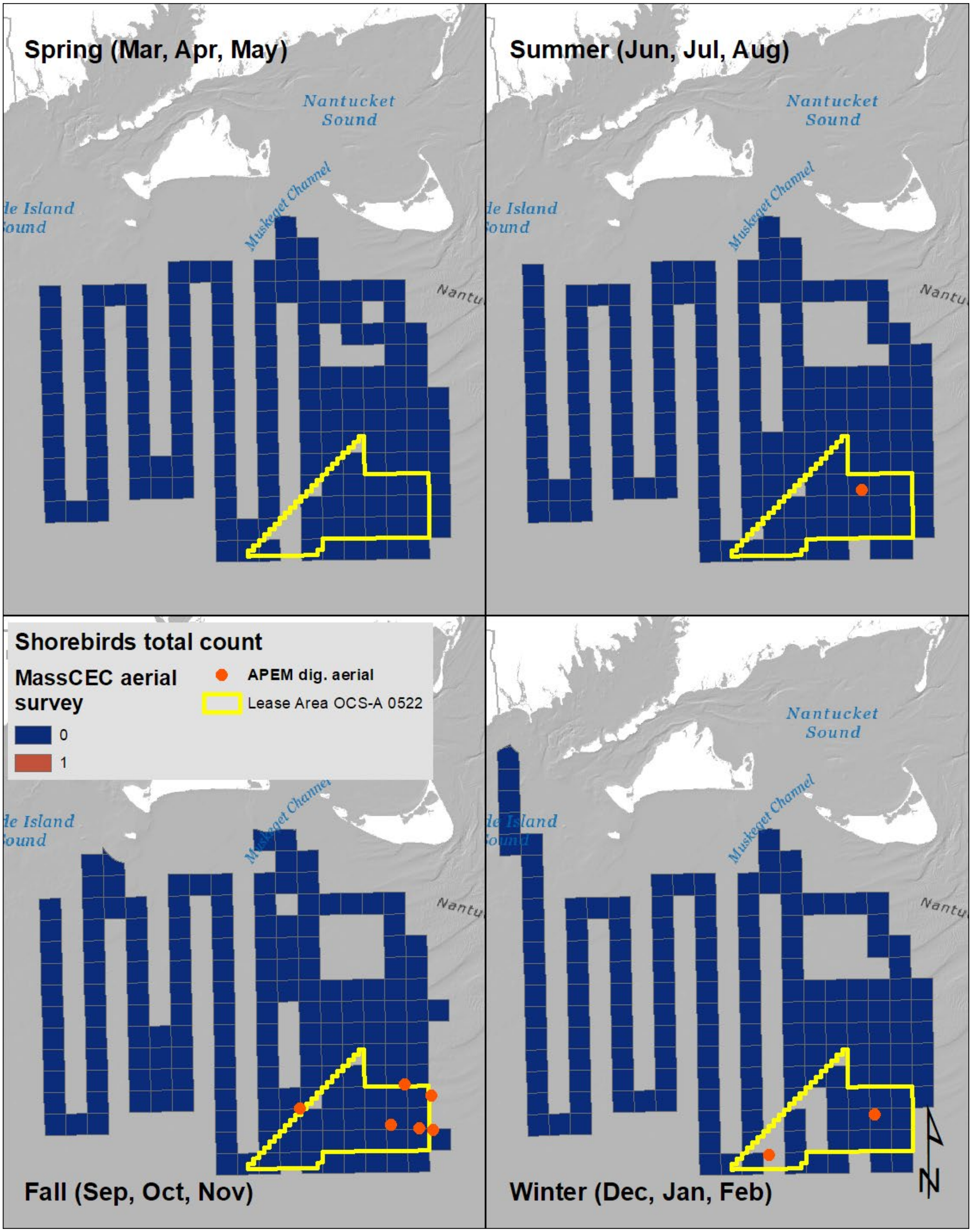


Figure 4-6: Shorebirds observed, by season, digital aerial surveys and MassCEC aerial surveys.

4.1.2.3. Relative Behavioral Vulnerability Assessment

Shorebird collision vulnerability is likely **low** because these birds often migrate at heights above the RSZ and fly during fair weather conditions. Tracked flights occurred generally when there was low precipitation. Model-estimated flight altitudes of non-stop flights over federal waters ranged (5–95%) from 28–2,940 m, with a mean of 914 m in spring, and 545 m in fall (Loring et al. 2020).

A recent tracking study conducted in inland Canada indicates that shorebirds need 2–14 km to climb above a 165 m turbine (Howell et al. 2019) and are expected to fly at high altitudes during migration (see Discussion for Piping Plover and Red Knot for additional detail). Since the closest portion of the Lease Area is approximately 46 km (29 miles) from the coast, shorebirds migrating during fair weather conditions are likely flying above the Vineyard Northeast's WTGs, which would reduce collision risk. However, shorebirds may reduce flight heights during periods of poor visibility.

Shorebirds are not expected to be particularly vulnerable to displacement because, with the exception of phalaropes (discussed in the Marine section), the offshore environment does not provide primary foraging habitat. Further, any avoidance of the Lease Area is unlikely to impact overall individual fitness due to the size of the Lease Area in relation to the birds' entire migratory trip (BOEM 2021). Therefore, vulnerability to displacement is expected to be **minimal**.

4.1.2.4. Risk

Given that shorebird exposure will be limited to migration, that these birds have minimal to low vulnerability to collision and displacement, and that they often fly at high altitudes above the RSZ, population level risk during construction and operation is expected to be ***minimal*** to ***low***.

4.1.3. Endangered Shorebird Species

4.1.3.1. Piping Plover

4.1.3.1.1. Spatiotemporal Context

Species General Description

The Piping Plover is a small shorebird that nests on beaches, sand flats, and wetlands along the Atlantic coast of North America, in the Great Lakes, and in the Midwestern plains (Elliott-Smith and Haig 2020). Piping Plovers feed on terrestrial and aquatic invertebrates, particularly in the intertidal zone and along wrack lines, and spend most of their time on the ground rather than aloft (Elliott-Smith and Haig 2020). The Atlantic coast-breeding subspecies of Piping Plover (*Charadrius m. melodus*), which is the only population likely to occur in Massachusetts, breeds as individual pairs on sandy beaches from Newfoundland to North Carolina (Elliott-Smith and Haig 2020). Breeding generally occurs in May through early August, with variation in the onset of breeding related to local pair densities as well as seasonal weather conditions (Elliott-Smith and Haig 2020). Non-migratory movements in May to August appear to be exclusively coastal (Burger et al. 2011). Nocturnal activities during the breeding period are less well known, but appear to be similar to daytime activities in many respects, including foraging, incubating nests, and short local flights when birds are disturbed (Staine and Burger 1994), and recovery data suggest that there may be several distinct breeding populations within the Atlantic coast subspecies, with individuals exhibiting philopatry and/or site fidelity, i.e., largely returning to areas where they were hatched or known to breed in previous years (USFWS 2009a; Amirault-Langlais et al. 2014).

Migration periods are primarily April to May and August to September (BOEM 2014), though breeding Piping Plovers arrive in Massachusetts beginning around mid-March (MA DFW 2016). Post-breeding movements of fledged chicks (≤50 km [31.1 mi]) and adults can occur prior to initiation of migration (Elliott-Smith and Haig 2020), and post-breeding migratory movements can begin as early as June, with adult birds departing Massachusetts by late August (Elliott-Smith and Haig 2020; Loring et al. 2017). Migration occurs primarily during nocturnal periods when winds are blowing to the south to southwest with takeoff during the early evening (Loring et al. 2017). Both breeding and wintering habitats include islands >5 km (3.1 mi) from the coast, including the Bahamas, which is greater than 160 km (99.4 mi) from the U.S. Atlantic coast (Normandeau Associates Inc. 2011). This, along with the infrequency of observations of migratory flocks along the Atlantic coast, may indicate that many Atlantic-breeding Piping Plovers make nonstop long-distance migratory flights (Normandeau Associates Inc. 2011).

The species winters in coastal areas of the southeastern U.S. and the Caribbean (BOEM 2014; Elliott-Smith and Haig, 2020; USFWS 2009). The winter range is not well understood, particularly for U.S. Atlantic breeders and for wintering locations outside the U.S., but wintering areas include the U.S. coast from North Carolina to Texas, as well as Mexico, and several Caribbean islands (USFWS 2009). Within the U.S. wintering range, the Atlantic subpopulation appears to primarily winter along the southern Atlantic coast and the Gulf coast of Florida, though Massachusetts-breeding birds are known to winter as far as the Texas coast (Elliott-Smith and Haig, 2020; USFWS 2009).

Listing and Population Status

The Atlantic population of Piping Plovers is listed as *Threatened* under the ESA, with an estimated 2,289 nesting pairs in the U.S. as of 2021 (USFWS 2022), and breeding grounds are heavily managed to promote population recovery (Elliott-Smith and Haig 2004). Coastal habitat loss and degradation, as well as human-related disturbance, represent some of the greatest threats to the population; predation is also an issue on the breeding grounds and, in Massachusetts, this issue is exacerbated by anthropogenic disturbance (BOEM 2014; Elliott-Smith and Haig, 2020; USFWS 2009). The viability of the species is heavily dependent on adult and juvenile survival rates (USFWS 2009). However, the New England recovery unit of the population has nearly met or exceeded the USFWS-defined minimum abundance goal for recovery (625 pairs) every year since 1998 (USFWS 2022). The Massachusetts population, which is by far the largest of the New England states, was estimated to be 794 pairs in 2020 (MassWildlife 2021).

Regional Information

Piping Plovers are present in Massachusetts during spring and fall migratory periods and during the breeding season (mid-March to late August or early September (BOEM 2014; Elliott-Smith and Haig 2020). Large numbers of Piping Plovers have been observed in pre-migratory staging in southeastern Cape Cod in late summer (BOEM 2014).

Only recently have data started to become available on the potential for macro-scale exposure of migrating Piping Plovers to WEAs along the Atlantic coast. Piping Plovers breeding in Rhode Island and in the Monomoy National Wildlife Refuge in Massachusetts were tracked with NanoTags (a type of very high frequency [VHF] transmitter; *n*=150) and monitored using automated telemetry stations in terrestrial areas. The telemetry stations' standard detection range did not extend to the offshore Lease Area, however. Migration trajectories in areas well offshore are interpolated from observed flight trajectories in coastal areas, as well as subsequent detections of individuals at other telemetry stations. The tracked individuals chose both offshore and coastal migration routes from their nesting locations (Loring et al. 2019).

These recent data present evidence for offshore migratory "hops" between coastal areas, such as Cape Cod, Long Island, coastal New Jersey/Delaware, and the Outer Banks of North Carolina. Large flocks of Piping Plovers have been observed during migratory stopover in Virginia, Cape May, New Jersey, and Cape Lookout, North Carolina (Elliott-Smith and Haig 2020), providing additional evidence in support of this hypothesis.

4.1.3.1.2. Exposure Assessment

Exposure was assessed using species accounts and the results of individual tracking studies. The NanoTag movement study estimated that nine tracked Piping Plovers (tagged in Massachusetts) passed through lease areas in Massachusetts to the west of OCS-A 522: Lease Area OCS-A 0501 (which at the time of the study included Lease Area OCS-A 0534) and OCS-A 0500 (Loring et al. 2019). The study did not estimate exposure events for OCS-A 522 and modeled track lines did not cross the Lease Area (Figure 4-7). The exposure estimates are considered a minimum estimate because of lost tags and incomplete coverage of the offshore environment, including the Lease Area, by land-based receivers (Loring et al. 2019). Piping Plovers were not observed during the digital aerial surveys (Figure 4-8). In sum, since Piping Plover exposure to the Lease Area would hypothetically only occur during migration and there is no breeding or foraging habitat for the species in the Lease Area, the expected exposure is minimal to low. These conclusions are consistent with those determined by comprehensive risk assessments conducted for Vineyard Wind 1 (BOEM 2018; BOEM 2019).

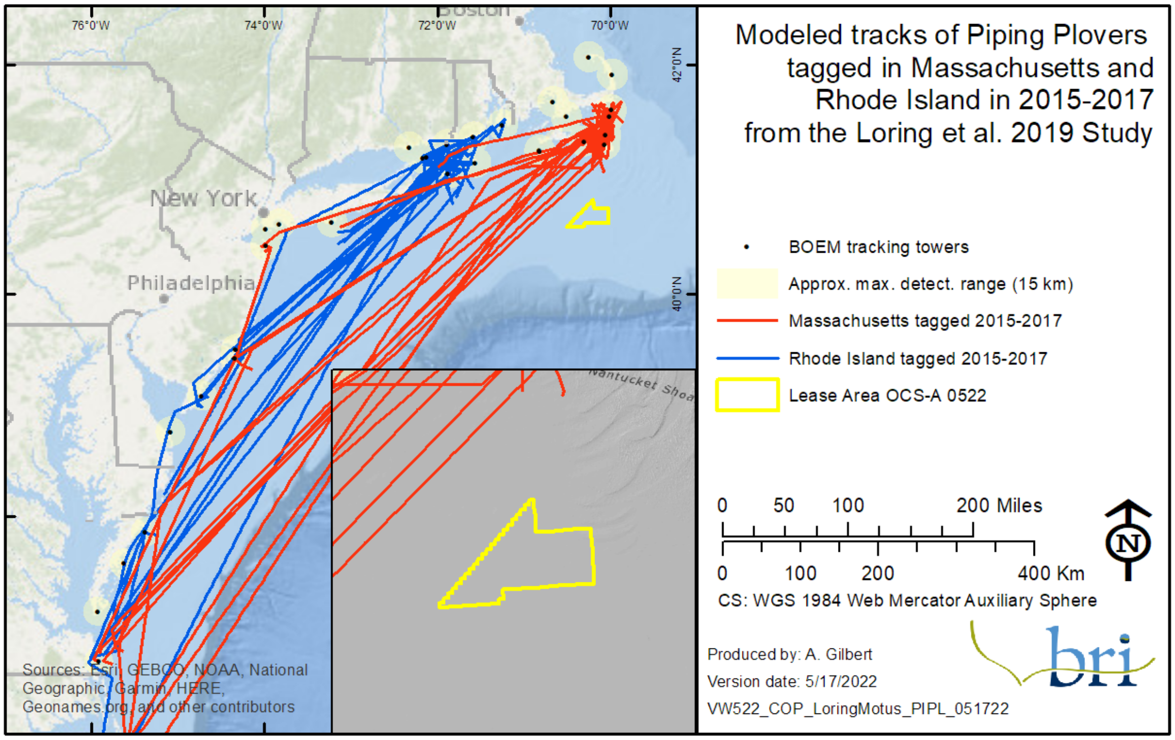


Figure 4-7: Modeled flight paths of migratory Piping Plovers equipped with NanoTags (Loring et al. 2019). All data are not actual flight paths but interpolated (model generated) flight paths. Flight paths were modeled by detections of movements between land-based towers. Towers had a typical detection range <15 km, so birds were only detected when flying within approximately 15 km of one of the towers. (See Figure 5 [tower locations] in Loring et al. [2019] and Appendix K [detection probability] for details). Appendices are found at https://espis.boem.gov/final%20reports/BOEM_2019-017a.pdf. Data provided by USFWS and used with permission.

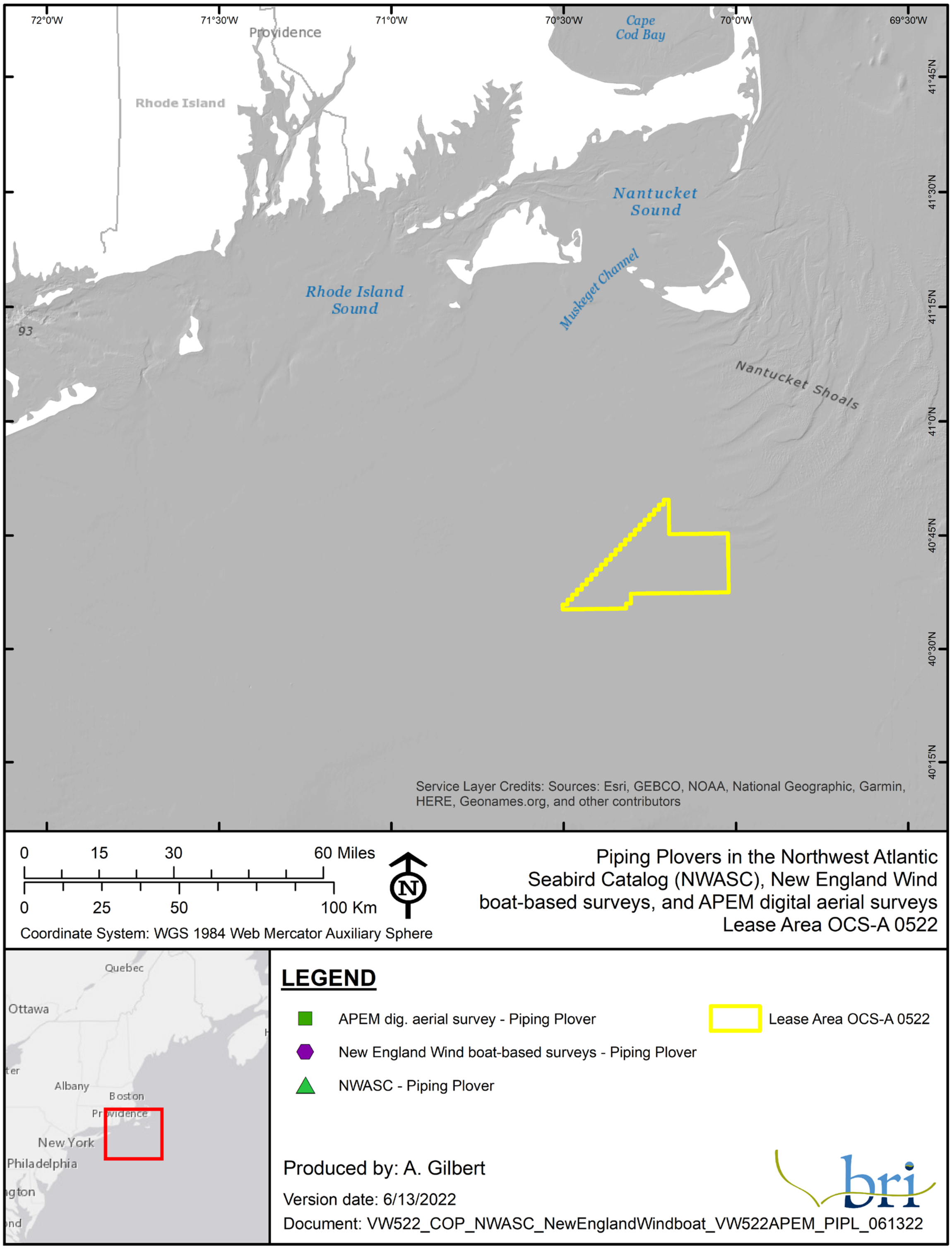


Figure 4-8: No Piping Plover observations in the vicinity of the Lease Area in the Northwest Atlantic Seabird Catalog, digital aerial surveys, or New England Wind boat-based surveys.

4.1.3.1.3. Relative Behavioral Vulnerability Assessment

Piping Plovers have **minimal** to **low** behavioral vulnerability to collision and **minimal** behavioral vulnerability to displacement. Piping Plovers are thought to migrate at flight heights well above the RSZ (i.e., greater than 300 m [984.2 ft]) under most circumstances, greatly reducing exposure to collision with WTGs, construction equipment, or other structures. Loring et al. (2019) found that migratory flight heights of Piping Plovers tagged with NanoTags were generally above a hypothetical RSZ (250 m [820 ft]), with 15.2% of birds flying between 25–250 m (82–820 ft) in WEAs. Offshore radar studies have recorded shorebirds flying at 1,000–2,000 m (3,000–6,500 ft; Richardson 1976; Williams and Williams 1990 *in* Loring et al. 2019), while nearshore radar studies have recorded lower flight heights of 100 m (330 ft; Dirksen et al. 2000 *in* Loring et al. 2019). Flight heights can vary with weather, and during periods of poor visibility, plovers may fly lower (Dirksen et al. 2000 *in* Loring et al. 2019)

Since Piping Plovers are generally expected to migrate at flight heights above the RSZ and have good visual acuity and maneuverability in the air (Burger et al. 2011), there is no evidence to suggest that they are particularly vulnerable to collision or displacement. Thus, the Piping Plover is expected to have **minimal** behavioral vulnerability to displacement. Piping Plovers would not be displaced during breeding or migratory staging because the Lease Area provides no habitat for the species during these life history stages. They could potentially be exposed to the Lease Area ephemerally during migration (see Section 6.2.1), but the Lease Area is not located near Piping Plover stopover locations.

4.1.3.1.4. Risk

Piping Plovers are expected to have **minimal** to **low** exposure to construction and operation activities occurring in the Lease Area. They are expected to have **minimal** to **low** behavioral vulnerability to collision and **minimal** vulnerability to displacement. Because of the limited exposure and the lack of behavioral vulnerability based on flight height during migration, risk to Piping Plover individuals is considered **minimal** to **low**. These findings are supported by the results of a collision risk model carried out by BOEM for Piping Plovers potentially passing through the Vineyard Wind 1 WDA, which estimated the annual number of fatalities as zero and found that any extra energy expenditure resulting from the avoidance of an offshore wind farm would be minimal (BOEM 2019).

4.1.3.2. Red Knot

4.1.3.2.1. Spatiotemporal Context

Species General Description

The Red Knot is a medium-sized shorebird with one of the longest migrations in the world, undertaking a nonstop flight of up to 8,000 km (4,970 mi) on its circumpolar travels between breeding and wintering locations (Baker et al. 2020). When not actively migrating, Red Knots feed exclusively in terrestrial locations, primarily in the intertidal zone, on mussels, clams, and other invertebrates, and spend most of their time on the ground rather than aloft.

During migration, Red Knots tend to: (1) embark on migratory flights a few hours before sunset, on sunny days, and days with tailwinds, and (2) migrate in flocks numbering in the dozens to hundreds of individuals (Baker et al. 2020). Migration routes appear to be highly diverse, however, with some individuals flying over the open ocean from the northeastern U.S. directly to stopover and wintering sites in the Caribbean and South America, while others make the ocean "jump" from farther south or follow the U.S. Atlantic coast for the duration of migration (Baker et al. 2020; BOEM 2014). Some of this variation may be due to birds avoiding large storms in the Atlantic (Baker et al. 2020).

Listing and Population Status

The *rufa* subspecies of the Red Knot is listed as *Threatened* under the ESA, primarily because the Atlantic flyway population decreased by approximately 70% from 1981 to 2012 to less than 30,000 individuals (Burger et al. 2011; USFWS 2015; Baker et al. 2020). This subspecies appears to include three distinct populations in the western Hemisphere, with individuals wintering in the southeastern U.S. and Caribbean, northern Brazil, and Tierra del Fuego (Baker et al. 2020). All three populations breed in the High Arctic and share several key migration stopover areas along the eastern coast of the U.S., particularly in Delaware Bay and coastal islands of Virginia (Burger et al. 2011). Increasingly limited food resources in these staging areas, as well as breeding conditions in the Arctic and habitat degradation on the wintering grounds, are thought to be contributing to the population's decline (Baker et al. 2020). Climate change impacts on habitats, food availability, and migration are also expected to negatively influence Red Knot populations. Population status is thought to be strongly influenced by adult survival and recruitment rates, conditions on the breeding grounds, and food availability on stopover sites (97 to 98% of individuals are estimated to use the same small number of stopover locations in some areas) (Baker et al. 2020).

Regional Information

The Red Knot is present in Massachusetts only during migratory periods (BOEM 2014). All three populations of *rufa* are known to stop over on Monomoy Island during southward migration in the fall (Baker et al. 2020). The fall migration period is July to October and is characterized by a concentration of migrant activity and departures in Massachusetts, particularly Cape Cod, in August (Baker et al. 2020; Burger et al. 2011). In addition to arriving and departing at slightly different times, adults and juveniles appear to use different stopover locations in Cape Cod and mainland Massachusetts (Baker et al. 2020).

During their northward migration in spring, all three wintering populations of *rufa* use Delaware Bay as a key stopover location in late April to June, before undertaking long flights to locations in the Canadian Arctic (Baker et al. 2020). Birds in the southeastern U.S. wintering population may also make multiple stops along the eastern seaboard, including in Massachusetts; spring migration through Massachusetts may thus include both offshore migratory activity and more coastal activity after birds make landfall farther south (BOEM 2014). Reports from the 1800s suggest many thousands of Red Knots stopping over in Massachusetts in late May and early June, but relatively few birds are observed in Massachusetts Bay today (Baker et al. 2020). While at stopover locations, Red Knots make local movements (e.g., commuting flights between foraging locations related to tidal changes), but are thought to remain within 5 km (3.1 mi) of shore (Burger et al. 2011).

4.1.3.2.2. Exposure Assessment

The Northwest Atlantic Seabird Catalog has no records of Red Knots in the Lease Area, and none were observed during the daytime digital aerial surveys (Figure 4-9), although the birds generally fly at night. Most adult *rufa* fly offshore over the Atlantic from Canadian or U.S. staging areas to South America (Baker et al. 2020); this is the period in which Red Knots could potentially move through the Lease Area (BOEM 2014). In a recent telemetry study, two birds tagged in Massachusetts (*n*=99) were detected as potentially crossing Lease Area OCS-A 0501, which is situated approximately 24 km (13 nm) to the northwest of Lease Area OCS-A 0522 (Loring et al. 2018). Since Red Knot exposure to the Lease Area is limited to migration and there is no habitat for the species in the Lease Area, the expected exposure is **minimal** to **low**.

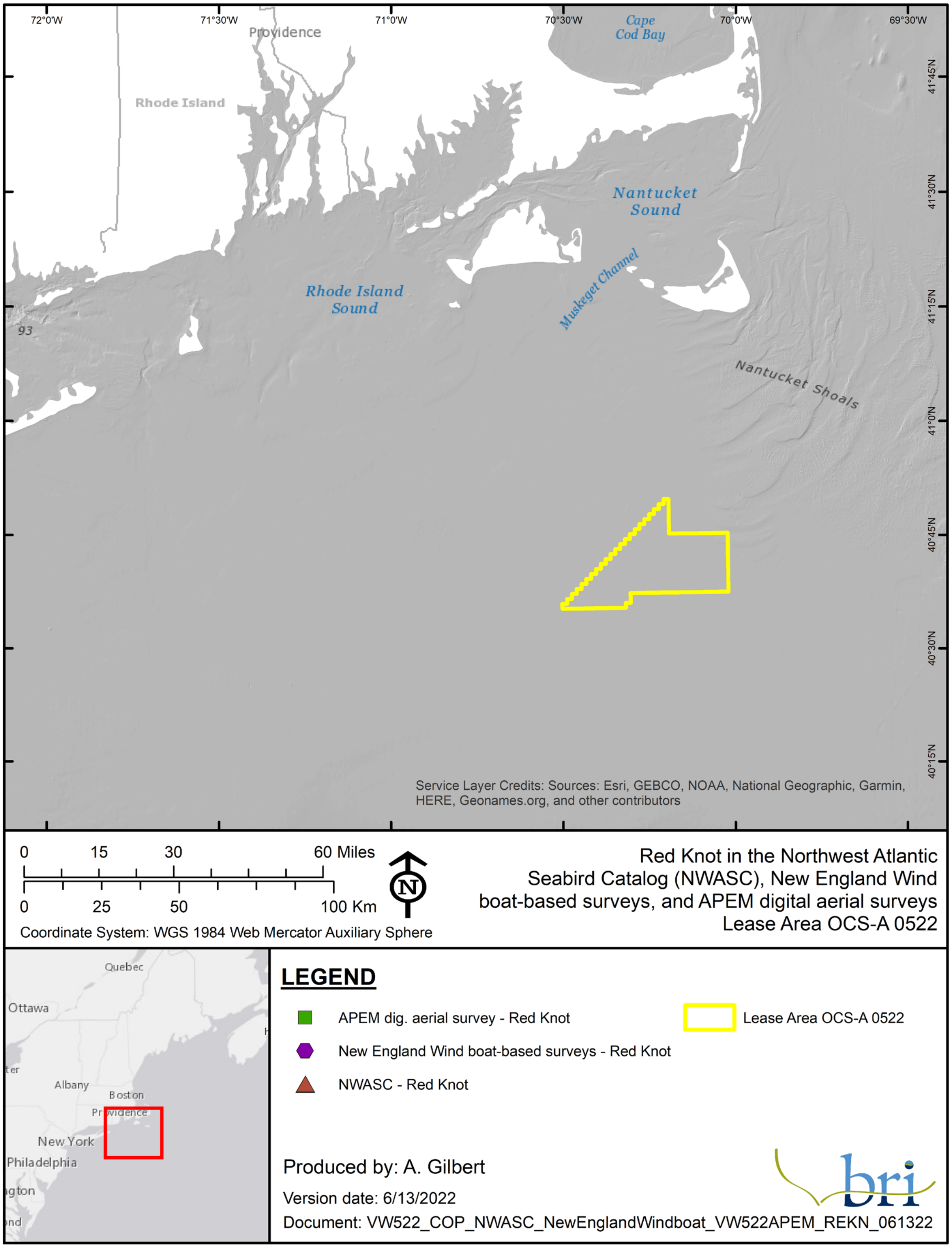


Figure 4-9: No Red Knot observations in the vicinity of the Lease Area in the Northwest Atlantic Seabird Catalog, digital aerial surveys, or New England Wind boat-based surveys.

4.1.3.2.3. Relative Behavioral Vulnerability Assessment

Red Knots have **low** behavioral vulnerability to collision and **minimal** behavioral vulnerability to displacement. Red Knots are thought to migrate at flight heights well above the RSZ (i.e., greater than 300 m [984.2 ft]) under most circumstances, greatly reducing exposure to collisions with WTGs, construction equipment, or other structures. During long-distance flights, Red Knots are generally considered to migrate at flight heights well above the RSZ (Burger et al. 2012), reducing exposure to collisions with WTGs, construction equipment, or other structures, but a movement study using NanoTags did indicate that they can also fly within a hypothetical RSZ of 20–200 m (65–656 ft; Loring et al. 2018). Of note, the flight heights of Red Knots captured during the same study from Delaware Bay in 2016 were estimated to be higher; in the spring and fall, mean flight heights were 502 m (1,647 ft) and 475 m (1,558 ft), respectively, when Red Knots flew over proposed Atlantic OCS WEAs (Loring et al. 2018). Flight heights during long-distance migrations are thought to normally be 1,000–3,000 m (3,000–10,000 ft), except during takeoff and landing at terrestrial locations (Burger et al. 2011). Red Knots likely adjust their altitude to take advantage of local weather conditions, including flying at lower altitudes in headwinds (Baker et al. 2020) or during periods of poor weather and high winds (Burger et al. 2011). Red Knots have good visual acuity and maneuverability in the air (Burger et al. 2011), and there is no evidence to suggest that they are particularly vulnerable to collisions or displacement. In addition, migration flights are generally undertaken at night in good weather conditions, lessening any risk of collision (Loring et al. 2018).

The Red Knot is expected to have **minimal** behavioral vulnerability to displacement. There is little evidence and research on shorebird avoidance at offshore wind developments, but Red Knots are not considered to be vulnerable to displacement because their feeding habitat is strictly coastal (Burger et al. 2011). Therefore, while there is little data on displacement for Red Knots, avoidance behavior is not likely to lead to habitat loss offshore. Red Knots would not be displaced during breeding or migratory staging because the Lease Area provides no habitat for the species during these life history stages. Red Knots could potentially be exposed to Lease Area ephemerally during migration, but shorebirds generally fly at high altitudes well above RSZs during migration (Nisbet 1963; Richardson 1979) and the Lease Area is not located near Red Knot stopover locations (Burger et al. 2011).

4.1.3.2.4. Risk

Red Knots are expected to have **minimal** to **low** exposure to construction and operation activities occurring in the Lease Area. They are expected to have **low** behavioral vulnerability to collision and **minimal** vulnerability to displacement. Because of the limited exposure and the lack of behavioral vulnerability, anticipated risk to Red Knots is **minimal** to **low**. These findings are supported by the results of a collision risk model carried out by BOEM for Red Knots potentially passing through the Vineyard Wind 1 WDA, which estimated the annual number of fatalities as zero and found that any extra energy expenditure resulting from the avoidance of an offshore wind farm would be insignificant (BOEM 2019).

4.1.4. Wading Birds

4.1.4.1. Spatiotemporal Context

Like the smaller shorebirds, long-legged wading birds, such as herons and egrets, are coastal breeders and shallow water foragers that generally avoid straying out over deep water (Frederick 2001). Most long-legged waders breeding along the Atlantic coast migrate south to the Gulf coast, the Caribbean islands, Central America, and South America (Heron Conservation 2018); thus, they are capable of crossing large areas of ocean and may traverse the Lease Area during spring and fall migration periods.

4.1.4.2. Exposure Assessment

Exposure was assessed using tracking studies, species accounts, and baseline survey data. Recent results of Great Blue Herons tracked with satellite transmitters indicate that these birds tend to fly inshore of the Lease Area, but that some individuals travel farther offshore. Despite the distance from shore, a few Great Blue Herons appeared to traverse the Lease Area, but it is important to note that the location of individual birds is unknown between satellite transmitter positions and the line connections between positions simply shows a potential flight path (Figure 4-11). Given that long-legged wading birds spend much of the year in freshwater aquatic systems and coastal marine systems, that they were not observed in the Lease Area during the digital aerial and MassCEC surveys (Figure 4-10), and that the tracking data showed most birds flew coastally, overall exposure of this group to the Lease Area is expected to be **minimal** to **low**.

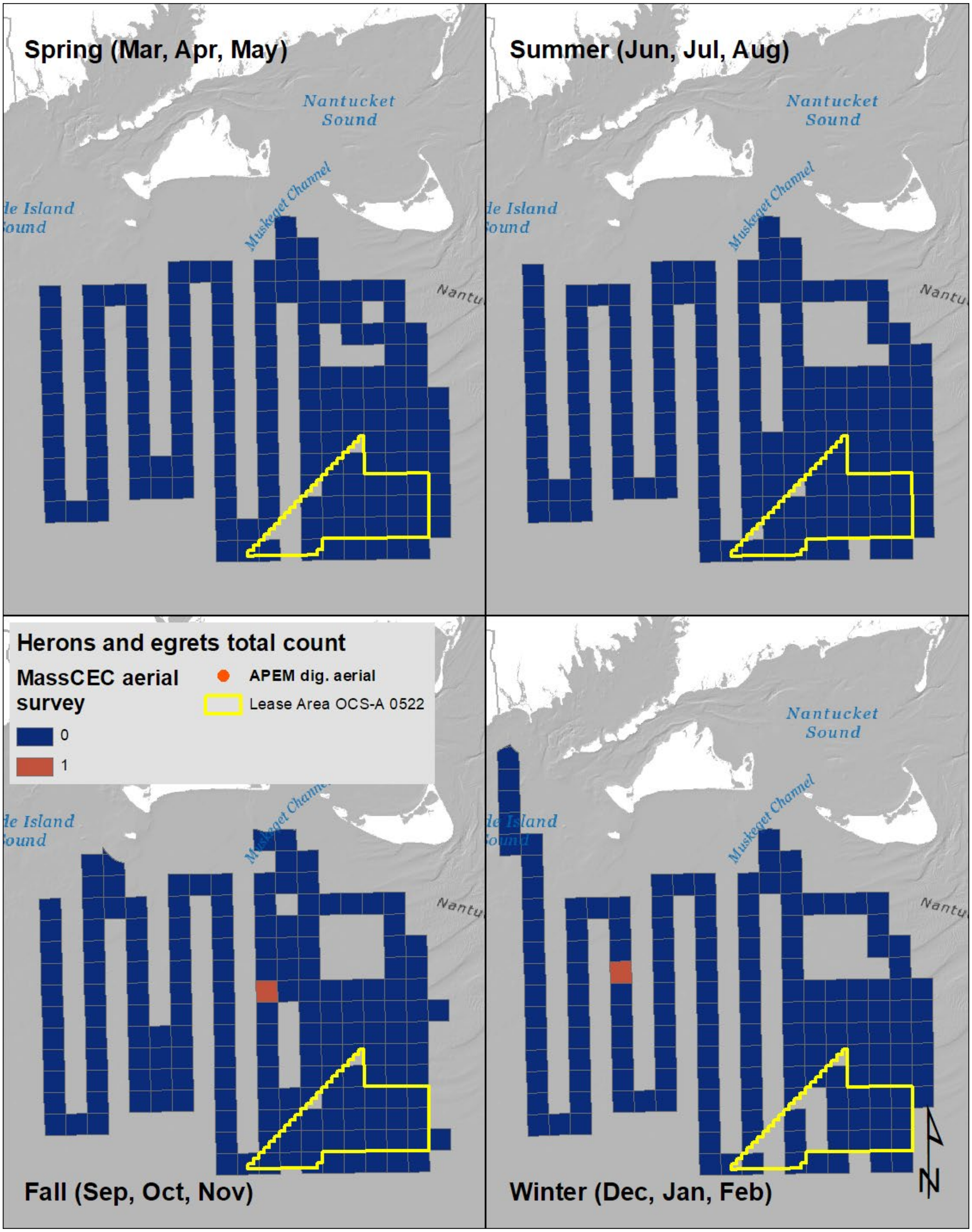


Figure 4-10: Herons and egrets observed, by season, during the digital aerial surveys and MassCEC aerial surveys.

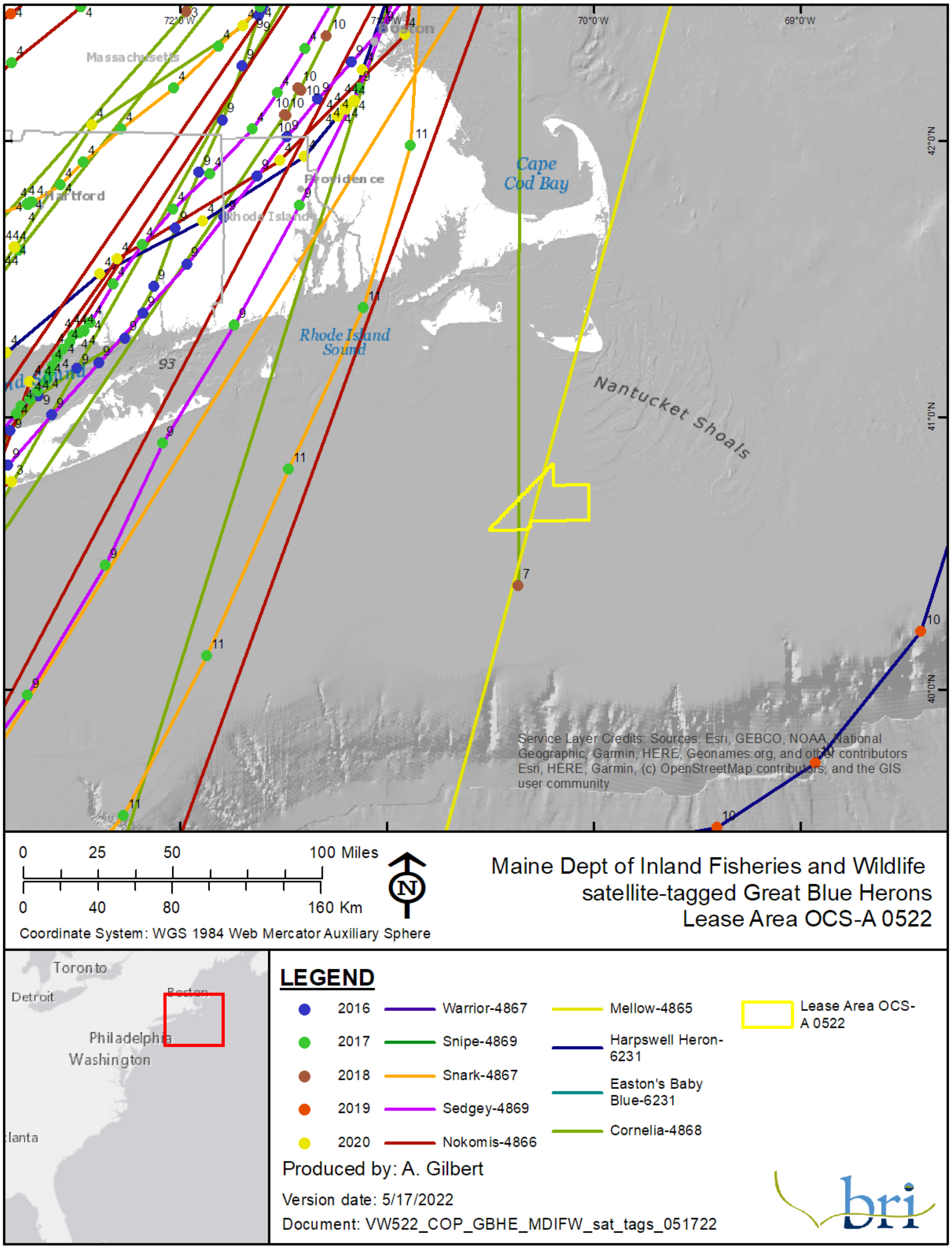


Figure 4-11: Track lines of Great Blue Herons captured in Maine and equipped with satellite transmitters. Each tag location is labeled with the month of the position. Data provided by Maine Department of Inland Fisheries and Wildlife and used with permission.

4.1.4.3. Relative Behavioral Vulnerability Assessment

While little is known about migratory behavior of herons, recent studies have documented long-distance migratory flights and use of the offshore environment during these periods. Purple Herons (*Ardea purpurea*), satellite-tagged prior to fledging in Europe, were documented migrating distances over 4,000 km (2,486 mi) in less than a week, including one individual that made a 5,600 km (3,480 mi) non-stop flight over mostly ocean (Van Der Winden et al. 2010). A recent telemetry study found that 43% of flight altitudes of Great Blue Herons occurred within the height range of terrestrial wind turbines in Maine (Dolinski 2019). Birds migrating offshore, however, may fly at higher altitudes to take advantage of favorable tail winds. For example, herons tracked via radar migrating over the Strait of Messina in southern Italy had mean flight heights of 821 m (Mateos-Rodríguez and Liechti 2012). While there remains uncertainty on heron vulnerability, they have been identified as having a potential for collision sensitivity (Willmott et al. 2013); tracking data indicates that within the Atlantic OCS, they have the potential within the RSZ (Figure 4-12); and there have been some individual mortalities detected at terrestrial wind projects (AWWI 2016). There does not, however, appear to be many records of wading birds colliding with WTGs at terrestrial wind farms. Wading birds are not expected to be vulnerable to displacement because the offshore environment is not providing primary foraging habitat. For these reasons, collision vulnerability is considered to be **low** and displacement **minimal**.

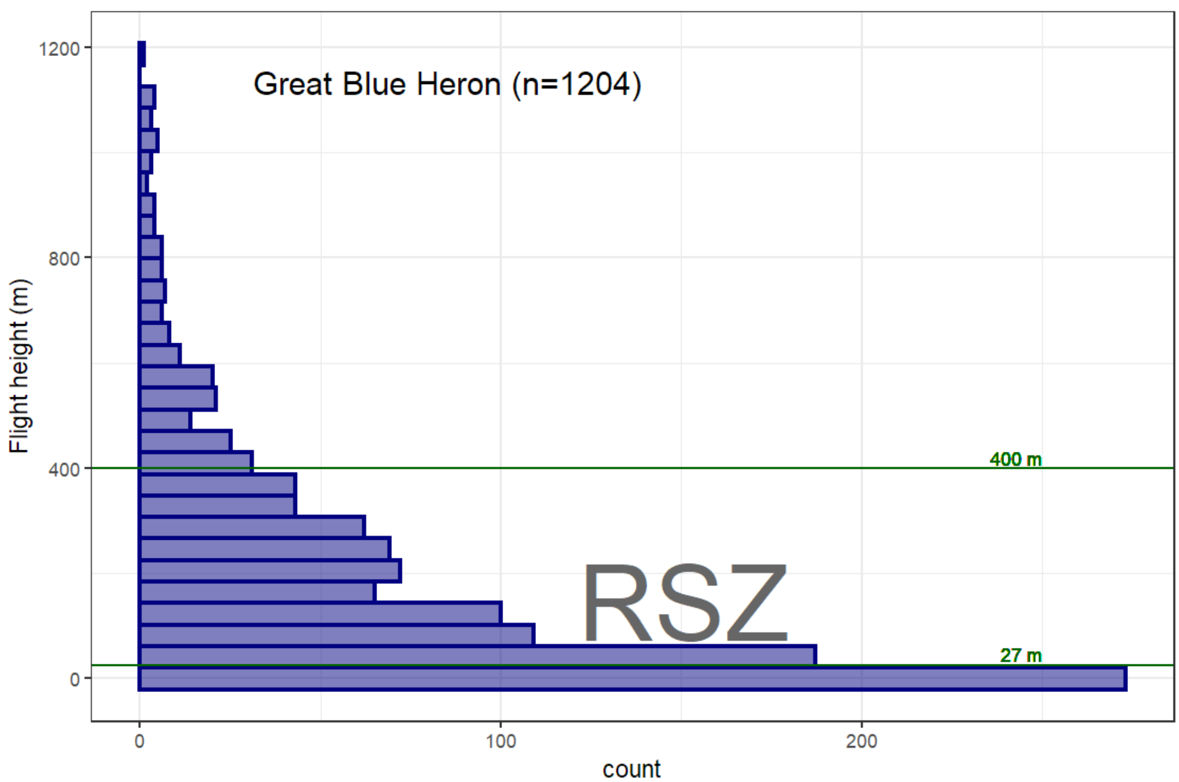


Figure 4-12: Flight heights (m) of Great Blue Herons satellite-tagged in Maine, flying over the Atlantic OCS, in relation to the upper and lower limits of the RSZ for the maximum WTG (27–400 m).

4.1.4.4. Risk

Given that wading bird exposure will be limited to migration, and that these birds have minimal to low vulnerability to collision and displacement, population level risk during construction and operation is expected to be **minimal** to **low**.

4.1.5. Raptors

4.1.5.1. Spatiotemporal Context

Raptor exposure to the Lease Area during migration will be dictated by a species' body design and general flight strategy (i.e., flapping versus soaring), which influences a species' ability or willingness to cross large expanses of open water where thermal formation is poor (Kerlinger 1985). Species that use soaring flight depend upon thermals and generally do not cross large expanses of water. *Buteo* hawks (i.e., the Red-tailed Hawk [*Buteo jamaicensis*], Broad-winged Hawk [*Buteo platypterus*], and Red-shouldered Hawk [*Buteo lineatus*]) that depend on soaring flight during migration are rarely observed in offshore settings (DeSorbo et al. 2012). *Accipiter* hawks (i.e., the Northern Goshawk [*Accipiter gentilis*], Cooper's Hawk [*Accipiter cooperii*], and Sharp-shinned Hawk [*Accipiter striatus*]), which use a mixture of powered and soaring flight, are encountered at offshore islands, but only in low numbers and are rarely observed offshore (Desorbo et al. 2017). Most owls do not utilize the offshore environment, although there is evidence of Northern Saw-whet Owls (*Aegolius acadicus*) passing over islands in Maine during migration (DeSorbo et al. 2012), and Long-eared Owls (*Asio otus*) are known to migrate along the coast.

Among raptors, falcons are the most likely to be encountered in offshore settings (Cochran 1985; DeSorbo et al. 2012; DeSorbo et al. 2018). Merlins (*Falco columbarius*) are the most abundant diurnal raptor observed at offshore islands during fall migration (DeSorbo et al. 2012; DeSorbo et al. 2018). Peregrine Falcons (*Falconidae peregrinus*) fly hundreds of kilometers offshore during migration and have been observed on vessels and oil drilling platforms located considerable distances from shore (McGrady et al. 2006; Johnson et al. 2011; DeSorbo et al. 2015). Recent individual tracking studies in the eastern U.S. indicate that migrating Peregrine Falcons (predominantly hatching year birds), likely originating from breeding areas in the Canadian Arctic and Greenland, commonly used offshore habitats during fall migration (DeSorbo et al. 2015; DeSorbo et al. 2018) while breeding adults from New Hampshire either used inland migration routes or were non-migratory (DeSorbo et al. 2018).

Ospreys (*Pandion haliaetus*) exhibit a wing morphology that enables open water crossings (Kerlinger 1985). However, satellite telemetry data from Ospreys in New England and the mid-Atlantic suggest that these birds generally follow coastal or inland migration routes. The raptors listed in Massachusetts are detailed in Table 4-4.

Table 4-4: Raptors listed in Massachusetts and their federal status.

Common Name	Scientific Name	MA Status	Federal Status
Bald Eagle	*Haliaeetus leucocephalus*	T	
Northern Harrier	*Circus cyaneus*	T	
Peregrine Falcon	*Falco peregrinus*	T	
Barn Owl	*Tyto alba*	SC	
Long-eared Owl	*Asio otus*	SC	
Short-eared Owl	*Asio flammeus*	E	

E = Endangered; T = Threatened; SC = Special Concern.

4.1.5.2. Exposure Assessment

Exposure for raptors was assessed using species accounts, baseline survey data, and individual tracking data. Overall, use of the Lease Area by most raptors is minimal during breeding or winter seasons and will be limited to falcons, and possibly Osprey during migration. The exposure of *Buteos*, *Accipiters*, and owls is expected to be **minimal**. Individual tracking data and species accounts indicate that falcons fly within the vicinity of the Lease Area (Figure 4-15). Therefore, the exposure is considered **low** for falcons because tracking data indicates they may pass through offshore waters in Massachusetts, and there is potential that falcons could be exposed to the Lease Area. Falcons may be attracted to turbines as offshore perching and hunting sites, which may increase temporal exposure during migration. Osprey exposure is expected to be **minimal** because the passage of individual birds through the Lease Area likely represents a small proportion of the overall populations and Osprey are likely to stay closer to land (Figure 4-16). Only one Osprey was reported during the digital aerial surveys in May and none were observed during the MassCEC surveys (Figure 4-13 and Figure 4-14).

Figure 4-13: Monthly relative densities of Osprey in the survey area from digital aerial surveys.

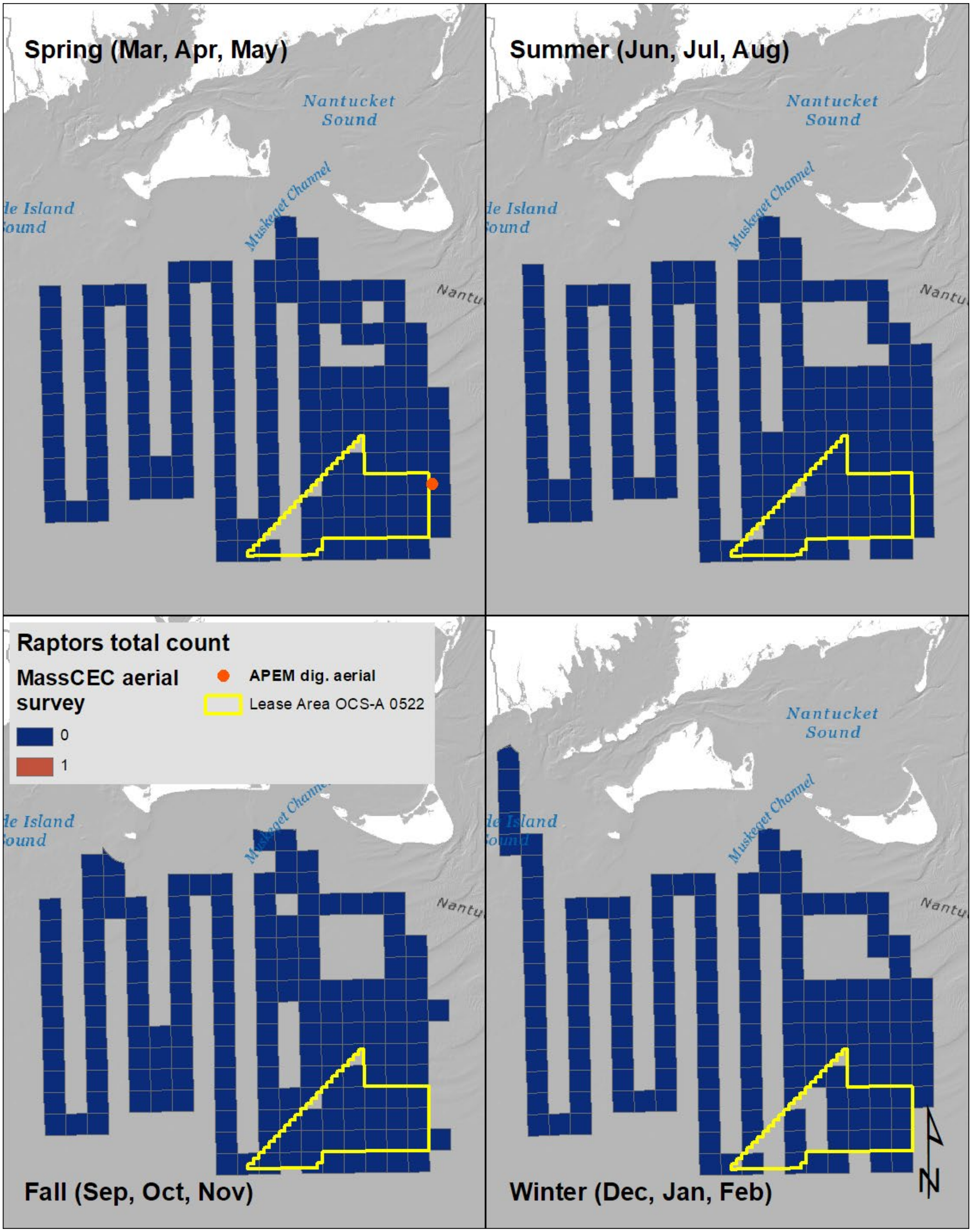


Figure 4-14: Raptors observed, by season, during the digital aerial surveys and MassCEC aerial surveys.

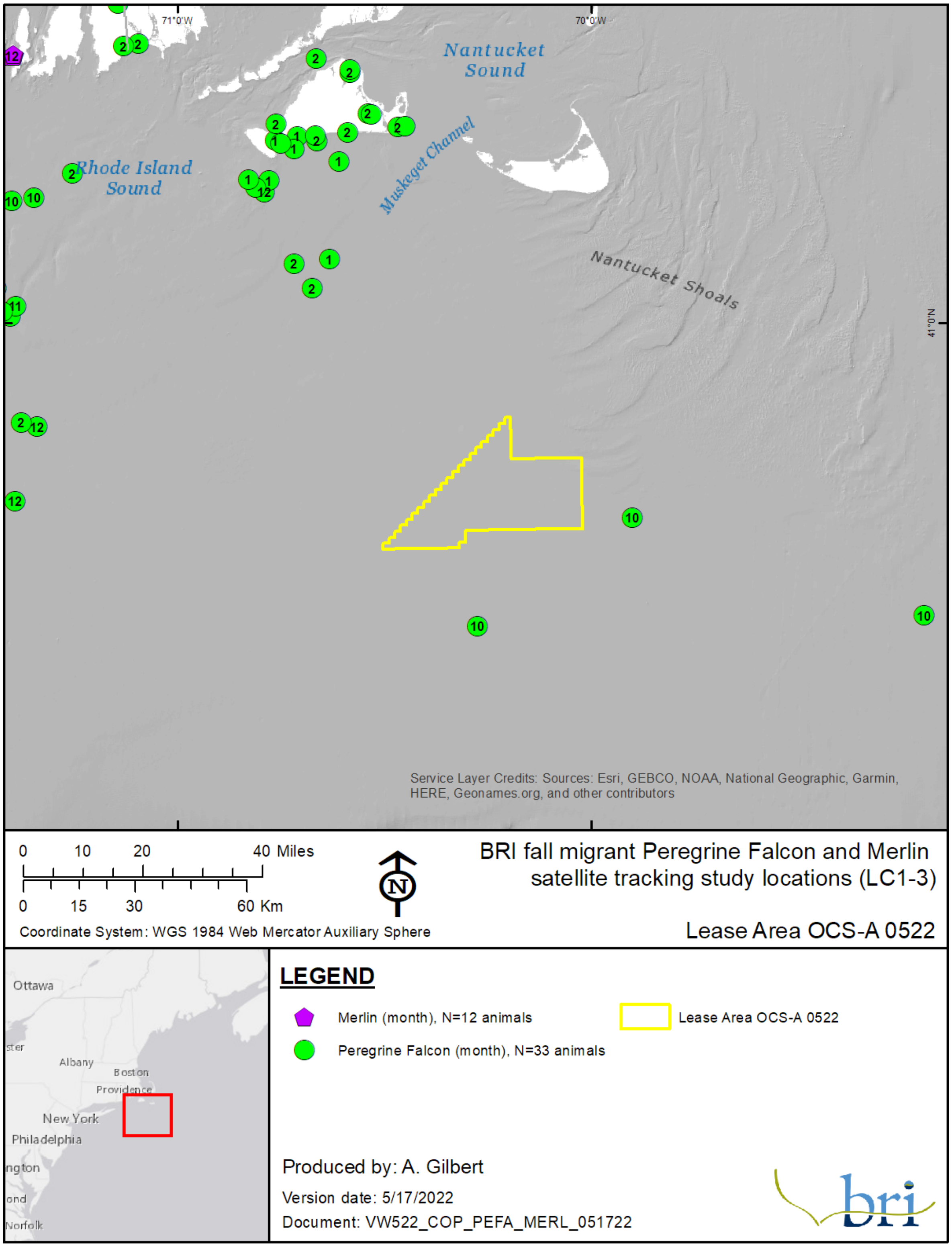


Figure 4-15: Location estimates from satellite transmitters deployed on Peregrine Falcons and Merlins tracked from three raptor research stations along the Atlantic coast, 2010–2018 (DeSorbo et al. 2018).

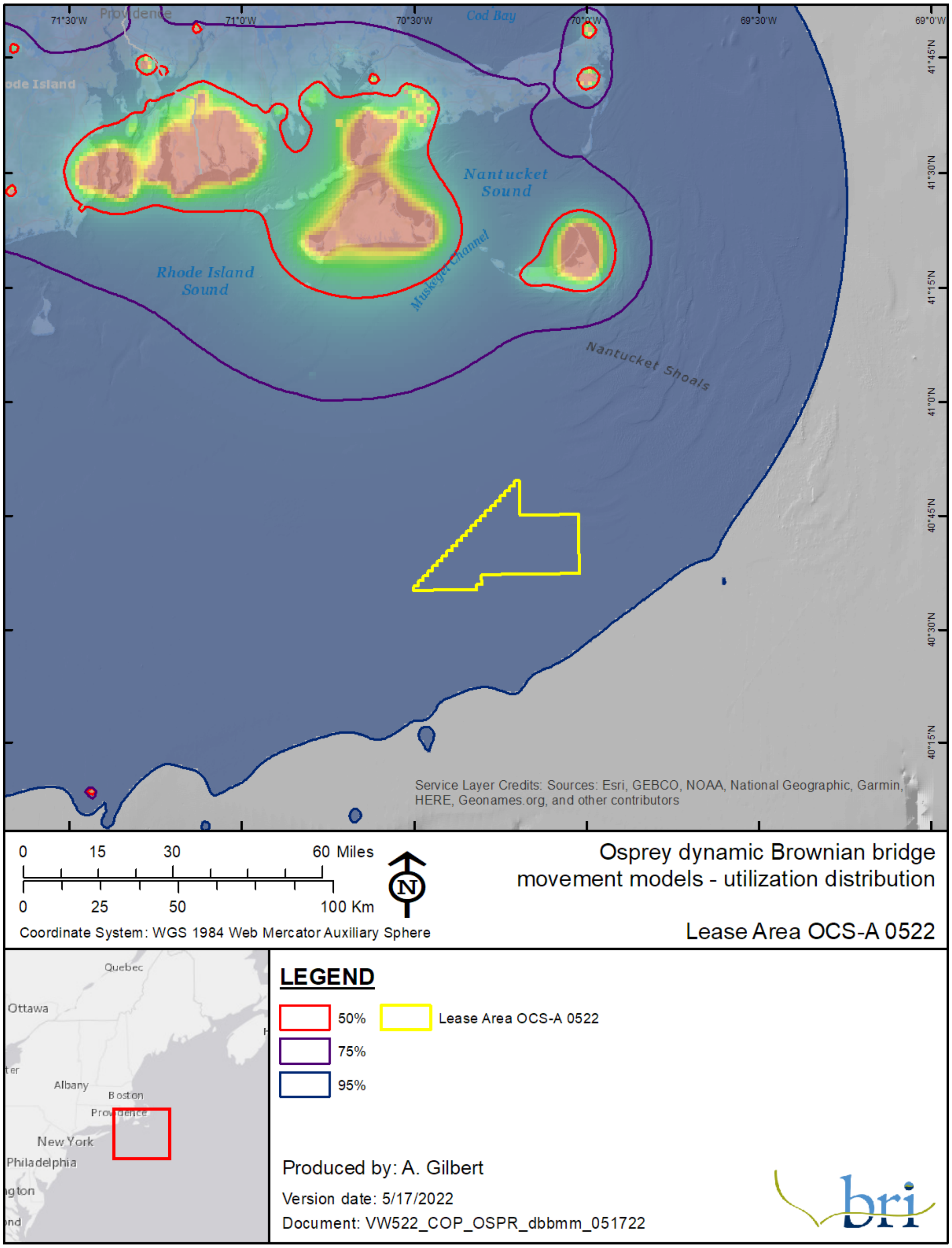


Figure 4-16: Dynamic Brownian bridge movement models for Ospreys (n = 127) tracked with satellite transmitters; the contours represent the percentage of the use area across the UD surface and represent various levels of use from 50% (core use) to 95% (home range).

4.1.5.3. Relative Behavioral Vulnerability Assessment

Migrating Peregrine Falcons, Merlins, and Ospreys are expected to have **low** to **medium** behavioral vulnerability to collisions. There is little information on how Osprey respond to WTGs, but falcons may be attracted to WTGs as perching sites and Peregrine Falcons and kestrels have been observed landing on the platform deck of offshore WTGs (Hill et al. 2014; Skov et al. 2016). A radar and laser rangefinder study found evidence indicating that multiple migrating raptor species were attracted to offshore WTGs in Denmark (Skov et al. 2016), and satellite-tagged Ospreys and Peregrine Falcons have been confirmed to perch on offshore barges and structures.

Little information exists documenting Peregrine Falcon mortalities, especially in offshore settings. However, Peregrine Falcon moralities have not been documented at European offshore wind developments, such as during the monitoring effort at the Thanet Offshore Wind Farm (Skov et al. 2018). Jensen et al. (2014) considered Peregrine Falcons to have low collision risk vulnerability at the proposed Horns Rev 3 wind development based on visual observations and radar data collated from two nearby existing wind farms. While Peregrine Falcon collisions with transmission lines have been documented (Olsen and Olsen 1980; White et al. 2002) only a few accounts of mortalities are associated with terrestrial-based WTGs in Europe (Meek et al. 1993; Hötker et al. 2006; Dürr 2011) and one in New Jersey (Mizrahi et al. 2009). Breeding adults and several young Peregrine Falcons were killed after colliding with a three-WTG terrestrial wind energy facility located close to their urban nest site in Massachusetts (MassWildlife 2018). Carcasses were not detected in post-construction mortality studies at several terrestrial projects in the U.S. (West Virginia and California) and New Zealand with falcon activity (Bull et al. 2013; Hein et al. 2013; DiGaudio and Geupel 2014).

In terrestrial habitats providing foraging and nesting opportunities not present offshore, American Kestrel (*Falco sparverius*) carcasses have been found in post-construction monitoring of much smaller terrestrial WTGs (1.8 MW) in Washington State (Erickson et al. 2008) but American Kestrel mortality has been demonstrated to decrease as WTG size increases (Smallwood 2013). Evidence of nocturnal soaring, perching, and feeding under lighted structures in terrestrial and offshore settings has been noted in Peregrine Falcons (Voous 1961; Cochran 1985; Johnson et al. 2011; Kettel et al. 2016), and these behaviors increase the exposure risk in this species.

Vulnerability to displacement is expected to be **minimal** to **low**. Observations of raptors at the Anholt Offshore Wind Farm in the Baltic Sea (20 km [12.4 mi] from the coast) indicate macro (i.e., avoiding entire wind farm) avoidance behavior (13–59% of birds observed depending on the species), which has the potential to cause a barrier for migrants in some locations, but may also reduce collision risk. Birds may also exhibit meso-avoidance, which involves significant changes in flight height prior to entering a wind farm. The percentage of Merlins and kestrels showing macro-/meso-avoidance behavior was 14/36 % and 46/50%, respectively (Jacobsen et al. 2019).

4.1.5.4. Risk

Falcons and Osprey are expected to have **minimal** to **low** exposure, primarily during migration, to operational activities in the Lease Area. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have **low** to **medium** behavioral vulnerability to collision. Population vulnerability assessment was not conducted. Because exposure is probably limited to individual migrants, population level risk to falcons and Osprey is expected to be **minimal** to **low**.

4.1.6. Bald and Golden Eagle

4.1.6.1. Spatiotemporal Context

Species General Description

The Bald Eagle is broadly distributed across North America. The species generally nests and perches in association with water (lakes, rivers, bays) in both freshwater and marine-based habitats, often remaining within roughly 500 m (1,640 ft) of the shoreline (Buehler 2020). Foraging habits are seasonally opportunistic, but individuals generally prefer fish, when available. In some regions, the diets of Bald Eagles nesting in offshore coastal settings are dominated by birds (i.e., waterfowl, cormorants, and gulls), whereas the diets of inland nesters in New England consist largely of fish (Murie 1940; Todd et al. 1982). Bald Eagles commonly scavenge dead birds, fish, and mammals, particularly during the winter when live fish prey is often scarce.

The Golden Eagle (*Aquila chrysaetos*) diet is generally comprised of small mammals, such as rabbits, mice, and prairie dogs, but numerous other prey items have also been reported (Kochert et al. 2002). Eagles are generally associated with open habitats, particularly in the western U.S., but satellite-tracked individuals wintering in the eastern U.S. have also been documented to use forested regions heavily (Katzner et al. 2012). In addition to breeding populations in Europe and Asia, Golden Eagles are broadly distributed across western North America, but are comparatively rare in the eastern U.S. (Kochert et al. 2002). Golden Eagles commonly winter in the southern Appalachians and are regularly observed in the mid-Atlantic U.S., spanning coastal plain habitat in Virginia, Delaware, North Carolina, South Carolina, and other southeastern U.S. states. Individuals migrating between Appalachian states and easternmost breeding populations in Canada generally use inland migration routes following the Appalachian Mountains, rather than coastal migration flyways (Katzner et al. 2012).

Unlike many groups of birds, such as falcons, gulls, and shorebirds, eagles have a high weight to wing area ratio (Mendelsohn et al. 1989). This wing-loading characteristic causes eagles to rely heavily on thermals during long-distance movements and to generally avoid large water crossings (Kerlinger 1985). Bald Eagles will, however, travel to coastal islands to nest, forage (i.e., at seabird colonies; Todd et al. 1982), and possibly to stopover during long-distance movements (Mojica et al. 2008).

Listing and Population Status

The Bald Eagle was removed from the federal list of threatened and endangered species in 2007 but is currently listed as *Threatened* in Massachusetts. Breeding populations of Golden Eagles are extirpated in the eastern U.S. (Katzner et al. 2012). The nearest known breeding populations are in Canada, where they are common in several eastern Provinces, such as Québec, and

Newfoundland and Labrador (Katzner et al. 2012). Both Bald Eagles and Golden Eagles remain federally protected under the Bold and Golden Eagle Protection Act.

Regional Information

Bald Eagles are present year-round in Massachusetts, including Martha's Vineyard, Nantucket, and other nearby islands (eBird 2018). In a study evaluating the spatial distribution of Bald Eagles captured in Chesapeake Bay, the Cape Cod region was associated with very low levels of use (Mojica et al. 2016). Between 2012 and 2013, a large offshore area in the mid-Atlantic U.S. was surveyed, using both boat-based and digital aerial surveys, and only four Bald Eagles were detected, all within 6 km (3.7 mi) of shore (Williams et al. 2015). Given that the study area was near one of the largest Bald Eagle population centers in North America (Chesapeake Bay), this finding supports the hypothesis that Bald Eagles rarely venture far offshore. Eagles were not seen in or near the Lease Area in the MassCEC aerial surveys or digital surveys, and there were no records of eagles near the Lease Area in the Northwest Atlantic Seabird Catalog.

4.1.6.2. Exposure

The general morphology of both Bald Eagles and Golden Eagles dissuades regular use of offshore habitats. These two species generally rely on thermals, which are poorly developed over the ocean, during migration movements. Golden Eagle exposure in the Lease Area is expected to be **minimal** due to their dietary habits, limited distribution in the eastern U.S., and reliance on terrestrial habitats (BOEM 2014). Bald Eagle exposure in the Lease Area is also expected to be **minimal** because the Lease Area is not located along any likely or known Bald Eagle migration routes, they tend not to fly over large water bodies, and features that might potentially attract them offshore (i.e., islands) are absent nearby. Since exposure is expected to be **minimal** for both species and there is no evidence that they will be exposed to the Lease Area, eagles will not be addressed further.

4.1.7. Songbirds

4.1.7.1. Spatiotemporal Context

Songbirds almost exclusively use terrestrial, coastal, and aquatic habitats and do not use the offshore marine system except during migration. Many North American breeding songbirds migrate to the tropical regions of Mexico, the Caribbean islands, Central America, and South America. On their migrations, these Neotropical migrants mostly travel at night and at high altitudes, where favorable winds can aid them along their trip. Songbirds regularly cross large bodies of water, such as the Mediterranean Sea or the Gulf of Mexico (Bruderer and Lietchi 1999; Gauthreaux and Belser 1999), and there is some evidence that species migrate over the northern Atlantic as well (Drury and Keith 1962). Some birds may briefly fly over the water while others, like the Blackpoll Warbler (*Setophaga striata*), can migrate non-stop over vast expanses of ocean (Faaborg et al. 2010; Deluca et al. 2015).

Landbird migration may occur across broad geographic areas rather than in narrow "flyways" as has been described for some waterbirds (Faaborg et al. 2010). Evidence for a variety of species suggests that over-water migration in the Atlantic is much more common in fall (than in spring), when the frequency of overwater flights increases perhaps due to consistent tailwinds (Morris et al. 1994; Deluca et al. 2015). Blackpoll Warbler is the species that is most likely to fly offshore during migration (Faaborg et al. 2010; Deluca et al. 2015). Migrating songbirds have been detected at or near smaller offshore wind developments in Europe (Kahlert et al. 2004; Krijgsveld et al. 2011; Pettersson and Fågelvind 2011) and may have greater passage rates during the middle of the night (Hüppop and Hilgerloh 2012). Songbirds listed in Massachusetts are detailed in Table 4-5.

Table 4-5: Songbirds listed in Massachusetts and their federal status.

Common Name	Scientific Name	MA Status	Federal Status
Sedge Wren	*Cistothorus platensis*	E	
Golden-winged Warbler	*Vermivora chrysoptera*	E	
Northern Parula	*Parula americana*	T	
Blackpoll Warbler	*Dendroica striata*	SC	
Mourning Warbler	*Oporornis philadelphia*	SC	
Vesper Sparrow	*Pooecetes gramineus*	T	
Grasshopper Sparrow	*Ammodramus savannarum*	T	
Eastern Whip-poor-will	*Caprimulgus vociferous*	SC	

E = Endangered; T = Threatened; SC = Special Concern.

4.1.7.2. Exposure Assessment

Exposure for songbirds was assessed using species accounts and baseline survey data. During the digital aerial surveys, a few individual songbirds were observed in the fall (September and October), although it should be noted that digital aerial surveys are not designed to detect migratory songbirds, which are flying primarily at night (Figure 4-17 and Figure 4-18). Given that songbirds do not use the offshore marine system as habitat and there is little evidence of songbird use of the Lease Area outside of the migratory period, exposure is expected to be **minimal** to **low**.

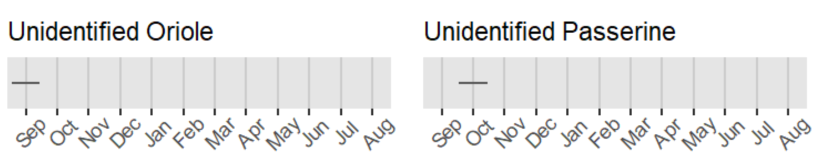


Figure 4-17:Monthly relative densities of songbirds in the survey area from digital aerial surveys.

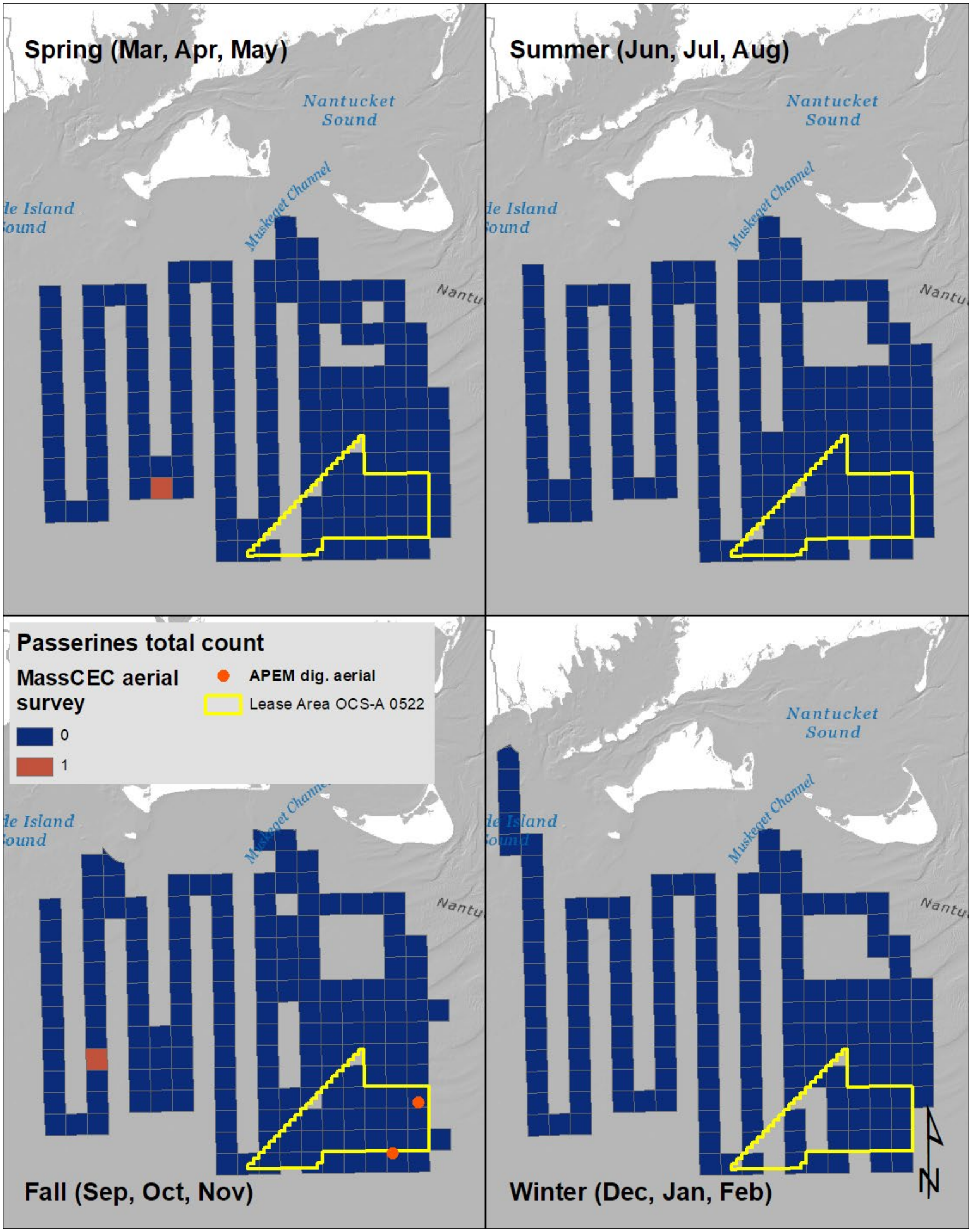


Figure 4-18: Songbirds (passerines) observed, by season, during the digital aerial surveys and MassCEC aerial surveys.

4.1.7.3. *Relative Behavioral Vulnerability Assessment*

Songbirds are expected to have **low** to **medium** behavioral vulnerability to collision. Mortalities of songbirds are documented at terrestrial WTGs (Erickson et al. 2014; Choi et al. 2020). In some instances, songbirds may be able to avoid colliding with offshore WTGs (Petersen et al. 2006) but are known to collide with illuminated terrestrial and marine structures (Fox et al. 2006). Movement during low visibility periods creates the highest collision risk conditions; at an offshore research station with substantial lighting, songbird mortalities have been documented during poor weather conditions (Hüppop et al. 2006). While avian fatality associated with terrestrial WTGs ranges from three to five birds per MW per year (AWWI 2016), direct comparisons between morality rates recorded at terrestrial and offshore wind developments should be made with caution because collisions with offshore WTGs could be lower either due to differing behaviors or lower exposure (NYSERDA 2015). At the Thanet Offshore Wind Farm, thermal imaging did not detect any songbird collisions (Skov et al. 2018). At Nysted, Denmark, in 2,400 hours of monitoring with an infrared video camera, only one collision of an unidentified small bird was detected (Petersen et al. 2006).

Passerines (songbirds) typically migrate at 90–600 m (295–1,968.5 ft; NYSERDA 2010), but can fly lower during inclement weather or with headwinds. In a study in Sweden, nocturnal migrating songbirds flew on average at 330 m (1,083 ft) above the ocean during the fall and 529 m (1,736 ft) during the spring (Pettersson 2005). Given the limited understanding of songbird migration, exposure of migratory songbirds to the Lease Area is uncertain, but some birds will likely cross the Lease Area during fall migration. Under poor weather conditions, individual vulnerability to collision may increase as birds fly at lower altitudes and may be more likely to fly through RSZs. Mortality is likely to be stochastic and infrequent. However, the mortality from all terrestrial WTGs in the U.S. and Canada combined is predicted to have a small effect on passerine populations (Erickson et al. 2014).

4.1.7.4. *Risk*

Songbirds are expected to have **minimal** to **low** exposure, primarily during migration, to construction and operational activities in the Lease Area. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have **low** to **medium** behavioral vulnerability to collision during migration. Because exposure is probably limited to individual migrants, and terrestrial wind farms are considered to have a small effect on most songbird populations, population level risk to songbirds is expected to be **minimal** to **low**.

4.2. Marine Birds

4.2.1. Regional Context

The following section presents the results of our marine bird exposure and vulnerability assessments for the Lease Area. The Lease Area is located to the west of Nantucket Shoals, which forms the southwest boundary between the Gulf of Maine and the New England continental shelf and is at the confluence of the cold water of the Labrador Current and the warm water of the Gulf Stream (Bowman et al. 2022). The Shoals, formed by Pleistocene glaciers (White and Veit 2020), are 52–93 km (32–58 mi) from Nantucket Island and are characterized as an area of submerged gravel and sand at depths that range from shallow shoals of only a few meters (10+ ft) to deeper channels that are 20–30 m (66–98 ft; (Limeburner and Beardsley 1982). These shallow waters have high primary and secondary productivity, tidal fronts, rotary currents, and upwelling (White and Veit 2020).

The shallow, sunlit Shoals support a high abundance of benthic mollusks and amphipods, providing important foraging areas for sea ducks (Bowman et al. 2022), and other marine birds (Veit et al. 2016). The density of high-quality prey is particularly important to bird species that need to increase body condition prior to migration (White et al. 2009), to sea ducks during winter months (Veit et al. 2016), and to terns found in higher numbers over the Shoals in May (Veit et al. 2016). The influence of the Shoals on bird abundance, primarily sea ducks, is seen in the MDAT models (Figure 4-19) and the MassCEC/digital aerial survey integrated models (Figure 4-20).

4.2.2. Assessment and Modeling Overview

Marine birds were assessed by species within each major taxonomic group, which included loons, sea ducks, petrels and allies, gannets and allies, gulls and allies, terns, and auks. Exposure assessment maps, tables, and figures are presented based on numerous references and data sets including, but not limited to, the digital aerial surveys (Figure 4-21), MassCEC aerial surveys, integrated models (INLA), NOAA MDAT (Figure 4-19) models, occurrence data, individual tracking data, relevant literature, and published species accounts. Species occurrence is also quantified based on observed densities both within and outside the Lease Area (Table 4-6).

Given that there were two survey data sets available, integrated density models were developed (see detailed methods in Section 5). Joint species density models incorporate all availability data to unify the density results across multiple surveys. For the Lease Area, regional surveys (conducted by the MassCEC) provide information on marine bird densities from 2011–2015 with aerial surveys, and the APEM digital aerial survey provided similar data from 2019–2021. Using a joint density analysis approach, survey biases were accounted for, and species density was integrated throughout Lease Area and the surrounding environment.

When interpreting these integrated density models, a few factors should be considered. First, survey data density (i.e., survey effort) is much higher within the Lease Area than outside of it. The MassCEC effort was a broad-scale regional survey, while the APEM effort was a high-intensity site characterization survey. While these differences in survey effort were accounted for in the model, there is evidence that effort is affecting model-predicted density outside of the Lease Area survey area for some species. The model uncertainty estimates can help identify areas with low confidence in model predictions, and the density patterns outside of the Lease Area should be interpreted with some caution. Second, APEM surveys detect animals more frequently than the MassCEC surveys. These differences likely depend on the viewing angle, flight height of the plane, and the data recording practices of each survey method. These differences are corrected for in the analysis, and densities are predicted from the joint model as the number of expected detections in that grid cell for the APEM surveys.

In the sections below, a relative behavioral vulnerability assessment is considered for both collision and displacement (Table 4-7), including flight height data relative to proposed WTG parameters. Flight heights are presented at the taxonomic level for brevity, though species-specific flight heights are accounted for in each vulnerability assessment. Flight heights used in the assessment were gathered from datasets in the Northwest Atlantic Seabird Catalog.

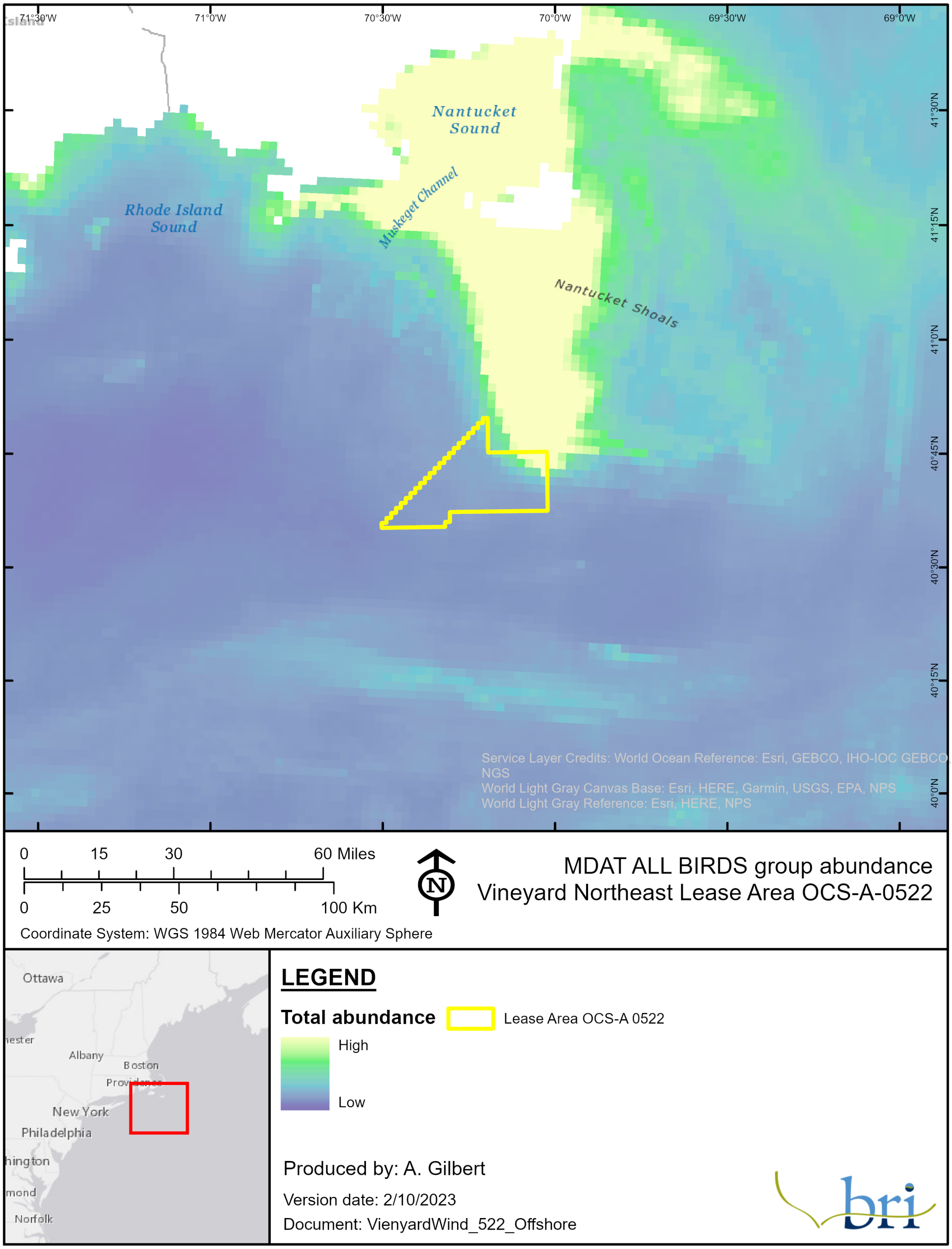


Figure 4-19: Bird abundance estimates from the MDAT models.

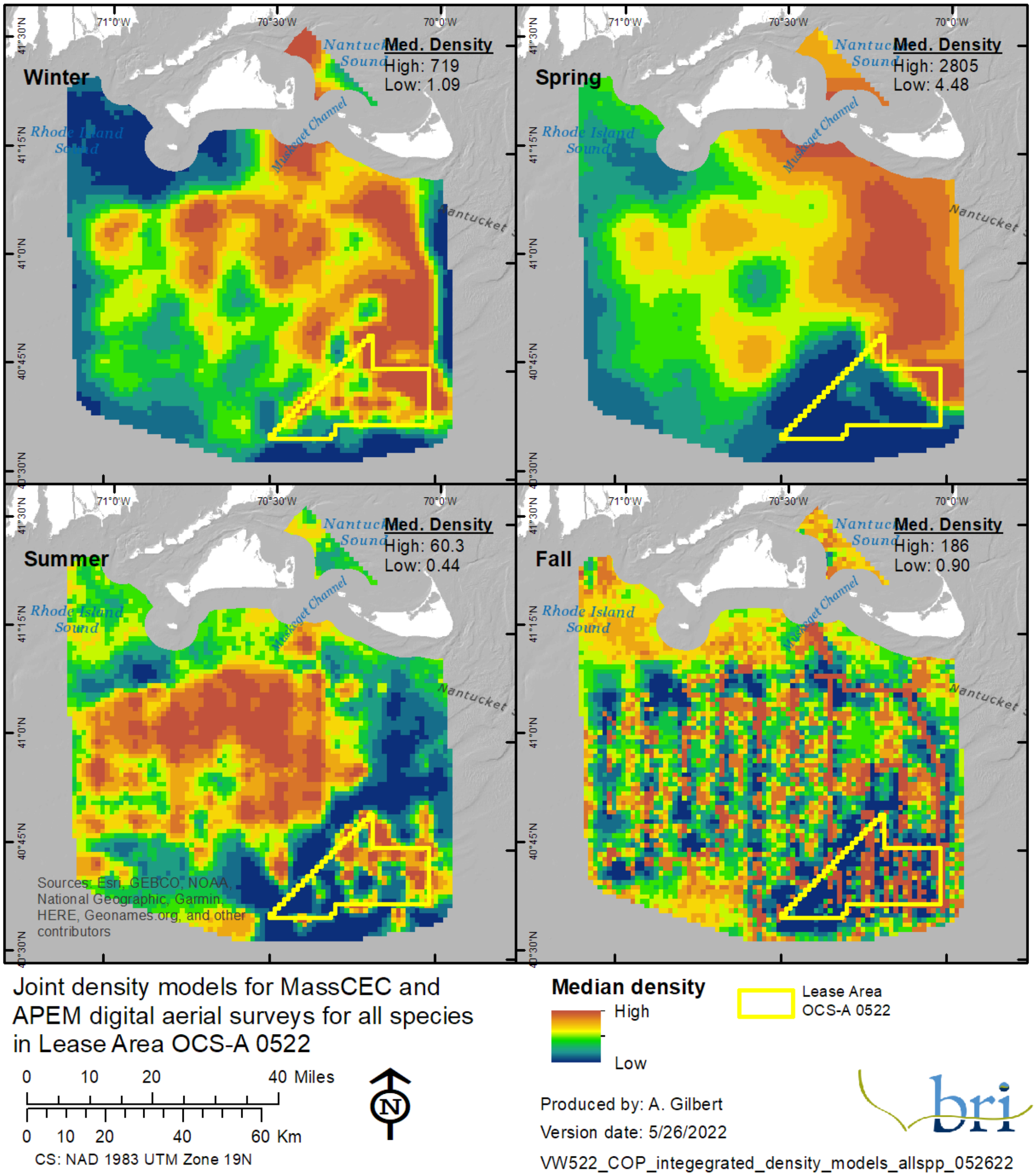


Figure 4-20: Joint density estimates for all species in Lease Area OCS-A 0522. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

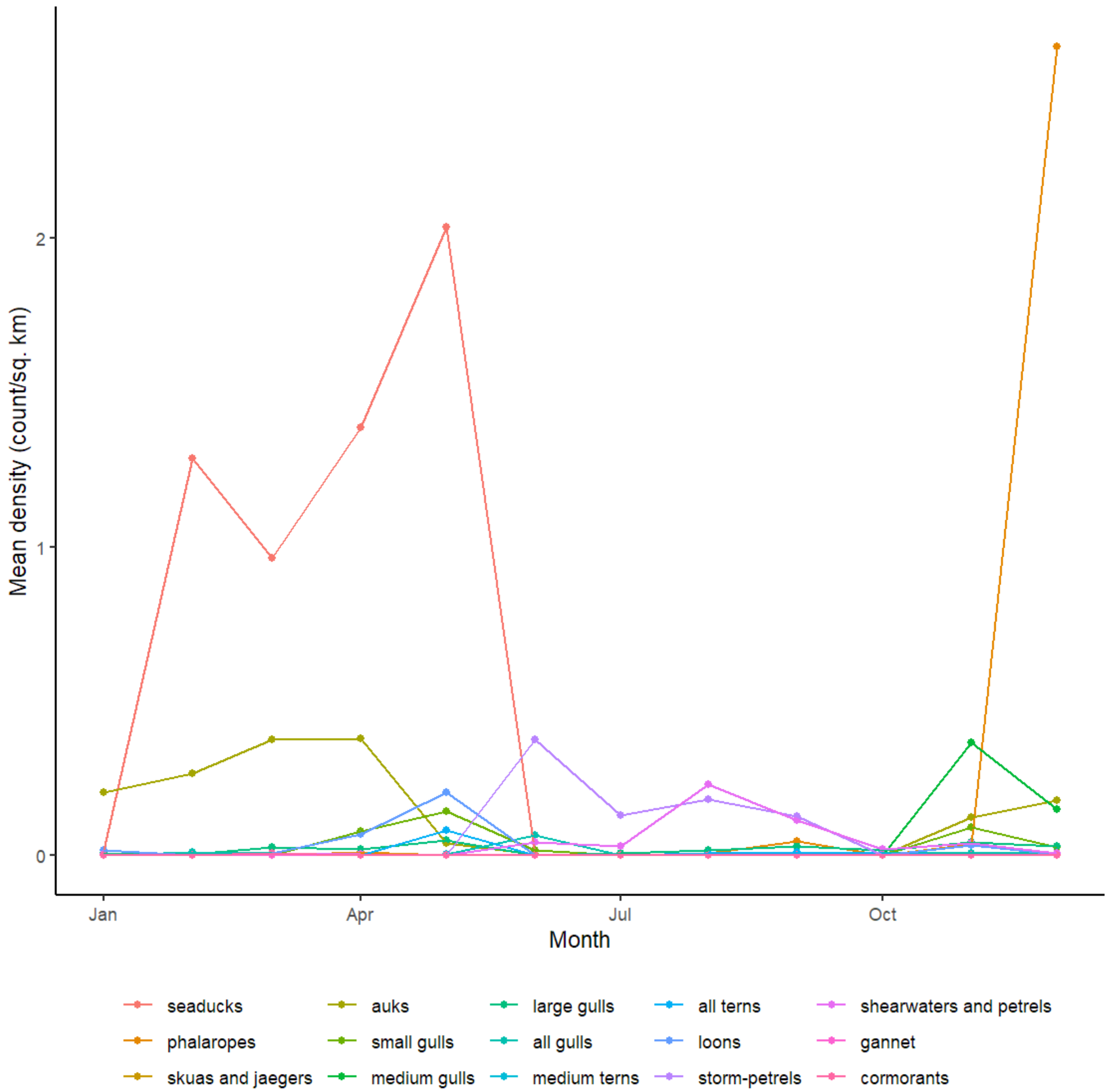


Figure 4-21: Mean species group densities from the digital aerial surveys.

Table 4-6: Integrated INLA modeled seasonal taxonomic mean density models comparing densities within the OCS-A 0522 Lease Area and the MassCEC baseline/APEM digital aerial combined study area.

Taxonomic group	INLA integrated modeled density (animals/sq. km)							
	Integrated Study Area				Lease Area OCS-A 0522			
	winter	spring	summer	fall	winter	spring	summer	fall
Sea ducks	2.15	17.2		0.004	5.58	52.2		0.002
Phalaropes	1.97	0.087	0.148	0.113	4.6	0.091	0.045	0.195
Auks	4.14	8.75		0.604	4.21	13.1		1.29
Small Gulls	0.075	0.19		0.209	0.075	0.303		0.305
Medium Gulls	0.563	0.022		1.31	0.566	0.021		1.71
Large Gulls	0.283	0.64	0.754	0.387	0.235	0.667	0.197	0.553
Terns		0.165				0.187		
Loons	0.24	7.58		0.129	0.126	2.54		0.102
Storm-Petrels			1.1	0.149			1.15	0.253
Shearwaters and Petrels	0.145	0.149	2.11	2.61	0.149	0.183	3.16	2.95
Gannet	1.03	0.548		0.832	1.07	0.602		0.88

Table 4-7: Vulnerability assessment rankings by species within each broad taxonomic grouping.

Species	Collision Vulnerability (CV)	Displacement Vulnerability (DV)	Population Vulnerability (PV)
Waterfowl			
Brant	medium (0.6)	medium (0.5)	low (0.47)
Sea Ducks			
Black Scoter	low (0.27)	high (0.9)	low (0.4)
Common Eider	low (0.27)	high (0.9)	low (0.47)
Long-tailed Duck	low (0.3)	high (0.9)	low (0.27)
Red-breasted Merganser	medium (0.53)	medium (0.5)	low (0.27)
Surf Scoter	low (0.27)	high (0.9)	medium (0.53)
White-winged Scoter	low (0.27)	high (0.8)	medium (0.53)
Shorebirds			
Piping Plover	.	low (0.3)	medium (0.67)
Red Knot	.	low (0.3)	medium (0.53)
Phalaropes			
Red Phalarope	low (0.47)	medium (0.5)	low (0.27)
Skuas and Jaegers			
Pomarine Jaeger	medium (0.73)	low (0.3)	low (0.4)
Auks			
Common Murre	minimal (0.23)	high (0.8)	low (0.4)
Dovekie	low (0.3)	medium (0.7)	low (0.4)
Razorbill	minimal (0.2)	high (0.8)	medium (0.6)
Gulls			
Great Black-backed Gull	medium (0.63)	medium (0.7)	minimal (0.2)
Herring Gull	medium (0.7)	medium (0.5)	medium (0.53)
Black-legged Kittiwake	medium (0.57)	medium (0.6)	low (0.33)
Laughing Gull	low (0.47)	medium (0.5)	low (0.4)
Bonaparte's Gull	medium (0.5)	medium (0.5)	low (0.33)
Terns			

Species	Collision Vulnerability (CV)	Displacement Vulnerability (DV)	Population Vulnerability (PV)
Common Tern	low (0.33)	high (0.8)	medium (0.6)
Roseate Tern	low (0.33)	high (0.8)	high (0.87)
Loons			
Common Loon	low (0.47)	high (0.8)	medium (0.6)
Red-throated Loon	low (0.33)	high (0.9)	low (0.47)
Storm-Petrels			
Wilson's Storm-Petrel	low (0.43)	medium (0.6)	low (0.4)
Petrels and Shearwaters			
Cory's Shearwater	low (0.33)	medium (0.6)	medium (0.6)
Great Shearwater	low (0.3)	medium (0.6)	medium (0.67)
Manx Shearwater	low (0.37)	medium (0.6)	medium (0.53)
Northern Fulmar	low (0.37)	medium (0.6)	low (0.47)
Sooty Shearwater	low (0.4)	medium (0.6)	medium (0.53)
Gannet			
Northern Gannet	low (0.43)	medium (0.6)	low (0.47)
Cormorants			
Double-crested Cormorant	medium (0.6)	low (0.4)	minimal (0.13)

4.2.3. Sea Ducks

4.2.3.1. Spatiotemporal Context

Sea ducks include the eiders, scoters, and Long-tailed Ducks (*Clangula hyemalis*), all of which are northern boreal, Gulf of Maine, or Arctic breeders that winter along the U.S. Atlantic coast. In winter, sea ducks can gather in large flocks in areas of appropriate habitat, sometimes in mixed species groups. Most sea ducks forage on mussels, other shellfish, and benthic invertebrates. They generally winter in shallower inshore waters or out over large offshore shoals, where they can access their benthic prey. Sea ducks generally forage in depths shallower than 30 m (98 feet) (Loring et al. 2014; Meattey et al. 2019), though long-tailed ducks have been documented foraging in substantially deeper areas (60 m [197 ft]; Cottam 1939, Schorger 1947).

The Nantucket Sound and Shoals is recognized as one of 85 key habitat sites for sea ducks across North America (Bowman et al. 2022; Figure 4-23).The western side of the Nantucket Shoals, immediately east of the Lease Area, is a well-recognized important area for wintering sea ducks (Silverman et al. 2013; Meattey et al. 2019), particularly for Long-tailed Ducks (White and Veit 2020) and other marine bird species (Veit et al. 2016). Long-tailed Ducks and other sea ducks winter on the Nantucket Shoals in large aggregations from November to April; as much as 30% of the continental population of Long-tailed Ducks (White et al. 2009), and a significant proportion of the Atlantic population of White-winged Scoters (*Melanitta deglandi*), can spend the winter in that location (Silverman et al. 2012).

Analysis of satellite-tracked Surf Scoters (*Melanitta perspicillata*), which were captured and tagged in the mid-Atlantic region, revealed their winter distributions to be largely well inshore of the mid-Atlantic WEAs, although they did exhibit a smaller core wintering area in Nantucket Sound (Stenhouse et al. 2020). Core use areas of wintering White-winged Scoters, however, were identified across the Nantucket Shoals. Satellite-tracked movements of these birds highlighted several within-winter movements throughout the southern New England coastal area, suggesting the possibility that White-winged Scoters could cross the Lease Area during these movements (Meattey et al. 2019). Satellite tracking indicated that Black Scoters (*Melanitta americana*) were concentrated closer to the islands and Long-tailed Ducks were concentrated around Nantucket. The regional MDAT abundance models and mid-winter aerial waterfowl surveys (Silverman et al. 2012) show that most sea ducks are concentrated close to shore and between Nantucket Island, Martha's Vineyard, and Cape Cod.

4.2.3.2. Exposure Assessment

Exposure was assessed using species accounts, tracking data, baseline survey data, and habitat maps. The eastern portion of the Lease Area overlaps with Key Habitat Site identified by Sea Duck Joint Venture (Figure 4-23). Tracking data indicates that Surf Scoters, Black Scoter, and Long-tailed Duck core use areas are generally inshore of the Lease Area (Figure 4-24, Figure 4-25, and Figure 4-27), while White-winged Scoter core use areas overlap with the northeastern portion of the Lease Area (Figure 4-26). During the digital aerial surveys, sea ducks were detected from December–May and scoters and Long-tailed Ducks were among the most abundant species in the Lease Area during the winter months (Figure 4-22). Sea duck distribution in the winter and spring seasons was strongly biased to the northeast towards Nantucket Shoals and aligns with tracking data, MassCEC surveys, and the MDAT models (see maps 3 – 21). Density estimates developed from the integrated INLA models indicate higher abundance in the Lease Area compared to the entire survey area due to the influence of the Shoals (Table 4-6); however, densities of Long-tailed Ducks and White-winged Scoters were substantially higher in the 1.85 km (1 nm) mile buffer of the survey area than the Lease Area, indicating that the Lease Area is just at the edge of the sea duck concentration areas in the Shoals. The seasonal exposure scores for the sea duck group (six species) ranged from **minimal** to **medium**. Black Scoter are expected to have **minimal** exposure in all seasons; White-winged Scoter have **medium** exposure in the spring and **minimal** to **low** exposure in other seasons; and all other species have **minimal** to **low** exposure across the seasons. Final exposure scores across species ranged from **minimal** to **low**. Due to the overlap with key habitat and that tracking and survey data indicate high use of the northeast portion of the Lease Area, a higher range (**medium**) was added to the final exposure score for the species group.

The Massachusetts OECC travels from the northernmost corner of the Lease Area along the northeast boundary of the MA WEA and Rhode Island/Massachusetts (RI/MA) WEA, south of Nomans Land, and across Buzzards Bay towards the Horseneck Beach Landfall Site in Westport. The initial route was adjusted to be further offshore to avoid sea duck and other marine bird habitat associated with Nantucket Shoals, and by staying predominantly in federal offshore waters, largely avoids high marine bird abundance areas. The route now only has a small overlap with sea duck core use areas, which is limited to the winter and spring seasons (Table 4-8 and Figure 4-23–Figure 4-27). The Connecticut OECC travels from the southwestern tip of Lease Area OCS-A 0522 along the southwestern edge of the MA WEA, and then heads between Block Island and the tip of Long Island, towards potential landfall sites near New London, Connecticut. The portion of the route off the eastern tip of Long Island partially passes through core use areas of sea ducks (primarily black scoter) in the winter and spring (Table 4-8 and Figure 4-23–Figure 4-27).

Table 4-8. Percent overlap between Connecticut and Massachusetts Offshore Export Cable Routes and Dynamic Brownian Bridge Movement Model contour areas.

Species	State	Season	Percent Overlap		
			50% Contour	75% Contour	95% Contour
WWSC	CT	Fall	0	0	0
WWSC	CT	Winter	16.68	28.51	51.74
WWSC	CT	Spring	0	0	4.33
SUSC	CT	Fall	0	0	0
SUSC	CT	Winter	0	0	0
SUSC	CT	Spring	6.64	3.15	79.98
BLSC	CT	Fall	0	20.92	53.28
BLSC	CT	Winter	23.7	36.07	56.2
BLSC	CT	Spring	33.85	50.51	58.78
LTDU	CT	Fall	0	0	0
LTDU	CT	Winter	0	0	0
LTDU	CT	Spring	0	0	0
WWSC	MA	Fall	0	0	58.49
WWSC	MA	Winter	1.99	5.01	0
WWSC	MA	Spring	4.39	8.83	0
SUSC	MA	Fall	0	0	64.5
SUSC	MA	Winter	0	0	32.21
SUSC	MA	Spring	7.43	56.62	0
BLSC	MA	Fall	0	0	78.31
BLSC	MA	Winter	0	37.12	78.01
BLSC	MA	Spring	0	3.43	61.24
LTDU	MA	Fall	0	0	0
LTDU	MA	Winter	7.88	35.93	52.73
LTDU	MA	Spring	0	0	12.87

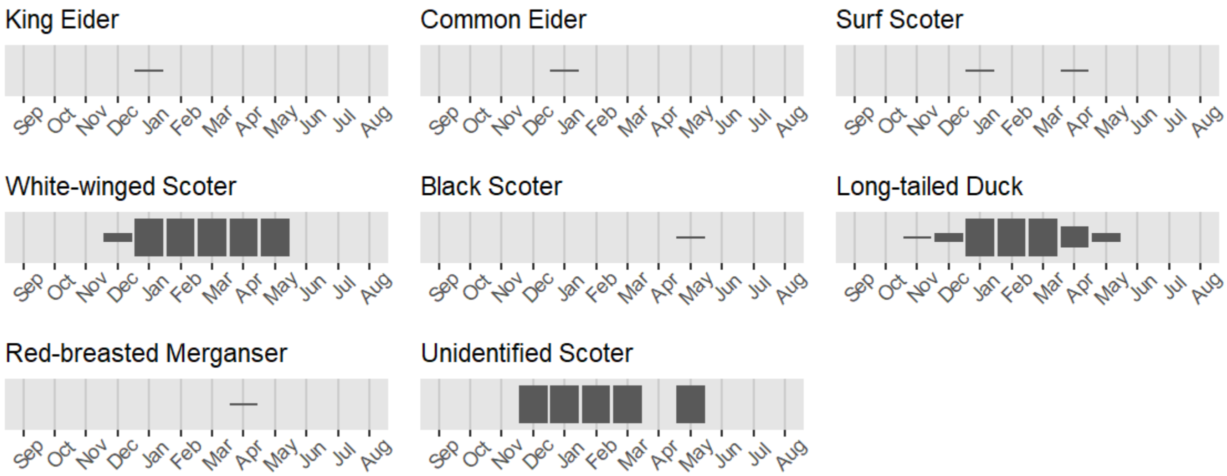


Figure 4-22: Monthly relative densities of sea ducks in the survey area from digital aerial surveys.

Table 4-9: Seasonal exposure rankings for the sea ducks group.

Sea Ducks	Season	Local Rank	Regional Rank	Total Rank	Exposure Score
Black Scoter	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	.	0	minimal
	Fall	0	0	0	minimal
Common Eider	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	2	2	low
Long-tailed Duck	Winter	0	1	1	low
	Spring	0	0	0	minimal
	Summer	0	.	0	minimal
	Fall	0	0	0	minimal
Red-breasted Merganser	Winter	0	1	1	low
	Spring	0	0	0	minimal
	Summer	0	.	0	minimal
	Fall	0	.	0	minimal
Surf Scoter	Winter	0	1	1	low
	Spring	0	0	0	minimal
	Summer	0	.	0	minimal
	Fall	0	0	0	minimal
White-winged Scoter	Winter	0	2	2	low
	Spring	0	3	3	medium
	Summer	0	.	0	minimal
	Fall	0	0	0	minimal

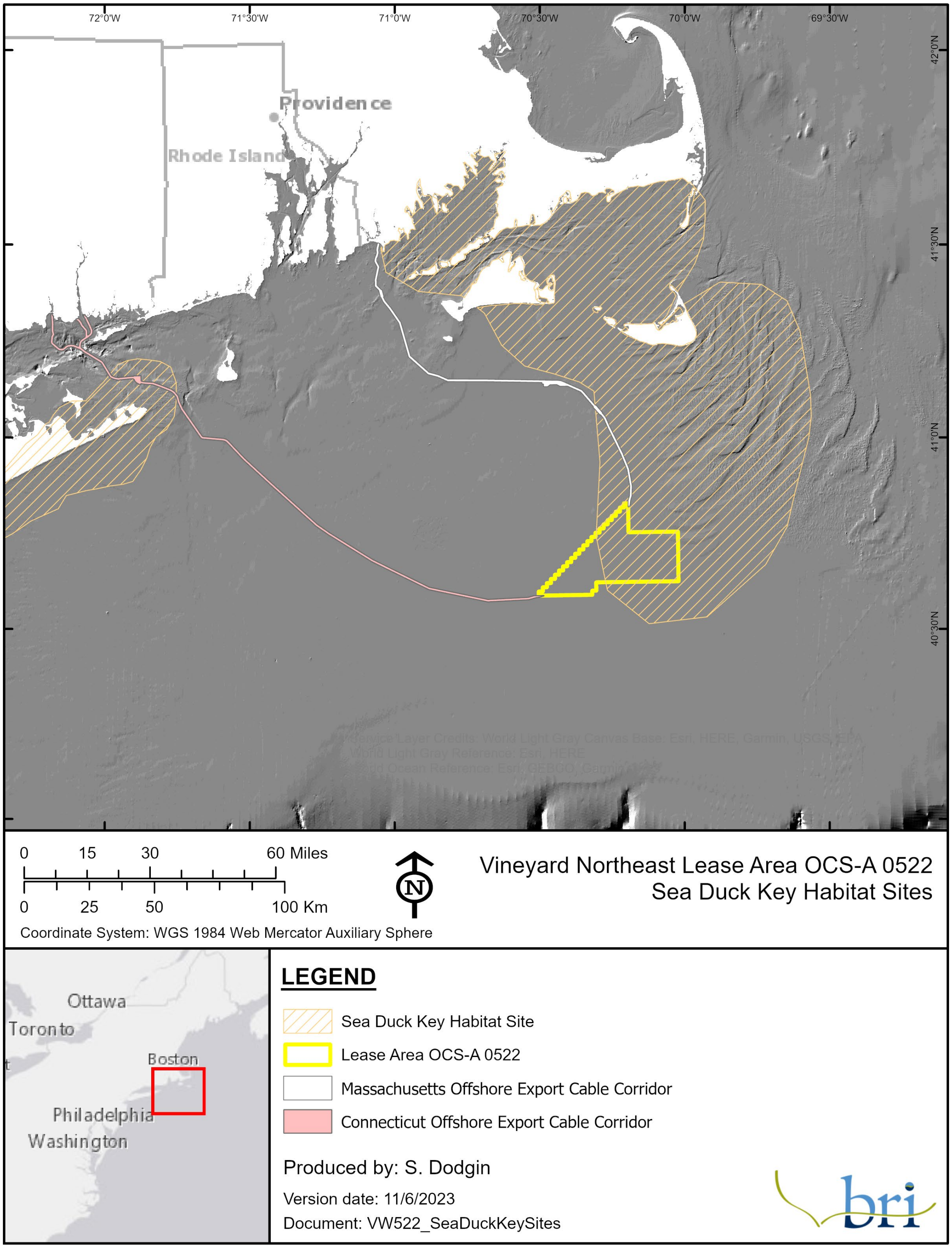


Figure 4-23: The Nantucket Sound and Shoals area identified as a key habitat site in North America for sea ducks (see Bowman et al. 2022).

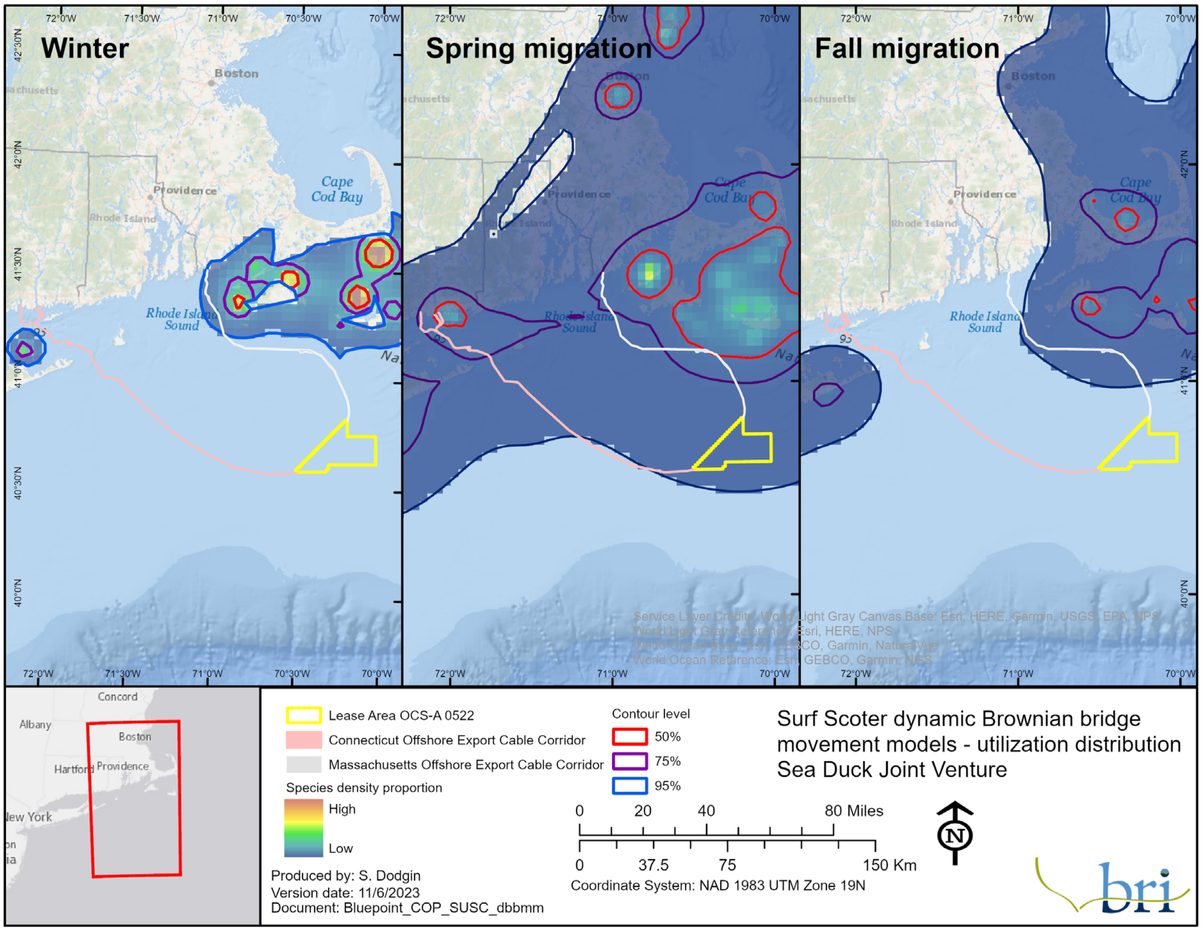


Figure 4-24: Dynamic Brownian bridge movement models for Surf Scoter that were tracked with satellite transmitters; the contours represent the percentage of the use area across the UD surface and represent various levels of use from 50% (core use) to 95% (home range). Data provided by BOEM and used with permission.

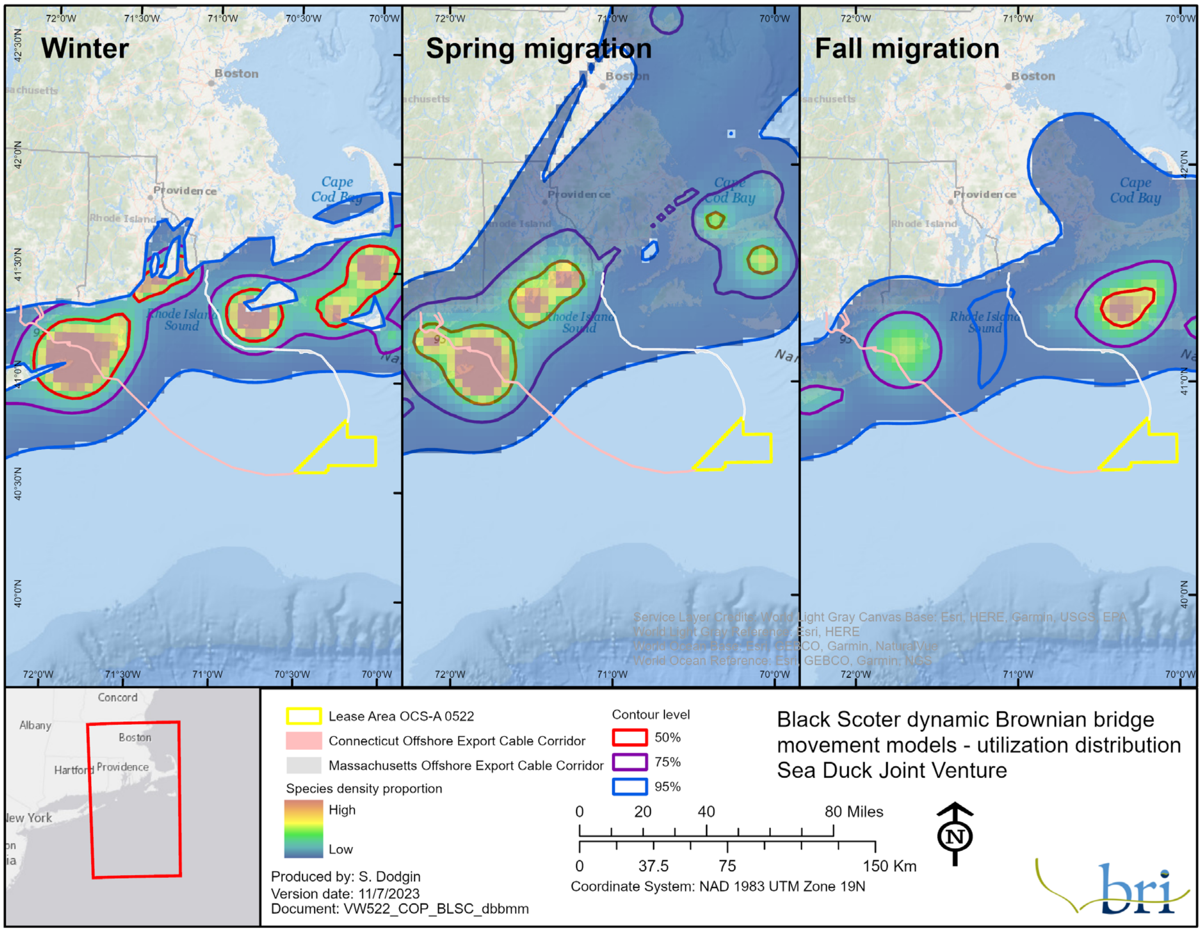


Figure 4-25: Dynamic Brownian bridge movement models for Black Scoter that were tracked with satellite transmitters; the contours represent the percentage of the use area across the UD surface and represent various levels of use from 50% (core use) to 95% (home range). Data provided by multiple sea duck researchers and used with permission.

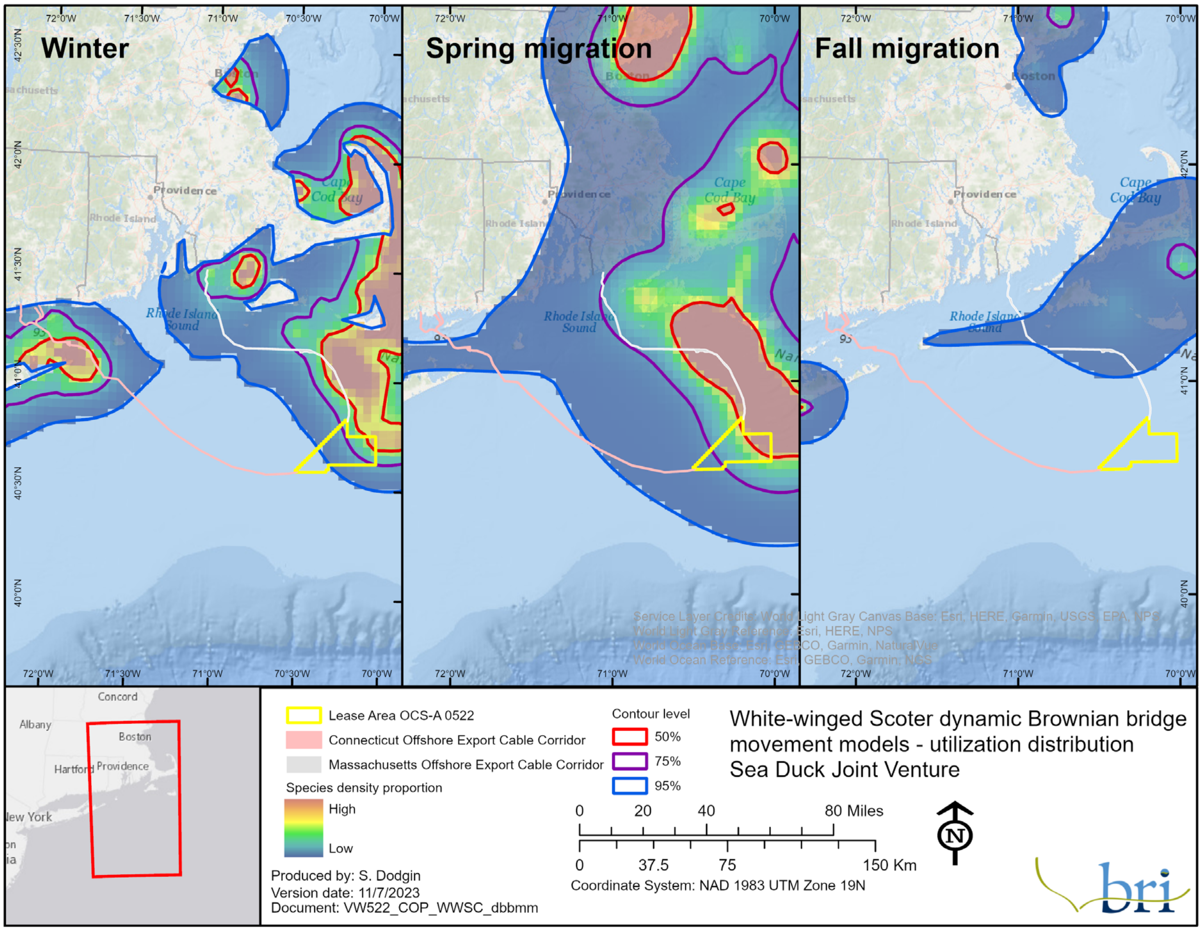


Figure 4-26: Dynamic Brownian bridge movement models for White-winged Scoter that were tracked with satellite transmitters: the contours represent the percentage of the use area across the UD surface and represent various levels of use from 50% (core use) to 95% (home range). Data provided by multiple sea duck researchers and used with permission.

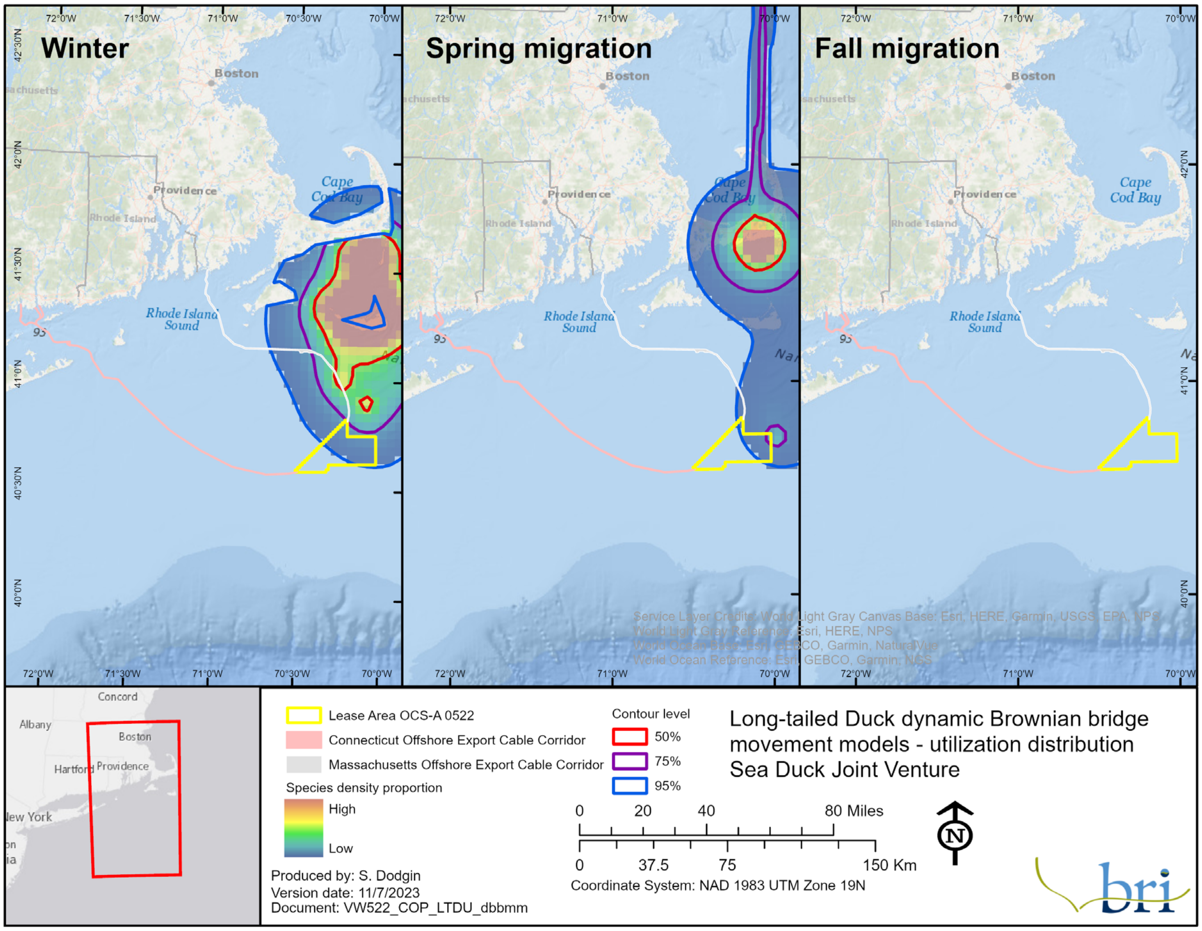


Figure 4-27: Dynamic Brownian bridge movement models for Long-tailed Duck that were tracked with satellite transmitters; the contours represent the percentage of the use area across the UD surface and represent various levels of use from 50% (core use) to 95% (home range). Data provided by multiple sea duck researchers and used with permission.

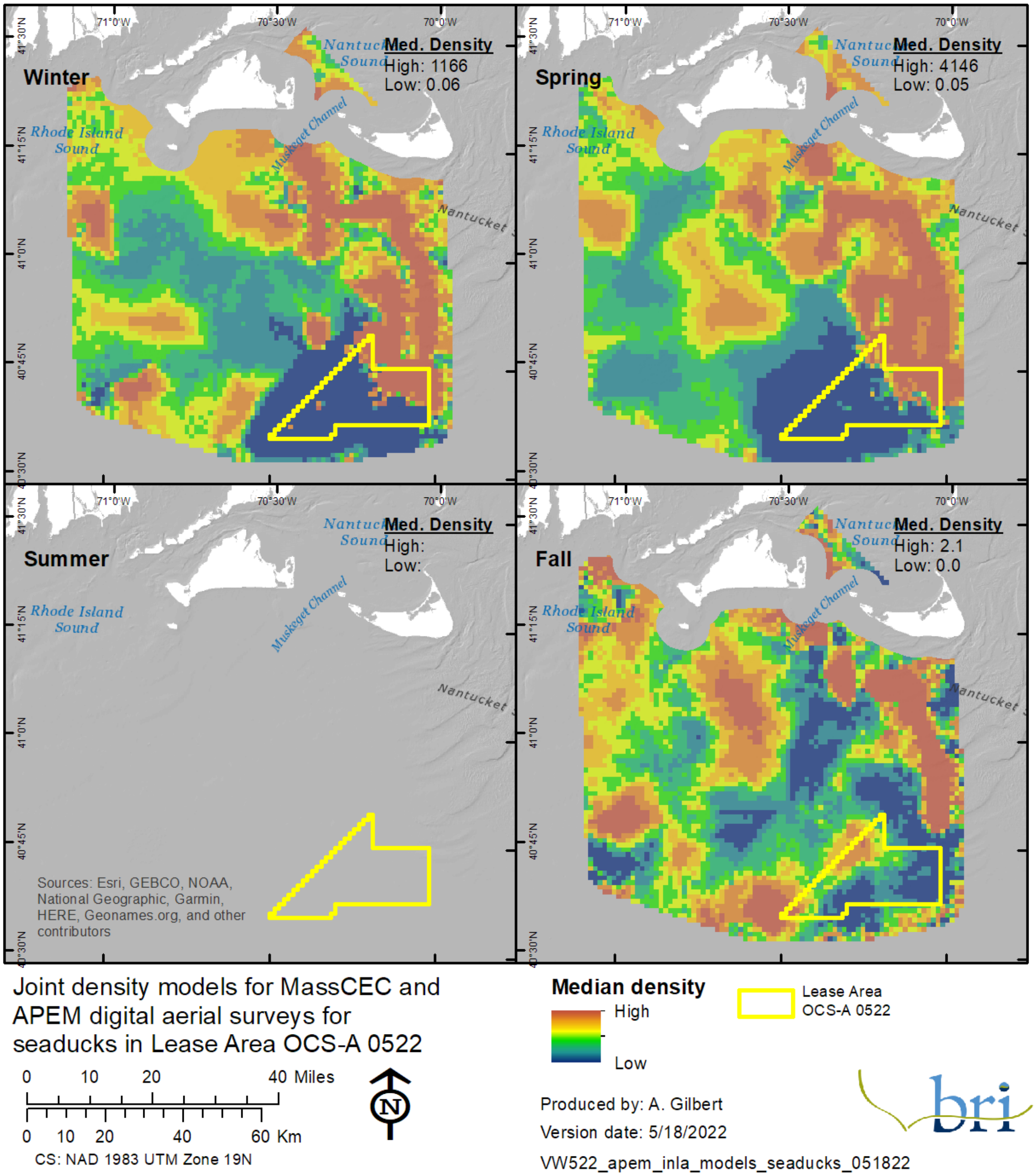


Figure 4-28: Spatial changes in density for sea ducks across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

4.2.3.3. Relative Behavioral Vulnerability Assessment

Sea ducks are generally not considered vulnerable to collision (Table 4-10; Furness et al. 2013) and have a **low** collision vulnerability score (excluding Red-breasted Merganser) because the birds fly primarily below the RSZ (Figure 4-29) and have strong avoidance behavior. For the WTGs under consideration, sea ducks were estimated to fly in the RSZ 0.21–3.89% of the time (with exception of 13.45% for Red-breasted Merganser). Avoidance behavior has been documented for Black Scoter, Common Eider (Desholm and Kahlert 2005; Larsen and Guillemette 2007), and Greater Scaup (Dirksen and van der Winden 1998 *in* Langston 2013).

Sea ducks are expected to have **medium** to **high** behavioral vulnerability to displacement (Table 4-10). Avoidance occurs through macro-avoidance (Langston 2013) and has been demonstrated by a 4.5-fold reduction in waterfowl flocks entering an offshore development post-construction (Desholm and Kahlert 2005). After loons, sea ducks, particularly scoters, are considered to have greater displacement vulnerability than all other seabirds (Furness et al. 2013). Avoidance behavior can lead to permanent or semi-permanent displacement, resulting in effective habitat loss (Petersen and Fox 2007; Percival 2010; Langston 2013), but avoidance of individual wind arrays is not expected to significantly increase energy expenditure (Masden et al. 2009). However, it is important to note that these avoidance studies were conducted on smaller turbines, which were spaced closer together than are being considered by Vineyard Northeast and so may not accurately reflect the future behavior of sea ducks around Vineyard Northeast. For some species, this displacement may cease several years after construction as food resources, behavioral responses, or other factors change (Petersen and Fox 2007; Leonhard et al. 2013). Overall, displacement from individual wind facilities is unlikely to affect populations because relatively few individuals are affected (Fox and Petersen 2019). Since there is evidence of birds returning to wind facilities once they become operational, vulnerability to long-term displacement will vary by species and a lower range is added to displacement vulnerability.

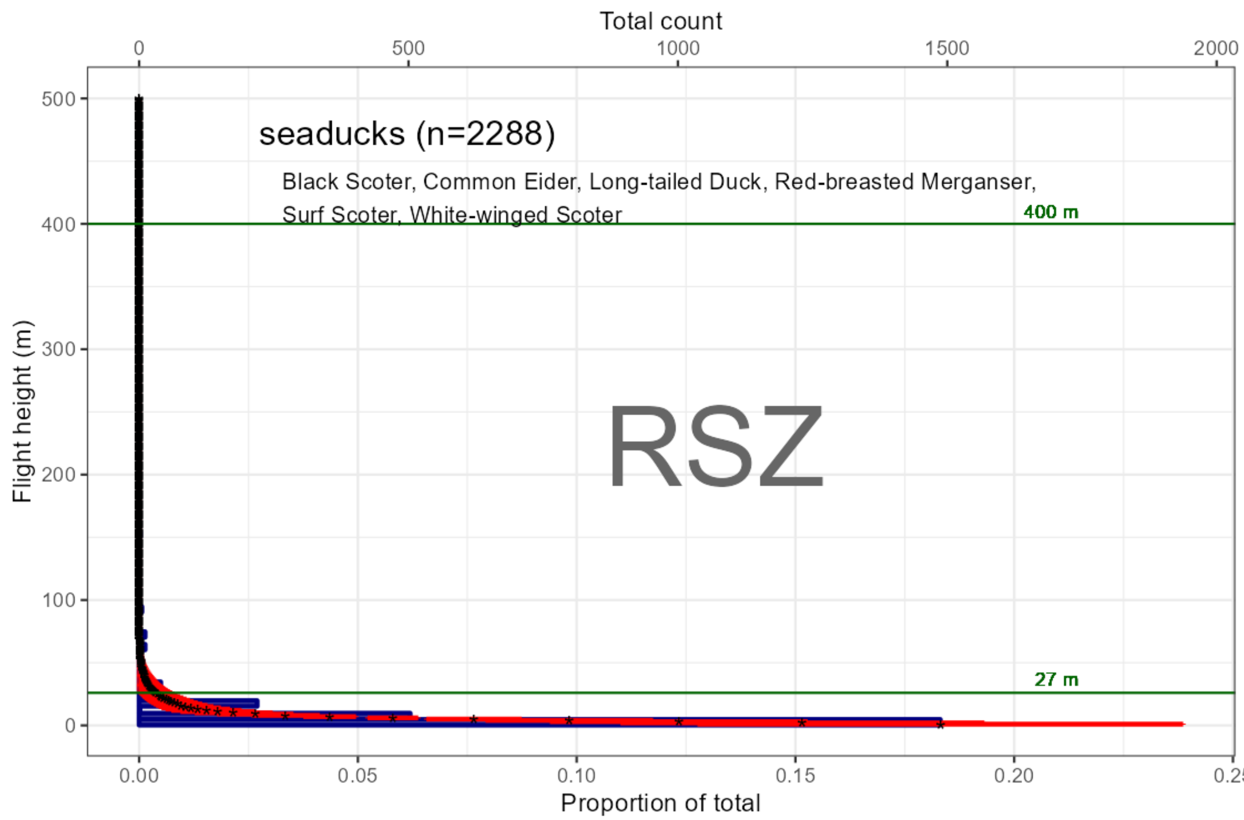


Figure 4-29: Flight heights of sea ducks (m) derived from the Northwest Atlantic Seabird Catalog, showing the actual number of birds in 5 m intervals (blue bars), and the modeled average flight height in 1 m intervals (asterisk) and the standard deviation (red lines), in relation to the upper and lower limits of the RSZ. Data provided by NOAA and used with permission.

Table 4-10: Summary of sea duck vulnerability; based upon the literature, displacement vulnerability was adjusted to include a lower range limit (green) to account for macro-avoidance rates potentially decreasing with time

Species	Collision Vulnerability (CV)	Displacement Vulnerability (DV)	Population Vulnerability (PV)
Black Scoter	low (0.27)	medium–high (0.9)	low (0.4)
Common Eider	low (0.27)	medium–high (0.9)	low (0.47)
Long-tailed Duck	low (0.3)	medium–high (0.9)	low (0.27)
Red-breasted Merganser	medium (0.53)	low–medium (0.5)	low (0.27)
Surf Scoter	low (0.27)	medium–high (0.9)	medium (0.53)
White-winged Scoter	low (0.27)	medium–high (0.8)	medium (0.53)

4.2.3.4. Risk

Sea ducks are expected to have **minimal** to **medium** exposure to the construction and operational activities in the Lease Area. Exposure will be greatest for White-winged Scoter in the spring in the northeast corner of the Lease Area. They are expected to have **low** behavioral vulnerability to collision and to have **medium** to **high** behavioral vulnerability to displacement.

Because the bird's exposure will be concentrated towards the northeast portion of the Lease area, is only at the edge of the high use area on Nantucket Shoals, and displacement has not been tied to fitness effects, population level risk to this species group is expected to be **minimal** to **medium**.

4.2.4. Phalaropes

4.2.4.1. Spatiotemporal Context

The phalaropes (Red Phalarope [*Phalaropus fulicarius*] and Red-necked Phalarope [*P. lobatus*]) are the only shorebird species that use the offshore marine environment to any degree, largely during the non-breeding season. Red Phalaropes are thought to overwinter far out to sea at the inner edge of the Gulf Stream, from about North Carolina south to Florida and beyond to the Caribbean islands (Tracy et al. 2020). While Red-necked Phalarope wintering habitat is less well understood, mixed flocks (of Red Phalaropes and Red-necked Phalaropes) wintering off the southeast coast of the U.S. occur primarily in the mid-shelf zone of the OCS (Rubega et al. 2020).

4.2.4.2. Exposure Assessment

Phalaropes were detected in the Lease Area during the winter, summer, and fall and their distribution was patchy and varied by season (Figure 4-30), with high numbers detected in the early winter (Figure 4-1).). Final exposure scores across the two species were **minimal**. In general, phalaropes are associated with areas of coastal and offshore upwelling and winter well south of the Lease Area and thus received a **minimal** final exposure score (Table 4-11).

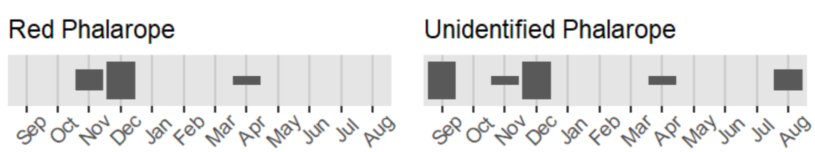


Figure 4-30. Monthly relative densities of phalaropes in the survey area from digital aerial surveys.

Table 4-11: Seasonal exposure rankings for the phalaropes

Phalarope	Season	Local Rank	Regional Rank	Total Rank	Exposure Score
Red-necked Phalarope	Winter	0	.	0	minimal
	Spring	0	1	1	low
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Red Phalarope	Winter	0	.	0	minimal
	Spring	0	1	1	low
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal

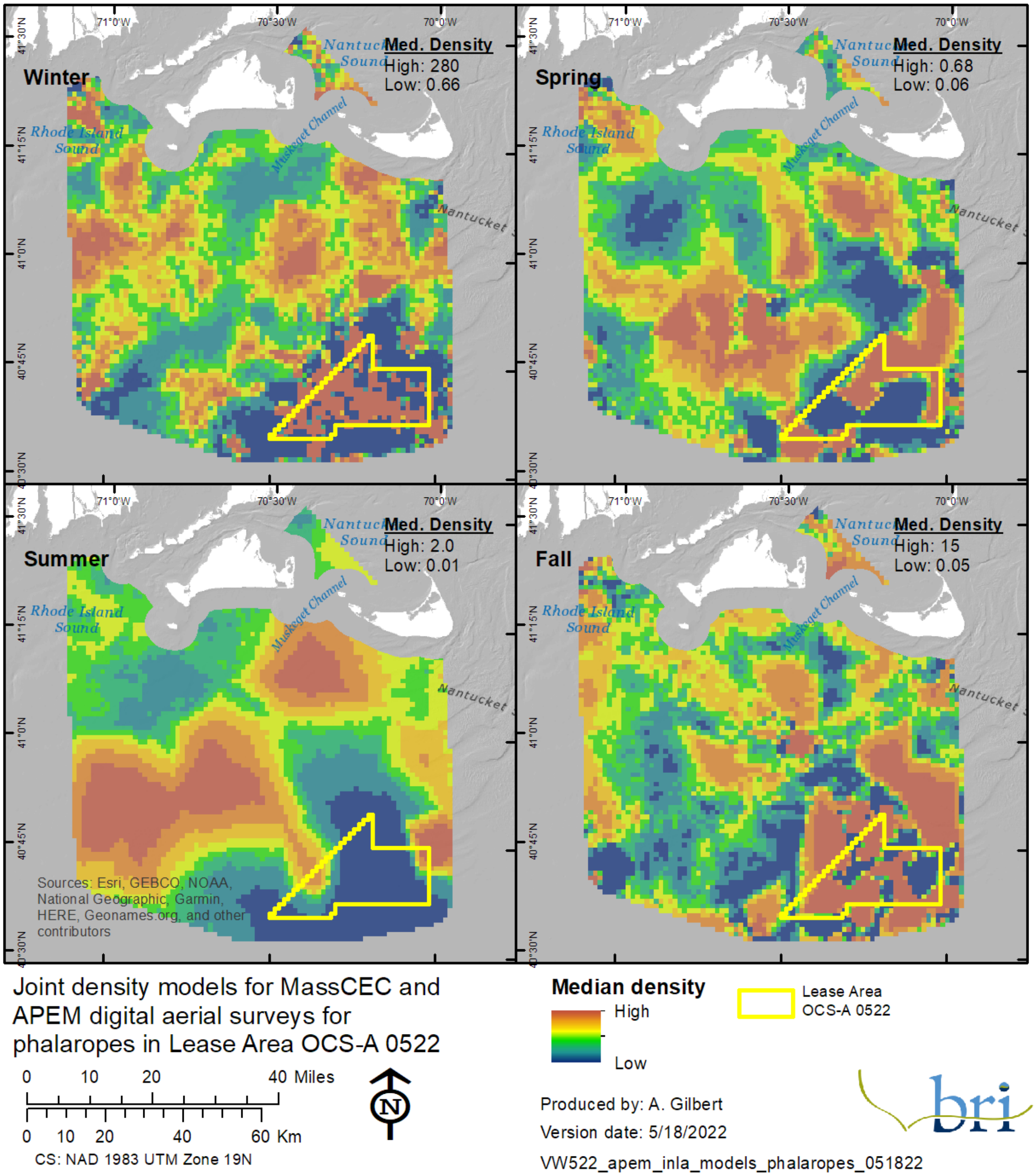


Figure 4-31: Spatial changes in density for Phalaropes across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

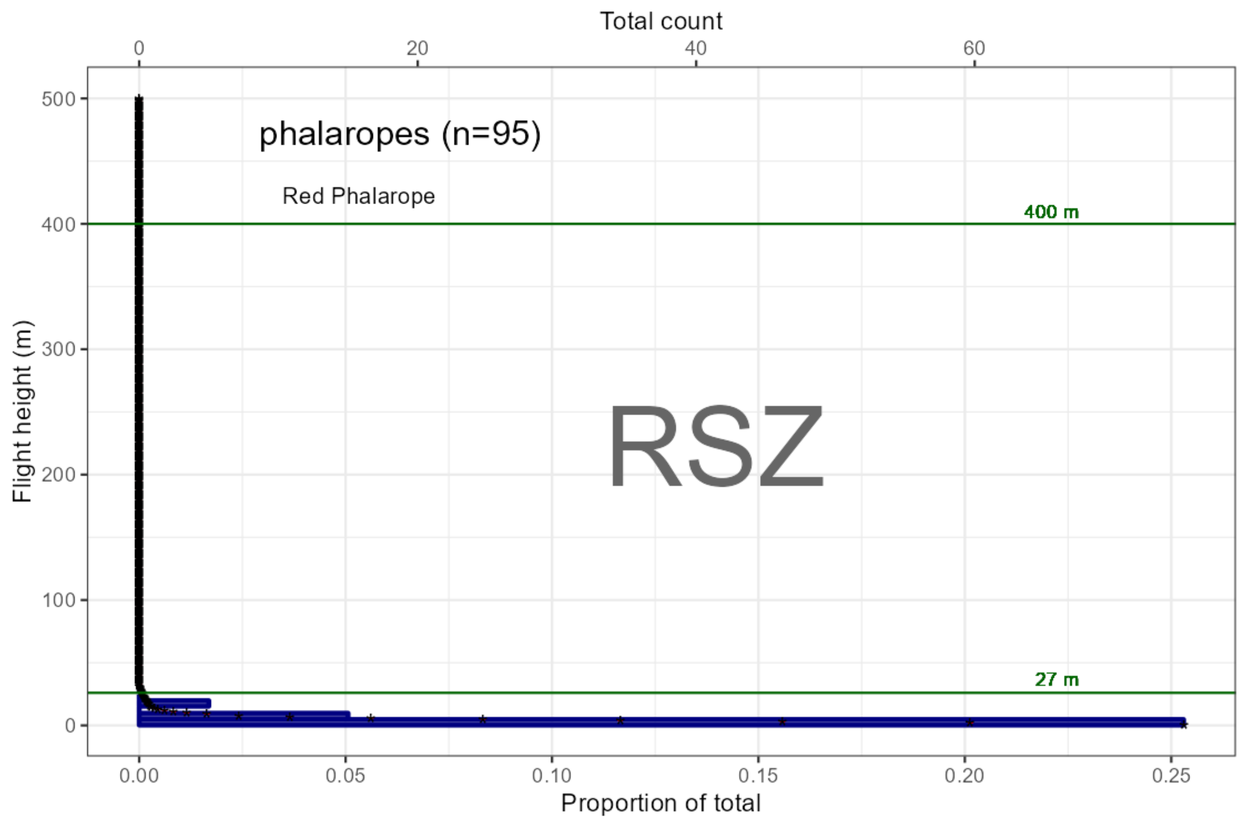


Figure 4-32. Flight heights of phalaropes derived from the Northwest Atlantic Seabird Catalog, showing the actual number of birds in 5 m intervals (blue bars), and the modeled average flight height in 1 m intervals.

4.2.4.3. *Relative Behavioral Vulnerability Assessment*

While little is known how phalaropes will respond to offshore wind turbines, phalaropes received a **low** collision vulnerability score and a **medium** displacement vulnerability score (Table 4-7). Collision risk is expected to be low, since the available data suggest the birds are flying well below the RSZ. Any avoidance of the Lease Area is unlikely to impact overall individual fitness due to the size of the Lease Area in relation to the birds' potential offshore non-breeding habitat use.

4.2.4.4. *Risk*

Phalaropes are expected to have **minimal** exposure to the construction and operational activities in the Lease Area. They are expected to have **low** behavioral vulnerability to collision and to have **medium** behavioral vulnerability to displacement. Because the birds have limited exposure, population level risks to this species group are expected to be **minimal**.

4.2.5. Auks

4.2.5.1. *Spatiotemporal Context*

The auk species present in the region are generally northern or Arctic-breeders that winter along the U.S. Atlantic OCS, including offshore waters off Massachusetts. However, the annual abundance and distribution of auks along the Atlantic coast in winter is erratic, depending upon broad climatic conditions and the availability of prey (Gaston and Jones 1998). In winters with prolonged harsh weather, which may prevent foraging for extended periods, these generally pelagic species often move inshore or are driven considerably farther south than usual. As a group, auks are commonly impacted in this way during severe storms, although die-off events also regularly impact the petrels and shearwaters and occasionally Northern Gannets (Fraser 2017). The regional MDAT abundance models show that auks are concentrated offshore and south of Nova Scotia.

4.2.5.2. *Exposure Assessment*

Exposure was assessed using species accounts and baseline survey data. During the digital aerial surveys, auks were among the most abundant species observed in the fall, winter, and spring (Figure 4-33). In the Lease Area, auk distribution varied by season and lacked a specific spatial trend (Figure 4-34). The seasonal exposure scores for the auk group (six species) were generally **minimal** for all species except for Razorbill (*Alca torda*), which is expected to have **medium** exposure in the winter, with **high** exposure during the spring, and **minimal** exposure during the other seasons (Table 4-12). Overall, the Atlantic Puffin (*Fratercula arctica*), Black Guillemot (*Cepphus grylle*), and Thick-billed Murre (*Uria lomvia*) are expected to have **minimal** exposure during all seasons. The Common Murre (*Uria aalge*) is expected to have **low** exposure during the winter and Dovekie (*Alle alle*) in the fall, with **minimal** exposure during the rest of the year. Final exposure scores across species ranged from **minimal** to **medium**.

Figure 4-33: Monthly relative densities of auks in the survey area from digital aerial surveys.

Table 4-12: Seasonal exposure rankings for auks.

Auks	Season	Local Rank	Regional Rank	Total Rank	Exposure Score
Atlantic Puffin	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Black Guillemot	Winter	0	·	0	minimal
	Spring	0	·	0	minimal
	Summer	0	0	0	minimal
	Fall	0	·	0	minimal
Common Murre	Winter	0	1	1	low
	Spring	0	0	0	minimal
	Summer	0	.	0	minimal
	Fall	0	.	0	minimal
Dovekie	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	1	1	low
Razorbill	Winter	0	3	3	medium
	Spring	2	3	5	high
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Thick-billed Murre	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	.	0	minimal
	Fall	0	·	0	minimal

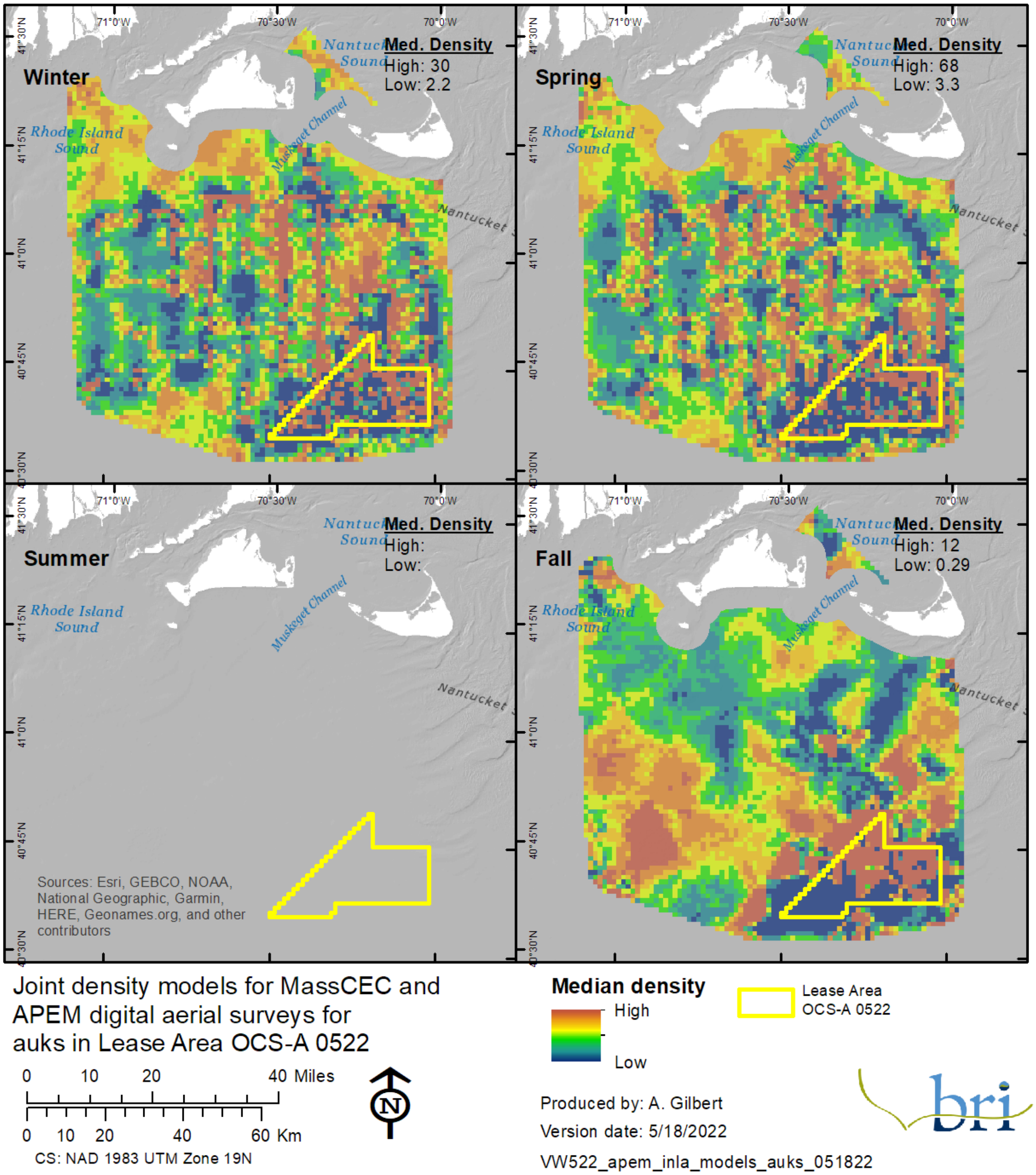


Figure 4-34: Spatial changes in density for auks across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

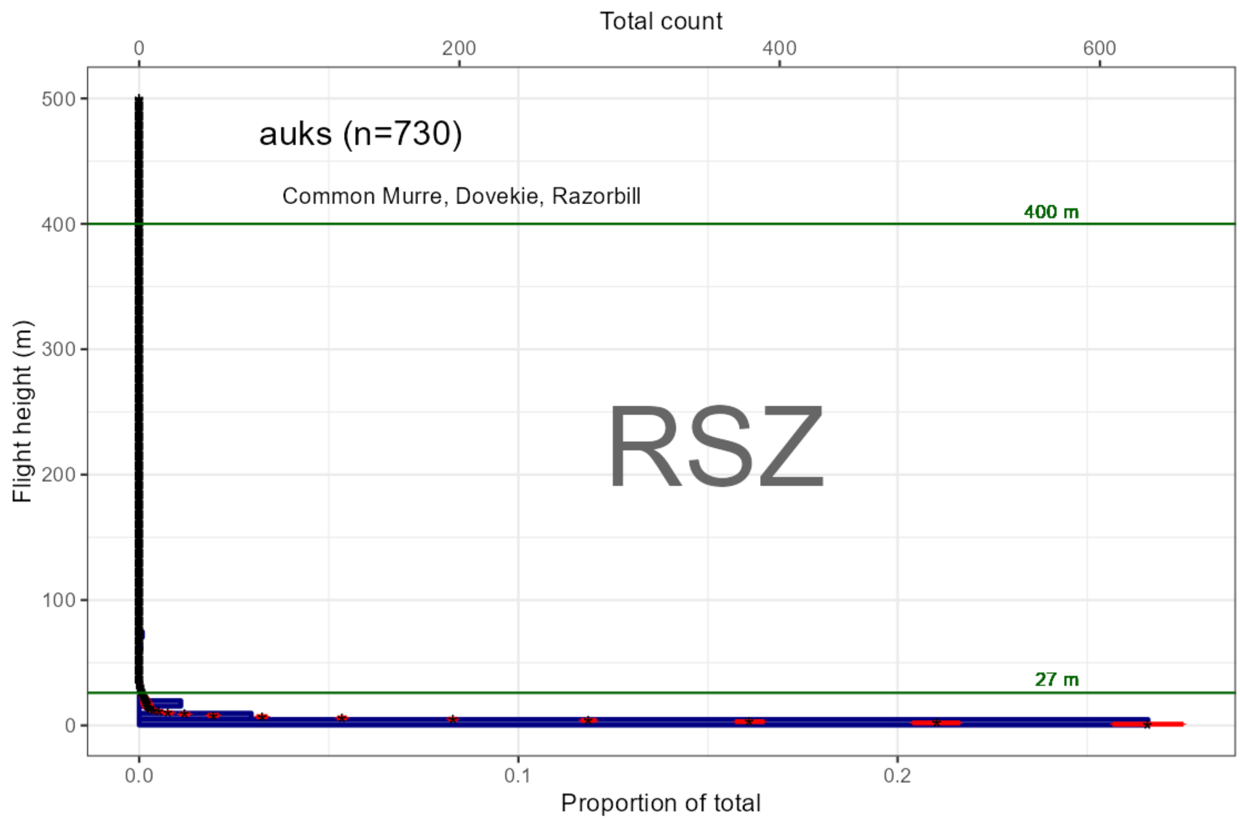


Figure 4-35: Flight heights of auks (m) derived from the Northwest Atlantic Seabird Catalog, showing the actual number of birds in 5 m intervals (blue bars), and the modeled average flight height in 1 m intervals (asterisk) and the standard deviation (red lines), in relation to the upper and lower limits of the RSZ. Data provided by NOAA and used with permission.

Table 4-13: Summary of auk vulnerability

Species	Collision Vulnerability (CV)	Displacement Vulnerability (DV)	Population Vulnerability (PV)
Common Murre	minimal (0.23)	high (0.8)	low (0.4)
Dovekie	low (0.3)	medium (0.7)	low (0.4)
Razorbill	minimal (0.2)	high (0.8)	medium (0.6)

4.2.5.3. Relative Behavioral Vulnerability Assessment

Auks are expected to have **minimal** to **low** behavioral vulnerability to collision (Table 4-13). Auks have a 45 to 68% macro-avoidance rate and a 99.2% total avoidance rate (Cook et al. 2012). At considerably smaller WTGs than those being considered for Vineyard Northeast, Atlantic Puffins (*Fratercula arctica*), Razorbills, and Common Murres were estimated to fly between 20–150 m (66–492 ft) 0.1%, 0.4%, and 0.01% of the time, respectively (Cook et al. 2012). For the WTGs being considered, auks were estimated to fly in the RSZ 0.04 to 0.41% of the time (Figure 4-34).

Auks are expected to have **medium** to **high** behavioral vulnerability to displacement. Due to their sensitivity to disturbance from boat traffic and a high habitat specialization, many auks rank high in displacement vulnerability assessments (Furness et al. 2013; Dierschke et al. 2016; Wade et al. 2016). Studies in Europe have documented varying levels of displacement with rates ranging from no apparent displacement to 70% (Ørsted 2018). Auks have a total avoidance rate of 99.2% (Cook et al. 2012). Common Murres and Razorbills decrease in abundance in the area of wind farms by 71% and 64%, respectively (Vanermenet al. 2015), and auks have been shown to have a 75% lower abundance inside offshore wind farms and were estimated to start avoidance behaviors at 2–4 km (1.24–2.49 mi; (Welcker and Nehls 2016).

4.2.5.4. Risk

Auks are expected to have **minimal** and **medium** exposure to the construction and operational activities in the Lease Area. They are expected to have **minimal** to **low** behavioral vulnerability to collision and **medium** to **high** behavioral vulnerability to displacement. For the species that received a **minimal** exposure score, population level risk is expected to be **minimal**. Note, the overall collision risk for auks is minimal because Dovekie was the only species to receive a low CV score, but this species had minimal exposure. For Razorbill, risk from collision is expected to be **minimal**, due to minimal vulnerability, and risk from displacement is expected to be **medium** due to moderate exposure. Auks received a low to medium population vulnerability score, but auk populations are generally stable (Ainley et al. 2002; Lowther et al. 2002; Lavers et al. 2009).

4.2.6. Gulls, Skuas, and Jaegers

4.2.6.1. Spatiotemporal Context

The gulls present in the region are a large and varied group. The larger gull species (Herring Gull [*Larus argentatus*] and Great Black-backed Gull [*Larus marinus*]) are resident to the region year-round, but roam further offshore outside of the breeding season (Veit et al. 2016). While gulls tend to be coastal, they will follow fishing vessels offshore. Jaegers and skuas are a highly pelagic group of dark, gull-like species. The jaegers (Pomarine Jaeger [*Stercorarius pomarinus*], Parasitic Jaeger [*Stercorarius parasiticus*], and Long-tailed Jaeger [*Stercorarius longicaudus*]) are all Arctic breeders that regularly migrate through the western North Atlantic region. Although their wintering ranges are poorly understood, they are known to occur in the Caribbean and off the coast of South America (Wiley and Lee 2000), or as far as southwest Africa (Long-tailed Jaeger; Wiley and Lee 1998). The Parasitic Jaeger is often observed closer to shore during migration than the other species (Wiley and Lee 2020). The Great Skua (*Stercorarius skua*) is also a northern breeder that may pass along the Atlantic OCS outside the breeding season. In recent decades, skuas observed in the western North Atlantic have increasingly been identified as South Polar Skuas (*Stercorarius maccormicki*; Lee 1989), which breed in the southern hemisphere and wander north during the austral winter. The regional MDAT abundance models show that these birds have a wide distribution ranging from near shore (gulls) to offshore (jaegers).

4.2.6.2. *Exposure Assessment*

Exposure was assessed using species accounts and baseline survey data. During the digital aerial surveys, the Herring Gull (*Larus argentatus*) and Great Black-backed Gull (*Larus marinus*) were among the most common gulls and were observed nearly year-round, but had relatively lower densities (Table 4-28); Bonaparte's Gull (*Chroicocephalus philadelphia*) were most common during spring and fall migration; and Black-legged Kittiwake (*Rissa tridactyla*), among the gulls, had the highest densities in the fall and winter (Table 4-28) and were most common in November and December (Figure 4-36). The distribution of gulls in the Lease Area varied by season and did not have consistent pattern (Figure 4-37, Figure 4-38, and Figure 4-39). There were only a few observations of skuas and jaegers, which were in September and November. The seasonal exposure scores for the gull, skua, and jaeger group (multiple species) ranged from **minimal** to **medium** (Table 4-14).

Skuas and jaegers generally had **minimal** exposure scores; and exposure scores for gulls mostly ranged from **minimal** to **low.** The Black-legged Kittiwake had **medium** exposure expected in the winter and fall, low in the spring, and minimal in the summer, which aligns with the results of the digital aerial surveys. Final exposure scores across species ranged from **minimal** to **medium**.

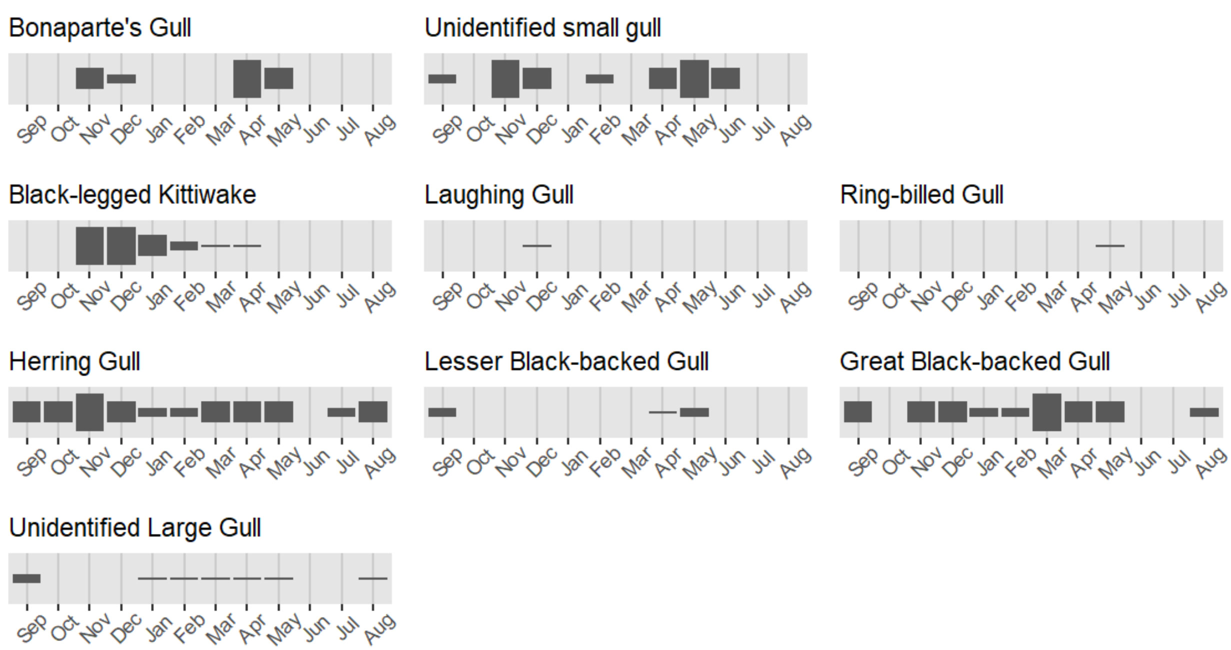


Figure 4-36: Monthly relative densities of gulls in the survey area from digital aerial surveys.

Table 4-14: Seasonal exposure rankings for skuas and jaegers, small gulls, medium gulls, and large gulls.

Group	Season	Local Rank	Regional Rank	Total Rank	Exposure Score
Skuas and Jaegers					
Great Skua	Winter	0	.	0	minimal
	Spring	0	.	0	minimal
	Summer	0	.	0	minimal
	Fall	0	0	0	minimal
Parasitic Jaeger	Winter	0	.	0	minimal
	Spring	0	0	0	minimal
	Summer	0	2	2	low
	Fall	0	0	0	minimal
Pomarine Jaeger	Winter	0	.	0	minimal
	Spring	0	0	0	minimal
	Summer	0	1	1	low
	Fall	0	0	0	minimal
South Polar Skua	Winter	0	.	0	minimal
	Spring	0	.	0	minimal
	Summer	0	1	1	low
	Fall	0	0	0	minimal
Small Gulls					
Bonaparte's Gull	Winter	3	0	3	medium
	Spring	1	0	1	low
	Summer	0	.	0	minimal
	Fall	0	0	0	minimal
Medium Gulls					
Black-legged Kittiwake	Winter	2	1	3	medium
	Spring	0	2	2	low
	Summer	0	.	0	minimal
	Fall	3	0	3	medium
Laughing Gull	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Ring-billed Gull	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	1	1	low
	Fall	0	1	1	minimal
Large Gulls					
Great Black-backed Gull	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Herring Gull	Winter	0	0	0	minimal
	Spring	2	0	2	low
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal

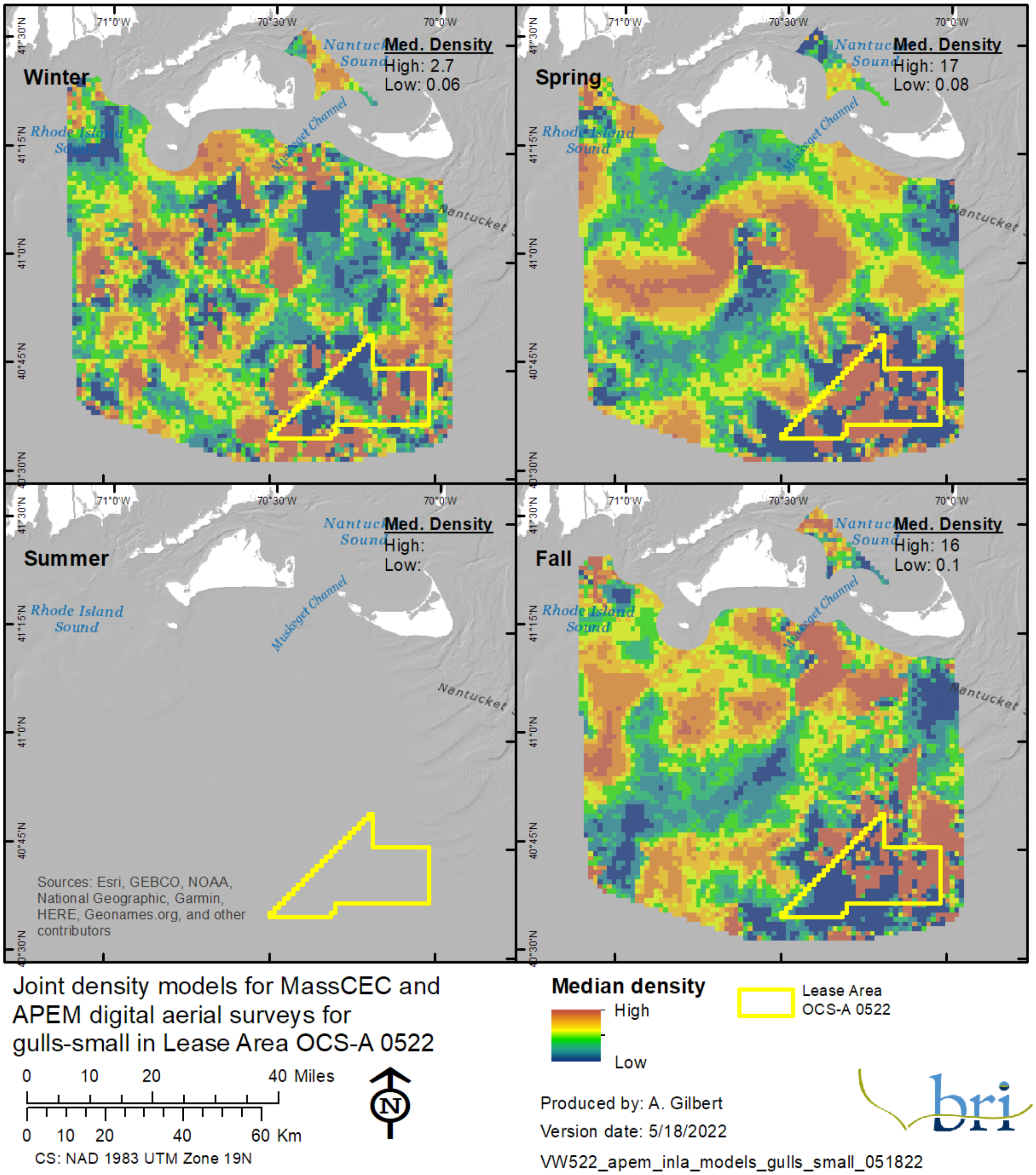


Figure 4-37: Spatial changes in density for small gulls across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

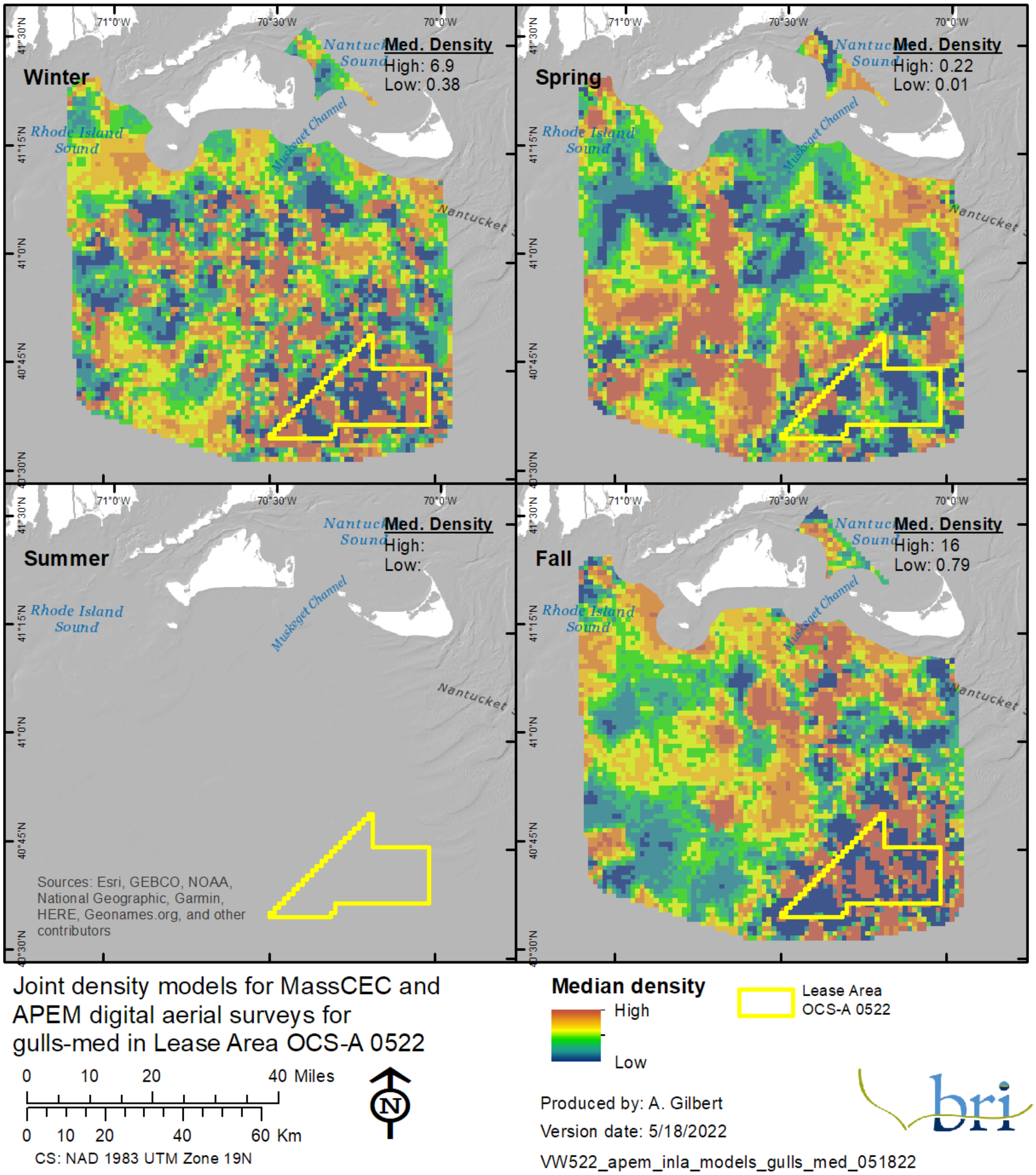


Figure 4-38: Spatial changes in density for medium gulls across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

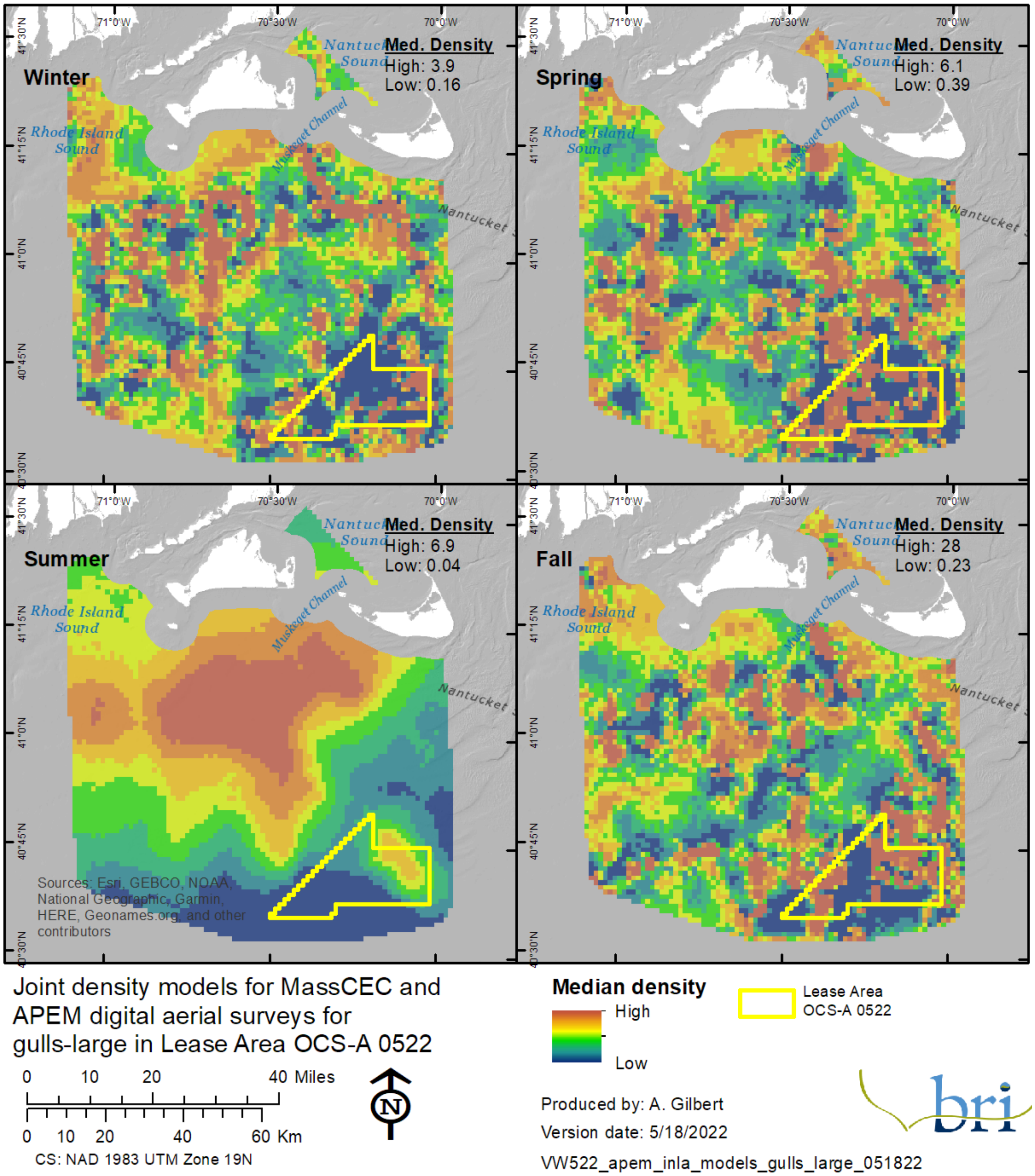


Figure 4-39: Spatial changes in density for large gulls across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

4.2.6.3. Relative Behavioral Assessment

Jaegers and gulls are expected to have **low** to **medium** behavioral vulnerability to collisions (Table 4-15). Little is known about how jaegers respond to offshore WTGs, but the birds generally fly low (0–10 m [0–32.8 ft] above the sea surface), although they could fly higher during kleptoparasitic chases (Wiley and Lee 2020). For the WTGs under consideration, jaegers were estimated to fly in the RSZ 7.91% of the time (Figure 4-40).

Gulls ranks at the top of collision vulnerability assessments because they can fly within the RSZ (Johnston et al. 2014), have a documented attraction to WTGs (Vanermen et al. 2015), and individual birds have been documented to collide with WTGs (Skov et al. 2018). During boat-based surveys around existing and proposed European wind farms, Herring Gulls have been detected between 20–150 m (66–492 m) during 28.4% of observations and Great Black-Backed Gulls were detected during 33.1% of observations (Cook et al. 2012). For the WTGs being considered, gulls were estimated to fly in the RSZ 2.09–22.18% of the time (Figure 4-40 and Figure 4-41). At European offshore wind developments, gulls have been documented to be attracted to WTGs, which may be due to increased boat traffic, new food resources, or new loafing habitat (i.e., perching areas; Fox et al. 2006; Vanermen et al. 2015), but interaction with offshore wind developments varies by season (Thaxter et al. 2015). Recent research suggests that some gull species may not exhibit macro-avoidance of a wind farm, but will preferentially fly between WTGs, suggesting meso-avoidance that would reduce overall collision risk (Thaxter et al. 2018). Furthermore, gulls may be disproportionately attracted to certain WTGs at the edge of a wind farm array, potentially limiting collision risk to a small subset of WTGs (Vanermen et al. 2019).

While the collision risk is thought to be greater for gulls, total avoidance rates are estimated to range from 98% (Cook et al. 2012) to 99% (Skov et al. 2018). At Horns Rev, Denmark, gull numbers increased at the wind development, possibly due to their attraction to boat traffic, new food resources, or new loafing habitat (i.e., perching areas) (Fox et al. 2006). In Belgium, numbers of Lesser Black-backed Gulls increased by a factor of 5.3 and Herring Gulls by 9.5 within the Bligh Bank wind farm area (Vanermen et al. 2015).

However, there can be inter- and intra-annual variation in the degree that birds interact with offshore wind developments. Lesser Black-backed Gulls (*Larus fuscus*) are found to be present at differing levels per year, and their use of the offshore environment was highest during chick-rearing and lowest before breeding and during incubation. In addition, males and females use the area differently, with males present more in the late breeding season (Thaxter et al. 2015).

Gulls, skuas, and jaegers are expected to have **low** to **medium** behavioral vulnerability to displacement (Table 4-15). There is little information available on how jaegers (or skuas) will respond to offshore wind farms, but jaegers rank low in vulnerability to displacement assessments (Furness et al. 2013) and there is no evidence in the literature that they are displaced from projects. Gulls rank low in displacement vulnerability assessments (Furness et al. 2013), and research suggests that distribution and abundance is either not affected by the presence of wind farms or, in the case of gulls, that the birds may be attracted to them (Krijgsveld et al. 2011; Lindeboom et al. 2011). At European offshore wind developments, gulls have been documented to be attracted to WTGs, which may be due to attraction to increased boat traffic, new food resources, or new loafing habitat (i.e., perching areas; Fox et al. 2006; Vanermen et al. 2015), but interaction with offshore wind developments varies by season (Thaxter et al. 2015).

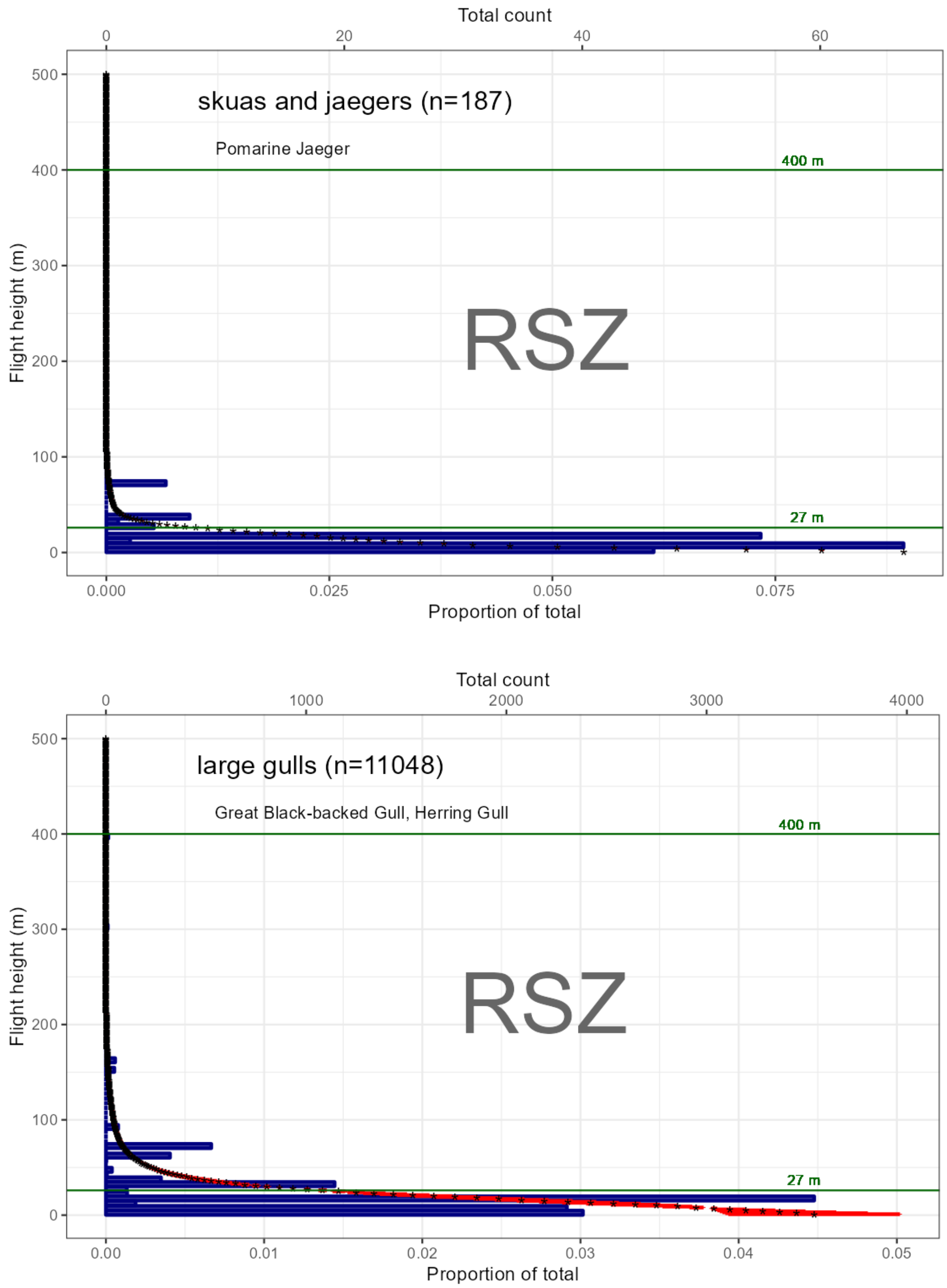
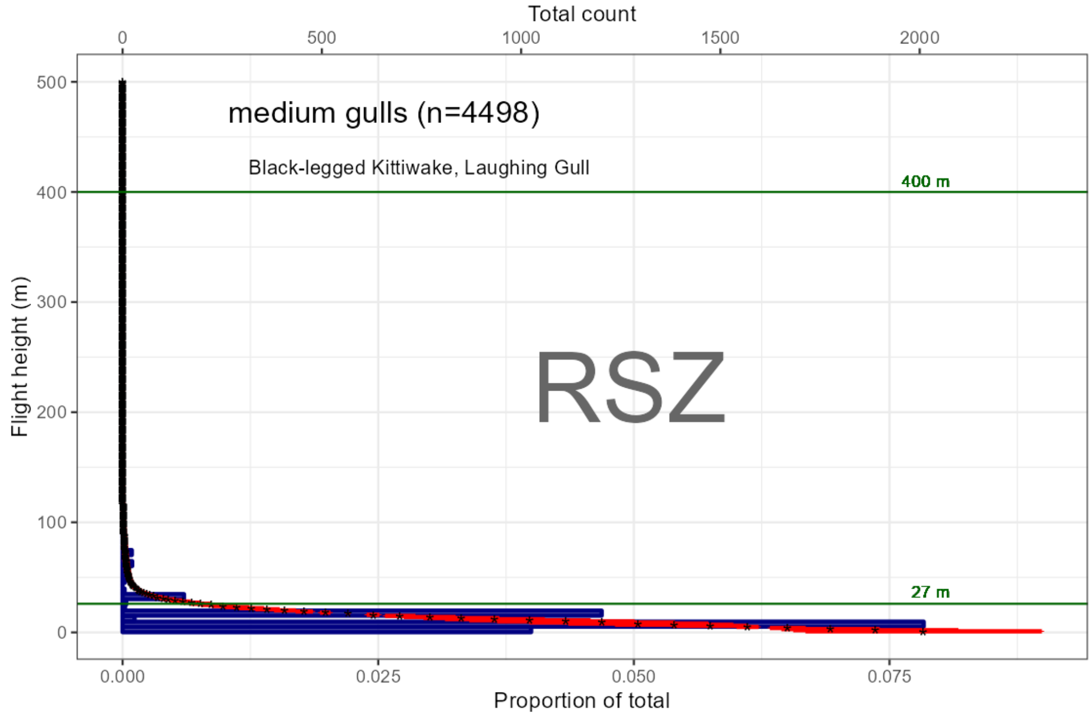


Figure 4-40: Flight heights of skuas and jaegers (upper panel) and large gulls (lower panel) derived from the Northwest Atlantic Seabird Catalog, showing the actual number of birds in 5 m intervals (blue bars), and the modeled average flight height in 1 m intervals (asterisk) and the standard deviation (red lines), in relation to the upper and lower limits of the RSZ. Data provided by NOAA and used with permission.



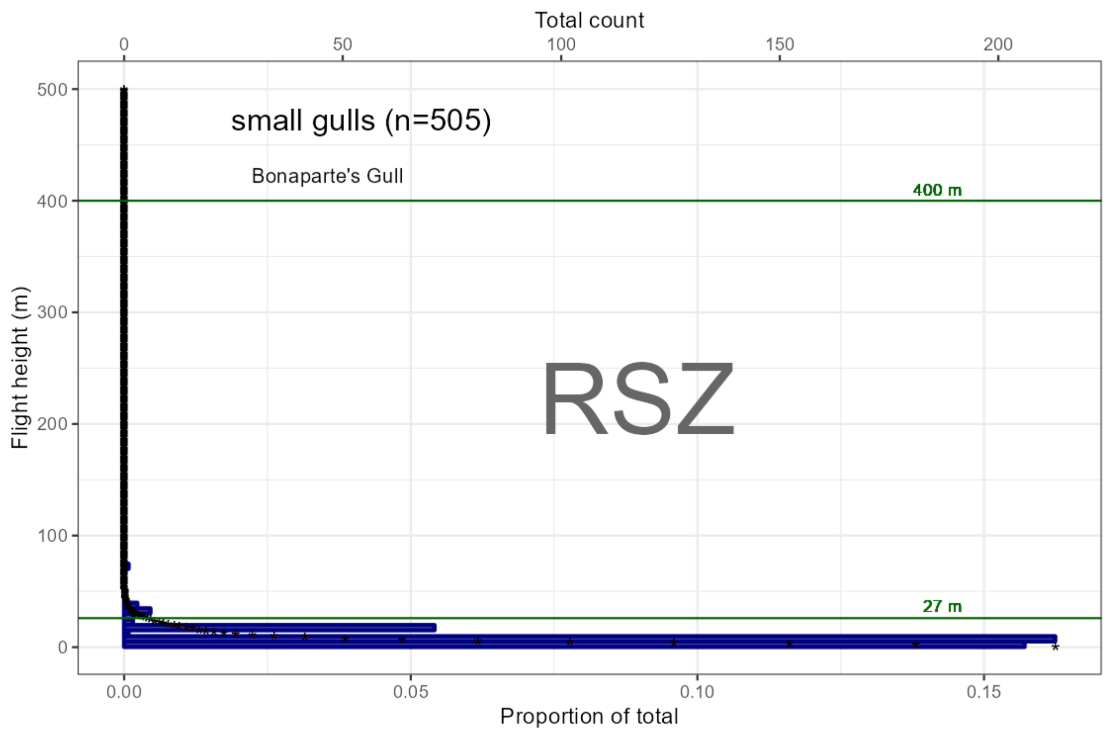


Figure 4-41: Flight heights of medium gulls (upper panel) and small gulls (lower panel) derived from the Northwest Atlantic Seabird Catalog, showing the actual number of birds in 5 m intervals (blue bars), and the modeled average flight height in 1 m intervals (asterisk) and the standard deviation (red lines), in relation to the upper and lower limits of the RSZ. Data provided by NOAA and used with permission.

Table 4-15: Summary of gull, skua, and jaeger vulnerability.

Species	Collision Vulnerability (CV)	Displacement Vulnerability (DV)	Population Vulnerability (PV)
Pomarine Jaeger	medium (0.73)	low (0.3)	low (0.4)
Bonaparte's Gull	medium (0.5)	medium (0.5)	low (0.33)
Black-legged Kittiwake	medium (0.57)	medium (0.6)	low (0.33)
Laughing Gull	low (0.47)	medium (0.5)	low (0.4)
Great Black-backed Gull	medium (0.63)	medium (0.7)	minimal (0.2)
Herring Gull	medium (0.7)	medium (0.5)	medium (0.53)

4.2.6.4. Risk

Jaegers and skua are expected to have **minimal** exposure to the construction and operational activities in the Lease Area. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have **medium** behavioral vulnerability to collision. Because these species have little exposure to the Lease Area, population level risk is expected to be **minimal**.

Due to their **medium** exposure scores in fall and winter and **medium** vulnerability, Black-legged Kittiwake are expected to have **medium** risk. The other gull species are expected to have **minimal** to **low** exposure to operational activities in the Lease Area and **low** to **medium** behavioral vulnerability to collision and displacement. Because most common gull populations are generally stable, population level risk to this species group is expected to be **minimal** to **low** and any habitat loss due to displacement is unlikely to affect population trends because of the relatively small area of the Lease Area in relation to available foraging habitat. Resident gull populations are robust and generally show high reproductive success (Good 1998; Pollet et al. 2012; Burger 2015).

4.2.7. Terns

4.2.7.1. Spatiotemporal Context

The Roseate Tern, Common Tern (*Sterna hirundo*), Least Tern (*Sterna antillarum*), and Artic Tern (*Sterna paradisae*) currently breed or have recently bred in Massachusetts, though other tern species may be present during other times of the year. Terns generally restrict themselves to coastal waters during breeding, although they may pass through the Lease Area on their migratory journeys. This is especially true of Common and Roseate Terns, which are known to aggregate around the Nantucket Shoals particularly in spring (Veit et al. 2016). The regional MDAT abundance models show that terns are generally concentrated closer to shore than near the Lease Area.

The Roseate Tern is federally listed as well as state-listed and is thus addressed in greater detail below.

4.2.7.2. Exposure Assessment

Exposure was assessed using species accounts, tracking data, and baseline survey data. During the digital aerial surveys, terns were observed in the fall, spring, and summer, and were most abundant in May (Figure 4-42). NOTE: digital aerial surveys were conducted twice a month in April, May, August, and September to increase effort when terns might be flying through the Lease Area during migration. In the Lease Area, terns were distributed centrally and to the south during the spring (Figure 4-43). Tracking data from two Common Terns indicate that two birds flew from points south through Cape Cod to Maine; and four Common Terns indicate the birds fly directly offshore during fall migration, largely avoiding the Lease Area (Loring et al. 2019; Figure 4-44 and Figure 4-45). The seasonal exposure scores for the tern group (multiple species) ranged from **minimal** to **low** (Table 4-16). Roseate Tern received a final **low** exposure score (low in the spring/fall; minimal in the summer/winter; note, a lower range [minimal] was added to the exposure score for the reasons discussed in the Roseate Tern section), and the other species received **minimal** final scores.

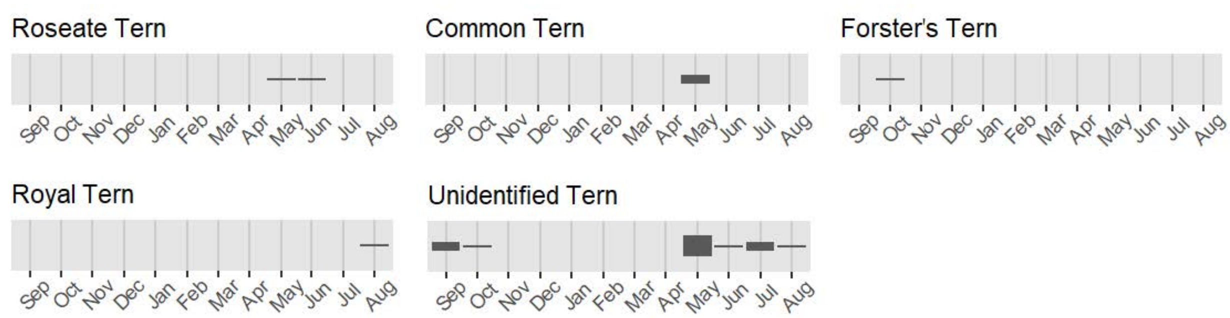


Figure 4-42: Monthly relative densities of terns in the survey area from digital aerial surveys.

Table 4-16: Seasonal exposure rankings for terns

Medium Terns	Season	Local Rank	Regional Rank	Total Rank	Exposure Score
Least Tern	Winter	0	.	0	minimal
	Spring	0	.	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Arctic Tern	Winter	0	·	0	minimal
	Spring	0	·	0	minimal
	Summer	0	0	0	minimal
	Fall	0	·	0	minimal
Bridled Tern	Winter	0	·	0	minimal
	Spring	0	.	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Common Tern	Winter	0	.	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	1	1	low
Roseate Tern	Winter	0	.	0	minimal
	Spring	0	1	1	low
	Summer	0	0	0	minimal
	Fall	0	2	2	low
Royal Tern	Winter	0	.	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Sooty Tern	Winter	0	·	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	·	0	minimal

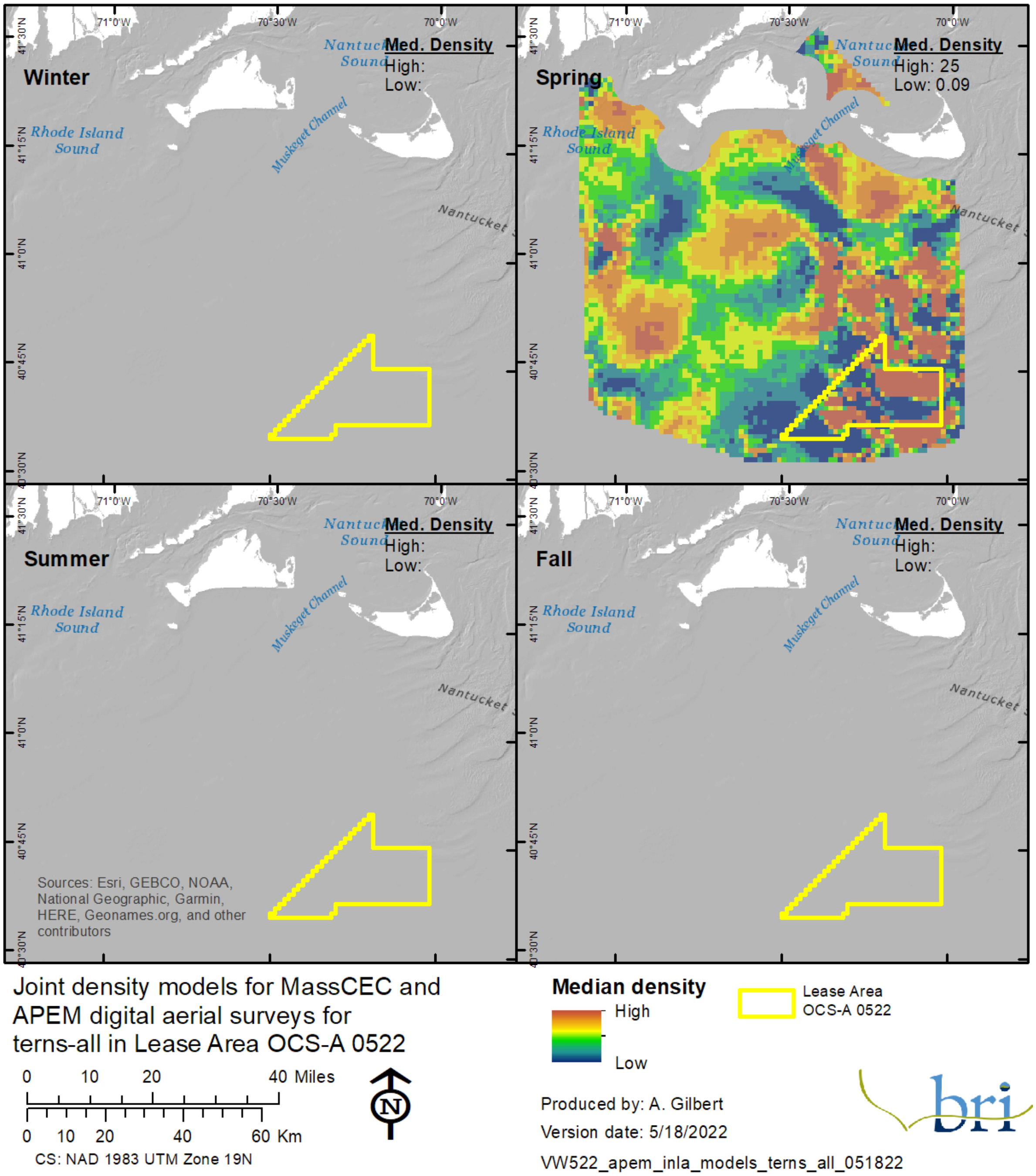


Figure 4-43: Spatial changes in density for terns across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area.

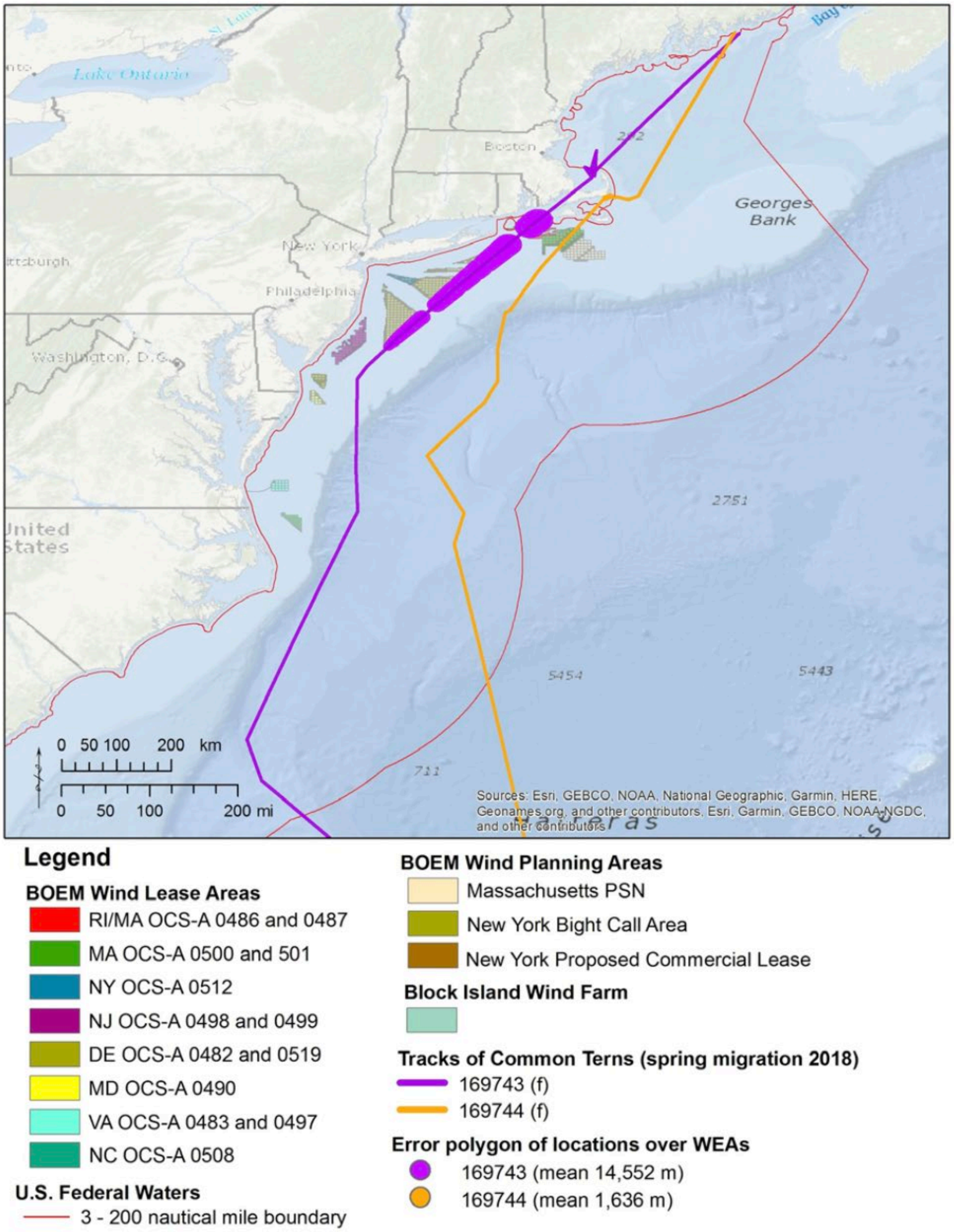


Figure 4-44: Common Tern spring migration model-estimated tracks from satellite transmitters (n = 2), from (Loring et al. 2019).

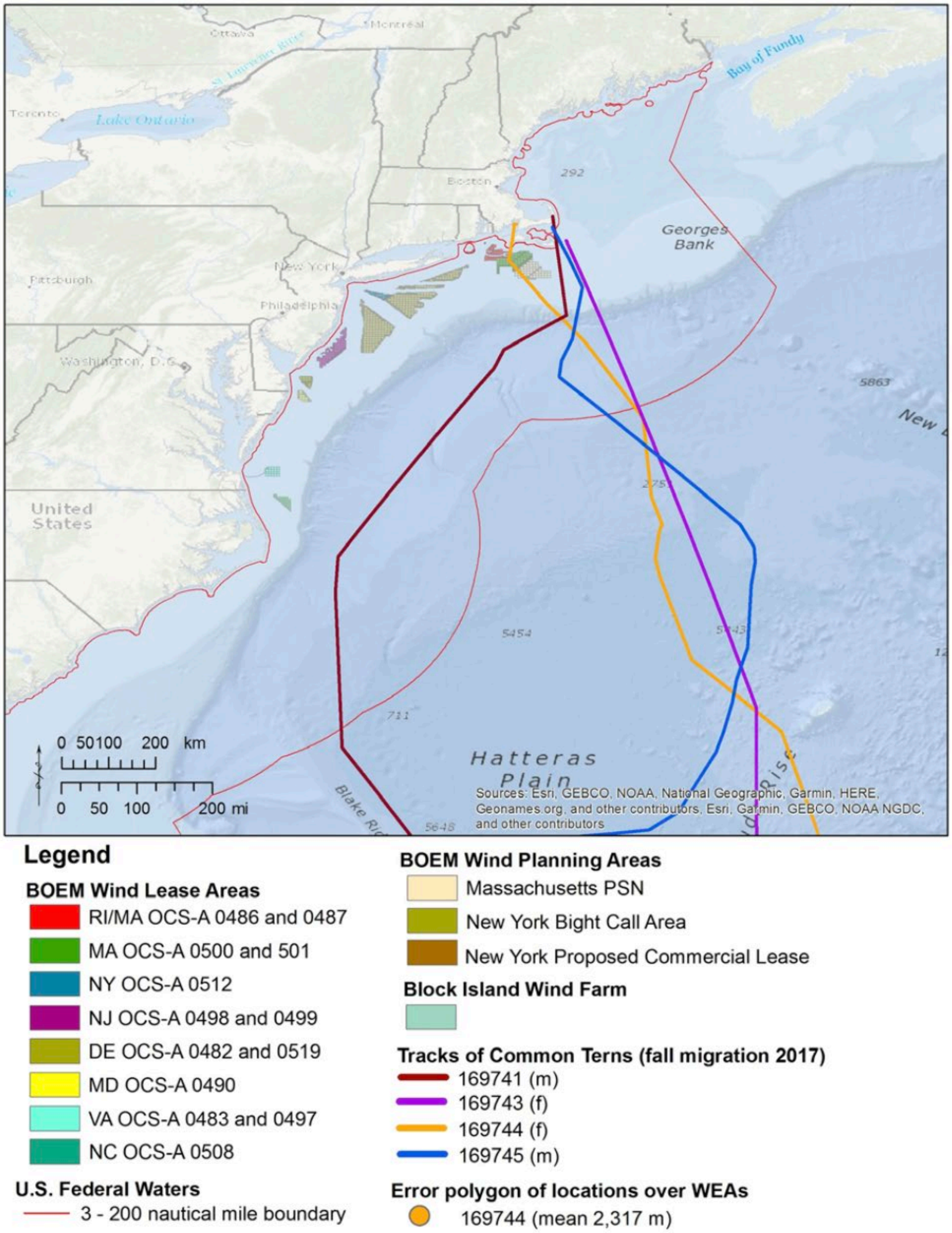


Figure 4-45: Common Tern fall migration model-estimated tracks from satellite transmitters (n = 4), from (Loring et al. 2019).

4.2.7.3. Behavioral Vulnerability Assessment

As a group, terns are expected to have **low** behavioral vulnerability to collisions (Table 4-17). Terns rank in the middle of collision vulnerability assessments (Garthe and Hüppop 2004; Furness et al. 2013) because they fly 2.8–12.7% of the time in the marine environment between 20–150 m (65.6–92.1 ft), have a 30–69.5% macro-avoidance rate (Cook et al. 2012), and have been demonstrated to avoid rotating WTGs (Vlietstra 2007). For the WTGs under consideration, Common Terns were estimated to fly in the RSZ 1.78% of the time (Figure 4-46). A movement study using NanoTags estimated that Common Terns primarily flew below the RSZ (<25 m [<82 ft]) and that the frequency of Common Terns flying offshore between 25–250 m (82–820 ft) ranged from 0.9–9.8 % (Loring et al. 2019). While the NanoTag flight height estimated birds flying below 164 ft (50 m), radar and observational studies provide evidence that terns in some instances can initiate migration at higher altitudes of 3,000–10,000 ft (1,000–3,000 m; Loring et al. 2019). For Common Terns and Arctic Terns, the probability of mortality is predicted to decline as the distance from the colony increases. Based on one year of NanoTag data collected at Petit Manan Island, Maine, tests of a decision support model for offshore wind farm siting suggest that the probability of occupancy and mortality rates during the breeding season at a turbine project drops to near zero beyond 15 km (9.3 mi) from a tern colony (Cranmer et al. 2017). This finding is corroborated by mortality monitoring of small to medium WTGs (200 and 600 kilowatts [kW]) in Europe, where mortality rates rapidly declined with distance from the colony (Everaert and Stienen 2007). Most observed tern mortalities in Europe have occurred at WTGs within 30 m (98 ft) from nests (Burger et al. 2011).

Terns are expected to have **medium** to **high** vulnerability to displacement. Terns have been shown to have a 76% lower abundance inside offshore wind farms and were estimated to start avoidance behaviors at 1.5 km (0.93 mi; Welcker and Nehls 2016). Common Terns and Roseate Terns have been demonstrated to avoid the airspace around a single 660 kW WTG (rotor-tip height: 240 ft [73 m]) in Buzzard's Bay, MA when the WTG was rotating and usually avoided the RSZ (Vlietstra 2007). Common Terns fall into the high category for macro-avoidance because of a 69.5% avoidance rate determined at Horns Rev (Cook et al. 2012), which had 2 MW WTGs (Petersen et al. 2006), and because (Willmott et al. 2013) categorized tern avoidance as greater than 40%. Here, a lower range was added to the displacement score (**medium;** Table 4-17) because: (1) terns received a "low" disturbance score according to (Wade et al. 2016); (2) terns were determined to have a 30% macro-avoidance of WTGs at Egmond aan Zee, the Netherlands (Cook et al. 2012); (3) terns have high uncertainty scores; and (4) displacement in terns has not been well studied.

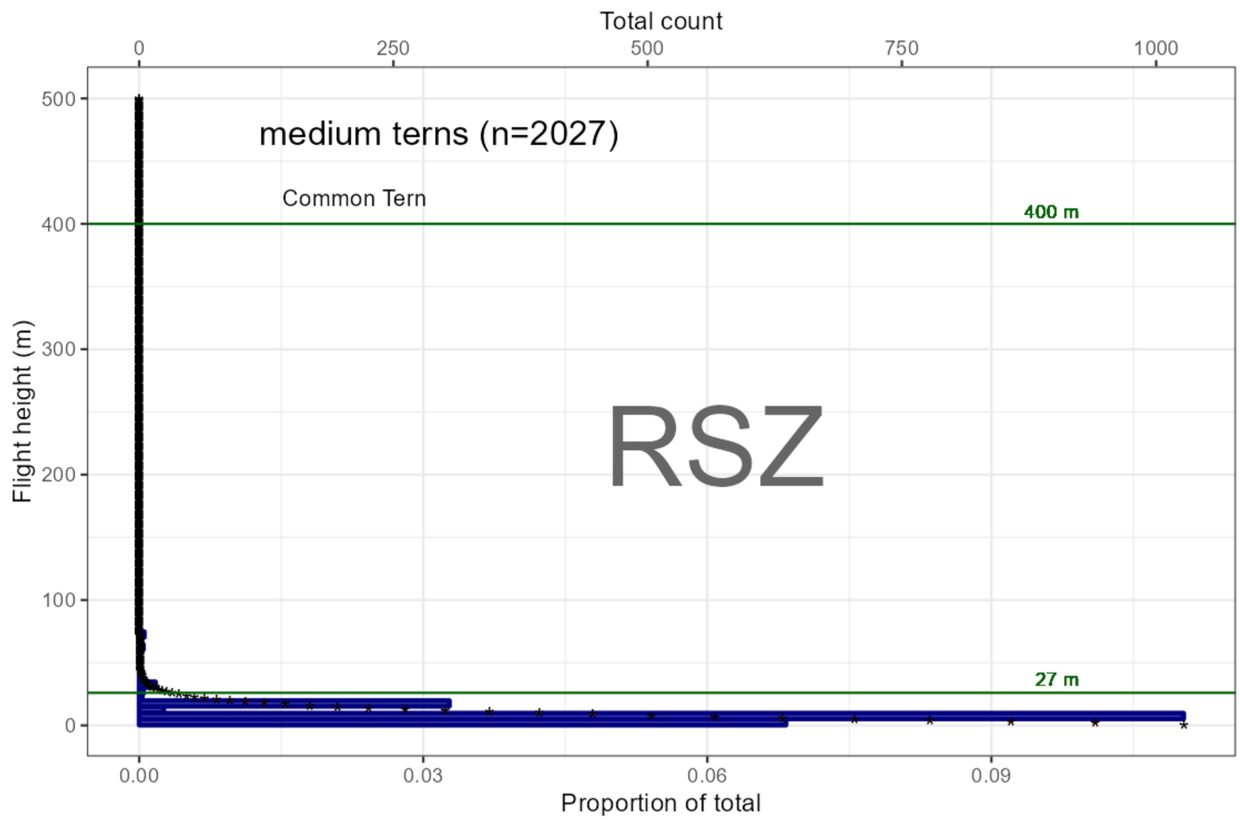


Figure 4-46: Flight heights of terns (m) derived from the Northwest Atlantic Seabird Catalog, showing the actual number of birds in 5 m intervals (blue bars), and the modeled average flight height in 1 m intervals (asterisk) and the standard deviation (red lines), in relation to the upper and lower limits of the RSZ. Data provided by NOAA and used with permission.

Table 4-17: Summary of tern vulnerability; based upon the literature on terns, collision and displacement vulnerability were adjusted to include a lower range limit (green)

Species	Collision Vulnerability (CV)	Displacement Vulnerability (DV)	Population Vulnerability (PV)
Common Tern	low (0.33)	medium- high (0.8)	medium (0.6)
Roseate Tern	low (0.33)	medium- high (0.8)	high (0.87)

4.2.7.4. Risk

Terns (including Roseate Terns) are expected to have **minimal** to **low** exposure to the construction and operational activities in the Lease Area. Terns are expected to have **low** behavioral vulnerability to collision and **medium** to **high** behavioral vulnerability to displacement. Because exposure will be limited, the birds generally do not fly through the RSZ, and the relatively small area of the Lease Area in relation to available foraging habitat, population level risk to terns is expected to be **minimal** to **low**. Roseate Terns are discussed in greater detail below.

4.2.7.5. *Federally Endangered Tern Species*

4.2.7.5.1. Roseate Tern

4.2.7.5.1.1. Spatiotemporal Context

Species General Description

The Roseate Tern is a small tern species that breeds colonially on coastal islands. In North America, the Atlantic Ocean population of Roseate Terns (*Sterna d. dougallii*) breeds in northeastern United States and Atlantic Canada, and winters in South America, primarily in eastern Brazil (USFWS 2010; Mostello et al. 2014). Roseate Terns generally arrive at their northwest Atlantic breeding colonies in late April to late May, with nesting occurring between roughly mid-May and late July. They commonly forage during the breeding season in shallow water areas (i.e., less than 5 m [16.4 ft] water depth), such as sand bars (USFWS 2010; Mostello et al. 2014). In Canada, breeding Roseate Terns stayed within 15.4 km (9.6 mi) of the colony and had the highest occurrence near the colony (Pratte et al. 2021). Roseate Terns forage by shallow plunge-diving or surface-dipping to catch small fish, such as sand lance (*Ammodytes* spp.; Goyert et al. 2014; Mostello et al. 2014).

Over 90% of Roseate Terns in this population breed at three colony locations in Massachusetts (Bird Island, Ram Island, and Penikese Island in Buzzards Bay), and one colony location in New York (Great Gull Island, near the entrance to Long Island Sound; (Mostello et al. 2014; Loring et al. 2017). Breeding Roseate Terns generally stay within about 10 km (6.2 mi) of the colony while foraging for food, but may travel up to 30–50 km (18.6–31 mi) from the colony while provisioning chicks (USFWS 2010; Burger et al. 2011; Mostello et al. 2014; Loring et al. 2017). The closest Roseate Tern nesting colony to the Lease Area is located at South Monomoy Island in Chatham, MA, approximately 80 km (~50 mi) from the northernmost tip of the Lease Area, which has supported a small number of terns in recent years.

Following the breeding season, adult and hatch year Roseate Terns move to post-breeding coastal staging areas from approximately late July to mid-September (USFWS 2010). There are roughly 20 staging areas in southeastern Cape Cod and nearby islands, which represent the majority of the breeding population for the northwest Atlantic (USFWS 2010). Foraging activity during the staging period is known to occur up to 16 km (10 mi) from the coast, though most foraging activity occurs much closer to shore (Burger et al. 2011). The nearest pre-migratory staging area to the Lease Area is located on the western tip of Nantucket Island (Atwood 2022), approximately 50 km [~31 mi] from the Lease Area.

Roseate Tern migration routes are poorly understood, but they appear to migrate primarily well offshore (Nisbet 1984; USFWS 2010; Burger et al. 2011). Six Roseate Terns tracked with data loggers in the 2000's flew directly between Massachusetts and eastern Caribbean islands during spring and fall migrations, crossing the ocean near the edge of the continental shelf and in some cases spending several days at sea (USFWS 2010; Mostello et al. 2014). The trip from Cape Cod to Puerto Rico in the fall took 1.5–2.5 days on average (900–1,500 km/day [559–932 mi/day]), with birds flying all night and stopping to feed at times during the day (Mostello et al. 2014).

Spring migration from South America to breeding locations was swifter overall, but migration between the northeastern Caribbean and Massachusetts was less direct, tended to be farther west than in fall (though still well offshore), and included nocturnal as well as diurnal stopover periods (Mostello et al. 2014).

Spring pre-breeding staging locations appear to be similar to post-breeding staging areas (Mostello et al. 2014). A NanoTag tracking study found movements of Common Terns and Roseate Terns primarily occurred from Cape Cod, MA, to Long Island Sound, NY, and that track densities were highest within 50 km (31 mi) of nesting colonies. During post-breeding, terns dispersed to staging areas in southeastern Massachusetts, with high densities on Monomoy Island, Nantucket, and Muskeget Island. One Roseate Tern made a long-distance (greater than 250 km [155 mi]) flight during the post-breeding period to New Jersey (Loring et al. 2019).

Listing and Population Status

The northwest Atlantic Ocean population of Roseate Terns has been federally listed as *Endangered* since 1987. Other breeding populations of Roseate Terns, such as the Caribbean breeding population, are unlikely to occur in the Lease Area (BOEM 2014). Declines in the northwest Atlantic population have been largely attributed to low reproductive rates, partially related to predator impacts on breeding colonies, and habitat loss and degradation, though adult Roseate Tern survival is also unusually low for a small tern species. As of 2017, approximately 50% of the Northeast U.S. population (4,446 pairs) nested in Massachusetts (Mostello et al. 2019).

Regional Information

Areas around Cape Cod that have been identified as important for Roseate Tern foraging activity in past years have largely been concentrated in Buzzard's Bay, Vineyard Sound, and along the southern coast of the Cape in Nantucket Sound (MMS 2008), though foraging locations can be highly dynamic. Non-breeding individuals, including juveniles and non-reproductive adults, are thought to: (1) move between foraging and staging areas more frequently, and (2) move over longer distances than breeding individuals (USFWS 2017).

Aerial survey data suggest that Nantucket Shoals may also be an important area for Common Terns and Roseate Terns in spring (during the month of May), prior to initiation of breeding (Veit et al. 2016). In aerial surveys of the MA WEA and vicinity in 2015, *Sterna* terns were observed offshore most commonly during the spring season, though median estimates of terns per square kilometer remained low in all seasons (Veit et al. 2016).

4.2.7.5.1.2. Exposure Assessment

Overall, the regional and site-specific information indicate limited use of the Lease Area by Roseate Terns during spring, summer, and fall (terns are not present in the winter). The MDAT abundance models suggest that Roseate Tern occupancy and abundance in the Lease Area is likely to be much lower than in Nantucket Sound in all seasons examined—spring, summer, and fall (Curtice et al. 2019)—and during the breeding and post-breeding periods, very few, if any, Roseate Terns are predicted to occur within the Lease Area (BOEM 2014, Curtice et al. 2019).

During digital aerial surveys, two Roseate Terns were observed immediately south of the Lease Area (one in May of 2020, and one in June of 2021; Figure 4-49). No Roseate Terns were confirmed in the Lease Area in the MassCEC aerial survey data (note, terns were not identified to species), nor in any other dataset in the Northwest Atlantic Seabird Catalog (Figure 4-49).

A movement study used NanoTags to track Roseate Terns tagged in Massachusetts and New York. While the movement models are not representative of the entire breeding and post-breeding period for many individuals (due to incomplete spatial coverage of the receiving stations and tag loss), none of the tracked birds (*n*=145; Figure 4-48) were estimated to pass through the Lease Area (Loring et al. 2019).

Roseate Terns may occur at the Lease Area ephemerally during spring and fall migration, and possibly during post-breeding as they move towards staging areas (Burger et al. 2011; BOEM 2014), although the little evidence there is from surveys suggest that the occurrence of terns is probably sporadic and more likely to occur in the spring during migration and potentially just after arrival at breeding areas. Tracking data shows that in July and August, individuals move between staging locations on islands in Nantucket Sound, Block Island, and Montauk (Loring et al. 2019). There is no evidence of post-breeding movements through the Lease Area (Loring et al. 2019), likely due to its location to the south of known breeding and staging locations, although it should be noted that the onshore receiver network did not full cover the offshore environment.

In summary, Roseate Terns are expected to have limited use of the Lease Area during all seasons, and any exposure will probably occur only during migration and just after arrival at breeding areas. The MDAT abundance models predict low use of the Lease Area, with birds concentrated generally closer to shore than near the Lease Area. Since Roseate Terns generally forage in shallow water they would not be expected to use the Lease Area as foraging habitat. While Roseate Tern received a low exposure score, a lower range (minimal) was added, given that terns are rarely observed in the Lease Area and exposure is likely limited to migration and potentially just after arrival for breeding; thus, the expected exposure of Roseate Terns is minimal to low. These conclusions are consistent with those determined by BOEM in comprehensive risk assessments conducted for Vineyard Wind 1

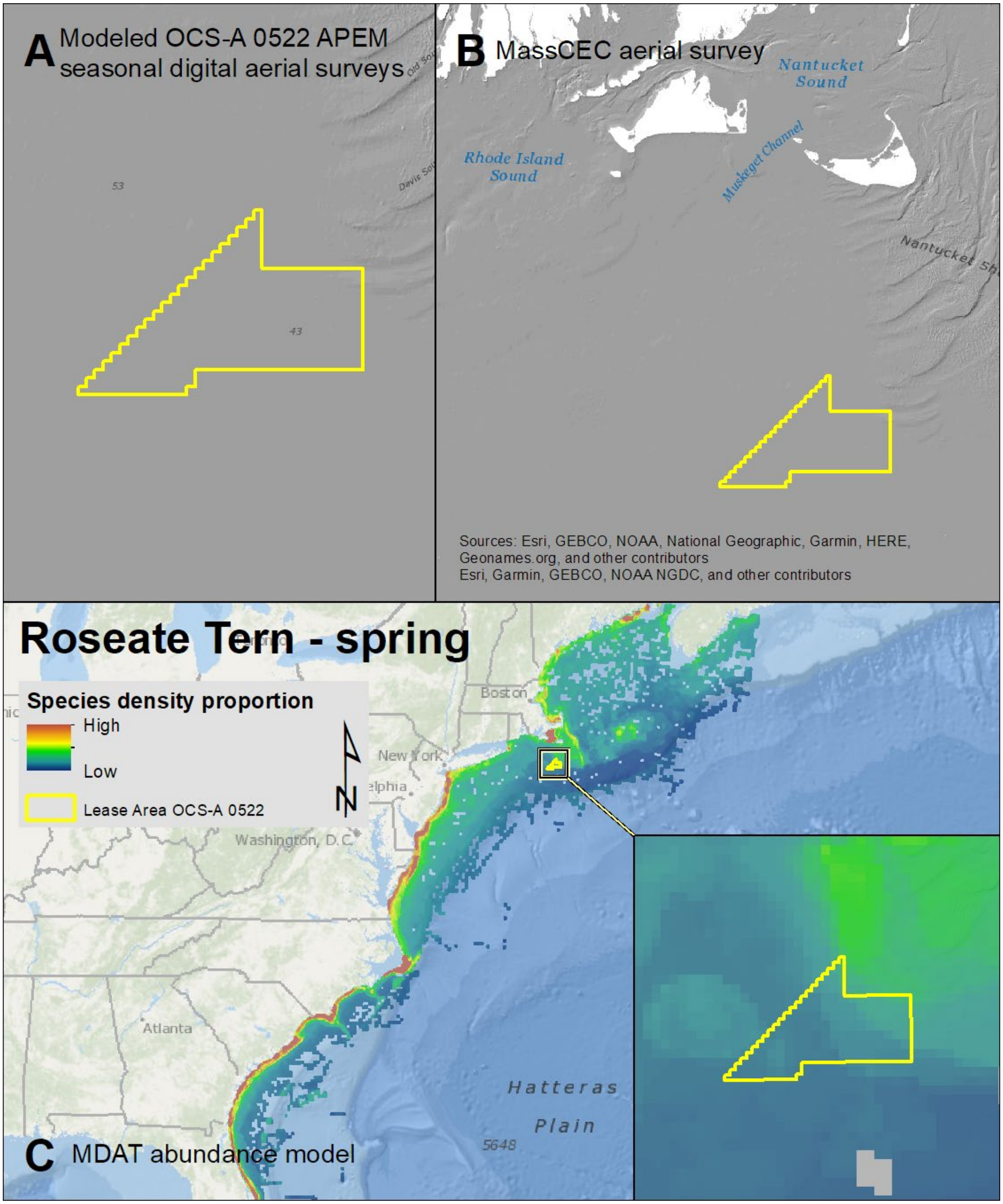


Figure 4-47: Spring Roseate Tern density proportions in digital aerial surveys (A), the MassCEC aerial surveys (B) and the MDAT data at regional (C) and local scales (inset); the scale for all maps is representative of relative spatial variation in the sites within the season for each data source.

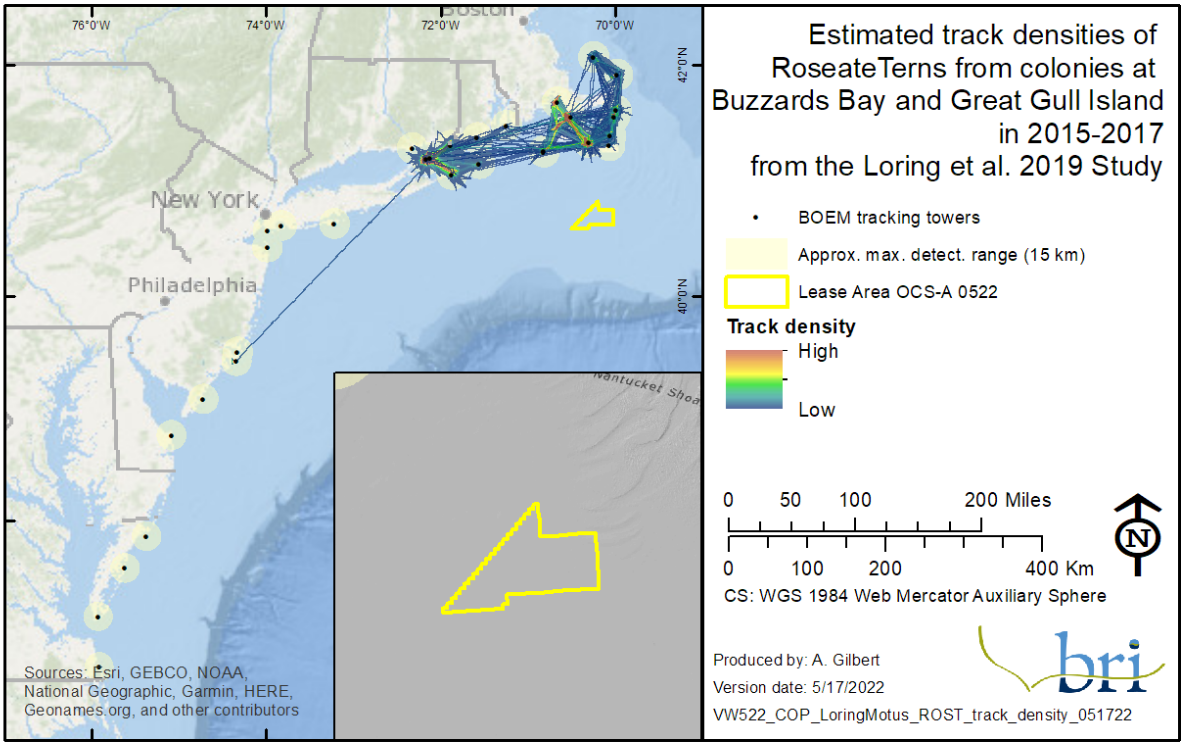


Figure 4-48: Track densities of Roseate Terns (*n*=90) tracked with NanoTags from Great Gull Island during the breeding and post-breeding period from 2015–2017 (Loring et al. 2019).

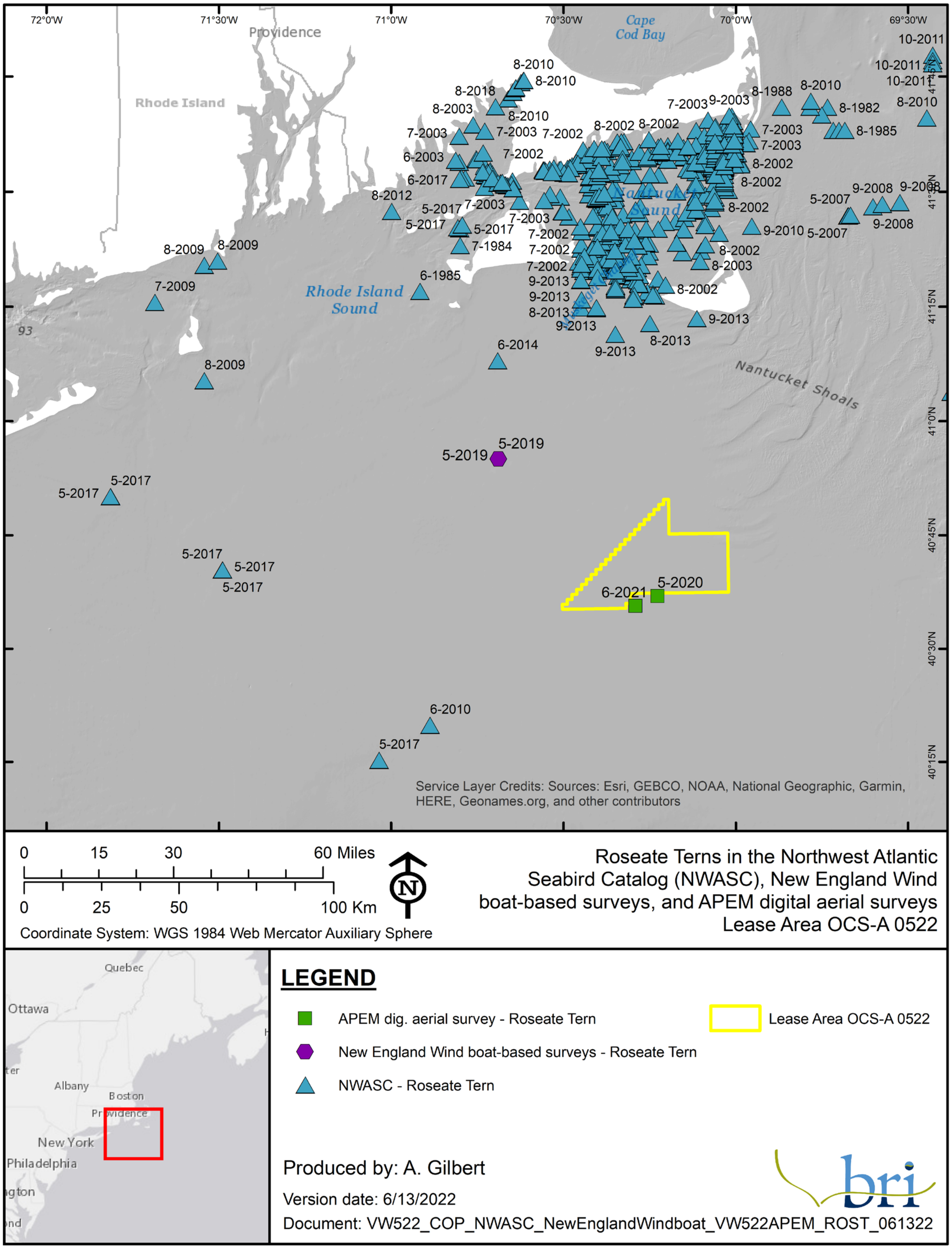


Figure 4-49: Roseate Tern observations from the Northwest Atlantic Seabird Catalog, digital aerial surveys, and New England Wind boat-based surveys.

4.2.7.5.1.3. Relative Behavioral Vulnerability Assessment

If Roseate Terns are exposed to the Lease Area, they are expected to have **low** behavioral vulnerability to collisions because terns do not rank high in collision vulnerability assessments (Furness et al. 2013). In general, terns have been observed to regularly exhibit micro-avoidance behaviors to avoid actively spinning WTG blades (Vlietstra 2007) and Roseate Terns are unlikely to fly within the RSZ.

Flight heights of Roseate Terns during foraging typically varies from 1 to 12 m (3.3 to 39.4 ft) above the water's surface and are most commonly less than 6 m (19.7 ft; Mostello et al. 2014). Roseate Terns do conduct courtship flights (high flights) that can range from 30 to 300 m (98.4 to 984 ft) in altitude and may continue throughout much of the breeding season (Mostello et al. 2014); such displays are most common near the breeding grounds, although they have also been observed at foraging locations (MMS 2008). European studies of related tern species have suggested that approximately 4 to 10% of birds may fly at potential rotor height (20–150 m [65.6–492.1 ft] above sea level) during local flights (Jongbloed 2016). In the U.S., data on Roseate Terns from a single 660 kW terrestrial WTG in Buzzard's Bay, Massachusetts, suggested that most flew below the RSZ of the small WTG when flying over land (9–21 m [29.5–68.9 ft]; Burger et al. 2011). Estimates of tern flight height from surveys in the Nantucket Sound area suggested that 95% of Common Terns and Roseate Terns flew below Cape Wind's proposed RSZ of 23 to 134 m (75.5 to 439.6 ft; MMS 2008).

While data on Roseate Tern flight during migration is limited, a movement study using NanoTags estimated that terns primarily flew below a hypothetical RSZ of 25 to 250 m (82 to 820 ft), and that Roseate Terns flying offshore only occasionally flew within the lower portion of the hypothetical RSZ (federal waters, 6.4%; WEAs, 0%; Loring et al. 2019). The study also indicated increased offshore movements in fair weather (Loring et al. 2019). Roseate Terns tracked with immersion sensors frequently rested on the water's surface during migration and wintering periods (two to three hours/day on average, including at night; Mostello et al. 2014). Data from other tern species suggest that flight height during migration varies with weather; headwinds may constitute optimal weather conditions for combining foraging with low-altitude migration (Jongbloed 2016), while terns may choose to fly at higher altitudes in tailwinds.

There is limited nocturnal and crepuscular data available, but it appears that nocturnal flights during breeding and post-breeding periods are limited to travel to and from foraging areas and occur only at time periods near dusk and dawn (MMS 2008). Peak exposure of birds tracked with NanoTags to federal offshore waters was in the morning, and Common Terns have been documented to initiate post-breeding movements within two hours prior to sunrise (Loring et al. 2019). Terns in nocturnal transit between roosting and daytime use areas (e.g., shoals and other foraging locations, coastal loafing locations) may fly at higher altitudes (e.g., 37 to 60 m [121.4 to 196.9 ft]; MMS 2008).

Studies conducted at operational WTGs indicate that terns exhibit avoidance behavior. Common terns were estimated to have a 69.5% avoidance rate of 2 MW WTGs at Horns Rev, Denmark (Petersen and Maim 2006; Cook et al. 2012) and were determined to have a 30% macro-avoidance of WTGs at Egmond aan Zee, the Netherlands (Cook et al. 2012). In Europe, terns have been documented to lower their flight altitude when approaching wind developments to avoid RSZs (Krijgsveld et al. 2011). At the 660-kW terrestrial WTG in Buzzard's Bay, Massachusetts, no tern mortalities were found during a multi-year study, even though Common Terns regularly flew within 50 m (164 ft) of the WTG (Burger et al. 2011). There was little evidence of terns reducing avoidance of this WTG in fog, but micro-avoidance of actual RSZs occurred when WTGs were spinning. Terns may detect WTG blades during operation, both visually and acoustically, and avoid flying between WTG rotors while they are in motion (MMS 2007; Vlietstra 2007).

Given what is known for Common Terns, Roseate Terns are expected to have **medium** to **high** behavioral vulnerability to displacement based on the displacement vulnerability ranking. Terns have been shown to have a 76% lower abundance inside offshore wind farms and were estimated to start avoidance behaviors at 1.5 km (0.93 mi; (Welcker and Nehls 2016). However, terns in general are not considered vulnerable to disturbance (Furness et al. 2013). Research also suggests that tern distribution and abundance is not affected by the presence of wind developments (Krijgsveld et al. 2011; Lindeboom et al. 2011). Even if terns avoid the Lease Area, there is no indication that Roseate Terns would lose important breeding season foraging habitat at the Lease Area because they prefer shallow waters, such as shoals (Burger et al. 2011). If Roseate Terns forage during migration, they could avoid the Lease Area, but it is unclear just how much they forage during migration (Burger et al. 2011).

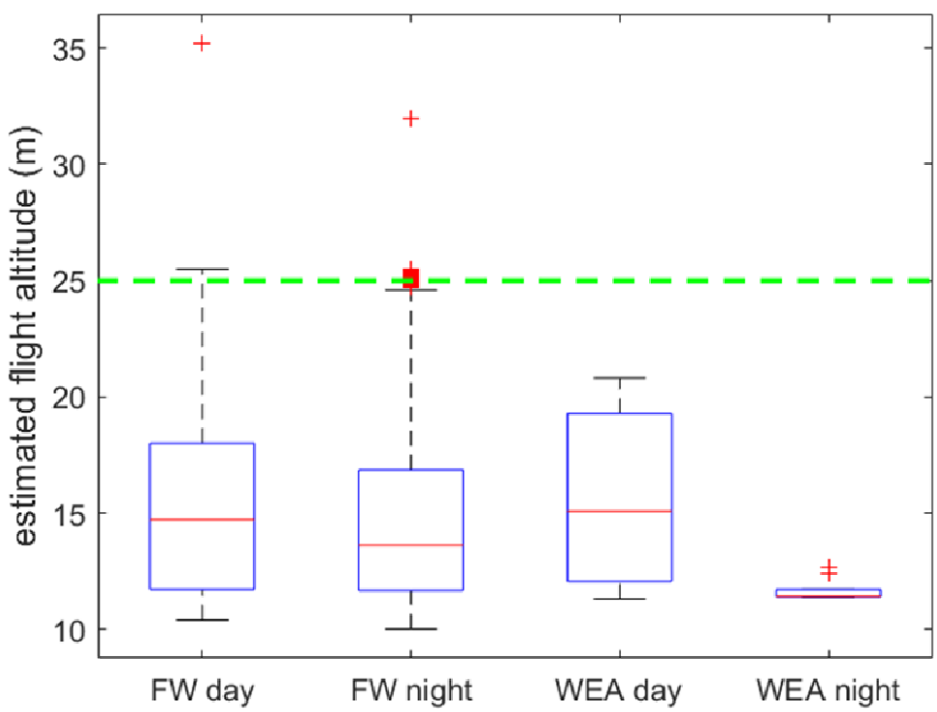


Figure 4-50: Model-estimated flight altitude ranges (m) of Roseate Terns during exposure to Federal waters and Atlantic OCS WEAs during day and night. The green-dashed line represents the lower limit of a potential RSZ (25 m [82 ft]; from Loring et al. [2019]).

4.2.7.5.1.4. Risk

Roseate Terns are expected to have **minimal** to **low** exposure to the Lease Area, **low** vulnerability collisions, and **medium** to **high** behavioral vulnerability to displacement. Because the exposure will be limited, and the birds generally avoid, or do not fly through, the RSZ, it is unlikely that Roseate Tern individuals will collide with turbines. This finding is consistent with BOEM's Biological Assessment for Vineyard Wind 1, which concluded that Roseate Tern mortality from collision would be zero and that the likelihood of collision fatalities would be "insignificant and discountable" (BOEM 2019).

Because exposure will be limited due to the relatively small area of the Lease Area in relation to available foraging habitat, it is unlikely that Roseate Tern individuals will be displaced from important foraging habitat. These findings are consistent with BOEM's Biological Assessment for Vineyard Wind 1, which found for the Roseate Tern that "[it] is reasonable to assume that any extra energy expenditure, if any, resulting from making a relatively minor course correction to avoid of the offshore portions of the Action Area would be inconsequential and would not result in a measurable negative affect." The Biological Opinion subsequently issued for Vineyard Wind 1 concluded that impacts to these species from barrier effects (displacement) would be insignificant and discountable (BOEM 2019).

Overall, due to the species high population vulnerability, the lower range of the final risk determination was removed, leading to a risk determination of **low** for both collision and displacement.

4.2.8. Loons

4.2.8.1. Spatiotemporal Context

Both Common Loons (*Gavia immer*) and Red-throated Loons (*Gavia stellata*) use the Atlantic OCS in winter. Analysis of satellite-tracked Red-throated Loons captured and tagged in the mid-Atlantic area found their winter distributions to be largely in the mid-Atlantic, with little exposure to Massachusetts WEAs and the Lease Area (Stenhouse et al. 2020). Wintering Common Loons generally show a broader and more dispersed distribution offshore in winter (Evers et al. 2020).

4.2.8.2. Exposure Assessment

Exposure was assessed using species accounts, tracking data, and baseline survey data. The regional MDAT abundance models show that these birds are concentrated closer to shore and in the mid-Atlantic. During spring migration, Red-throated Loons use Nantucket Shoals, immediately east of the Lease Area, as a stopover site (Figure 4-52; Stenhouse et al. 2020). During the digital aerial surveys, loons were detected from November–May and Red-throated Loons were among the most abundant species in April and May (Figure 4-51). The bird's distribution through the Lease Area varied by season (Figure 4-53). The exposure scores for loons were **minimal** during all seasons (Table 4-18), leading to a final exposure score of **minimal** for the species group.

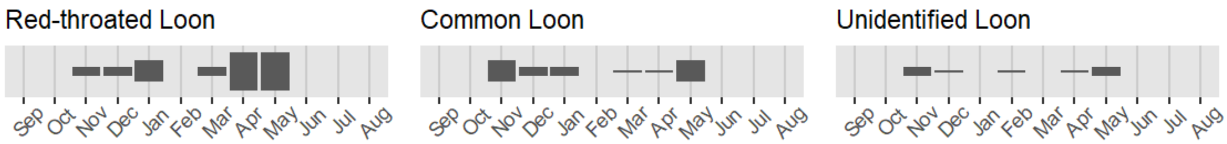


Figure 4-51: Monthly relative densities of loons in the survey area from digital aerial surveys.

Table 4-18: Seasonal exposure rankings for the loons group

Loons	Season	Local Rank	Regional Rank	Total Rank	Exposure Score
Common Loon	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Red-throated Loon	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	.	0	minimal
	Fall	0	0	0	minimal

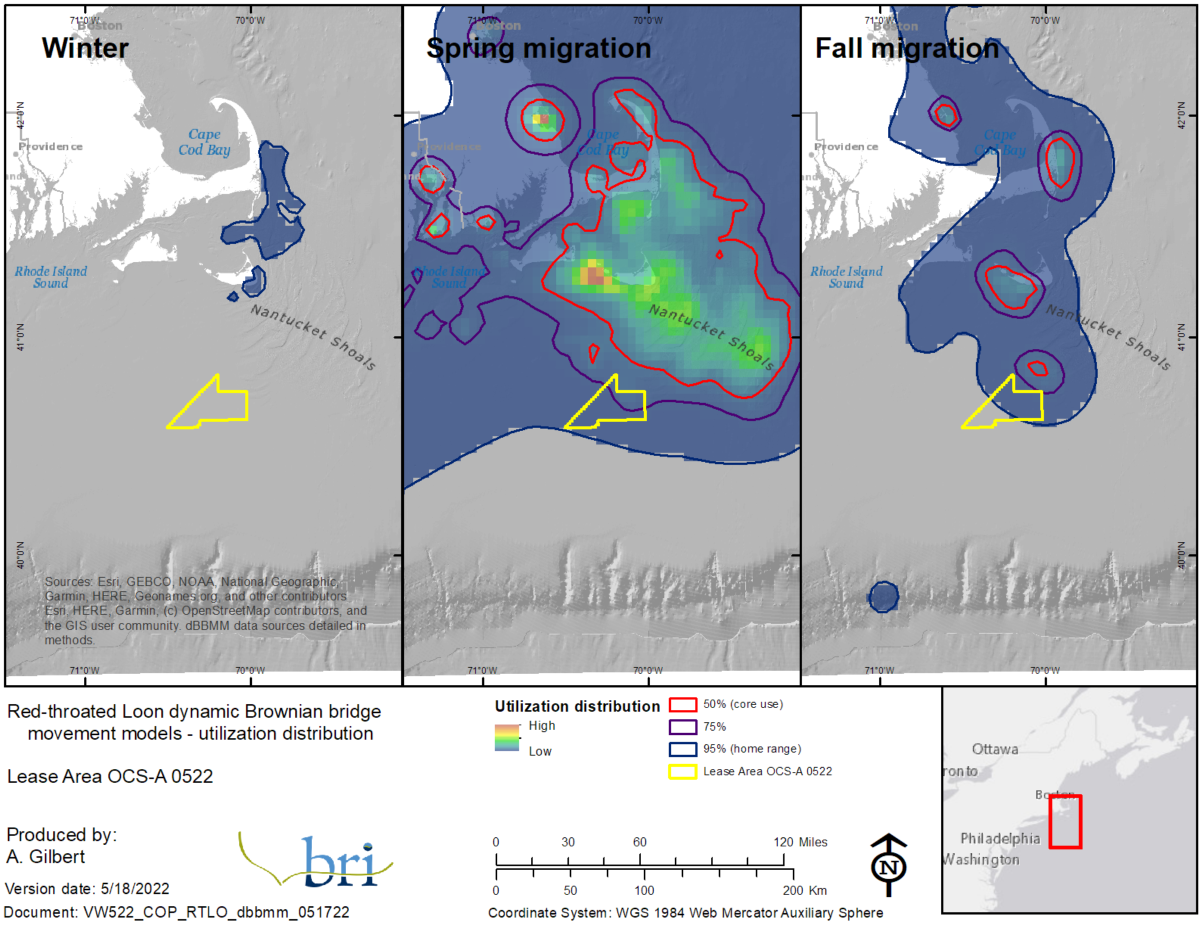


Figure 4-52: Dynamic Brownian bridge movement models for Red-throated Loons that were tracked with satellite transmitters; the contours represent the percentage of the use area across the UD surface and represent various levels of use from 50% (core use) to 95% (home range). Data provided by BOEM/USFWS and used with permission.

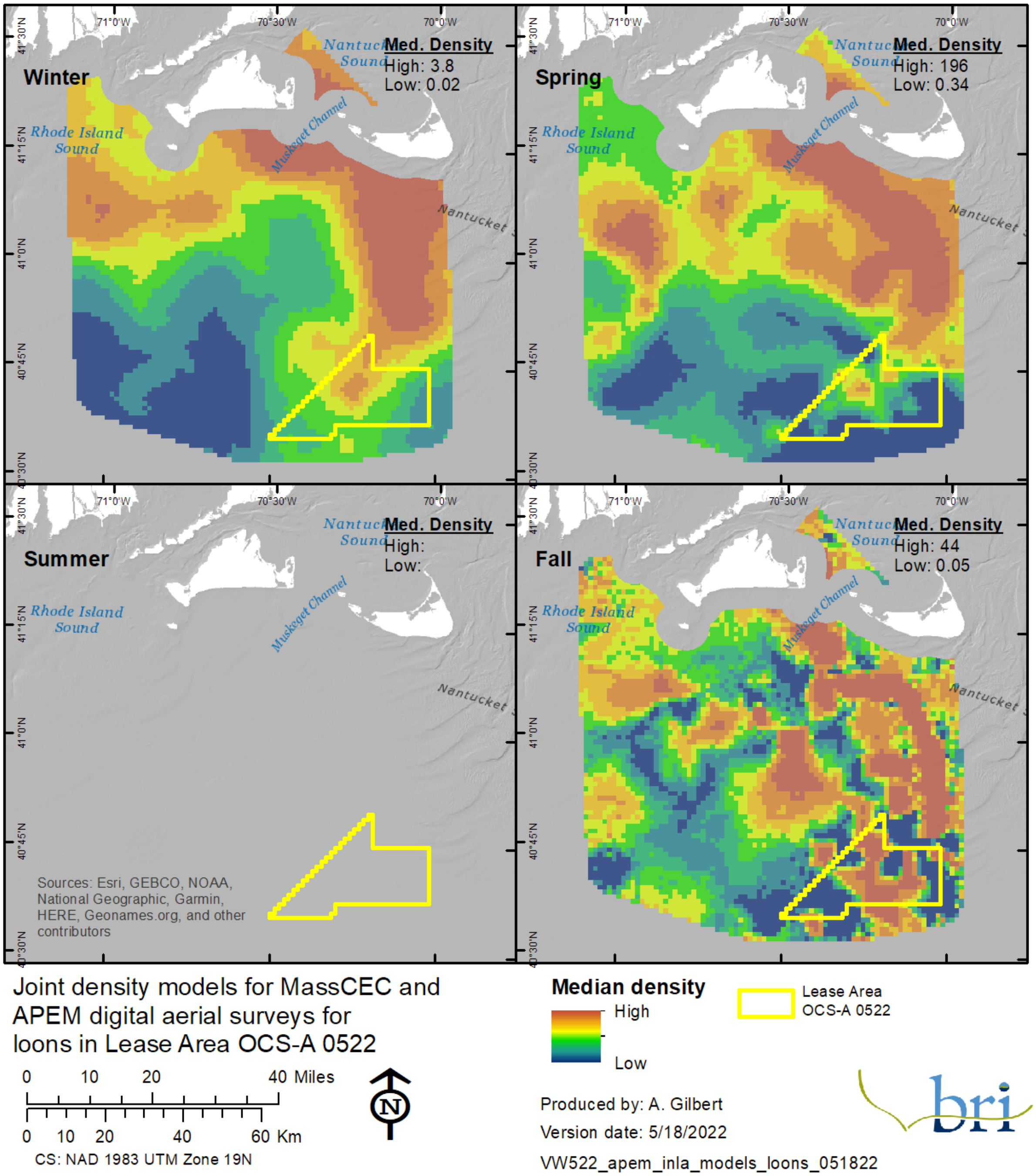


Figure 4-53: Spatial changes in density for loons across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

4.2.8.3. Relative Behavioral Vulnerability Assessment

Loons are expected to have **minimal** to **low** behavioral vulnerability to collision because these birds have consistently been documented to strongly avoid offshore wind projects and are widely considered to have low vulnerability to collision (Furness et al. 2013). Pre- and post-construction monitoring at offshore developments demonstrates that Red-throated Loons consistently avoid wind farms and do not habituate to the development (Percival 2010; Lindeboom et al. 2011). Consequently, due to consistent avoidance behavior, Red-throated Loons are not likely to collide with offshore WTGs. There is little empirical evidence on how Common Loons will respond to offshore wind developments, but they will likely respond similarly to Red-throated Loons and are not considered vulnerable to collision. In addition, loons tend to fly below the RSZ. For the WTGs under consideration, loons were estimated to fly in the RSZ 7.48–21.16% of the time (Figure 4-54), further reducing collision vulnerability. The collision vulnerability score for loons was **low**, but a lower range was added to the score (**minimal**) because of the birds' strong avoidance response (Table 4-19).

Loons are expected to have **high** behavioral vulnerability to displacement. Loons are identified as the birds most vulnerable to displacement (Garthe and Hüppop 2004; Furness et al. 2013) and received a **high** displacement vulnerability score. Red-throated Loons are documented to consistently avoid offshore wind farms (Mendel et al. 2019). In addition to displacement caused by WTG arrays, Red-throated Loons have also been shown to be negatively affected by increased boat traffic associated with construction and O&M (Mendel et al. 2019). Common Loons may have similar avoidance responses.

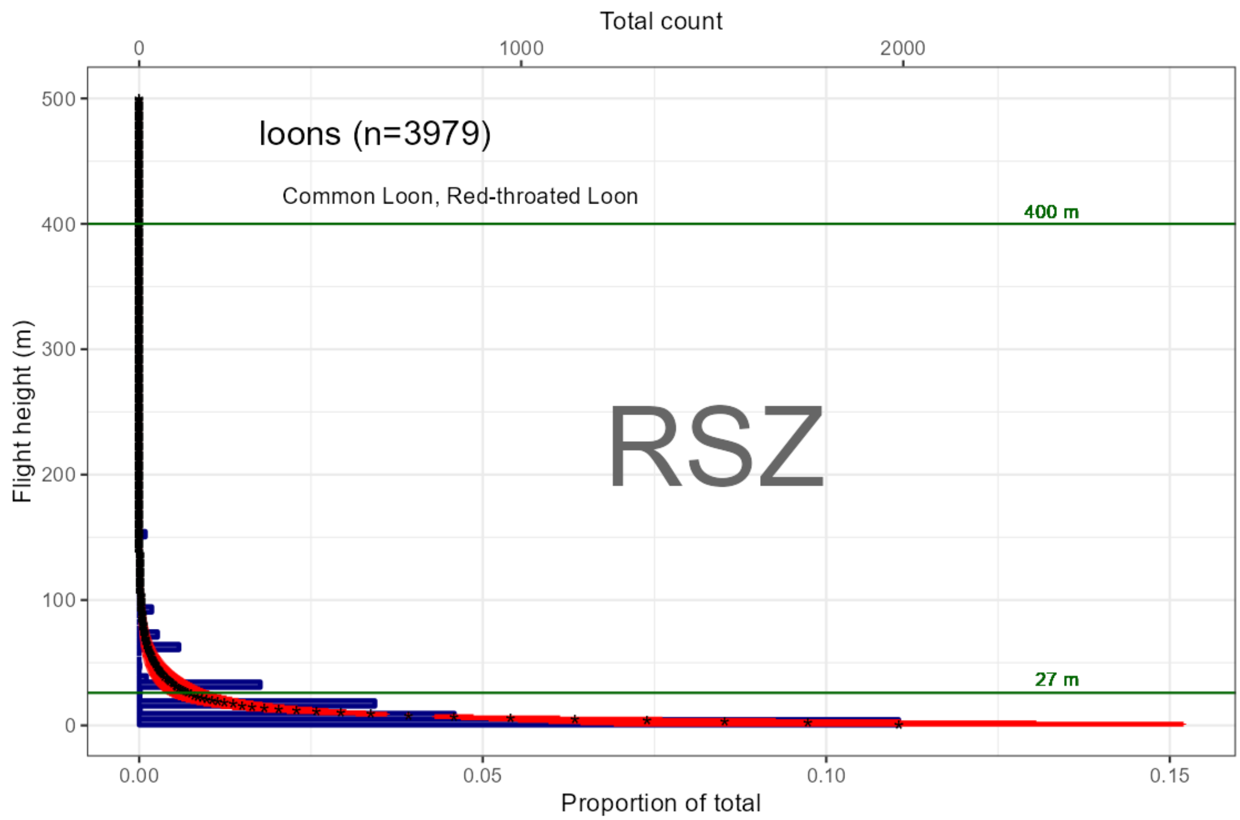


Figure 4-54: Flight heights of loons (m) derived from the Northwest Atlantic Seabird Catalog, showing the actual number of birds in 5 m intervals (blue bars), and the modeled average flight height in 1 m intervals (asterisk) and the standard deviation (red lines), in relation to the upper and lower limits of the RSZ. Data provided by NOAA and used with permission.

Table 4-19: Vulnerability assessment rankings by species for the loons group. Based upon the literature, collision vulnerability was adjusted to include a lower range limit (green)

Species	Collision Vulnerability (CV)	Displacement Vulnerability (DV)	Population Vulnerability (PV)
Common Loon	min–low (0.47)	high (0.8)	medium (0.6)
Red-throated Loon	min–low (0.33)	high (0.9)	low (0.47)

4.2.8.4. Risk

Loons are expected to have **minimal** exposure to construction and operational activities in the Lease Area. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have **minimal** to **low** behavioral vulnerability to collision and have **high** behavioral vulnerability to displacement. While these birds are vulnerable to displacement, there is uncertainty about how displacement will affect individual fitness (e.g., changes in energy expenditure due to avoidance) and effective methodologies for assessing population-level displacement effects are lacking (Fox and Petersen 2019; Mendel et al. 2019). Due to their limited exposure and because this species group has been documented to avoid offshore wind farms, limiting collision risk, and the Lease Area probably does not have important foraging habitat for loons, population level risk to this species group is expected to be **minimal**.

4.2.9. Shearwaters, Petrels, and Storm-Petrels

4.2.9.1. Spatiotemporal Context

Petrels and shearwaters that breed in the southern hemisphere visit the northern hemisphere during the austral winter (boreal summer) in vast numbers. These species use the U.S. Atlantic OCS region, including areas offshore of Massachusetts, so heavily that they greatly outnumber the locally breeding species and year-round residents at this time of year (Nisbet et al. 2013). Several of these species (e.g., Great Shearwater [*Puffinus gravis*], Cory's Shearwater [*Calonectris diomedea*], and Wilson's Storm-Petrel [*Oceanites oceanicus*]) are found in high densities across the broader region (Veit et al. 2015), and within the MA WEA (Veit et al. 2016) in summer. The regional MDAT abundance models show that the birds are concentrated offshore south of Maine and Nova Scotia.

The Black-capped Petrel is currently proposed for federal listing as threatened in the U.S. (USFWS 2018) and is thus addressed in further detail, below.

4.2.9.2. Exposure Assessment

Exposure was assessed using species accounts and baseline survey data. During the digital aerial surveys, storm-petrels and shearwaters were among the most abundant species from June through November. Northern Fulmar had a different temporal pattern, and were most abundant through the fall, winter, and spring (Figure 4-55). The distribution of this species group in the Lease Area varied by season, with a southwest trend in the spring and fall for the petrel and shearwater group (Figure 4-56) and in the summer and fall for the storm-petrels (Figure 4-57). The seasonal exposure scores for the shearwater, petrel, and storm-petrel group (nine species) ranged from **minimal** to **medium**. Leach's Storm-Petrel (*Hydrobates leucorhous*), Sooty Shearwater (*Puffinus griseus*), Audubon's Shearwater (*Puffinus Iherminieri*), and Black-capped Petrel had seasonal exposure scores of **minimal**. Wilson's Storm-Petrel, Great Shearwater, and Northern Fulmar (*Fulmarus glacialis*) had exposure scores ranging from **minimal** to **low**, and Cory's Shearwater and Manx Shearwater (*Puffinus puffinus*) had exposure scores ranging from **minimal** to **medium** (Table 4-20). Final exposure scores across species ranged from **minimal** to **medium**.

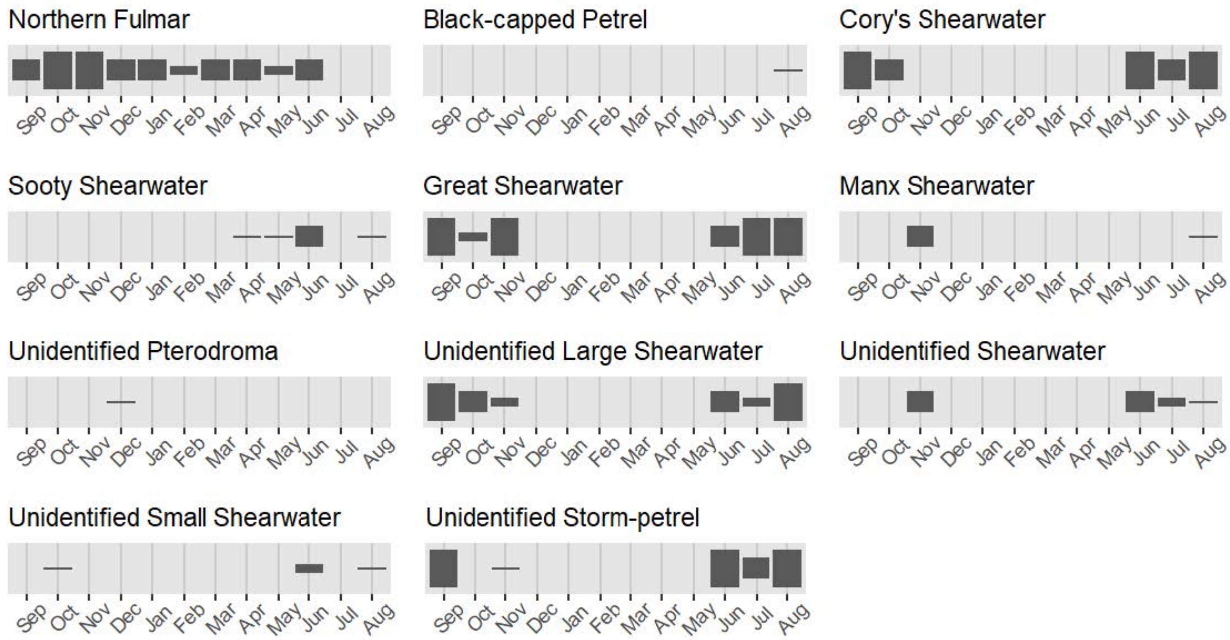


Figure 4-55: Monthly relative densities of petrels, storm-petrels, and shearwaters in the survey area from digital aerial surveys.

Table 4-20: Seasonal exposure rankings for the shearwaters, petrels, and storm-petrels

Shearwaters and Petrels	Season	Local Rank	Regional Rank	Total Rank	Exposure Score
Audubon's Shearwater	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Black-capped Petrel	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Cory's Shearwater	Winter	0	.	0	minimal
	Spring	0	0	0	minimal
	Summer	0	3	3	medium
	Fall	3	1	4	medium
Great Shearwater	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	1	1	low
	Fall	2	0	2	low
Manx Shearwater	Winter	0	.	0	minimal
	Spring	0	0	0	minimal
	Summer	0	1	1	low
	Fall	3	0	3	medium
Northern Fulmar	Winter	2	0	2	low
	Spring	2	0	2	low
	Summer	0	0	0	minimal

Shearwaters and Petrels	Season	Local Rank	Regional Rank	Total Rank	Exposure Score
	Fall	0	0	0	minimal
Sooty Shearwater	Winter	0	.	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Leach's Storm-Petrel	Winter	0	.	0	minimal
	Spring	0	0	0	minimal
	Summer	0	0	0	minimal
	Fall	0	0	0	minimal
Wilson's Storm-Petrel	Winter	0	.	0	minimal
	Spring	1	0	1	low
	Summer	0	1	1	low
	Fall	0	0	0	minimal

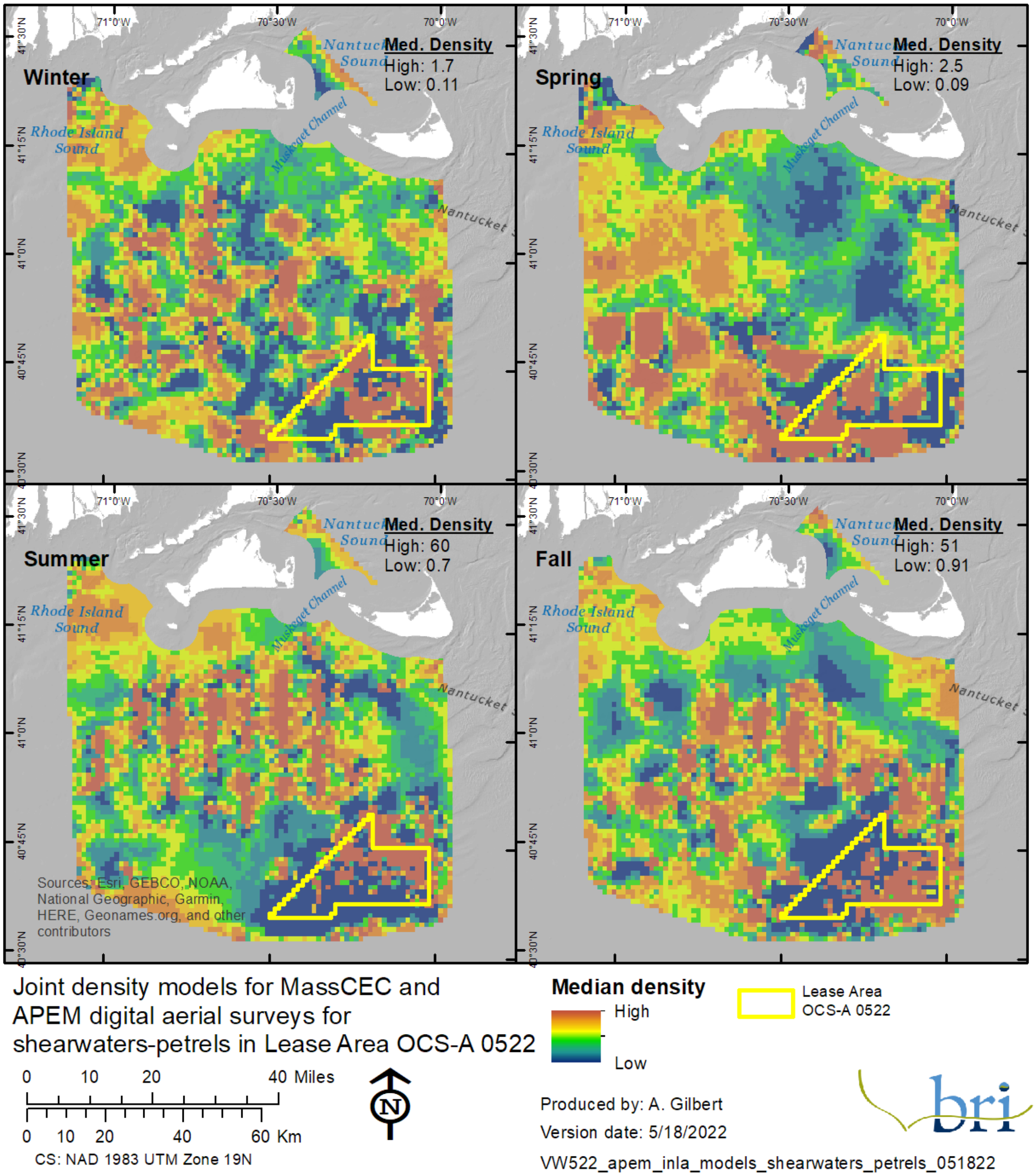


Figure 4-56: Spatial changes in density for petrels and shearwaters across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

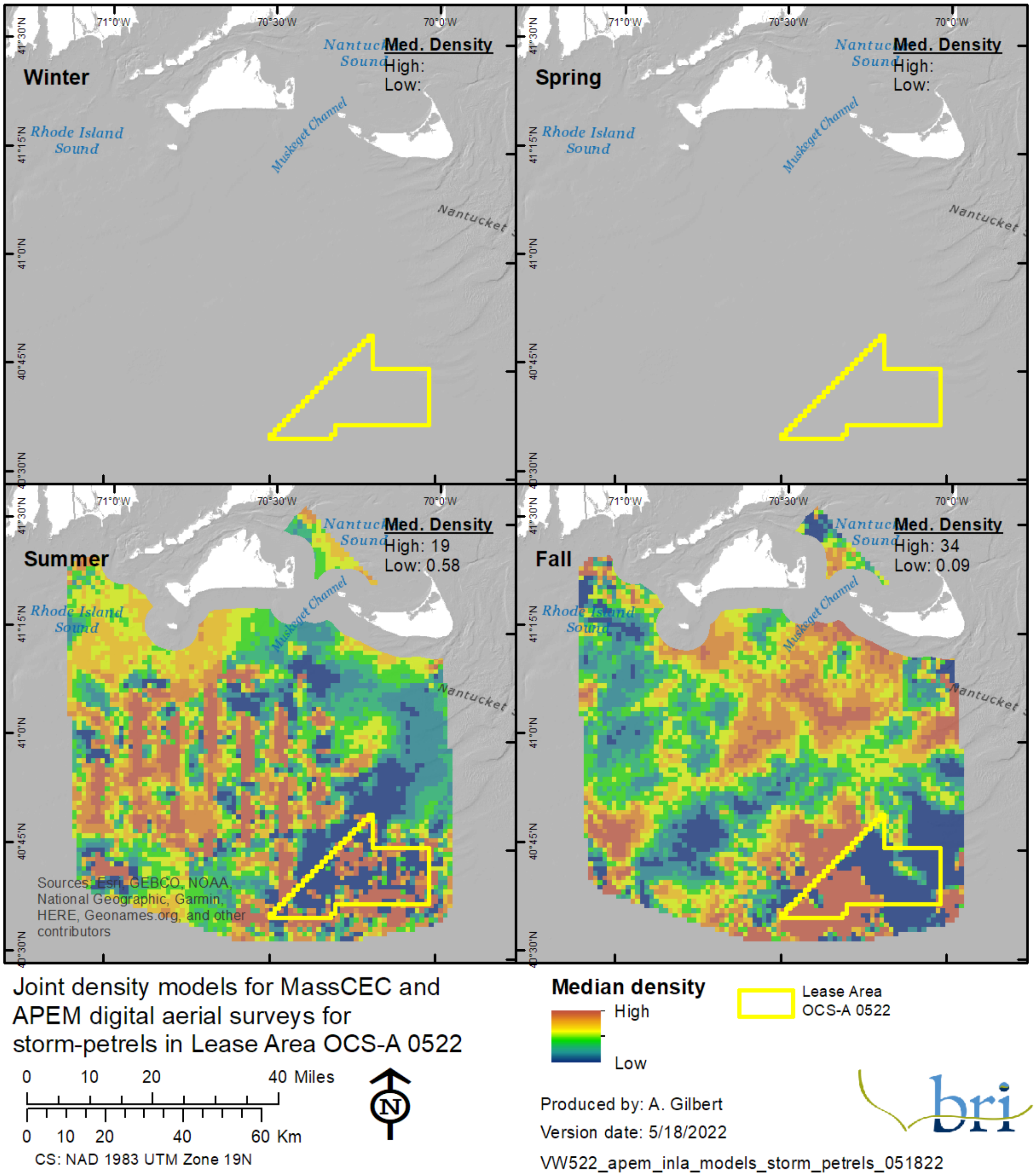


Figure 4-57: Spatial changes in density for storm-petrels across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

4.2.9.3. Relative Behavioral Vulnerability Assessment

Shearwaters, storm-petrels, and petrels are expected to have **low** behavioral vulnerability to collision (Table 4-21). Shearwaters, storm-petrels, and auks all rank extremely low for collision risk (Furness et al. 2013), and the flight height data indicates extremely limited use, if any, of the RSZ. For the WTG under consideration, this group was estimated to fly in the RSZ less than 0.2% of the time (Figure 4-58).

Some species within this group forage at night on vertically migrating bioluminescent aquatic prey and are instinctively attracted to artificial light sources (Imber 1975; Montevecchi 2006). This may be particularly true during periods of poor visibility when collision risk is likely to be highest. However, there is little data on avian behavior in the marine environment during such periods as surveys are limited to good weather during daylight hours. Studies that exist indicate that light-induced mass mortality events are primarily a land-based, juvenile issue involving fledging birds leaving their colonies at night (Corre et al. 2002; Rodríguez et al. 2014; Rodríguez et al. 2015; Rodríguez et al. 2017). Responses to intermittent light-emitting diode (LED) lights, likely to be used at offshore wind farms, are largely unknown at this point, but are unlikely to have population-level effects.

Shearwaters, petrels, and storm-petrels are expected to have **low** to **medium** behavioral vulnerability to displacement. Displacement has not been well studied for this taxonomic group, but Furness et al. (2013) ranked species in this group as having the lowest displacement rank. A study at Egmond aan Zee, the Netherlands, found that 50% (*n*=10) of tube-nosed species passed through the wind farm, which results in the birds receiving a displacement vulnerability score of 5 and thus “medium” vulnerability. Wade et al. (2016) identified that there was “very high” uncertainty on displacement vulnerability for these species. Based upon the evidence in the literature and identified uncertainty, a lower range (**low**) was added to the displacement vulnerability assessment of shearwaters, petrels, and storm-petrels.

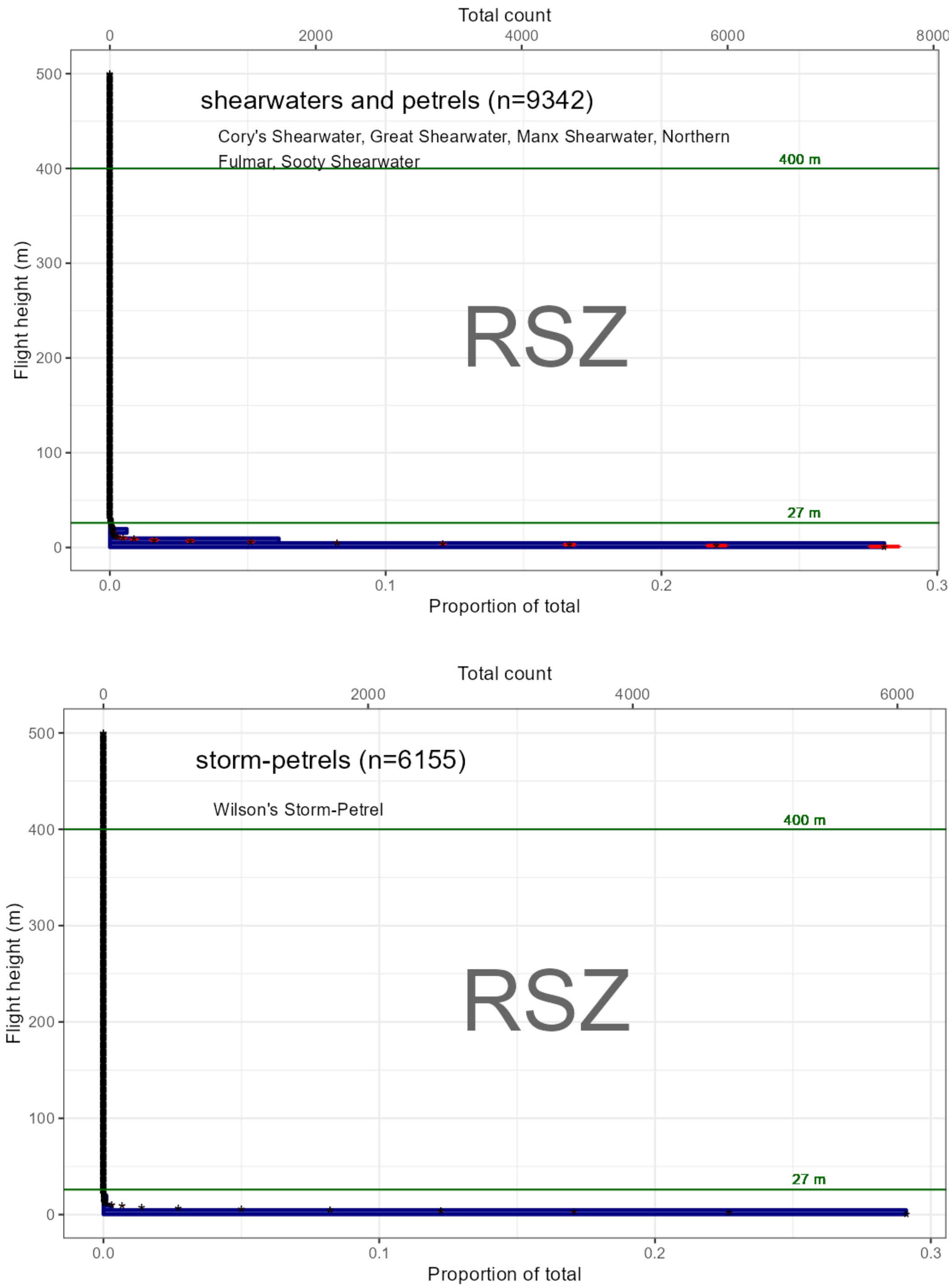


Figure 4-58: Flight heights of shearwaters and petrels (upper panel), and storm-petrels (lower panel) derived from the Northwest Atlantic Seabird Catalog, showing the actual number of birds in 5 m intervals (blue bars), and the modeled average flight height in 1 m intervals (asterisk) and the standard deviation (red lines), in relation to the upper and lower limits of the RSZ. Data provided by NOAA and used with permission.

4.2.9.1. *Risk*

Shearwaters, petrels, and storm-petrels are expected to have **minimal** to **medium** exposure to the construction and operational activities in the Lease Area. If they are exposed, they are expected to have **low** behavioral vulnerability to collision and **low** to **medium** behavioral vulnerability to displacement. Population level risk for Cory's Shearwater is expected to be **low** to **medium**, due to medium exposure. Since the other species in this group have **minimal** to **low** exposure, population level risk to these species is expected to be **minimal** to **low**.

Table 4-21: Summary of petrel, shearwater, and storm-petrel vulnerability. Based upon the literature, displacement vulnerability was adjusted to include a lower range limit (green).

Species	Collision Vulnerability (CV)	Displacement Vulnerability (DV)	Population Vulnerability (PV)
Cory's Shearwater	low (0.33)	low - medium (0.6)	medium (0.6)
Great Shearwater	low (0.3)	low - medium (0.6)	medium (0.67)
Manx Shearwater	low (0.37)	low - medium (0.6)	medium (0.53)
Northern Fulmar	low (0.37)	low - medium (0.6)	low (0.47)
Sooty Shearwater	low (0.4)	low - medium (0.6)	medium (0.53)
Wilson's Storm-Petrel	low (0.43)	low - medium (0.6)	low (0.4)

4.2.9.2. *Candidate Petrel Species*

4.2.9.2.1. Black-capped Petrel

4.2.9.2.1.1. *Spatiotemporal Context*

Species General Description

The Black-capped Petrel is a pelagic seabird that breeds in small colonies on remote forested mountainsides of Caribbean islands, although breeding is now thought to be mostly restricted to the islands of Hispaniola (Haiti and the Dominican Republic) and possibly Cuba (Simons et al. 2013). During their breeding season (January–June), Black-capped Petrels travel long distances to forage over deep waters (200–2,000 m [650–6,500 ft]) of the southwestern North Atlantic, the Caribbean basin, and the southern Gulf of Mexico (Simons et al. 2013). Outside the breeding season, they regularly spend time in U.S. waters along the shelf edge of the South Atlantic Bight, commonly as far north as Cape Hatteras and occasionally beyond (Jodice et al. 2015) but are rarely seen in waters offshore of Massachusetts.

Listing and Population Status

The small, declining global population, which is likely less than 2,000 breeding pairs, has been listed as *Endangered* on the International Union for Conservation of Nature's Red List since 1994 (BirdLife International 2018), and is currently proposed for federal listing under the ESA as *Threatened* (USFWS 2018) due to its heavy use of the Gulf Stream within U.S. waters (USFWS 2018). The Black-capped Petrel was pushed to the edge of extinction in the late 1800s due to hunting and harvest for food (Simons et al. 2013). Predation of adults and eggs by invasive mammals as well as breeding habitat loss and degradation remain major threats to their existence, while the effects of climate change on the biology of the species and its prey are largely unknown (Goetz et al. 2012). Nevertheless, an increase in the frequency and intensity of hurricanes due to climate change is expected to drastically increase mortality in breeding Black-capped Petrels (Hass et al. 2012). Given the small size of the breeding population, the species' resiliency (i.e., the ability to withstand normal environmental variation and stochastic disturbances over time) is considered to be low (USFWS 2018).

Regional Information

The Black-capped Petrel is extremely uncommon in areas not directly influenced by the warmer waters of the Gulf Stream (Haney 1987) and is thought to be found in coastal waters of the U.S. only as a result of tropical storms (Lee 2000). The Northwest Atlantic Seabird Catalog contains approximately 5,000 individual observations of Black-capped Petrels at sea from 1979–2006 (Simons et al. 2013), with some observations off of Long Island. Recent tracking of Black-capped Petrels with satellite transmitters confirms that the birds primarily use areas beyond the shelf break (Figure 4-59; O'Connell et al. 2009).

4.2.9.2.1.2. Exposure Assessment

One Black-capped Petrel was observed during the digital aerial surveys. None were detected during the MassCEC aerial surveys and other data sources (i.e., tracking studies) indicate that the birds are unlikely to pass through the Lease Area (Figure 4-60). Therefore, annual exposure to the Lease Area is expected to be **minimal**.

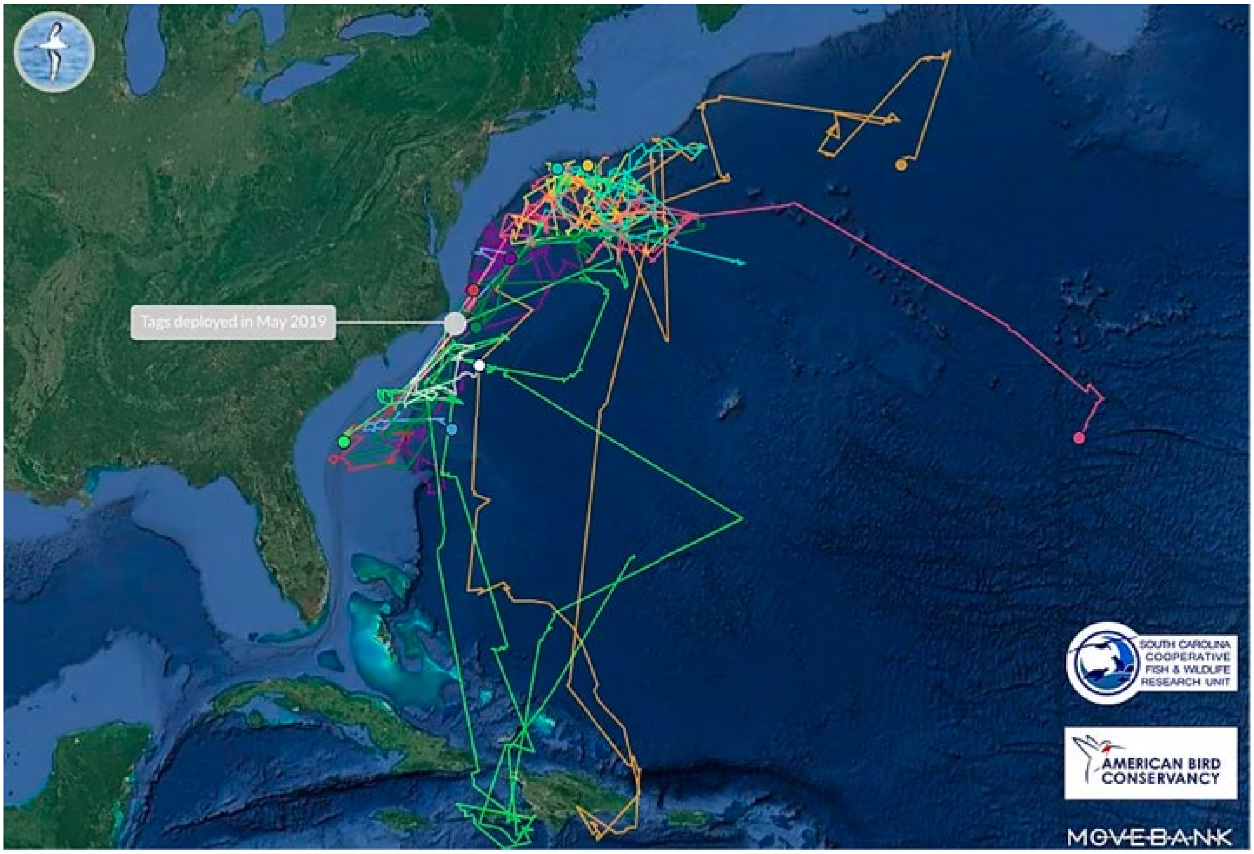


Figure 4-59: Track lines of Black-capped Petrels tagged with satellite transmitters (Atlantic Seabirds 2019).

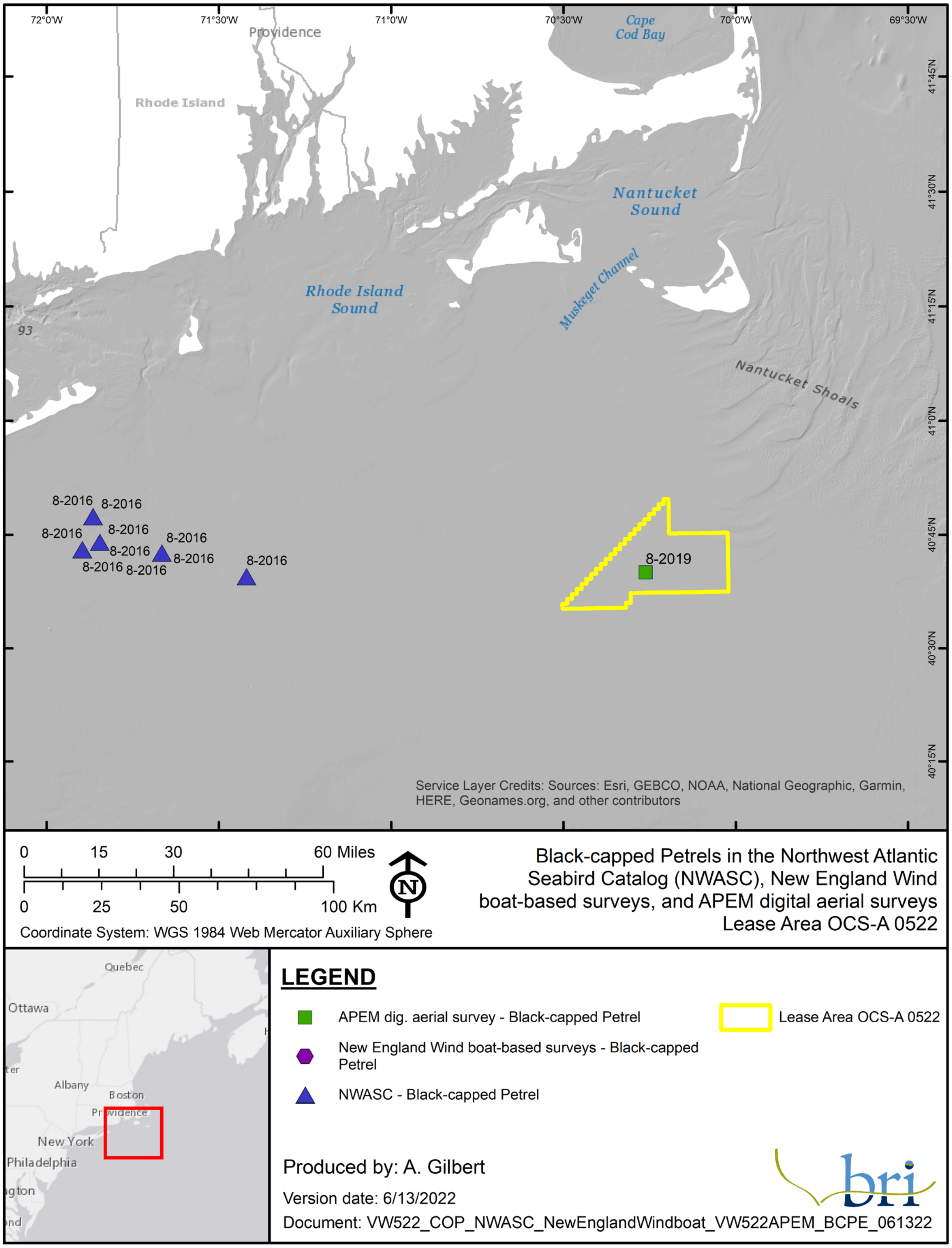


Figure 4-60. Black-capped Petrel observations from the Northwest Atlantic Seabird Catalog, digital aerial surveys, and adjacent boat-based surveys.

4.2.9.2.1.3. *Relative Behavioral Vulnerability Assessment*

Based on the assessment for shearwaters, petrels, and storm-petrels, collision vulnerability is considered **low** and displacement **low** to **medium**. Like most petrels, this species is attracted to lights, and is known to collide with lighted telecommunication towers on breeding islands (Goetz et al. 2012). This behavior could make Black-capped Petrels vulnerable to collision with lighted offshore vessels and structures. Despite some concern about the potential effects of wind facilities on Black-capped Petrels at sea, the highly pelagic nature of this species and its near absence from continental shelf waters of the southeastern U.S., led Simons et al. (2013) to conclude it unlikely that wind facilities will be detrimental to this species. Due to a lack of data, however, a vulnerability score was not developed for this species, and the vulnerability range for the other petrel species is used as a proxy.

4.2.9.2.1.4. *Risk*

This analysis suggests that the potential risk to the Black-capped Petrel is **minimal** because, overall, these birds have low spatial and temporal exposure, and based on the analysis for other petrel species (above), have low to medium vulnerability.

4.2.10. Gannets

4.2.10.1. Spatiotemporal Context

The Northern Gannet (*Morus bassanus*) breeds in southeastern Canada and winters along the U.S. Atlantic OCS, particularly in the mid-Atlantic region and the Gulf of Mexico. Based on analysis of satellite-tracked Northern Gannets captured and tagged in the mid-Atlantic region, these birds show a preference for shallower, more productive waters and are mostly found inshore of the mid-Atlantic WEAs in winter (Stenhouse et al. 2017). They are opportunistic foragers capable of long-distance oceanic movements and generally migrate on a broad front, all of which may increase their exposure to offshore wind facilities, compared with species that are truly restricted to inshore habitats (Stenhouse et al. 2017).

4.2.10.2. Exposure Assessment

Exposure was assessed using species accounts, tracking data, and baseline survey data. Tracking data indicates the birds concentrate around Cape Cod and surrounding islands; during fall migration, a small portion of the bird's 50% core use area (i.e., 50% probability of occurrence) overlaps with the southwestern portion of the Lease Area (Figure 4-62). During digital aerial surveys, Northern Gannets were observed in the Lease Area in all months except for July and were among the most common species November–January and April and May (Figure 4-61). The distribution of this species in the Lease Area varied by season and did not have a consistent pattern (Figure 4-63). The seasonal exposure scores for Northern Gannets ranged from **minimal** to **medium,** with **medium** exposure expected only during the fall, leading to an overall exposure score of **low** (Table 4-22).

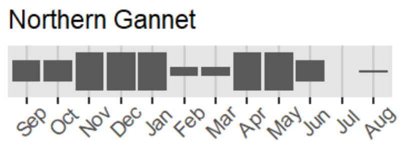


Figure 4-61: Monthly relative densities of Northern Gannets in the survey area from digital aerial surveys.

Table 4-22: Seasonal exposure rankings for Northern Gannets.

Gannet	Season	Local Rank	Regional Rank	Total Rank	Exposure Score
Northern Gannet	Winter	1	0	1	low
	Spring	1	1	2	low
	Summer	0	0	0	minimal
	Fall	2	1	3	medium

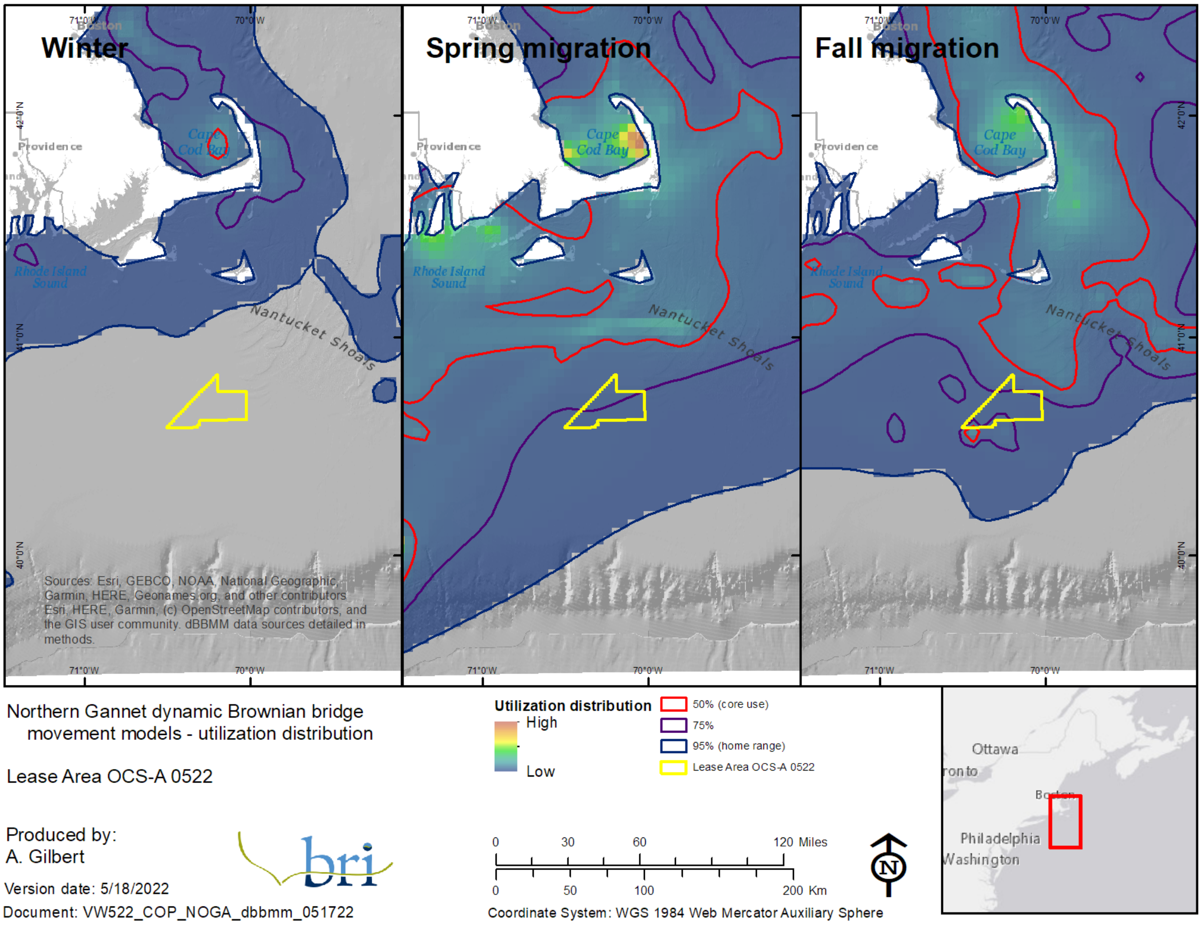


Figure 4-62: Dynamic Brownian bridge movement models for Northern Gannets (n = 34, 35, 36 [winter, spring, fall]) that were tracked with satellite transmitters; the contours represent the percentage of the use area across the UD surface and represent various levels of use from 50% (core use) to 95% (home range). Data provided by BOEM/USFWS and used with permission.

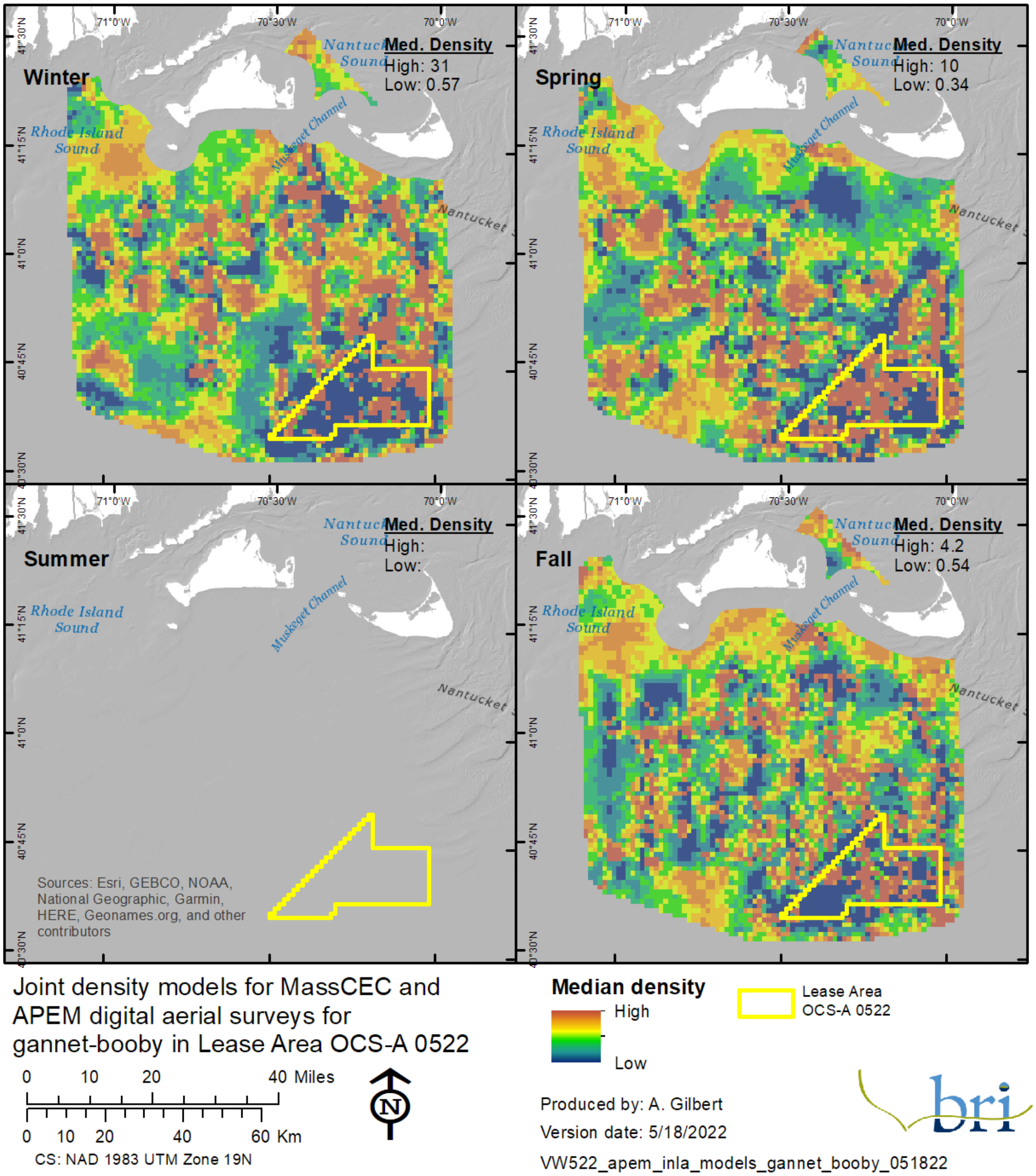


Figure 4-63: Spatial changes in density for Northern Gannets across the Lease Area. Survey data from the MassCEC and Lease Area digital aerial surveys were combined in a joint framework to estimate changes across the study area. Density scales change each season to best visualize patterns.

4.2.10.3. Relative Behavioral Vulnerability Assessment

The Northern Gannet is expected to have **low** behavioral vulnerability to collision (Table 4-23). While Northern Gannets are considered by some to be vulnerable to collision risk (Furness et al. 2013; Garthe et al. 2014; Cleasby et al. 2015), many studies indicate that they avoid wind developments (Hartman et al. 2012; Garthe et al. 2014; Vanermen et al. 2015). Satellite tracking studies indicate near complete avoidance of active wind developments by Northern Gannets (Garthe et al. 2017). For example, avoidance rates have been estimated to be 64 to 84% (macro) and 99.1% (total) (Cook et al. 2012; Krijgsveld et al. 2011; Vanermen et al. 2015; Skov et al. 2018). When Northern Gannets enter a wind development, they fly between 20 to 150 m (66 to 492 ft) only 9.6% of the time (Cook et al. 2012), and models indicate a low proportion of birds fly at risk height (Johnston et al. 2014). For the WTGs under consideration, gannets were estimated to fly in the RSZ 17.5% of the time (Figure 4-64).

The Northern Gannet is expected to have a **medium** behavioral vulnerability to displacement (Table 4-23). While Northern Gannets rank low for displacement in some vulnerability assessments (Furness et al. 2013), many studies indicate that they avoid wind developments (Cook et al. 2012; Dierschke et al. 2016; Garthe et al. 2017; Hartman et al. 2012; Krijgsveld et al. 2011; Vanermen et al. 2015). In Belgium, Northern Gannets have been shown to avoid wind development areas and have decreased in abundance by 85% after a project was constructed (Vanermen et al. 2015). Eighty-nine percent of tracked Northern Gannets breeding in Helgoland, Germany, predominantly avoided nearby operational offshore wind areas, and if they did enter the area, they typically flew between 250 and 450 m from turbines (not approaching closer than 79 m; Peschko et al. 2021), and there is some evidence that this displacement may be long-lasting. A study in the Belgian North Sea found that numbers of Northern Gannets dropped by 98% in the Thornton Bank offshore wind area (plus a 0.5 km buffer) after six years of post-construction monitoring; however, they were not displaced from the 0.5–3 km zone around the edge of the wind farm (Vanermen et al. 2019). Since Northern Gannets feed on highly mobile surface-fish and follow their prey throughout the OCS (Mowbray 2002), avoidance of the Lease Area is unlikely to lead to habitat loss.

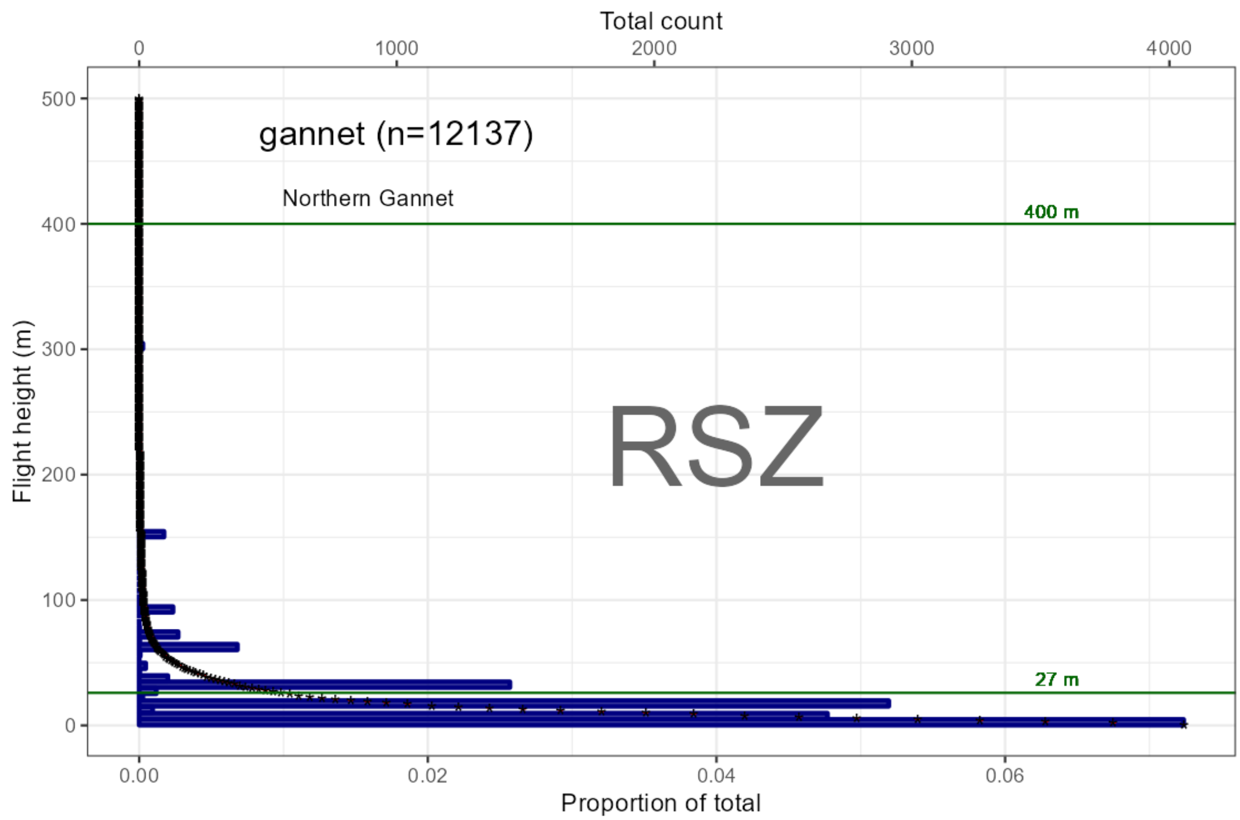


Figure 4-64: Flight heights of Northern Gannet (m) derived from the Northwest Atlantic Seabird Catalog, showing the actual number of birds in 5 m intervals (blue bars), and the modeled average flight height in 1 m intervals (asterisk) and the standard deviation (red lines), in relation to the upper and lower limits of the RSZ. Data provided by NOAA and used with permission.

Table 4-23: Summary of Northern Gannet vulnerability.

Species	Collision Vulnerability (CV)	Displacement Vulnerability (DV)	Population Vulnerability (PV)
Northern Gannet	low (0.43)	medium (0.6)	low (0.47)

4.2.10.4. Risk

Northern Gannets are expected to have overall **low** exposure to construction and operational activities in the Lease Area. They are expected to have **low** behavioral vulnerability to collision and **medium** behavioral vulnerability to displacement. However, there is uncertainty about how displacement will affect individual fitness (e.g., will it increase energy expenditure due to avoidance) and foraging opportunities (Fox and Petersen 2019). Because Northern Gannets have been documented to avoid offshore wind farms, the birds are unlikely to be displaced from important foraging habitat, and populations have been generally increasing, population level risk to this species is expected to be **low**.

4.2.11. Cormorants

4.2.11.1. Spatiotemporal Context

The Double-crested Cormorant (*Phalacrocorax auritus*) is the most likely species of cormorant to have exposure to the Lease Area. While Great Cormorants (*Phalacrocorax carbo*) could possibly pass through the Lease Area during the non-breeding season, they are likely to remain in coastal waters (Hatch et al. 2000). Double-crested Cormorants tend to forage and roost close to shore. The regional MDAT abundance models show that cormorants are concentrated closer to shore and to the south. This aligns with the literature, which indicates that these birds rarely use the offshore environment (Dorr et al. 2020).

4.2.11.2. Exposure Assessment

Exposure was assessed using species accounts and baseline survey data. During the digital aerial surveys, cormorants were observed only in March and were among the less common species (Figure 4-65). The seasonal exposure scores for Double-crested Cormorant are generally **minimal**, with **low** exposure expected in the summer, leading to an overall exposure score of **minimal** (Table 4-24).

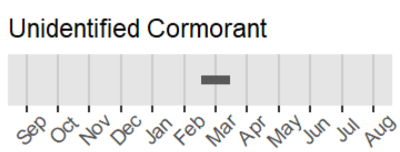


Figure 4-65: Monthly relative densities of cormorants in the survey area from digital aerial surveys.

Table 4-24: Seasonal exposure rankings for the Double-crested Cormorant.

Cormorants	Season	Local Rank	Regional Rank	Total Rank	Exposure Score
Double-crested Cormorant	Winter	0	0	0	minimal
	Spring	0	0	0	minimal
	Summer	0	1	1	low
	Fall	0	0	0	minimal

4.2.11.3. Relative Behavioral Vulnerability Assessment

The Double-crested Cormorant is expected to have **medium** behavioral vulnerability to collision (Table 4-25). Cormorants have been documented to be attracted to WTGs because of an increase in food resources and newly available loafing habitat (i.e., perching areas; Krijgsveld et al. 2011; Lindeboom et al. 2011), but are not considered to have high vulnerability to collisions because they infrequently fly between 20 to 150 m (65.6 to 92.1 ft) above sea level (Furness et al. 2013). For the WTGs under consideration, Double-crested Cormorants were estimated to fly in the RSZ 36.33% of the time (Figure 4-66). WTGs with jacket foundations may provide additional perching sites for cormorants, which have the potential to increase attraction and possibly intensify vulnerability to collision.

The Double-crested Cormorant is expected to have a **low** behavior vulnerability to displacement because they have been documented to be attracted to wind developments (Krijgsveld et al. 2011; Lindeboom et al. 2011), it is not a species known to exhibit avoidance behavior, and they rank towards the middle of displacement vulnerability assessments (Furness et al. 2013).

Table 4-25: Summary of cormorant vulnerability.

Species	Collision Vulnerability (CV)	Displacement Vulnerability (DV)	Population Vulnerability (PV)
Double-crested Cormorant	medium (0.6)	low (0.4)	minimal (0.13)

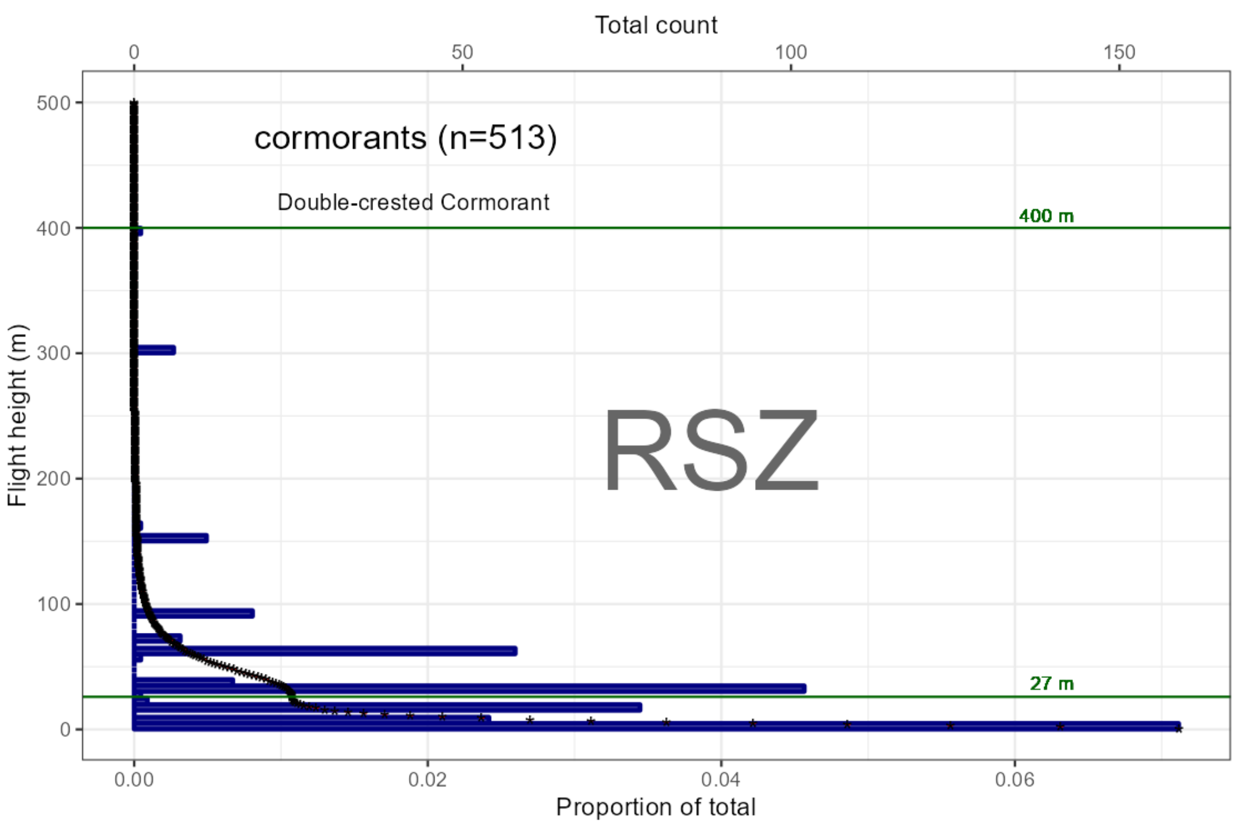


Figure 4-66: Flight heights of Double-crested Cormorant (m) derived from the Northwest Atlantic Seabird Catalog, showing the actual number of birds in 5 m intervals (blue bars), and the modeled average flight height in 1 m intervals (asterisk) and the standard deviation (red lines), in relation to the upper and lower limits of the RSZ . Data provided by NOAA and used with permission.

4.2.11.4. Risk

Double-crested Cormorants are expected to have **minimal** exposure to the construction and operational activities in the Lease Area. They are expected to have **medium** behavioral vulnerability to collision and **low** behavioral vulnerability to displacement. Because Double-crested Cormorants are predicted to have **minimal** exposure to the Lease Area, population level risk to this species is **minimal.** The Double-crested Cormorant also had a minimal population vulnerability score, but the final risk score could not be adjusted down because the birds already were in the lowest risk category.

4.3. Conclusions

During construction, operations, and decommissioning, coastal birds are expected to be ephemerally exposed during migration, and marine birds are expected to be exposed during all seasons. The confidence in data sources for the exposure assessment was lowest for coastal waterbirds and waterfowl, songbirds, phalaropes, and eagles, mostly due to the lack of an MDAT model or tracking studies, and highest for marine birds, including sea ducks, terns, loons and gannets, where both multiple survey datasets and tracking data were available (Table 4-27). Furthermore, digital aerial surveys were designed to capture tern use, strengthening our confidence for terns in general, including the federally listed Roseate Tern. Generally, because of the additional digital aerial survey effort during migratory periods, there is greater confidence in the results of the assessment.

Overall, coastal birds are expected to have **minimal** to **medium** behavioral vulnerability. Of the coastal birds, shorebirds, wading birds, falcons, and songbirds may have **minimal** to **low** exposure to the Lease Area, and this will be limited to migration. Depending on the species, marine birds are expected to have a range of behavioral vulnerability and range of exposure to the Lease Area. Of the marine birds, sea ducks, auks, gulls, and shearwaters were the species groups with **minimal** to **medium** exposure to the Lease Area—all other species groups had **minimal** to **low** exposure (Table 4-26).

During construction, operations, and decommissioning, exposure of federally listed species is expected to be **minimal** to **low** and would largely be restricted to migration. Roseate Terns are expected to have **minimal** to **low** exposure to the Lease Area, **low** vulnerability to collision, and **medium** to **high** vulnerability to displacement. Piping Plovers are expected to have **minimal** to **low** exposure and **minimal** to **low** vulnerability. Like Roseate Terns, Piping Plovers may be exposed during migration periods, though flight heights during migration are thought to be generally well above RSZs. Red Knots are expected to have **minimal** to **low** exposure and **minimal** to **low** behavioral vulnerability. Black-capped Petrels are expected to have **minimal** exposure and **low** to **medium** behavioral vulnerability (Table 4-26).

Table 4-26: Overall summary of the assessment of potential effects on birds. Categories that are adjusted up due to population vulnerability are highlighted in orange (none were adjusted down).

Group	Exposure	Relative Vulnerability to				Collision Risk	Displacement Risk
		Collision	Displacement		Population		
			Temporary	Long-term			
Coastal Waterbirds	min	.	.	.	.	.	.
Shorebirds	min–low	low	min	min	.	min–low	min
Piping Plover	min–low	min–low	min	min	med	min–low	min
Red Knot	min–low	low	min	min	med	min–low	min
Wading Birds	min–low	low	min	min	.	min–low	min
Raptors (falcons)[1]	low	low–med	min–low	min–low	.	low	min–low
Eagles	min	.	.	.	.	.	.
Songbirds	min–low	low–med	min	min		min–low	min
Marine Birds							
Sea Ducks[2]	min–med	low	high	med	low–med	min–low	min–med
Phalaropes	min	low	med	med	low	min	min
Auks	min–med	min–low	med–high	med–high	low–med	min	min–med
Gulls, Jaegers & Skuas	min–med	low–med	low–med	low–med	min–med	min–med	min–med
Terns (excluding Roseate Tern)	min	low	med–high	med–high	med	min	min
Roseate Tern	min–low	low	med–high	med–high	high	low	low
Loons	min	min–low	high	high	low–med	min	min
Shearwaters, Petrels & Storm-Petrels	min–med	low	low–med	low–med	low–med	min–low	min–med
Black-capped Petrel	min	low	low–med	low–med	.	min	min
Gannets & Cormorants							
Northern Gannet	low	low	med	med	low	low	low
Double-crested Cormorant	min	med	low	low	min	min	min

[1]Almost exclusively Peregrine Falcon and Merlin. Non-falcon raptors have limited use of the offshore environment. [2] Excluding Red-breasted Merganser.

Table 4-27: Data sources available and confidence in exposure assessments.

Taxa	Literature	Data Sources				Score	Confidence
		MDAT	Baseline	Site-specific	Tracking		
NON-MARINE BIRDS							
Coastal waterbirds & waterfowl	•		1	1		2	Low
Shorebirds	•		1	1	1	3	Medium
Wading Birds	•		1	1	1	3	Medium
Raptors	•		1	1	1	3	Medium
Songbirds	•		1	1		2	Low
MARINE BIRDS							
Sea ducks	•	1	1	1	1	4	High
Phalaropes	•		1	1		2	Low
Auks	•	1	1	1		3	Medium
Gulls, Skuas, Jaegers	•	1	1	1		3	Medium
Terns	•	1	1	1	1	4	High
Loons	•	1	1	1	1	4	High
Shearwaters, Petrels, Storm-Petrels	•	1	1	1		3	Medium
Gannets	•	1	1	1	1	4	High
Cormorants and Pelicans	•	1	1	1		3	Medium
LISTED SPECIES							
Black-capped Petrel	•		1	1	1	3	Medium
Roseate Tern	•	1	1	1	1	4	High
Bald Eagle, Golden Eagle	•		1	1		2	Low
Piping Plover	•		1	1	1	3	Medium
Red Knot	•		1	1	1	3	Medium

4.4. Supplemental Information: Seasonal Densities in the Lease Area

Table 4-28: Seasonal bootstrap mean and 95% CI densities (counts/sq. km) within Lease Area OCS-A 0522 compared with the study area buffer.

Species	Mean density (95% CI) inside OCS-A0522				Mean density (95% CI) outside OCS-A0522			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Sea ducks								
Black Scoter	·	<0.001 (<0.001-<0.001)	·	·	·	0.002 (<0.001-0.005)	·	·
Common Eider	<0.001 (<0.001-<0.001)	·	·	·	0.003 (<0.001-0.008)	·	·	·
King Eider	0.002 (<0.001-0.005)	·	·	·	<0.001 (<0.001-<0.001)	·	·	·
Long-tailed Duck	2.33 (0.711-4.39)	0.176 (0.097-0.273)	·	0.001 (<0.001-0.004)	6.72 (0.711-13.5)	1.23 (0.097-1.87)	·	<0.001 (<0.001-<0.001)
Red-breasted Merganser	·	<0.001 (<0.001-<0.001)	·	·	·	0.002 (<0.001-0.005)	·	·
Surf Scoter	<0.001 (<0.001-<0.001)	0.002 (<0.001-0.006)	·	·	0.003 (<0.001-0.008)	<0.001 (<0.001-<0.001)	·	·
White-winged Scoter	0.727 (0.364-1.2)	11.9 (5.79-19.4)	·	·	8.49 (0.364-14)	21.4 (5.79-33.6)	·	·
Shorebirds								
Greater Yellowlegs	·	·	·	<0.001 (<0.001-<0.001)	·	·	·	0.006 (<0.001-0.017)
Phalaropes								
Red Phalarope	1.69 (1.17-2.31)	0.006 (<0.001-0.015)	·	0.012 (<0.001-0.035)	0.679 (1.17-0.966)	0.009 (<0.001-0.028)	·	0.002 (<0.001-0.005)
Skuas and Jaegers								
Great Skua	·	·	·	<0.001 (<0.001-<0.001)	·	·	·	0.002 (<0.001-0.005)
Long-tailed Jaeger	·	·	·	<0.001 (<0.001-<0.001)	·	·	·	0.002 (<0.001-0.005)
Parasitic Jaeger	·	·	·	0.001 (<0.001-0.003)	·	·	·	0.013 (<0.001-0.038)
South Polar Skua	·	·	·	0.002 (<0.001-0.006)	·	·	·	0.003 (<0.001-0.01)

Species	Mean density (95% CI) inside OCS-A0522				Mean density (95% CI) outside OCS-A0522			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Auks								
Atlantic Puffin	0.065 (0.038-0.095)	0.241 (0.191-0.296)	0.006 (<0.001-0.015)	0.004 (<0.001-0.01)	0.082 (0.038-0.142)	0.334 (0.191-0.427)	0.002 (<0.001-0.007)	0.007 (<0.001-0.018)
Dovekie	0.033 (0.013-0.057)	0.004 (<0.001-0.009)	·	·	0.054 (0.013-0.135)	0.004 (<0.001-0.009)	·	·
Razorbill	0.287 (0.141-0.466)	0.018 (0.004-0.04)	·	0.121 (0.075-0.176)	0.176 (0.141-0.276)	0.027 (0.004-0.063)	·	0.109 (0.075-0.17)
Small Gulls								
Bonaparte's Gull	0.005 (<0.001-0.014)	0.073 (0.032-0.119)	·	0.014 (0.005-0.025)	0.003 (<0.001-0.008)	0.05 (0.032-0.139)	·	0.019 (0.005-0.039)
Medium Gulls								
Black-legged Kittiwake	0.166 (0.116-0.221)	0.001 (<0.001-0.003)	·	0.242 (0.182-0.313)	0.151 (0.116-0.208)	0.007 (<0.001-0.017)	·	0.332 (0.182-0.463)
Laughing Gull	<0.001 (<0.001-<0.001)	·	·	·	0.005 (<0.001-0.014)	·	·	·
Ring-billed Gull	·	0.001 (<0.001-0.003)	·	·	·	<0.001 (<0.001-<0.001)	·	·
Large Gulls								
Great Black-backed Gull	0.029 (0.017-0.044)	0.063 (0.045-0.084)	0.003 (<0.001-0.008)	0.03 (0.012-0.061)	0.041 (0.017-0.067)	0.039 (0.045-0.059)	0.007 (<0.001-0.02)	0.032 (0.012-0.05)
Herring Gull	0.023 (0.008-0.044)	0.052 (0.035-0.072)	0.034 (0.013-0.059)	0.07 (0.037-0.116)	0.035 (0.008-0.066)	0.044 (0.035-0.066)	0.03 (0.013-0.069)	0.032 (0.037-0.052)
Lesser Black-backed Gull	·	0.01 (0.002-0.021)	·	0.005 (0.001-0.012)	·	<0.001 (0.002-<0.001)	·	<0.001 (0.001-<0.001)
Medium Terns								
Common Tern	·	0.005 (0.001-0.01)	·	·	·	0.013 (0.001-0.039)	·	·
Forster's Tern	·	·	·	0.001 (<0.001-0.003)	·	·	·	<0.001 (<0.001-<0.001)
Roseate Tern	·	<0.001 (<0.001-<0.001)	<0.001 (<0.001-<0.001)	·	·	0.002 (<0.001-0.005)	0.002 (<0.001-0.007)	·
Royal Tern	·	·	0.003 (<0.001-0.008)	·	·	·	<0.001 (<0.001-<0.001)	·
Loons								

Species	Mean density (95% CI) inside OCS-A0522				Mean density (95% CI) outside OCS-A0522			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Common Loon	0.007 (0.002-0.013)	0.017 (0.008-0.027)	·	0.013 (0.006-0.022)	0.01 (0.002-0.025)	0.019 (0.008-0.035)	·	0.007 (0.006-0.017)
Red-throated Loon	0.01 (0.003-0.018)	0.305 (0.239-0.378)	·	0.006 (0.001-0.011)	0.019 (0.003-0.037)	0.292 (0.239-0.377)	·	<0.001 (0.001-<0.001)
Shearwaters and Petrels								
Black-capped Petrel	·	·	0.001 (<0.001-0.004)	·	·	·	<0.001 (<0.001-<0.001)	·
Cory's Shearwater	·	·	0.818 (0.471-1.29)	0.305 (0.184-0.451)	·	·	0.775 (0.471-1.13)	0.344 (0.184-0.548)
Great Shearwater	·	·	0.185 (0.112-0.283)	0.108 (0.079-0.14)	·	·	0.174 (0.112-0.327)	0.197 (0.079-0.301)
Manx Shearwater	·	·	0.003 (<0.001-0.007)	0.009 (0.003-0.016)	·	·	<0.001 (<0.001-<0.001)	0.008 (0.003-0.018)
Northern Fulmar	0.034 (0.019-0.052)	0.018 (0.01-0.027)	0.032 (0.015-0.052)	0.098 (0.073-0.126)	0.022 (0.019-0.044)	0.031 (0.01-0.053)	0.007 (0.015-0.02)	0.106 (0.073-0.151)
Sooty Shearwater	·	0.001 (<0.001-0.003)	0.009 (0.002-0.018)	·	·	0.003 (<0.001-0.009)	0.009 (0.002-0.02)	·
Raptors								
Osprey	·	<0.001 (<0.001-<0.001)	·	·	·	0.002 (<0.001-0.005)	·	·

5. Detailed Avian Assessment Methods

5.1. Exposure Framework

Exposure has both a horizontal and vertical component. The exposure assessment focused exclusively on the horizontal exposure of birds. Vertical exposure (i.e., flight height) was considered within the assessment of vulnerability. The exposure assessment was quantitative where site-specific survey data was available. For birds with no available site-specific data, species accounts and the literature were used to conduct a qualitative assessment. For all marine birds, exposure was considered both in the context of the proportion of the population predicted to be exposed to the Lease Area as well as absolute numbers of individuals. The following sections introduce the data sources used in the analysis, the methods used to map species exposure, methods used to assign an exposure metric, methods to aggregate scores to taxonomic group, and interpretation of exposure scores.

5.1.1. Exposure Assessment Data Sources and Coverage

To assess the proportion of marine bird populations exposed to the Lease Area, three primary data sources were used to evaluate local and regional marine bird use: (1) digital aerial surveys of the Lease Area, (2) MassCEC aerial surveys, which cover the Massachusetts Wind Energy Area (MA WEA; Veit et al. 2016), and (3) version 2 of the Marine-life Data and Analysis Team (MDAT) marine bird relative density and distribution model (Curtice et al. 2019). The digital aerial surveys provide the most current local coverage across the Lease Area plus a 1.85 km (1 nm) buffer. The MassCEC aerial surveys provide local coverage of both the Lease Area and surrounding waters. The MDAT models are modeled relative abundance data providing a large regional context for the Lease Area but are built from offshore survey data collected from 1978–2016. Each of these primary sources is described in more detail below, along with additional data sources that inform the avian impact assessment. Data collected during these surveys are in general agreement with BOEM guidelines and the goals detailed above and described below.

5.1.1.1. Digital Aerial Surveys

APEM Inc. were contracted by Vineyard Northeast LLC to provide monthly aerial digital survey data of the Lease Area from June 2019 until July 2021. The aim of the surveys was to assess the abundance and distribution of primarily birds present in the Lease Area, and to gather information on other marine megafauna, such as marine mammals, sharks, rays, and turtles.

APEM's digital camera system was fitted to a twin-engine aircraft. Custom flight planning software allowed each flight line to be accurately mapped out before takeoff. The camera system captured images along 15 survey lines spaced approximately 3 km (1.9 mi), within the Lease Area plus a 1.85 km (1 nm) buffer (Figure 5-1). The aircraft collected the data at an altitude of approximately 414 m (1,360 ft) and a speed of approximately 222 kph (120 kn), and the data collected were 1.5 cm (0.6 in) ground survey distance (GSD) digital still images[7]. To ensure the survey lines were flown with a high degree of accuracy, a GPS-linked flight management system was used. The images were collected continuously along the survey lines capturing abutting still imagery, with at least 20% coverage of the sea surface collected to be analyzed.

Surveys were carried out by an APEM camera technician and a pilot (Williams Aviation), and only undertaken when the weather was deemed appropriate by the survey crew. Sample imagery was evaluated during and after each survey to ensure it was of suitable quality for analysis. If the data were found to be of insufficient quality during any stage of the evaluation process, the lines were re-flown. Data were backed up on multiple secure servers after each survey.

Wherever possible one survey was undertaken each month from June 2019–July 2021 (Table 5-1). If this was not possible (e.g., due to poor weather), the survey was undertaken in the next available survey window. To allow an accurate investigation into potential use of the Lease Area by migrating and breeding terns, a second survey was undertaken during key migration months for these species: August, September, April, and May.

Table 5-1: Dates of high-definition digital aerial surveys across the Lease Area (hereafter "digital aerial surveys").

Survey	Year	Survey Month	Survey Date
1	2019	June	06/15
2		August	08/08
3		August	08/12
4		August	08/20
5		September	09/08
6		September	09/20
7		October	10/05
8		November	11/23
9		December	12/07
10	2020	January	01/18
11		February	02/17
12		March	03/08
13		April	04/07
14		April	04/19
15		May	05/05
16		May	05/13
17		August	08/21
18		September	09/04
19		September	09/14
20		September	09/24
21		October	10/14
22		November	11/14
23		December	12/04
24	2021	January	01/07
25		February	02/26
26		March	03/08

[7] Image Footprint: 110 m in length and 389 m in width.

Survey	Year	Survey Month	Survey Date
27		April	04/12
28		April	04/18
29		May	05/09
30		May	05/16
31		June	06/02
32		July	07/27

5.1.1.1.1. Survey Protocol

The data collected were processed to ensure the imagery was at the optimum clarity for screening purposes. Trained APEM analysts examined each image manually, using a systematic method. Images were split into those that contain targets (such as birds, marine mammals, turtles, fish shoals, vessels) and those that were “blank” (no targets present). Using a custom user interface, targets were measured and identified. Analysts were aided by an in-house image archive library, which provided images of avian and marine megafauna from overhead, in addition to bird reference lengths to improve identification. For example, for sitting birds, the relationship between pixel size and length was known, and this was compared to known reference lengths from multiple sources to aid identification. For flying birds, the measurements recorded were a minimum (as the wings may not be fully stretched), yet this was still useful in eliminating confusion between species. Using these tools, targets were identified to the lowest taxonomic level possible, even in low quality images. Once identified, each target was “snagged”, which provided the following data for each target:

- Unique ID and cropped image;
- Time and date at which individual image was collected;
- GPS coordinates for each individual recorded, at an accuracy of +/- 1–5 m (3–16.5 ft);
- Unique identifying numbers for each individual recorded, image number, and individual camera that captured that image;
- Details of avian target age, gender, and molt status, wherever possible;
- Behavioral information observed for avian records to provide data on whether a bird was sitting on the water, flying, or diving. Further information on whether an individual was part of a group, carrying food, or nursing a juvenile were also recorded.
- Behavior for marine mammals were recorded, such as whether an individual was submerged or surfacing;
- The orientation of birds in flight;
- Body length (cm) of all avian and marine megafauna, wingspan (cm) of flying birds.

Following positive identification of targets, a review process was undertaken for images deemed blank and for positive targets. The review was undertaken by internal quality control (QC) managers, experienced in the identification of the target taxa. During the QC process, 20% of the bird species identification undertaken by APEM (and 100% of listed species) were checked for accuracy. All listed species were also further verified by bird experts at BRI and any difference between BRI identifications and APEM identifications were flagged and discussed, and a consensus identification was agreed upon.

A random audit of 10% of images recorded as “blank” was undertaken to quantify detection success. If detection success was ≤95%, all data was reprocessed. This was repeated until detection success reached >95% to address any consistent errors and issues.

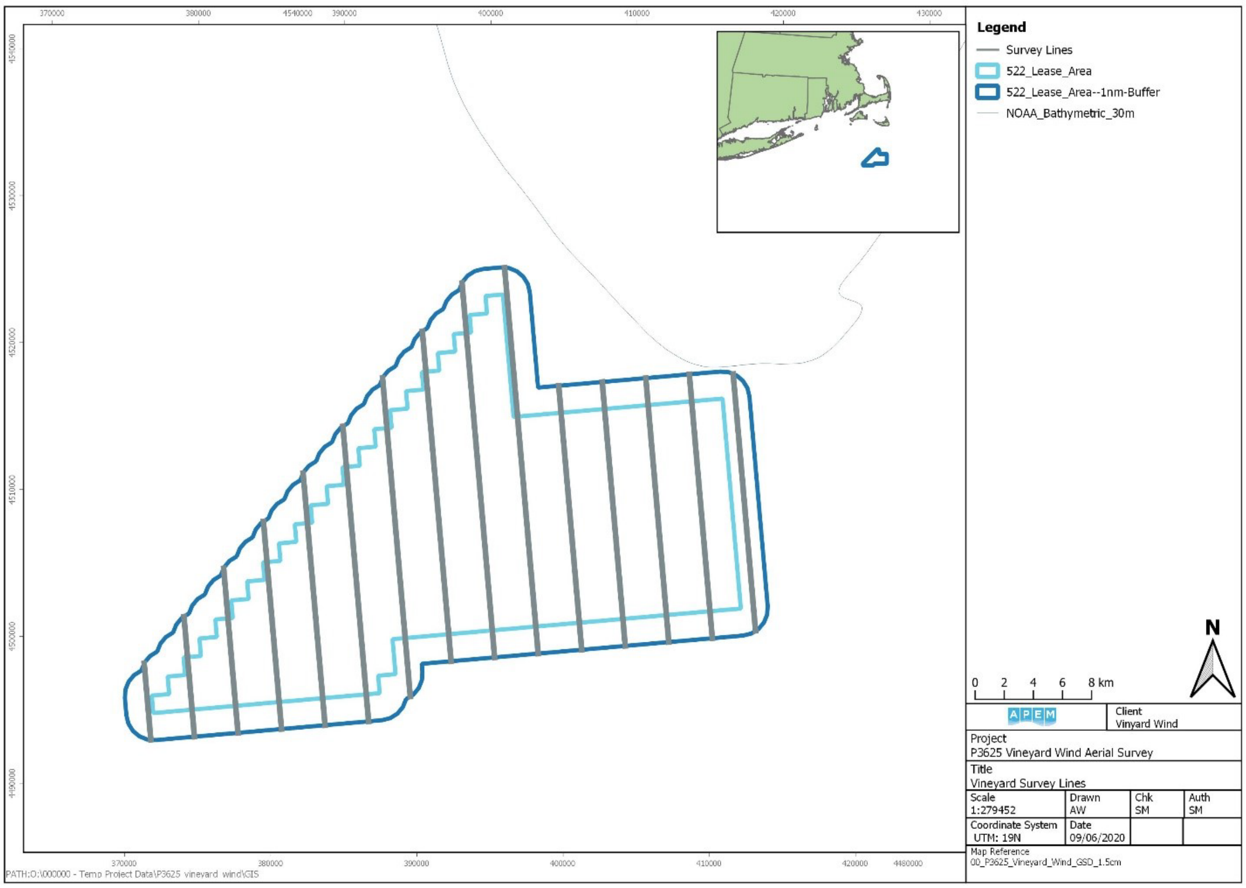


Figure 5-1: Digital aerial survey transect layout and coverage of the OCS-A 0522 Lease Area.

5.1.1.1.2. Integrated Modeling

Conservation decision-making relies on accurate descriptions of species density and occurrence to determine the potential costs and benefits of actions. When multiple data sources are available to describe density in a region, competing descriptions of density increase uncertainty in these decision-making processes and result in higher variance or higher bias outcomes for species of conservation concern. Joint species density models can be a useful tool in this situation to incorporate all availability data into a decision process and unify the density results across multiple surveys. In the case of Lease Area OCS-A 0522, regional surveys (conducted by the MassCEC) provide information on marine bird densities from 2011–2015 with aerial surveys, and APEM provided similar data with digital aerial surveys from 2019–2021. Using a joint density analysis approach, we can account for the survey biases for each and integrate our understanding of species density throughout Lease Area OCS-A 0522 and the surrounding environment.

When interpreting these integrated density models, a few factors should be considered. First, survey data density (i.e., survey effort) is much higher within the Lease Area than outside of it. The MassCEC effort was a broad-scale regional survey, while the APEM effort was a high-intensity site characterization survey. While these differences in survey effort were accounted for in the model, we see evidence that effort is affecting model-predicted density outside of the Lease Area survey area for some species. The model uncertainty estimates can help identify areas with low confidence in model predictions, and end-users should consider the density patterns outside of the Lease Area with some caution. Second, APEM surveys detect animals more frequently than the MassCEC surveys. These differences likely depend on the viewing angle, flight height of the plane, and the data recording practices of each survey method. We correct for these differences in the analysis, and densities are predicted from the joint model as the number of expected detections in that grid cell for the APEM surveys. Finally, these densities are estimated by assessing the latent spatial pattern of the observations and do not incorporate environmental covariates. Efforts to include more environmental data in the future could improve the model accuracy and precision, particularly in locations without survey effort.

Data Compilation

Bird surveys were conducted using two techniques in two different periods: 38 aerial surveys with human observers from November 2011 to January 2015, covering a large area in southern New England (MassCEC surveys), and 32 digital aerial surveys in the Offshore Development Area from June 2019 to July 2021 (APEM surveys). Both surveys used strip transect methods and counted all individuals possible, but there were significant differences in detection rates across these surveys. For the MassCEC surveys, observers used visual aids to determine the animals within the detection strip and described the number of groups and the group size per taxonomic unit. The APEM surveys were conducted using their standard digital aerial survey protocol and employed belly-mounted digital still cameras to collect high-resolution images along transects across the Lease Area. Birds were identified from the still photos using a combination of automated (AI) and manual (seabird experts) methods. Animals were identified to species level when possible and were otherwise assigned to the lowest possible taxonomic group (i.e., auk-species unknown or murre-species unknown). Taxonomic groupings were created to include species-unknown observations with taxonomically similar species (i.e., a group that includes all identified scoter species with the scoter-species unknown category).

These data were used in two different analyses describing species density. First, observations identified to species from the APEM survey (Table 5-2) were used to estimate specific-specific densities across the survey area. Second, observations from both surveys were joined at the species group level (Table 5-3) and used to jointly model species group densities in the Lease Area and the surrounding environment. In each case, a common projected coordinate system was used (Universal Transverse Mercator [UTM zone 19]) to standardize spatial information, and data were divided by season (Summer, Fall, Winter, Spring). For the individual species models, we estimated density surfaces for seasons with more than 20 observations, whereas we required 20 observations in both surveys to estimate a density surface in the joint models.

Spatial Modeling Framework

To model the observation density and account for the spatial dependence among observations, we fit spatially-explicit log Gaussian Cox Poisson (LGCP) process models to the year-round and seasonal survey data by species and taxa group using INLA, integrated nested Laplace approximation (Rue et al. 2009) for approximate Bayesian inference. The spatial dependence in the data is accounted for by incorporating a Gaussian Markov Random Field (GMRF) into the models. Briefly, LGCP models estimate the point density using a log link function, such that the log of the spatial inhomogeneous intensity function (λ) at any point is assumed to be Gaussian (Møller and Waagepetersen 2007). We implemented the stochastic partial differential equations (SPDE) approach (Lindgren et al. 2011) to incorporate the spatial random effect as a latent Gaussian Field (GF) with a Matérn covariance structure to account for the spatial dependence in the data. Put another way, bird densities are more likely to be similar in adjacent spatial units than in distant units; these models estimate these spatial correlations to evaluate changes in density over space.

As the strip transects did not cover the entire survey area, variation in survey effort was accounted for using sampling limits. For each survey, we determined the BOEM lease aliquots (16 aliquots to a BOEM lease block) with more than two visits throughout the survey protocol and determined these areas met coverage requirements. These aliquot grids were converted into a spatial polygon that limited model inference outside the allotted regions.

Table 5-2: Species observations from digital area survey data (in alphabetical order).

Common Name	Scientific Name	Number of Observations
Atlantic Puffin	*Fratercula arctica*	542
Black-capped Petrel	*Pterodroma hasitata*	1
Black-legged Kittiwake	*Rissa tridactyla*	585
Black Scoter	*Melanitta americana*	2
Bonaparte's Gull	*Chroicocephalus philadelphia*	135
Canada Goose	*Branta canadensis*	7
Common Eider	*Somateria mollissima*	1
Common Loon	*Gavia immer*	52
Common Tern	*Sterna hirundo*	9
Cory's Shearwater	*Calonectris diomedea*	1,396
Dovekie	*Alle alle*	48
Forster's Tern	*Sterna forsteri*	1
Great Black-backed Gull	*Larus marinus*	177
Great Shearwater	*Ardenna gravis*	462
Great Skua	*Stercorarius skua*	1
Greater Yellowlegs	*Tringa melanoleuca*	3
Herring Gull	*Larus argentatus*	229
King Eider	*Somateria spectabilis*	1
Laughing Gull	*Leucophaeus atricilla*	1

Common Name	Scientific Name	Number of Observations
Lesser Black-backed Gull	*Larus fuscus*	15
Long-tailed Duck	*Clangula hyemalis*	5,251
Long-tailed Jaeger	*Stercorarius longicaudus*	1
Manx Shearwater	*Puffinus puffinus*	15
Northern Fulmar	*Fulmarus glacialis*	254
Northern Gannet	*Morus bassanus*	815
Osprey	*Pandion haliaetus*	1
Parasitic Jaeger	*Stercorarius parasiticus*	5
Razorbill	*Alca torda*	460
Red-throated Loon	*Gavia stellata*	515
Red breasted Merganser	*Mergus serrator*	1
Red Phalarope	*Phalaropus fulicarius*	1,365
Ring-billed Gull	*Larus delawarensis*	1
Roseate Tern	*Sterna dougallii*	2
Royal Tern	*Thalasseus maximus*	2
Sooty Shearwater	*Ardenna grisea*	12
South Polar Skua	*Stercorarius maccormicki*	3
Surf Scoter	*Melanitta perspicillata*	3
White-winged Scoter	*Melanitta fusca*	30,927

Table 5-3: Number of observations for each survey by species group.

Species Group	Observations	
	Mass CEC	APEM
Auks	1,357	4081
Cormorants	11	3
Gannets	1,059	815
Skuas and Jaegers	6	15
Small gulls	191	331
Medium gulls	488	587
Large gulls	885	434
Unknown gulls	16	28
Loons	912	583
Grebes	3	1
Sea ducks	2,048	38,523
Shearwaters and Petrels	799	3,141
Storm-Petrels	269	580
Phalaropes	86	1,544
Shorebirds	0	48
Small terns	45	0
Medium terns	53	14
Unknown terns	214	71
Raptors	0	1
Dabblers, Geese, and Swans	4	42
Coastal divers	1	0
Heron and Egrets	2	0
Passerines	3	2
Unknown bird	0	5

Individual Species Models

To approximate the spatial relationships among observations, we constructed a constrained refined Delaunay triangulation spatial mesh covering the digital aerial survey area (Figure 5-2). An area of coarser density mesh (10 % of the survey area diameter) was added beyond the survey area to remove boundary effects that cause increased variance at the borders (Lindgren et al. 2011). We built the mesh using all bird observations of a given species or taxa as the initial triangulation nodes. To avoid an overly complex mesh, we also set a cutoff of 300 m, such that a single vertex replaces points at a closer distance than this prior mesh creation. We estimated smooth density surfaces by modeling the intensity (λ) at each spatial location (s) as a function of the spatial random effect (*u*).

$$\lambda(s) = \exp(\beta_0 + \boldsymbol{A}u(s))$$

Where β_0 is an intercept term and *u* is the GF representing the spatial random effect. The spatial effect *u* can be approximated at any point within the triangulated domain, using the projector matrix **A** to link the spatial GF (defined by the mesh vertices or nodes) to the locations of the observed data, *s* (Krainski et al. 2018). The Matérn covariance matrix priors for the spatial effect were derived using a penalized complexity (PC) approach (Fuglstad et al. 2018), where the hyperparameters of range (*r*) and the marginalized standard deviation of the field (σ) define the spatial random effect so that $P(r > r_0) = p$ and $P(\sigma > \sigma_0) = p$. Using the PC priors, the prior probability of the spatial range being less than 3 was 0.5 and the probability of spatial variance being less than 1 was 0.5.

Multi-survey integrated models

To estimate a single density surface across the entire survey area, a joint likelihood framework was used with the two surveys. Both likelihoods were constructed as LGCPs in *inlabru*, similar to the individual models, each with their own models of sampling effort. A spatial mesh was created using both sets of observation data (Figure 5-3) and was custom for each taxonomic group to provide accurate estimates of density changes over space. Similar assumptions were applied to the individual species models in mesh creation.

Each likelihood had a shared intercept and a survey-specific intercept, as well as a shared spatial random effect:

$$\lambda_1(s) = \exp(\beta_0 + \beta_{survey1} + \boldsymbol{A_1}u(s))$$
$$\lambda_2(s) = \exp(\beta_0 + \beta_{survey2} + \boldsymbol{A_2}u(s))$$

Where $\lambda_1(s)$ and $\lambda_2(s)$ represent the LGCP likelihoods for each of the surveys that each interfaced separately with the unified *u*(*s*) spatial effect via separate projector matrices ($\boldsymbol{A_1}$, $\boldsymbol{A_2}$). Thus, each model jointly contributes to the spatial density pattern across the study area while adjusting for differences in overall detection rate between surveys. We also used PC priors for these models on the spatial random effect, so the prior probability of the spatial range being less than 3 was 0.5, and the probability of spatial variance being less than 1 was 0.5.

Model prediction

Individual species density predictions were made to the BOEM 1200 m resolution aliquot grid encompassing the Lease Area with a 4 km buffer. Predictions from the species group models using the joint likelihood process were made at the same grid cell scale, but over a larger survey area that included both surveys. Density estimates were made by combining the overall intercept, the intercept from only the APEM surveys, and the spatial random effect. These predictions estimated densities assuming that the digital aerial surveys were conducted over the entire region.

All models were fit in R (version 4.0.2), (R Core Team 2020), using the R-INLA (version 21.02.23, https://www.r-inla.org, (Lindgren and Rue 2015) and inlabru (version 2.3.1, Bachl et al. 2019) packages.

5.1.1.2. MassCEC Aerial Surveys (Veit et al. 2016)

Data from 38 aerial surveys conducted between November 2011 and January 2015 for the Massachusetts Clean Energy Center (MassCEC) and BOEM were used to describe local-scale patterns of abundance (Figure 5-4 and Figure 5-5). These surveys provided baseline (pre-development) information on the distribution and abundance of marine birds in the MA WEA, which is located south of Martha’s Vineyard and Nantucket, and includes the Lease Area. The original count data were collected over three annual survey periods and occurred across all seasons. Seasons were chosen to describe broad changes in weather patterns in the offshore environment: spring (March–May), summer (June–August), fall (September–November), and winter (December–February).

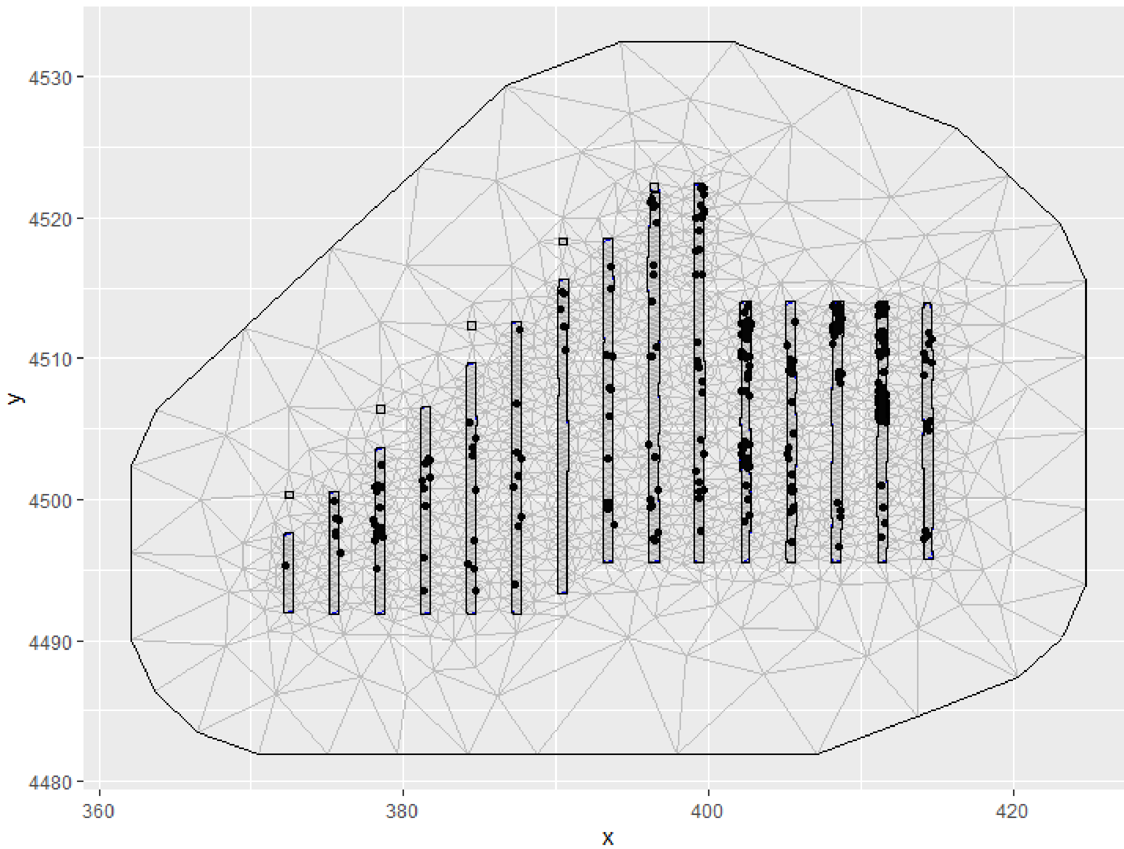


Figure 5-2: Constrained refined Delaunay triangulation spatial mesh for the digital aerial survey spatial models in the Lease Area. Meshes vary depending on the spatial distribution of the taxonomic group, and this figure represents Northern Gannets in winter. The shaded area represents the survey transects and the observations are black dots.

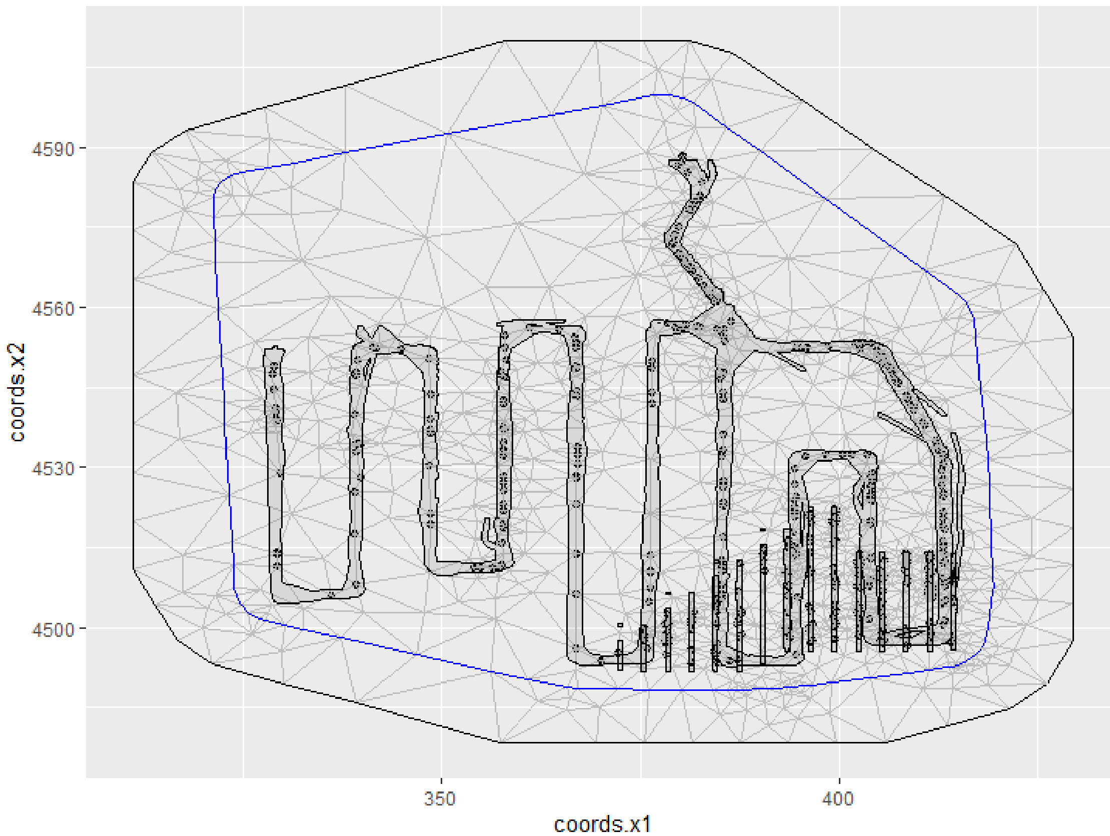


Figure 5-3: Constrained refined Delaunay triangulation spatial mesh for the multi-survey integrated model with the survey areas for each survey. Meshes vary depending on the spatial distribution of the taxonomic group, and this figure represents gannets and boobies in winter. The shaded area represents the survey transects and the observations are black dots. The blue line is the surveyed area covered by both surveys and the black line is the extent of the spatial model.

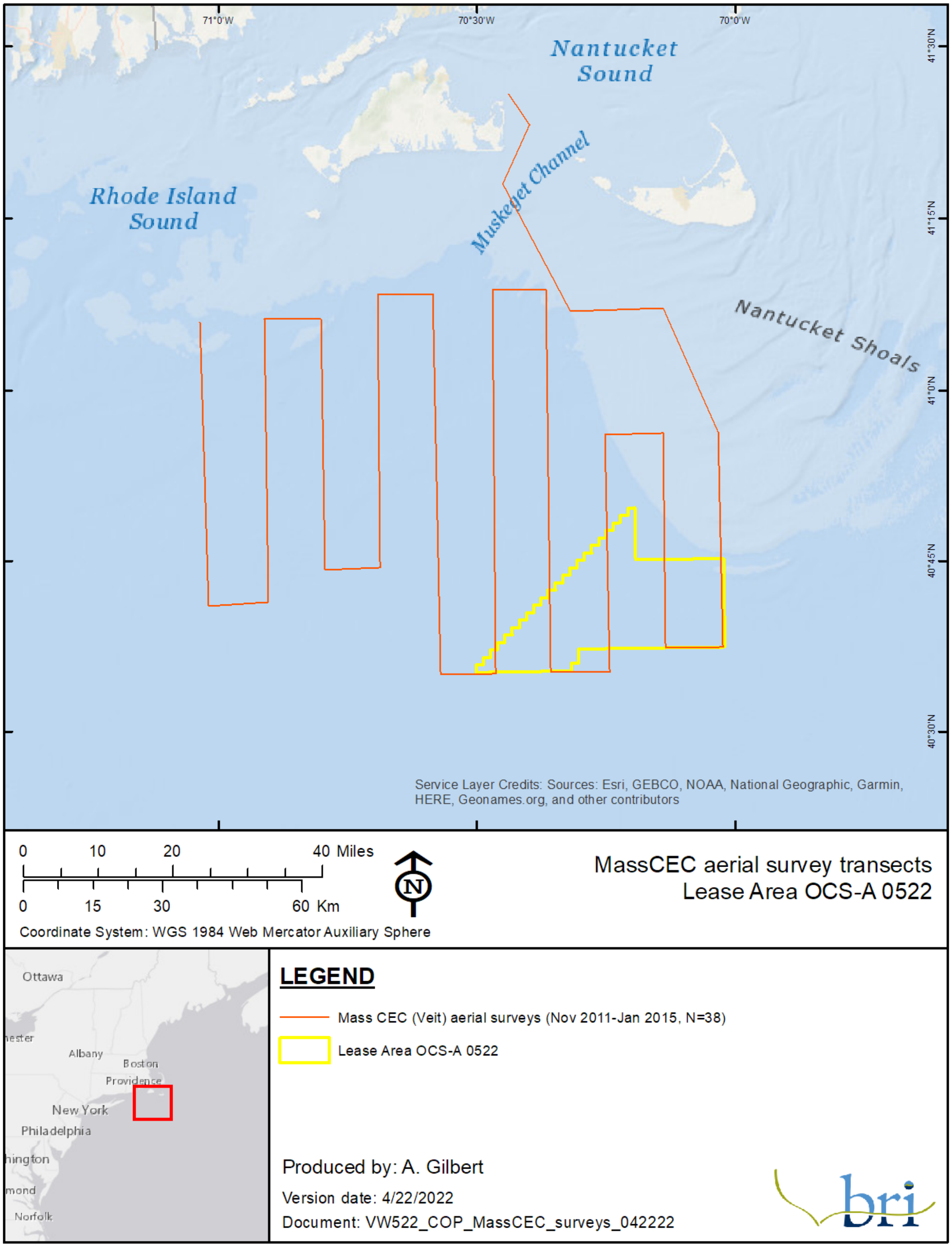


Figure 5-4: MassCEC aerial survey transects.

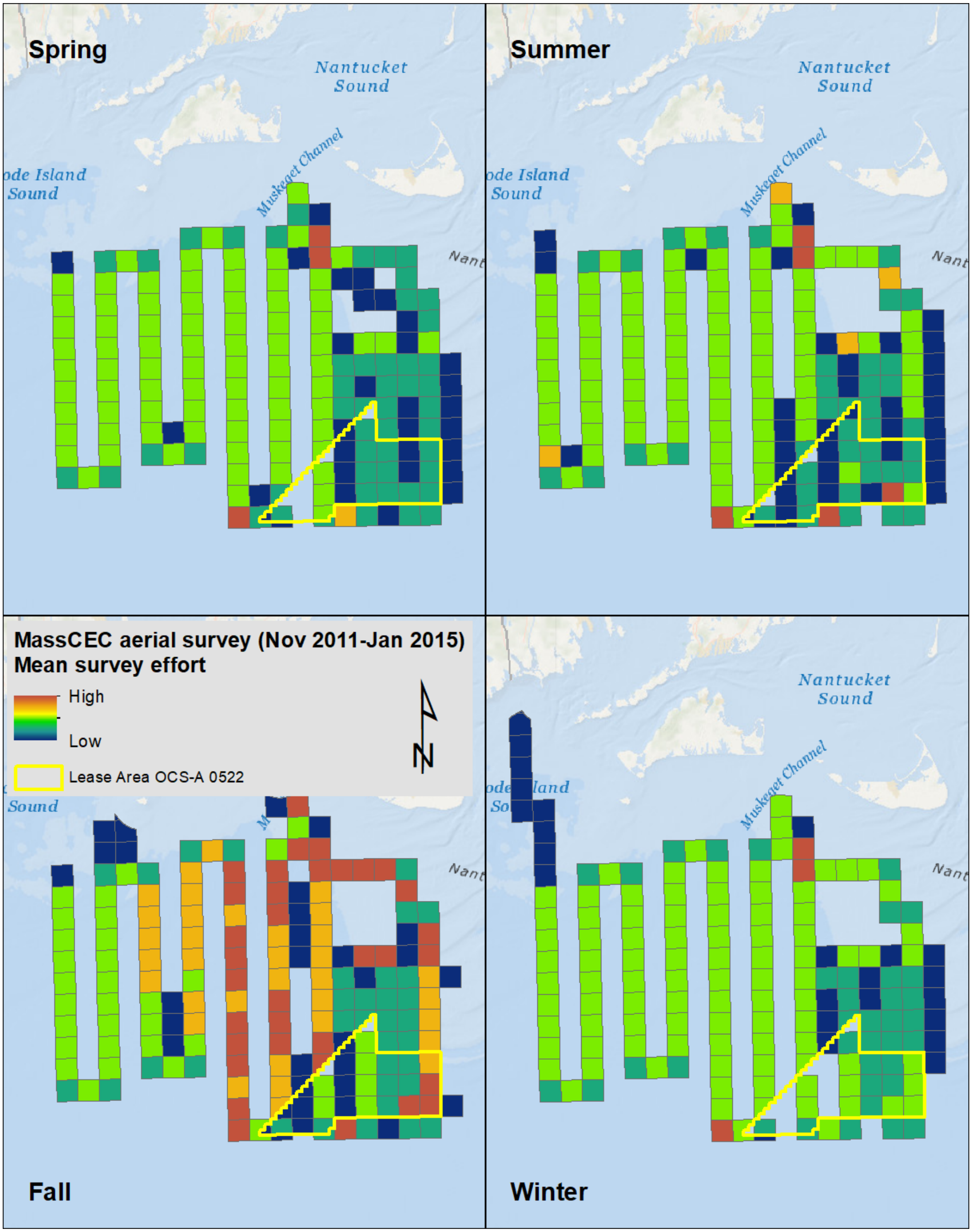


Figure 5-5: Seasonal mean survey effort from MassCEC aerial surveys.

5.1.1.3. The MDAT Marine Bird Abundance and Occurrence Models (Version 2)

Seasonal predictions of density were developed to support Atlantic marine renewable energy planning. Distributed as MDAT bird models (Winship et al. 2018; Curtice et al. 2019), they describe regional-scale patterns of abundance. Updates to these models (Version 2) are available directly from Duke University's Marine Geospatial Ecology Lab MDAT model web page[8]. The MDAT analysis integrated survey data (1978–2016) from the Atlantic Offshore Seabird Dataset Catalog[9] with a range of environmental variables to produce long-term average annual and seasonal models (Figure 5-6). These models were developed to support marine spatial planning in the Atlantic. In Version 2, relative abundance and distribution models were produced for 47 avian species using U.S. Atlantic waters from Florida to Maine; this resource thus provides an excellent regional context for local relative densities estimated from digital aerial surveys.

The MDAT, MassCEC aerial survey, and APEM digital aerial survey information sources each have strengths and weaknesses. The MassCEC aerial survey and APEM digital aerial survey data were collected in a standardized, comprehensive way, and the data describe recent distribution patterns in the Lease Area and surrounding areas. However, these surveys covered a fairly small area relative to the Northwest Atlantic distribution of most marine bird species, and the limited number of surveys conducted in each season means that individual observations (or lack of observations, for rare species) may in some cases carry substantial weight in determining seasonal exposure. These surveys also produced "unidentified" observations (e.g., "unknown large gull" or "unknown small tern"), which prove difficult for evaluating species-specific exposures. For this reason, these data were analyzed at higher taxonomic groupings.

The MDAT models, in contrast to baseline surveys (MassCEC aerial survey and APEM digital aerial survey), are based on data collected at much larger geographic and temporal scales. These data were also collected using a range of survey methods. The larger geographic scale is helpful for determining the importance of the Lease Area to marine birds relative to other available locations in the Northwest Atlantic, and is thus essential for determining overall exposure. However, these models are based on survey data from decades of surveys and long-term climatological averages of dynamic covariates; given changing climate conditions, these models may no longer accurately reflect current distribution patterns. Model outputs that incorporate environmental covariates to predict distributions across a broad spatial scale may also vary in the accuracy of those predictions at a local scale.

[8] http://seamap.env.duke.edu/models/mdat/

[9] https://coast.noaa.gov/digitalcoast/data/atloffshoreseabird.html

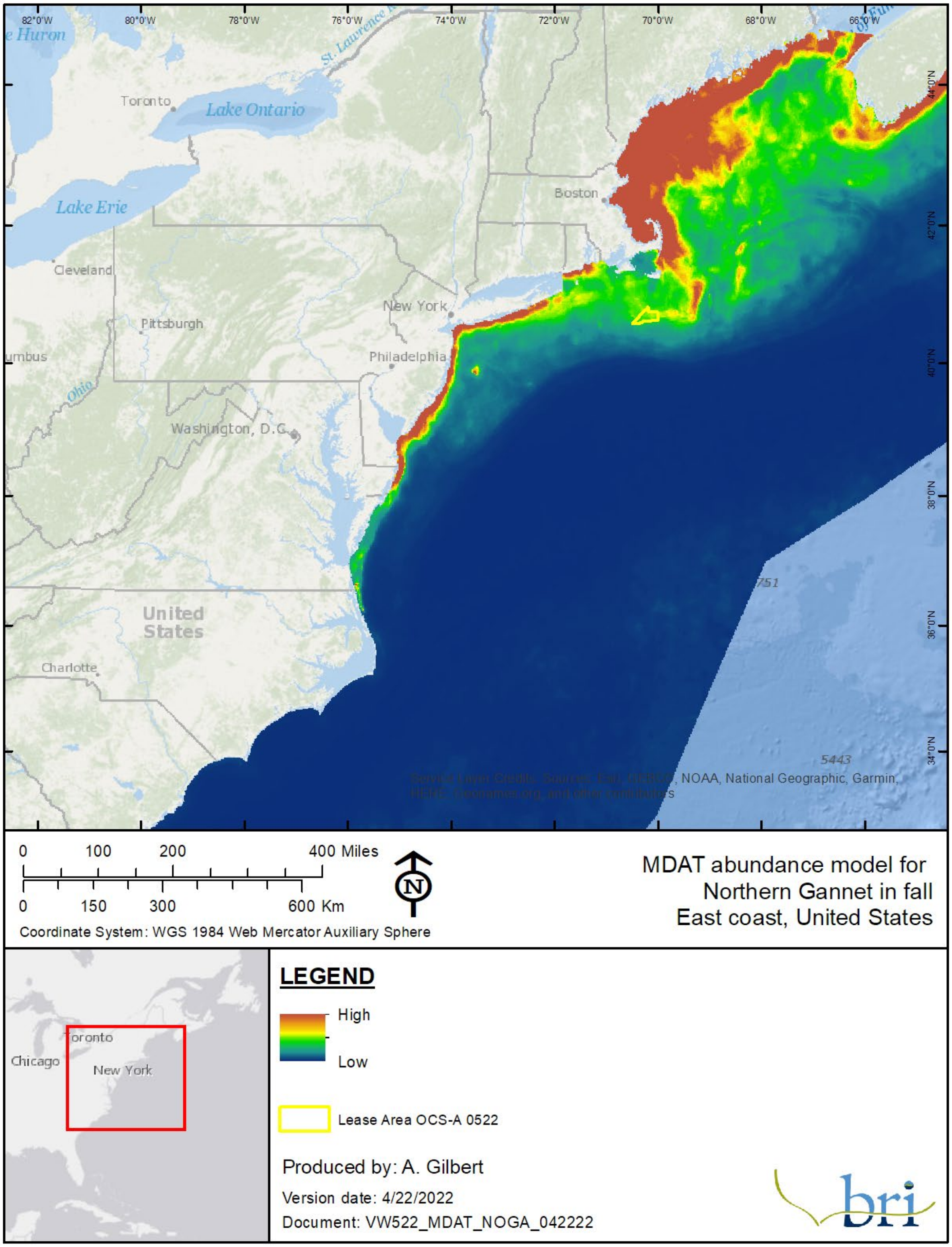


Figure 5-6: Example MDAT abundance model for Northern Gannet (*Morus bassanus*) in fall.

5.1.1.4. Secondary Sources

5.1.1.4.1. Northwest Atlantic Seabird Catalog

The Northwest Atlantic Seabird Catalog is the comprehensive database for the majority of offshore and coastal seabird surveys conducted in U.S. Atlantic waters from Maine to Florida. The database contains records from 1938–2019, having more than 200 datasets and approximately 750,000 observation records along with associated effort information (Arliss Winship, *personal communication*, 17 Nov 2021). The database is currently being managed by NOAA's National Center for Coastal Ocean Science (NCCOS). With BOEM's approval, NOAA provided the Catalog database to BRI to make queries for this assessment. All relevant data from the Catalog were mapped to determine the occurrence of rare species within the Lease Area.

5.1.1.4.2. Mid-Atlantic Diving Bird Tracking Study

A satellite telemetry tracking study in the mid-Atlantic was developed and supported by BOEM and the USFWS with objectives aimed at determining fine scale use and movement patterns of three species of marine diving birds during migration and winter (Spiegel et al. 2017). These species – the Red-throated Loon (*Gavia stellata*), Surf Scoter (*Melanitta perspicillata*), and Northern Gannet (*Morus bassana*) – are all considered species of conservation concern and exhibit various traits that make them vulnerable to offshore wind development. Nearly 400 individuals were tracked using satellite transmitters, Argos platform terminal transmitters (PTT), over the course of five years (2012–2016), including some tagged Surf Scoters as part of the Atlantic and Great Lakes Sea Duck Migration Study by Sea Duck Joint Venture (SDJV)[10]. Results provide a better understanding of how these diving birds use offshore areas of the mid-Atlantic OCS and beyond.

Utilization distributions (UDs) were determined for each species by calculating individual level dynamic Brownian-bridge movement model (dBBMM) surfaces (Kranstauber et al. 2012) using package Move for R (Kranstauber and Smolla 2016). Separate dBBMM surfaces were calculated for each of two winters with at least five days of data and combined into a weighted mean surface for each animal (as a percentage of the total number of days represented in the surface) with a minimum 30 total combined days of data. This method of combining multiple seasons was used for the migration periods as well, but with relaxed requirements for days of data, requiring only five days per year and seven total days per period since migration duration often occurred over a much shorter time period. Utilization contour levels of 50%, 75%, and 95% were calculated for the mean UD surface. The final UD was cropped to the 95% contour for mapping and further analyses (Spiegel et al. 2017).

[10] https://seaduckjv.org/science-resources/atlantic-and-great-lakes-sea-duck-migration-study/

5.1.1.4.3. Migrant Raptor Studies

Peregrine Falcon and Merlin

To facilitate research efforts on migrant raptors (i.e., migration routes, stopover sites, space use relative to Atlantic OCS wintering/summer range, origins, contaminant exposure), BRI has deployed satellite transmitters on fall migrating raptors at three different raptor migration research stations along the north Atlantic coast (DeSorbo et al. 2012; DeSorbo et al. 2018; DeSorbo et al. 2018). Research stations include the Block Island Raptor Research Station at Block Island, Rhode Island (Peregrines Falcons [*Falco peregrinus]*: 3 adult [ad.] females, 18 hatch year [HY] females, 17 HY males; Merlins [*Falco columbarius*]: 3 ad. females and 13 HY females; DeSorbo et al. 2018); Monhegan Island, Maine (Peregrine Falcons: 2 HY females); and Cutler, Maine (Peregrine Falcons: 1 ad. female).

Satellite-tagged Peregrine Falcons and Merlins provided information on fall migration routes along the Atlantic flyway. Positional data was filtered to remove poor quality locations using the Douglas Argos Filtering tool (Douglas et al. 2012) available online on the Movebank data repository[11] where these data are stored and processed. A request for data use was made to Chris DeSorbo, Raptor Program Director at BRI, who provided permission to utilize the results of the migrant raptor studies.

Osprey

Between 2000 and 2019, 106 tracking devices were fitted to Ospreys (*Pandion haliaetus*) captured at various locations between Chesapeake Bay and northern New Hampshire (www.ospreytrax.com). This data set includes both adults and juveniles, but emphasized tagging juveniles prior to their first migration. It represents the first dedicated study of dispersal, mortality, and migration in juvenile Osprey. Satellite transmitters were used in early years, but beginning in 2012, higher resolution cellular Global Positioning System (GPS) transmitters were deployed on adult males to better document their foraging behavior around nests and to provide additional details about migration (e.g., thermal soaring over land and dynamic soaring over water; Horton et al. 2014).

Separately, satellite Argos PTT tags were deployed on Ospreys in the U.S. and Canada between 1995 and 2001 (Martell et al. 2001; Martell and Douglas 2019). This data has been used to delineate both fall and spring migratory routes used by Ospreys breeding in the U.S. Tagging locations included areas in Oregon, Washington, Minnesota, New York, and New Jersey. Birds tagged in eastern states generally migrated along the U.S. Atlantic coast.

To characterize potential utilization of the offshore environment by Ospreys, UDs were generated for individual animals using a dBBMM (Kranstauber et al. 2012). Both Argos satellite data and GPS-derived positional data were used from the two different telemetry datasets from Movebank (as above). Both datasets were compiled together and a max speed filter by animal was applied, which excluded locations with instantaneous speeds greater than 100 kph (62 mph)

[11] https://www.movebank.org/

and also filtered points outside of an extent including the eastern U.S. and Atlantic Canada (including all offshore points for this region). Individual dBBMMs were generated for the last 365 consecutive days of available data per tag (or less if the tags provide less than 365 consecutive days), thus representing an annual cycle within the U.S. Models were composited into a weighted UD for the sampled population, weighting each animal's UD by the number of days data were available of the total number of days of all animals providing models.

5.1.1.4.4. Tracking movements of vulnerable terns and shorebirds in the Northwest Atlantic using NanoTags

Since 2013, BOEM and the USFWS have supported a study using NanoTags (coded VHF tags) and an array of automated very high frequency (VHF) radio telemetry stations to track the movements of vulnerable species, such as terns and shorebirds. The study was designed to assess the degree to which these species use offshore federal waters during breeding, pre-migratory staging periods, and on their migrations. In a pilot study in 2013, researchers attached NanoTags to Common Terns (*Sterna hirundo*) and American Oystercatchers (*Haematopus palliatus*) and set up eight automated sentry stations (Loring et al. 2017). Having proved the methods successful, the study was expanded to 16 automated stations in 2014, and from 2015–2017, tagging efforts included Piping Plovers and Roseate Terns. This study provided new information on the offshore movements and flight altitudes for these species gathered from a network of 33 automated telemetry stations, including areas of Massachusetts, New York, New Jersey, Delaware, and Virginia (Loring et al. 2019).

5.1.1.4.5. Tracking movements of rufa Red Knots in U.S. Atlantic Outer Continental Shelf Waters

Building from a previous tracking study, *rufa* Red Knots were fitted with digital VHF transmitters during their 2016 southbound migration at stopover locations in both Canada and along the U.S. Atlantic coast. Individuals were tracked via radio telemetry stations within the study area that extended from Cape Cod, Massachusetts, to Back Bay, Virginia. Modeling techniques were developed to describe the frequency and offshore movements over Federal waters and specific Wind Energy Areas (WEAs) within the study area. The primary study objectives were to: develop models related to offshore movements for *rufa* Red Knots; assess the exposure to each WEA during southbound migration; and examine WEA exposure and migratory departure movements in relation to various meteorological conditions (Loring et al. 2018).

5.1.1.4.6. Sea Duck Tracking Studies

The Atlantic and Great Lakes Sea Duck Migration Study, a multi-partner collaboration, was initiated by the Sea Duck Joint Venture (SDJV) in 2009 with the goals of: (1) fully describing full annual cycle migration patterns for four species of sea ducks (Surf Scoter, Black Scoter [*Melanitta americana*], White-winged Scoter [*Melanitta deglandi*], and Long-tailed Duck [*Clangula hyemalis*]), (2) mapping local movements and estimating length-of-stay during winter for individual radio-marked ducks in areas proposed for placement of WTGs, (3) identifying nearshore and offshore habitats of high significance to sea ducks to help inform habitat conservation efforts, and (4) estimating rates of annual site fidelity to wintering areas, breeding areas, and molting areas for all four focal species in the Atlantic flyway. To date, over 500 transmitters have been deployed in the U.S. and Canada by various project partners, including BRI, Canadian Wildlife Service, U.S. Geological Survey's Patuxent Wildlife Research Center, University of Rhode Island, Rhode Island Department of Environmental Management, USFWS, SDJV, and the University of Montreal. These collective studies have led to increased understanding of annual cycle dynamics of sea ducks, as well as potential interactions with and impacts from offshore wind energy development (Loring et al. 2014; SDJV 2015; Meattey 2018; Meattey et al. 2019).

In addition, BOEM and USFWS partnered with SDJV during 2012–2016 to deploy transmitters in Surf Scoters as part of a satellite telemetry tracking study in the mid-Atlantic, with the aim of determining fine scale use and movement patterns of three species of marine diving birds during migration and winter (Spiegel et al. 2017).

UDs were determined for each species by calculating individual level dBBMM surfaces (Kranstauber et al. 2012) using package Move for R (Kranstauber and Smolla 2016). Separate dBBMM surfaces were calculated for each of two winters with at least five days of data and combined into a weighted mean surface for each bird (as a percentage of the total number of days represented in the surface) with a minimum 30 total combined days of data. This method of combining multiple seasons was used for the migration periods as well, but with relaxed requirements for days of data, requiring only five days per year and seven total days per period since migration duration often occurred over a much shorter time period. Utilization contour levels of 50%, 75%, and 95% were calculated for the mean UD surface. The final UD was cropped to the 95% contour for mapping and further analyses (Spiegel et al. 2017).

5.1.1.4.7. Great Blue Heron Tracking Study

Since 2016, the Maine Department of Inland Fisheries and Wildlife (MDIFW) has been capturing Great Blue Herons each year in Maine and tracking their migrations with solar GPS satellite transmitters. Results to date indicate that Great Blue Herons breeding in Maine winter across southeastern states and the Caribbean, as far south as Haiti. In general, herons travel coastally, but some have been tracked much farther offshore than previously anticipated, with one bird going as far east as Bermuda on one southbound migration, likely taking advantage of offshore prevailing winds at the time. The full dataset is available in the Movebank repository (https://movebank.org/).

5.1.2. Exposure Mapping

Maps were developed to display local and regional context for exposure assessments. A three-part map was created for each species-season (winter: December– February; spring: March–May; summer: June–August; and fall: September–November) combination that includes MDAT and/or baseline survey data (See Attachment A of this Appendix). Any species-season combination which did not at least have either APEM digital aerial model, MDAT model, or MassCEC baseline survey data (i.e., blank maps) were left out of the final map set. An example map for Northern Gannet in fall is provided below to aid in discussion (Figure 5-7).

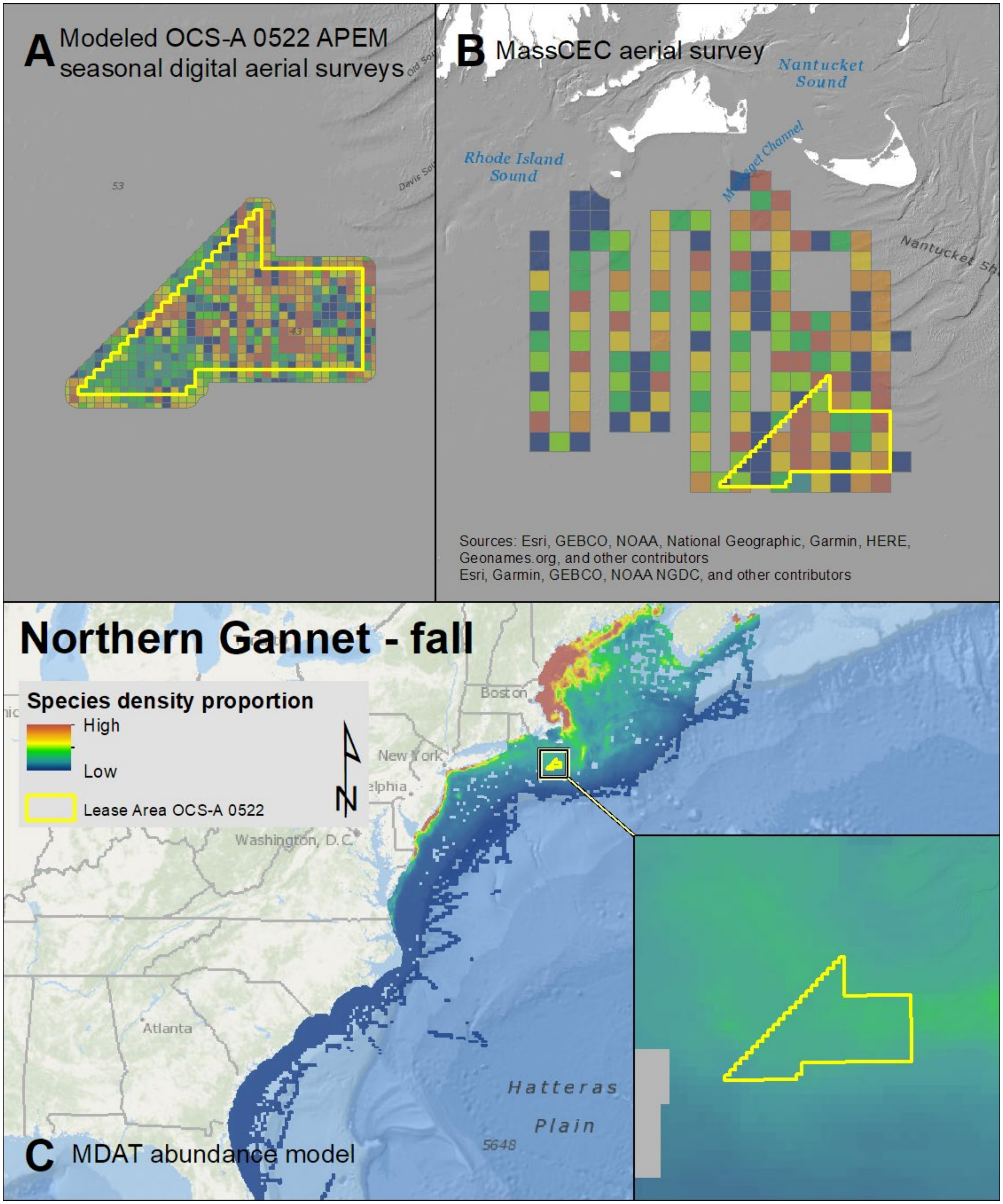


Figure 5-7: Example map of modeled APEM digital aerial absolute densities and relative density proportions locally (MassCEC) and regionally (MDAT) for Northern Gannet in fall.

The top left map panel (A) presents the INLA modeled APEM digital aerial survey data with absolute density predictions made at the BOEM aliquot (1/16th of a lease block) scale. APEM modeled density maps were symbolized using 10 quantiles of the density data within each species-season combination. Further detailed methods can be found in the discussion of individual species models above.

The top right map panel (B) presents the MassCEC aerial survey data as proportions of total effort-corrected counts (naïve density estimates). The proportion of the total effort-corrected counts (total counts per square kilometer of survey area) was calculated for each BOEM designated OCS[12] Lease Block[13], across all surveys in a given season. This method was useful as it scaled all effort-corrected count data from 0–1 to standardize data visualizations among species. Exposure was ranked from low–high for each species based on weighted quantiles of these count proportions. Quantiles were weighted by the count proportions because data were skewed towards zero. OCS Lease Blocks with zero counts were always the lowest, and blocks with more than one observation were divided into four weighted quantiles.

The lower map panel (C) and inset in the lower right of this panel present data from MDAT models at different scales. The base panel shows the modeled relative density output over the entire Northwest Atlantic, and the inset shows the modeled densities in the Lease Area and surrounding area. Density data are scaled in a similar way to the baseline survey data, so that the low–high designation for density is similar for both datasets. However, there are no true zeroes in the model outputs, and thus no special category for them in the MDAT data. All MDAT models were masked to remove areas of zero effort within a season. These zero-effort areas do have density estimates, but generally are of low confidence, so they were excluded from mapping and analysis to reduce anomalies in predicted species densities and to strengthen the analysis. Additionally, while the color scale for the MDAT data is approximately matched to that used for the baseline survey data, the values that underlie them are different (the MDAT data are symbolized using an ArcMap default color scale, which uses standard deviations from the mean to determine the color scale rather than quantiles). Maps should be viewed in a broadly relative way between local and regional assessments and even across species.

[12] The OCS is defined by the US Department of the Interior (https://www.bsee.gov/newsroom/library/glossary) as "All submerged lands seaward and outside the area of lands beneath navigable waters. Lands beneath navigable waters are interpreted as extending from the coastline 3 nautical miles into the Atlantic Ocean, the Pacific Ocean, the Arctic Ocean, and the Gulf of Mexico excluding the coastal waters off Texas and western Florida. Lands beneath navigable waters are interpreted as extending from the coastline 3 marine leagues into the Gulf of Mexico off Texas and western Florida."

[13] OCS Lease Blocks are defined (https://catalog.data.gov/dataset/outer-continental-shelf-lease-blocks-atlantic-region-nad83) as "small geographic areas within an Official Protraction Diagram (OPD) for leasing and administrative purposes. These blocks have been clipped along the Submerged Lands Act (SLA) boundary and along the Continental Shelf Boundaries. Additional details are available from: https://www.boem.gov/BOEM-Newsroom/Library/Publications/1999/99-0006-pdf.aspx"

5.1.3. Exposure Assessment Metrics

Avian exposure to the Lease Area was assessed on an individual level by calculating naïve densities using the APEM digital aerial surveys, on a local population level using the MassCEC aerial surveys, and on a regional population level using the MDAT models. The local and regional datasets were combined to create the species-specific exposure score (see next section). The exposure scores were developed from the MassCEC and MDAT models by comparing bird densities in the Lease Area with all other possible Lease Area-sized areas within the survey area for each dataset. For each species the mean densities were compiled for each Lease Area-sized area, quantiles calculated for the set of all Lease Area-sized areas, and a categorical score was assigned to each quantile. If the Lease Area was in the top quartile, a bird would get a high exposure score; if it was in the bottom, a minimal score. The analysis was done in the following two steps:

Step 1, assess regional exposure using MDAT models: Using the MDAT data, masked to remove zero-effort predicted cells, the predicted seasonal density surface for a given species was aggregated into a series of rectangles that were approximately the same size as the Lease Area, and the mean density estimate of each rectangle was calculated. This process compiled a dataset of density estimates for all species surveyed, for areas the same size as the Lease Area. The 25th, 50th, and 75th weighted quantiles of this dataset were calculated, and the quantile into which the density estimate for the Lease Area fell for a given species and season combination was identified. Quantiles were weighted by using the proportion of the total density across the entire modeled area that each sample represented. Thus, quantile breaks represent proportions of the total seabird density rather than proportions of the raw data. A categorical score was assigned to the Lease Area for each season-species: 0 (Minimal) was assigned when the density estimate for the Lease Area was in the bottom 25%; 1 (Low) when it was between 25% and 50%; 2 (Medium) when it was between 50% and 75%; and 3 (High) when it was in the top quartile (greater than 75%). While a "high" score does suggest importance within a local or regional scale, these scores need to be considered in context of scores at each spatial scale when assessing overall importance to the species in a season.

Step 2, assess local exposure using the MassCEC aerial survey: A similar process was used to categorize each species-season combination using the MassCEC baseline survey data. To compare the Lease Area to other locations within the survey region, the nearest 30 OCS full or partial Lease Blocks to each OCS Lease Block surveyed in the MassCEC aerial survey area in each season (winter, n = 167; spring, n = 174; summer, n = 180; and fall, n = 179) were identified and the relative density of each OCS Lease Block group was calculated. Thus, a dataset of relative densities for all possible Lease Area-sized OCS Lease Block groups was generated within the survey region using the baseline survey data. This data set was used to assign scores to all species-season combinations, based on the same quartile categories described for the MDAT models above. If a score for a species-season combination was not available using the baseline survey data (local assessment), and because the avian surveys made every effort to survey all species, then the local assessment score was assigned a zero since no animals were sighted for that species-season combination.

5.1.4. Species Exposure Scoring

To determine the relative exposure for a given species and season in the Lease Area compared to all other areas, the MDAT quartile score and baseline survey data quartile score were added together to create an exposure metric that ranged from 0 to 6. The density information at both spatial scales was equally weighed, and thus represents both the local and regional importance of the Lease Area to a given species during a given season. However, if a species-season combination was not available for the MDAT regional assessment, then the score from the local assessment (MassCEC baseline survey data) was accepted as the best available information for that species-season, and it was scaled to range from 0 to 6 (e.g., essentially doubled to match the final combined score).

The exposure score was categorized as ***minimal*** (a combined score of 0), ***low*** (combined score of 1–2), ***medium*** (combined score of 3–4), or ***high*** (combined score of 5–6; Table 5-4). In general terms, species-season combinations labeled as ***minimal*** had low densities at both the local and regional spatial scales. ***Low*** exposure was assessed for species with below-average densities at both spatial scales, or above-average density at one of the two spatial scales and low density at the other scale. ***Medium*** exposure describes several different combinations of densities; one or both spatial scales must be at least above-average density, but this category can also include species-season combinations where density was high for one spatial scale and low for another. ***High*** exposure is when density is high at both spatial scales, or one is high and the other is above average. Both local and regional exposure scores were viewed as equal in importance in the assessment of exposure. All exposure determinations are highlighted in bold throughout the text.

Table 5-4: Definitions of exposure levels developed for the avian assessment for each species and season; the listed scores represent the exposure scores from the local MassCEC baseline survey data and the regional MDAT on the left and right, respectively.

Exposure Level	Definition	Scores
Minimal	Densities at both local and regional scales are below the 25th percentile.	0, 0
Low	Local and/or regional density is between the 25th and 50th percentiles. OR Local density is between the 50th and 75th percentiles and regional density is below the 25th percentile, or vice versa.	1, 1 2, 0
Medium	Local or regional density is between the 50th and 75th percentiles. OR Local density is between the 50th and 75th percentiles and regional density between the 25th and 50th percentiles, or vice versa. OR Local density is greater than the 75th percentile and regional density is below the 25th percentile, or vice versa. OR 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).	2, 2 2, 1 3, 0 3, 1

High	Densities at both local and regional scales are above the 75th percentile. OR Local densities are greater than the 75th percentile and regional densities are between the 50th and 75th percentiles, or vice versa.	3, 3 3, 2

5.1.5. Interpreting Exposure Scores

The exposure scores for each species and season should be interpreted as a measure of the relative importance of the Lease Area for a species, as compared to other surveyed areas in the region and in the Northwest Atlantic. It does not indicate the absolute number of individuals likely to be exposed. Rather, the exposure score attempts to provide regional and population-level context for each species.

A ***high*** exposure score indicates that the observed and predicted densities of the species in the Lease Area were high relative to densities of that species in other surveyed areas. Conversely, a ***low*** or ***minimal*** exposure score means that the species was predicted to occur at lower densities in the Lease Area than in other locations. A ***minimal*** exposure score should not be interpreted to mean there are no individuals of that species in the Lease Area. In fact, common species may receive a ***minimal*** exposure score even if there are substantial numbers of individuals in the Lease Area, so long as their predicted densities *outside* the Lease Area are comparatively higher. The quantitative seasonal exposures scores were then considered with additional species-specific information, along with expert opinion, to place each species within a final exposure category.

5.1.6. Exposure Categories

The quantitative assessment of exposure (described above), other locally available data, existing literature, and species accounts were utilized to develop a final qualitative exposure determination for each species. Final species exposure level categories used in this assessment are described in Table 5-5 below. If exposure scores differed by species within a group, a range was provided as the final exposure score for the species group. Final group scores may be adjusted up depending on additional, taxa-level information.

Table 5-5: Assessment criteria used for assigning species to final exposure levels.

Final Exposure Level	Definition
Minimal	Minimal seasonal exposure scores in all seasons or minimal score in all but one season. OR Based upon the literature—and, if available, other locally available tracking or survey data—little to no evidence of use of the Lease Area or offshore environment for breeding, wintering, or staging, and low predicted use during migration.
Low	Low exposure scores in two or more seasons, or medium exposure score in one season.

Final Exposure Level	Definition
	OR Based upon the literature—and, if available, other locally available tracking or survey data—low evidence of use of the Lease Area or offshore environment during any season.
Medium	Medium exposure scores in two or more seasons, or High exposure score in one season. OR Based upon the literature—and, if available, other locally available tracking or survey data—moderate evidence of the Lease Area or use of the offshore environment during any season.
High	High exposure scores in two or more seasons. OR Based upon the literature—and, if available, other locally available tracking or survey data—high evidence of use of the Lease Area or offshore environment, and the offshore environment is primary habitat during any season.

5.1.7. Species and Taxonomic Densities

Uncommon species with few detections in the Lease Area may be somewhat over-rated for exposure using this method, while common species with relatively few detections in the Lease Area may be effectively under-rated in terms of total exposure to the Lease Area. Density estimates (count per sq. km) are presented to provide context for the exposure scores.

We provide two sets of tabular density estimates 1) the seasonal bootstrapped mean density (animals/sq. km) and 95% confidence interval (CI) for each species detected in the APEM digital aerial data within the Lease Area and outside (i.e., the buffer), and 2) the mean seasonal densities derived from the integrated joint INLA model at the taxonomic level for inside the Lease Area compared to the entire joint study area (which includes the Lease Area). The bootstrap mean and 95% CI density estimates were derived from APEM digital aerial survey data summarized using BOEM aliquot grid and resampled with replacement 10,000 times using a non-parametric bootstrap method. The bootstrap sampling was conducted in R version 4.1.1 (R Core Team, 2021) using package Boot version 1.3-28 (Canty and Ripley 2021). Taxa group level densities were derived from the integrated INLA density models as described above and were calculated as seasonal means from models for aliquots assigned to inside the Lease Area vs. the joint study area.

5.1.8. Sea Duck Overlap Methods

The Intersect tool in ArcGIS Pro (v2.9.3) was used to calculate the area of overlap between dynamic Brownian Bridge movement model (dBBMM) contours of four sea duck species during the fall, winter, and spring and the offshore export cable corridors (OECCs) Massachusetts and Connecticut. The area that each seasonal/species contour represented was exported as a polygon and overlaid with each OECC. Contour areas represent three levels of use across the UD surface: 95% (home range), 75%, and 50% (core use). The Connecticut OECC was represented by a 720 m wide polygon, while the Massachusetts OECC was resented as a line. To replicate the Intersect analysis for both corridors, a 360 m buffer was applied to the Massachusetts OECC. The Intersect analysis was then replicated using the three contour areas that represent percentage of use during the fall, winter, and spring of Black Scoter, Surf Scoter, White-winged Scoter, and Red-throated Loon.

5.2. Vulnerability Framework

Researchers in Europe and the U.S. have assessed the vulnerability of birds to offshore wind farms and general disturbance by combining ordinal scores across a range of key variables (Furness et al. 2013; Willmott et al. 2013; Wade et al. 2016; Kelsey et al. 2018; Fliessbach et al. 2019). The purpose of these indices was to prioritize species in environmental assessments (Desholm 2009) and provide a relative rank of vulnerability (Willmott et al. 2013). Importantly, past assessments and the one conducted here are intended to support decision-making by ranking the relative likelihood that a species will be sensitive to offshore wind farms but should not be interpreted as an absolute determination that there will or will not be collision mortality or habitat loss. Therefore, the results should be interpreted as a guide to species that have a higher likelihood of vulnerability.

The existing vulnerability methods assess individual-level vulnerability to collision and displacement independently and then incorporate population-level vulnerability to develop a final *species-specific* vulnerability score. These past efforts provide useful rankings across a region but are not designed to assess the vulnerability of birds to a particular wind farm or certain WTG designs. Collision risk models (e.g., Band 2012) do estimate site-specific mortality, but are substantially influenced by assumptions about avoidance rates (Chamberlain et al. 2006). Furthermore, collision risk models do not explicitly assess vulnerability to displacement (i.e., macro avoidance behaviors, leading to temporary or permanent displacement from a wind farm area, which can cause effective habitat loss). Thus, there is a need to develop a *project-specific* vulnerability score for each species that is inclusive of both collision and displacement and has fewer assumptions.

The scoring process in this assessment builds from the existing methods, Incorporates the specifications of the WTGs being considered, utilizes local bird conservation status, and limits the vulnerability score to the species observed in the local surveys. The results from this scoring method may differ for some species from the qualitative determinations made in other Construction and Operation Plan (COP) assessments because the input parameters use specific categorical definitions that in some cases are conservative (e.g., > 40% macro-avoidance receives the highest score; see below and Table 5-7).

The literature is also used to interpret scoring results, and, if empirical studies indicate a lower or higher vulnerability, a range is added to the final score (see uncertainty discussion below). For species or species group for which inputs are lacking, the literature is used to qualitatively determine a vulnerability ranking using the criteria in (Table 5-6). Below is a description of the scoring approach.

Table 5-6: Assessment criteria used for assigning species to each behavioral vulnerability level.

Behavioral Vulnerability Level	Definition
Minimal	0–0.25 ranking for collision or displacement risk in vulnerability scoring. **OR** No evidence of collisions or displacement in the literature. Unlikely to fly within the rotor-swept zone (RSZ).
Low	0.26–0.5 ranking for collision or displacement risk in vulnerability scoring. **OR** Little evidence of collisions or displacement in the literature. Rarely flies within the RSZ.
Medium	0.51–0.75 ranking for collision or displacement risk in vulnerability scoring. **OR** Evidence of collisions or displacement in the literature. Occasionally flies within the RSZ.
High	0.76–1.0 ranking for collision or displacement risk in vulnerability scoring. **OR** Significant evidence of collisions or displacement in the literature. Regularly flies within the RSZ.

5.2.1. Population Vulnerability

Many factors contribute to how sensitive a population is to mortality or habitat loss related to the presence of a wind farm, including vital rates, existing population trends, and relative abundance of birds (Goodale and Stenhouse 2016). In this avian risk assessment, the relative abundance of birds is accounted for by the exposure analysis described above. The vulnerability assessment creates a population vulnerability (PV) score by using Partners in Flight (PiF) "continental combined score" (CCSmax), a local "state status" (SSmax), and adult survival score (AS) (Equation 1 below). Survival is included as an independent variable that is not accounted for in the CCSmax. This approach is based upon methods used by Kelsey et al. (2018) and Fliessbach et al. (2019).

Each factor included in this assessment (CCSmax, SSmax, and AS) is weighted equally and receives a categorical score of 1–5 (Table 5-7). The final population level vulnerability scores are rescaled to a 0–1 scale, divided into quartiles, and are then translated into four final vulnerability categories (Table 5-6). Since using quartiles creates hard cut-off points and there is uncertainty present in all inputs (see discussion on uncertainty below), using scores alone can potentially misrepresent vulnerability (e.g., a 0.545 PV score leading to a ***medium*** category). To account for this, the scores are considered along with information in existing literature. If there is evidence in the literature that conflicts with the vulnerability score, then the score will be appropriately adjusted (up or down) according to documented empirical evidence. For example, if a PV score was assessed as *low*, but a paper indicated an increasing population, the score would be adjusted up to include a range of *low–medium*.

$$PV = CCSmax + SSmax + AS \qquad \text{Equation 1}$$

Specifics for each factor in PV are as follows:

- *CCSmax* is included in scoring because it integrates various factors PiF uses to indicate global population health. It represents the maximum value for breeding and non-breeding birds developed by PiF, and combines the scores for population size, distribution, global threat status, and population trend (Panjabi et al. 2019). The CCSmax score from PiF was rescaled to a 1–5 scale to achieve consistent scoring among factors.

- *SSmax* is included in scoring to account for local conservation status, which is not included in the CCSmax. Local conservations status is generally determined independently by states and accounts for the local population size, population trends, and stressors on a species within a particular state. It was developed following methods by Adams et al. (2016) in which the state conservation status for the relevant adjacent states is placed within five categories (1 = no ranking, to 5 = *Endangered*), and then, for each species, the maximum state ranking is selected.

- *AS* is included in the scoring because species with higher adult survival rates are more sensitive to increases in adult mortality because they tend to be species that are also long-lived and have low annual reproductive success (e.g., K strategists; Desholm 2009; Adams et al. 2016). The five categories are based upon those used in several vulnerability assessments (Willmott et al. 2013; Kelsey et al. 2018; Fliessbach et al. 2019), and the species-specific values were used from Willmott et al. (2013).

Table 5-7: Data sources and scoring of factors used in the vulnerability assessment.

Vulnerability Component	Factor	Definition and Source	Scoring
Population Vulnerability (PV)	continental combined score *(CCSmax)*	CCSmax is Partners in Flight continental combined score: pif.birdconservancy.org/ACAD/Database.aspx.	1 = Minor population sensitivity 2 = Low population sensitivity 3 = Medium population sensitivity 4 = High population sensitivity 5 = Very-High population sensitivity
	state status *(SSmax)*	SSmax from states adjacent to Vineyard Northeast from Adams et al. (2016).	1 = No Ranking[1] 2 = State/Federal Special Concern 3 = State/Federal Threatened 4 = State/Federal Endangered 5 = State & Federal End and/or Thr

Vulnerability Component	Factor	Definition and Source	Scoring
	adult survival (AS)	AS score: scores and categories taken from Willmott et al. (2013).	1 = <0.75 2 = 0.75 to 0.80 3 = >0.80 to 0.85 4 = >0.85 to 0.90 5 = >0.90
Collision Vulnerability (CV)	*rotor swept zone (RSZt)*	Wind turbine generator (WTG)-specific percentage of flight heights in RSZ. Flight heights modeled from Northwest Atlantic Seabird Catalog. Categories from Kelsey et al. (2018).	1 = < 5% in RSZ 3 = 5–20% in RSZ 5 = > 20% in RSZ
	macro-avoidance (MAc)	Avoidance rates and scoring categories from Willmott et al. (2013) and Kelsey et al. (2018).	1 = >40% avoidance 2 = 30 to 40% avoidance 3 = 18 to 29% avoidance 4 = 6 to 17% avoidance 5 = 0 to 5% avoidance
	Nocturnal Flight Activity (NFA); Diurnal Flight Activity (DFA).	NFA scores were taken from Willmot et al. (2013); DFA was calculated using locally available aerial surveys that records if birds are sitting or flying.	1 = 0–20% 2 = 21–40% 3 = 41–60% 4 = 61–80% 5 = 81–100%
Displacement Vulnerability (DV)	*Macro-avoidance rates (MAd)*	Macro-avoidance rates (MAd) that would decrease collision risk from Willmott et al. (2013) and Kelsey et al. (2018).	1 = 0–5% avoidance 2 = 6–17% avoidance 3 = 18–29% avoidance 4 = 30–40% avoidance 5 = > 40% avoidance
	Habitat flexibility (HF)	The degree to which a species is considered a habitat generalist (i.e., can forage in a variety of habitats) or a specialist (i.e., requires specific habitat and prey type). HF score and categories taken from Willmott et al. (2013).	0 = species does not forage in the Atlantic Outer Continental Shelf 1 = species uses a wide range of habitats over a large area and usually has a wide range of prey available to them 2 to 4 = grades of behavior between scores 1 and 5 5 = species with habitat- and prey-specific requirements that do not have much flexibility in diving-depth or choice of prey species

[1] Note actual definitions for state conservation ranking may be adjusted to follow individual state language.

5.2.2. Collision Vulnerability

Collision vulnerability (CV) assessments can include a variety of factors including nocturnal flight activity, diurnal flight activity, avoidance, proportion of time within the rotor swept zone (RSZ), maneuverability in flight, and percentage of time flying (Furness et al. 2013; Willmott et al. 2013;

Kelsey et al. 2018). The assessment process conducted here follows Kelsey et al. (2018) and includes proportion of time within the RSZ (RSZt), a measure of avoidance (MAc), and flight activity (NFA and DFA; Equation 2 below). Each factor was weighted equally and given a categorical score of 1–5 (Table 5-7).

The final collision vulnerability scores were rescaled to a 0–1 scale, divided into quartiles, and then translated into four final vulnerability categories (Table 5-6). As described in the PV section, the score is then considered along with information available in existing literature; if there is sufficient evidence to deviate from the quantitative score, a CV categorical range is assigned for each species.

$$CV = RSZt + MAc + (NFA + DFA)/2 \qquad \text{Equation 2}$$

Specifics for each factor in CV are as follows:

- RSZt is included in the score to account for the probability that a bird may fly through the RSZ. Flight height data was selected from the Northwest Atlantic Seabird Catalog, with additional data added from boat surveys in the Vineyard Wind 1 and New England Wind project areas. Flight heights calculated from digital aerial survey methods were excluded because the methods have not been validated (Thaxter et al. 2015) and the standard flight height data used in European collision assessments (Masden 2019) is modeled primarily from boat-based survey (Johnston et al. 2014). Three additional boat-based datasets were excluded because there was low confidence in the data (collected by citizen science efforts, less standardized, and of lower quality) or estimated flight heights only included part of the air space below 300 m (984 ft).

  Many of the boat-based datasets provided flight heights as categorical ranges for which the mid value of the range in meters were determined, as well as the lower and upper bounds of the category. Upper bounds that were given as greater than X m (or ft) were capped at 600 m (1969 ft) to estimate upper bounds. A few datasets provided exact flight height estimates which resulted in upper and lower ranges being the same as the mid value. A total of 100 randomized datasets were generated per species using the uniform distribution to select possible flight height values between lower and upper flight height bounds. Similar to methods from Johnston et al. (2014), flight heights were modeled using a smooth spline of the square root of the binned counts in 10-m (32-ft) bins. The integration of the smooth spline model count within each 1 m (3 ft) increment was calculated and the mean and standard deviation of all 100 models were calculated across all 1 m (3 ft) increments. The proportion of animals within each RSZ was estimated by summing the 1 m (3 ft) count integrations and dividing by the total estimate count of animals across all RSZ zones, then values were converted to a 1–5 scale based upon the categories used by Kelsey et al. (2018) (Table 5-7).

  The RSZ was defined by minimum and maximum WTG options being considered for Lease Area (two different power unit ranges at two different tower heights) (Table 5-8). The analysis was conducted in R Version 4.1.1.[14] Of note, there are several important uncertainties in flight height estimates: flight heights from boats can be skewed lower; flight heights are generally recorded during daylight and in fair weather; and flight heights may change when WTGs are present.

Table 5-8: WTG parameters used in the vulnerability analysis; mean Lower Low Water (MLLW) is the average height of the lowest tide recorded at a tide station each day during the recording period.

WTG Parameter	Envelope
Maximum tip height	400 m (1,312 ft) MLLW
Minimum tip clearance	27 m (89 ft) MLLW

- MAc is included in the score to account for macro-avoidance rates that would decrease collision risk. Macro-avoidance is defined as a bird's ability to change course to avoid the entire wind farm area (Kelsey et al. 2018), versus meso-avoidance (avoiding individual WTGs), and micro-avoidance (avoiding WTG blades) (Skov et al. 2018). The scores used in the assessment were based on Willmott et al. (2013), who conducted a literature review to determine known macro-avoidance rates and then converted them to a 1–5 score based upon the categories in Table 5-7.

- The MAc indicates that this factor is used in the CV versus the MAd, which was used in the displacement vulnerability (DV) score (described below). For the assessment conducted here, Willmott et al. (2013) avoidance rates were updated to reflect the most recent empirical studies (Cook et al. 2012; Cook et al. 2018; Krijgsveld et al. 2011; Vanermen et al. 2015), and indexes (Adams et al. 2016; Bradbury et al. 2014; Furness et al. 2013; Garthe and Hüppop 2004; Kelsey et al. 2018; Wade et al. 2016). For the empirical studies, the average avoidance was used when a range was provided in a paper. For the indices, the scores were converted to a continuous value using the median of a scores range; only one value was entered for related indices (e.g., Adams et al. 2016 and Kelsey et al. 2018). When multiple values were available for a species, the mean value was calculated. For some species, averaging the avoidance rates across both the empirical studies and indices led to some studies being counted multiple times. Indices were included to capture how the authors interpreted the avoidance studies and determined avoidance rates for species where data was not available. There are several important uncertainties in determining avoidances rates: the studies were all conducted in Europe; the studies were conducted at wind farms with WTGs much smaller than are

[14] R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

proposed for Lease Area; the methods used to record avoidance rates varied and included surveys, radar, and observers; the analytical methods used to estimate avoidance rates also varied significantly between studies; and the avoidance rate for species where empirical data is not available were assumed to be similar to closely-related species.

- NFA and DFA include scores of estimate percentage of time spent flying at night and during the day based upon the assumption that more time spent flying would increase collision risk. The NFA scores were taken directly from the scores, based upon literature review, from Willmott et al. (2013). The DFA scores were calculated from the baseline survey data that categorized if a bird was sitting or flying for each bird observation. Per Kelsey et al. (2018), the NFA and DFA scores were equally weighted and averaged.

5.2.3. Displacement Vulnerability

Rankings of DV account for two factors: (1) disturbance from ship/helicopter traffic and the wind farm structures (MAd), and (2) habitat flexibility (HF) (Furness et al. 2013; Kelsey et al. 2018). This assessment combines these two factors, weights them equally, and categorizes them from 1–5 (Equation 3 below) (Table 5-7).

It's worth noting that while Furness et al. (2013) down-weighted the DV score by dividing by 10 (they assumed displacement would have lower impacts on the population), the assessment conducted here maintains the two scores on the same scale. Empirical studies indicate that for some species, particularly sea ducks, avoidance behavior may change through time and that several years after projects have been built some individuals may forage within the wind farm. The taxonomic specific text indicates whether there is evidence that displacement may be partially temporary. The final displacement vulnerability scores are rescaled to a 0–1 scale, divided into quartiles, and translated into four final vulnerability categories (Table 5-6). As described in the PV section, the score is then considered along with the literature; if there is sufficient evidence to deviate from the quantitative score, a DV categorical range is assigned for each species.

$$DV = MAd + HF \qquad \text{Equation 3}$$

Specifics for each factor in DV are as follows:

- *MAd* is included to account for behavioral responses from birds that lead to macro-avoidance of wind farms, and that have the potential to cause effective habitat loss if the birds are permanently displaced (Fox et al. 2006). The MAd scores used in the assessment were based on Willmott et al. (2013), but updated to reflect the most recent empirical studies (Cook et al. 2012; Cook et al. 2018; Krijgsveld et al. 2011; Skov et al. 2018; Vanermen et al. 2015), and indexes (Adams et al. 2016; Bradbury et al. 2014; Furness et al. 2013; Garthe and Hüppop 2004; Kelsey et al. 2018; Wade et al. 2016). See MAc above for further details. The scores are the same as the MAc scores described above, but, following methods from Kelsey et al. (2018), are inverted so that a high avoidance rate (greater than 40%) is scored as a 5. Since the greater than 40% cutoff is a low threshold, many species can receive a high 5 score; there is a large range within this high category that includes species documented to have moderate avoidance rates (e.g., terns) and species with near complete avoidance (e.g., loons).

- *HF* accounts for the degree to which a species is considered a habitat generalist (i.e., can forage in a variety of habitats) or a specialist (i.e., requires specific habitat and prey type). The assumption is that generalists are less likely to be affected by displacement, whereas specialists are more likely to be affected (Kelsey et al. 2018). The values for HF used in this assessment were taken from Willmott et al. (2013). Note that Willmott et al. (2013) used a 1–5 scale plus a "0" to indicate that a species does not forage in the OCS.

5.3. Uncertainty

Uncertainty is recognized in this assessment for both exposure and vulnerability. Given the natural variability of ecosystems and recognized knowledge gaps, assessing how anthropogenic actions will affect the environment inherently involves a degree of uncertainty (Walker et al. 2003). Broadly defined, uncertainty is incomplete information about a subject (Masden et al. 2015) or a deviation from absolute determinism (Walker et al. 2003). In the risk assessment conducted here, uncertainty is broadly recognized as a factor in the process, and is accounted for by including, based upon the best available data, a range for the exposure, vulnerability, and population scores when appropriate. Furthermore, there is also uncertainty due to climate change, which may alter food webs, prey availability (Orgeret et al. 2022), and bird distribution in some areas. The long-term risk of climate change on birds, including sea level rise and extreme weather events, can be partially mitigated (Bateman et al. 2020) by wind energy (Barthelmie and Pryor 2021).

For offshore wind avian assessments, uncertainty primarily arises from two sources: predictions of bird use of a project area and region (i.e., exposure); and our understanding of how birds interact with WTGs (i.e., vulnerability). While uncertainty will always be present in any assessment of offshore wind, and acquiring data on bird movements during hours of darkness and in poor weather is difficult, overall knowledge on bird use of the marine environment has improved substantially in recent years through local survey efforts (e.g., MassCEC aerial surveys), revised regional modeling efforts (i.e., MDAT models), and individual tracking studies (e.g., falcons, terns, piping plover, red knot, diving birds). For many species, multiple data sources may be available to make an exposure assessment, such as survey and individual tracking data. If the data sources show differing patterns in use of the wind farm area, then a range of exposure is provided (e.g., minimal–low) to account for all available data and to capture knowledge gaps and general uncertainty about bird movements.

To quantify our 'confidence' in the exposure assessments, we developed a simple process by which we score each taxonomic group or listed species for the number of significant data sources available, those used in the exposure assessment itself, and those that support the result of the assessment. All species/group assessments start with information gleaned from available literature, including species accounts, published studies, incidental observations, and expert knowledge. Each species/group is then scored (1) for each additional data source (local baseline data, a regional database or distribution model, and spatial data from tracking studies), plus data sources that support the assessment (site-specific surveys), each of which is weighted equally (Table 5-10). These are tallied and the more resources contributing to or supporting the assessment, the higher the score, and the greater our confidence in the exposure assessment – 1 = Minimal, 2 = Low, 3 = Medium, 4 = High (Table 4-27).

Similarly, knowledge has been increasing on the vulnerability of birds to offshore wind facilities in Europe (e.g., Skov et al. 2018). Vulnerability assessments have either incorporated uncertainty into the scoring process to calculate a range of ranks (Willmott et al. 2013; Kelsey et al. 2018) or have developed separate standalone tables (Wade et al. 2016). In order to keep the scoring process as simple as possible, this assessment does not directly include uncertainty in the scoring, rather it uses the uncertainty assessment conducted by Wade et al. (2016) as a reference (Table 5-9) and references all available literature. Like exposure, if there is evidence in the literature, or from other data sources, that conflicts with the vulnerability score, the score will be adjusted up or down, as appropriate, to include a range that extends into the next category. This approach accounts for knowledge gaps and general uncertainty about vulnerability.

Table 5-9: Vulnerability uncertainty from Wade et al. (2016).

Species	Uncertainty Level: % of time at altitudes overlapping with turbine blades	Uncertainty Score	Uncertainty Level: Displacement caused by structures	Uncertainty Score	Uncertainty Level: Displacement caused by vessels and/or helicopters	Uncertainty Score	Uncertainty Level: Use of tidal races	Uncertainty Score	Overall Uncertainty Score (max 20)
European storm-petrel	Very high	1	Very high	1	High	2	Very high	1	5
Leach's storm-petrel	Very high	1	Very high	1	High	2	Very high	1	5
Sooty shearwater	Very high	1	Very high	1	High	2	Very high	1	5
Arctic skua	Moderate	3	Very high	1	Very high	1	Very high	1	6
Common goldeneye	Very high	1	Very high	1	High	2	High	2	6
Greater scaup	Very high	1	Very high	1	High	2	High	2	6
Manx shearwater	High	2	Very high	1	High	2	Very high	1	6
Slavonian grebe	Very high	1	High	2	High	2	Very high	1	6
White-tailed eagle	Very high	1	High	2	High	2	Very high	1	6
Great-crested grebe	High	2	High	2	High	2	Very high	1	7
Long-tailed duck	Very high	1	High	2	High	2	High	2	7
Roseate tern	Very high	1	High	2	High	2	High	2	7
Great skua	Moderate	3	High	2	High	2	Very high	1	8
Little tern	Very high	1	Moderate	3	Very high	1	Moderate	3	8
Velvet scoter	High	2	Very high	1	Moderate	3	High	2	8
Black-headed gull	Moderate	3	Moderate	3	High	2	Very high	1	9
Northern fulmar	Low	4	High	2	High	2	Very high	1	9
Arctic tern	Moderate	3	Moderate	3	High	2	High	2	10
Great northern diver	High	2	High	2	Very high	1	Very low	5	10
Little auk	Very high	1	Low	4	Low	4	Very high	1	10
Black-throated diver	High	2	Moderate	3	High	2	Low	4	11
Common gull	Low	4	Low	4	High	2	Very high	1	11
Common eider	Moderate	3	Moderate	3	Moderate	3	Moderate	3	12
Sandwich tern	Low	4	Low	4	High	2	High	2	12
Black guillemot	Very high	1	High	2	Very low	5	Very low	5	13
European shag	High	2	Low	4	High	2	Very low	5	13
Great black-backed gull	Low	4	Very low	5	Moderate	3	Very high	1	13
Great cormorant	Moderate	3	Very low	5	High	2	Moderate	3	13
Black-legged kittiwake	Very low	5	Very low	5	High	2	High	2	14
Common tern	Very low	5	Low	4	High	2	Moderate	3	14
Herring gull	Very low	5	Very low	5	Moderate	3	Very high	1	14
Lesser black-backed gull	Very low	5	Very low	5	Moderate	3	Very high	1	14
Northern gannet	Very low	5	Very low	5	High	2	High	2	14
Red-throated diver	Low	4	Low	4	High	2	Low	4	14
Common scoter	Low	4	Very low	5	Low	4	High	2	15
Atlantic puffin	Moderate	3	Moderate	3	Very low	5	Very low	5	16
Razorbill	Low	4	Very low	5	Very low	5	Low	4	18
Common guillemot	Low	4	Very low	5	Very low	5	Very low	5	19

Table 5-10: Description of data sources and their contribution to confidence scores.

Data Source	Description	Added to score
Literature	Species accounts, published studies, incidental observations, expert opinion	•
MDAT	Modeled spatial distributions and predicted relative densities across time	1
Baseline	Regional ecological baseline data, either historical (>10 years) or recent	1
Site-specific	Local baseline data that specifically overlaps the development area (recent)	1
Tracking	Spatial data from tracking studies, including VHF (Motus), GPS, or satellite	1
Scores: 1 = Minimal, 2 = Low, 3 = Medium, 4 = High		

6. References

Adams J, Kelsey EC, Felis JJ, Pereksta DM. 2016. Collision and displacement vulnerability among marine birds of the California Current System associated with offshore wind energy infrastructure: U.S. Geological Survey Open-File Report 2016-1154, 116 p., http://dx.doi.org/10.3133/ofr20161154. https://www.boem.gov/2016-043/.

Ainley DG, Nettleship DN, Carter HR, Storey AE. 2002. Common Murre (Uria aalge). Poole A, editor. The Birds of North America Online. 666. doi:10.2173/bna.666. http://bna.birds.cornell.edu/bna/species/666.

American Wind Wildlife Institute. 2016. Wind Turbine Interactions with Wildlife and Their Habitats: A Summary of Research Results and Priority Questions. (Updated June 2016). Washington, DC. Available at www.awwi.org.

Amirault-Langlais DL, Imlay TL, Boyne AW. 2014. Dispersal Patterns Suggest Two Breeding Populations of Piping Plovers in Eastern Canada. The Wilson Journal of Ornithology. 126(2):352–359. doi:10.1676/13-056.1.

Atwood J. 2022. Fall pre-migratory staging areas of Roseate Terns (Sterna dougallii) in northeastern North America, 1971-2020. Wilson Journal of Ornithology. 134:124–132.

Bachl FE, Lindgren F, Borchers DL, Illian JB. 2019. inlabru: an R package for Bayesian spatial modelling from ecological survey data. Methods in Ecology and Evolution. 10(6):760–766. doi:10.1111/2041-210X.13168.

Baker A, Gonzalez P, Morrison RIG, Harrington BA. 2020. Red Knot (*Calidris canutus*), version 1.0. In: Billerman SM, editor. Birds of the World. Ithaca, NY, USA: Cornell Lab of Ornithology. https://doi-org.uri.idm.oclc.org/10.2173/bow.redkno.01.

Baldassarre GA, Bolen EG. 2006. Waterfowl Ecology and Management. 2nd ed. Malabar FL: Krieger.

Band W. 2012. Using a collision risk model to assess bird collision risk for offshore windfarms. SOSS-02. Report to The Crown Estate Commission, London UK. 62 pp. https://www.bto.org/sites/default/files/u28/downloads/Projects/Final_Report_SOSS02_Band1ModelGuidance.pdf.

Bateman, BL, Taylor, L, Wilsey, C, Wu, J, LeBaron, GS, Langham, G. Risk to North American birds from climate change-related threats. *Conservation Science and Practice*. 2020; 2:e243. https://doi.org/10.1111/csp2.243

Barthelmie, Rebecca J., and Sara C. Pryor. 2021. Climate Change Mitigation Potential of Wind Energy. *Climate* 9, no. 9: 136. https://doi.org/10.3390/cli9090136

BirdLife International. 2018. *Pterodroma hasitata* . The IUCN Red List of Threatened Species 2018: e.T22698092A132624510. https://www.iucnredlist.org/species/22698092/132624510.

Bureau of Ocean Energy Management. 2014. Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore Massachusetts: Revised Environmental Assessment. OCS EIS/EA BOEM 2014-603. US Department of the Interior, Bureau of Ocean Energy Management, Herndon, VA. 674 pp.

Bureau of Ocean Energy Management. 2016. Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New York: Revised Environmental Assessment. OCS EIS/EA BOEM 2016-070.

Bureau of Ocean Energy Management. 2018. Vineyard Wind Offshore Wind Energy Project Draft Environmental Impact Statement. OCS EIS/EA BOEM 2018-060. U.S. Department of the Interior, Bureau of Ocean Energy Management, Headquarters, Herndon, VA. 478 pp.

Bureau of Ocean Energy Management. 2019. Vineyard Wind Offshore Wind Energy Project biological assessment: Final. Report by U.S. Department of the Interior, Bureau of Ocean Energy Management for the U.S. Fish and Wildlife Service. 51 pp.

Bureau of Ocean Energy Management (BOEM). 2021. Vineyard Wind 1 Offshore Wind Energy Project Final Environmental Impact Statement Volume II. OCS EIS/EA BOEM 2021-0012. p. 642.

Bowman TD, Churchill JL, Lepage C, Badzinski SS, Gilliland SG, McLellan N, Silverman E. 2022a. Atlas of sea duck key habitat sites in North America. Sea Duck Joint Venture March 2022.

Bruderer B, Lietchi F. 1999. Bird migration across the Mediterranean. In: Adams NJ, Slotow RH, editors. Proceedings of the 22nd International Ornithological Congress. Durban, Johannesburg, South Africa. p. 1983–1999.

Buehler DA. 2020. Bald Eagle (*Haliaeetus leucocephalus*), version 1.0. In: Poole AF, Gill FB, editors. Birds of the World. Ithaca, NY: Cornell Lab of Ornithology. https://doi-org.uri.idm.oclc.org/10.2173/bow.baleag.01.

Bull LS, Fuller S, Sim D. 2013. Post-construction avian mortality monitoring at Project West Wind. New Zealand Journal of Zoology. 40(1):28–46. doi:10.1080/03014223.2012.757242.

Burger J. 2015. Laughing Gull (*Leucophaeus atricilla*). In: Rodewald PG, editor. The Birds of North America. Cornell Lab of Ornithology, Ithaca, NY, USA.

Burger J, Gordon C, Lawrence J, Newman J, Forcey G, Vlietstra L. 2011. Risk evaluation for federally listed (roseate tern, piping plover) or candidate (red knot) bird species in offshore waters: A first step for managing the potential impacts of wind facility development on the Atlantic Outer Continental Shelf. Renewable Energy. 36(1):338–351. doi:10.1016/j.renene.2010.06.048.

Burger J, Niles LJ, Porter RR, Dey AD, Kock S, Gordon C. 2012. Migration and Over-Wintering of Red Knots (*Calidris canutus rufa*) along the Atlantic Coast of the United States. Condor. 114(2):302–313. doi:10.1525/cond.2012.110077.

Canty A, Ripley B. 2021. boot: Boostrap R (S-Plus) Functions. R package.

Chamberlain DE, Rehfisch MR, Fox AD, Desholm M, Anthony SJ. 2006. The Effect of Avoidance Rates on Bird Mortality Predictions Made by Wind Turbine Collision Risk Models. Ibis. 148:198–202. doi:10.1111/j.1474-919X.2006.00507.x.

Chesser RT, Burns KJ, Cicero C, Dunn JL, Kratter AW, Lovette IJ, Rasmussen PC, Remsen Jr. JV, Stotz DF, Winker K. 2019. Check-list of North American Birds (online). American Ornithological Society.

Choi DY, Wittig TW, Kluever BM. 2020. An evaluation of bird and bat mortality at wind turbines in the Northeastern United States. PLoS ONE. 15(8).

Cleasby IR, Wakefield ED, Bearhop S, Bodey TW, Votier SC, Hamer KC. 2015. Three-dimensional tracking of a wide-ranging marine predator: Flight heights and vulnerability to offshore wind farms. Journal of Applied Ecology. 52(6):1474–1482. doi:10.1111/1365-2664.12529.

Cochran William W. 1985. Ocean migration of Peregrine Falcons: is the adult male pelagic? In: Harwood M, editor. Proceedings of Hawk Migration Conference IV. Rochester, NY: Hawk Migration Association of North America. p. 223–237.

Cook Aonghais S C P, Johnston A, Wright LJ, Burton NHK. 2012. A Review of Flight Heights and Avoidance Rates of Birds in Relation to Offshore Wind Farms. BTO Research Report Number 618. British Trust for Ornithology, Thetford, UK. 61 pp. http://www.bto.org/sites/default/files/u28/downloads/Projects/Final_Report_SOSS02_BTOReview.pdf.

le Corre M, Ollivier A, Ribes S, Jouventin P, Anonymous. 2002. Light-induced mortality of petrels: A 4-year study from Réunion Island (Indian Ocean). Biological Conservation. 105(1):93–102. http://www.scopus.com/scopus/inward/record.url?eid=2-s2.0-0036128791&partner=40&rel=R5.0.4.

Cottam C. 1939. Food habits of North American diving ducks. US Department of Agriculture Technical Bulletin. 140.

Curtice C, Cleary J, Scumchenia E, Halpin PN. 2019. Marine-life Data and Analysis Team (MDAT) technical report on the methods and development of marine-life data to support regional ocean planning and management. Prepared on behalf of the Marine-life Data and Analysis Team (MDAT).

Curtice C, Cleary J, Shumchenia E, Halpin P. 2016. Marine-life Data and Analysis Team (MDAT) Technical Report on the Methods and Development of Marine-Life Data to Support Regional Ocean Planning and Management. Prepared on behalf of the Marine-life Data and Analysis Team (MDAT).

Deluca WV, Woodworth BK, Rimmer CC, Marra PP, Taylor PD, Mcfarland KP, Mackenzie SA, Norris DR. 2015. Transoceanic migration by a 12g songbird. Biology Letters. 11:1–4.

Desholm M, Kahlert J. 2005. Avian collision risk at an offshore wind farm. Biology Letters. 1(3):296–298.

DeSorbo CR, Gray RB, Tash J, Gray CE, Williams K.A., Riordan D. 2015. Offshore Migration of Peregrine Falcons (*Falco peregrinus*) Along the Atlantic Flyway. In Wildlife Densities and Habitat Use Across Temporal and Spatial Scales on the Mid-Atlantic Outer Continental Shelf: Final Report to the Department of Energy EER. Williams Kathryn A., Connelly EE, Johnson SarahM, Stenhouse IJ, editors. Award Number: DE-EE0005362. Report BRI 2015-11, Biodiversity Research Institute, Portland, Maine. 28 pp.

DeSorbo C.R., Martin C, Gravel A, Tash J, Gray R, Persico C, Gilpatrick L, Hanson W. 2018. Documenting Home Range, Migration Routes and Wintering Home Range of Breeding Peregrine Falcons in New Hampshire. A joint report prepared by Biodiversity Research Institute, Stantec Consulting Inc. and New Hampshire Audubon, submitted to Stantec Consulting Inc., Research and Development Grant Program. Biodiversity Research Institute, Portland Maine. http://www.briloon.org/breedingperegrines.

DeSorbo C. R., Persico C, Gilpatrick L. 2018. Studying migrant raptors using the Atlantic Flyway. Block Island Raptor Research Station, Block Island, RI: 2017 season. BRI Report # 2018-12 submitted to The Nature Conservancy, Block Island, Rhode Island, and The Bailey Wildlife Foundation, Cambridge, Massachusetts. Biodiversity Research Institute, Portland, Maine. 35 pp.

Desorbo CR, Persico C, Gray RB, Gilpatrick L. 2017. Studying migrant raptors using the Atlantic Flyway. Block Island Raptor Research Station, RI: 2016 season. BRI Report #2017-08 submitted to

The Nature Conservancy, Block Island, and The Bailey Wildlife Foundation, Cambridge, Massachusetts. Biodiversity Research Institute, Portland, Maine. 34 pp.

DeSorbo CR, Wright KG, Gray R. 2012. Bird migration stopover sites: ecology of nocturnal and diurnal raptors at Monhegan Island. Report BRI 2012-09 submitted to the Maine Outdoor Heritage Fund, Pittston, Maine, and the Davis Conservation Foundation, Yarmouth, Maine. Biodiversity Research Institute, Gorham, Maine. 43 pp. http://www.briloon.org/raptors/monhegan.

Dierschke V, Furness RW, Garthe S. 2016. Seabirds and offshore wind farms in European waters: Avoidance and attraction. Biological Conservation. 202:59–68. doi:10.1016/j.biocon.2016.08.016.

DiGaudio R, Geupel GR. 2014. Assessing Bird and Bat Mortality at the McEvoy Ranch Wind Turbine in Marin County, California, 2009-2012. Point Blue Conservation Science.

Dolinski L. 2019. Landscape Factors Affecting Foraging Flight Altitudes of Great Blue Heron in Maine; Relevance to Wind Energy Development. Orono, ME: University of Maine.

Dorr BS, Hatch JJ, Weseloh DV. 2020. Double-crested Cormorant (*Phalacrocorax auritus*), version 1.0. In: Poole AF, editor. Birds of the World. Ithaca, NY, USA: Cornell Lab of Ornithology. https://doi-org.uri.idm.oclc.org/10.2173/bow.doccor.01.

Douglas DC, Weinzierl R, C. Davidson S, Kays R, Wikelski M, Bohrer G. 2012. Moderating Argos location errors in animal tracking data. Methods in Ecology and Evolution. 3(6):999–1007. doi:10.1111/j.2041-210X.2012.00245.x.

Drury WH, Keith JA. 1962. Radar studies of songbird migration in coastal New England. Ibis. 104(4):449–489.

Dürr T. 2011. Bird loss of wind turbines in Germany: data from the central register of the National Fund Ornithological Station State Office for Environment Office, Health and Consumer Protection, Brandenburg, Germany.

eBird. 2018. eBird: An online database of bird distribution and abundance [web application]. Cornell Lab of Ornithology, Ithaca, New York. [accessed 2018 Oct 22]. http://www.ebird.org.

Elliott-Smith E, Haig SM. 2004. Piping Plover (*Charadrius melodus*), version 2.0. In: The Birds of North America (A.F. Poole, Editor). Ithaca, NY, USA: Cornell Lab of Ornithology. https://doi.org/10.2173/bna.2

Elliott-Smith E, Haig SM. 2020. Piping Plover (*Charadrius melodus*), version 1.0. In: The Birds of the World (A.F. Poole, Editor). Ithaca, NY, USA: Cornell Lab of Ornithology. https://doi-org.uri.idm.oclc.org/10.2173/bow.pipplo.01.

Erickson WP, Jeffrey JD, Poulton VK. 2008. Puget Sound Energy Wild Horse Wind Facility Post-Construction Avian and Bat Monitoring. First Annual Report. January - December 2007. Puget Sound Energy.

Erickson WP, Wolfe MM, Bay KJ, Johnson DH, Gehring JL. 2014. A comprehensive analysis of small-passerine fatalities from collision with turbines at wind energy facilities. PLoS ONE. 9(9):e107491. doi:10.1371/journal.pone.0107491.

Everaert J, Stienen EWM. 2007. Impact of wind Turbines on birds in Zeebrugge (Belgium): significant effect on breeding tern colony due to collisions. Biodiversity & Conservation. 16:3345–3359. doi:10.1007/s10531-006-9082-1.

Evers DC, Paruk JD, McIntyre JW, Barr JF. 2020. Common Loon (*Gavia immer*). verson 10 In Birds of the World (S M Billerman, Editor) Cornell Lab of Ornithology, Ithaca, NY, USA.

Faaborg John, Holmes RT, Anders AD, Bildstein KL, Dugger KM, Gauthreaux SA, Heglund P, Hobson KA, Jahn AE, Johnson DH, et al. 2010. Recent advances in understanding migration systems of New World land birds. Ecological Monographs. 80(1):3–48. doi:10.1890/09-0395.1.

Fliessbach KL, Borkenhagen K, Guse N, Markones N, Schwemmer P, Garthe S. 2019. A ship traffic disturbance vulnerability index for Northwest European seabirds as a tool for marine spatial planning. Front Mar Sci. 6:192. doi:10.3389/fmars.2019.00192.

Fox AD, Desholm M, Kahlert J, Christensen TK, Petersen IK. 2006. Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds. Ibis. 148:129–144. doi:10.1111/j.1474-919X.2006.00510.x.

Fox AD, Petersen IK. 2019. Offshore wind farms and their effects on birds. Dansk Orn Foren Tidsskr. 113:86–101.

Fraser D. 2017 Jun. Seabirds Washing Up and Dying on Cape Cod Beaches. Cape Cod Times.

Frederick PC. 2001. Birds in the Marine Environment. In: Schreiber EA, Burger J, editors. Biology of Marine Birds. Boca Raton, FL.: CRC Press. p. 617–655.

Fuglstad GA, Simpson D, Lindgren F, Rue H. 2018. Constructing Priors that Penalize the Complexity of Gaussian Random Fields. https://doi.org/101080/0162145920171415907. 114(525):445–452. doi:10.1080/01621459.2017.1415907.

Furness RW, Wade HM, Masden EA. 2013. Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management. 119:56–66. doi:10.1016/j.jenvman.2013.01.025.

Garthe S, Guse N, Montevecchi WA, Rail JF, Grégoire F. 2014. The daily catch: Flight altitude and diving behavior of northern gannets feeding on Atlantic mackerel. Journal of Sea Research. 85:456–462. doi:10.1016/j.seares.2013.07.020.

Garthe S., Hüppop O. 2004. Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. Journal of Applied Ecology. 41(4):724–734. doi:10.1111/j.0021-8901.2004.00918.x.

Gaston AJ, Jones IL. 1998. The Auks: Alcidae. Bird Families of the World, vol. 5. Oxford: Oxford University Press.

Gauthreaux SA, Belser CG. 1999. Bird migration in the region of the Gulf of Mexico. In: Adams NJ, Slotow RH, editors. Proceedings of the 22nd International Ornithological Congress. Durban, Johannesburg, South Africa: BirdLife South Africa. p. 1931–1947.

Goetz JE, Norris JH, Wheeler JA. 2012. Conservation Action Plan for the Black-capped Petrel (*Pterodroma hasitata*). http://www.fws.gov/birds/waterbirds/petrel.

Good TP. 1998. Great Black-backed Gull (Larus marinus). In: Rodewald PG, editor. The Birds of North America. Ithaca, NY: Cornell Lab of Ornithology.

Goodale MW, Stenhouse IJ. 2016. A conceptual model to determine vulnerability of wildlife populations to offshore wind energy development. Human-Wildlife Interactions. 10(1):53–61. doi:10.26077/1d31-m472.

Goyert HF, Manne LL, Veit RR. 2014. Facilitative interactions among the pelagic community of temperate migratory terns, tunas and dolphins. Oikos. 123(March):1400–1408. doi:10.1111/oik.00814.

Haney JC. 1987. Aspects of the pelagic ecology and behavior of the Black-capped Petrel. The Wilson Bulletin. 99(2):153–168.

Hartman JC, Krijgsveld KL, Poot MJM, Fijn RC, Leopold MF, Dirksen S. 2012. Effects on birds of Offshore Wind farm Egmond aan Zee (OWEZ). An overview and integration of insights obtained. Report 12-005. Bureau Waardenburg, Culemborg, Netherlands.

Hass T, Hyman J, Semmens BX. 2012. Climate change, heightened hurricane activity, and extinction risk for an endangered tropical seabird, the black-capped petrel Pterodroma hasitata. Marine Ecology Progress Series. 454:251–261. doi:10.3354/meps09723.

Hein CD, Prichard A, Mabee T, Schirmacher MR. 2013. Avian and Bat Post-construction Monitoring at the Pinnacle Wind Farm, Mineral County, West Virginia: 2012 Final Report. An annual report submitted to Edison Mission Energy and the Bats and Wind Energy Cooperative. Bat Conservation International, Austin, TX. 45pp.

Hijmans RJ. 2020. raster: Geographic Data Analysis and Modeling. R package version 3.3-13. https://CRAN.R-project.org/package=raster.

Hill JM, Sandercock BK, Renfrew RB. 2019. Migration Patterns of Upland Sandpipers in the Western Hemisphere. Frontiers in Ecology and Evolution. 7(November):1–18. doi:10.3389/fevo.2019.00426.

Hill R, Hill K, Aumuller R, Schulz A, Dittmann T, Kulemeyer C, Coppack T. 2014. Of birds, blades, and barriers: Detecting and analysing mass migration events at alpha ventus. In: Federal Maritime and Hydrographic Agency, Federal Ministry of the Environment Nature Conservation and Nuclear Safety, editors. Ecological Research at the Offshore Windfarm alpha ventus. Berlin, Germany: Springer Spektrum. p. 111–132.

Holberton RL, Taylor PD, Tudor LM, O'Brien KM, Mittelhauser GH, Breit A. 2019. Automated VHF radiotelemetry revealed site-specific differences in fall migration strategies of Semipalmated Sandpipers on stopover in the Gulf of Maine. Frontiers in Ecology and Evolution. 7:1–14. doi:10.3389/fevo.2019.00327.

Hötker H, Thomsen K-M, Jeromin H. 2006. Impacts on Biodiversity of Exploitation of Renewable Energy Sources: The Example of Birds and Bats. - Facts, Gaps in Knowledge, Demands for Further Research, and Ornithological Guidelines for the Development of Renewable Energy Exploitation. Michael-Otto-Institut im NABU, Bergenhusen. 65 pp. http://mhk.pnl.gov/publications/impacts-biodiversity-exploitation-renewable-energy-sources.

Howell JE, McKellar AE, Espie RHM, Morrissey CA. 2019 Aug 19. Predictable shorebird departure patterns from a staging site can inform collision risks and mitigation of wind energy developments. Ibis. doi:10.1111/ibi.12771.

Hüppop O, Dierschke J, Exo K-M, Fredrich E, Hill R. 2006. Bird migration studies and potential collision risk with offshore wind turbines. Ibis. 148:90–109. doi:10.1111/j.1474-919X.2006.00536.x.

Hüppop O, Hilgerloh G. 2012. Flight call rates of migrating thrushes: effects of wind conditions, humidity and time of day at an illuminated offshore platform. Journal of Avian Biology. 43:85–90.

Imber MJ. 1975. Behaviour of petrels in relation to the Moon and artificial lights. Notornis. 22(4):302–306.

Jacobsen EM, Jensen FP, Blew J. 2019. Avoidance Behaviour of Migrating Raptors Approaching an Offshore Wind Farm. In: Bispo R, Bernardino J, Coelho H, Lino Costa J, editors. Wind Energy and Wildlife Impacts: Balancing Energy Sustainability with Wildlife Conservation. Cham: Springer International Publishing. p. 43–50. https://doi.org/10.1007/978-3-030-05520-2_3.

Jensen F, Laczny M, Piper W, Coppack T. 2014. Horns Rev 3 Offshore Wind Farm - Migratory Birds. Orbicon, Rosklide, Denmark. http://www.4coffshore.com/windfarms/horns-rev-1-denmark-dk03.html.

Jodice PGR, Ronconi RA, Rupp E, Wallace GE, Satgé Y. 2015. First satellite tracks of the Endangered Black-capped Petrel. Endangered Species Research. 29:23–33. doi:10.3354/esr00697.

Johnson JA, Storrer J, Fahy K, Reitherman B. 2011. Determining the Potential Effects of Artificial Lighting from Pacific Outer Continental Shelf (POCS) Region Oil and Gas Facilities on Migrating Birds. Prepared by Applied Marine Sciences, Inc. and Storrer Environmental Services for the U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulations and Enforcement. Camarillo, CA. OCS Study BOEMRE 2011-047. 29 pp.

Johnston A, Cook ASCP, Wright LJ, Humphreys EM, Burton NHK. 2014. Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Frederiksen M, editor. Journal of Applied Ecology. 51(1):31–41. doi:10.1111/1365-2664.12191.

Jongbloed RH. 2016. Flight height of seabirds. A literature study IMARES. Report C024/16.

Kahlert I, Fox A, Desholm M, Clausager I, Petersen J. 2004. Investigations of Birds During Construction and Operation of Nysted Offshore Wind Farm at Rødsand. Report by National Environmental Research Institute (NERI). pp 88.

Katzner TE, Brandes D, Miller T, Lanzone M, Maisonneuve C, Tremblay JA, Mulvihill R, Merovich GT. 2012. Topography drives migratory flight altitude of golden eagles: Implications for on-shore wind energy development. Journal of Applied Ecology. 49(Hunt 2002):1178–1186. doi:10.1111/j.1365-2664.2012.02185.x.

Kelsey EC, Felis JJ, Czapanskiy M, Pereksta DM, Adams J. 2018. Collision and displacement vulnerability to offshore wind energy infrastructure among marine birds of the Pacific Outer Continental Shelf. Journal of Environmental Management. 227:229–247. doi:10.1016/j.jenvman.2018.08.051.

Kerlinger P. 1985. Water-crossing behavior of raptors during migration. Wilson Bulletin. 97(1):109–113.

Kettel EF, Gentle LK, Yarnell RW. 2016. Evidence of an urban Peregrine Falcon (*Falco peregrinus*) feeding young at night. Journal of Raptor Research. 50(3):321–323. doi:10.3356/JRR-16-13.1.

Kochert MN, Steenhof K, McIntyre CL, Craig EH. 2002. Golden Eagle (Aquila chrysaetos). In: Poole A, Gill F, editors. The Birds of North America, No. 684. Philadelphia, PA. p. 44.

Krainski E, Gómez-Rubio V, Bakka H, Lenzi A, Castro-Camilo D, Simpson D, Lindgren F, Rue H. 2018 Dec 7. Advanced Spatial Modeling with Stochastic Partial Differential Equations Using R and INLA. Advanced Spatial Modeling with Stochastic Partial Differential Equations Using R and INLA. doi:10.1201/9780429031892.

Kranstauber B, Kays R, Lapoint SD, Wikelski M, Safi K. 2012. A dynamic Brownian bridge movement model to estimate utilization distributions for heterogeneous animal movement. The Journal of Animal Ecology. 81(4):738–46. doi:10.1111/j.1365-2656.2012.01955.x.

Kranstauber B, Smolla M. 2016. Move: Visualizing and Analyzing Animal Track Data. R package version 2.1.0. https://cran.r-project.org/package=move.

Krijgsveld KL, Fljn RC, Japink M, van Horssen PW, Heunks C, Collier MP, Poot MJM, Beuker D, Birksen S. 2011. Effect Studies Offshore Wind Farm Egmond aan Zee: Final Report on Fluxes, Flight Altitudes and Behaviour of Flying Birds. Bureau Waardenburg report no. 10-219. Institute for Marine Resources & Ecosystem Studies, Wageningen UR, Netherlands.

Langston RHW. 2013. Birds and wind projects across the pond: A UK perspective. Wildlife Society Bulletin. 37(1):5–18. doi:10.1002/wsb.262.

Larsen JK, Guillemette M. 2007. Effects of wind turbines on flight behaviour of wintering common eiders: implications for habitat use and collision risk. Journal of Applied Ecology. 44:516–522. doi:10.1111/j.1365-2664.2007.1303.x.

Lavers J, Hipfner M, Chapdelaine G, Hipfner JM. 2009. Razorbill (Alca torda). Poole A, editor. The Birds of North America Online. (635). doi:10.2173/bna.635. http://bna.birds.cornell.edu/bna/species/635.

Lee DS. 1989. Jaegers and skuas in the Western North Atlantic: some historical misconceptions. American Birds. 43(1):18–20.

Lee DS. 2000. Status and Conservation Priorities for Black-capped Petrels in the West Indies. In: Schreiber EA, Lee DS, editors. Status and Conservation of West Indian Seabirds. Special Pu. Ruston, LA: Society of Caribbean Ornithology. p. 11–18.

Leonhard SB, Pedersen J, Gron PN, Skov H, Jansen J, Topping C, Petersen IK. 2013. Wind farms affect common scoter and red-throated diver behaviour. In: Danish Offshore Wind: Key Environmental Issues - A Follow-up. The Environment Group: The Danish Energy Agency. The Danish Nature Agency, DONG Energy and Vattenfall. p. 70–93.

Limeburner R, Beardsley RC. 1982. The seasonal hydrography and circulation over Nantucket Shoals. Journal of Marine Research. 40:371–406.

Lindeboom H.J., Kouwenhoven HJ, Bergman MJN, Bouma S, Brasseur S, Daan R, Fijn RC, de Haan D, Dirksen S, van Hal R, et al. 2011. Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environmental Research Letters. 6(3):035101. doi:10.1088/1748-9326/6/3/035101.

Lindgren F, Rue H. 2015. Bayesian Spatial Modelling with R - INLA . Journal of Statistical Software. 63(19). doi:10.18637/jss.v063.i19.

Lindgren F, Rue H, Lindstrom J. 2011. An explicit link between gaussian fields and gaussian Markov random fields: the stochastic partial differential equation approach (with discussion). Journal of the Royal Statistical Society B. 73(4):423–498. doi:10.1111/j.1467-9868.2011.00777.x.

Loring P, Goyert H, Griffin C, Sievert P, Paton P. 2017. Tracking Movements of Common Terns, Endangered Roseate Terns, and Threatened Piping Plovers in the Northwest Atlantic. 2017 Annual Report to the Bureau of Ocean Energy Management. US Fish and Wildlife Service, Hadley, MA. 134 pp.

Loring PH, Lenske AK, McLaren JD, Aikens M, Anderson AM, Aubrey Y, Dalton E, Dey A, Friis C, Hamilton D, et al. 2020. Tracking Movements of Migratory Shorebirds in the U.S. Atlantic Outer Continental Shelf Region Tracking Movements of Migratory Shorebirds in the US Atlantic Outer Continental Shelf Region. Sterling (VA): US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2021-008.

Loring PH, McLaren JD, Smith PA, Niles LJ, Koch SL, Goyert HF, Bai H. 2018. Tracking Movements of Threatened Migratory rufa Red Knots in U.S. Atlantic Outer Continental Shelf Waters. OCS Study BOEM 2018-046. US Department of the Interior, Bureau of Ocean Energy Management, Sterling (VA) 145 pp. OCS Study BOEM 2018-046. U.S. Department of the Interior, Bureau of Ocean Energy Management, Sterling, VA. 145 pp.

Loring PH, Paton PWC, McLaren JD, Bai H, Janaswamy R, Goyert HF, Griffin CR, Sievert PR. 2019. Tracking offshore occurrence of Common Terns, endangered Roseate Terns, and threatened Piping Plovers with VHF arrays. OCS Study BOEM 2019-017. US Department of the Interior, Bureau of Ocean Energy Management, Sterling, VA. 140 pp.

Loring PH, Paton PWC, Osenkowski JE, Gilliland SG, Savard J-PL, Mcwilliams SR. 2014. Habitat use and selection of black scoters in southern New England and siting of offshore wind energy facilities. The Journal of Wildlife Management. 78(4):645–656. doi:10.1002/jwmg.696.

Lowther PE, Diamond AW, Kress SW, Robertson GJ, Russell K. 2002. Atlantic Puffin (*Fratercula arctica*). In: Rodewald PG, editor. The Birds of North America. Ithaca, NY: Cornell Lab of Ornithology.

MA DFW (Massachusetts Division of Fisheries and Wildlife). 2016. Habitat Conservation Plan for Piping Plovers. Westborough, MA.

Martell MS, Douglas D. 2019. Data from: Fall migration routes, timing, and wintering sites of North American Ospreys as determined by satellite telemetry. Movebank Data Repository. doi:doi:10.5441/001/1.sv6335t3.

Martell MS, Henny CJ, Nye PE, Solensky MJ. 2001. Fall migration routes, timing, and wintering sites of North American Ospreys as determined by satellite telemetry. Condor. 103(4):715–724. doi:doi:10.1650/0010-5422(2001)103[0715:FMRTAW]2.0.CO;2 url:https://sora.unm.edu/node/54078.

Masden EA. 2019. Avian Stochastic CRM v2.3.1.

Masden EA, Haydon DT, Fox AD, Furness RW, Bullman R, Desholm M. 2009. Barriers to movement: impacts of wind farms on migrating birds. ICES Journal of Marine Science. 66(4):746–753. doi:10.1093/icesjms/fsp031.

MassWildlife. 2018. Summary of the 2017 Massachusetts Piping Plover Census. https://www.mass.gov/files/documents/2018/01/25/Plover census report Mass 2017 FINAL.pdf.

MassWildlife. 2021. Summary of the 2020 Massachusetts Piping Plover Census. Westborough, MA.

Mateos-Rodríguez M, Liechti F. 2012. How do diurnal long-distance migrants select flight altitude in relation to wind? Behavioral Ecology. 23(2):403–409. doi:10.1093/beheco/arr204.

McGrady MJ, Young GS, Seegar WS. 2006. Migration of a Peregrine Falcon *Falco peregrinus* over water in the vicinity of a hurricane. Ringing and Migration. 23:80–84.

Meattey DE. 2018. Annual cycle phenology and winter habitat selection of white-winged scoters in eastern North America. University of Rhode Island.

Meattey D.E., Mcwilliams SR, Paton PWC, Lepage C, Gilliland SG, Savoy L, Olsen GH, Osenkowski JE. 2019. Resource selection and wintering phenology of White-winged Scoters in southern New England : Implications for offshore wind energy development. 121:1–18. doi:10.1093/condor/duy014.

Meek ER, Ribbands JB, Christer WG, Davy PR, Higginson I. 1993. The effects of aero-generators on moorland bird populations in the Orkney Islands, Scotland. Bird Study. 40(2):140–143. doi:10.1080/00063659309477139.

Mendel B, Schwemmer P, Peschko V, Müller S, Schwemmer H, Mercker M, Garthe S. 2019. Operational offshore wind farms and associated ship traffic cause profound changes in distribution patterns of Loons (*Gavia* spp.). Journal of Environmental Management. 231:429–438. doi:10.1016/j.jenvman.2018.10.053.

Mendelsohn JM, Kemp AC, Biggs HC, Biggs R, Brown CJ. 1989. Wing areas, wing loadings and wing spans of 66 species of African raptors. Ostrich. 60:35–42.

Minerals Management Service. 2008. Cape Wind Energy Project Nantuckt Sound: Biological Assessment. https://www.boem.gov/Renewable-Energy- Program/Studies/FEIS/Appendix-G---May-2008-Cape-Wind-Final-BA.aspx.

Mizrahi D, Fogg R, Peters KA, Hodgetts PA. 2009. Assessing nocturnal bird and bat migration patterns on the Cape May peninsula using marine radar: potential effects of a suspension bridge spanning Middle Thoroughfare, Cape May County, New Jersey. :240.

[MMS] Minerals Management Service. 2007. Programmatic Environmental Impact Statement for alternative energy development and production and alternate use of facilities on the Outer Continental Shelf: Final Environmental Impact Statement. OCS EIS/EA MMS 2007-046. U.S. Department of the Interior Minerals Management Service.

Mojica EK, Meyers JM, Millsap B a., Haley KL. 2008. Migration Of Florida Sub-Adult Bald Eagles. The Wilson Journal of Ornithology. 120(2):304–310. doi:10.1676/07-079.1. http://www.bioone.org/doi/abs/10.1676/07-079.1.

Mojica EK, Watts BD, Turrin CL. 2016. Utilization probability map for migrating Bald Eagles in Northeastern North America: a tool for siting wind energy facilities and other flight hazards. Plos One. 11(6). doi:10.1371/journal.pone.0157807.

Møller J, Waagepetersen RP. 2007. Modern Statistics for Spatial Point Processes*. Scandinavian Journal of Statistics. 34(4):643–684. doi:10.1111/J.1467-9469.2007.00569.X.

Montevecchi WA. 2006. Influences of artificial light on marine birds. In: Rich C, Longcore T, editors. Ecological Consequences of Artificial Night Lighting. Washington, D.C.: Island Press. p. 94–113.

Morris SR, Richmond ME, Holmes DW. 1994. Patterns of stopover by warblers during spring and fall migration on Appledore Island, Maine. Wilson Bulletin. 106(4):703–718.

Mostello CS, Nisbet ICT, Oswald SA, Fox JW. 2014. Non-breeding season movements of six North American Roseate Terns Sterna dougallii tracked with geolocators. Seabird. 27(2014):1–21.

Mostello CS, Walker K, Veinotte A, Longsdorf J. 2019. Inventory of Terns, Laughing Gulls, and Black Skimmers Nesting in Massachusetts in 2017. Massachusetts Division of Fisheries & Wildlife.

Mowbray TB. 2002. Northern Gannet (*Morus bassanus*). In: Poole A, Gill F, editors. The Birds of North America. Philadelphia, PA: The Birds of North America Inc.

Murie OJ. 1940. Food habits of the northern Bald Eagle in the Aleutian Islands, Alaska. Condor. 42(4):198–202. http://www.jstor.org/stable/1363948.

Nisbet ICT. 1963. Measurements with radar of the height of nocturnal migration over Cape Cod, Massachusetts. Bird-Banding. 34(2):57–67.

Nisbet ICT. 1984. Migration and winter quarters of North American Roseate Terns as shown by banding recoveries. Journal of Field Ornithology. 55(1):1–17.

Nisbet ICT, Veit RR, Auer SA, White TP. 2013. Marine Birds of the Eastern United States and the Bay of Fundy: Distribution, Numbers, Trends, Threats, and Management. No. 29. Cambridge, MA: Nuttall Ornithological Club.

Normandeau Associates Inc. 2011. New insights and new tools regarding risk to roseate terns, piping plovers, and red knots from wind facility operations on the Atlantic Outer Continental Shelf. Report No. BOEMRE 048-2011. US Department of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, New Orleans, LA. 287 pp.

[NYDEC] New York Department of Environmental Conservation. 2018. 2018 Long Island Colonial Waterbird & Piping Plover Update Harbor Herons & Other Waterbirds of the Greater NY/NJ Harbor Working Group. https://www.hudsonriver.org/wp-content/uploads/2017/11/Jennings_NYSDEC-Region1_LI-Update_2018.pdf.

NYSERDA. 2010. Pre-development Assessment of Avian Species for the Proposed Long Island New York City Offshore Wind Project Area. NYSERDA Report No. 9998-03. New York State Energy Research and Development Authority, Albany, NY. 228 pp.

NYSERDA. 2015. Advancing the Environmentally Responsible Development of Offshore Wind Energy in New York State: A Regulatory Review and Stakeholder Perceptions. Final Report. NYSERDA Report 15-16. New York State Energy Research and Development Authority, Albany, NY. 228 pp.

O'Connell AF, Gardner AT, Gilbert AT, Laurent K. 2009. Compendium of Avian Occurrence Information for the Continental Shelf Waters along the Atlantic Coast of the United States, Final Report (Database Section - Seabirds). OCS Study BOEM 2012-076. Prepared by the USGS Patuxent Wildlife Research Center, Beltsville, MD. U.S. Department of the Interior, Geological Survey, and Bureau of Ocean Energy Management Headquarters. 362 pp. http://www.gomr.boemre.gov/homepg/espis/espismaster.asp?appid=1.

Olsen J, Olsen P. 1980. Alleviating the impact of human disturbance on the breeding peregrine falcon II: Public and Recreational Lands. Corella. 4(3):54–57.

Orgeret, F., Thiebault, A., Kovacs, K.M., Lydersen, C., Hindell, M.A., Thompson, S.A., et al. (2022) Climate change impacts on seabirds and marine mammals: The importance of study duration, thermal tolerance and generation time. *Ecology Letters*, 25, 218– 239. https://doi.org/10.1111/ele.13920

Ørsted. 2018. Hornsea Three Offshore Wind Farm Environmental Statement: Volume 2, Chapter 5 – Offshore Ornithology. Report No. A6.2.5. London, UK.

Owen M, Black JM. 1990. Waterfowl Ecology. New York, NY: Chapman & Hall.

Panjabi AO, Easton WE, Blancher PJ, Shaw AE, Andres BA, Beardmore CJ, Camfield AF, Demarest DW, Dettmers R, Keller RH, et al. 2019. Avian Conservation Assessment Database Handbook, Version 2019. Partners in Flight Technical Series No. 8. Available from pif.birdconservancy.org/acad_handbook.pdf.

Percival SM. 2010. Kentish Flats Offshore Wind Farm: Diver Surveys 2009-10. Durham, UK.

Peschko V, Mendel B, Mercker M, Dierschke J, Garthe S. 2021. Northern gannets (*Morus bassanus*) are strongly affected by operating offshore wind farms during the breeding season. Journal of Environmental Management. 279. doi:10.1016/j.jenvman.2020.111509.

Petersen IK, Christensen TK, Kahlert J, Desholm M, Fox AD. 2006. Final results of bird studies at the offshore wind farms at Nysted and Horns Rev, Denmark. Report by The National Environmental Research Institute to DONG energy and Vattenfall A/S. 161 pp.

Petersen IK, Fox AD. 2007. Changes in bird habitat utilisation around the Horns Rev 1 offshore wind farm, with particular emphasis on Common Scoter.

Petersen JK, Maim T. 2006. Offshore windmill farms: threats to or possibilities for the marine environment. Ambio. 35(2):75–80. http://www.ncbi.nlm.nih.gov/pubmed/16722252.

Pettersson J. 2005. The Impact of Offshore Wind Farms on Bird Life in Southern Kalmar Sound Sweden Final Report Based on Studies 1999-2003. Report by the Department of Animal Ecology, Lund University, Sweden for the Swedish Energy Agency. 124 pp. http://www.wind-energie.de/fileadmin/dokumente/Themen_A-Z/Vogelschutz/Voegel_Offshore_Sweden.pdf.

Pettersson J, Fågelvind JP. 2011. Night Migration of Songbirds and Waterfowl at the Utgrunden Off-Shore Wind Farm: A Radar-Assisted Study in Southern Kalmar Sound.

Pollet IL, Shutler D, Chardine JW, Ryder JP. 2012. Ring-billed Gull (Larus delawarensis), The Birds of North America (P. G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America: https://birdsna.org/Species-Account/bna/species/ribgul.

Pratte I, Ronconi RA, Craik SR, McKnight J. 2021. Spatial ecology of endangered roseate terns and foraging habitat suitability around a colony in the western North Atlantic. Endangered Species Research. 44:339–350.R Core Team. 2021a. R: a language and environment for statistical computing. http://www.r-project.org.

Richardson WJ. 1979. Southeastward shorebird migration over Nova Scotia and New Brunswick in autumn: a radar study. Canadian Journal of Zoology. 57(1):107–124. doi:10.1139/z79-009.

Rodríguez A, Burgan G, Dann P, Jessop R, Negro JJ, Chiaradia A. 2014. Fatal attraction of short-tailed shearwaters to artificial lights. PLoS ONE. 9(10):1–10. doi:10.1371/journal.pone.0110114.

Rodríguez A, Dann P, Chiaradia A. 2017. Reducing light-induced mortality of seabirds: High pressure sodium lights decrease the fatal attraction of shearwaters. Journal for Nature Conservation. 39:68–72. doi:10.1016/j.jnc.2017.07.001.

Rodríguez A, Rodríguez B, Negro JJ. 2015. GPS tracking for mapping seabird mortality induced by light pollution. Scientific Reports. 5:1–11. doi:10.1038/srep10670.

Rubega MA, Schamel D, Tracy DM. 2020. Red-necked Phalarope (*Phalaropus lobatus*), version 1.0. In: Billerman SM, editor. Birds of the World. Ithaca, NY: Cornell Lab of Ornithology.

Rue H, Martino S, Chopin N. 2009. Approximate Bayesian inference for latent Gaussian models using integrated nested Laplace approximations (with discussion). Journal of the Royal Statistical Society B. 71:319–392. doi:10.1111/j.1467-9868.2008.00700.x.

Schorger AW. 1947. The deep diving of the loon and old-squaw and its mechanism. The Wilson Bulletin. 59(3):151–159.

SDJV. 2015. Atlantic and Great Lakes Sea Duck Migration Study: progress report June 2015.

Silverman ED, Leirness JB, Saalfeld, David T, Koneff MD, Richkus KD. 2012. Atlantic Coast Wintering Sea Duck Survey, 2008-2011. Laurel, MD.

Silverman ED, Saalfeld DT, Leirness JB, Koneff MD. 2013. Wintering Sea Duck Distribution Along the Atlantic Coast of the United States. Journal of Fish and Wildlife Management. 4(1):178–198. doi:10.3996/122012-JFWM-107.

Simons TR, Lee DS, Hanley JC. 2013. Diablotin (Pterodroma hasitata): A biography of the endangered Black-capped Petrel. Marine Ornithology. 41(Special Issue):S3–S43.

Skov H, Desholm M, Heinänen S, Kahlert JA, Laubek B, Jensen NE, Žydelis R, Jensen BP. 2016. Patterns of migrating soaring migrants indicate attraction to marine wind farms. Biology Letters. 12(12):20160804. doi:10.1098/rsbl.2016.0804.

Skov H, Heinanen S, Norman T, Ward RM, Mendez-Roldan S, Ellis I. 2018. ORJIP Bird Collision and Avoidance Study. Final Report - April 2018. Report by NIRAS and DHI to The Cabon Trust, U.K. 247 pp.

Smallwood KS. 2013. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildlife Society Bulletin. 37(1):19–33. doi:10.1002/wsb.260.

Spiegel CS, Berlin AM, Gilbert AT, Gray CO, Montevecchi WA, Stenhouse IJ, Ford SL, Olsen GH, Fiely JL, Savoy L, et al. 2017. Determining fine-scale use and movement patterns of diving bird species in federal waters of the Mid-Atlantic United States using satellite telemetry. OCS Study BOEM 2017-069. Department of the Interior, Bureau of Ocean Energy Management, Sterling, VA. 293 pp. https://www.boem.gov/espis/5/5635.pdf.

Staine KJ, Burger J. 1994. Nocturnal foraging behavior of breeding Piping Plovers (Charadrius melodus) in New Jersey. Auk. 111(3):579–587.

Stenhouse IJ, Berlin AM, Gilbert AT, Goodale MW, Gray CE, Montevecchi WA, Savoy L, Spiegel CS. 2020. Assessing the exposure of three diving bird species to offshore wind areas on the U.S. Atlantic Outer Continental Shelf using satellite telemetry. Diversity and Distributions. n/a(n/a). doi:10.1111/ddi.13168.

Stenhouse IJ, Montevecchi WA, Gray CE, Gilbert AT, Burke CM, Berlin AM. 2017. Occurrence and Migration of Northern Gannets Wintering in Offshore Waters of the Mid-Atlantic United States.

In: Spiegel CS, editor. Determining Fine- scale Use and Movement Patterns of Diving Bird Species in Federal Waters of the Mid- Atlantic United States Using Satellite Telemetry. Sterling, VA: U.S. Department of the Interior, Bureau of Ocean Energy Management, Division of Environmental Sciences.

Stout BE, Nuechterlein GL. 2020. Red-necked Grebe (*Podiceps grisegena*), version 1.0. In: Billerman SM, editor. Birds of the World. Ithaca, NY: Cornell Lab of Ornithology.

Sullivan BL, Wood CL, Iliff MJ, Bonney RE, Fink D, Kelling S. 2009. eBird: A citizen-based bird observation network in the biological sciences. Biological Conservation. 142(10):2282–2292. doi:10.1016/j.biocon.2009.05.006.

Thaxter CB, Ross-Smith VH, Bouten W. 2015. Seabird – wind farm interactions during the breeding season vary within and between years: A case study of lesser black-backed gull *Larus fuscus* in the UK. Biological Conservation. 186:347–358. doi:10.1016/j.biocon.2015.03.027.

Thaxter CB, Ross-Smith VH, Bouten W, Masden EA, Clark NA, Conway GJ, Barber L, Clewley GD, Burton NHK. 2018. Dodging the blades: New insights into three-dimensional space use of offshore wind farms by lesser black-backed gulls *Larus fuscus*. Marine Ecology Progress Series. 587:247–253. doi:10.3354/meps12415.

Todd CS, Young LS, Owen, Jr. RB, Gramlich FJ. 1982. Food habits of bald eagles in Maine. Journal of Wildlife Management. 46:363–645. doi:10.2307/3808554.

Tracy DM, Schamel D, Dale J. 2020. Red Phalarope (*Phalaropus fulicarius*), version 1.0. In: Billerman SM, editor. Birds of the World. Ithaca, NY: Cornell Lab of Ornithology.

U.S. Fish and Wildlife Service. 2022. Abundance and Productivity Estimates – 2021 Update: Atlantic Coast Piping Plover Population. . Hadley, MA.

U.S. Fish and Wildlife Service. 2009a. Endangered and Threatened Wildlife and Plants; Removal of the Brown Pelican (*Pelecanus occidentalis*) from the Federal List of Endangered and Threatened Wildlife. Federal Register 74: 59444-59472. Federal Register 74: 59444-59472.

U.S. Fish and Wildlife Service. 2009b. Piping Plover 5-Year Review: Summary and Evaluation. Hadley, Massachusetts and East Lansing, Michigan.

U.S. Fish and Wildlife Service. 2010. Caribbean Roseate Tern and North Atlantic Roseate Tern (*Sterna dougallii dougallii*) 5-Year Review: Summary and Evaluation.

U.S. Fish and Wildlife Service. 2015. Status of the Species - Red Knot.

U.S. Fish and Wildlife Service. 2017. The Service’s independent “reasonable and prudent” determination regarding the originally proposed draft turbine curtailment measure in the Service’s October 2008 draft Biological Opinion (BO) for the Cape Wind project. Memorandum in response to decision. Hadley, Massachusetts.

Van Der Winden J, Poot MJM, Van Horssen PW. 2010. Large birds can migrate fast: The post-breeding flight of the Purple Heron *Ardea purpurea* to the Sahel. Ardea. 98(3):395–402. doi:10.5253/078.098.0313.

Vanermen N, Courtens W, van de Walle M, Verstraete H, Stienen WM E. 2019. Seabird Monitoring at the Thornton Bank Offshore Wind Farm-Final Displacement Results After 6 Years of Post-Construction Monitoring & an Explorative Bayesian Analysis of Common Guillemot Displacement Using INLA. https://www.researchgate.net/publication/338914647.

Vanermen N, Courtens W, Van De Walle M, Verstraete H, Stienen WM E. 2019. Seabird Monitoring at the Thornton Bank Offshore Wind Farm-Final Displacement Results After 6 Years of Post-Construction Monitoring & an Explorative Bayesian Analysis of Common Guillemot Displacement Using INLA.

Vanermen Nicolas, Onkelinx T, Courtens W, van de walle M, Verstraete H, Stienen EWM. 2015. Seabird avoidance and attraction at an offshore wind farm in the Belgian part of the North Sea. Hydrobiologia. 756(1):51–61. doi:10.1007/s10750-014-2088-x.

Vanermen N., Onkelinx T, Courtens W, van de walle M, Verstraete H, Stienen EWM. 2015. Seabird avoidance and attraction at an offshore wind farm in the Belgian part of the North Sea. Hydrobiologia. 756(1):51–61. doi:10.1007/s10750-014-2088-x.

Vanermen Nicolas, Onkelinx T, Verschelde P, Courtens W, van de walle M, Verstraete H, Stienen EWM. 2015. Assessing seabird displacement at offshore wind farms: power ranges of a monitoring and data handling protocol. Hydrobiologia. 756:155–167. doi:10.1007/s10750-014-2156-2.

Veit RR, Goyert HF, White TP, Martin M-C, Manne LL, Gilbert A. 2015. Pelagic Seabirds off the East Coast of the United States 2008-2013. US Dept. of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Sterling, VA. OCS Study BOEM 2015-024. 186 pp.

Veit RR, White TP, Perkins S.A., Curley S. 2016. Abundance and distribution of seabirds off Southeastern Massachusetts, 2011-2015 Final Report. OCS Study BOEM 2016-067. U.S. Department of the Interior, Bureau of Ocean Energy Management, Sterling VA. 82 pp.

Veit RR, White TP, Perkins Simon A., Curley S. 2016. Abundance and Distribution of Seabirds off Southeastern Massachusetts, 2011-2015: Final Report. OCS Study. Sterling, Virginia: U.S. Department of the Interior, Bureau of Ocean Energy Management.

Vlietstra LS. 2007. Potential Impact of the Massachusetts Maritime Academy Wind Turbine on Common (*Sterna hirundo*) and Roseate (*S. dougallii*) Terns. Massachusetts Maritime Academy.

Voous KH. 1961. Records of the Peregrine Falcon on the Atlantic Ocean. Ardea. 49:176–177.

Wade HM, Masden EA, Jackson AC, Furness RW. 2016. Incorporating data uncertainty when estimating potential vulnerability of Scottish seabirds to marine renewable energy developments. Marine Policy. 70:108–113. doi:10.1016/j.marpol.2016.04.045.

Walker WE, Harremoes P, Rotmans J, van der Sluijs JP, van Asselt MBA, Janssen P, Krayer Von Krauss MP. 2003. Defining Uncertainty. Integrated Assessment. https://www.narcis.nl/publication/RecordID/oai:tudelft.nl:uuid:fdc0105c-e601-402a-8f16-ca97e9963592.

Watts BD, Smith FM, Hines C, Duval L, Hamilton DJ, Keyes T, Paquet J, Pirie-Dominix L, Rausch J, Truitt B, et al. 2021. Whimbrel populations differ in trans-atlantic pathways and cyclone encounters. Scientific Reports. 11(1):1–9. doi:10.1038/s41598-021-92429-z.

Welcker J, Nehls G. 2016. Displacement of seabirds by an offshore wind farm in the North Sea. Marine Ecology Progress Series. 554:173–182. doi:10.3354/meps11812.

White CM, Clum NJ, Cade TJ, Hunt WG. 2002. Peregrine Falcon (Falco peregrinus). In: Poole A, editor. The Birds of North America Online No. 660. Ithaca, NY: Cornell Lab of Ornithology. p. 58. http://bna.birds.cornell.edu/bna/species/660.

White TP, Veit RR. 2020. Spatial ecology of long-tailed ducks and white-winged scoters wintering on Nantucket Shoals. Ecosphere. 11(1). doi:10.1002/ecs2.3002.

White TP, Veit RR, Perry MC. 2009. Feeding ecology of Long-tailed Ducks Clangula hyemalis wintering on the Nantucket Shoals. Waterbirds. 32(2):293–299.

Wiley HR, Lee DS. 2000. Pomarine Jaeger (*Stercorarius pomarinus*). In: Rodewald PG, editor. The Birds of North America. Ithaca, NY: Cornell Lab of Ornithology.

Wiley RH, Lee DS. 1998. Long-tailed Jaeger (*Stercorarius longicaudus*). In: Rodewald PG, editor. The Birds of North America. Ithaca, NY: Cornell Lab of Ornithology.

Wiley RH, Lee DS. 2020. Parasitic Jaeger (*Stercorarius parasiticus*), version 1.0. In: Billerman SM, editor. Birds of the World. Ithaca, NY, USA: Cornell Lab of Ornithology. https://doi-org.uri.idm.oclc.org/10.2173/bow.parjae.01.

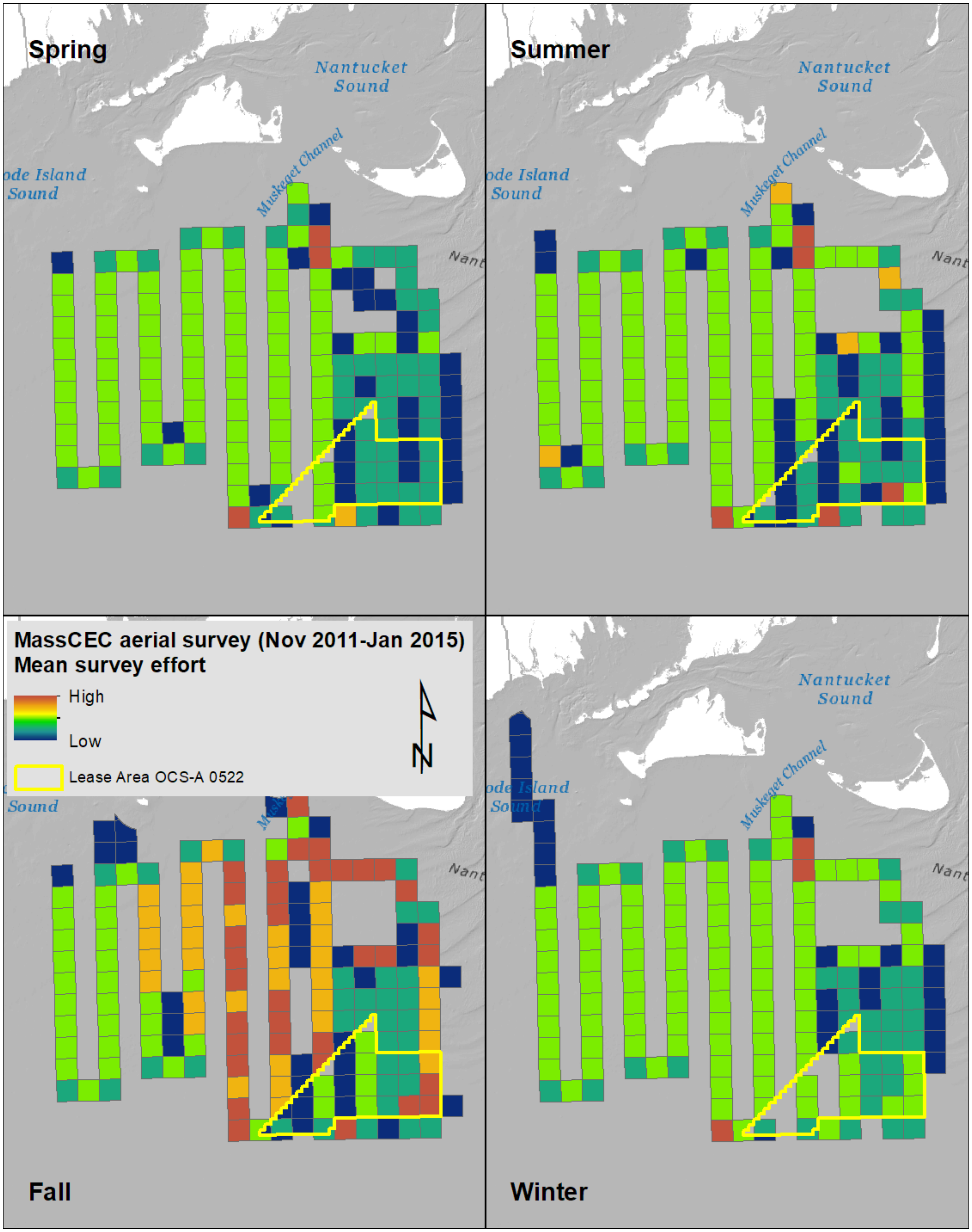
Williams KA, Stenhouse IJ, Connelly EE, Johnson SM. 2015. Mid-Atlantic Wildlife Studies: Distribution and Abundance of Wildlife along the Eastern Seaboard 2012-2014. Biodiversity Research Institute. Portland, Maine. Science Communications Series BRI 2015-19. 32 pp.

Willmott JR, Forcey G, Kent A. 2013. The Relative Vulnerability of Migratory Bird Species to Offshore Wind Energy Projects on the Atlantic Outer Continental Shelf: An Assessment Method and Database. OCS Study BOEM 2013-207. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Herndon, VA. 275 pp.

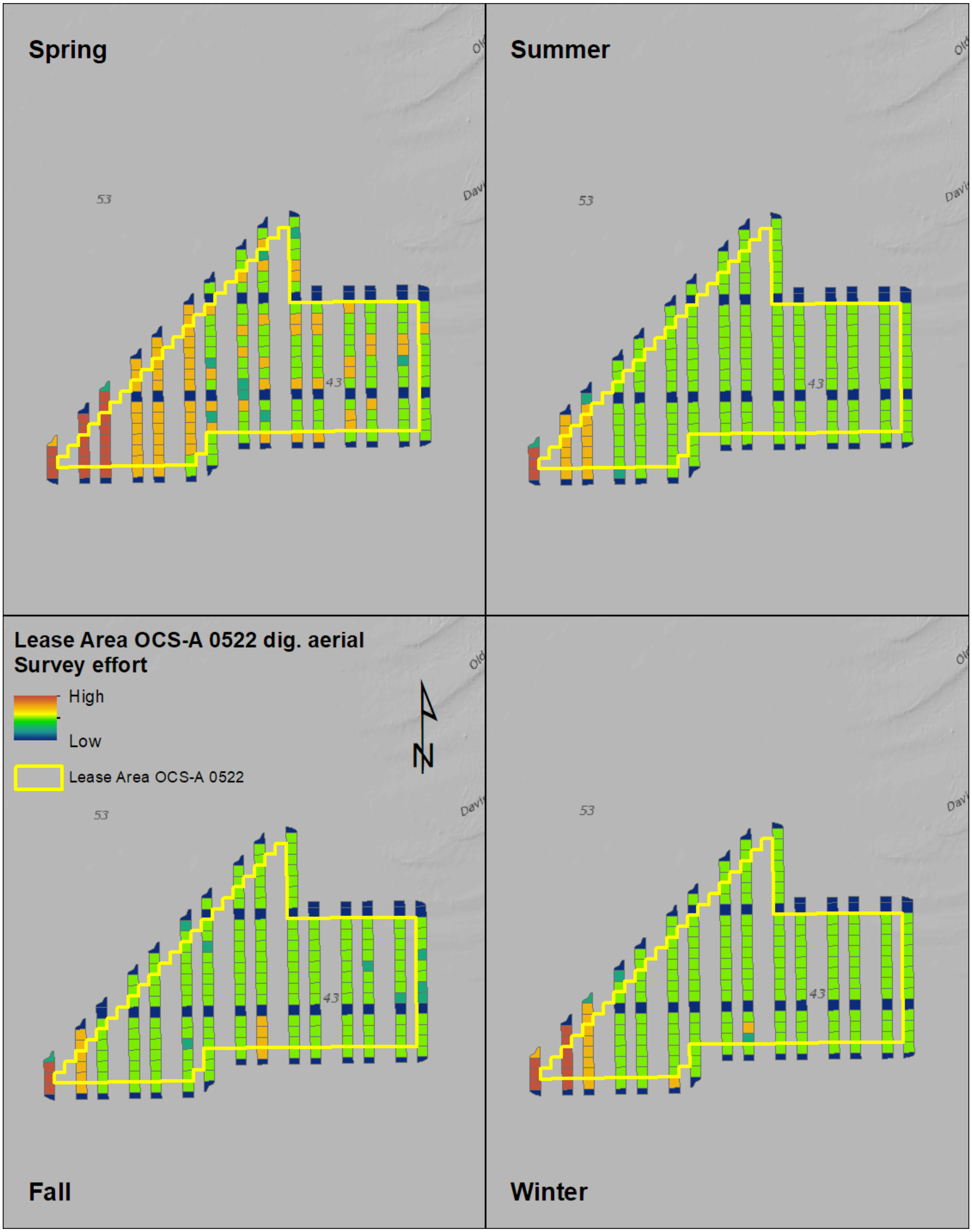
Winship A, Kinlan B, White T, Leirness J, Christensen J. 2018. Modeling at-sea density of marine birds to support Atlantic marine renewable energy planning. OCS Study BOEM 2018-010. U.S. Department of the Interior, Bureau of Ocean Energy Managment, Stirling, VA. 67 pp. https://tethys.pnnl.gov/sites/default/files/publications/Winship-et-al-2018-BOEM.pdf.

Attachment A: Maps of exposure for marine birds in and around the Lease Area

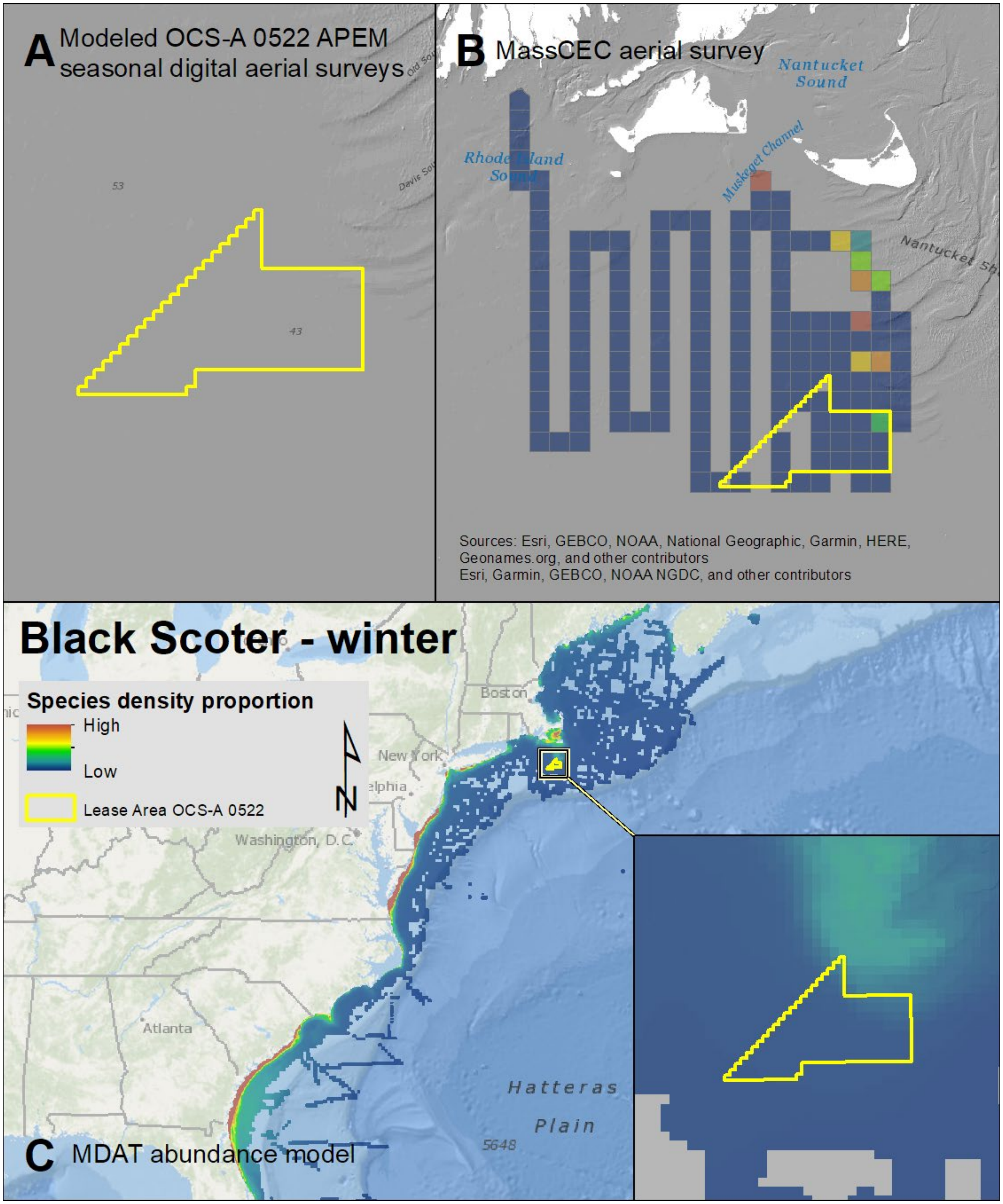
Table of Maps



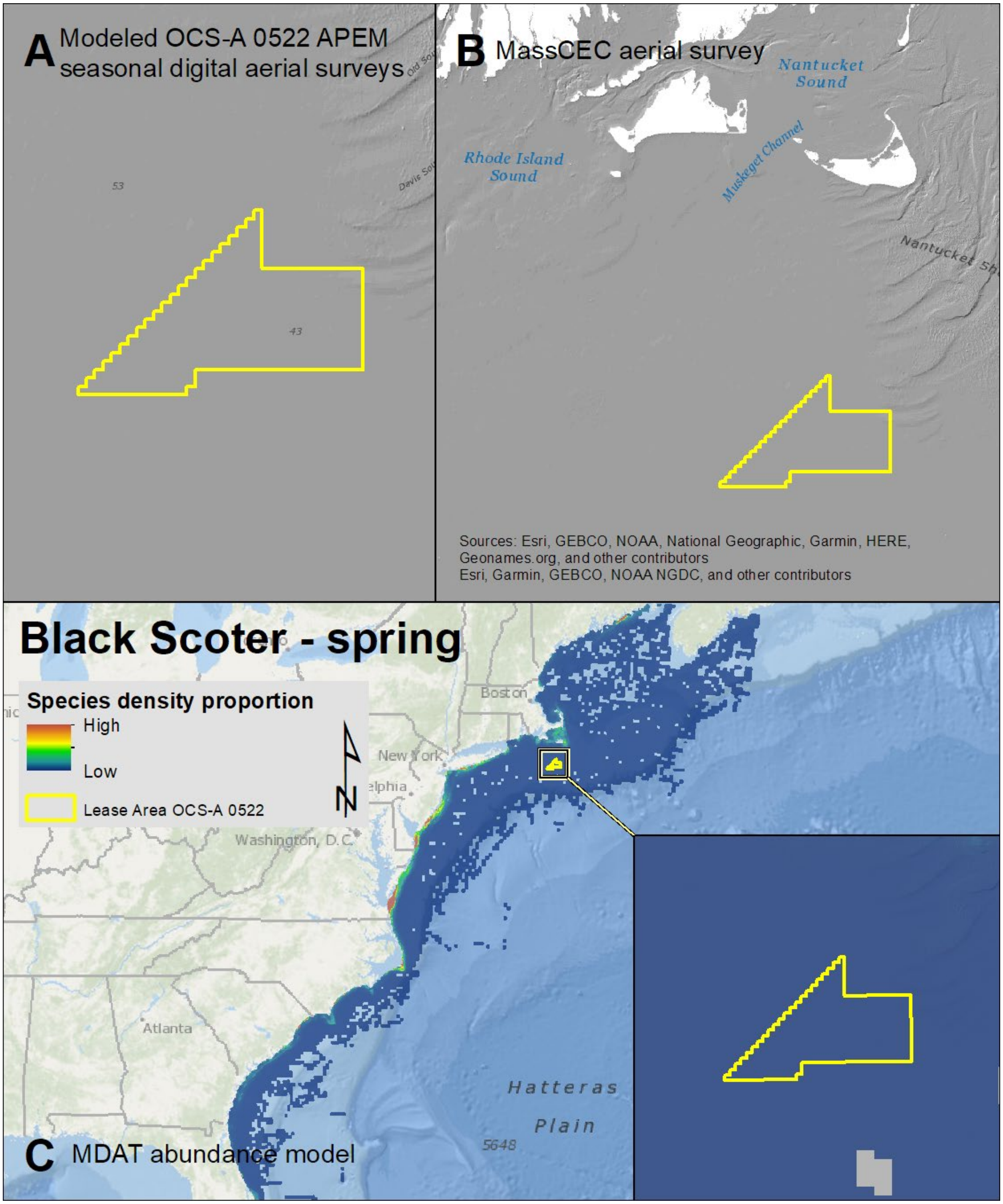
Map 1. MassCEC aerial baseline seasonal survey effort; mean survey effort in sq. km by full or partial lease block inside and outside the Lease Area OCS-A 0522.



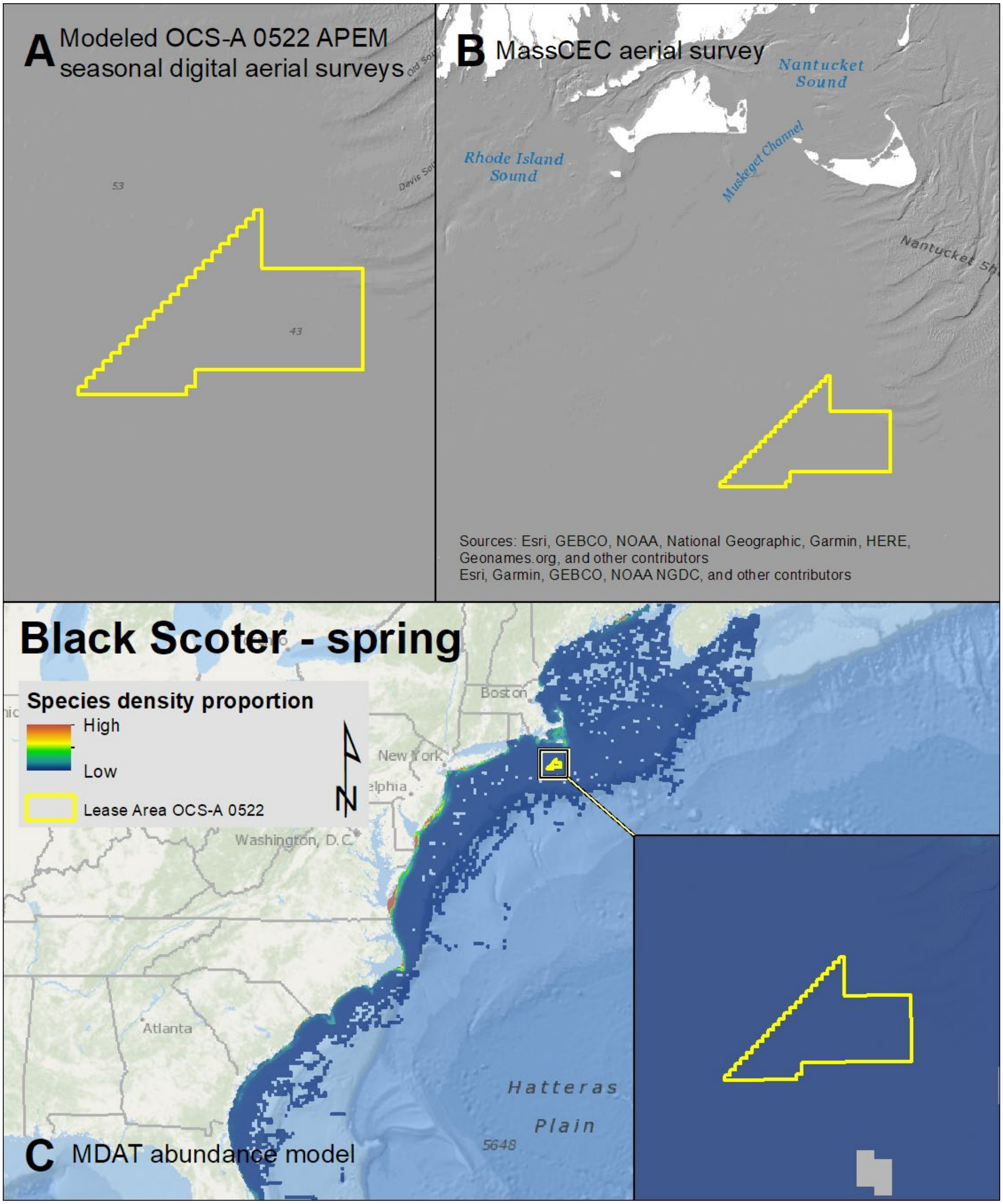
Map 2. Lease Area OCS-A 0522 APEM digital aerial seasonal survey effort. Survey effort totaled within each full or partial lease block inside and outside the Area.



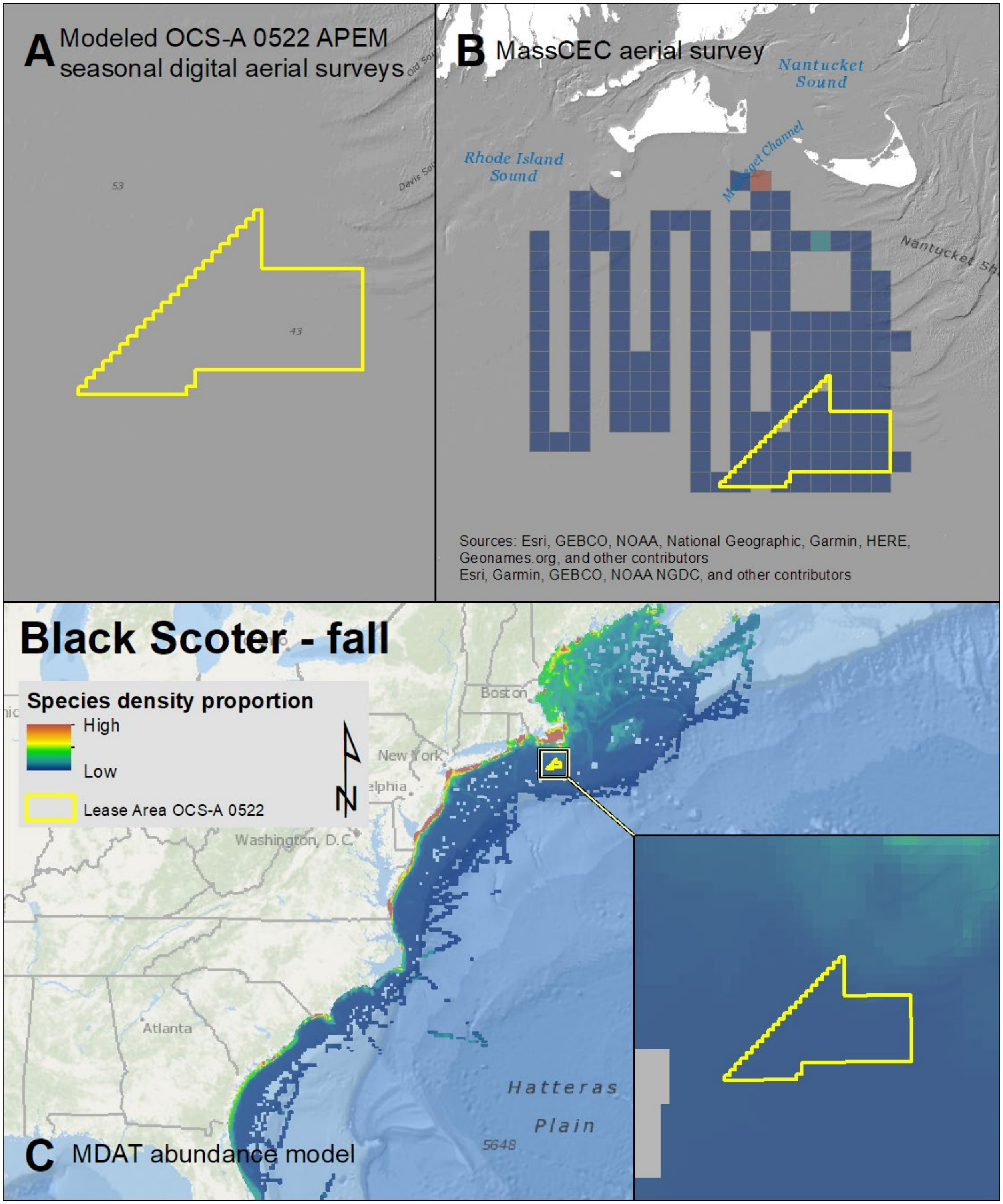
Map 3. Winter Black Scoter modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



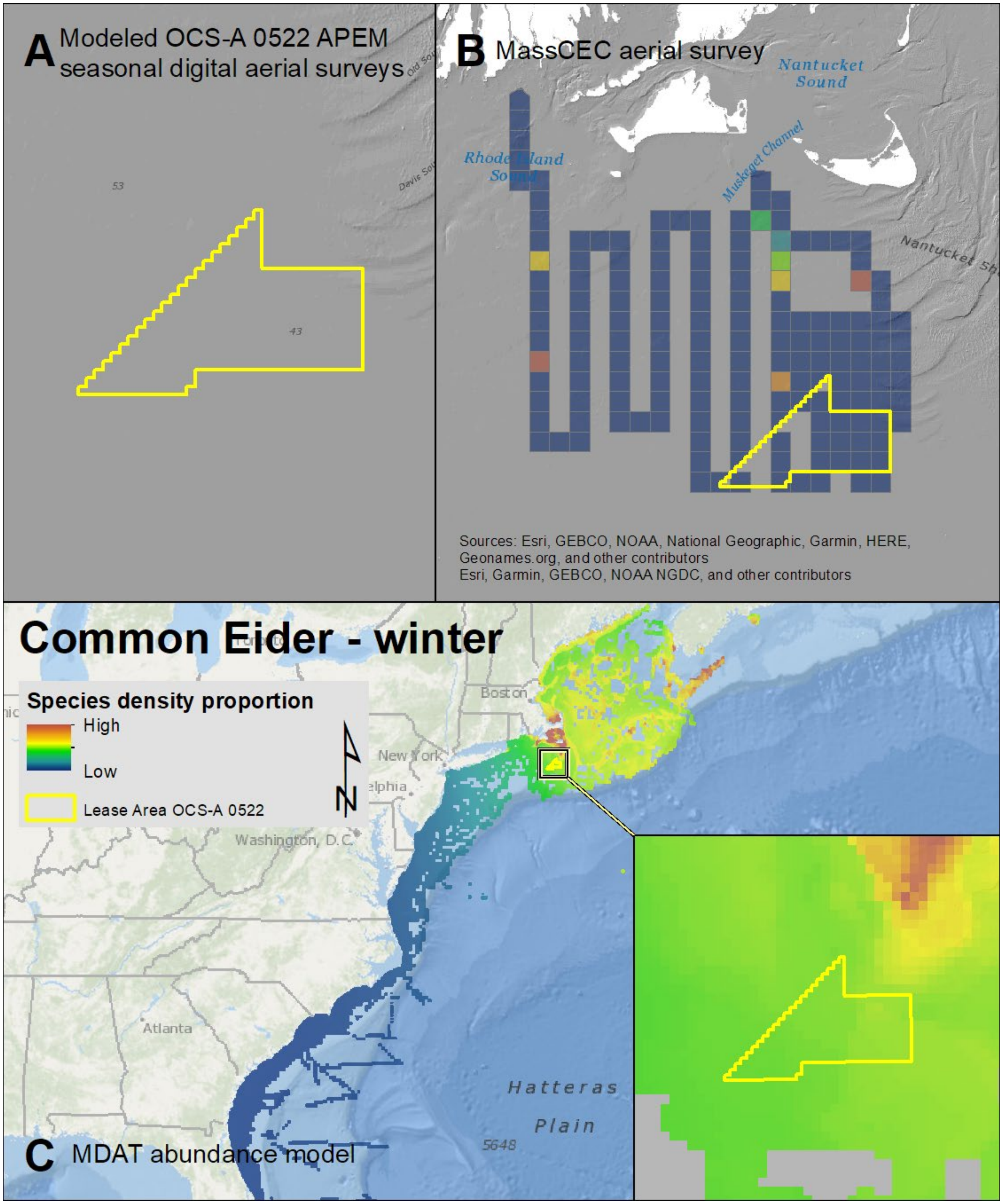
Map 4. Spring Black Scoter modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



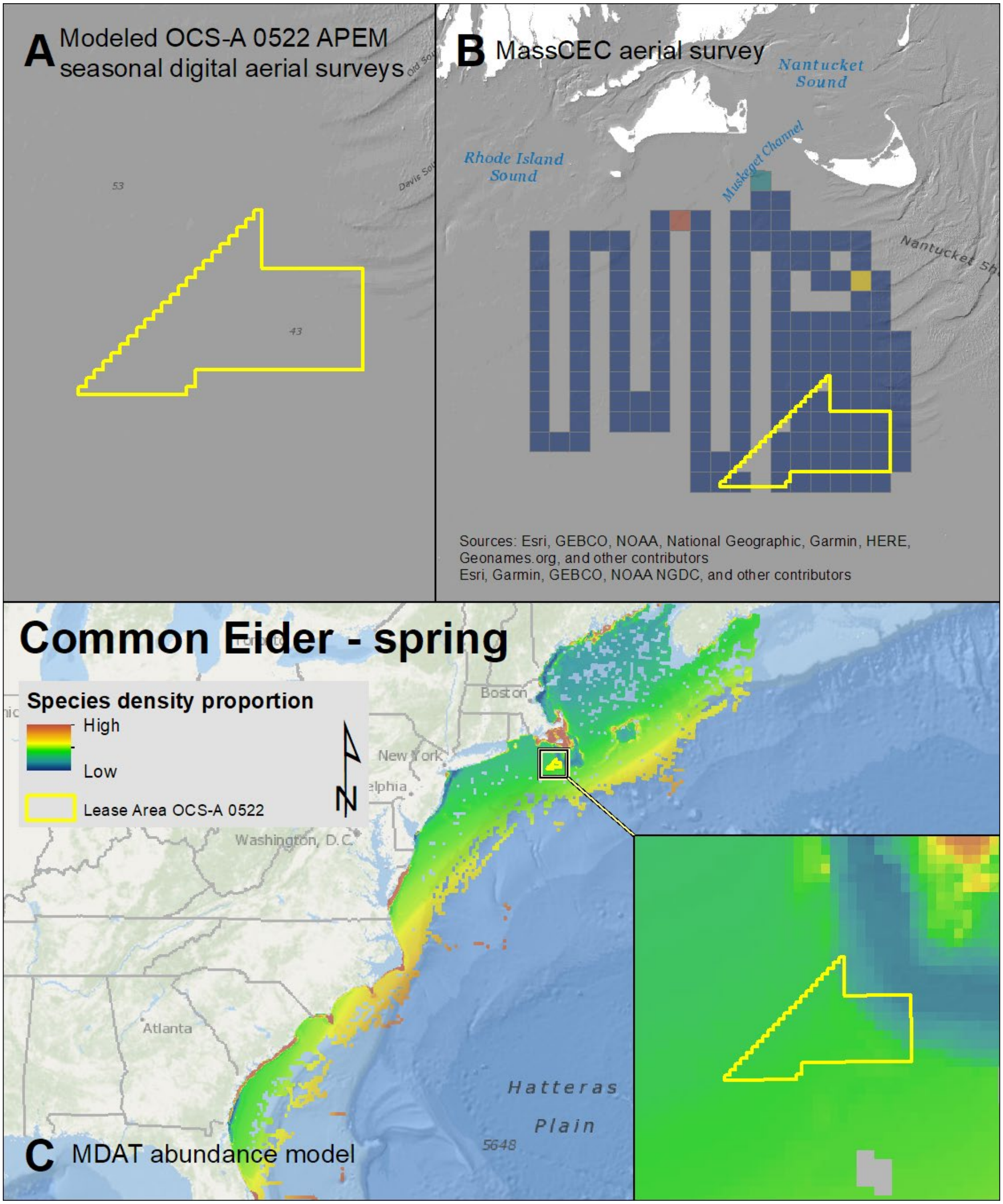
Map 5. Spring Black Scoter modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



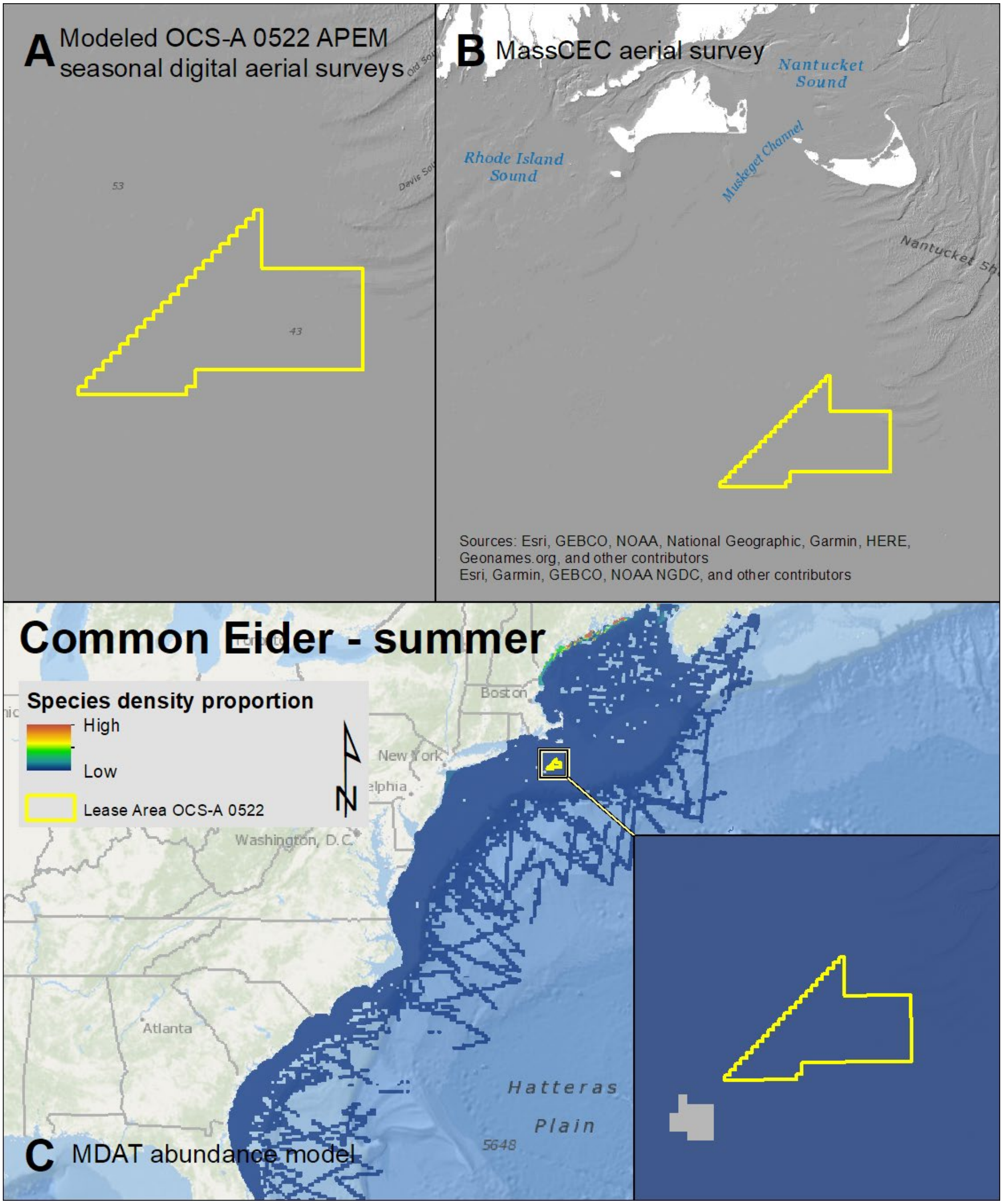
Map 6. Fall Black Scoter modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



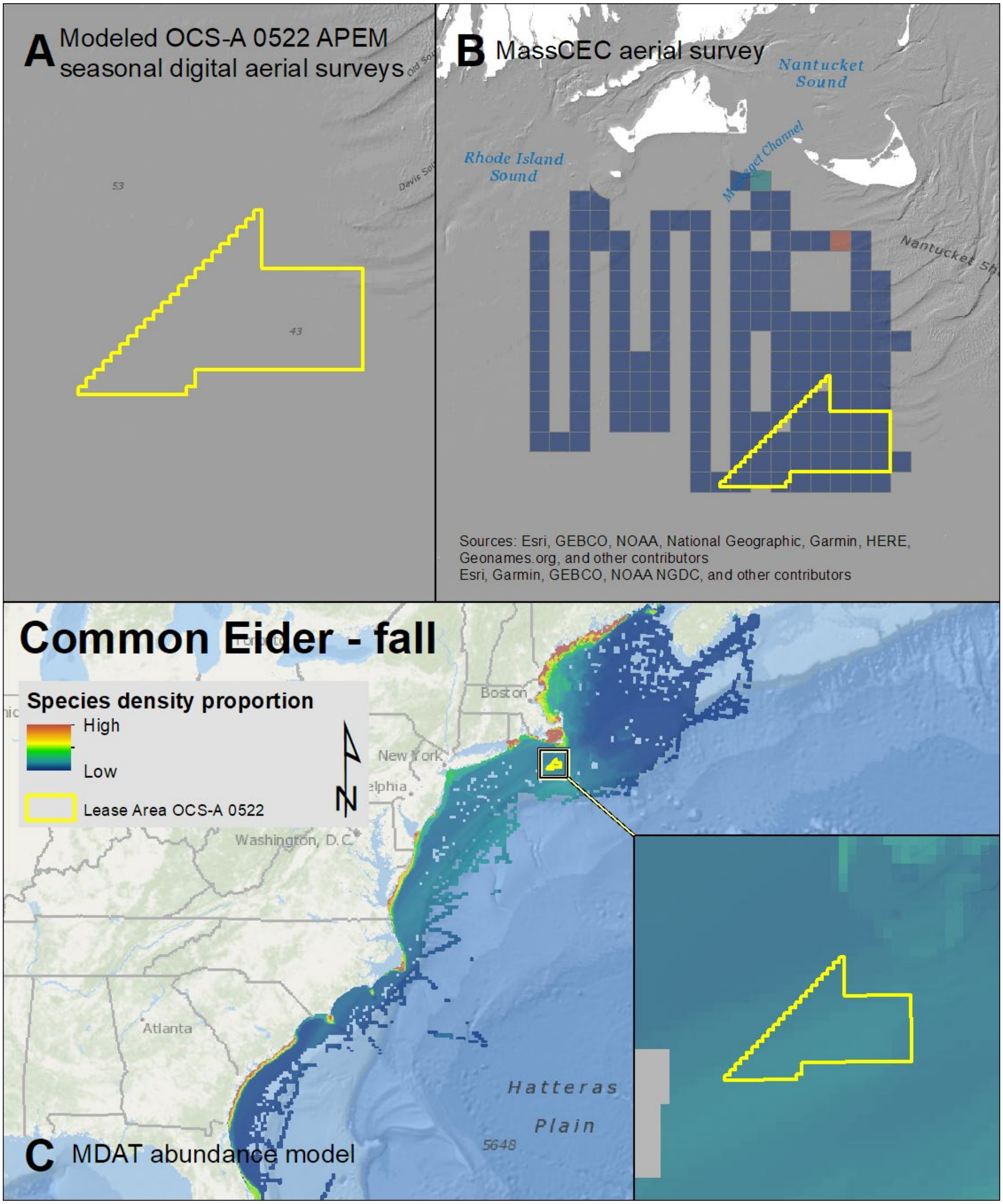
Map 7. Winter Common Eider modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



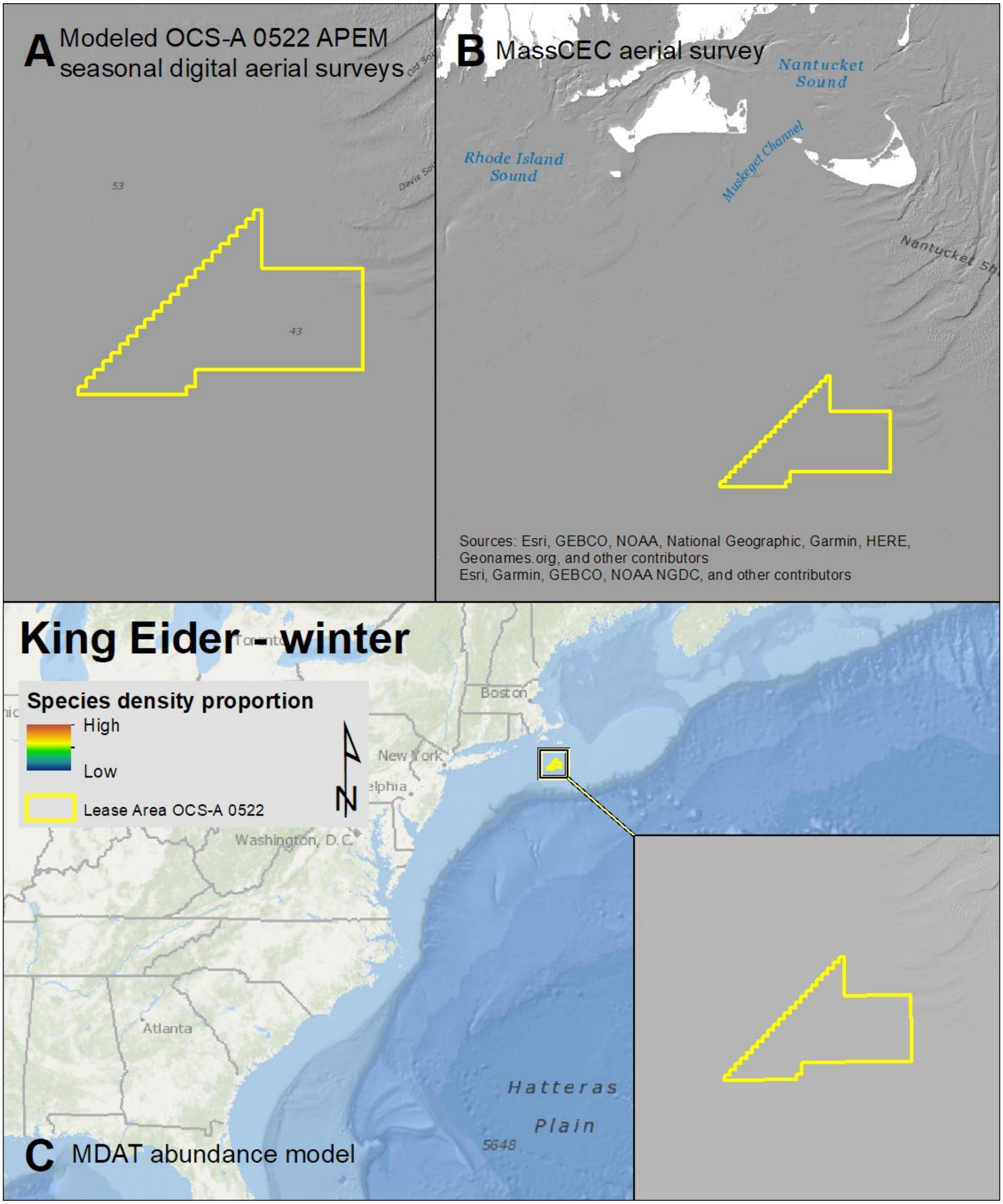
Map 8. Spring Common Eider modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



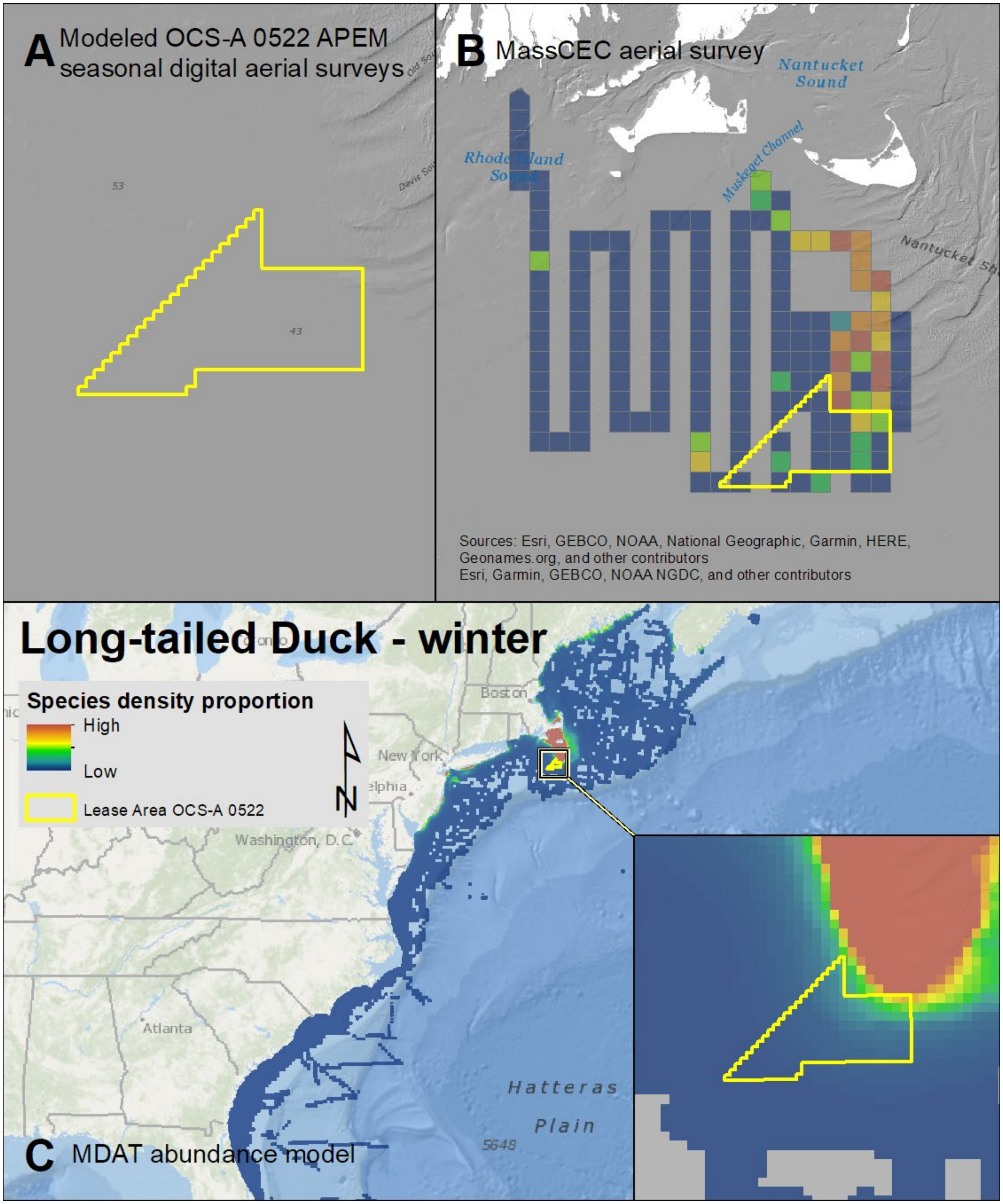
Map 9. Summer Common Eider modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



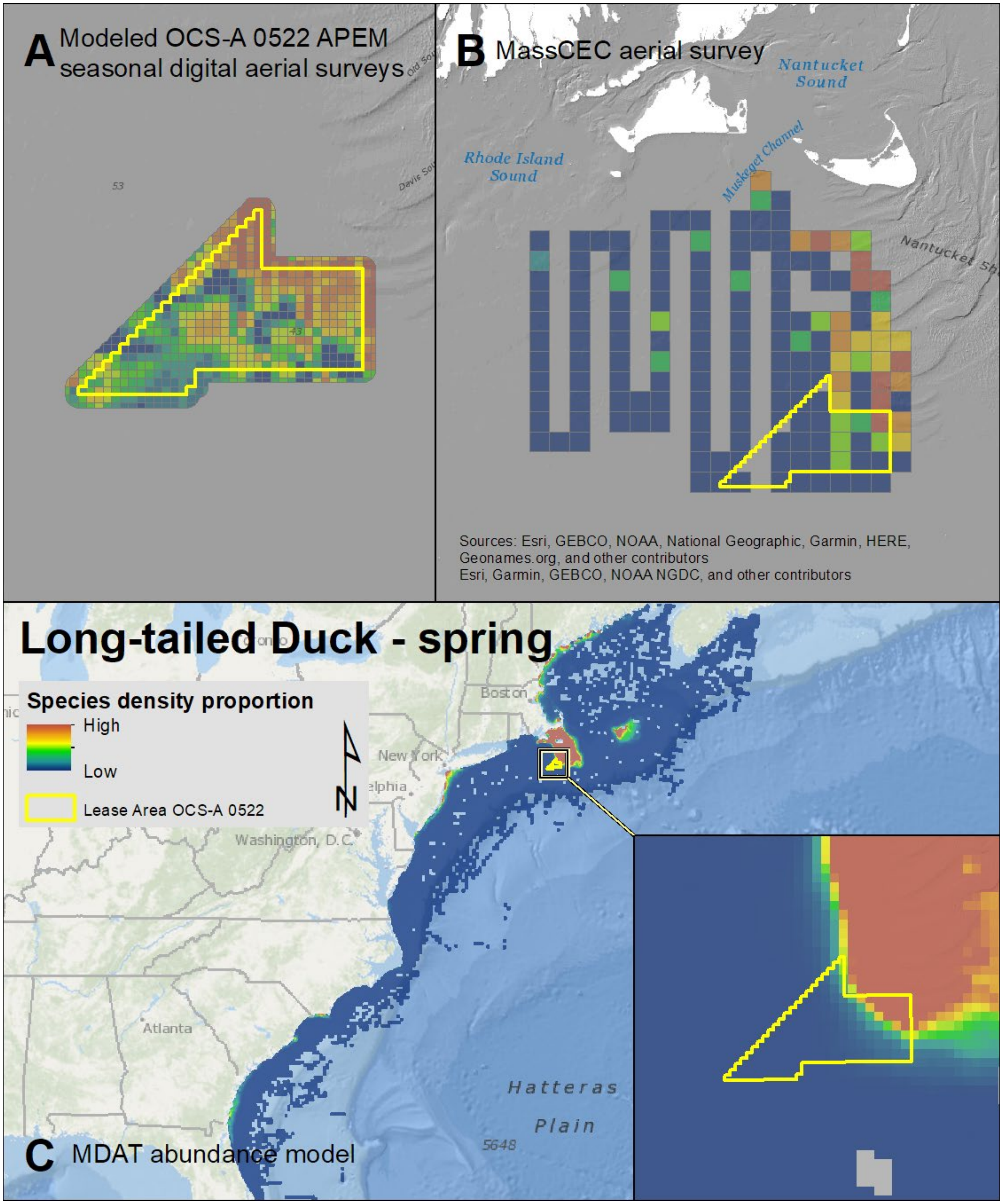
Map 10. Fall Common Eider modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



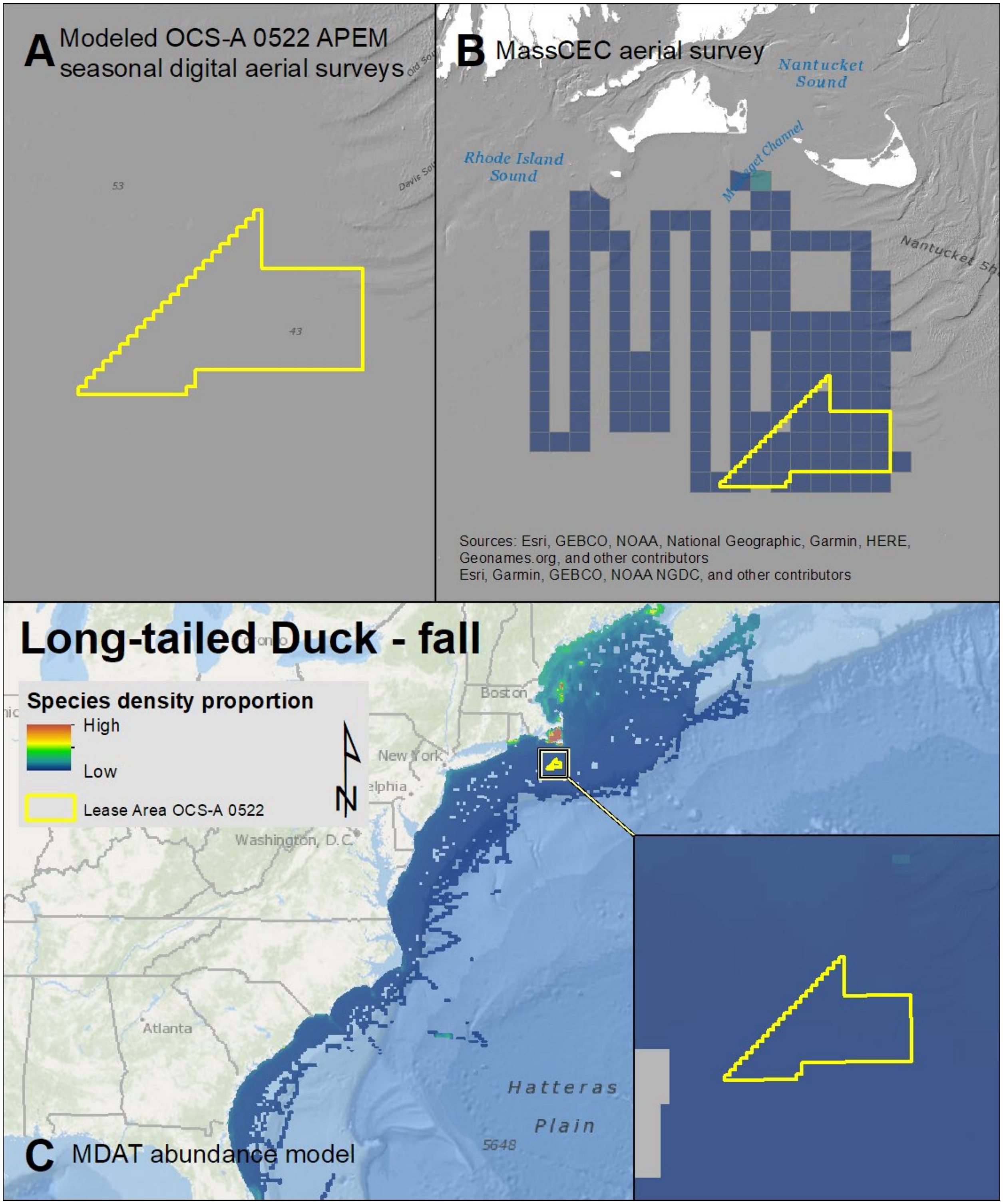
Map 11. Winter King Eider modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



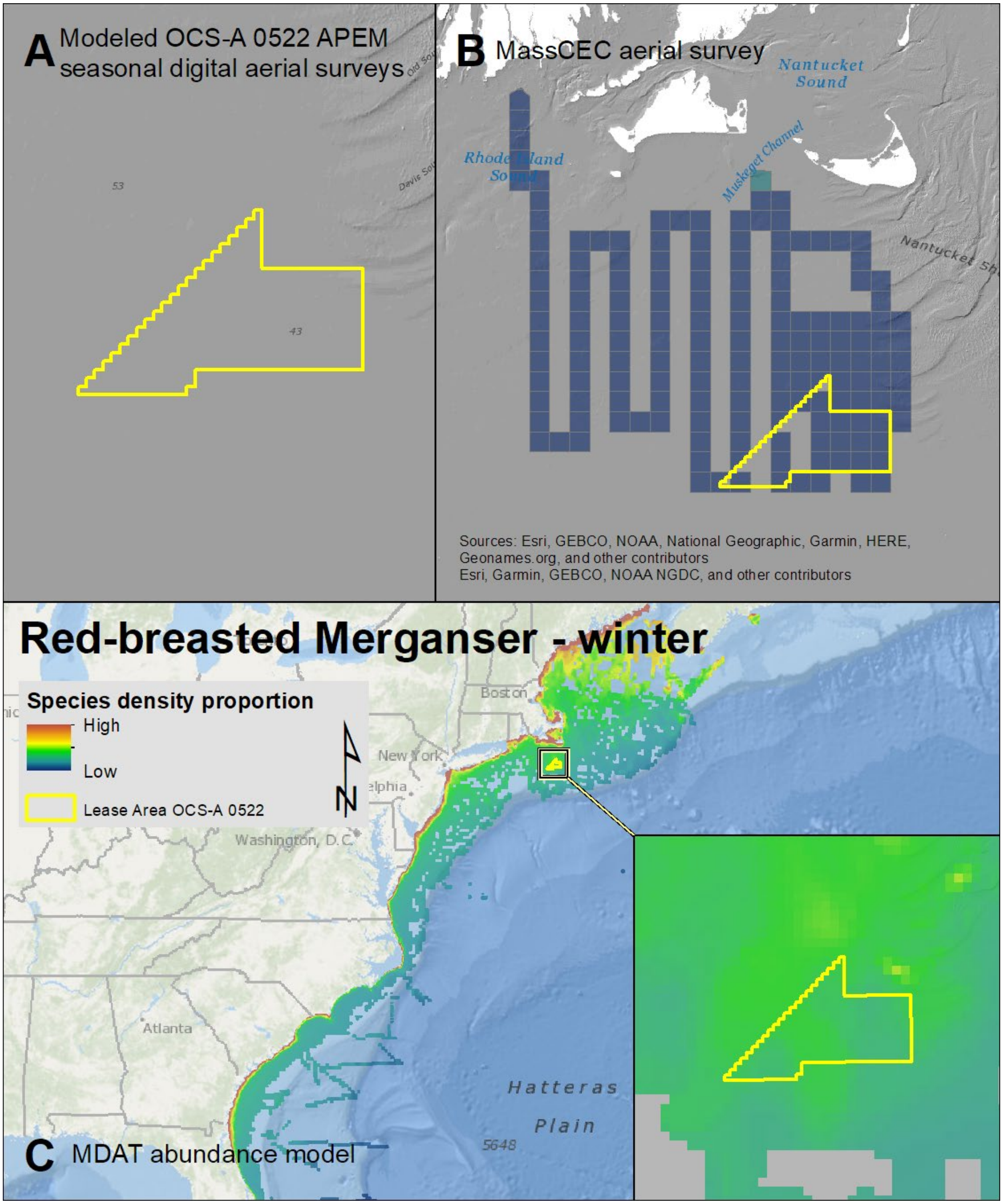
Map 12. Winter Long-tailed Duck modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



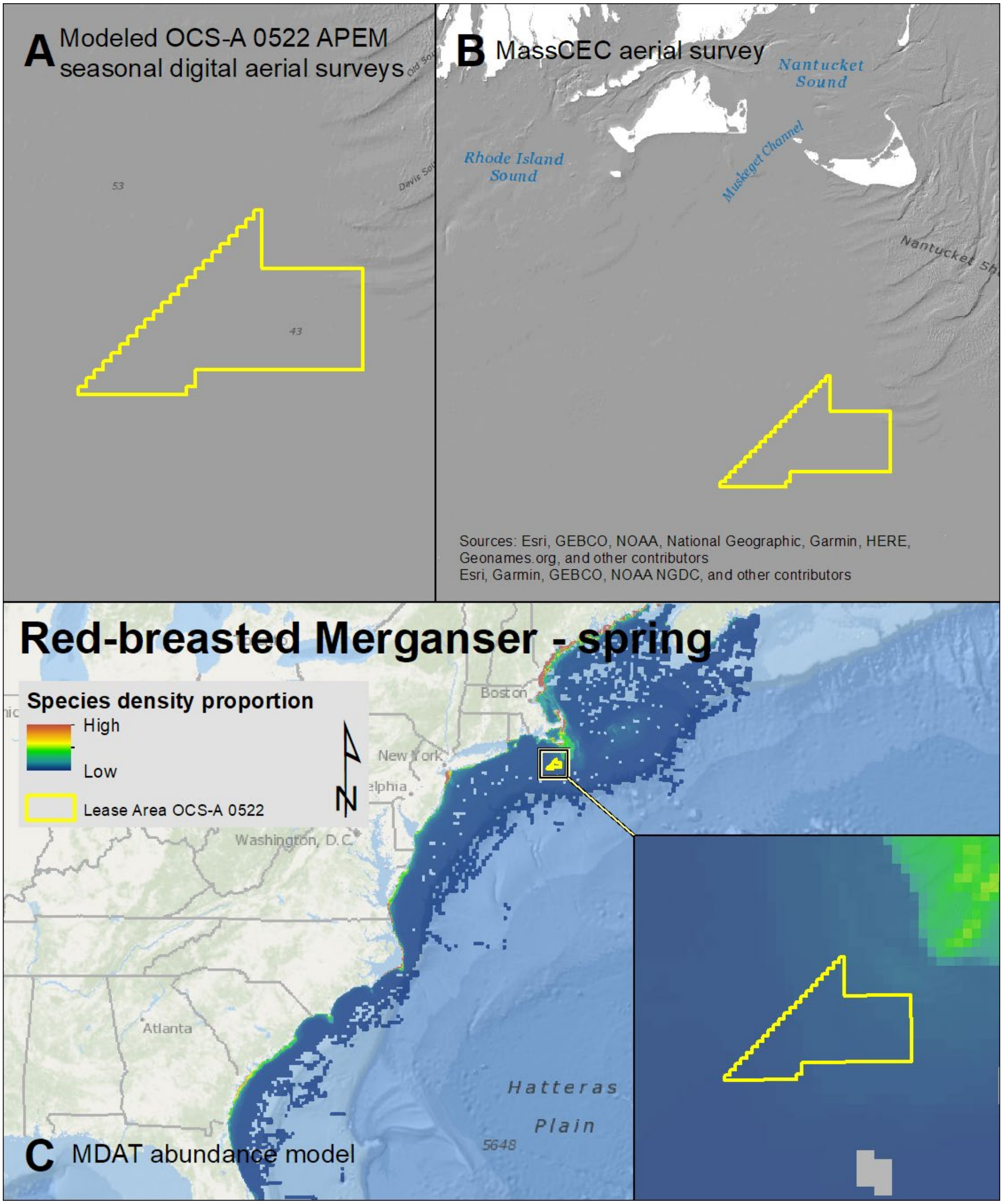
Map 13. Spring Long-tailed Duck modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



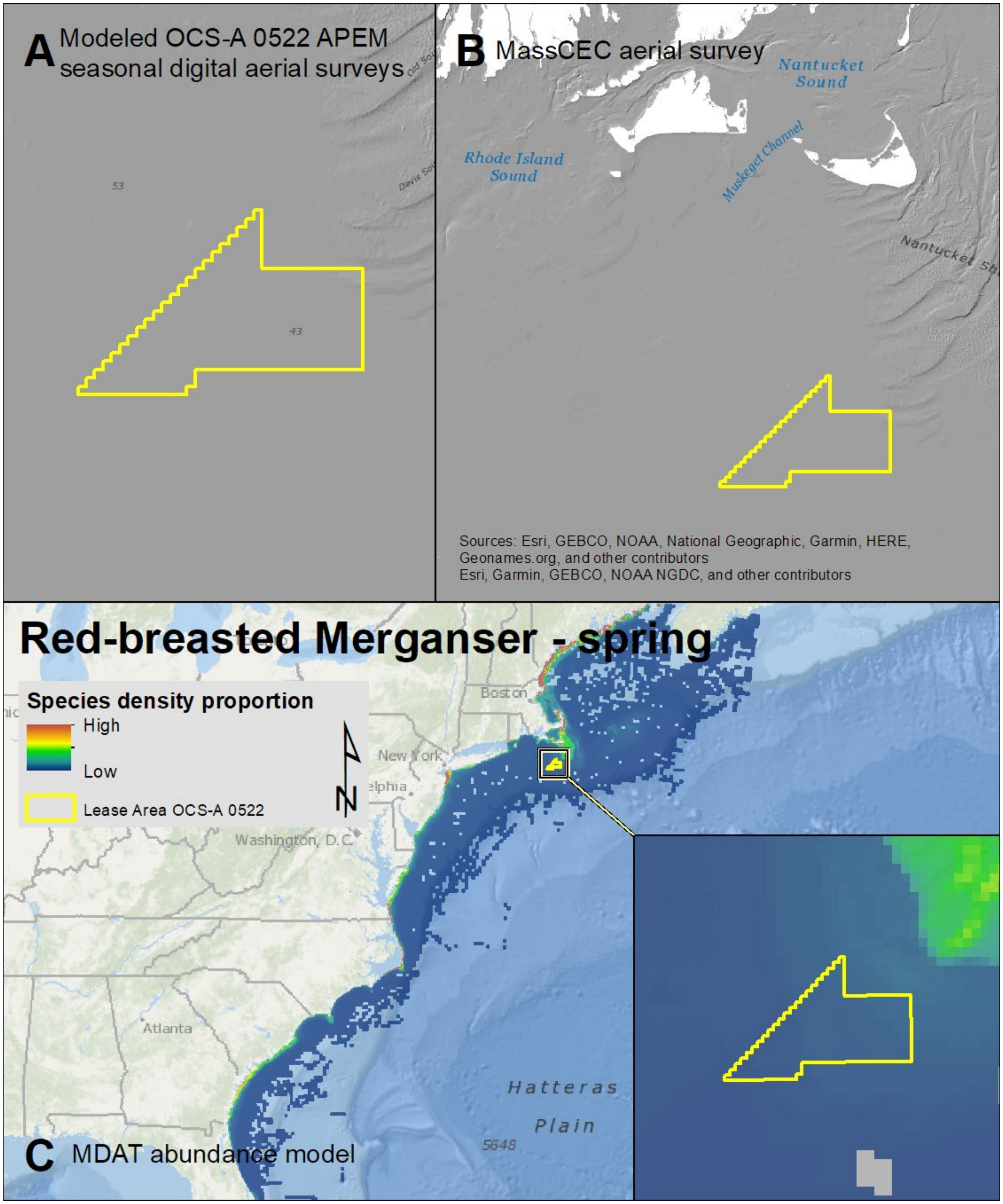
Map 14. Fall Long-tailed Duck modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



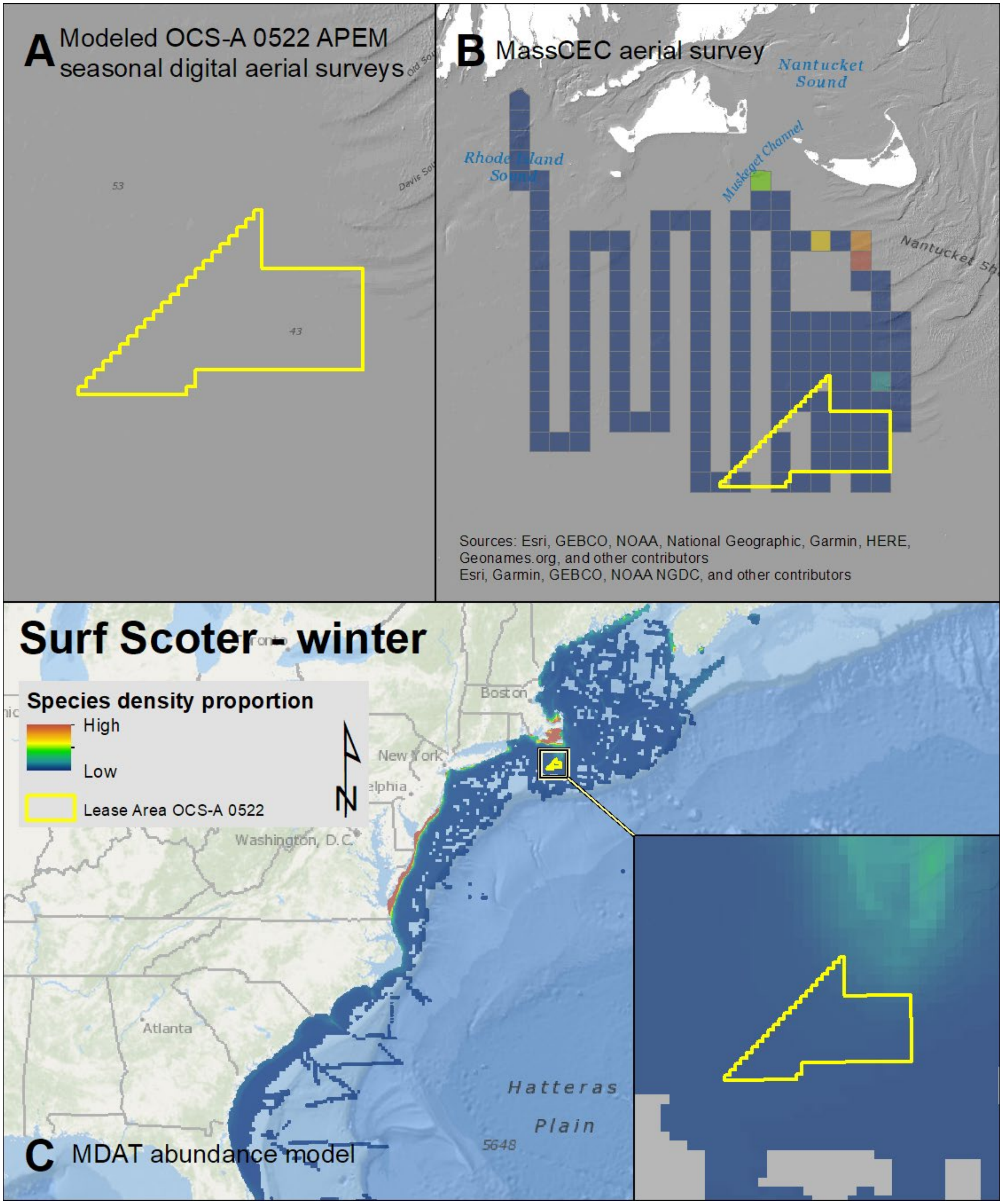
Map 15. Winter Red-breasted Merganser modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



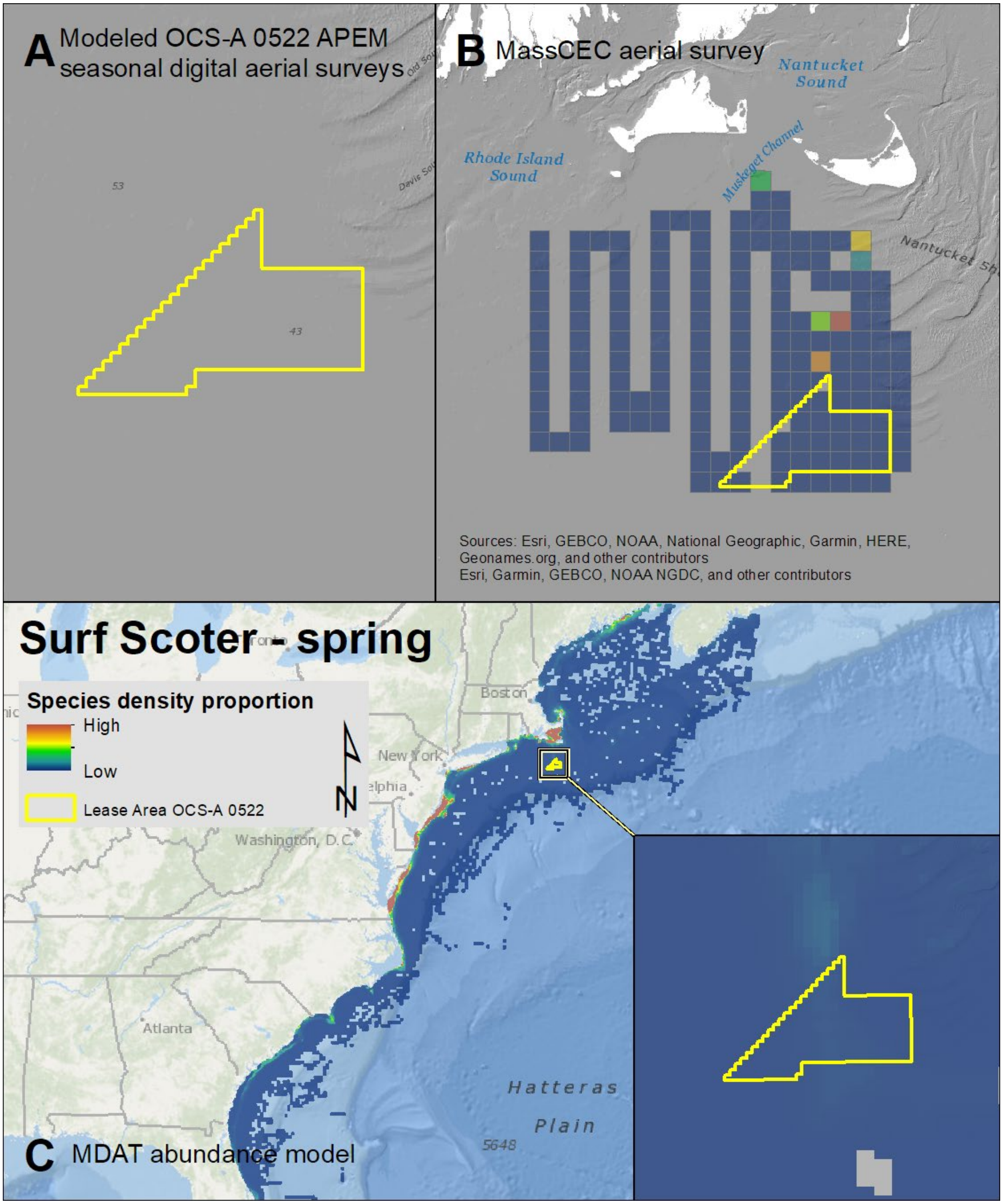
Map 16. Spring Red-breasted Merganser modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



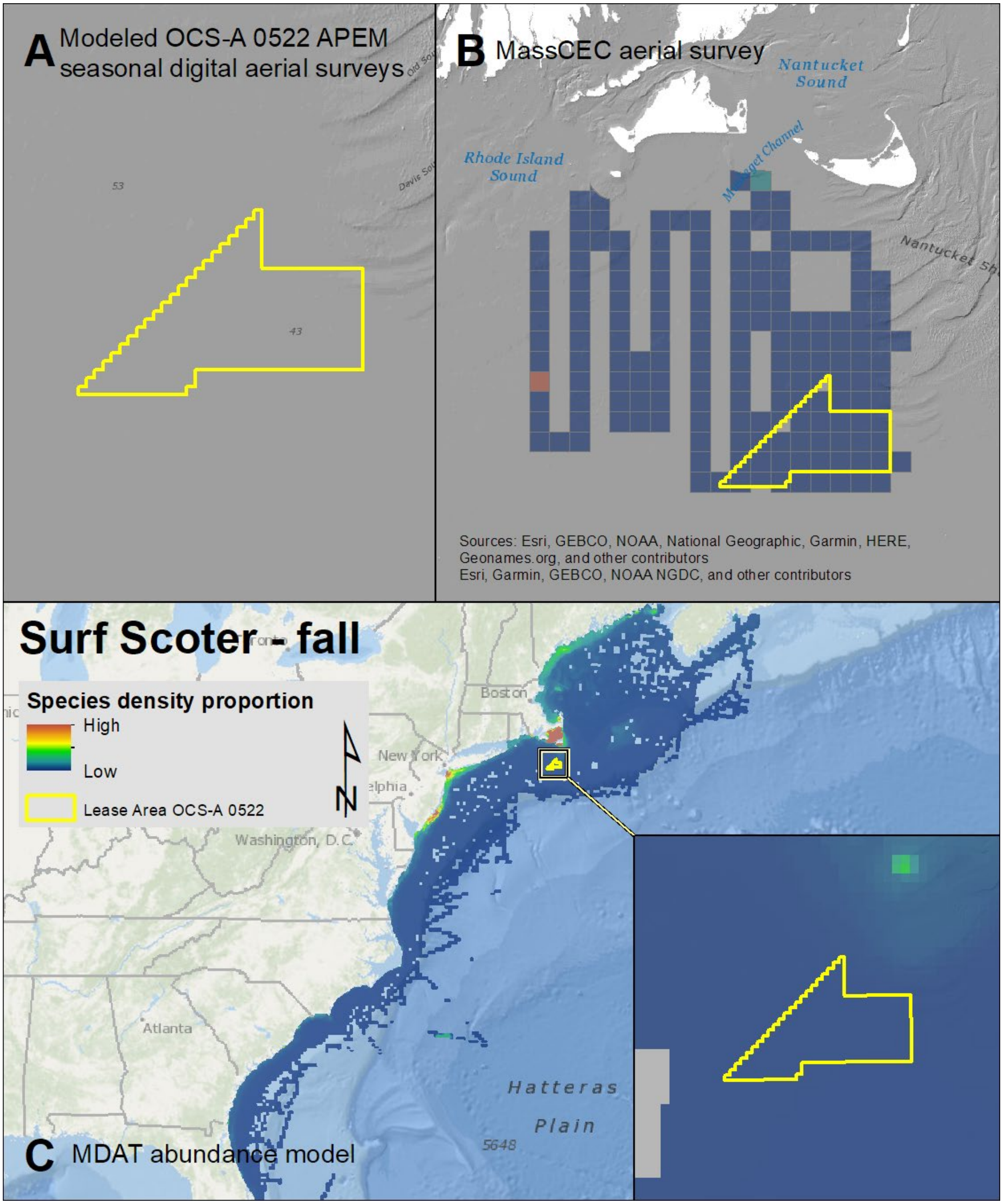
Map 17. Spring Red-breasted Merganser modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



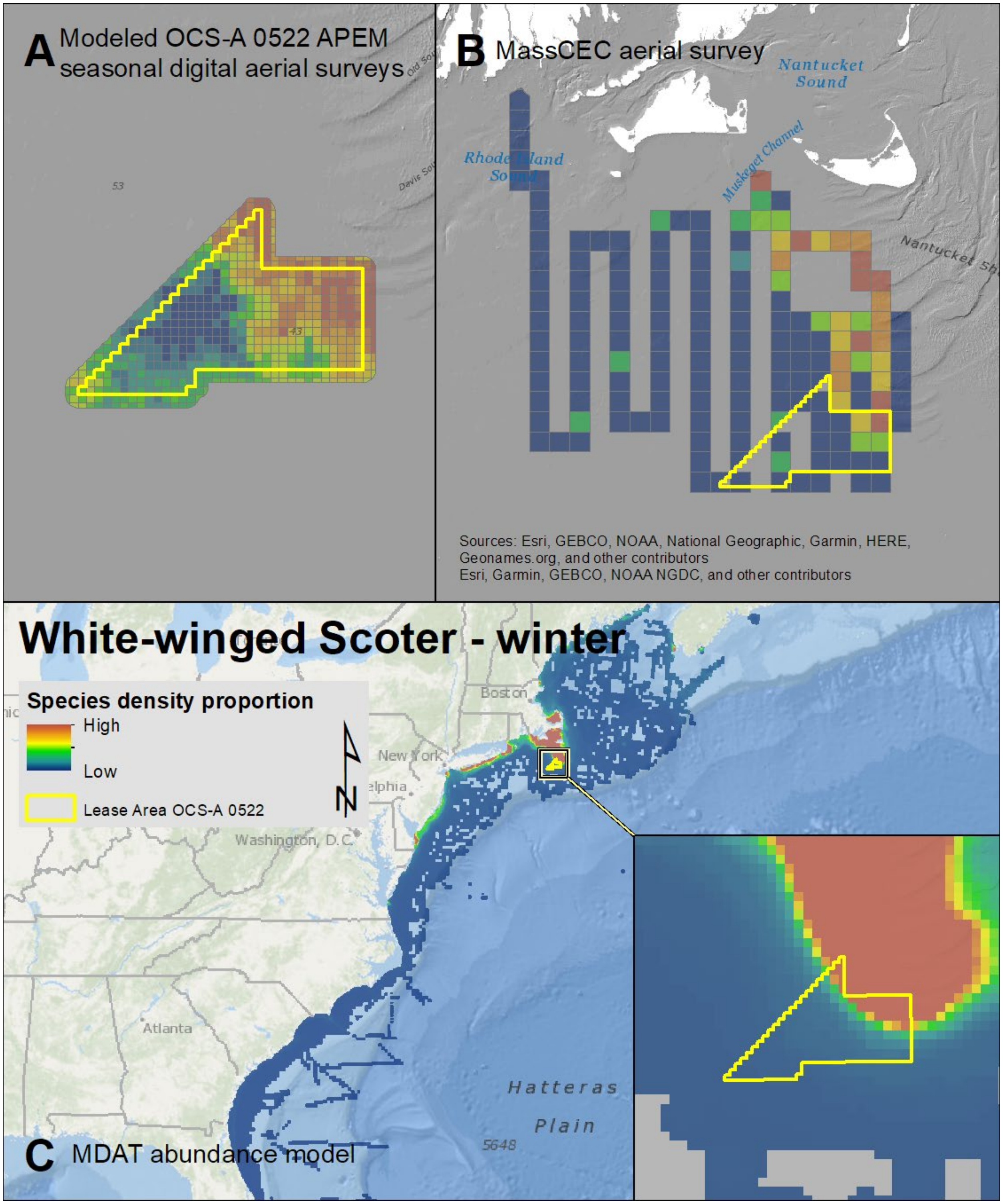
Map 18. Winter Surf Scoter modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



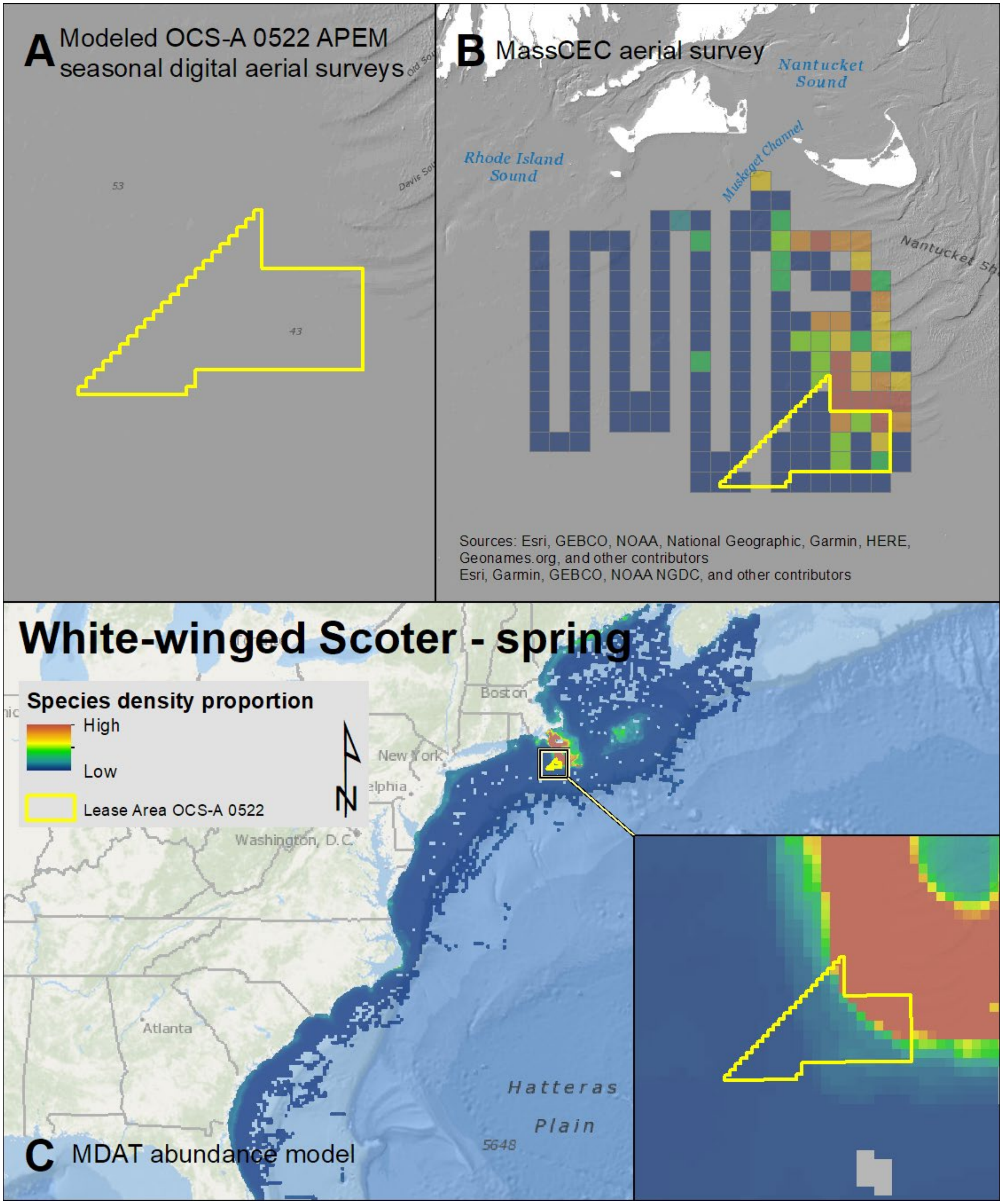
Map 19. Spring Surf Scoter modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



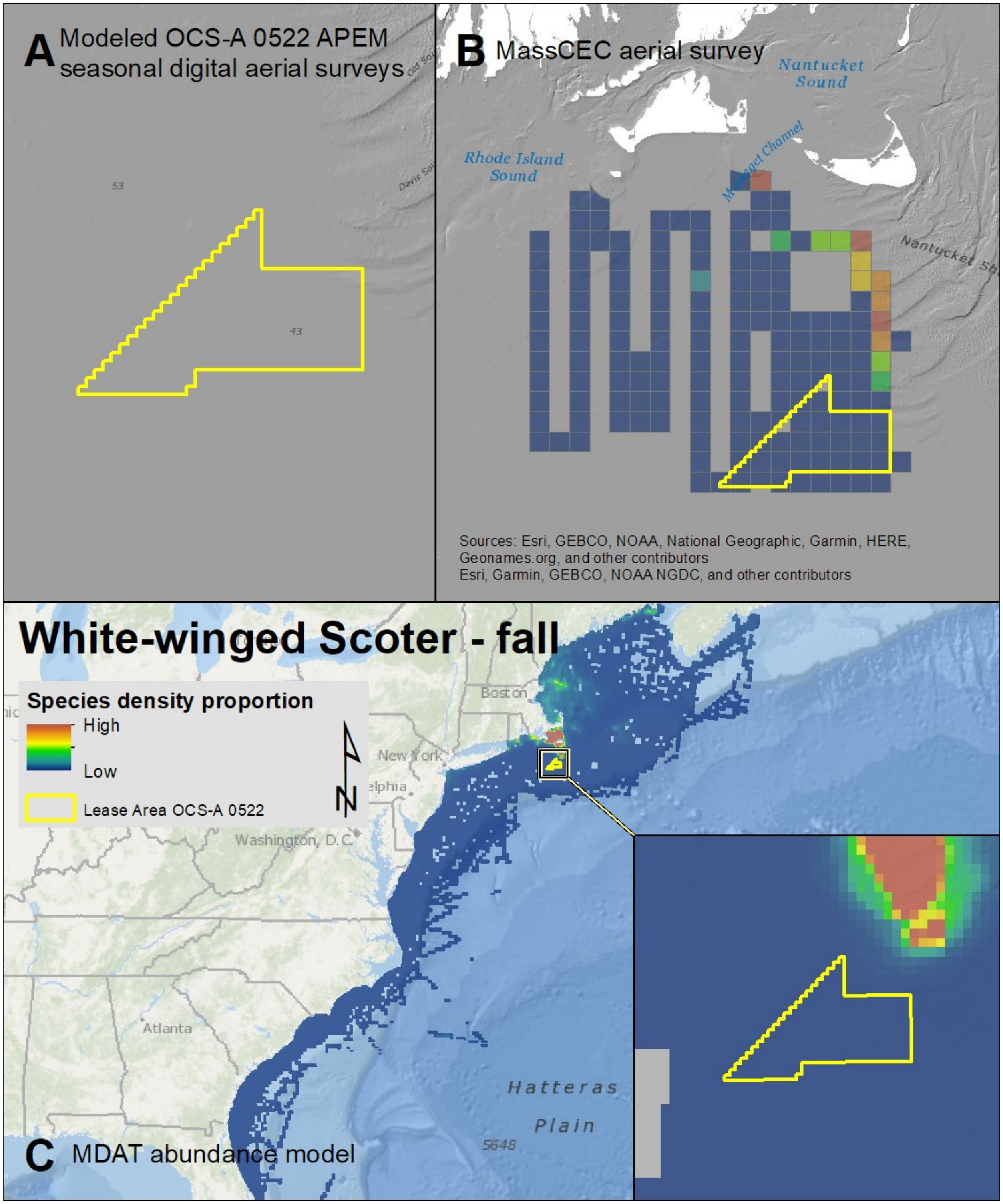
Map 20. Fall Surf Scoter modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



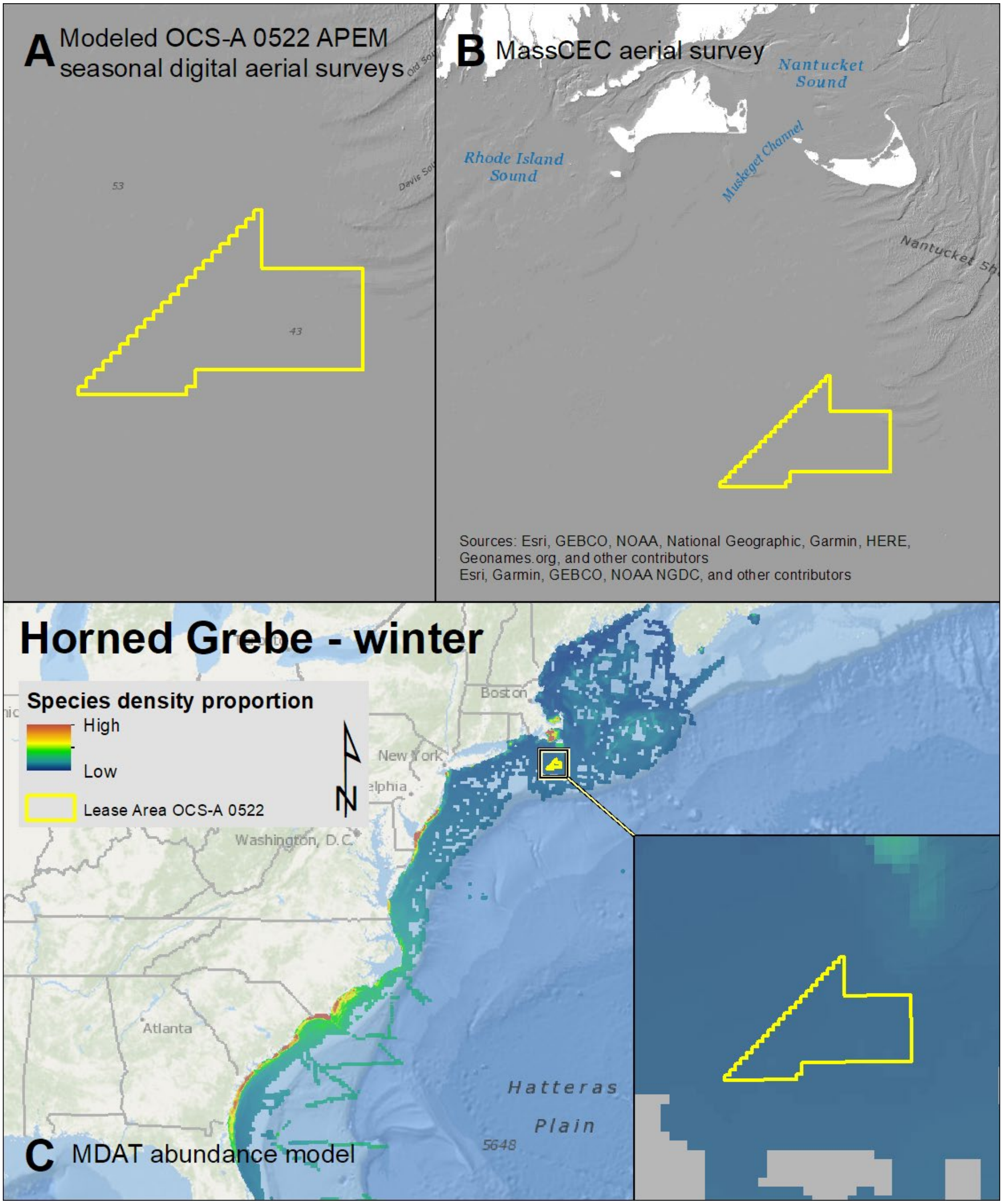
Map 21. Winter White-winged Scoter modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



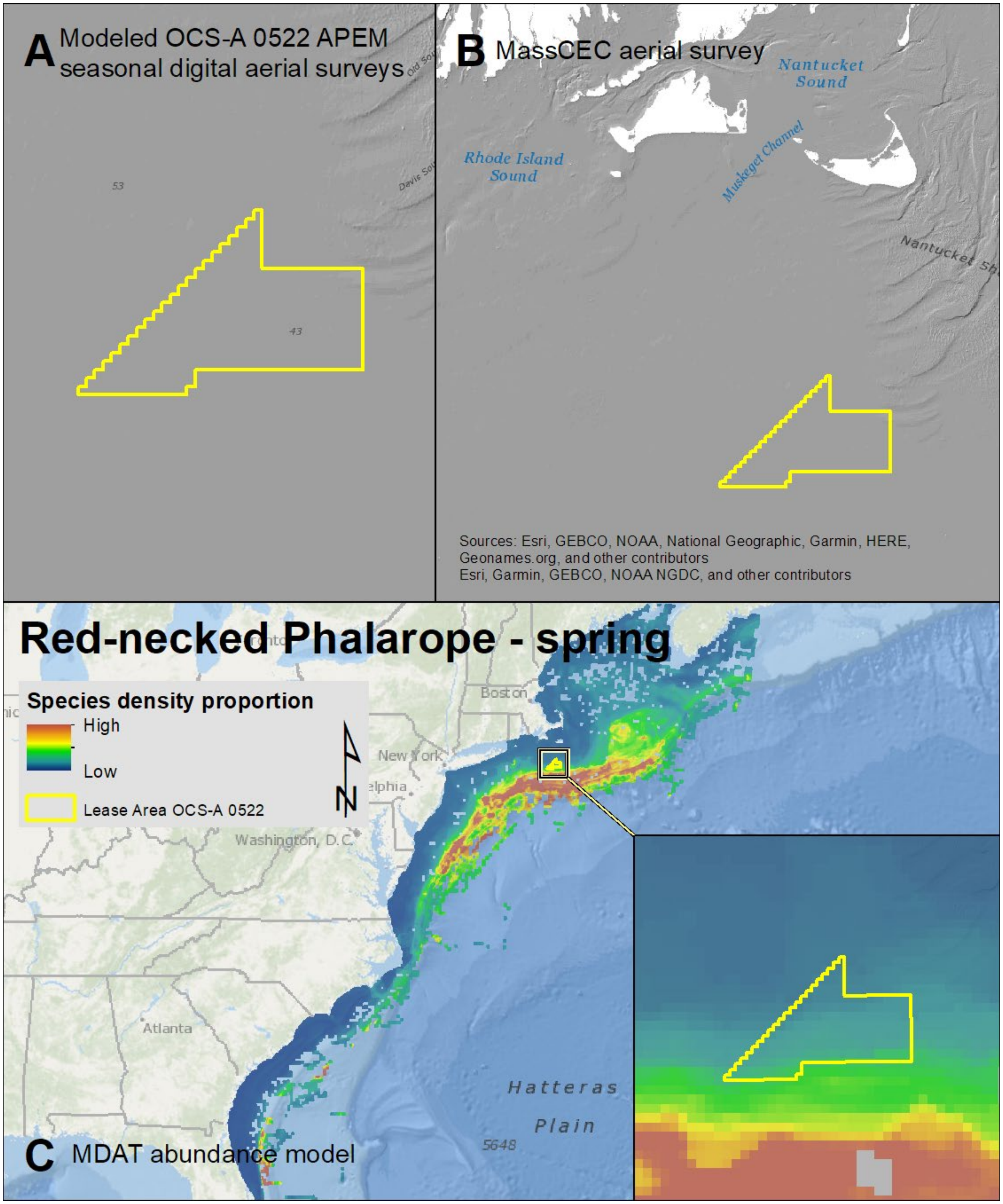
Map 22. Spring White-winged Scoter modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



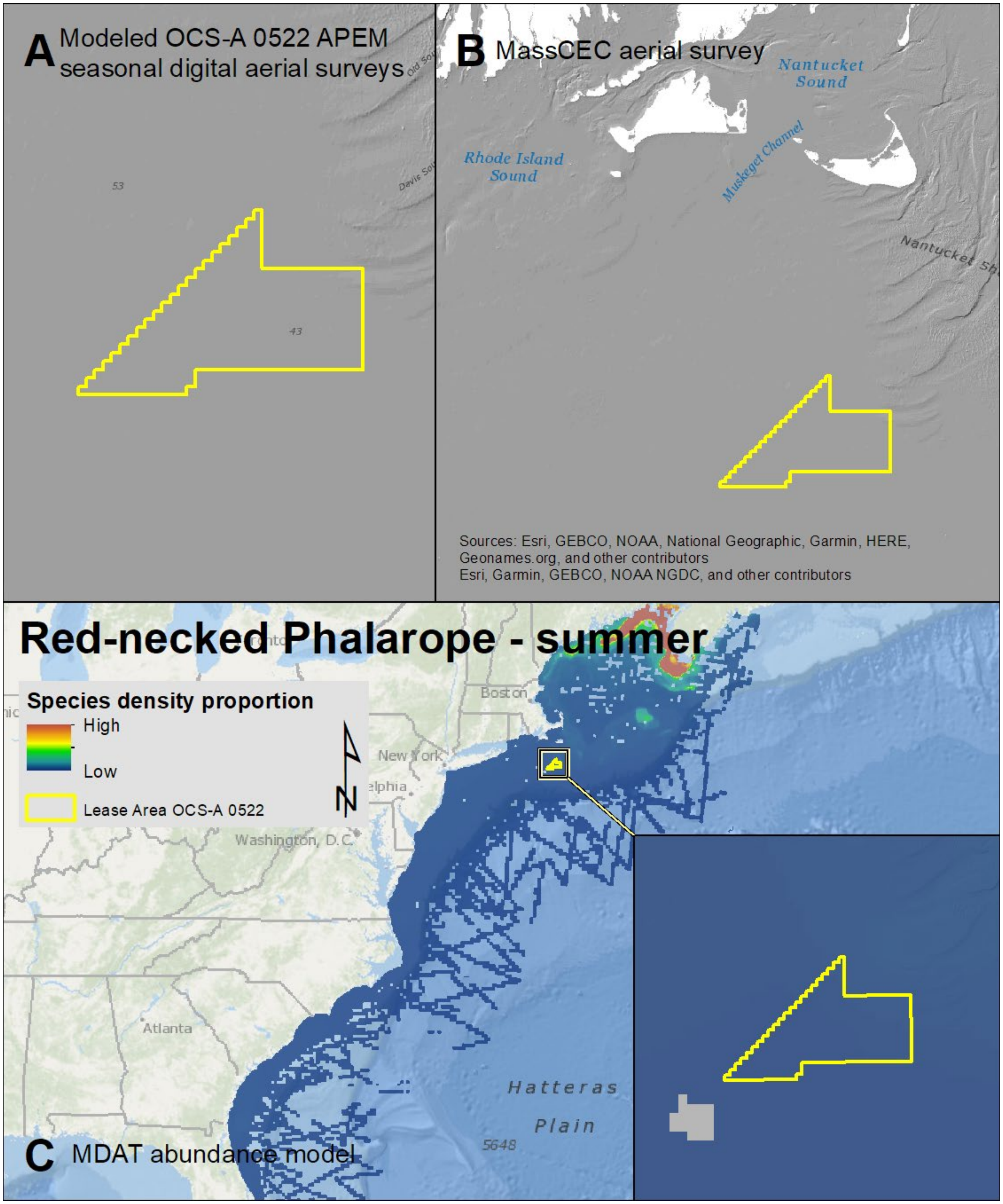
Map 23. Fall White-winged Scoter modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



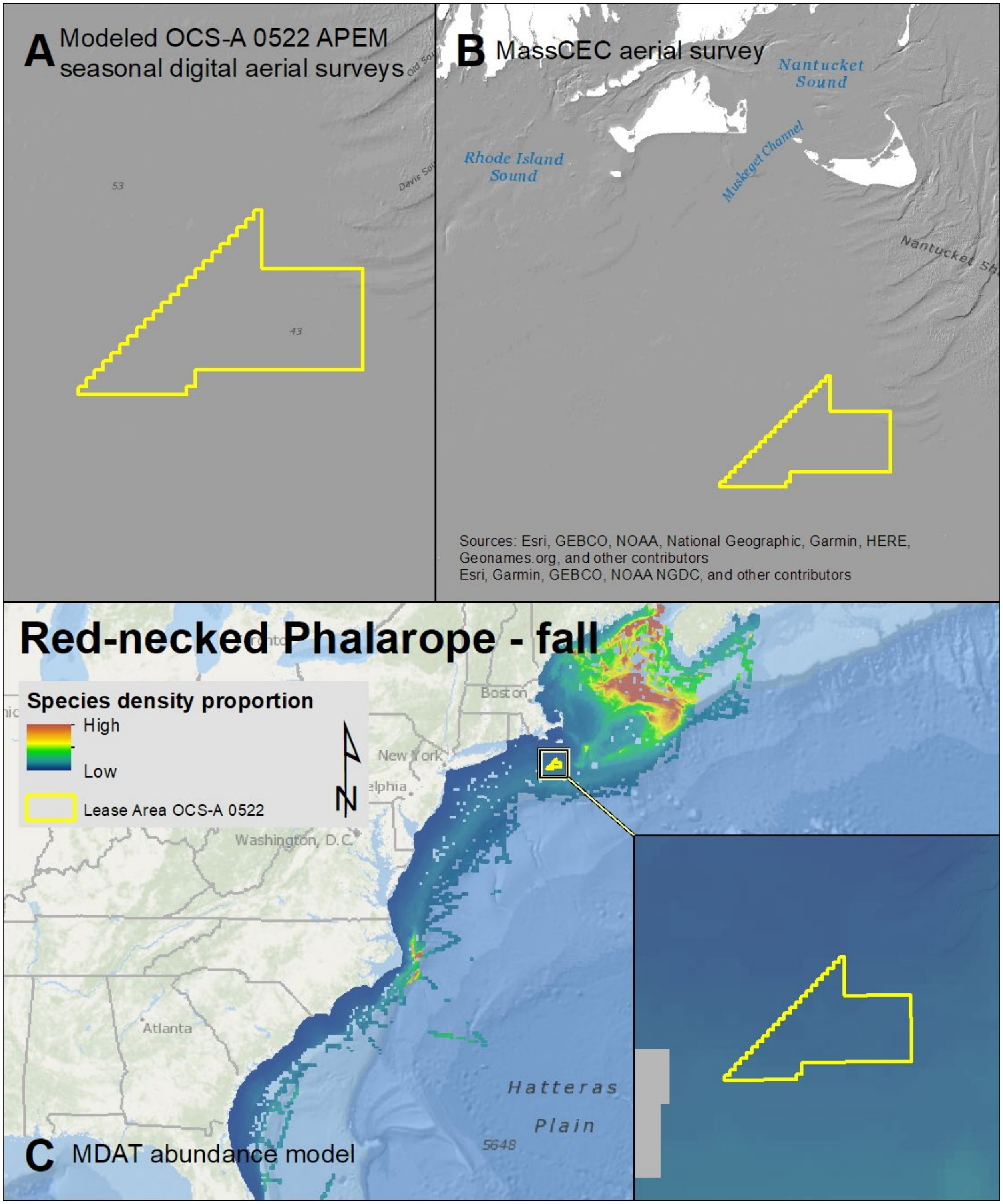
Map 24. Winter Horned Grebe modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



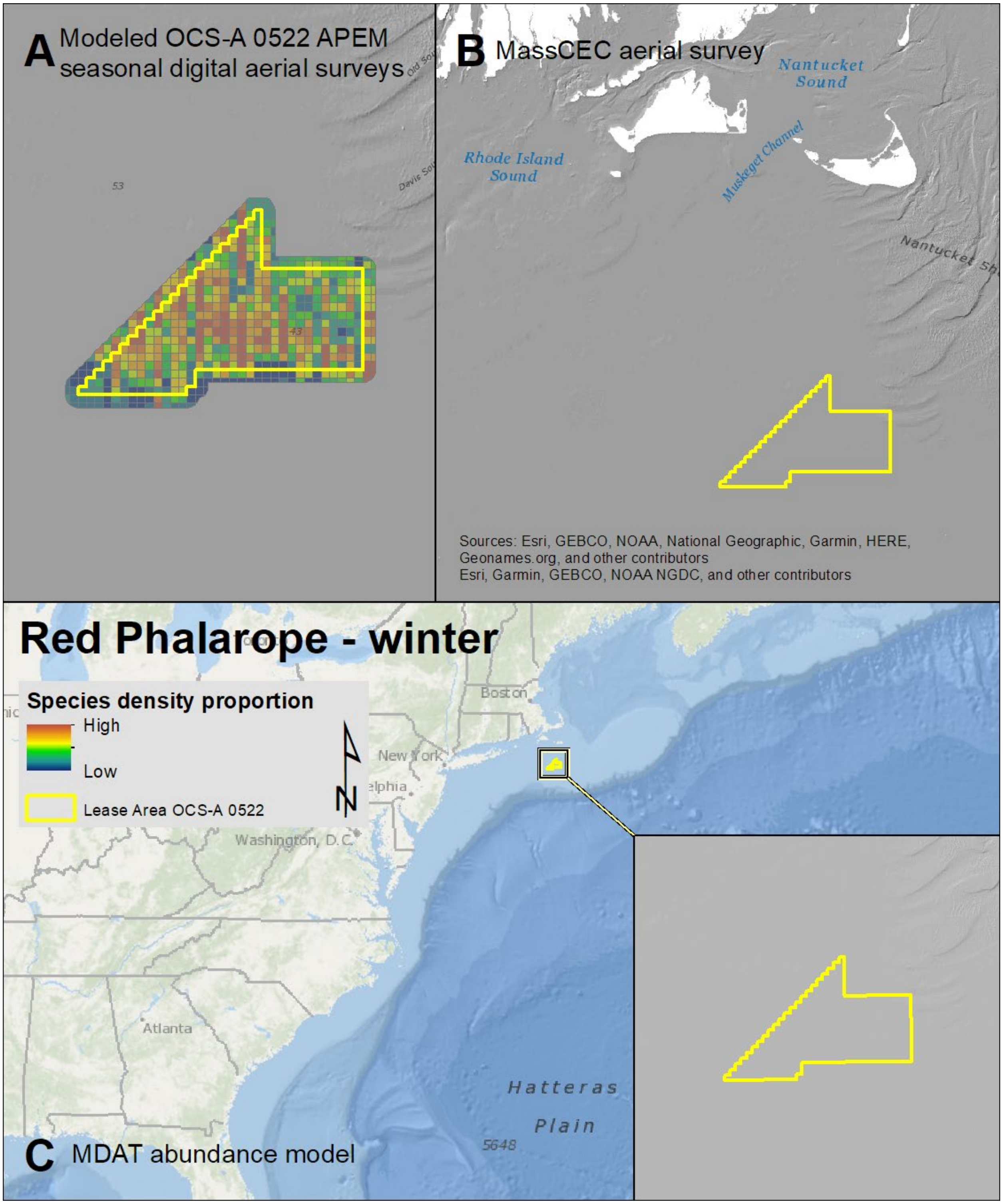
Map 25. Spring Red-necked Phalarope modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



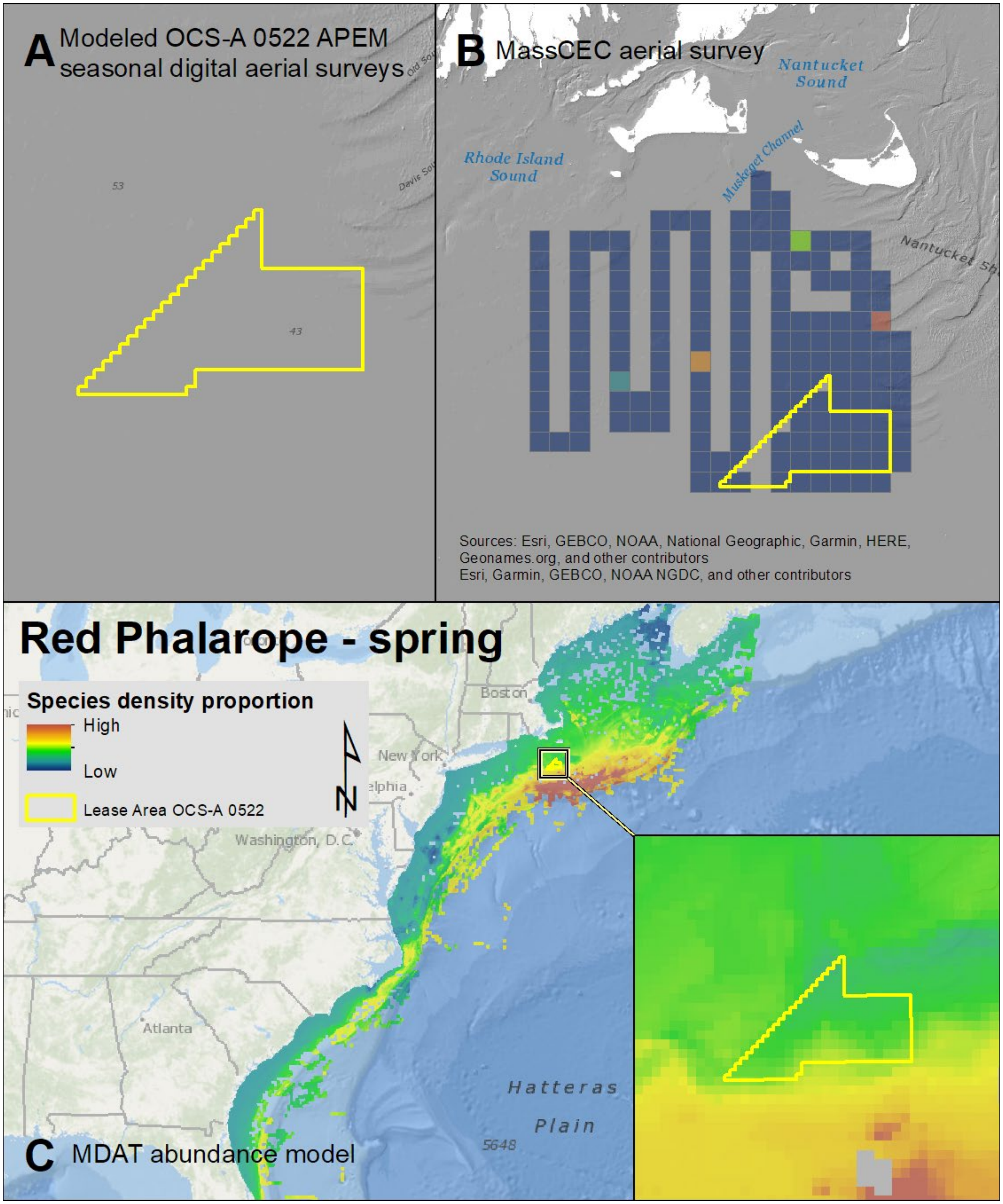
Map 26. Summer Red-necked Phalarope modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



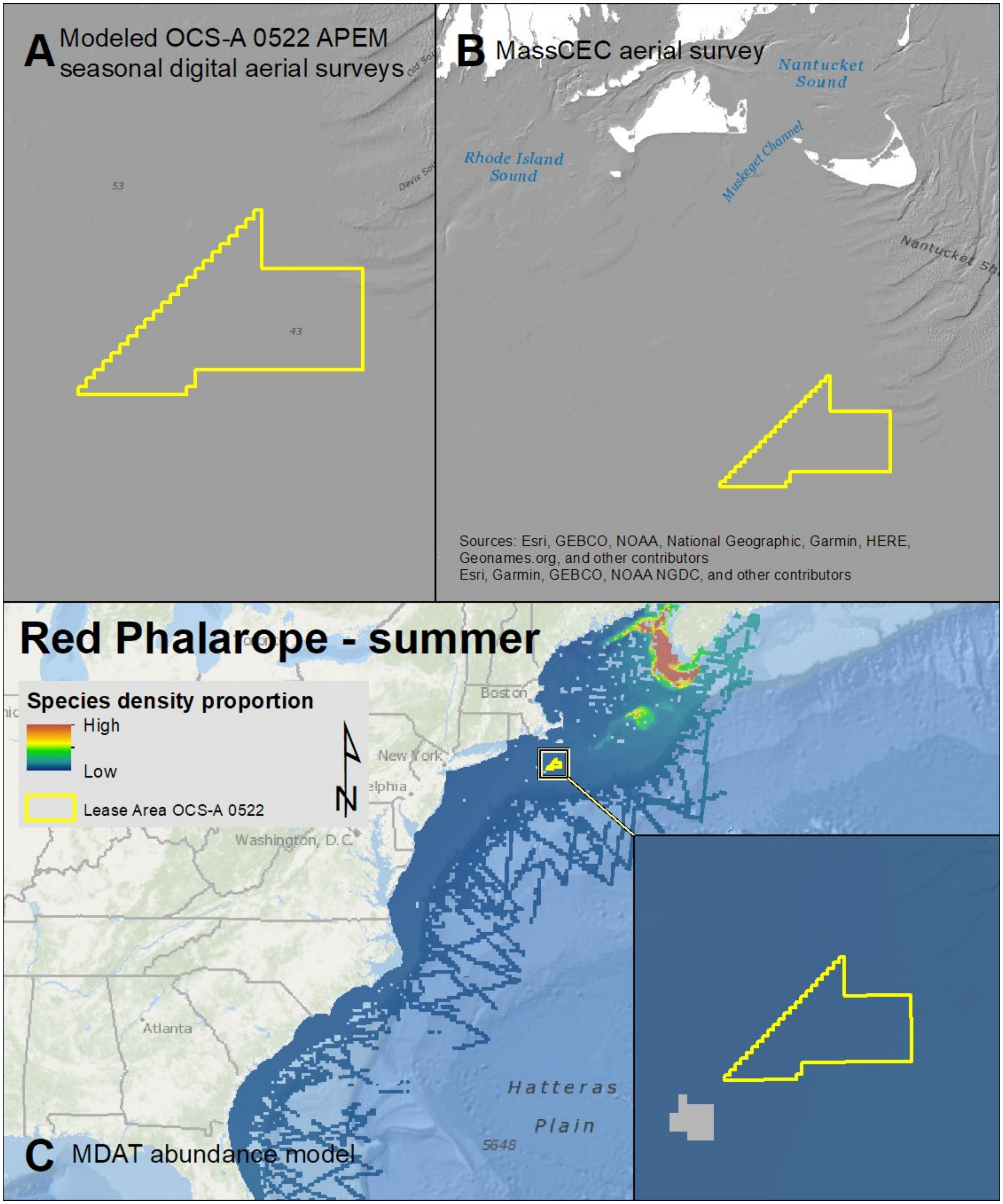
Map 27. Fall Red-necked Phalarope modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



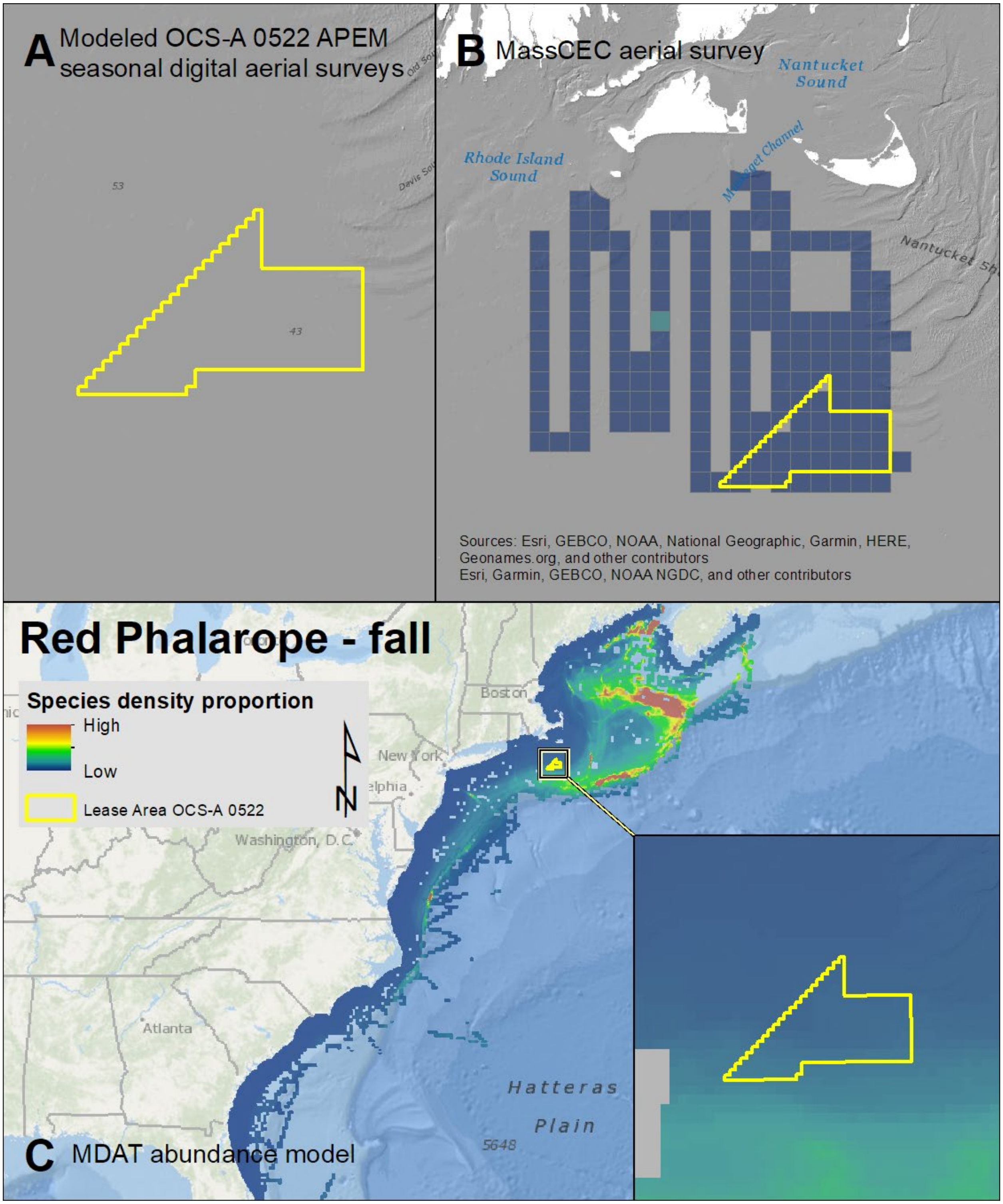
Map 28. Winter Red Phalarope modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



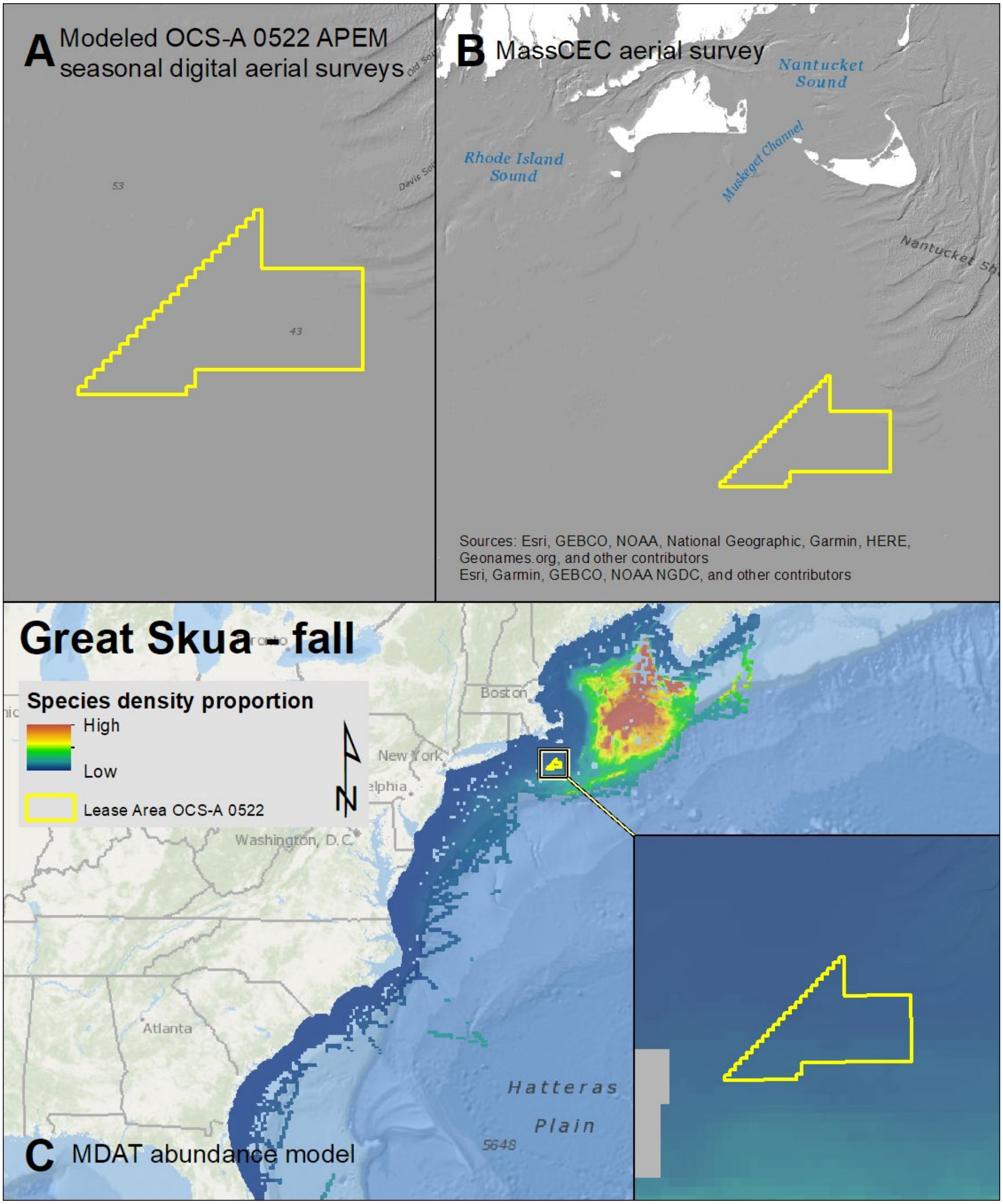
Map 29. Spring Red Phalarope modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



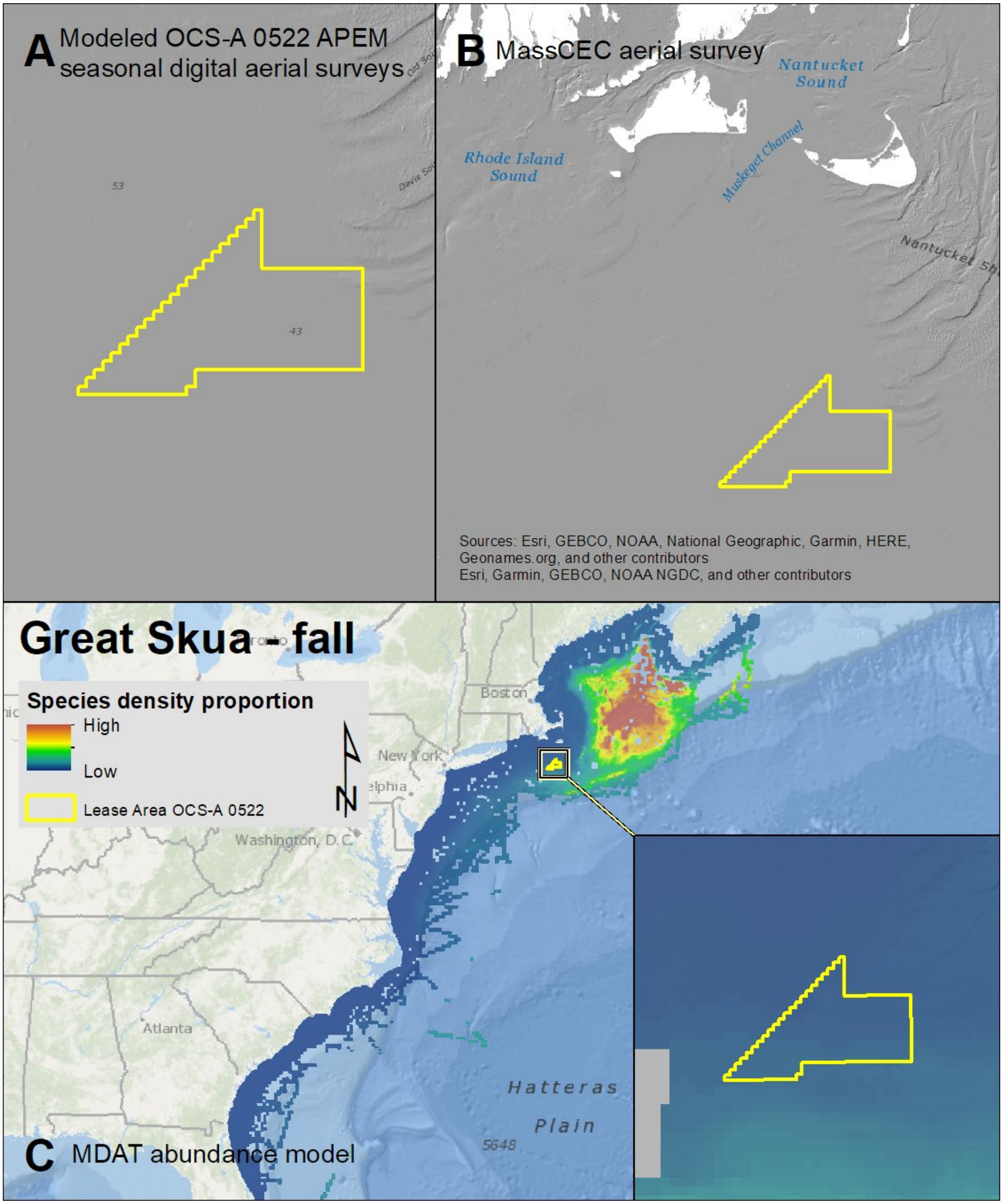
Map 30. Summer Red Phalarope modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



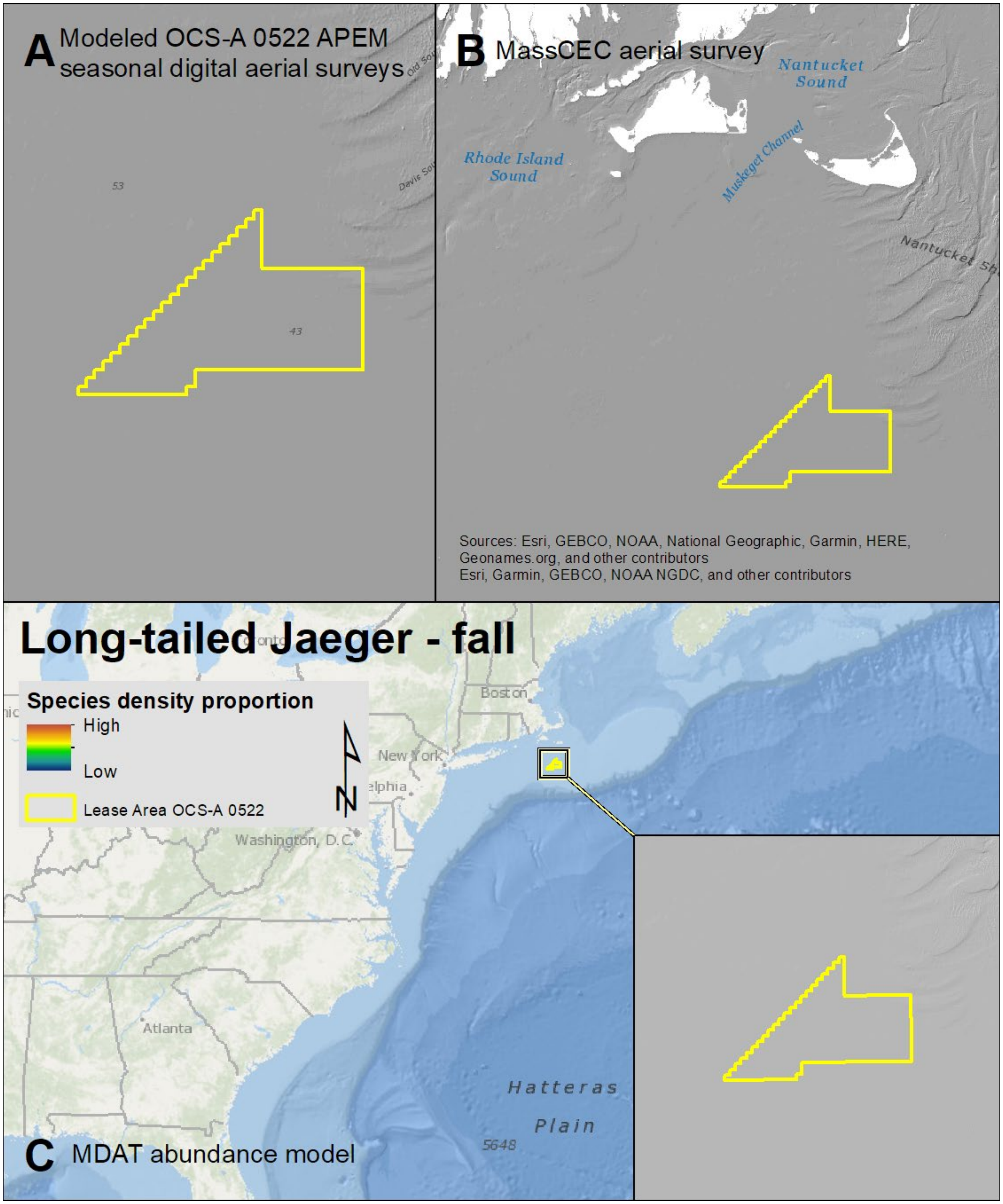
Map 31. Fall Red Phalarope modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



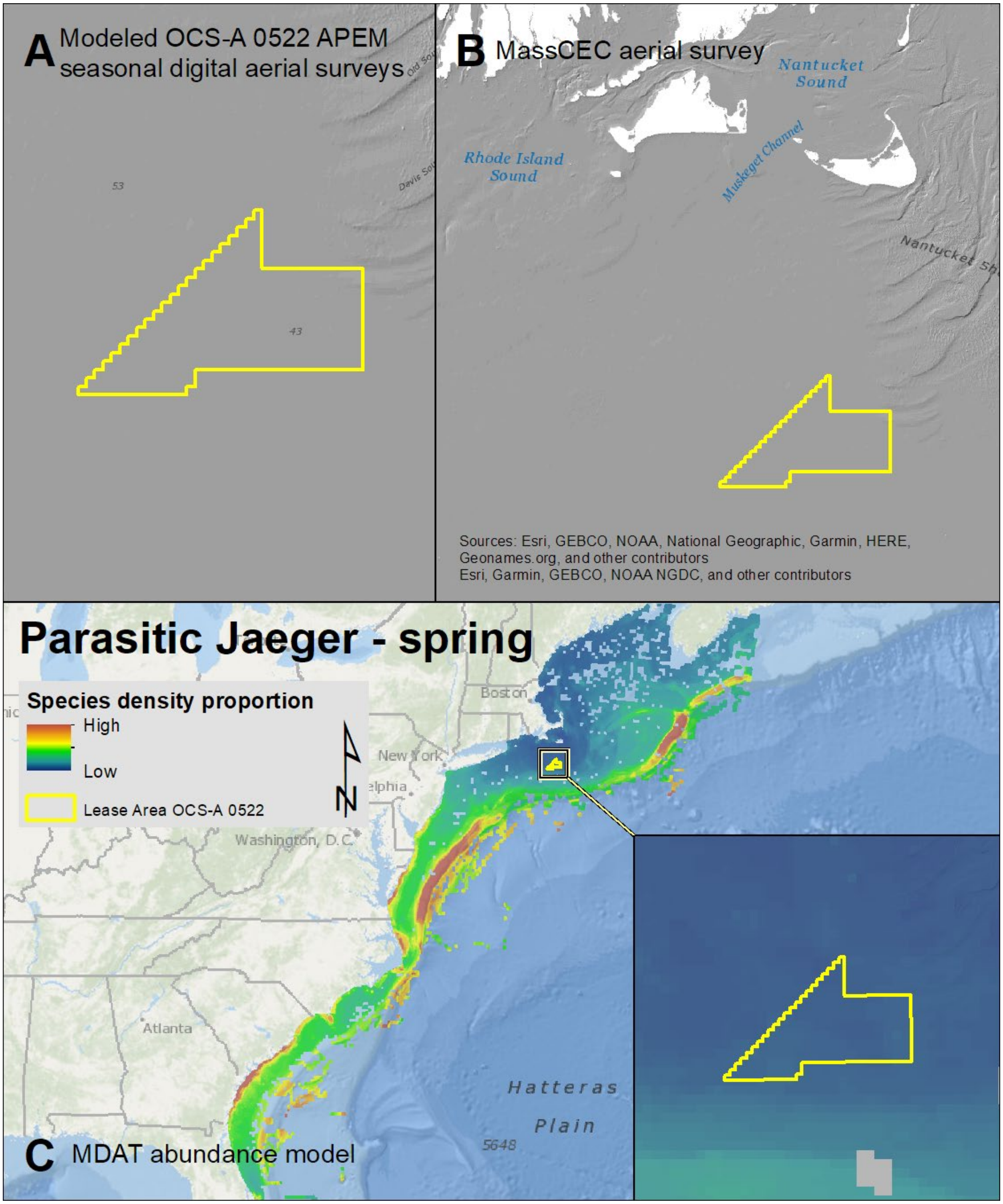
Map 32. Fall Great Skua modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



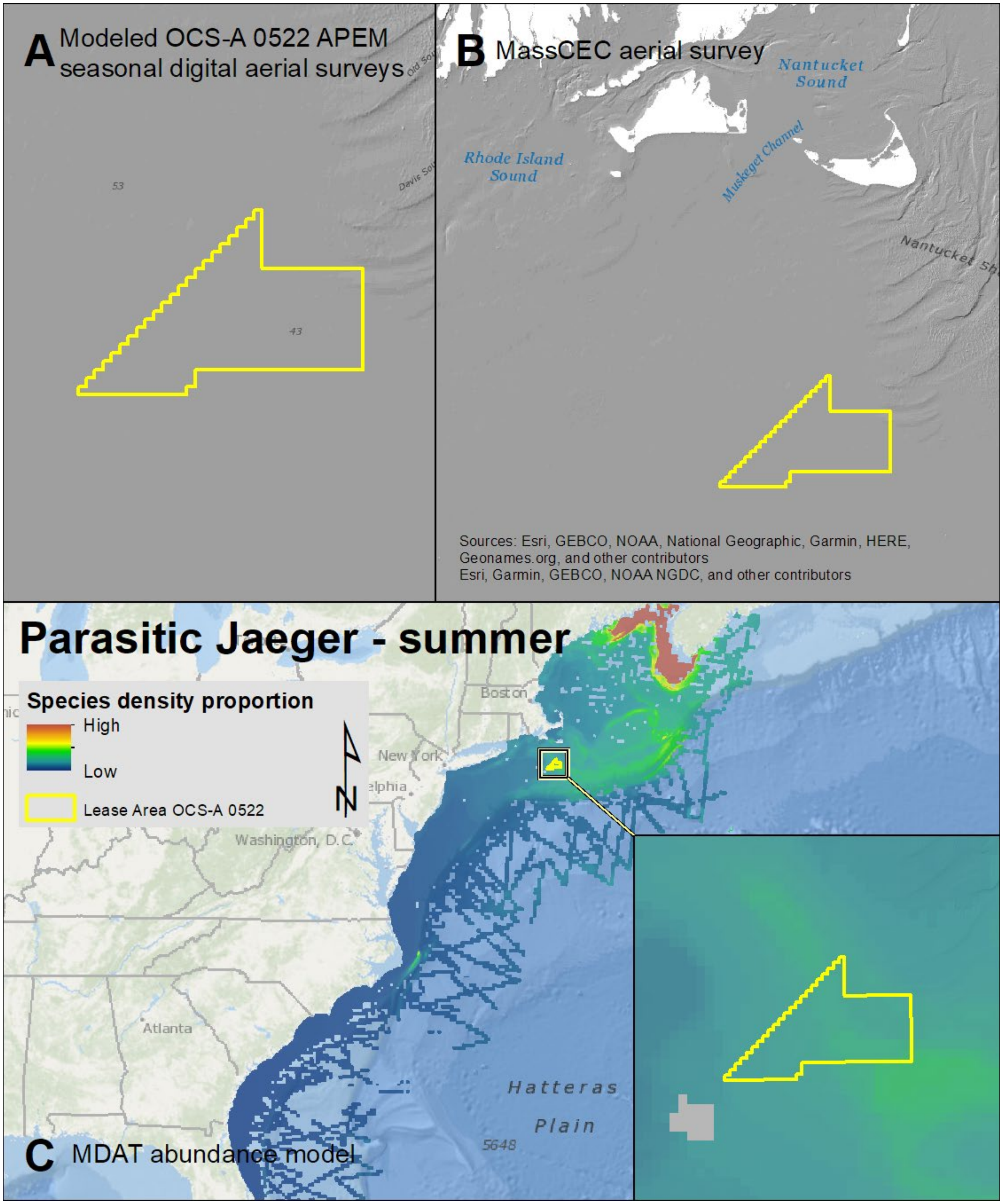
Map 33. Fall Great Skua modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



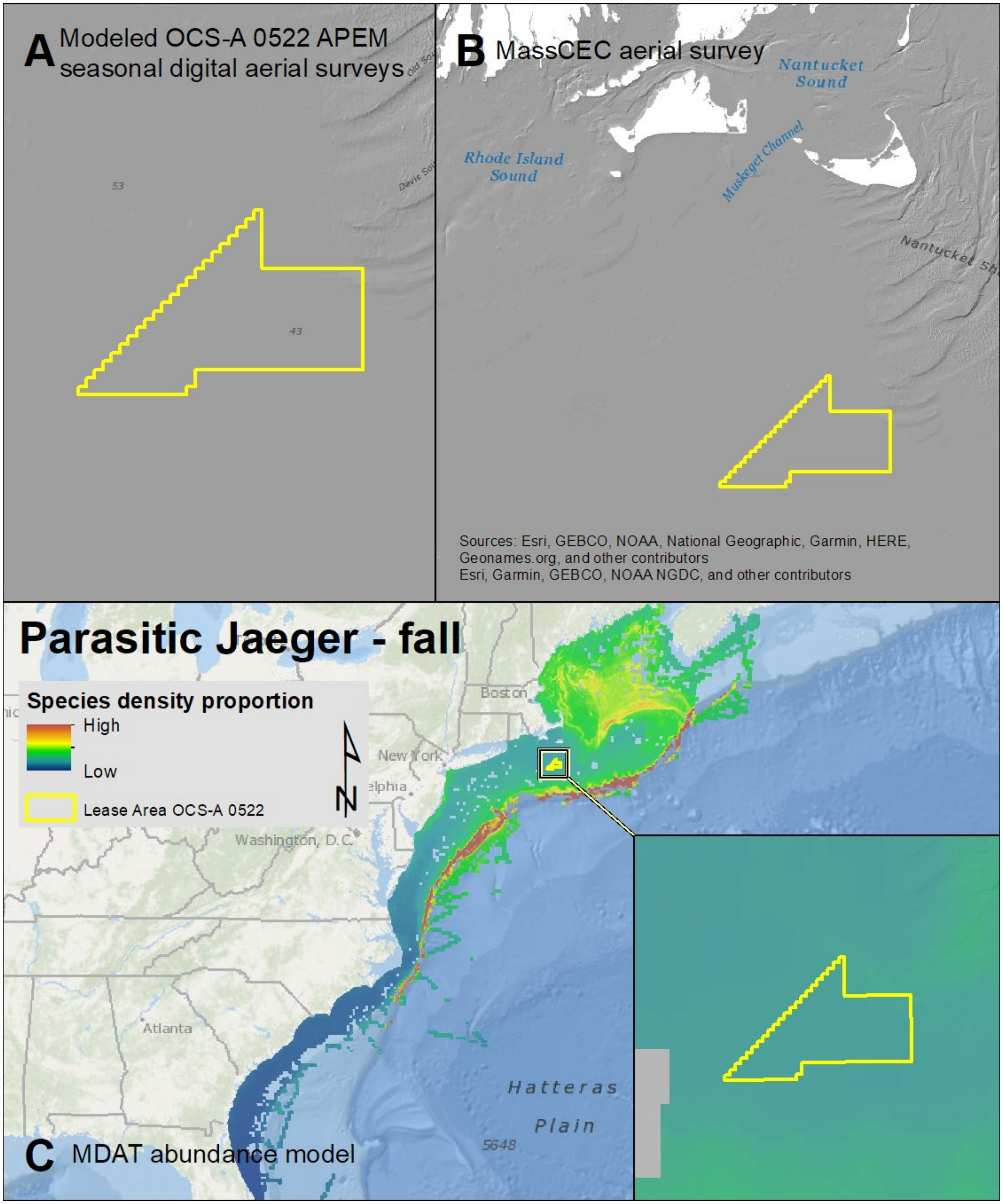
Map 34. Fall Long-tailed Jaeger modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



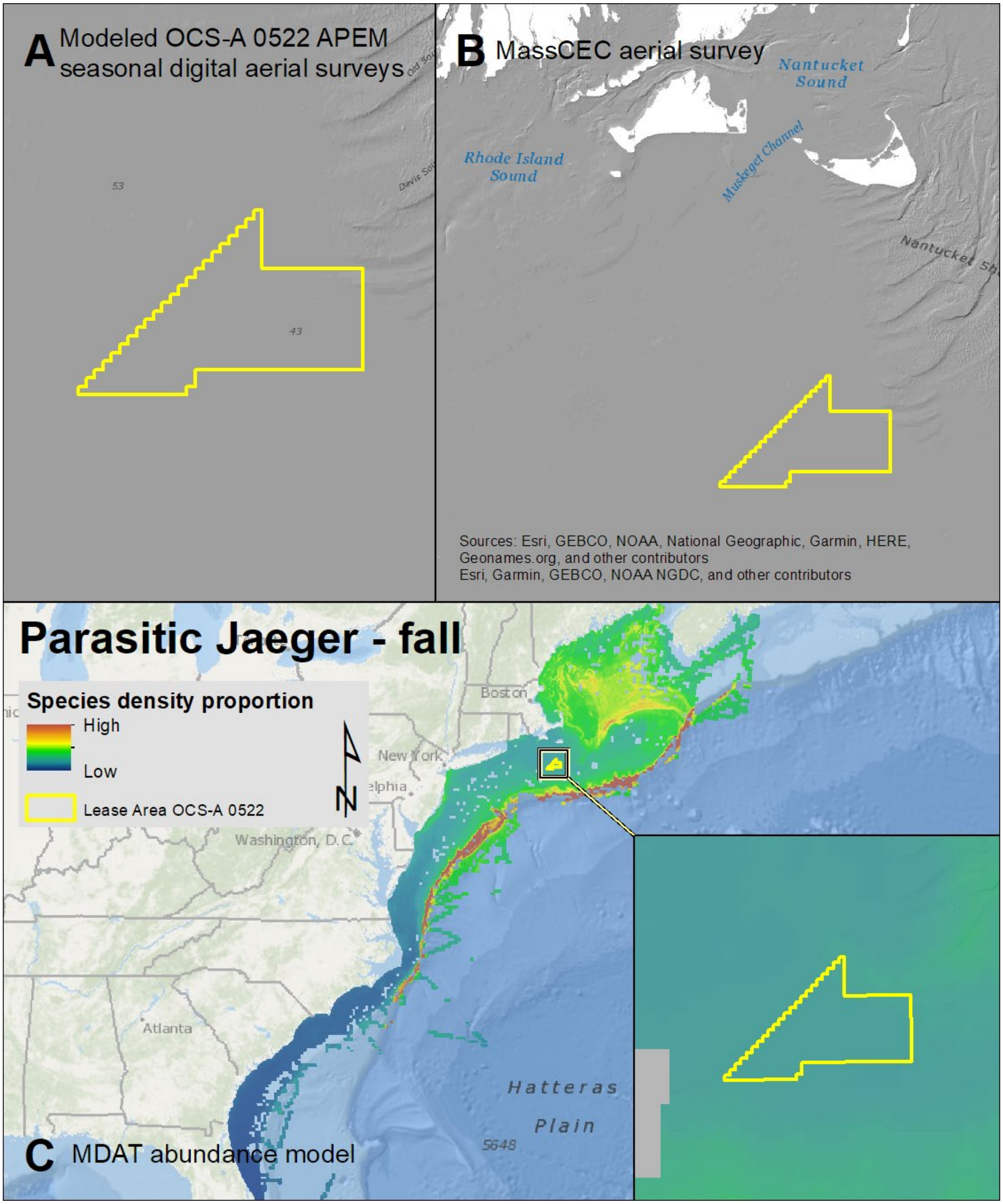
Map 35. Spring Parasitic Jaeger modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



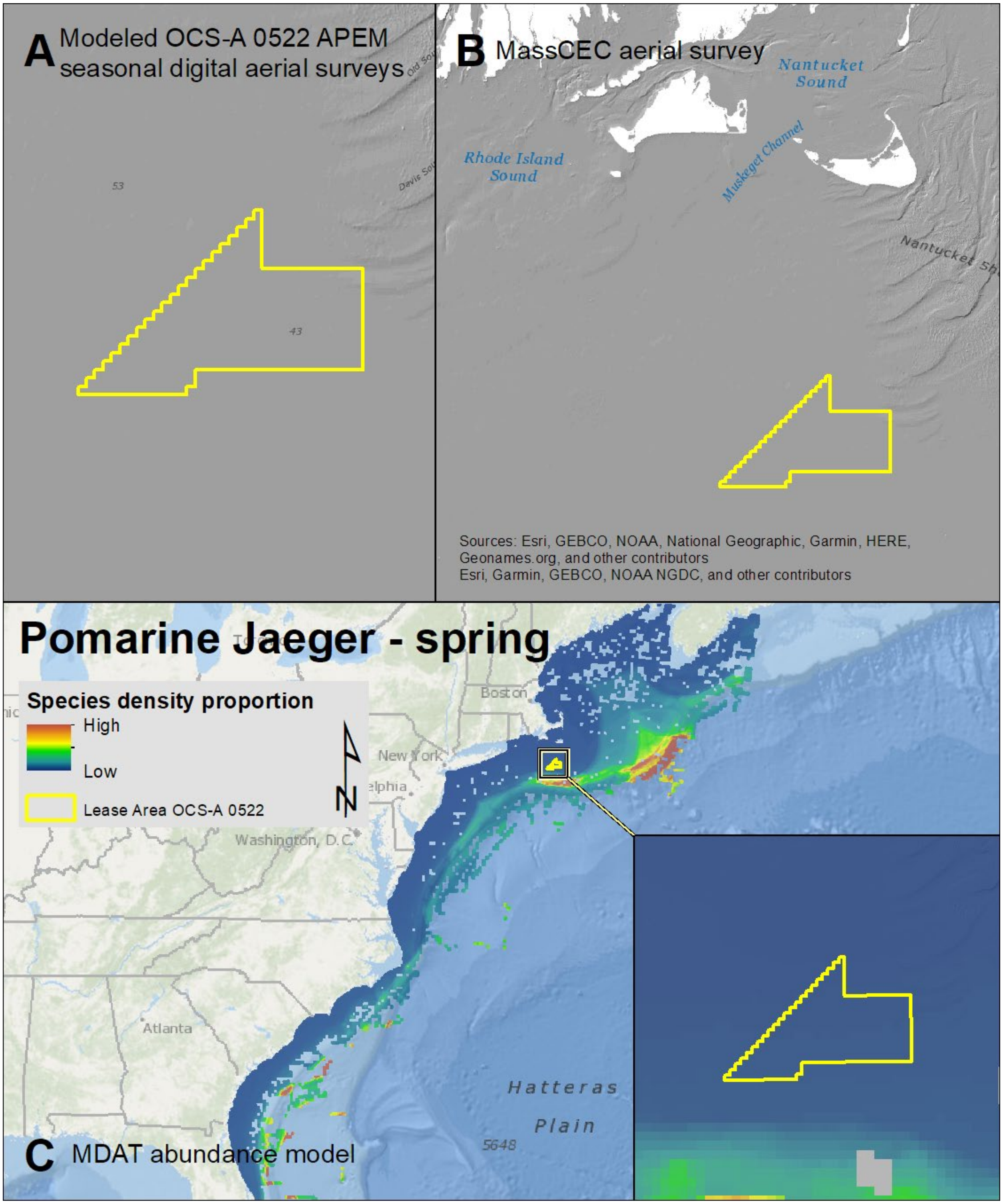
Map 36. Summer Parasitic Jaeger modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



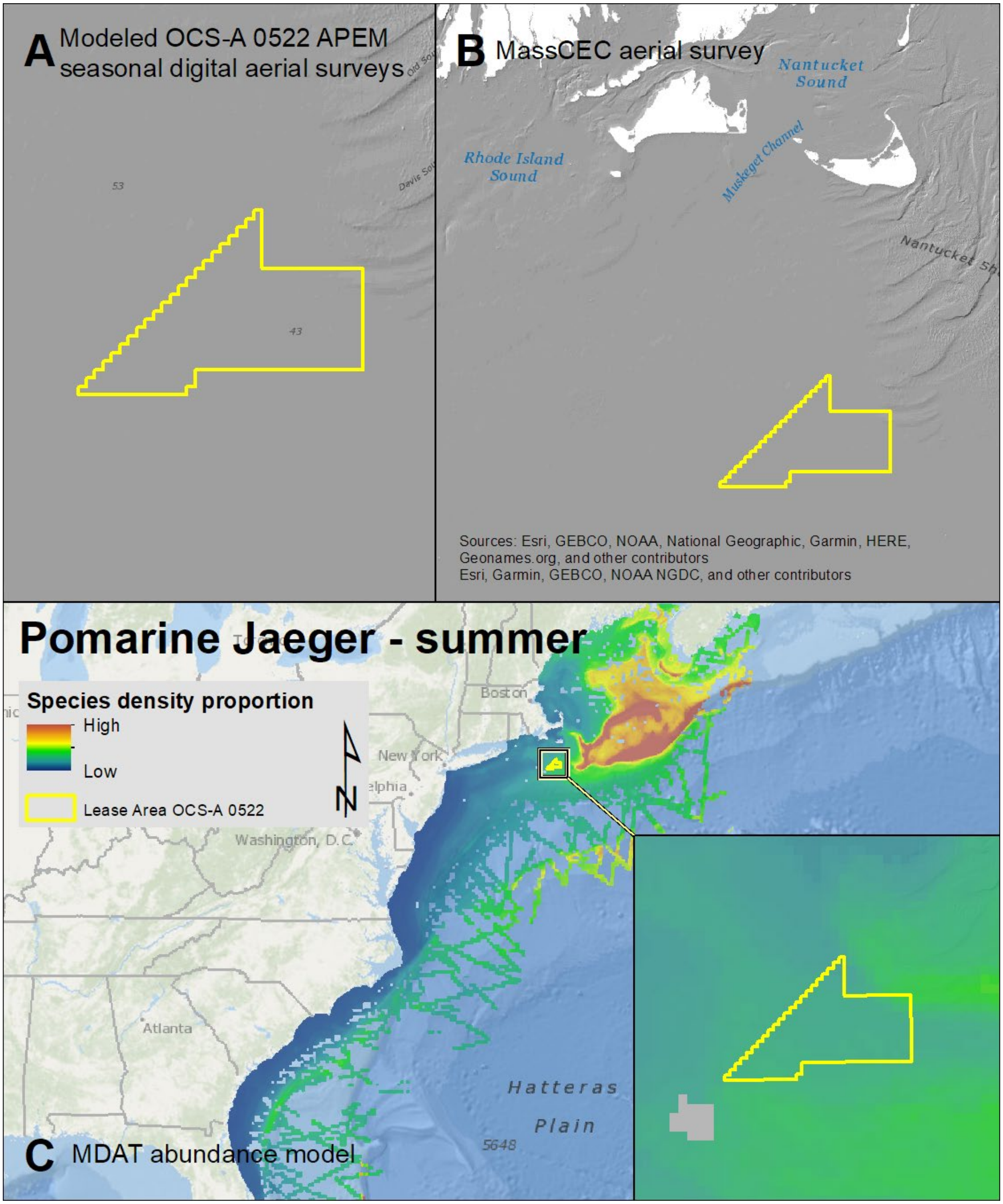
Map 37. Fall Parasitic Jaeger modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



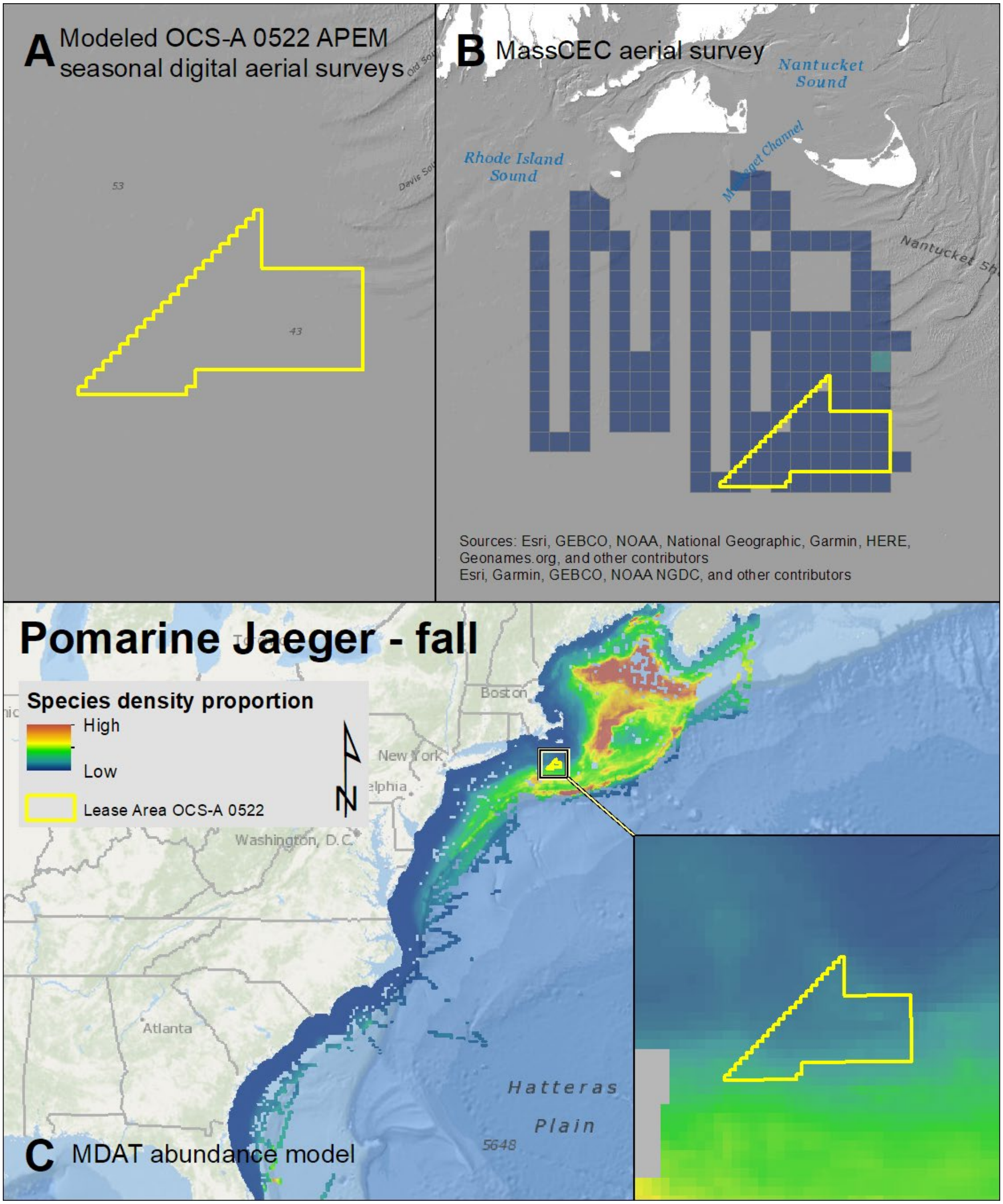
Map 38. Fall Parasitic Jaeger modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



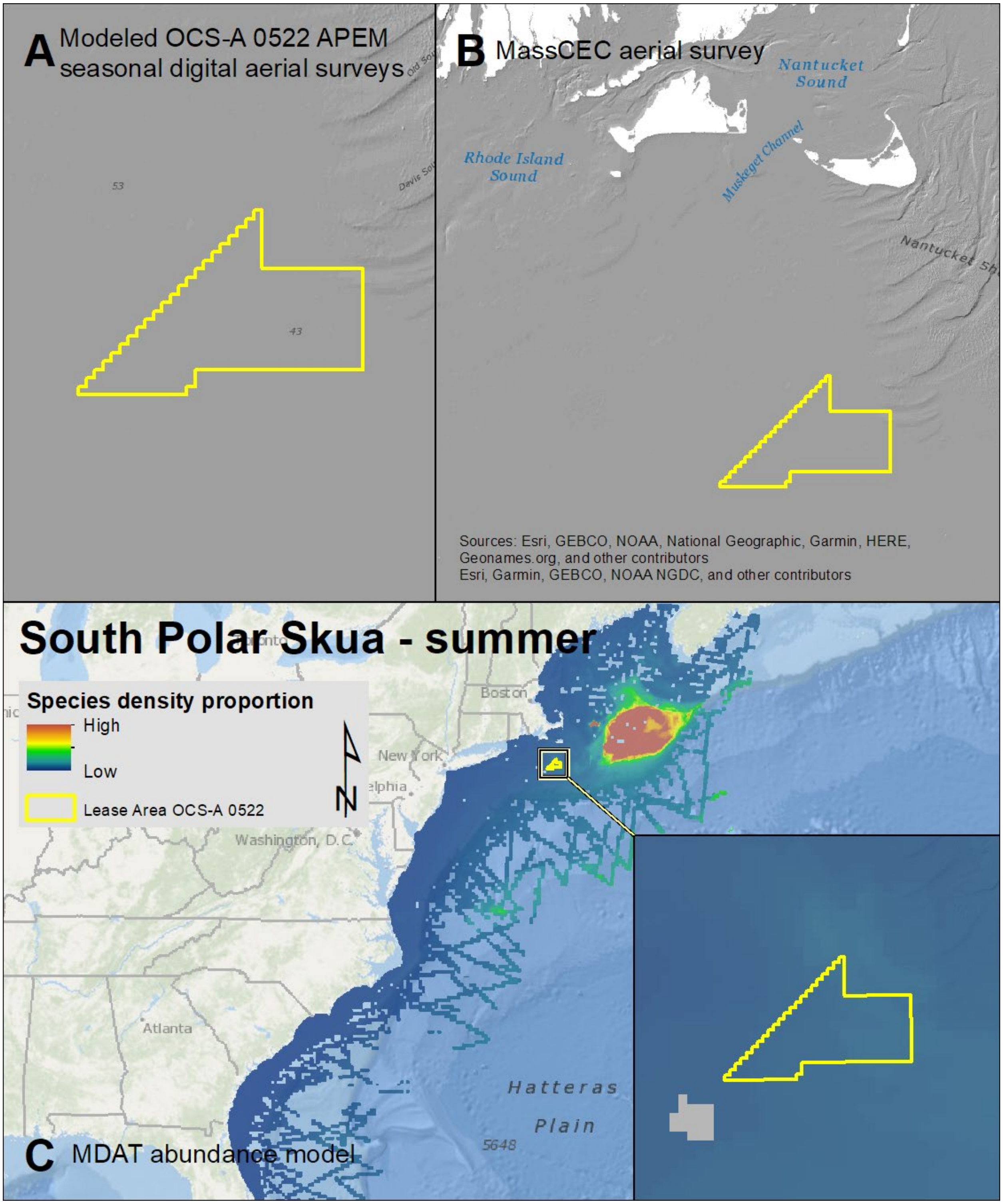
Map 39. Spring Pomarine Jaeger modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



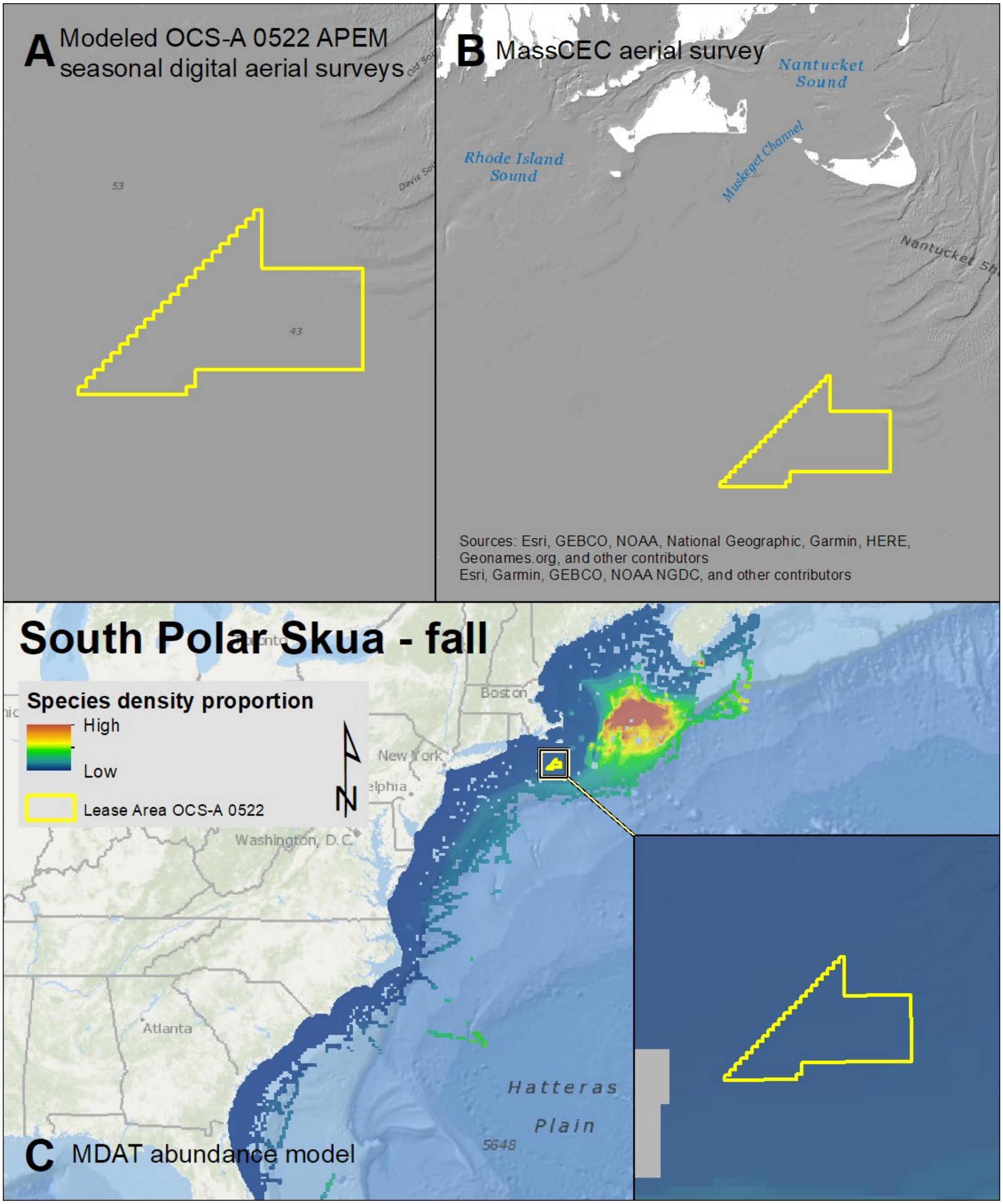
Map 40. Summer Pomarine Jaeger modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



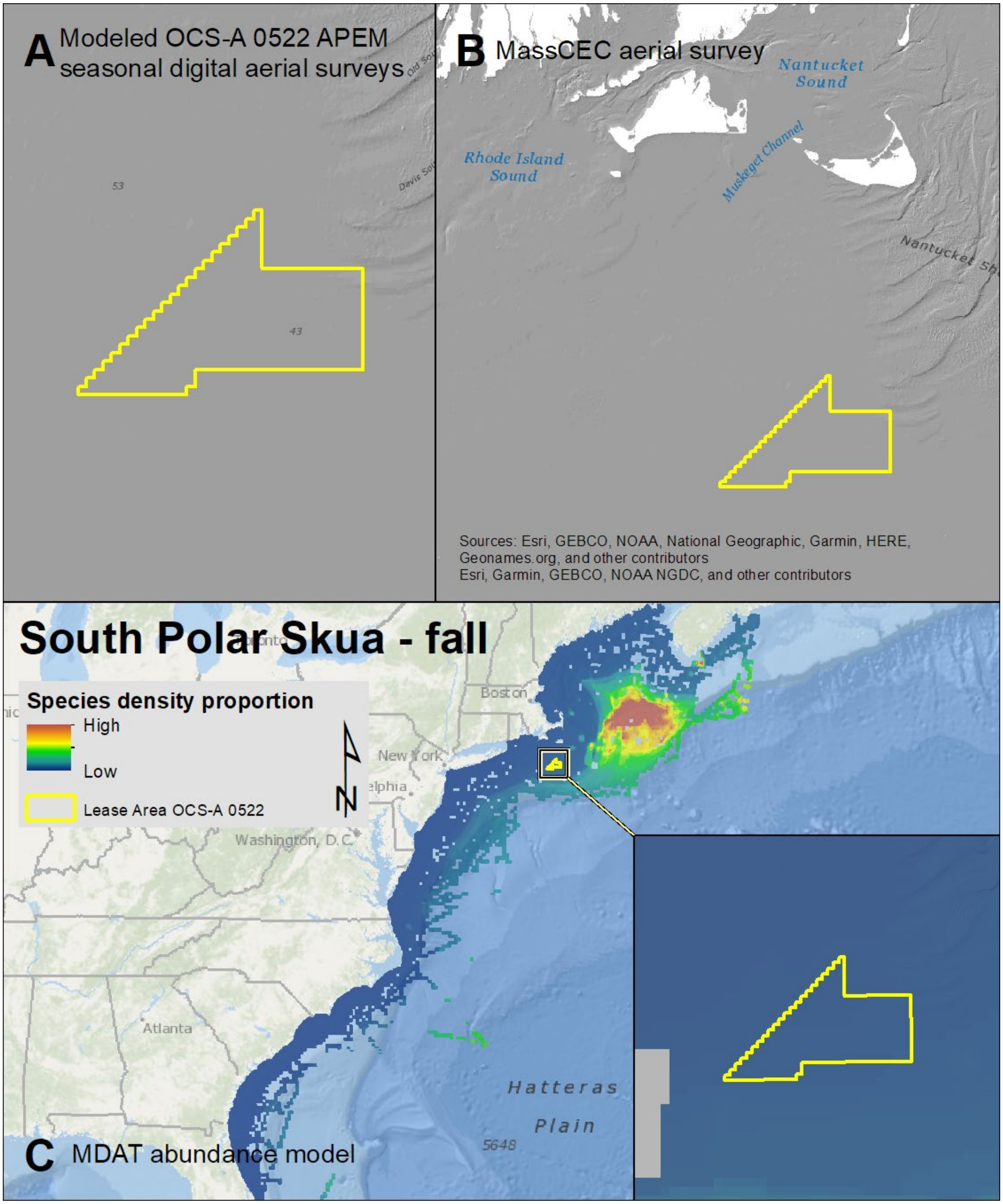
Map 41. Fall Pomarine Jaeger modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



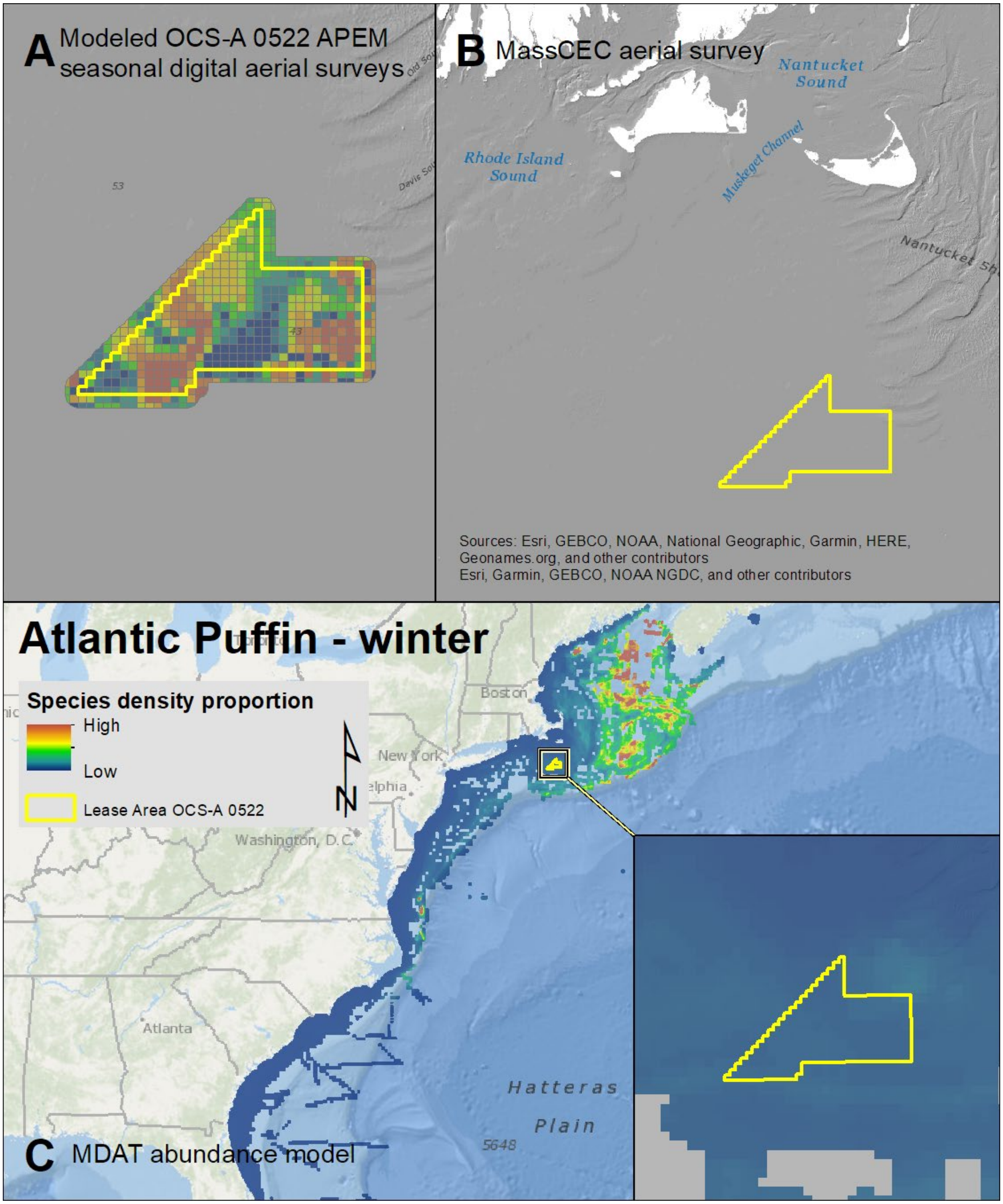
Map 42. Summer South Polar Skua modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



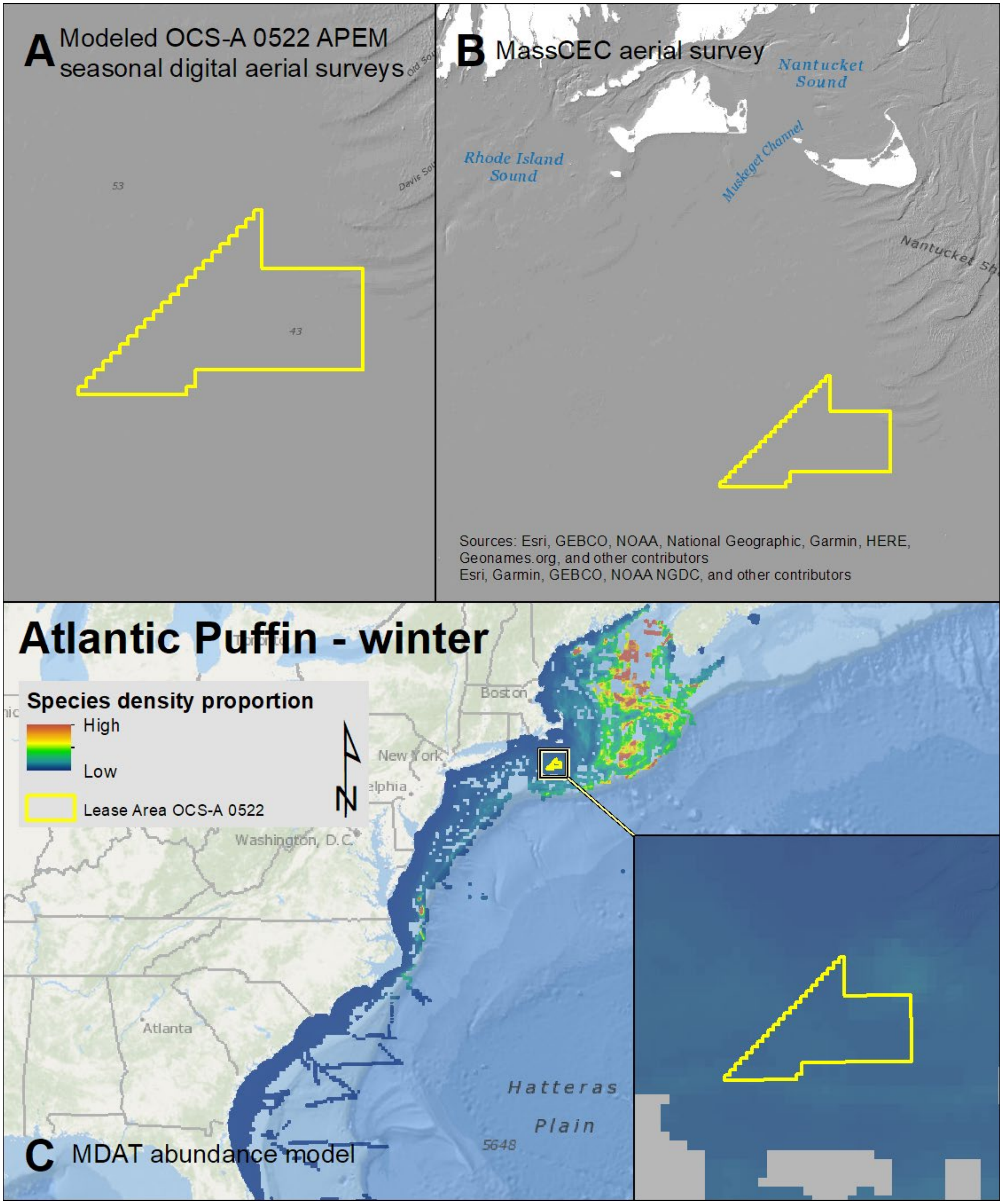
Map 43. Fall South Polar Skua modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



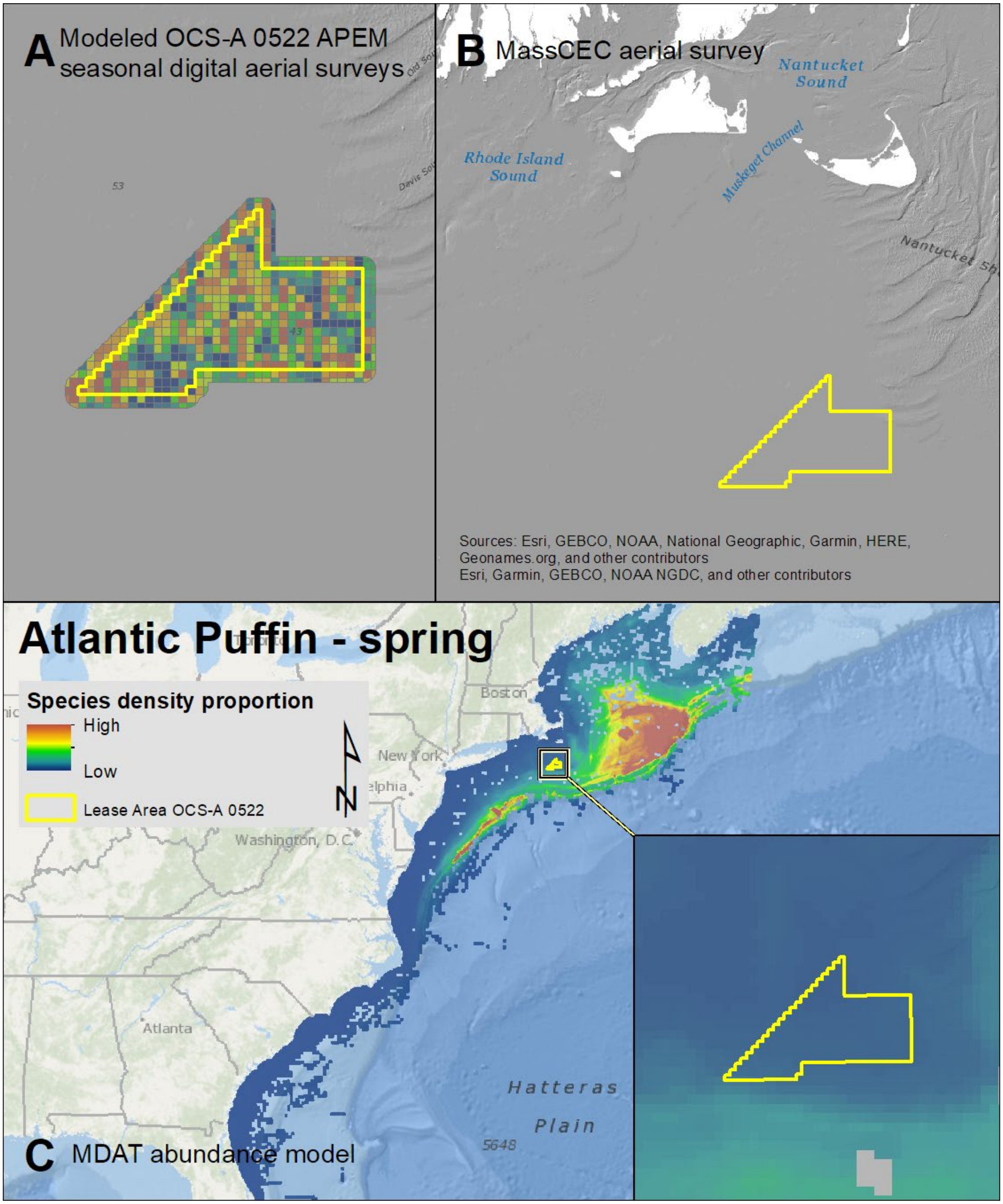
Map 44. Fall South Polar Skua modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



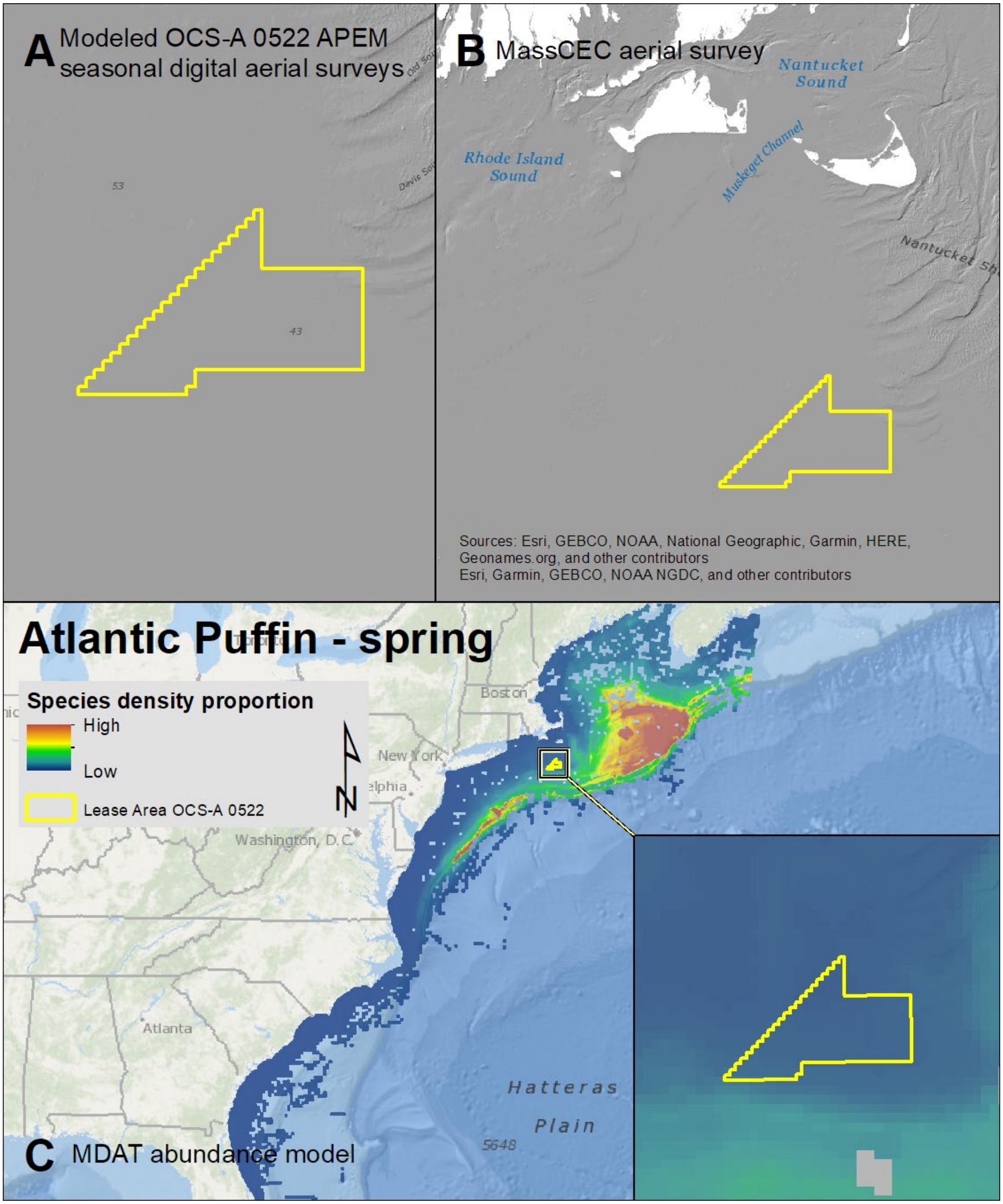
Map 45. Winter Atlantic Puffin modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



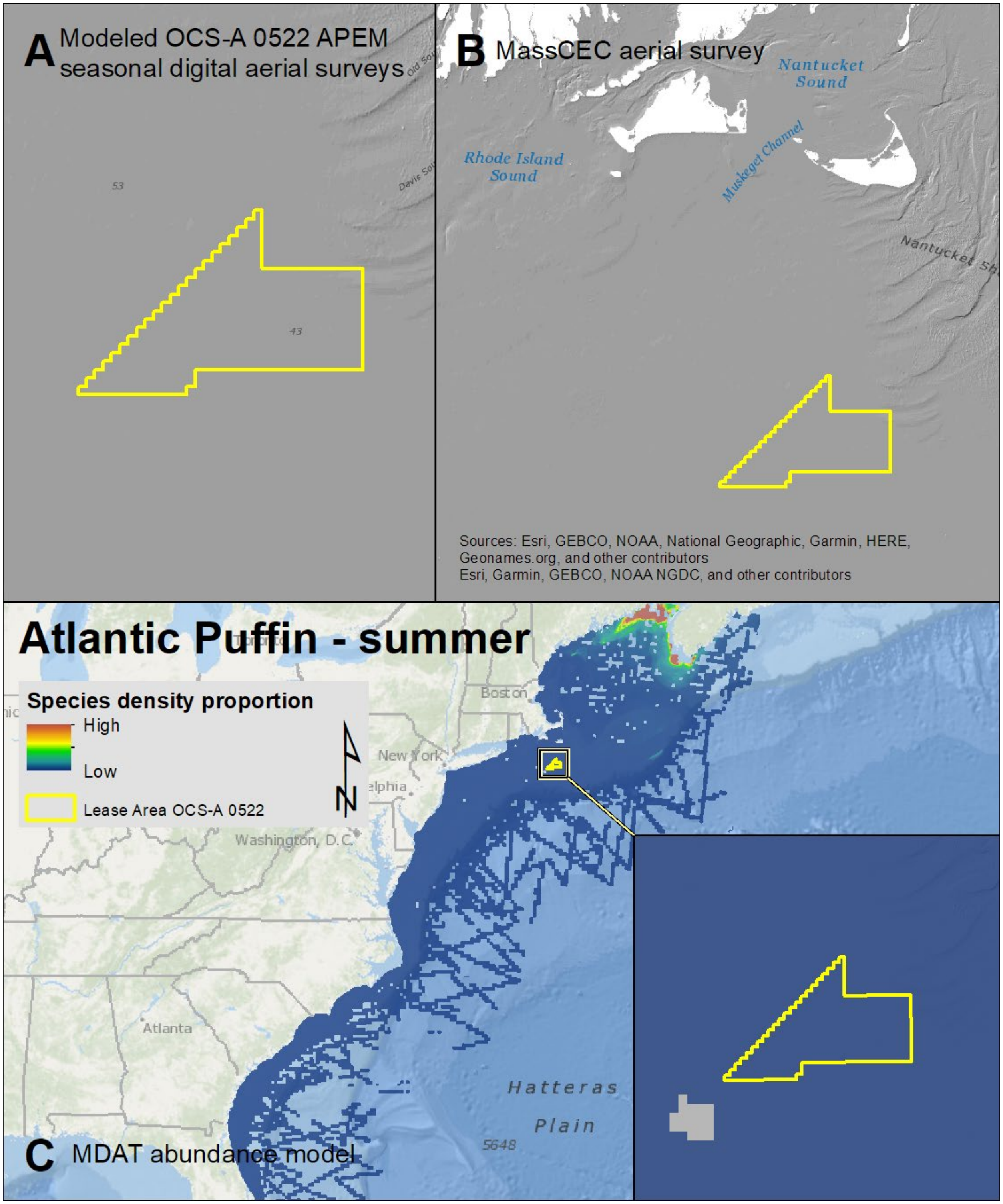
Map 46. Winter Atlantic Puffin modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



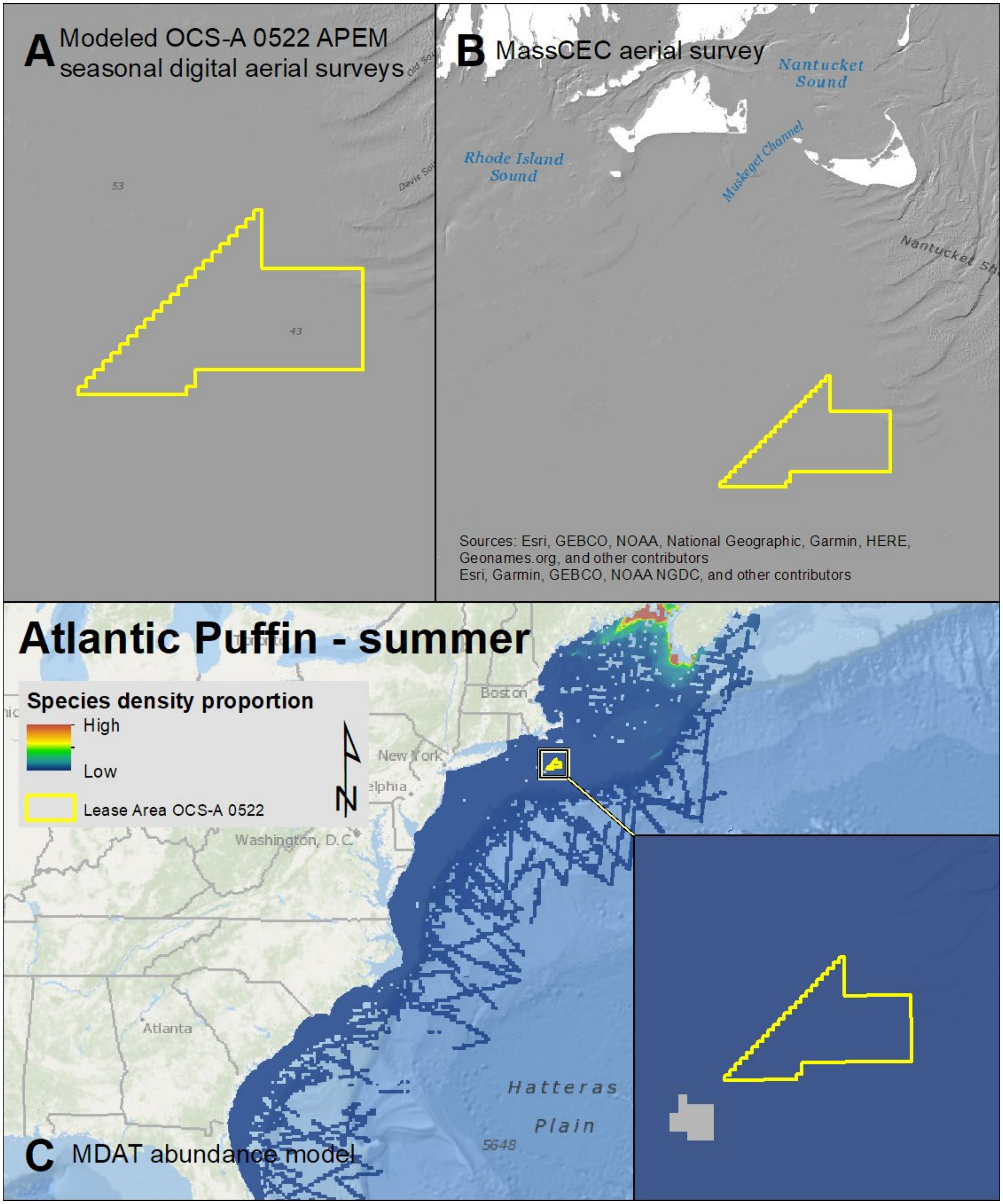
Map 47. Spring Atlantic Puffin modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



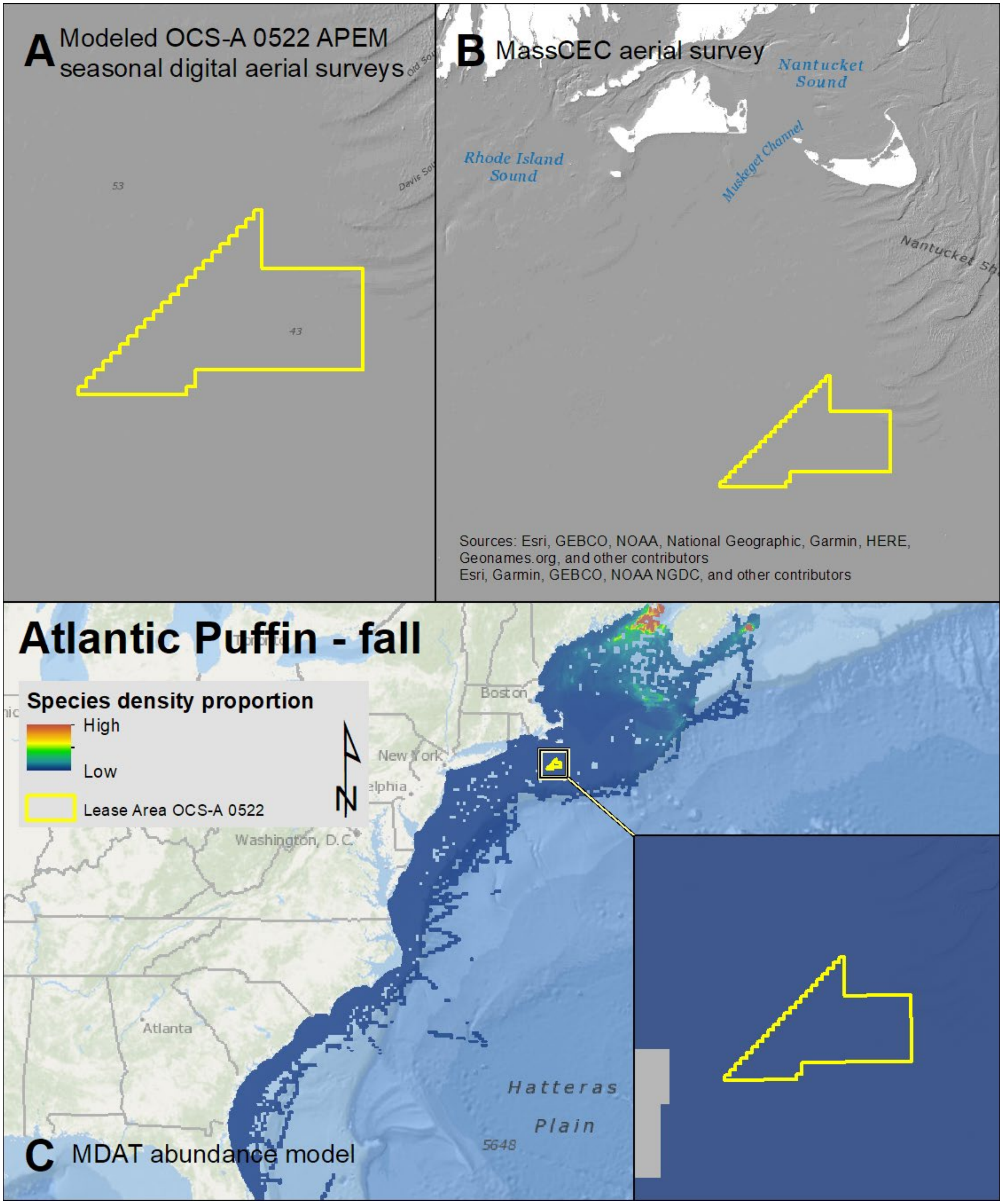
Map 48. Spring Atlantic Puffin modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



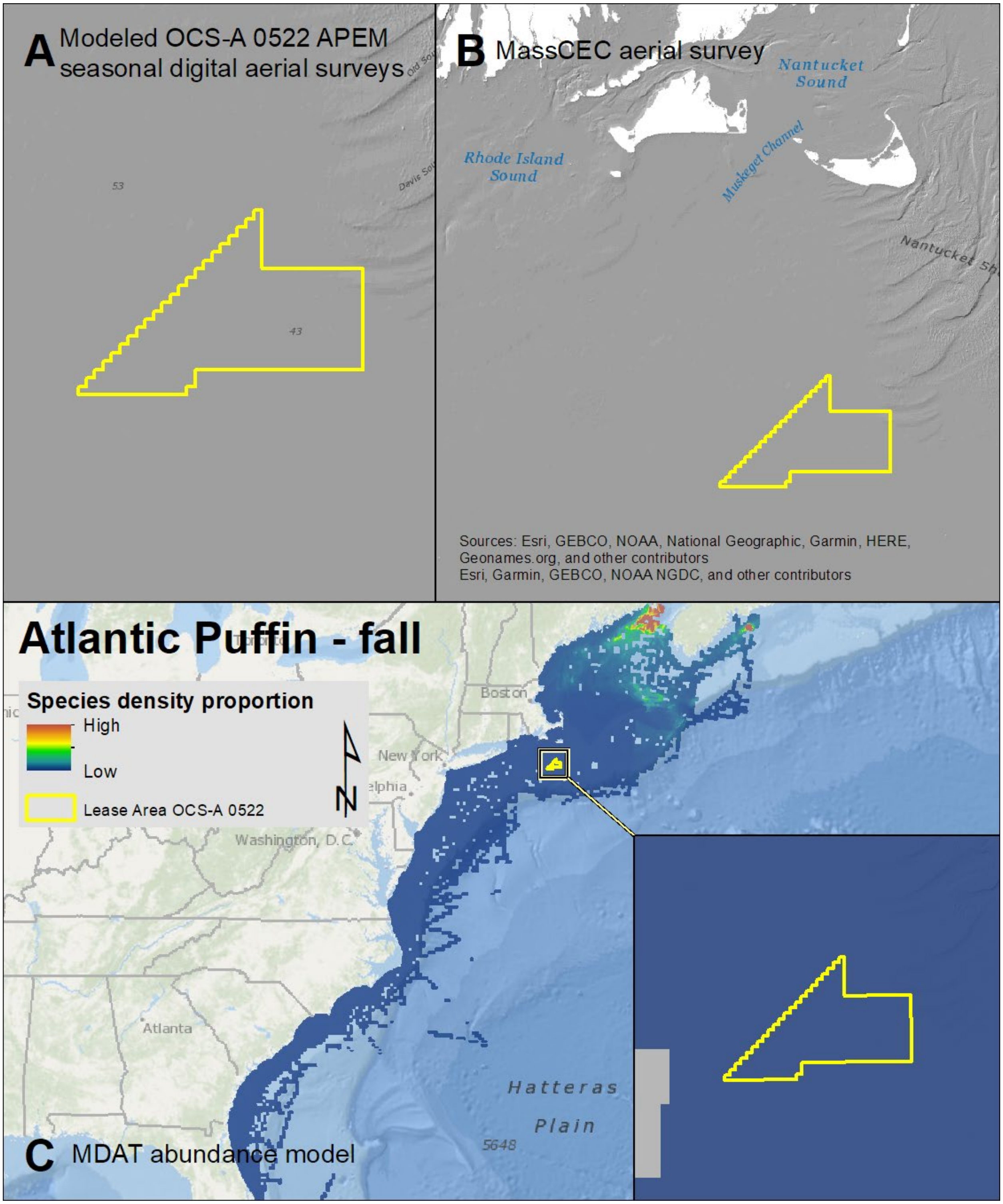
Map 49. Summer Atlantic Puffin modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



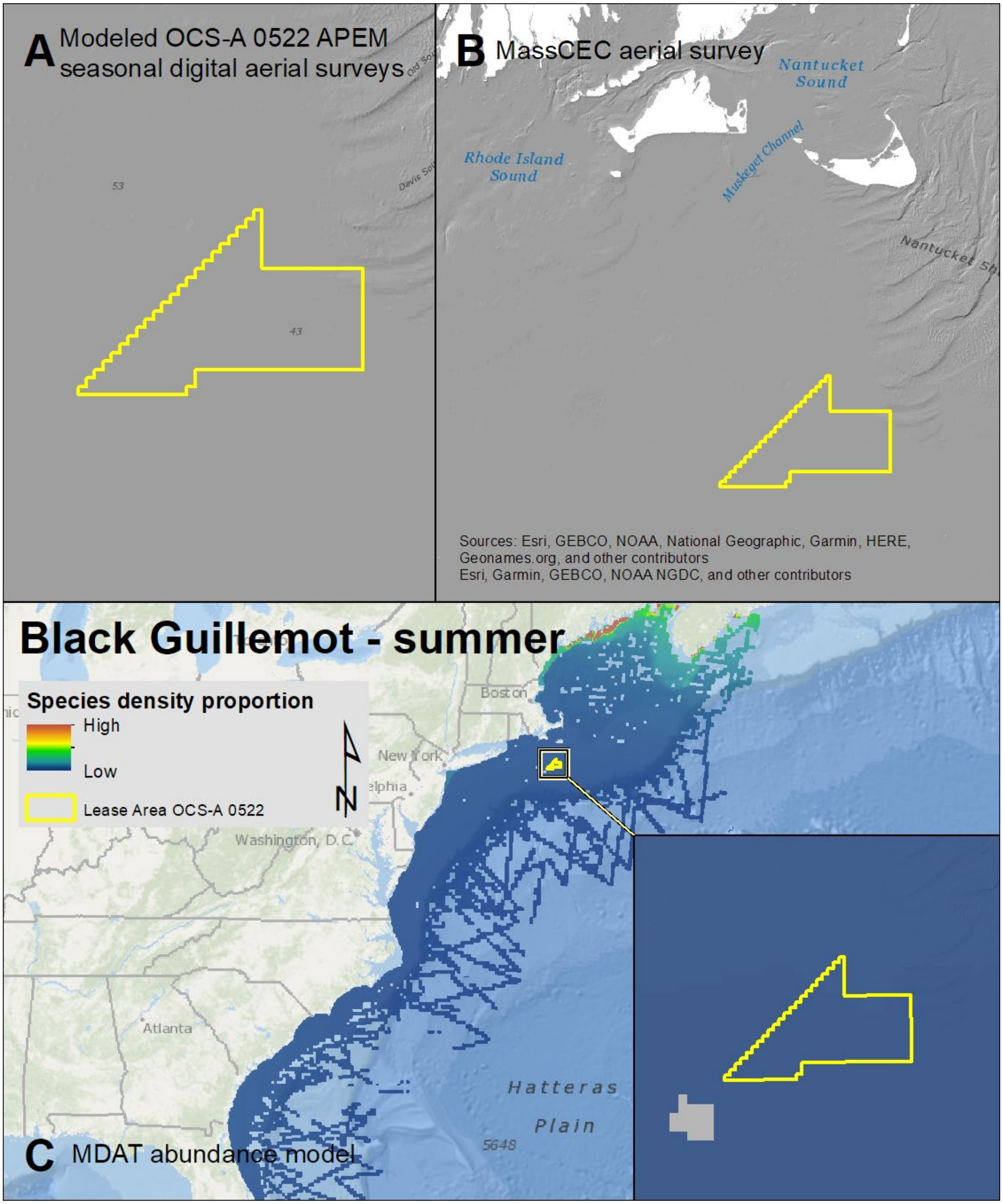
Map 50. Summer Atlantic Puffin modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



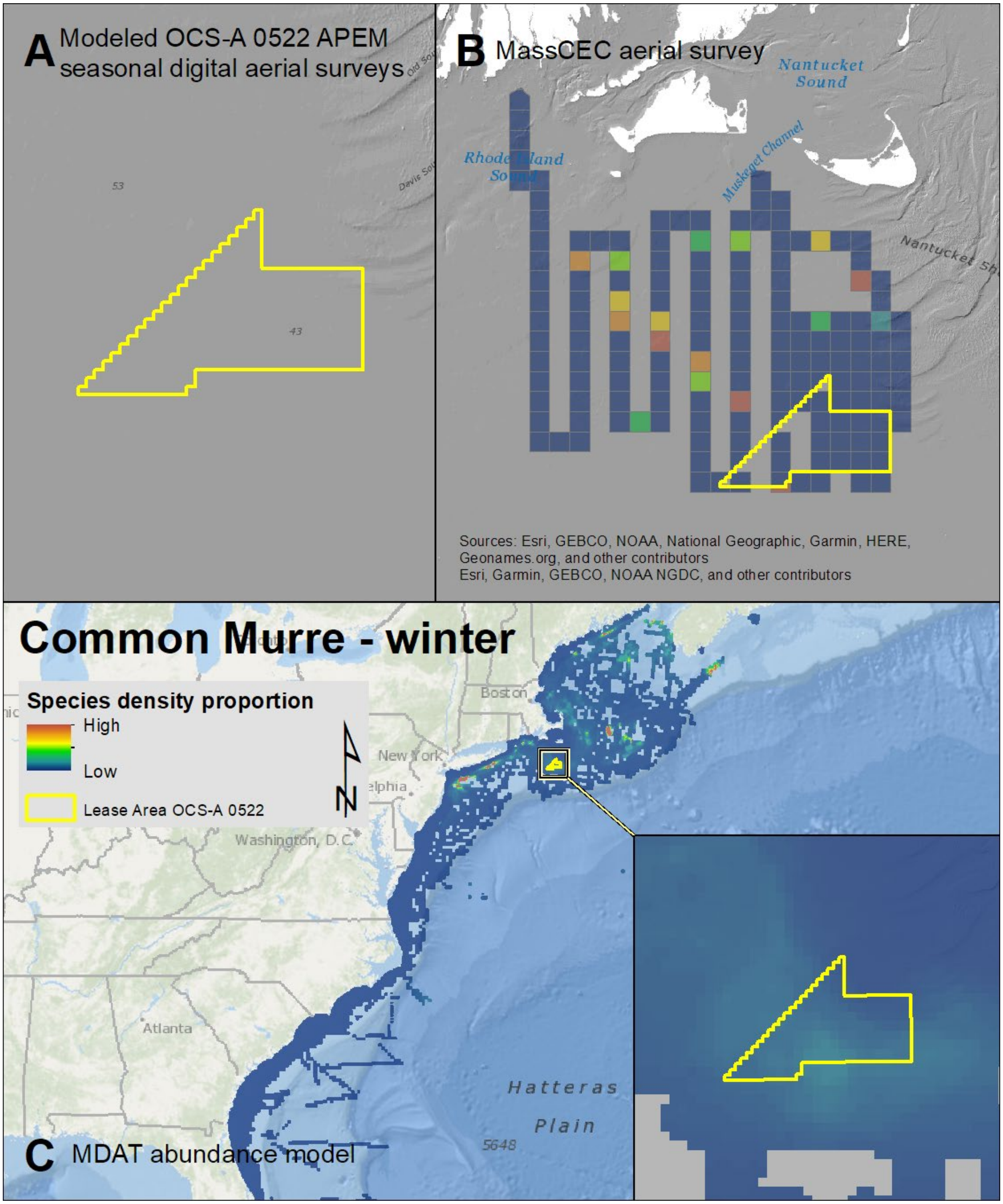
Map 51. Fall Atlantic Puffin modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



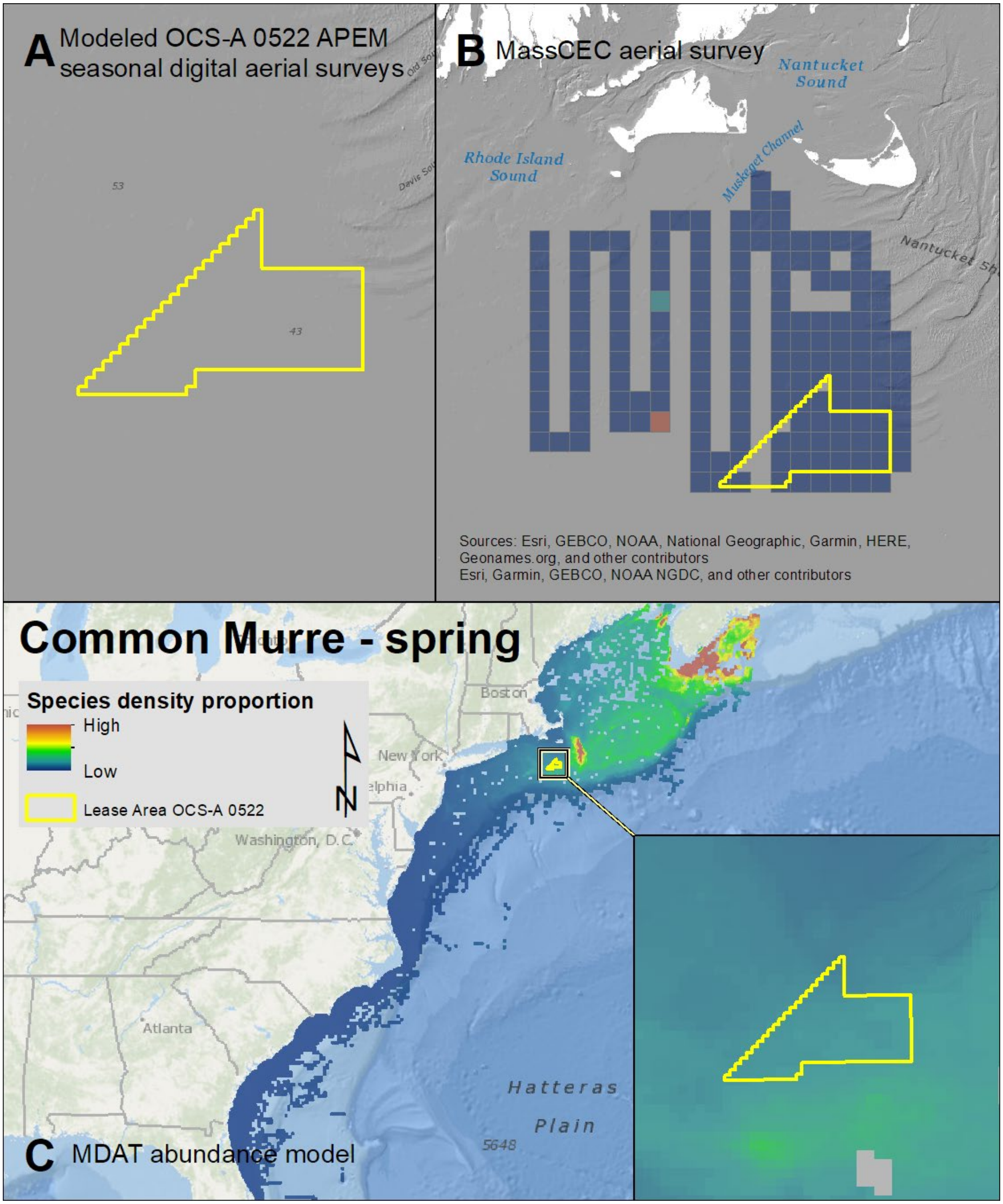
Map 52. Fall Atlantic Puffin modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



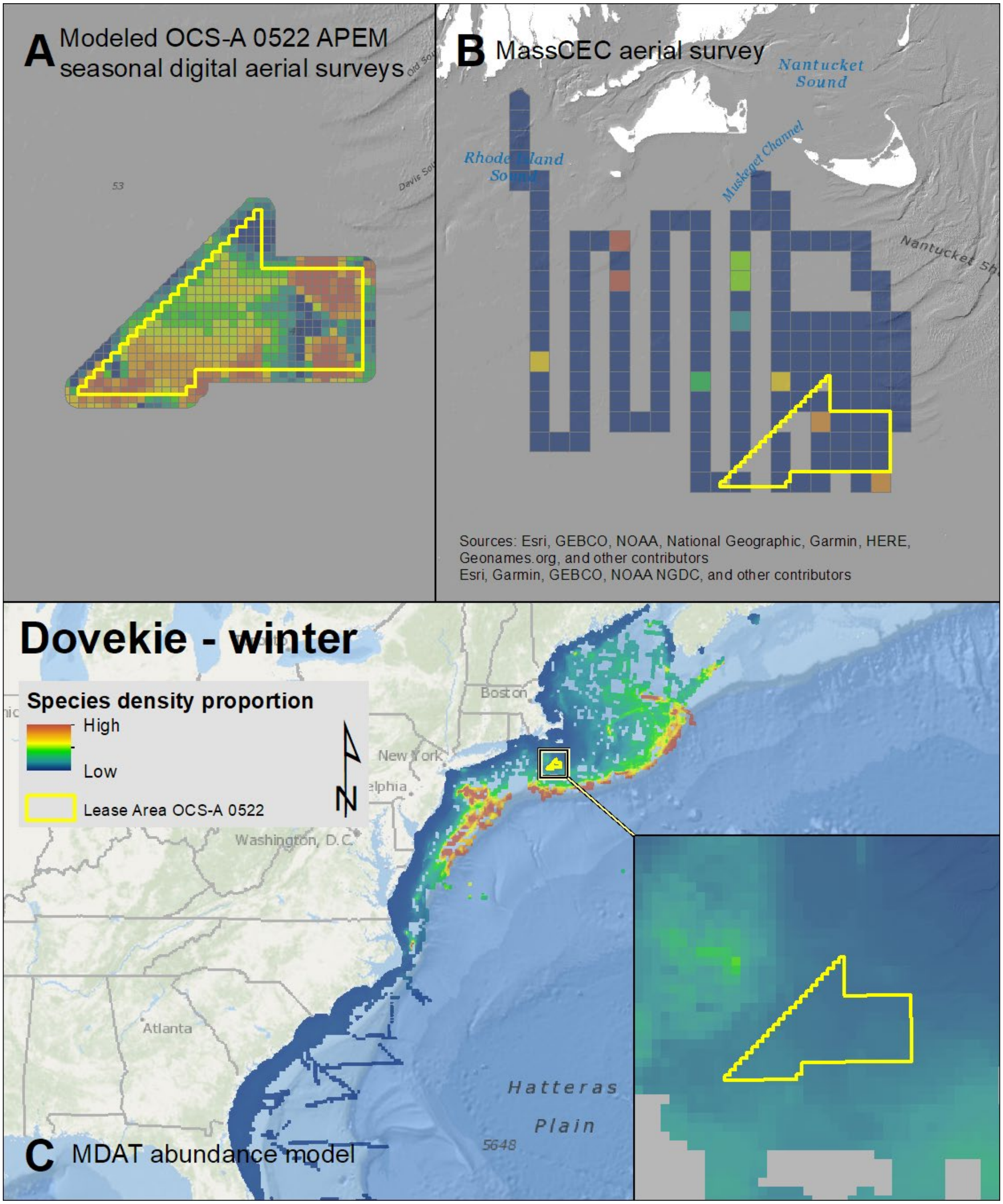
Map 53. Summer Black Guillemot modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



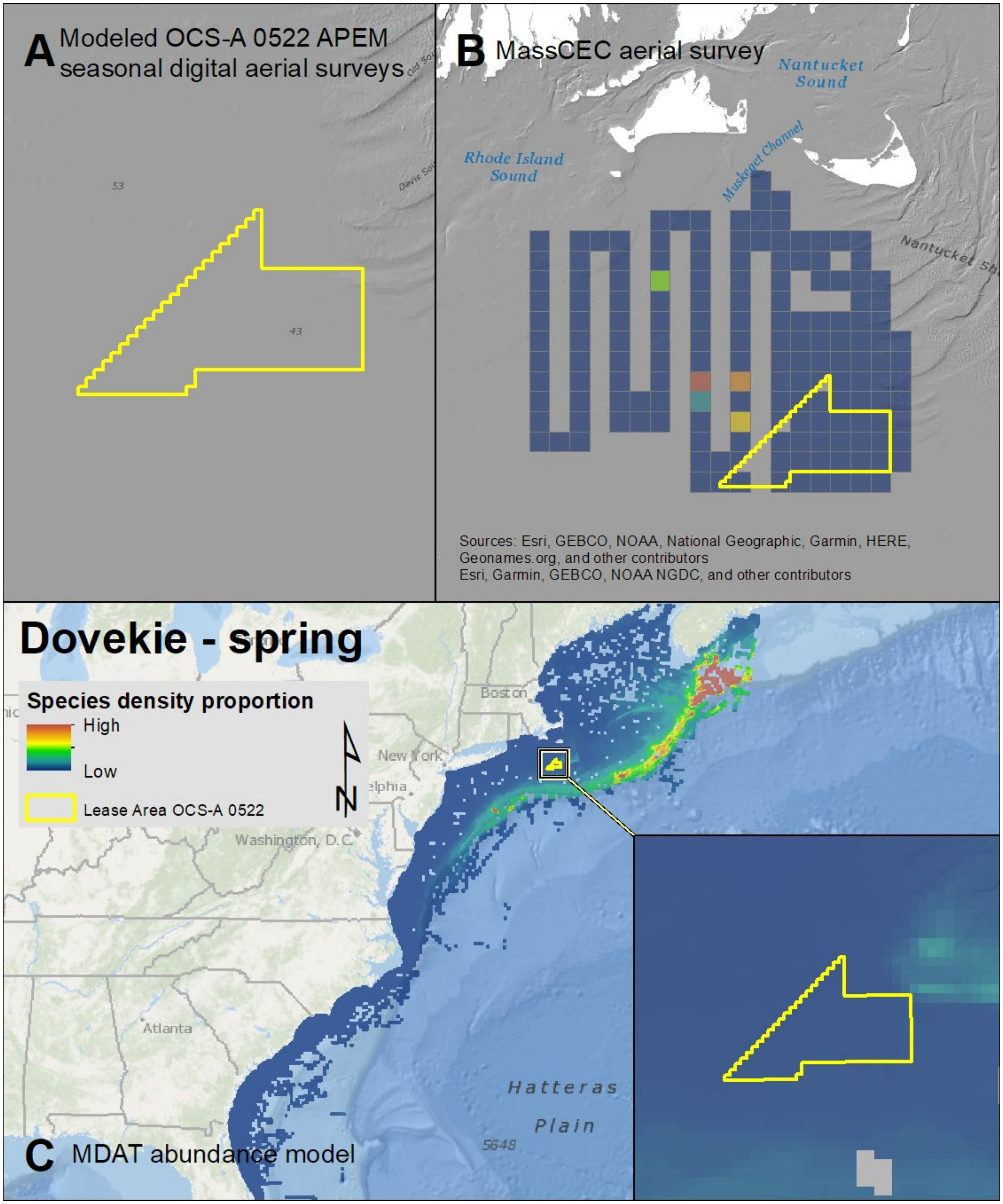
Map 54. Winter Common Murre modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



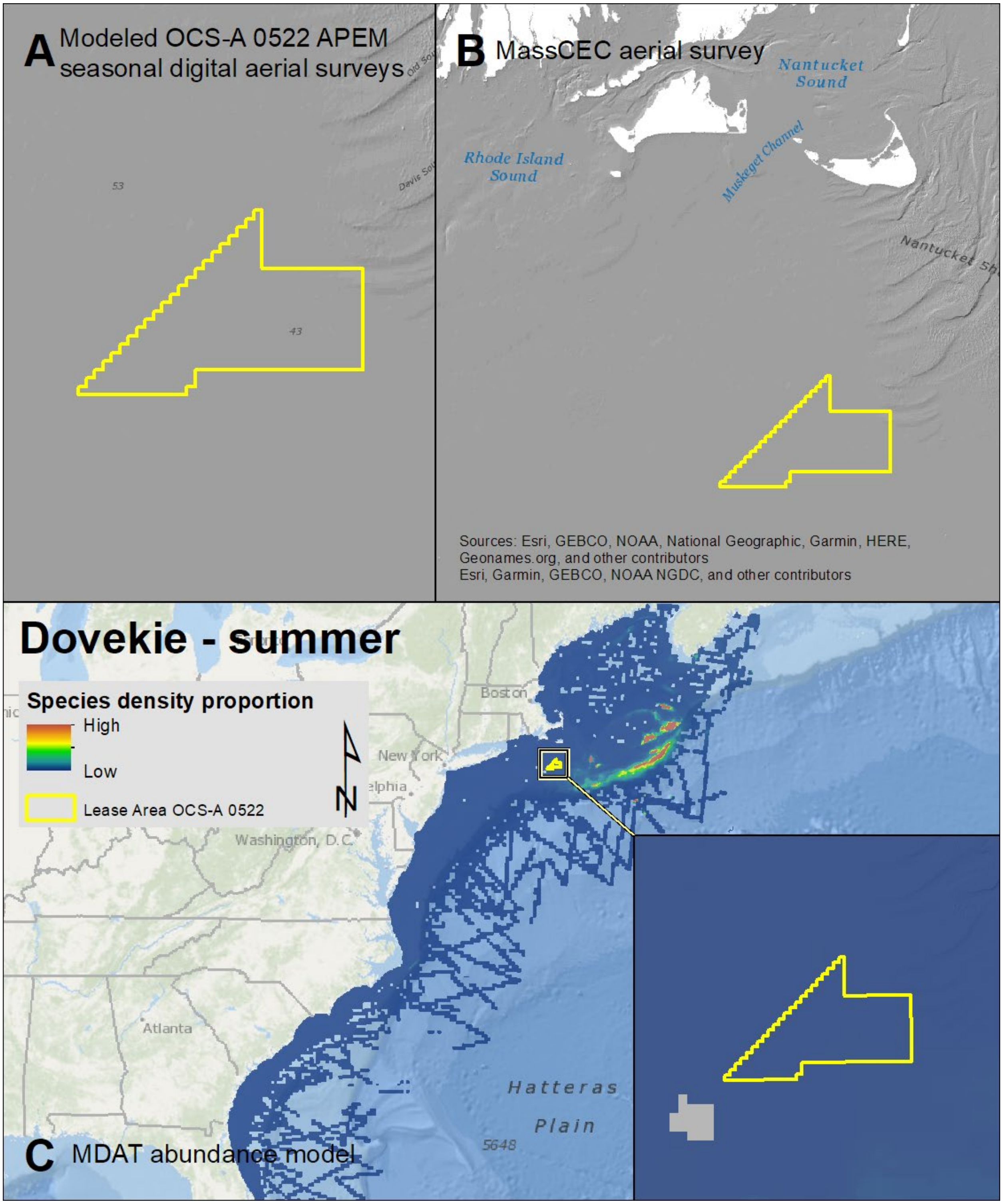
Map 55. Spring Common Murre modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



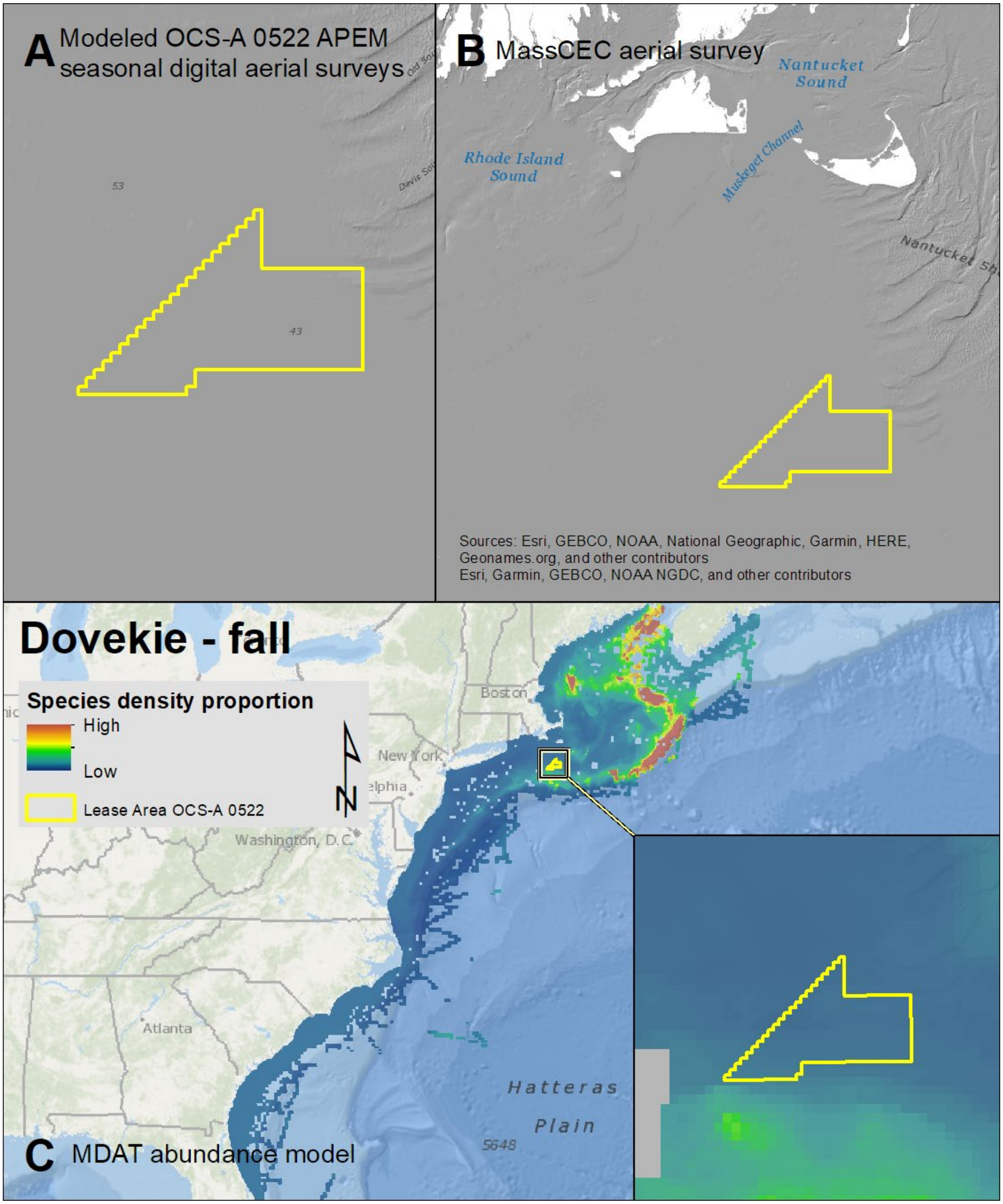
Map 56. Winter Dovekie modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



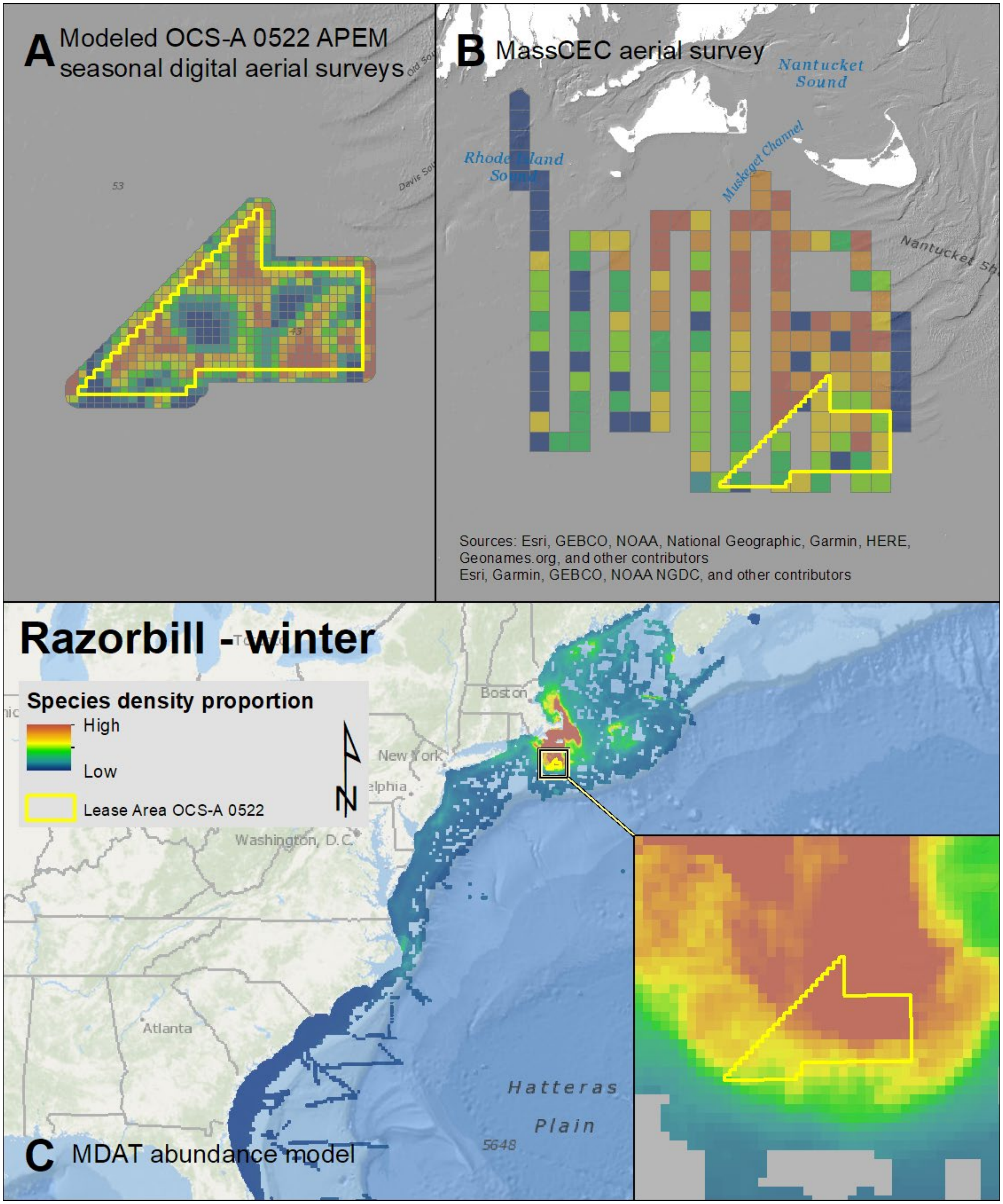
Map 57. Spring Dovekie modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



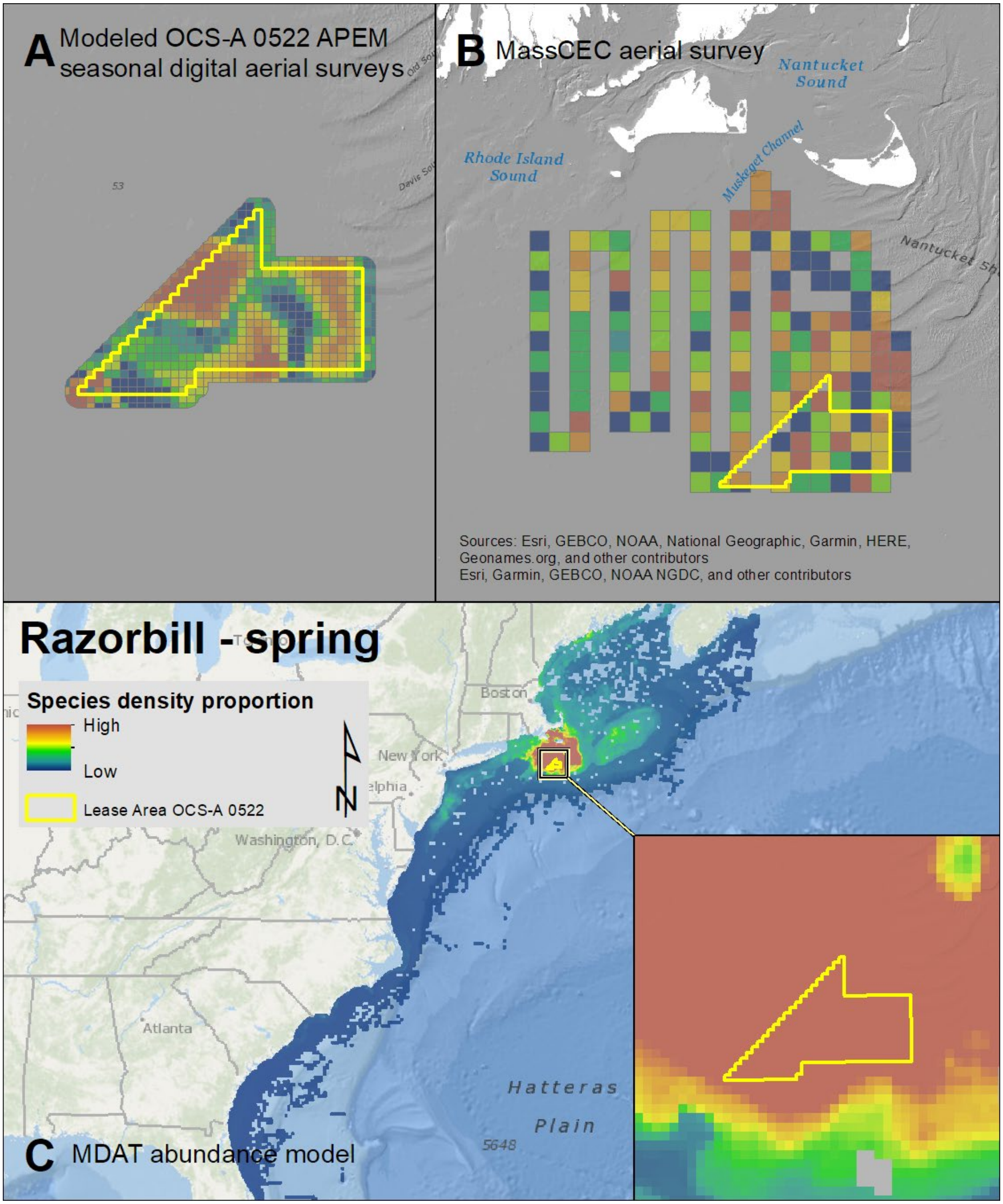
Map 58. Summer Dovekie modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



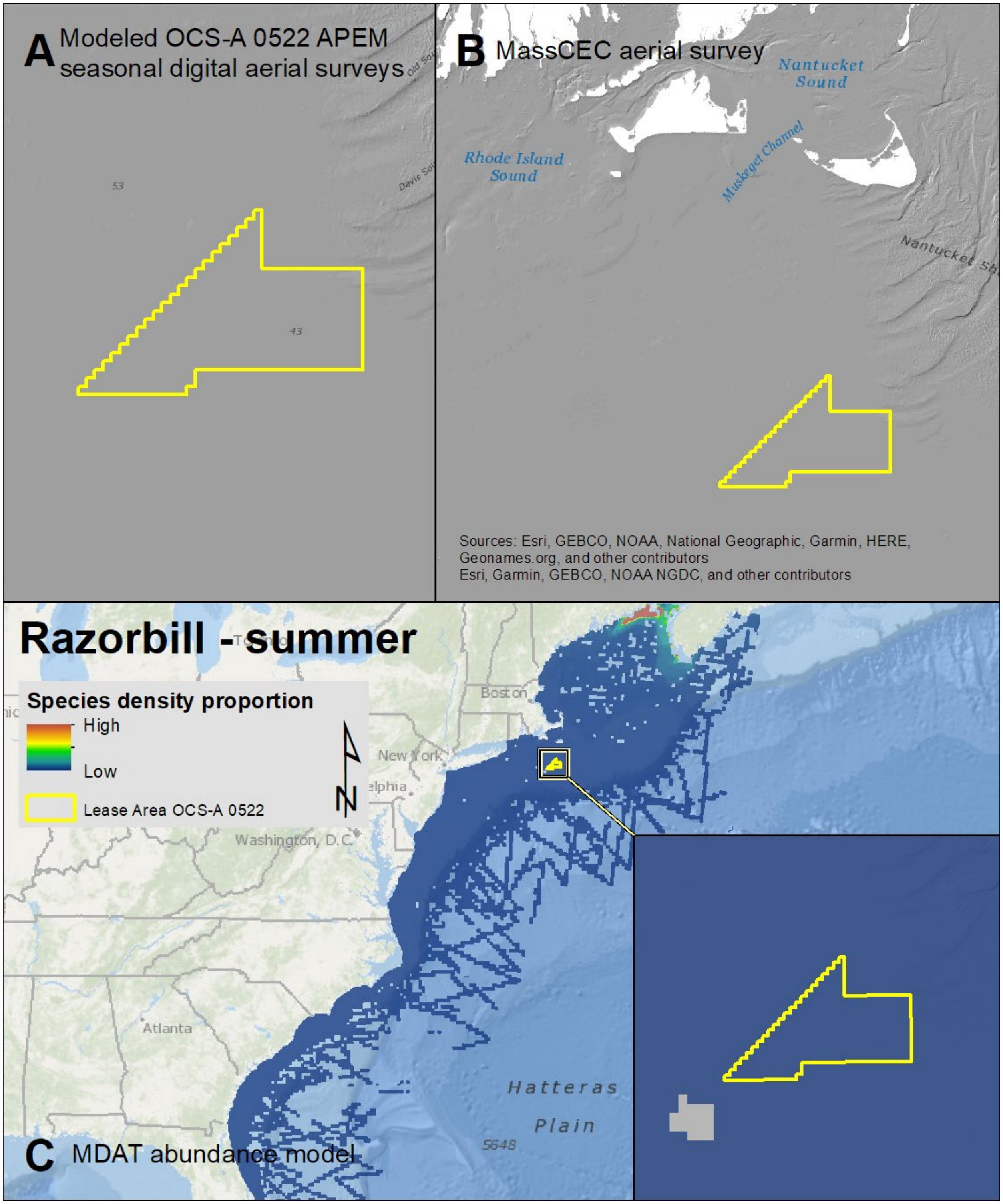
Map 59. Fall Dovekie modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



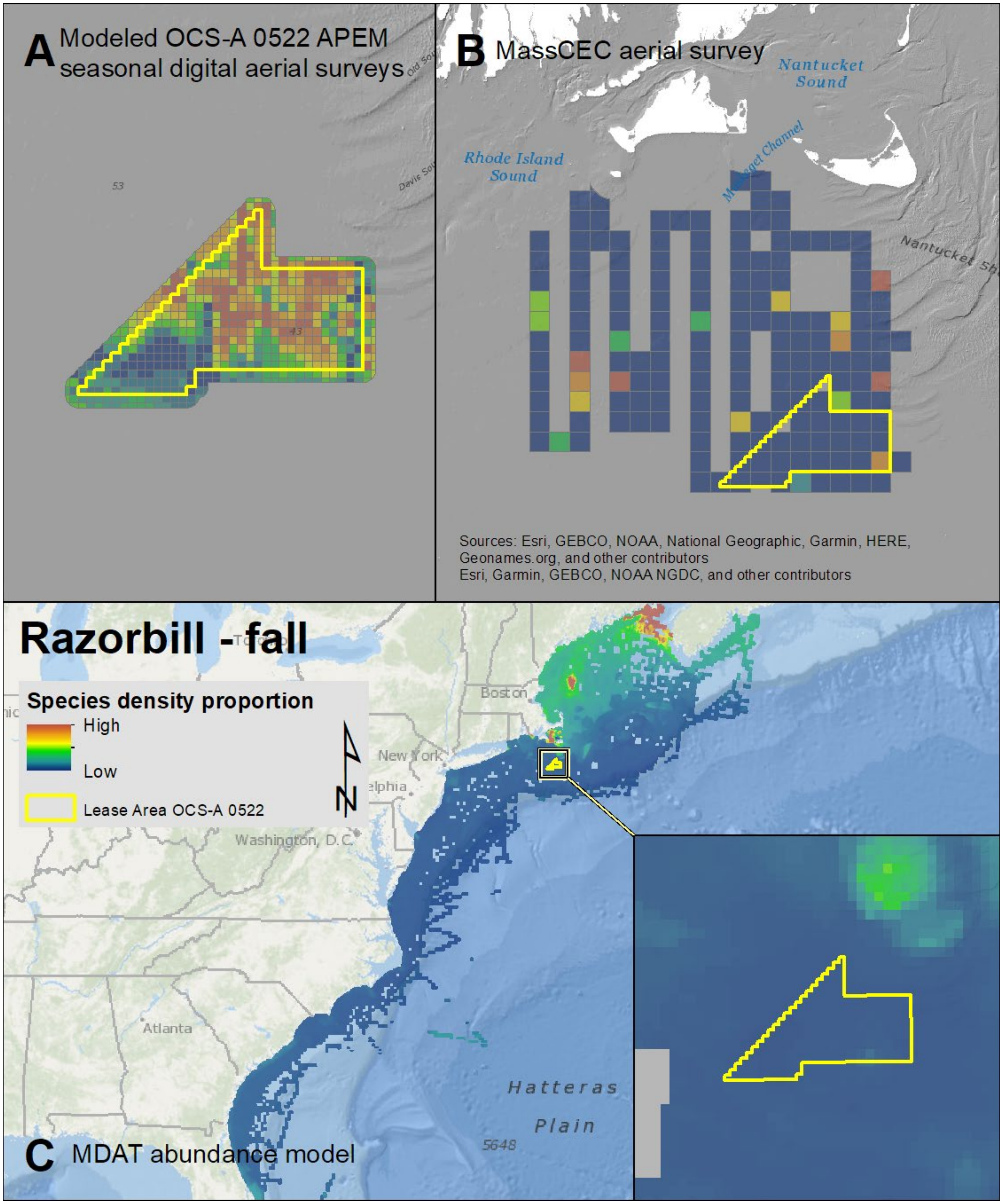
Map 60. Winter Razorbill modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



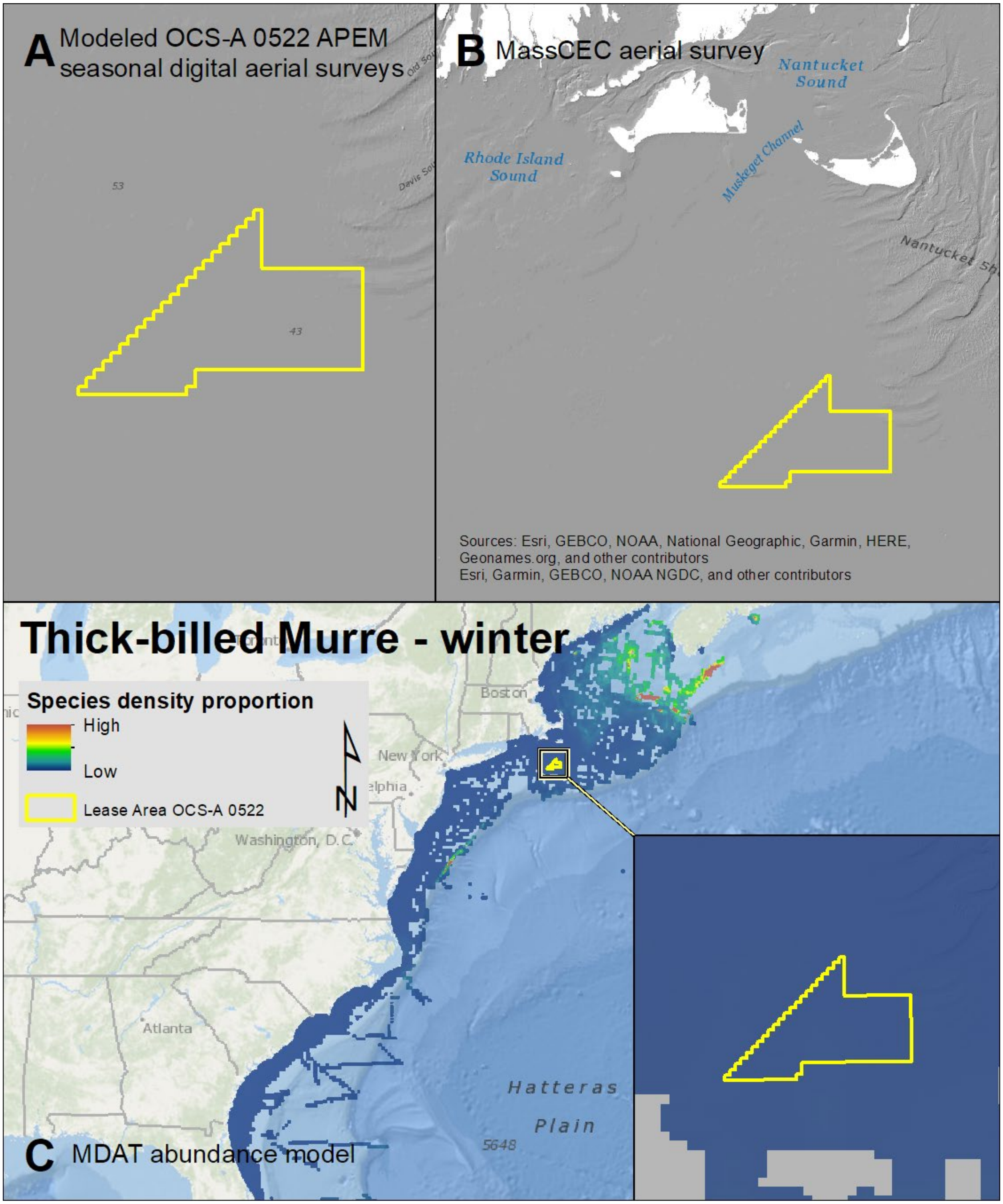
Map 61. Spring Razorbill modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



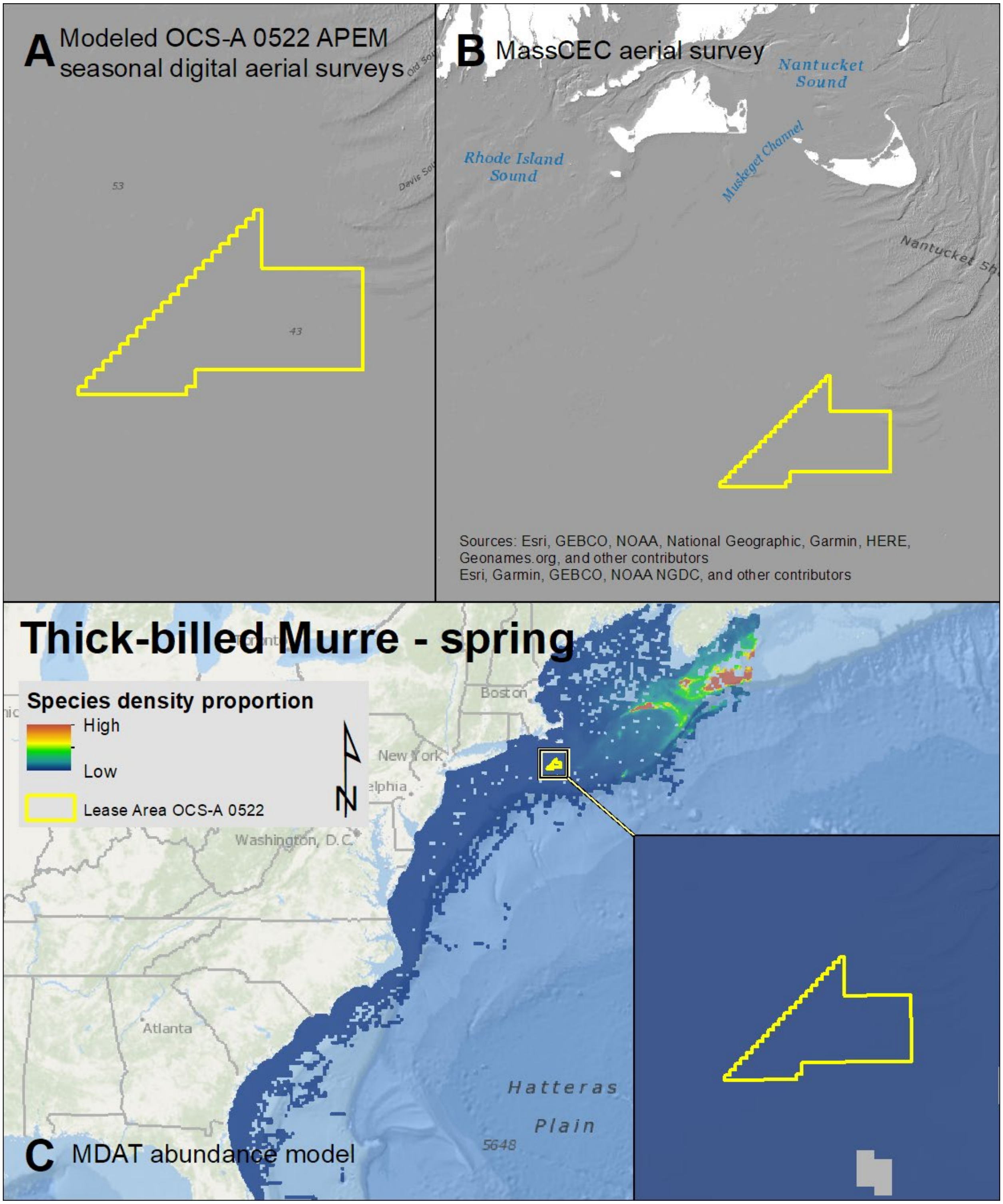
Map 62. Summer Razorbill modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



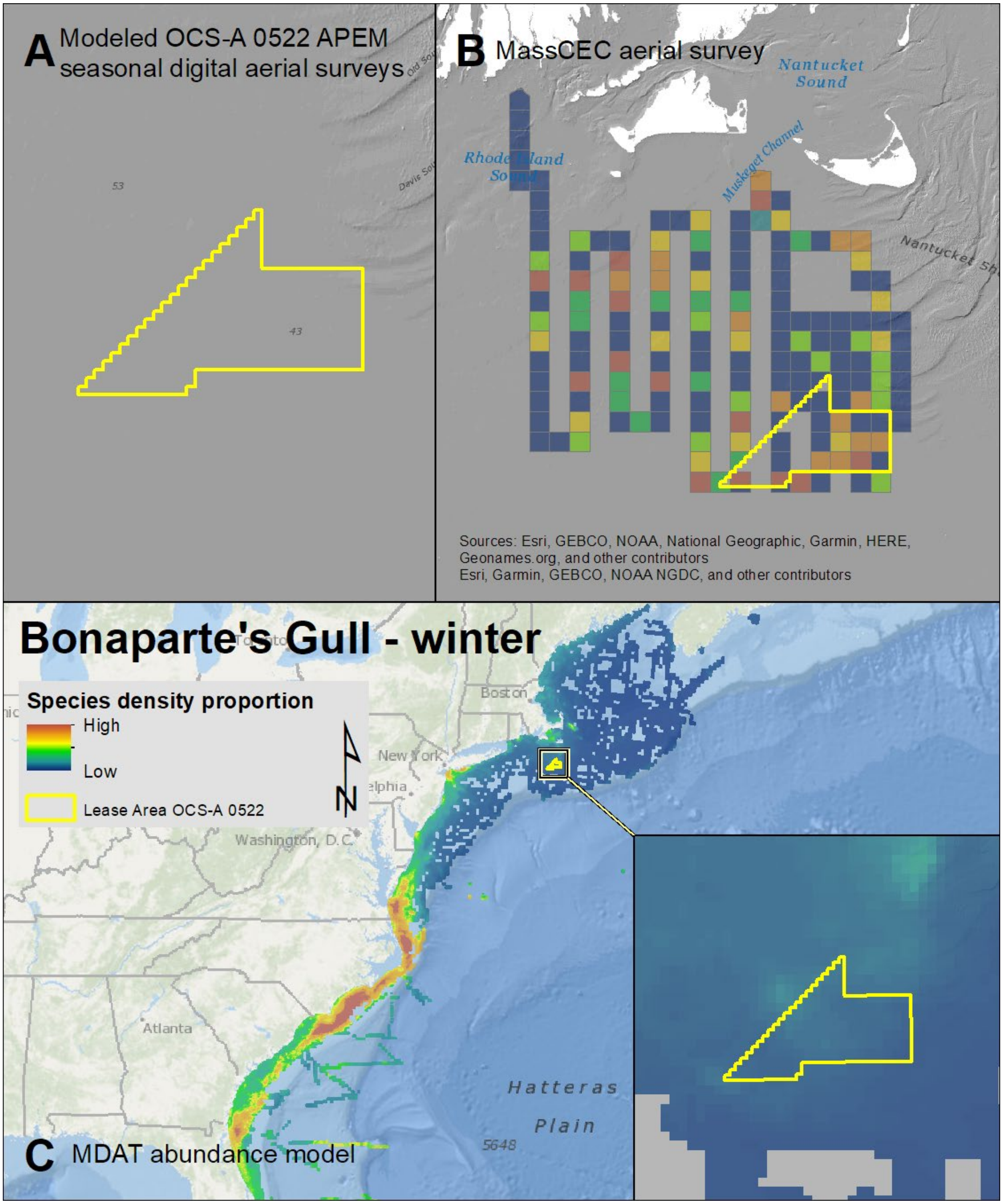
Map 63. Fall Razorbill modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



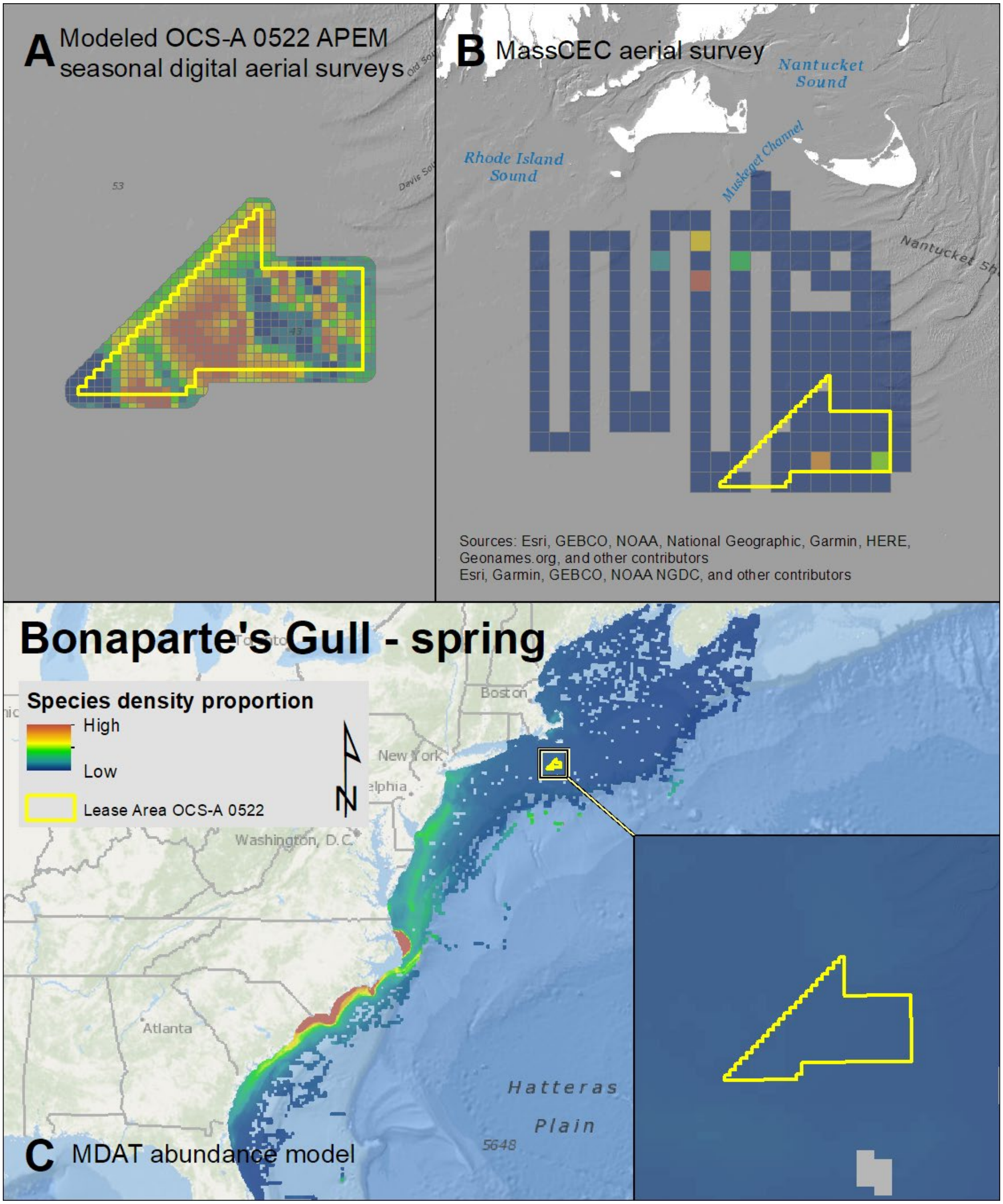
Map 64. Winter Thick-billed Murre modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



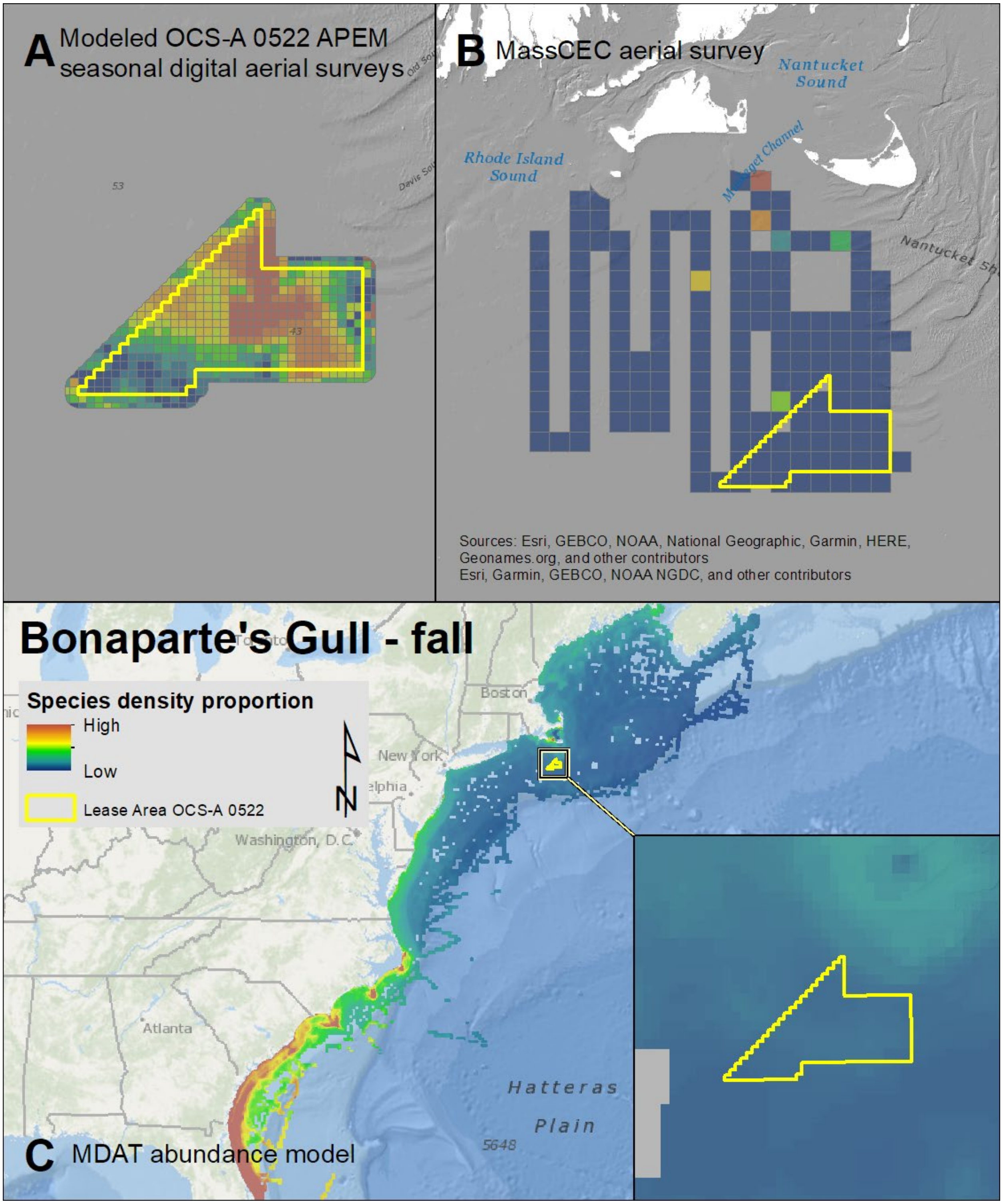
Map 65. Spring Thick-billed Murre modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



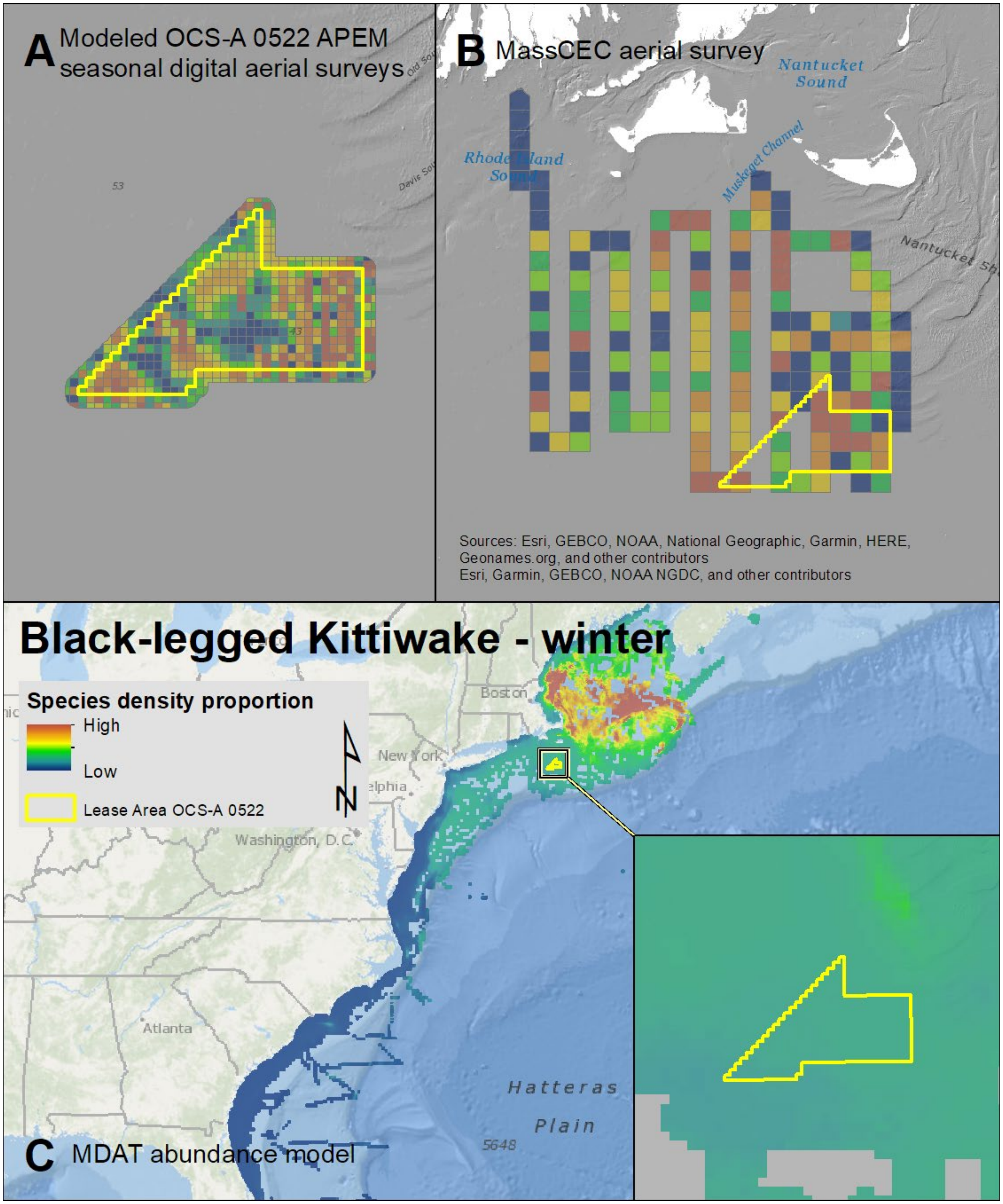
Map 66. Winter Bonaparte's Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



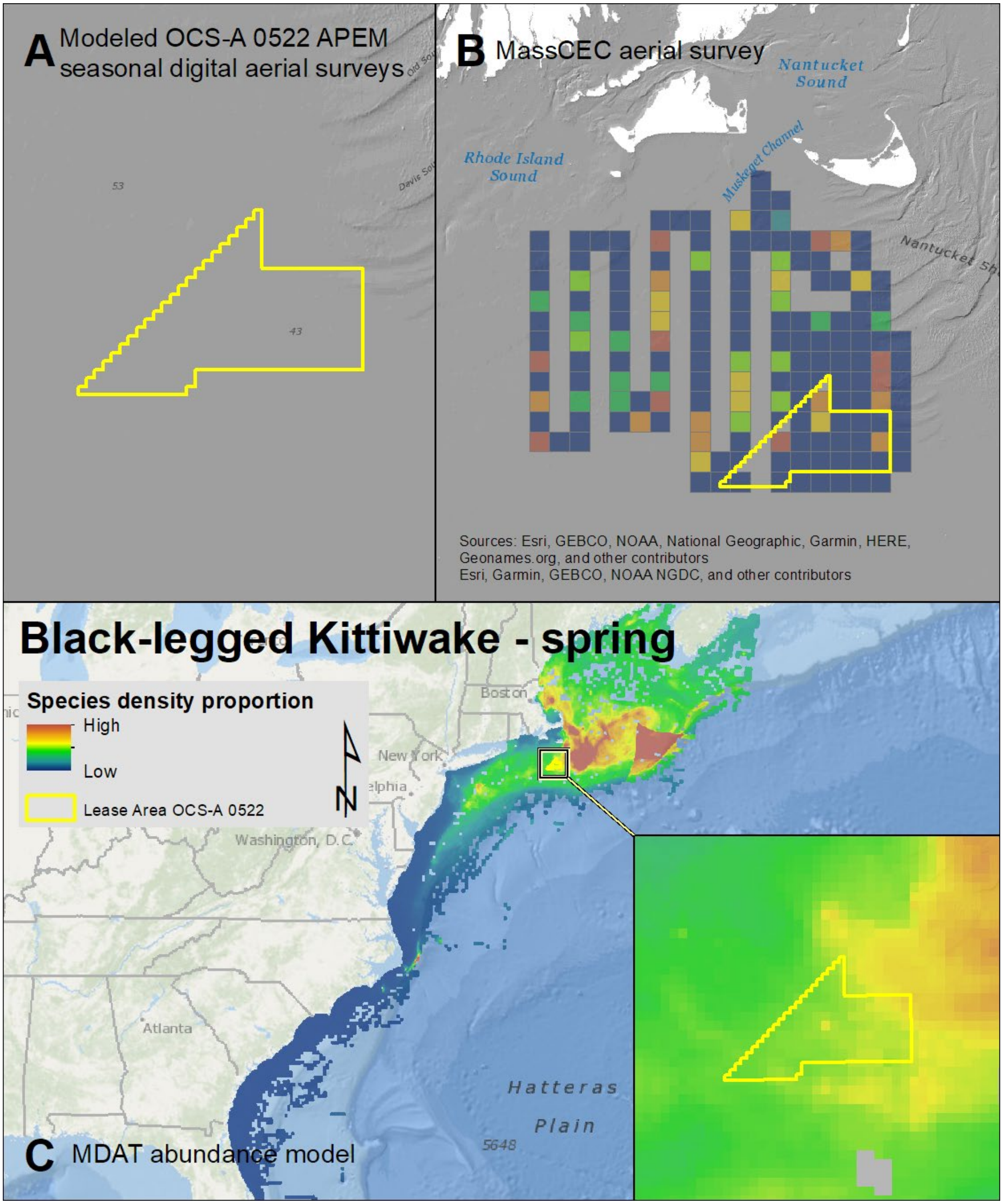
Map 67. Spring Bonaparte's Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



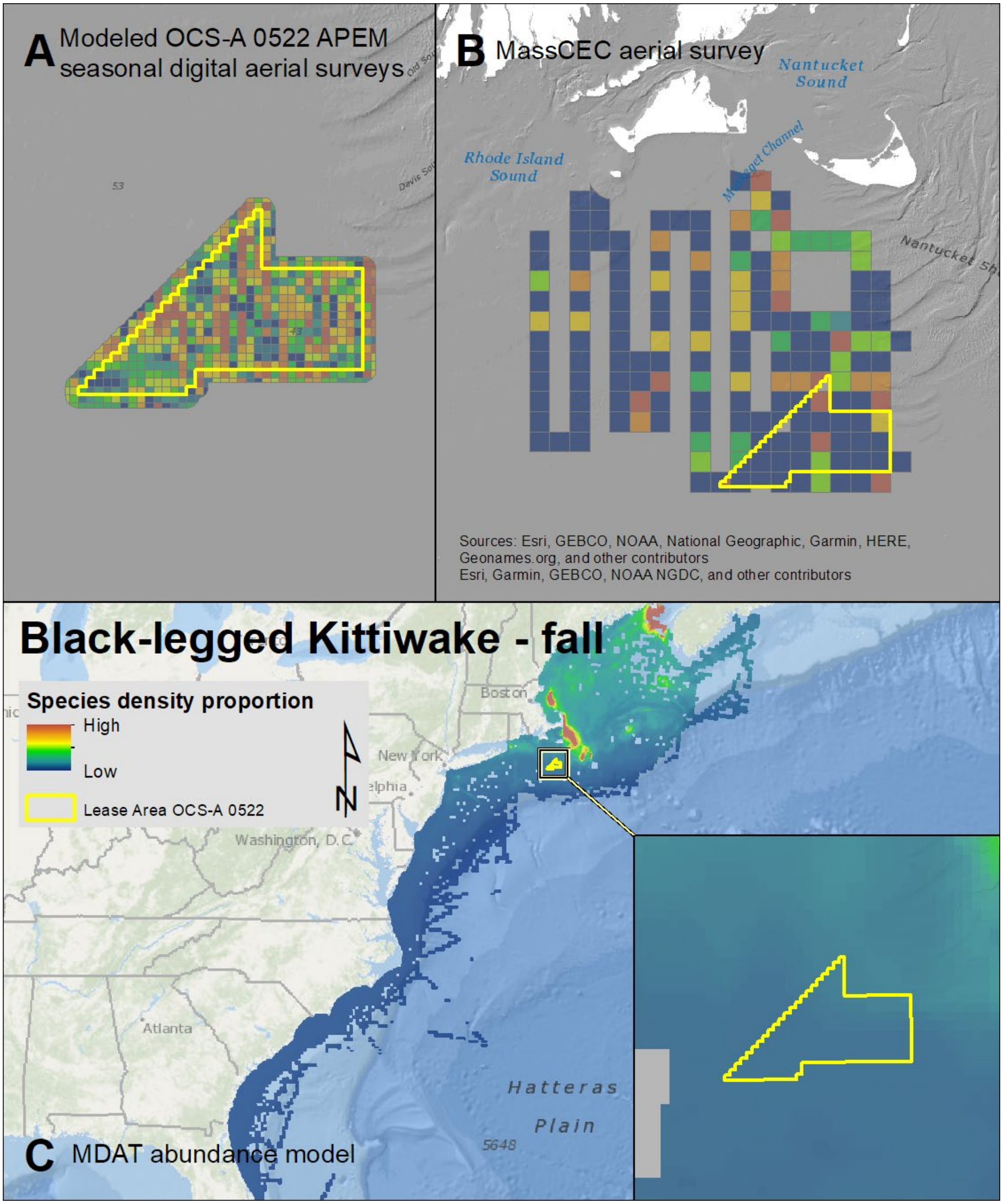
Map 68. Fall Bonaparte's Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



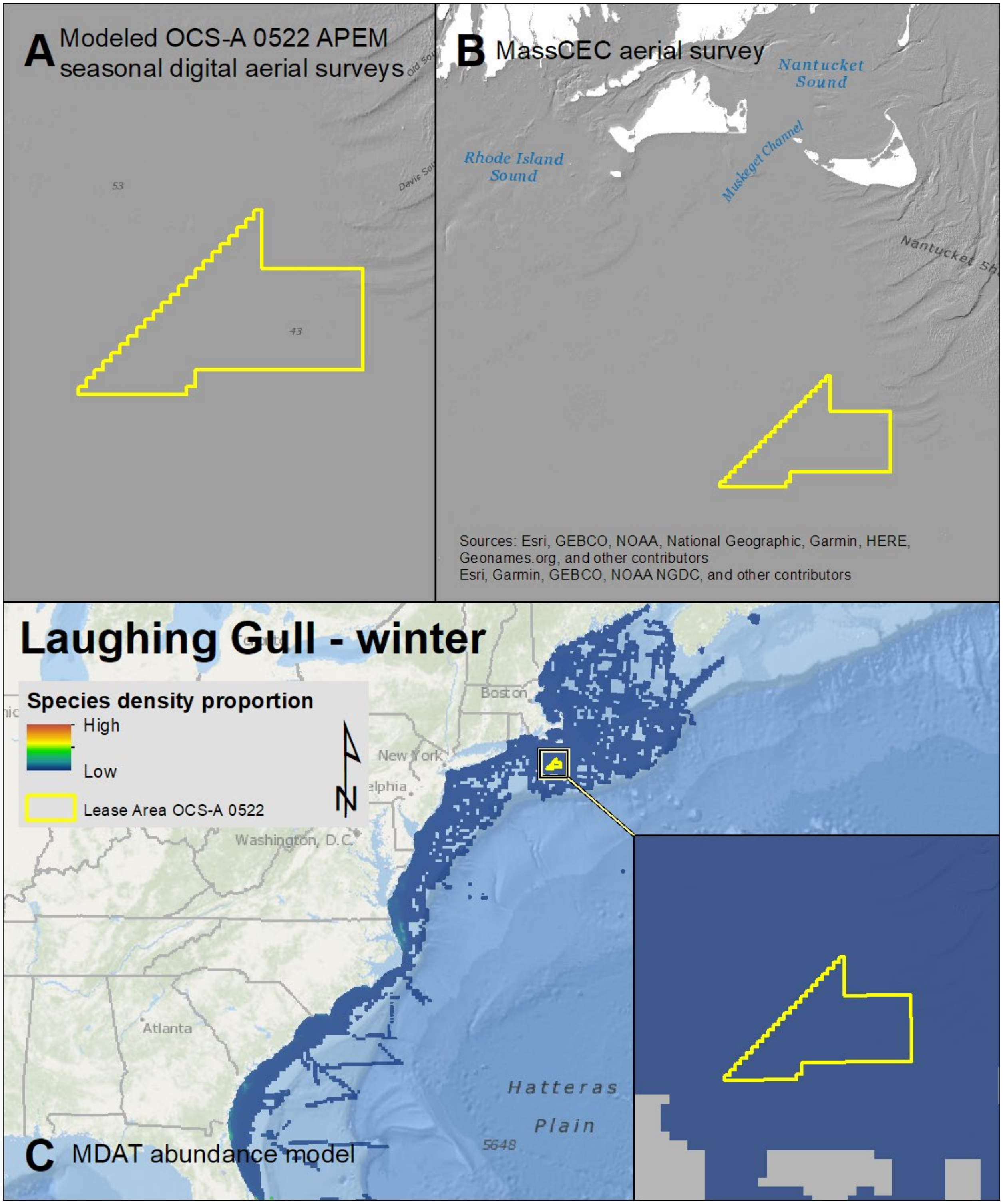
Map 69. Winter Black-legged Kittiwake modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



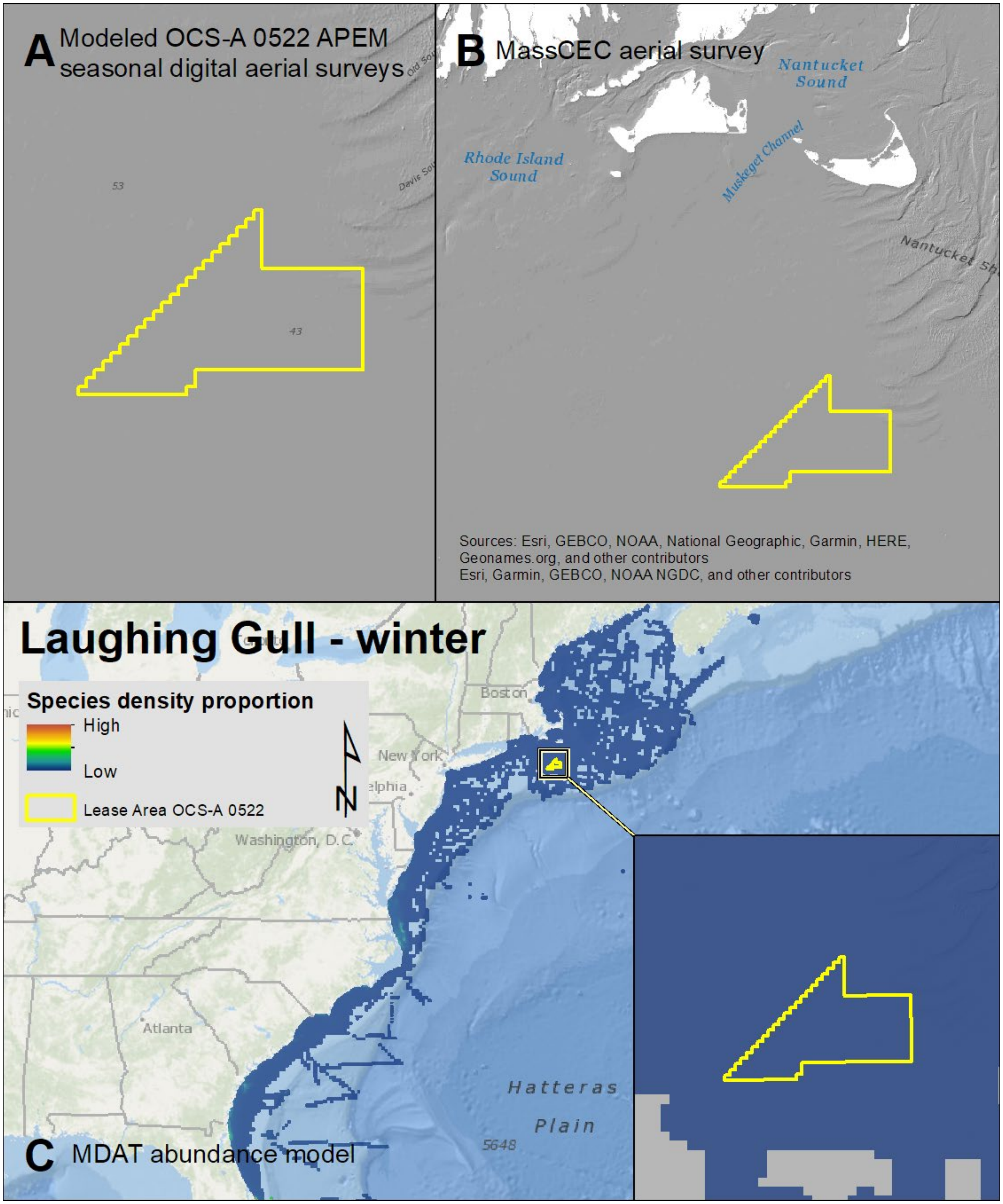
Map 70. Spring Black-legged Kittiwake modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



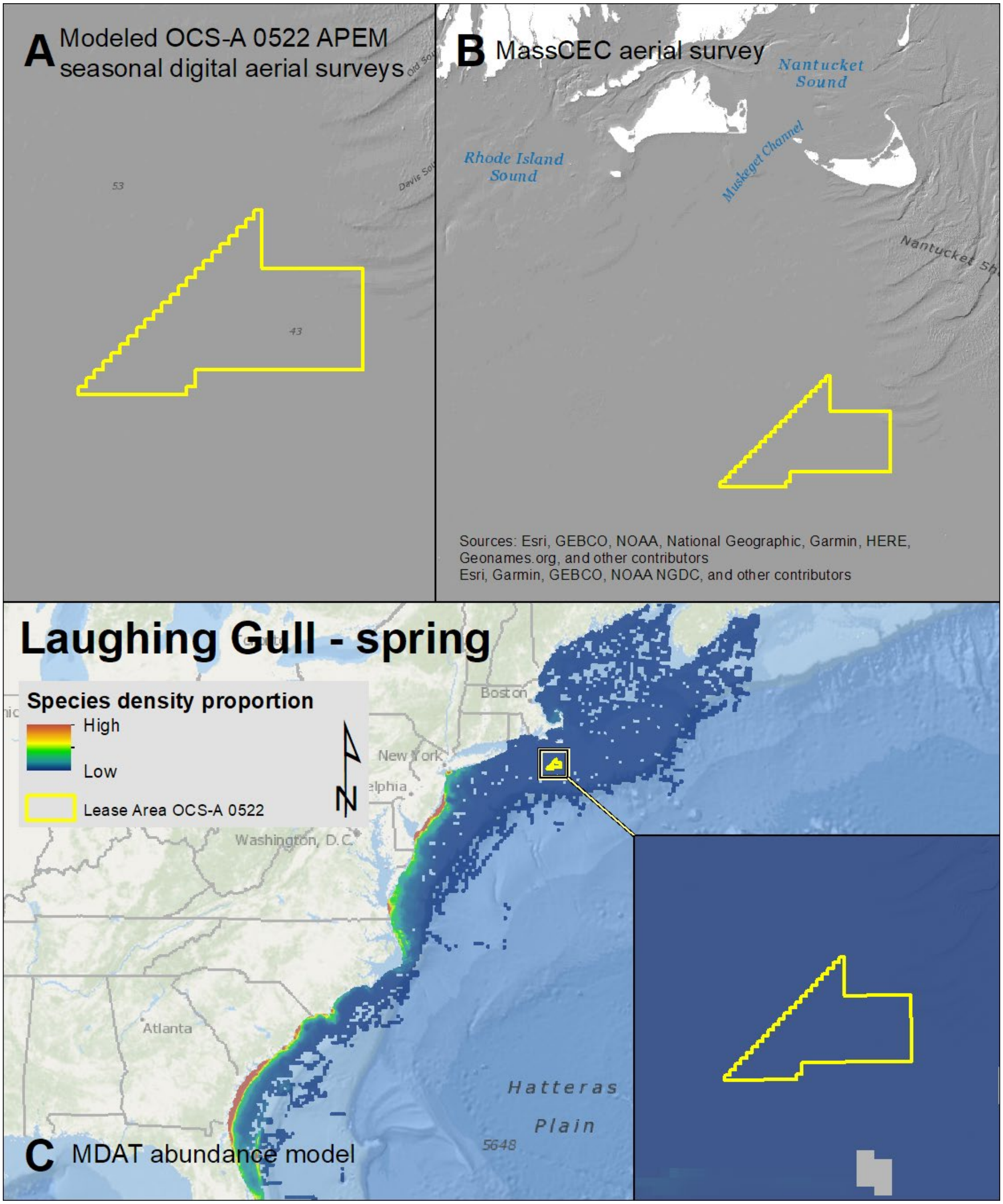
Map 71. Fall Black-legged Kittiwake modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



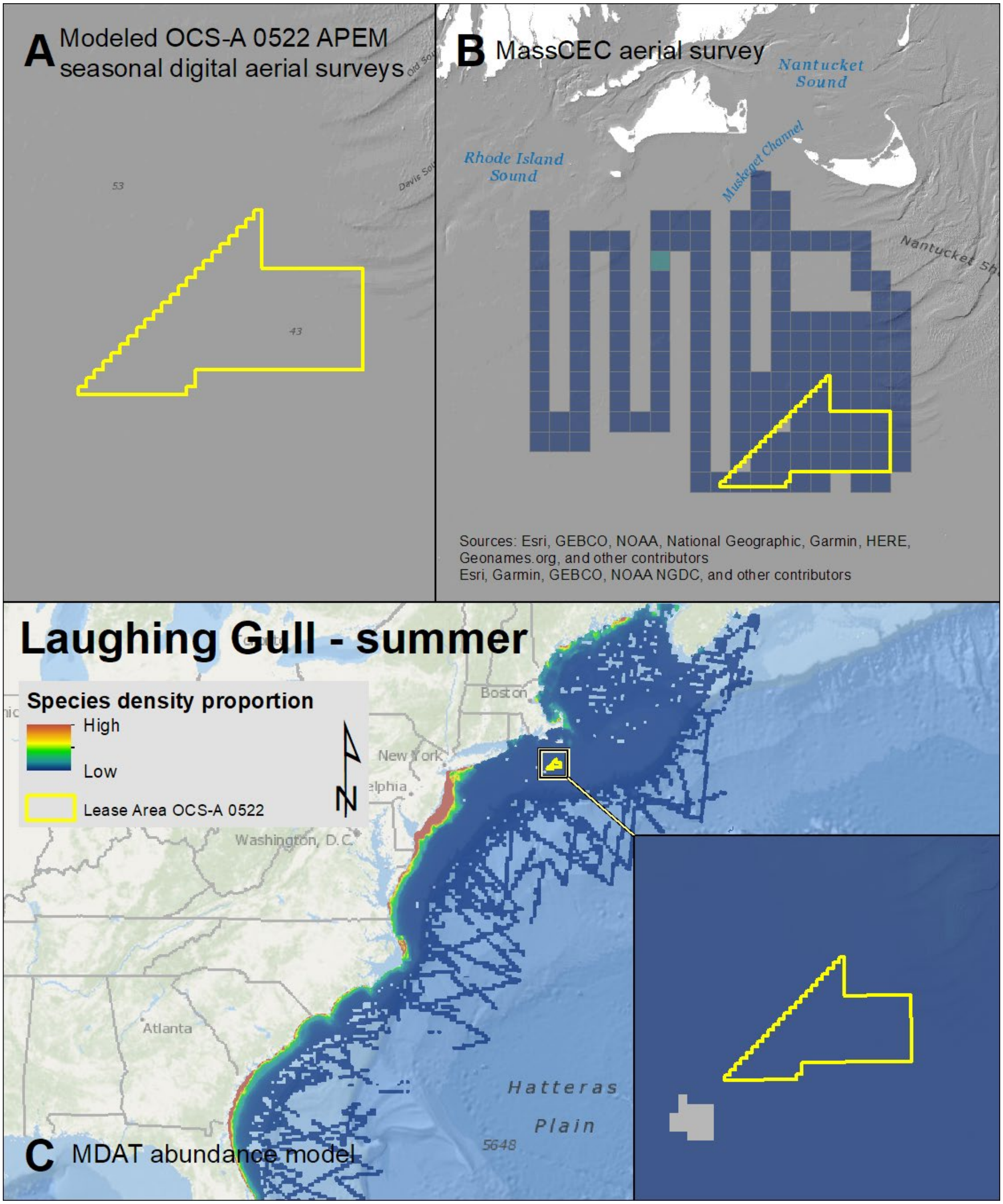
Map 72. Winter Laughing Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



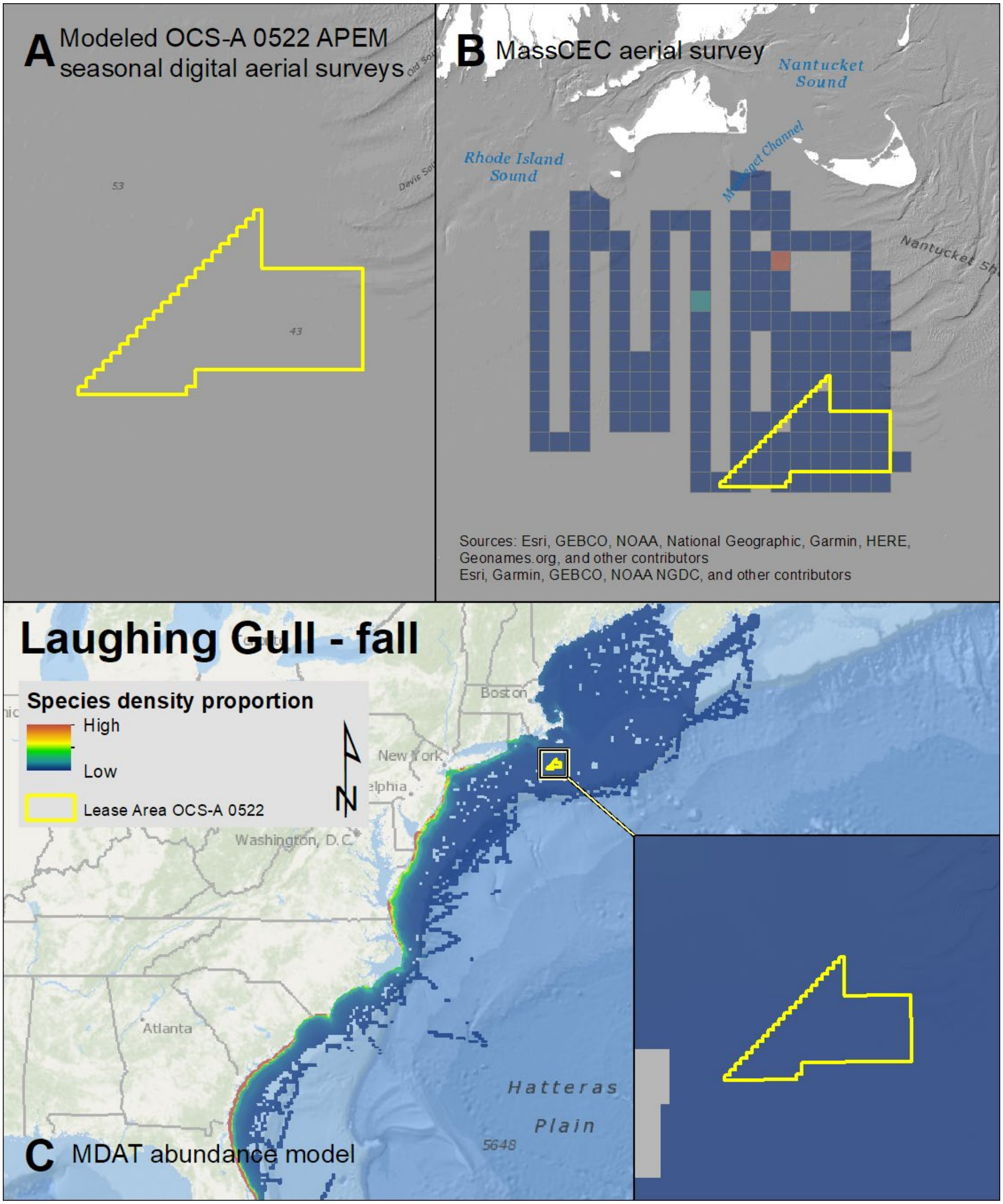
Map 73. Winter Laughing Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



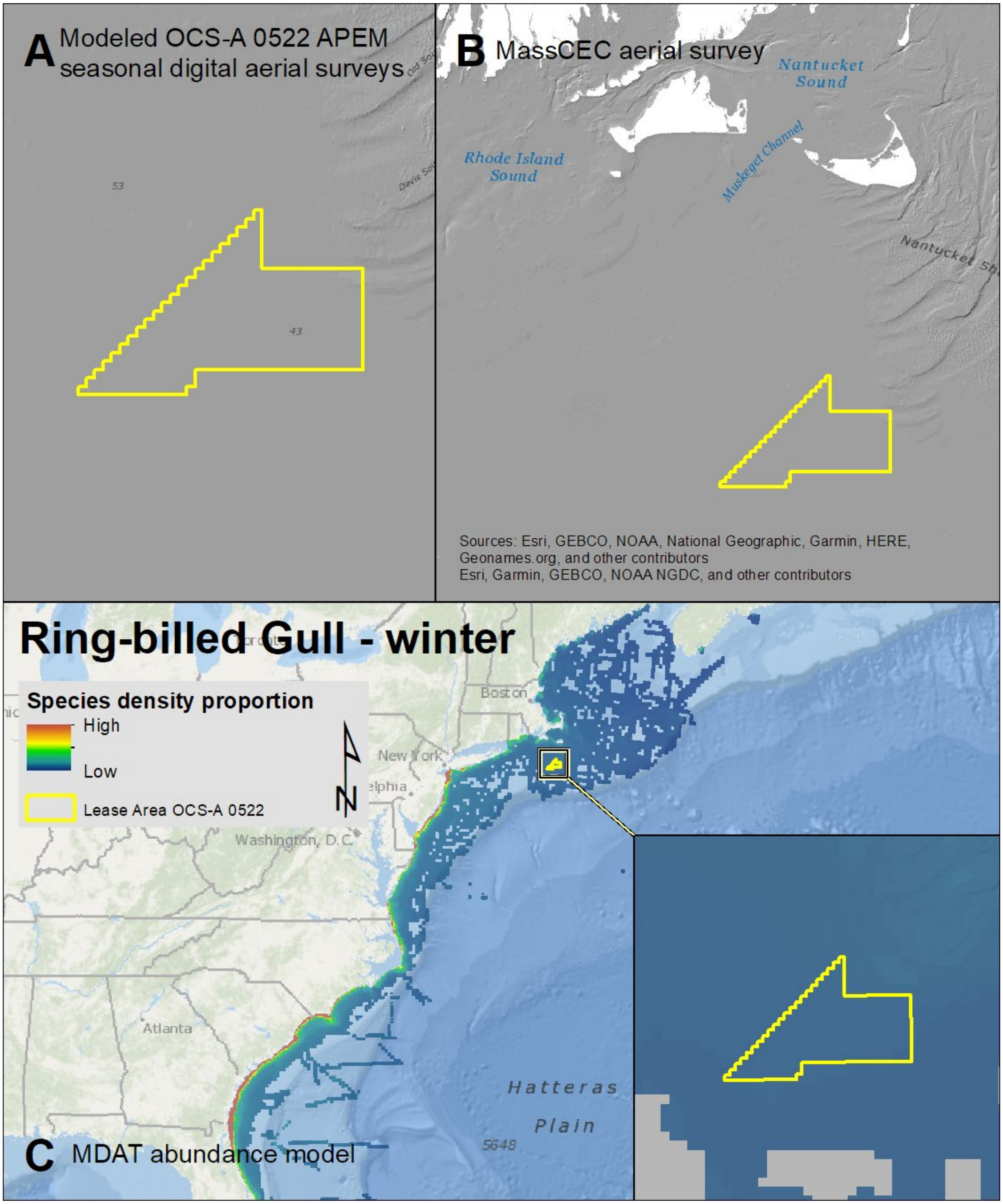
Map 74. Spring Laughing Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



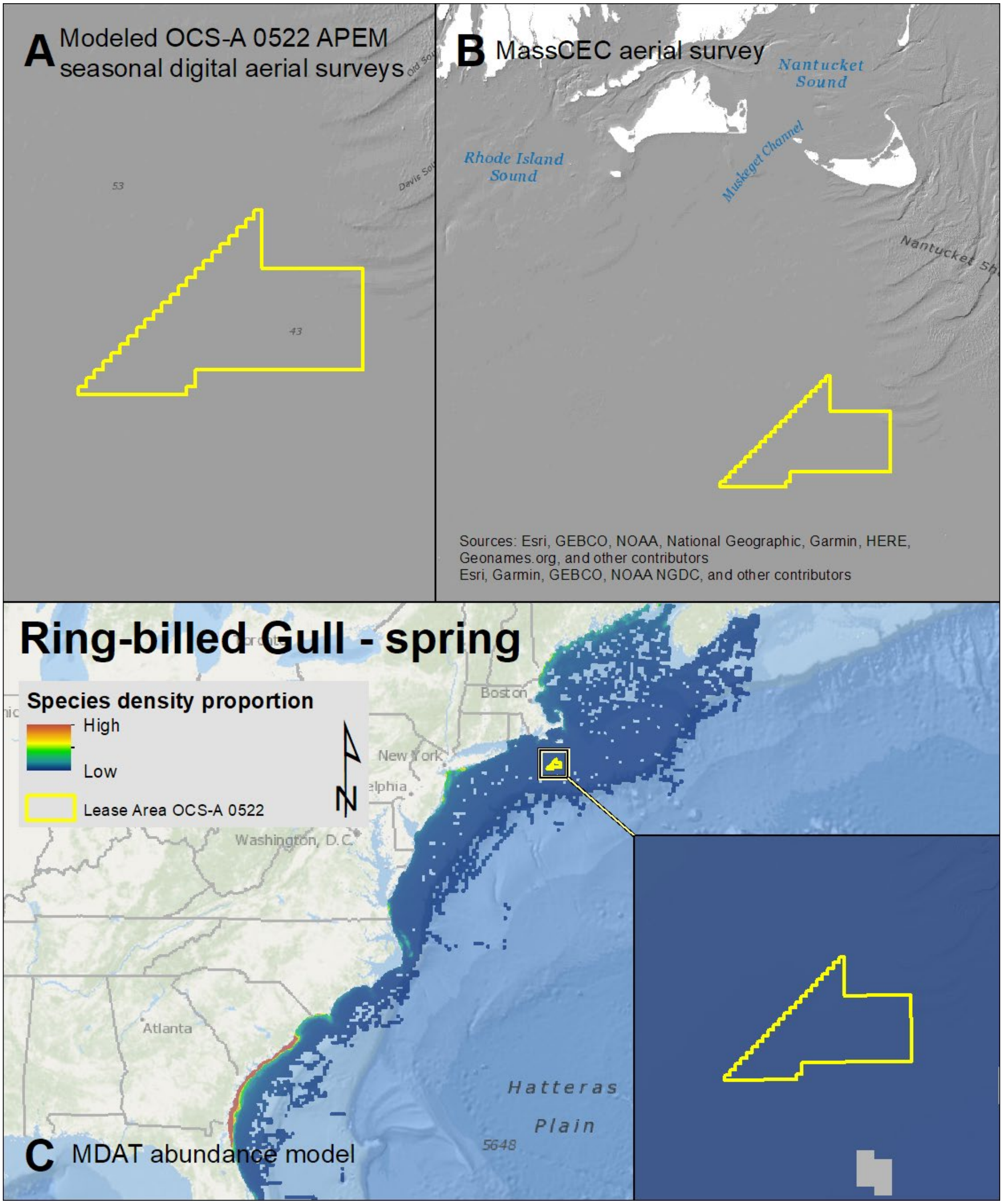
Map 75. Summer Laughing Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



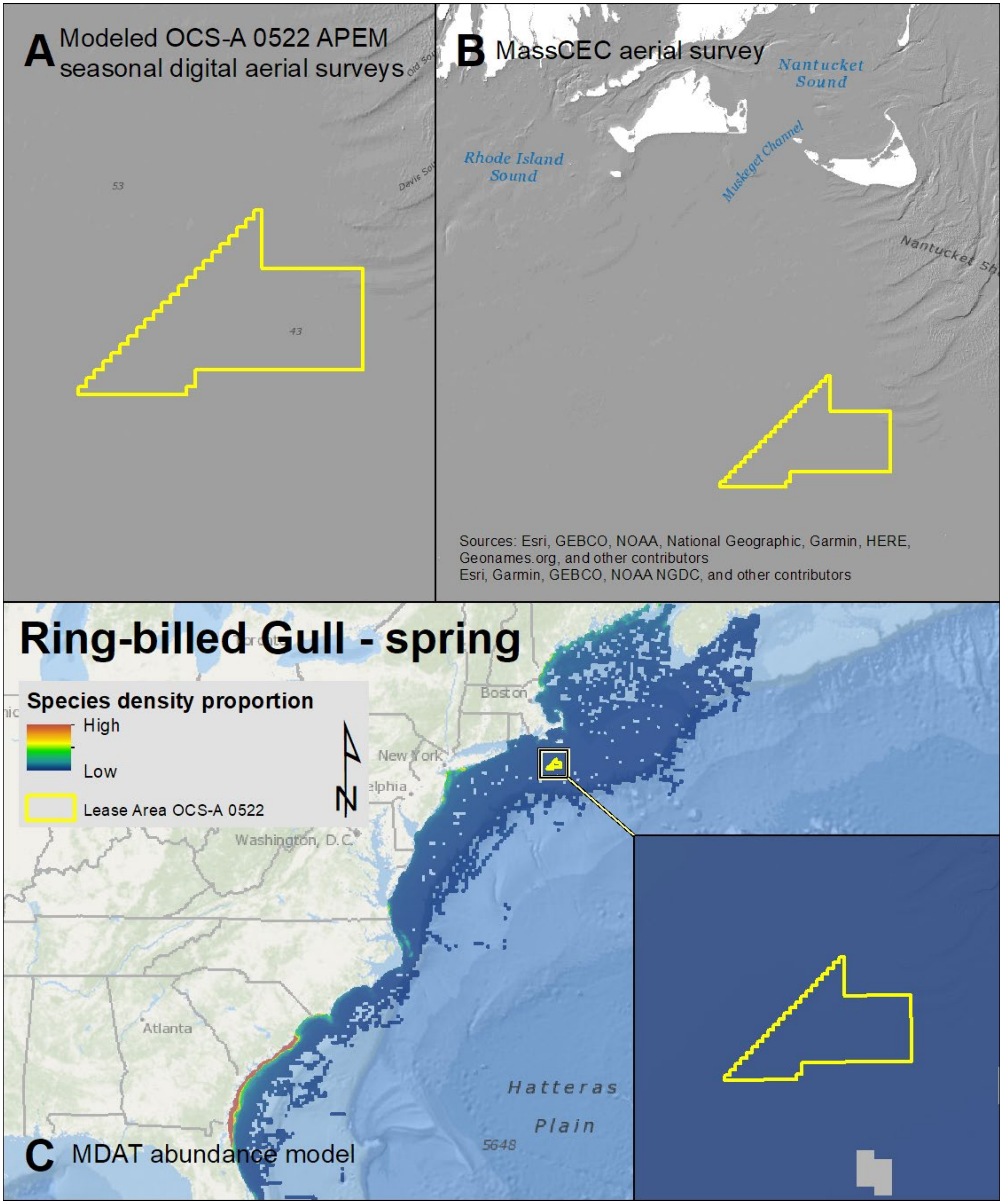
Map 76. Fall Laughing Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



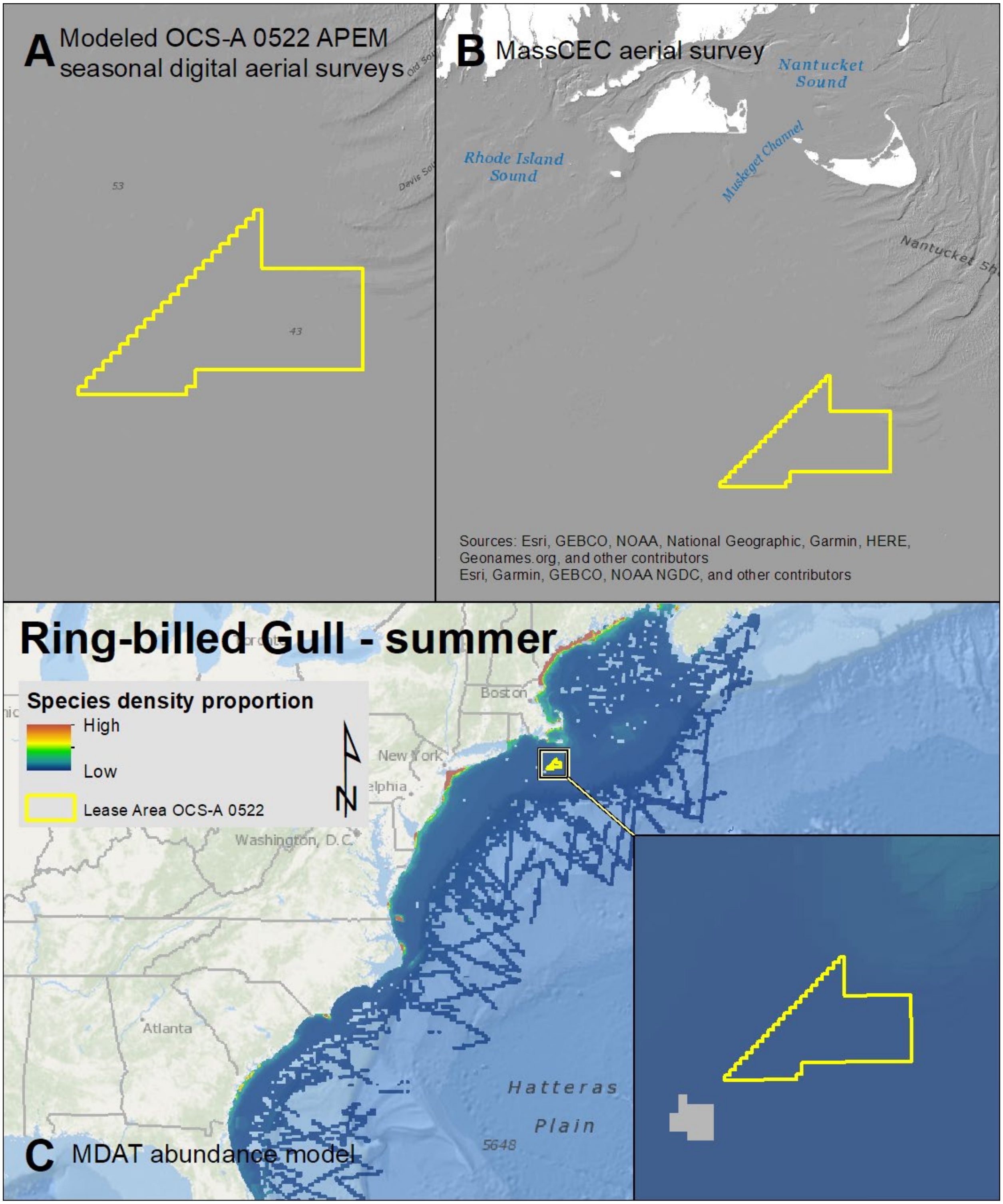
Map 77. Winter Ring-billed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



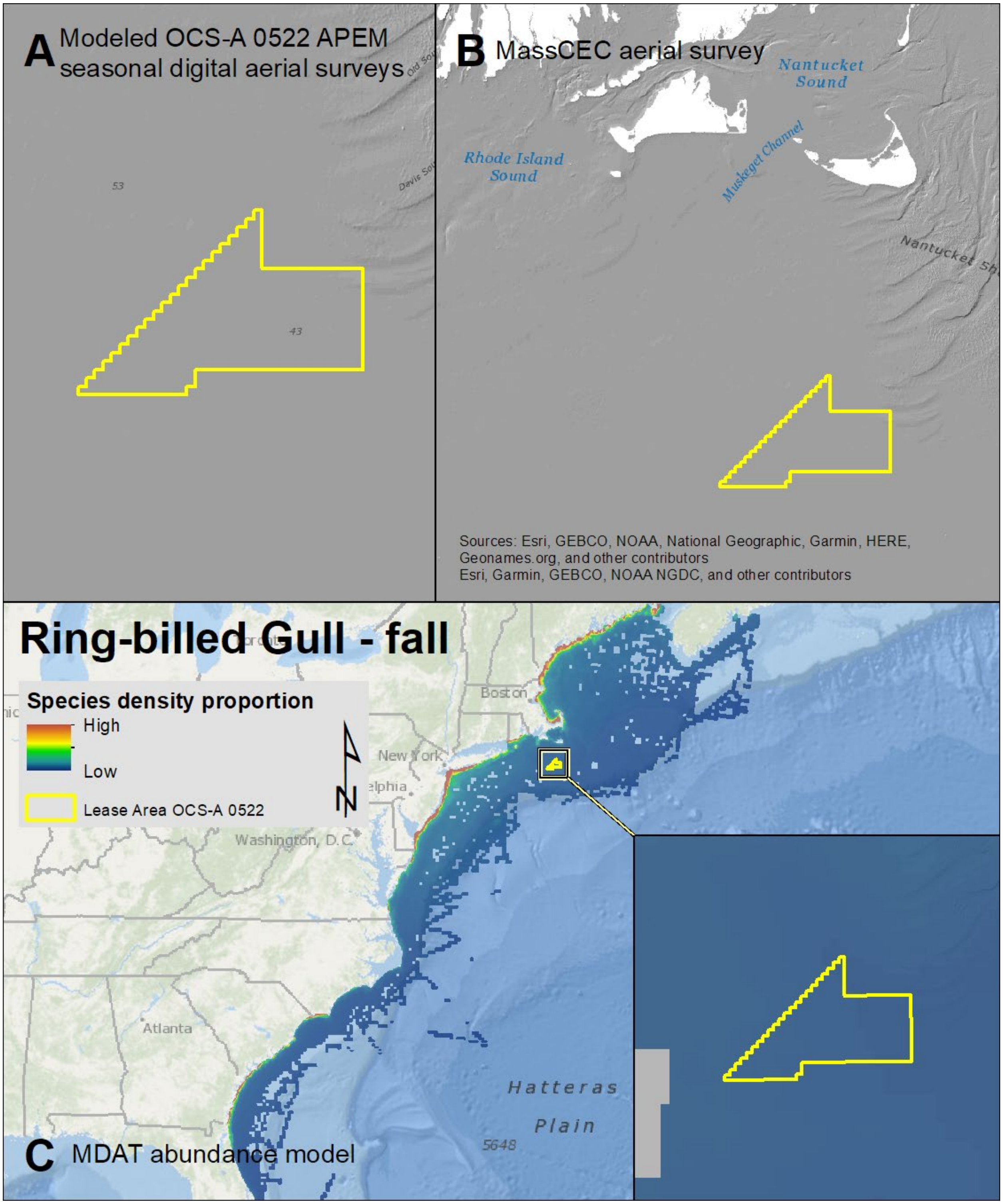
Map 78. Spring Ring-billed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



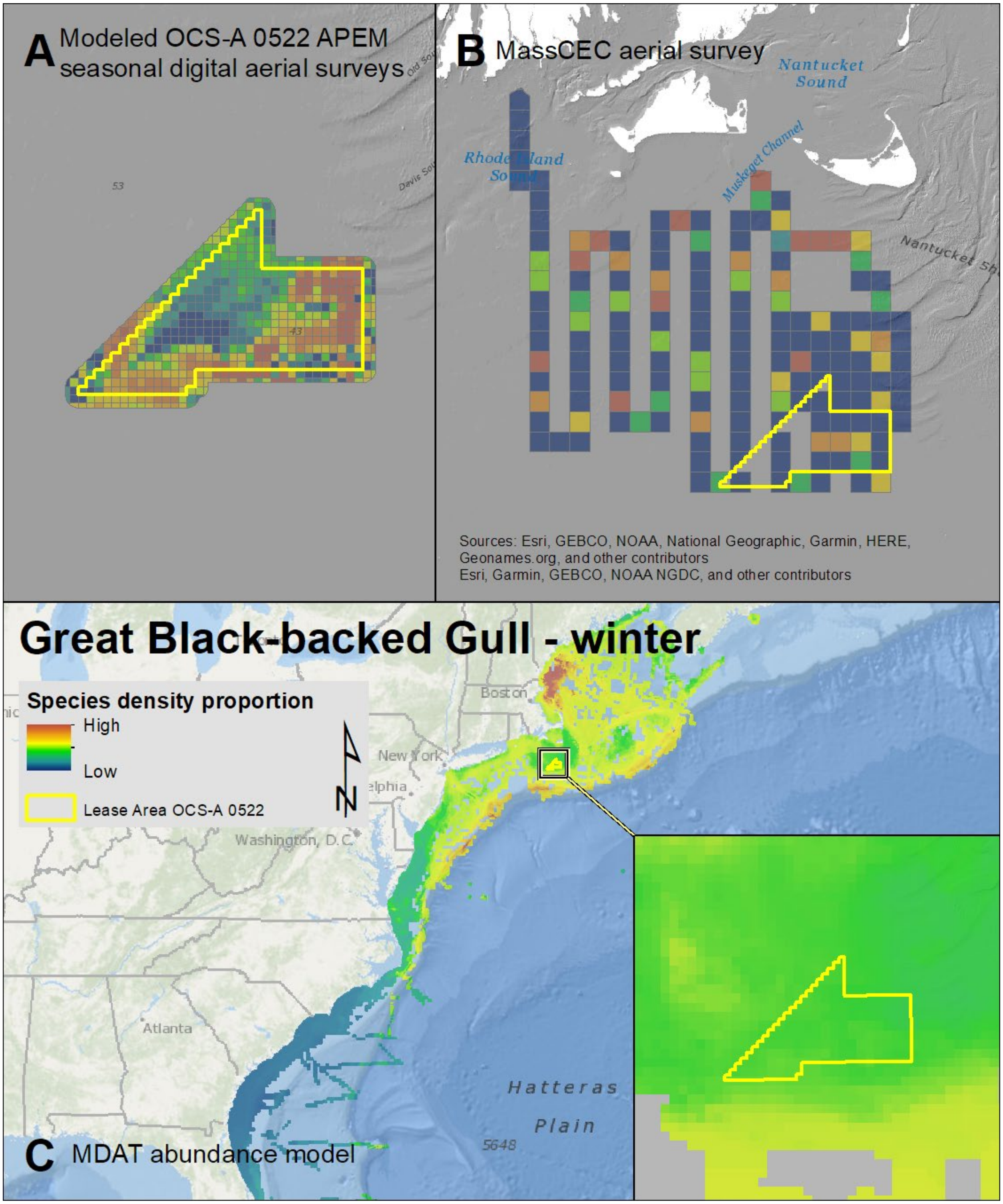
Map 79. Spring Ring-billed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



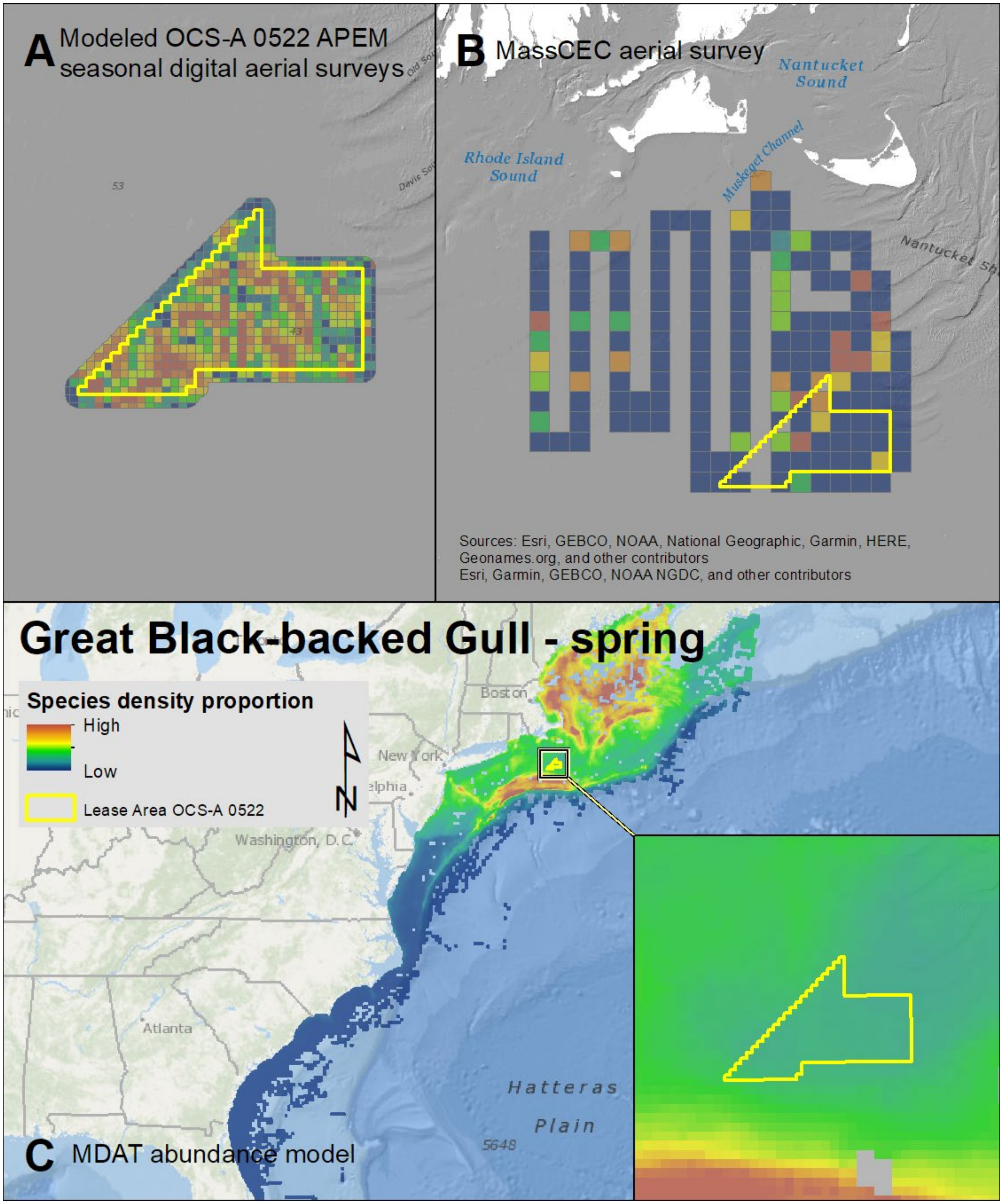
Map 80. Summer Ring-billed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



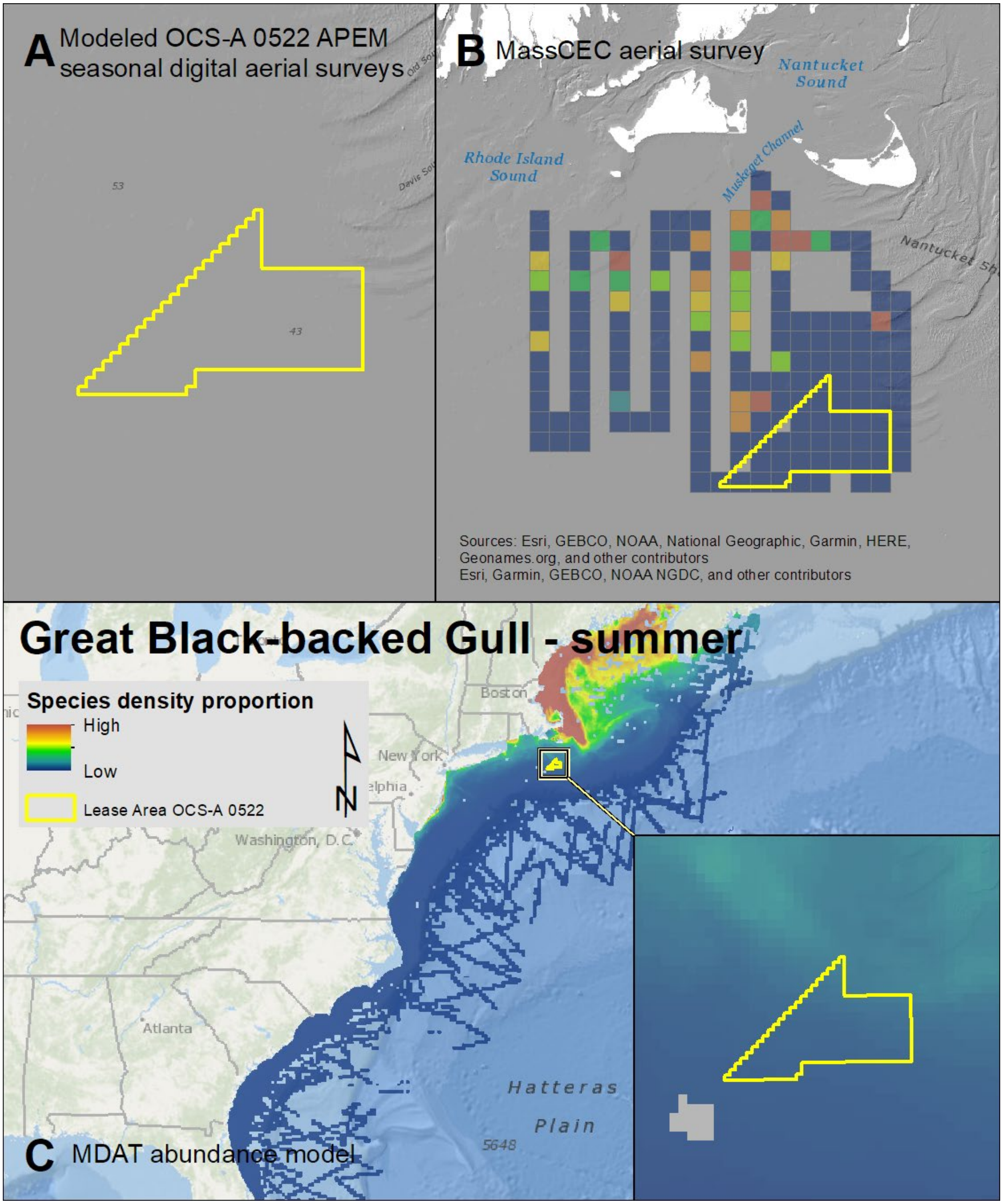
Map 81. Fall Ring-billed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



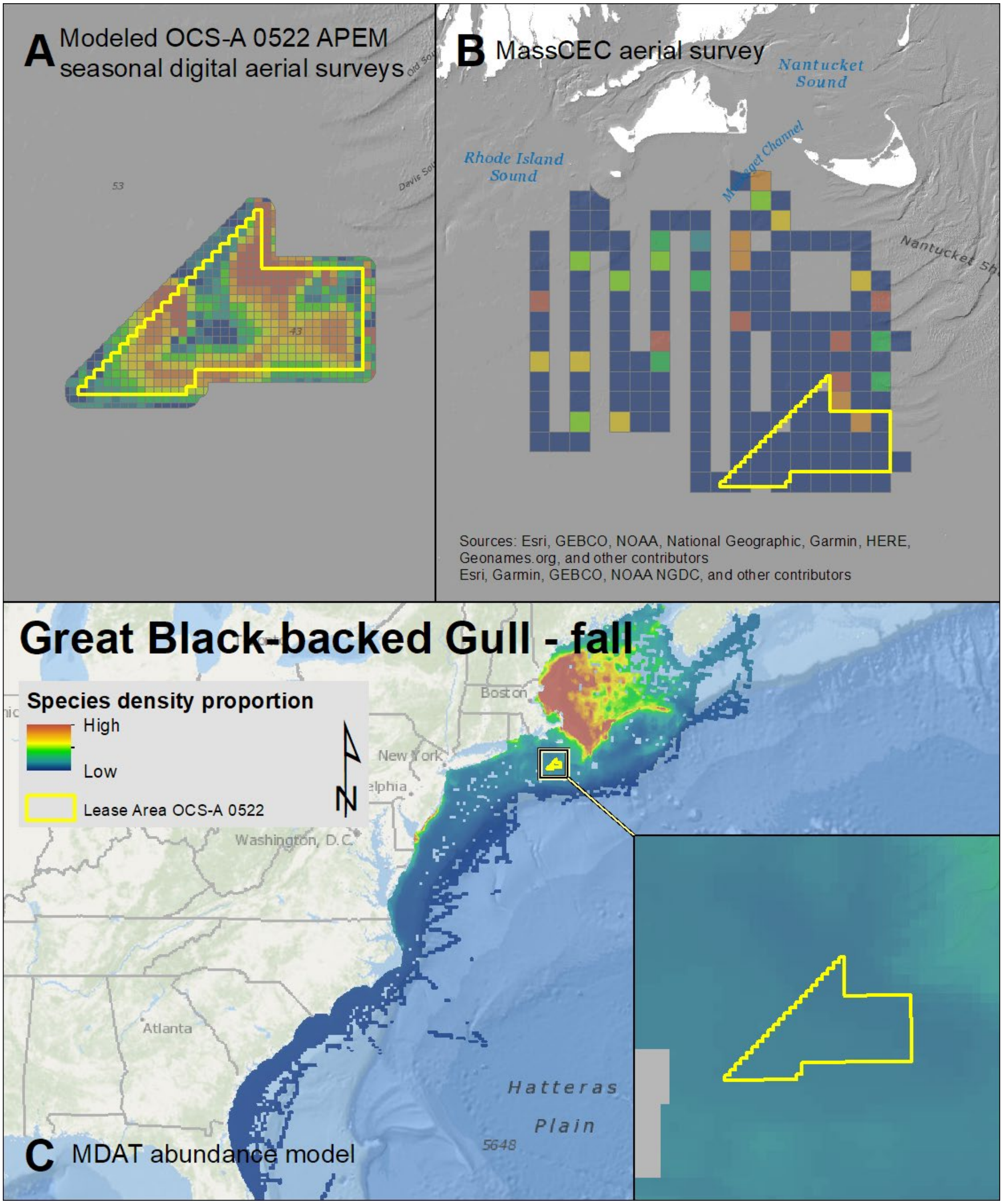
Map 82. Winter Great Black-backed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



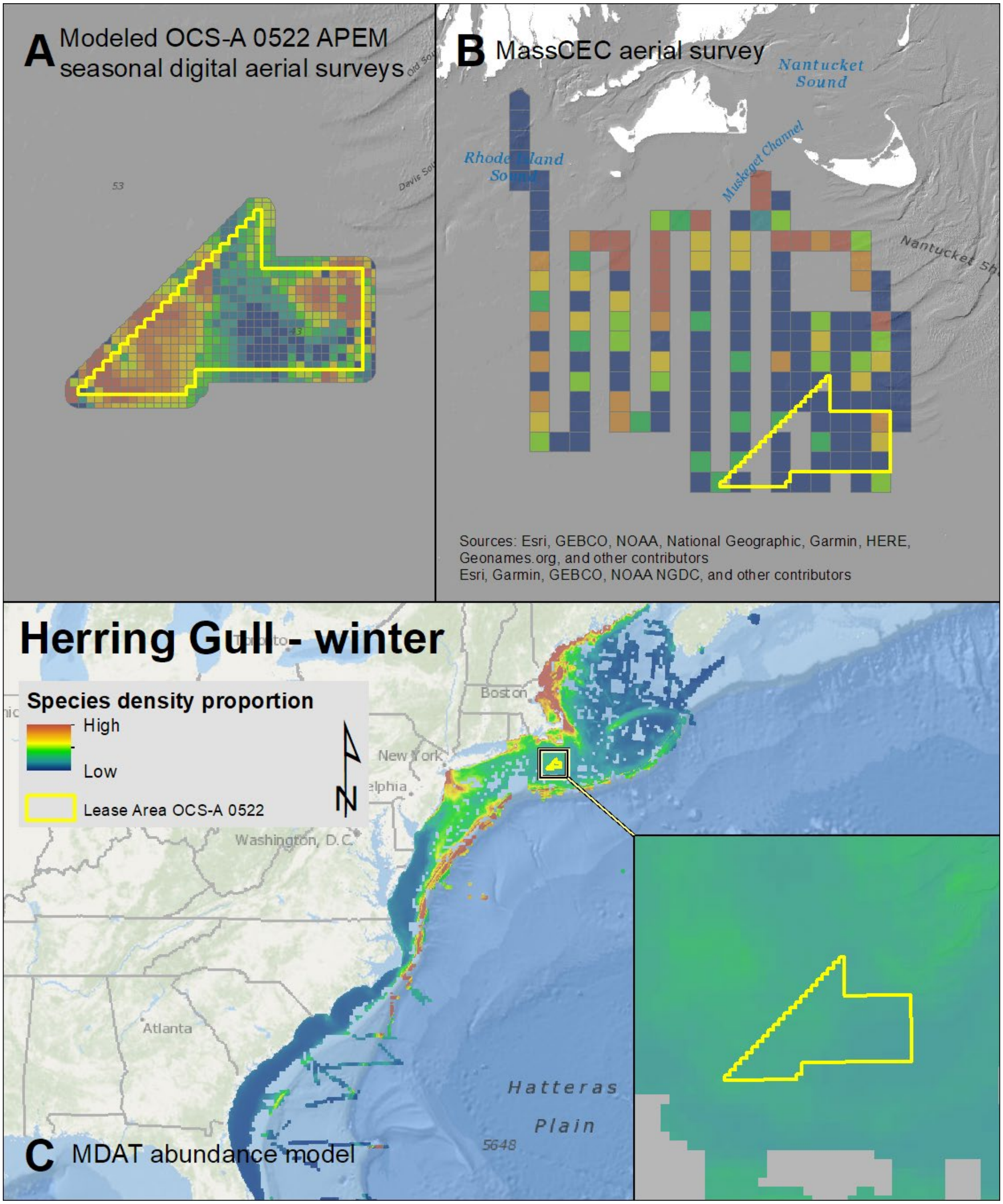
Map 83. Spring Great Black-backed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



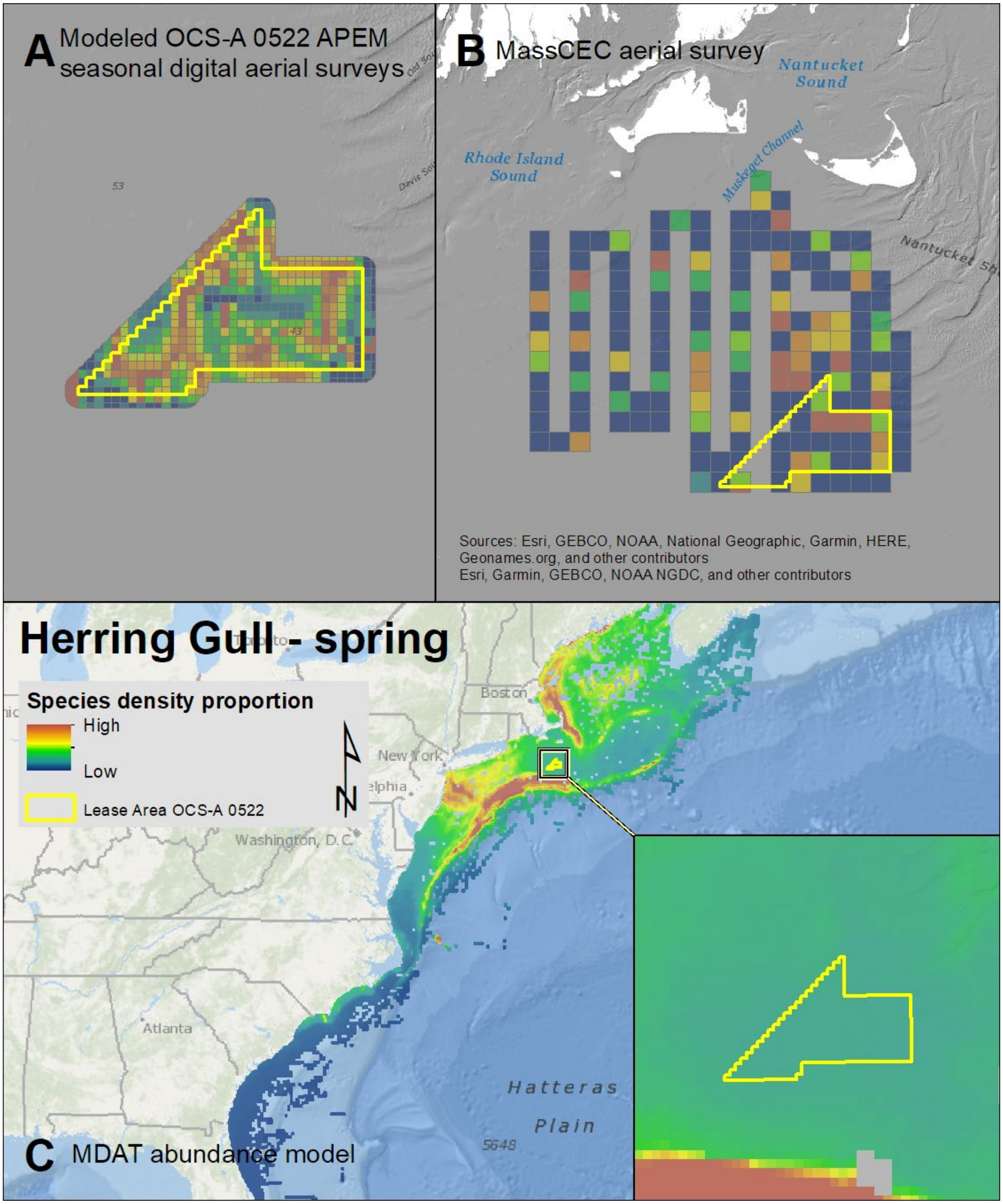
Map 84. Summer Great Black-backed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



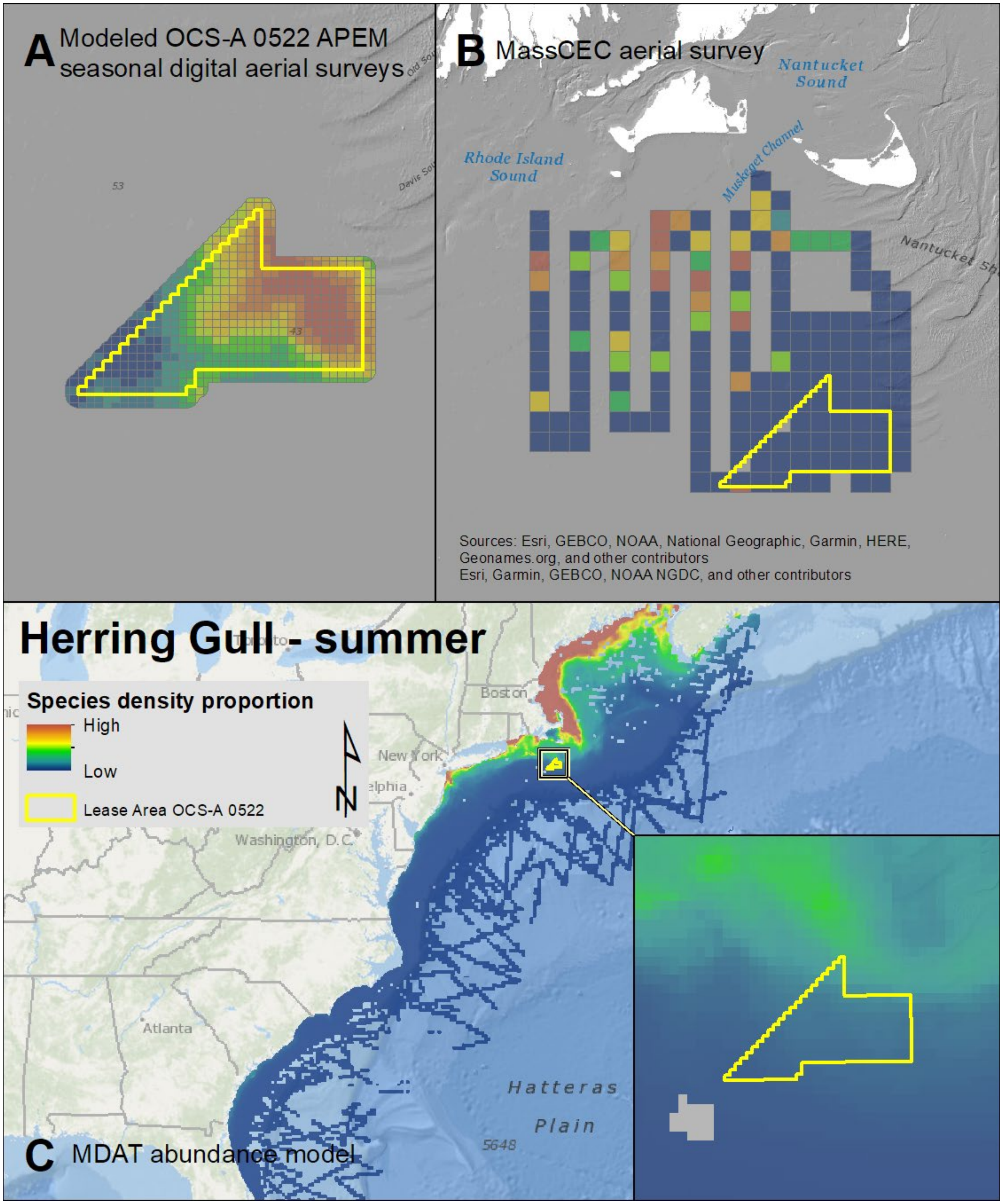
Map 85. Fall Great Black-backed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



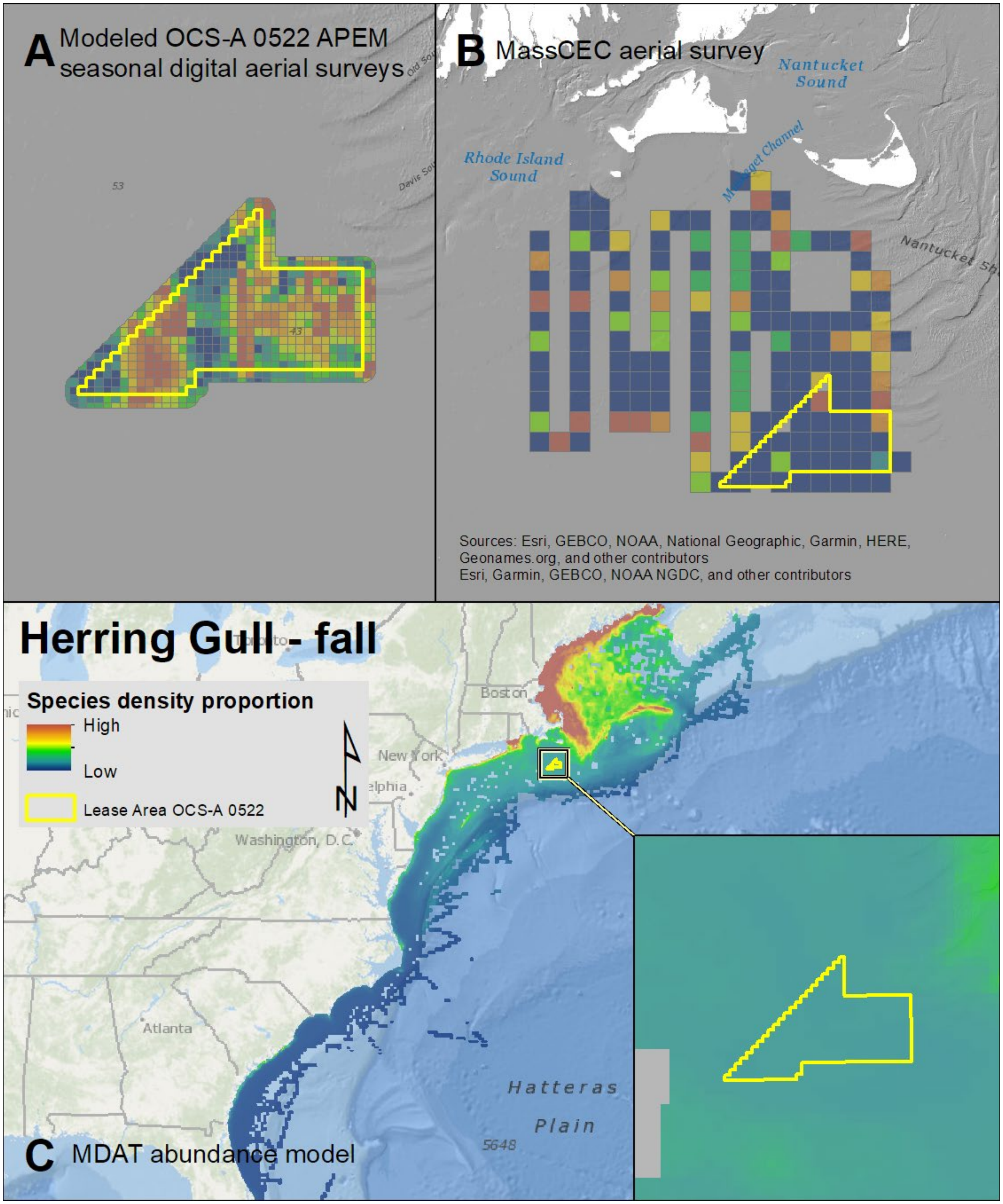
Map 86. Winter Herring Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



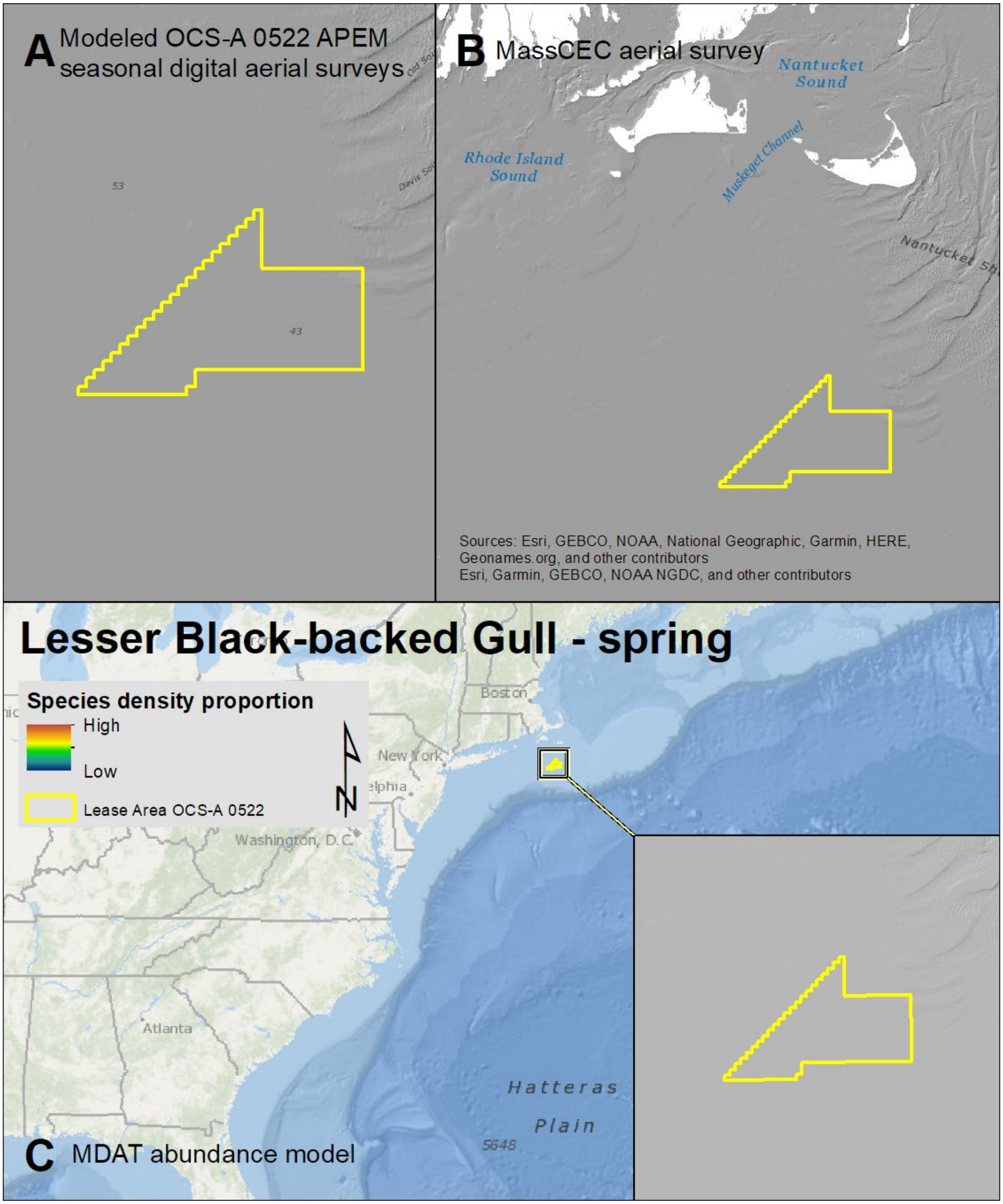
Map 87. Spring Herring Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



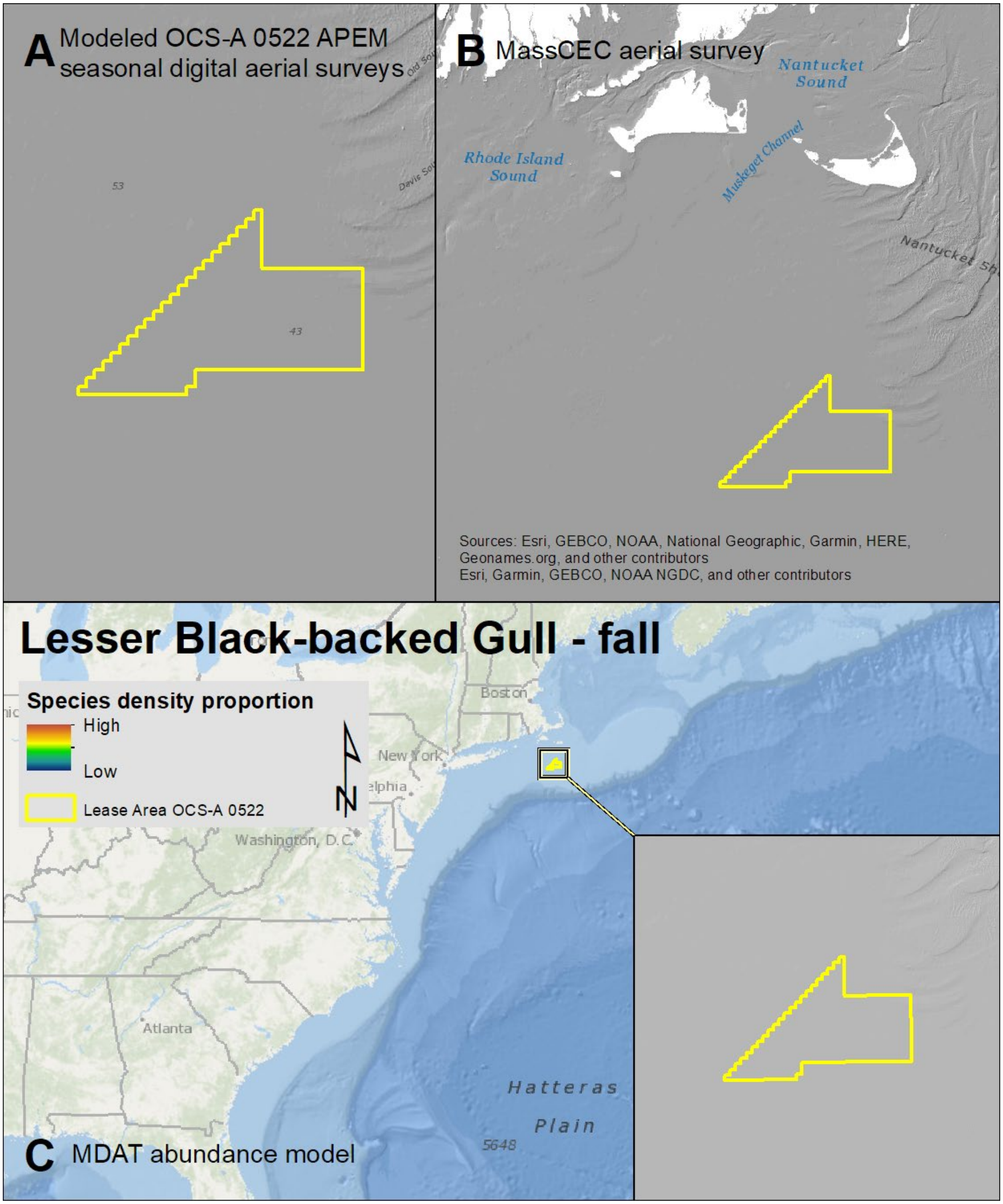
Map 88. Summer Herring Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



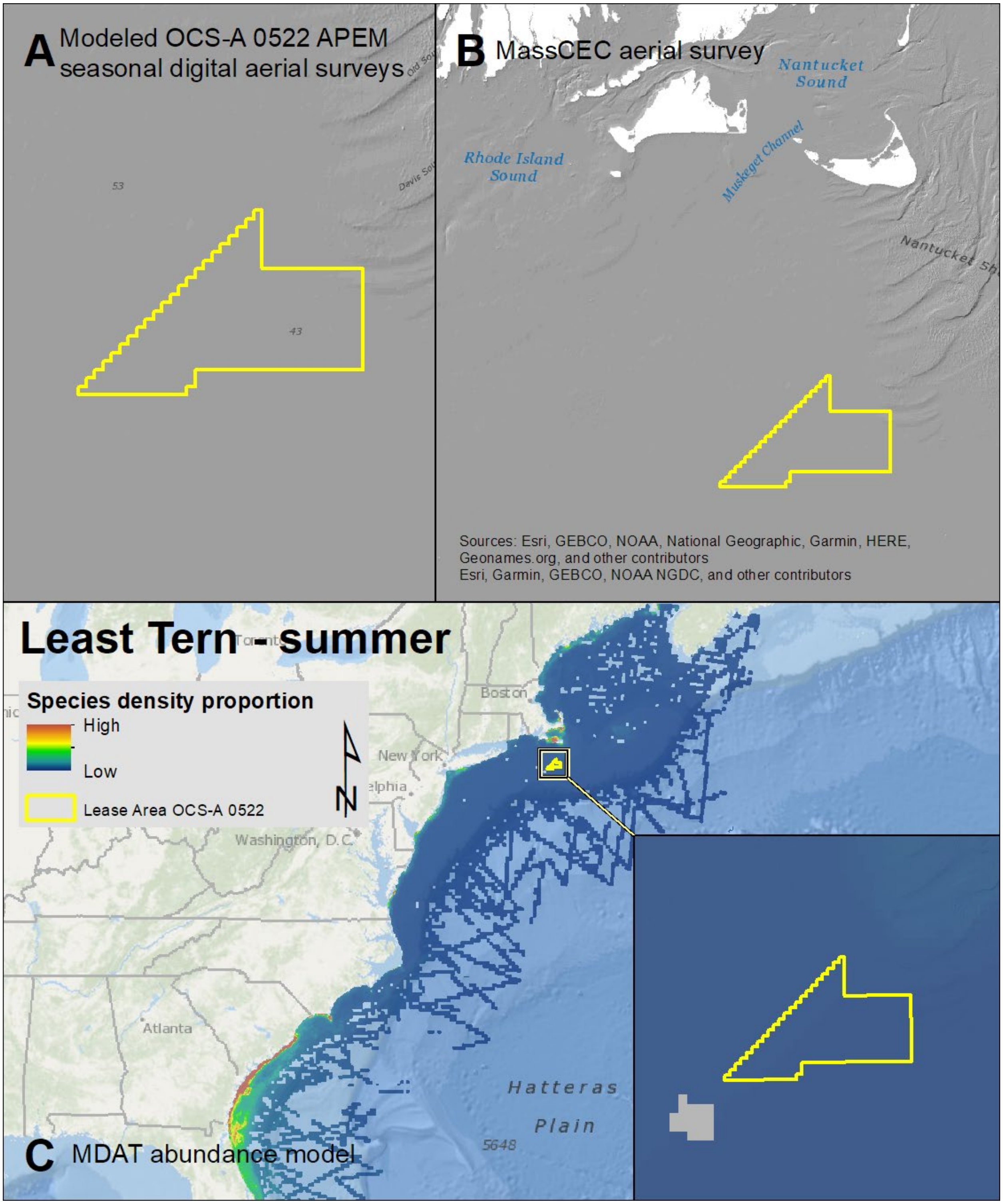
Map 89. Fall Herring Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



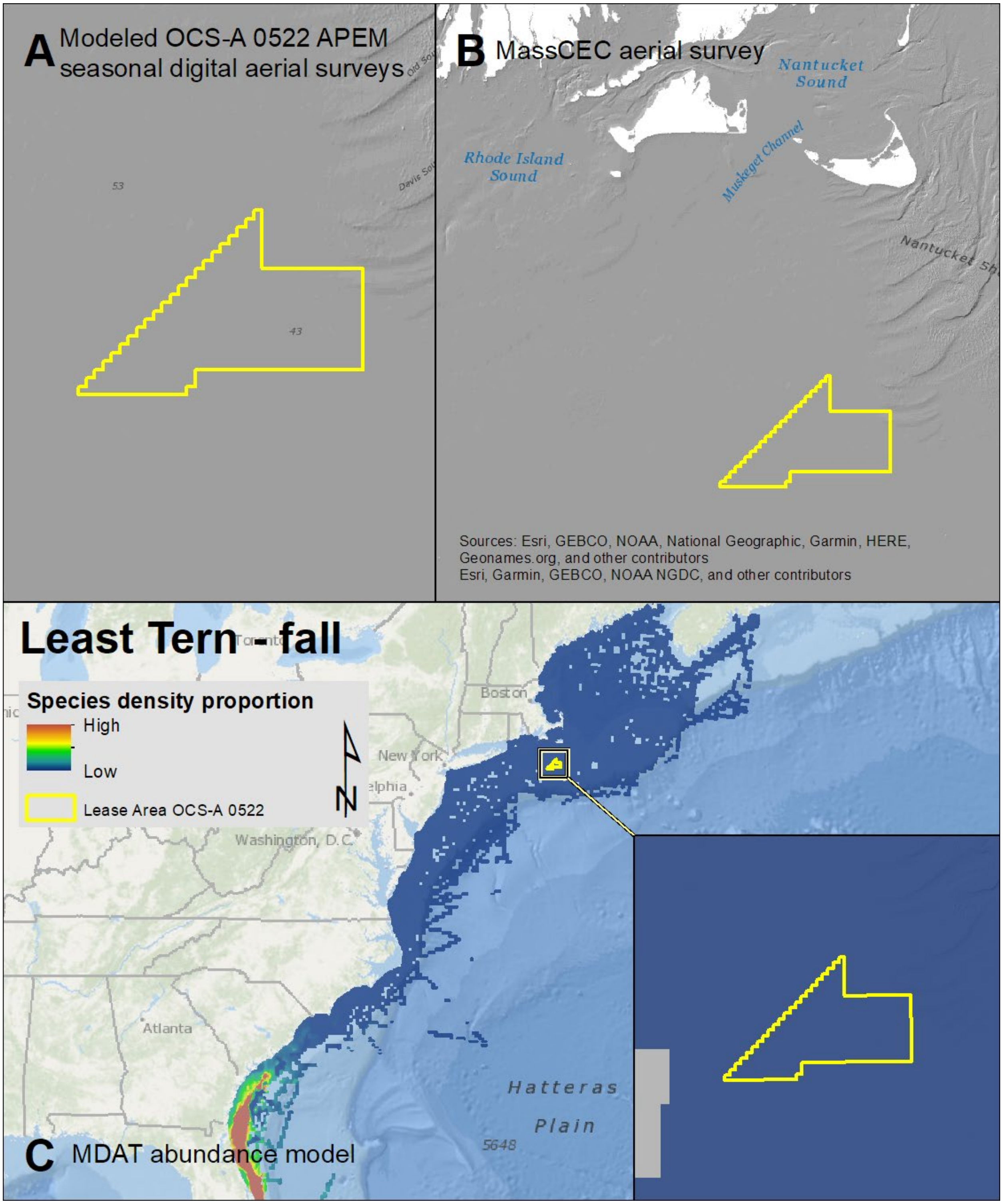
Map 90. Spring Lesser Black-backed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



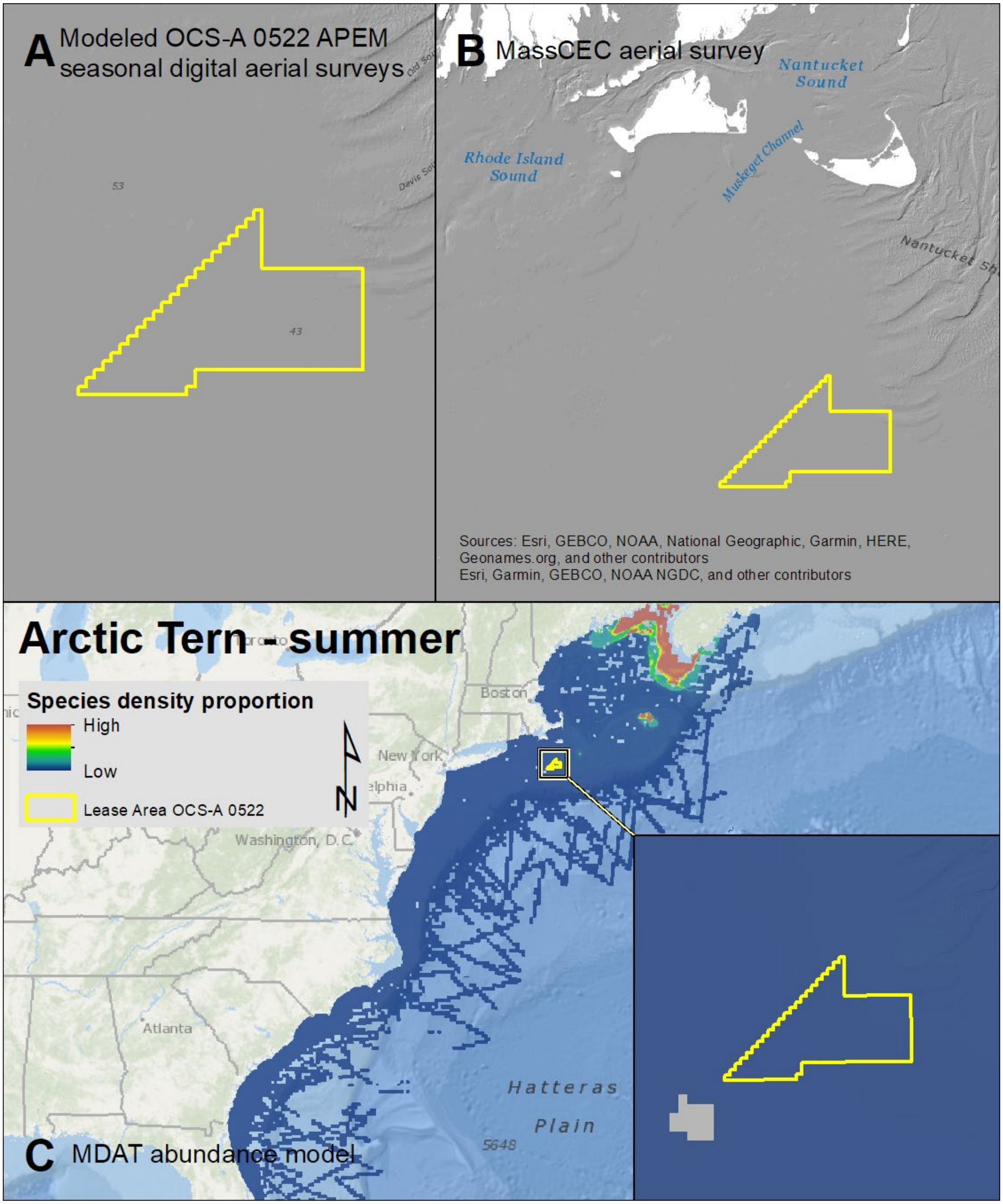
Map 91. Fall Lesser Black-backed Gull modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



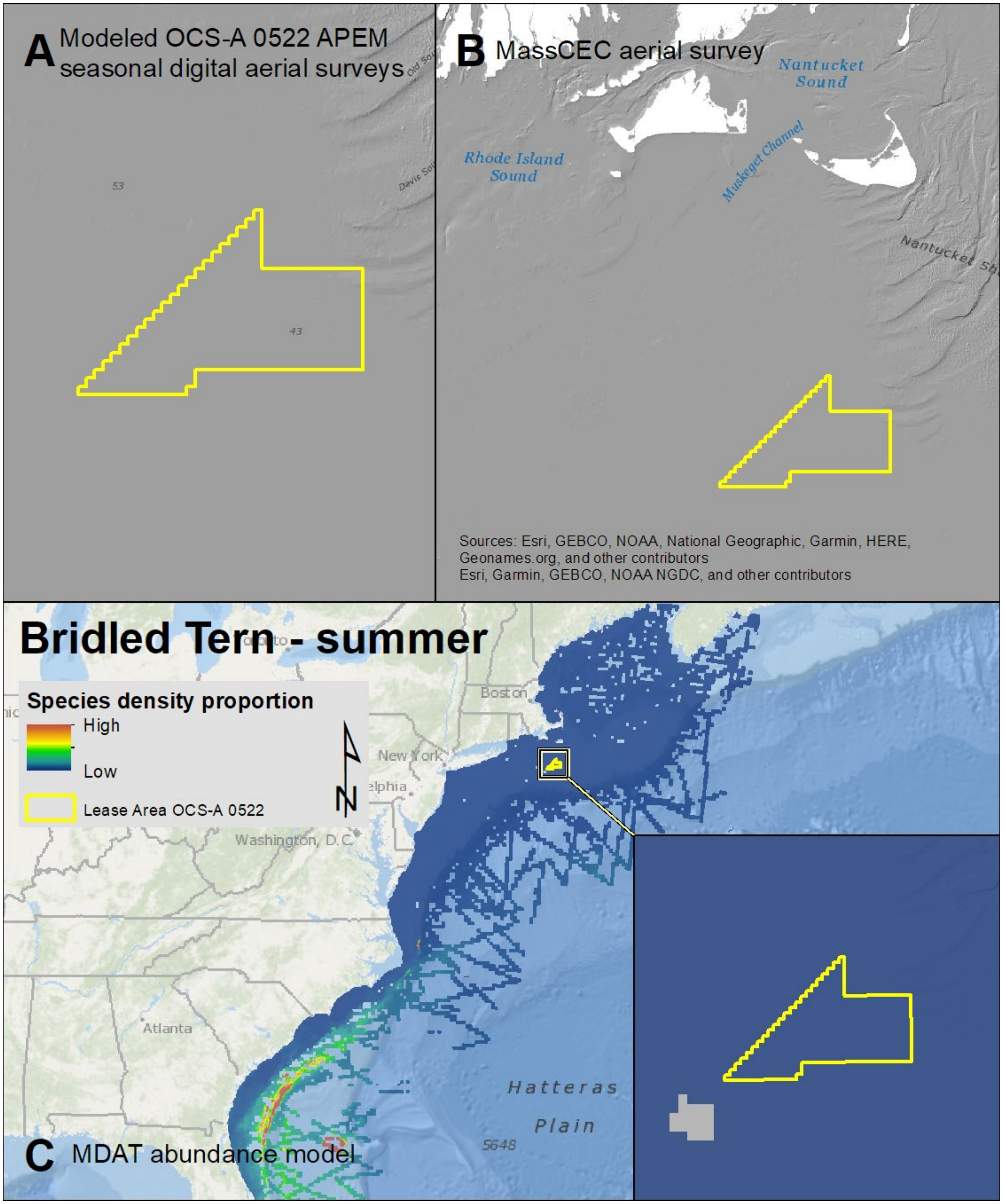
Map 92. Summer Least Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



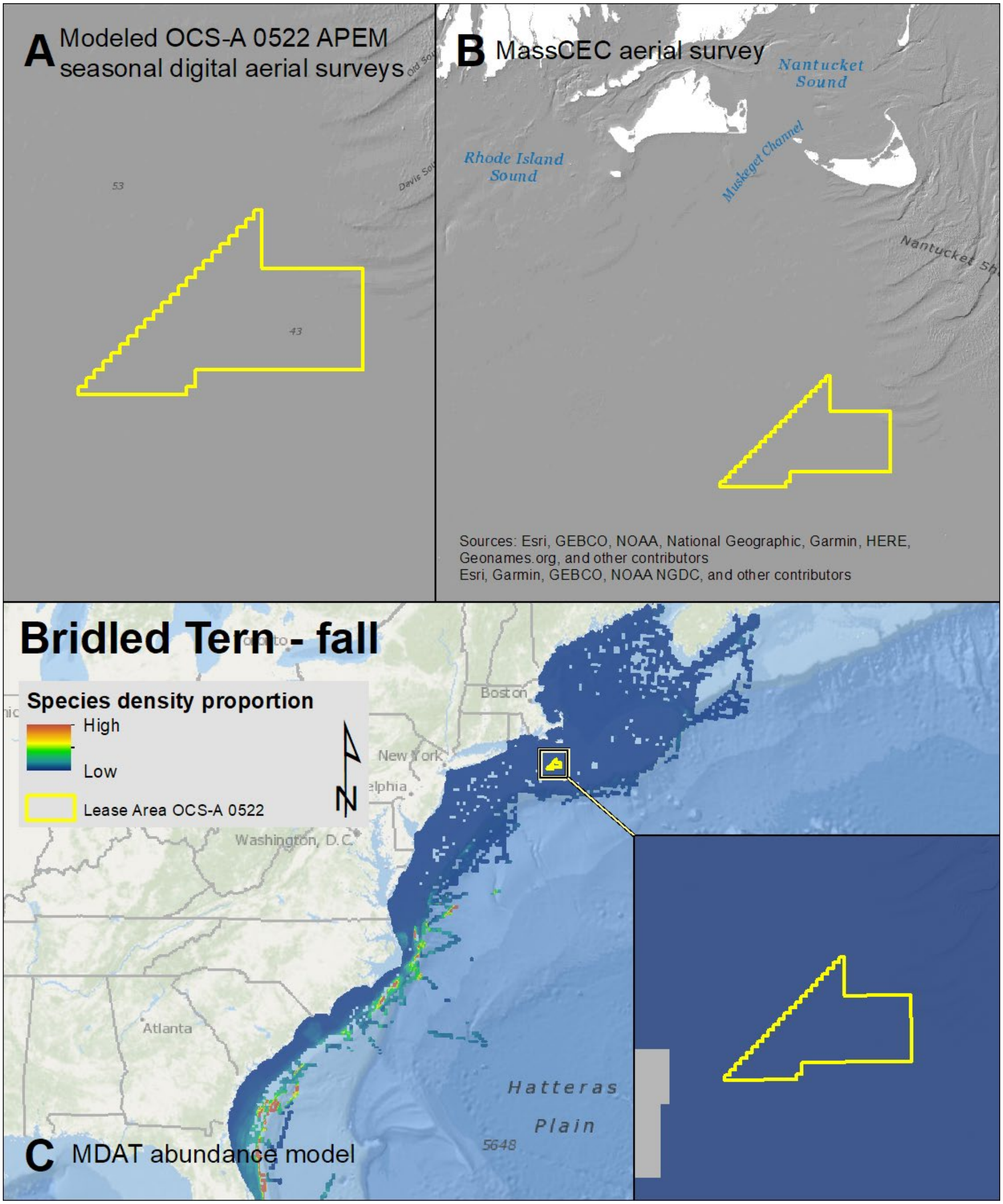
Map 93. Fall Least Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



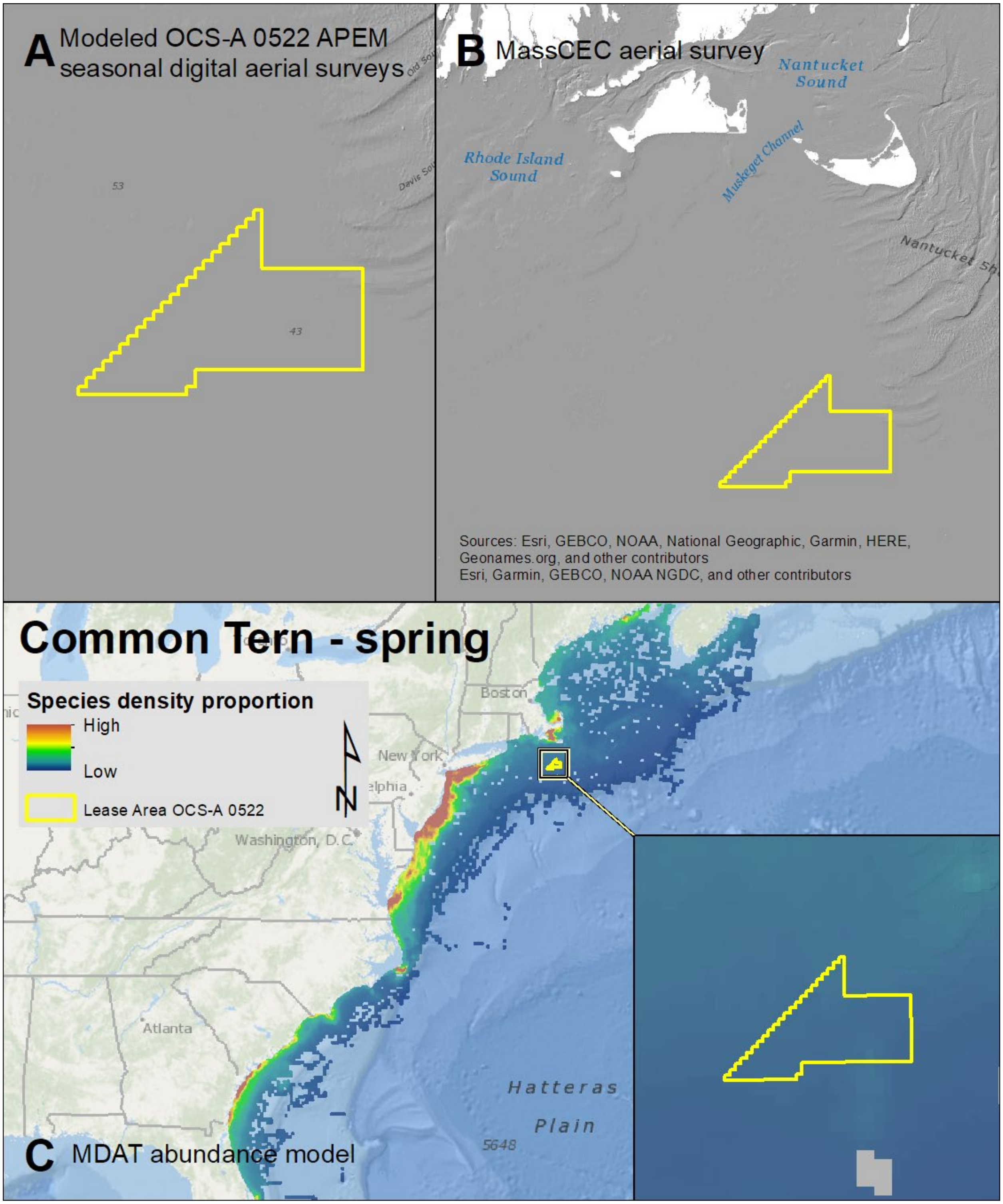
Map 94. Summer Arctic Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



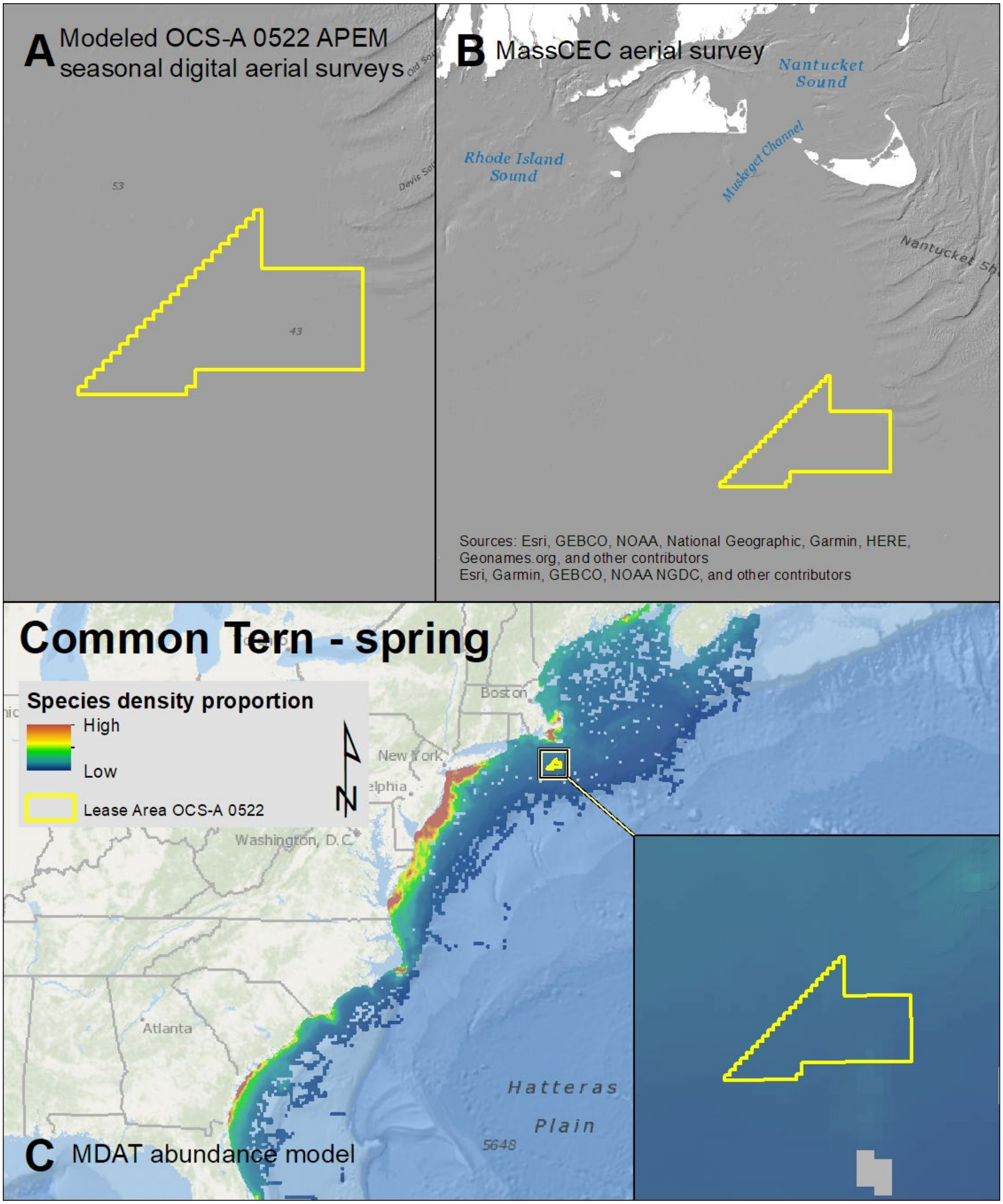
Map 95. Summer Bridled Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



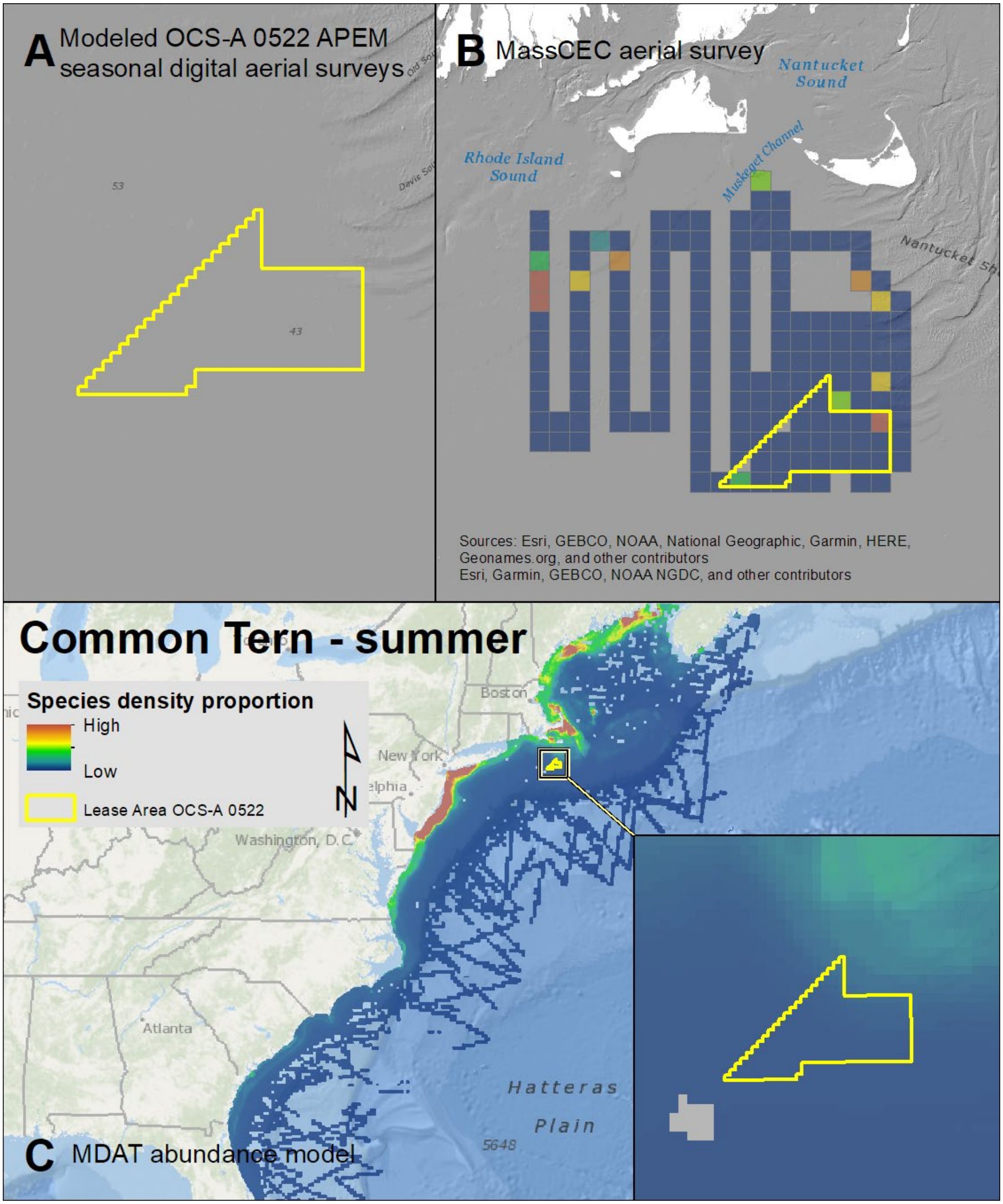
Map 96. Fall Bridled Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



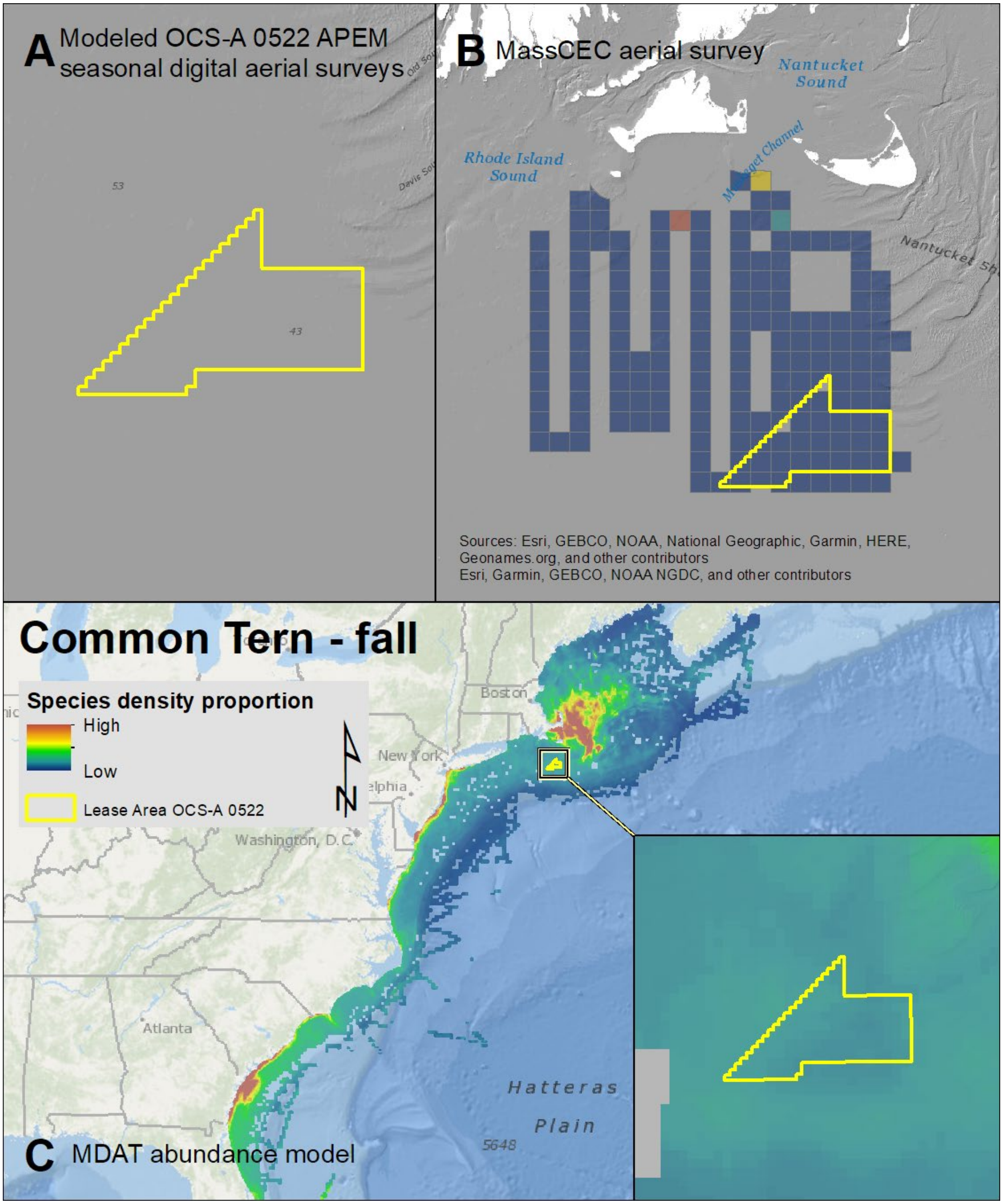
Map 97. Spring Common Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



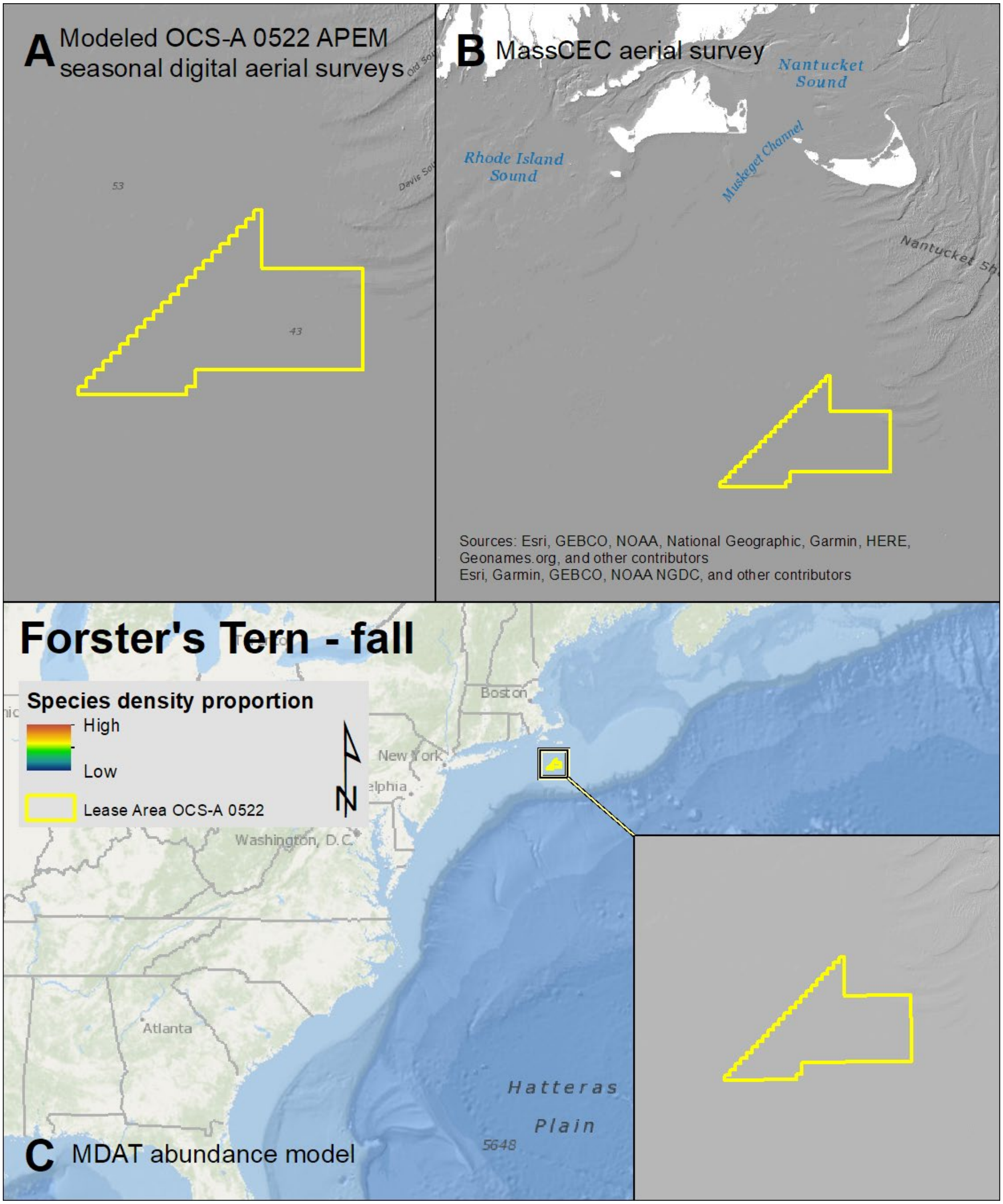
Map 98. Spring Common Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



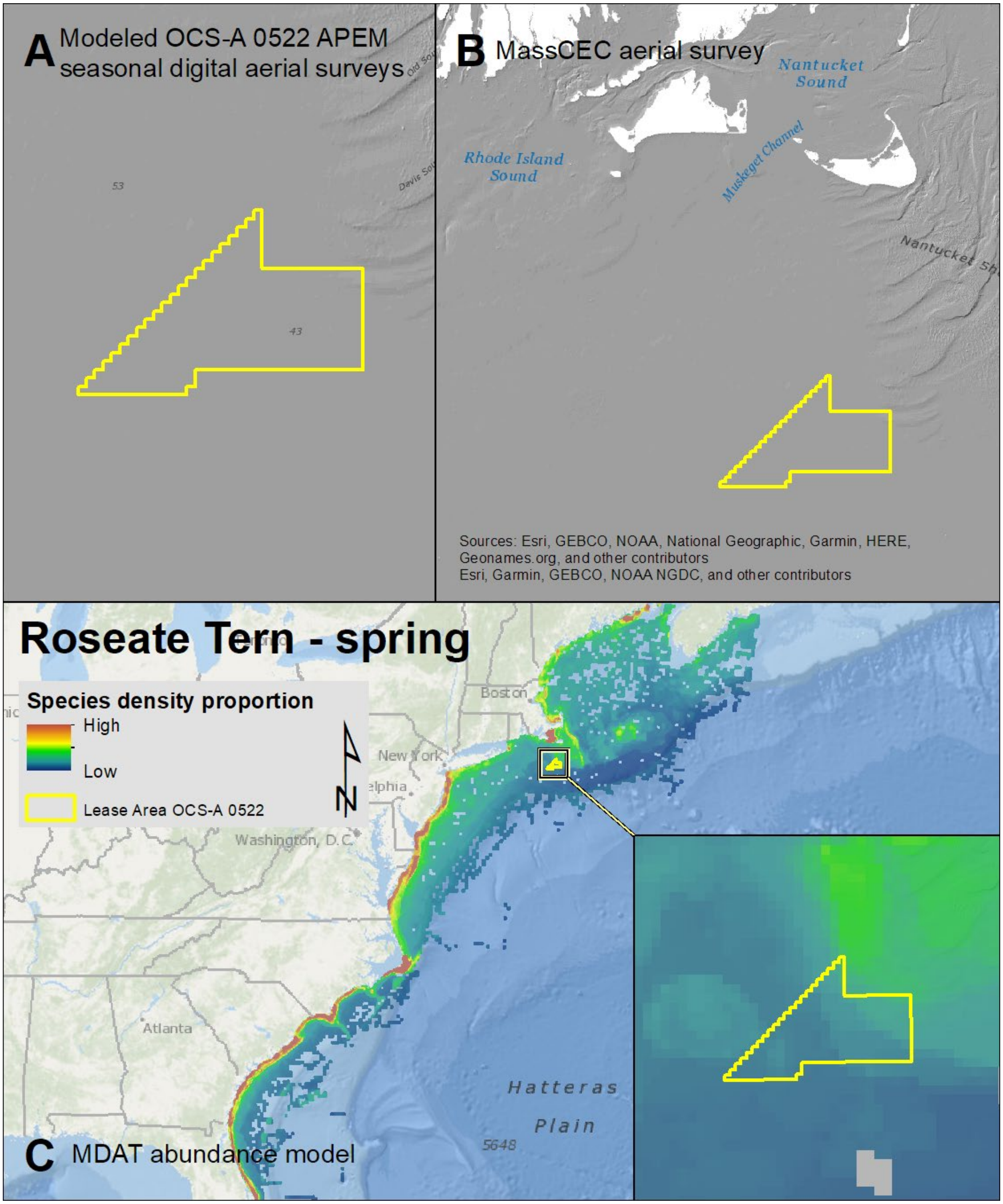
Map 99. Summer Common Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



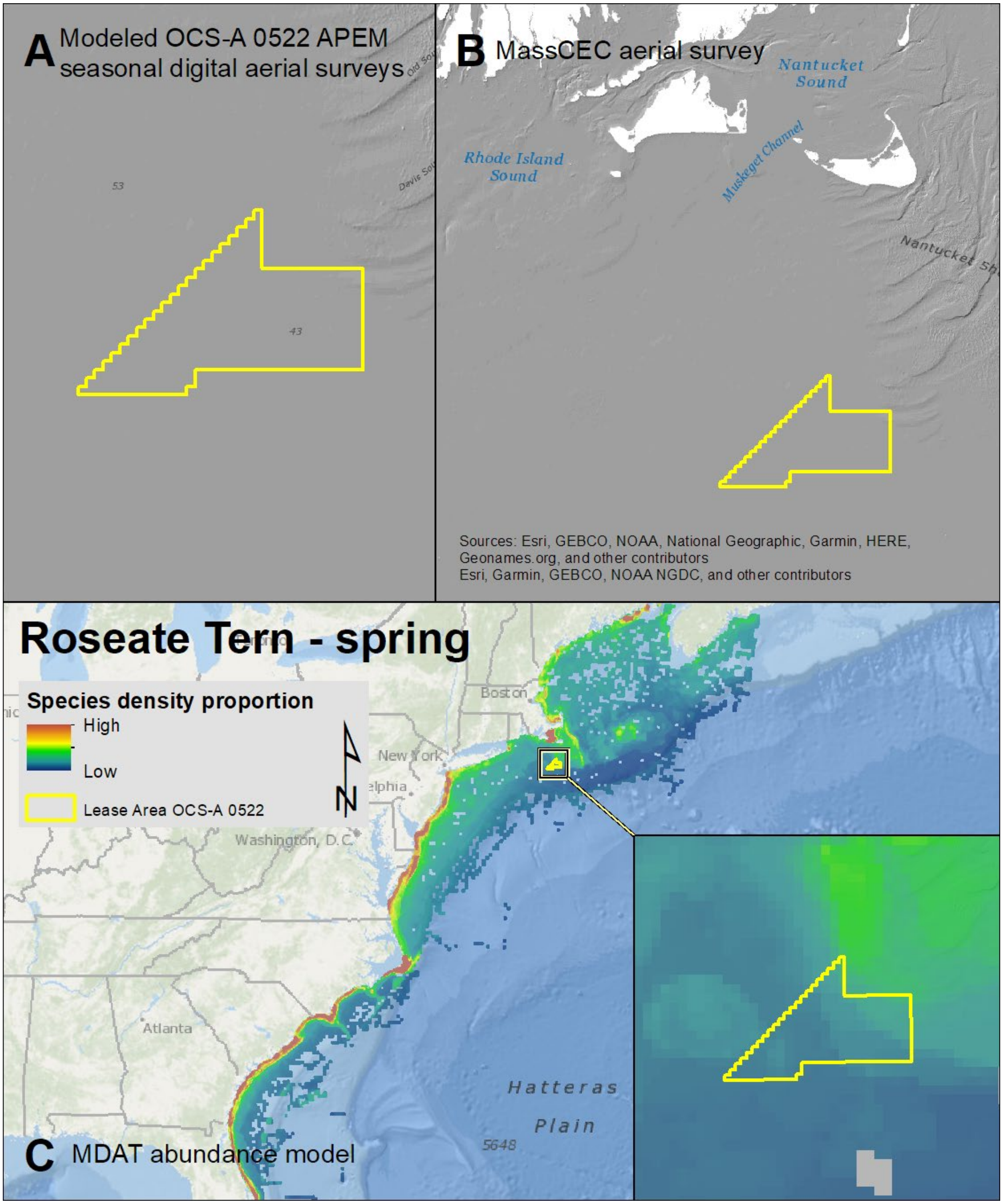
Map 100. Fall Common Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



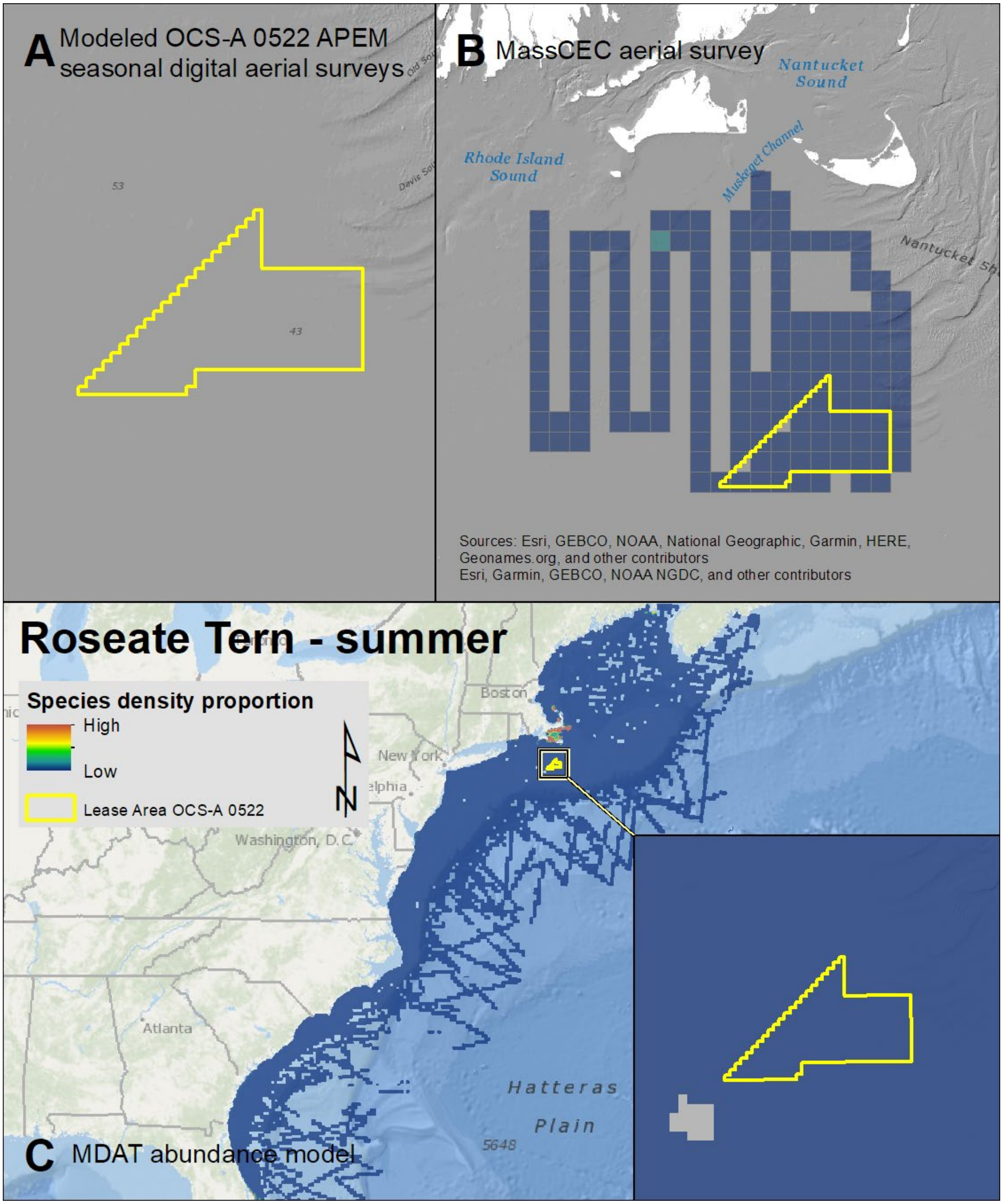
Map 101. Fall Forster's Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



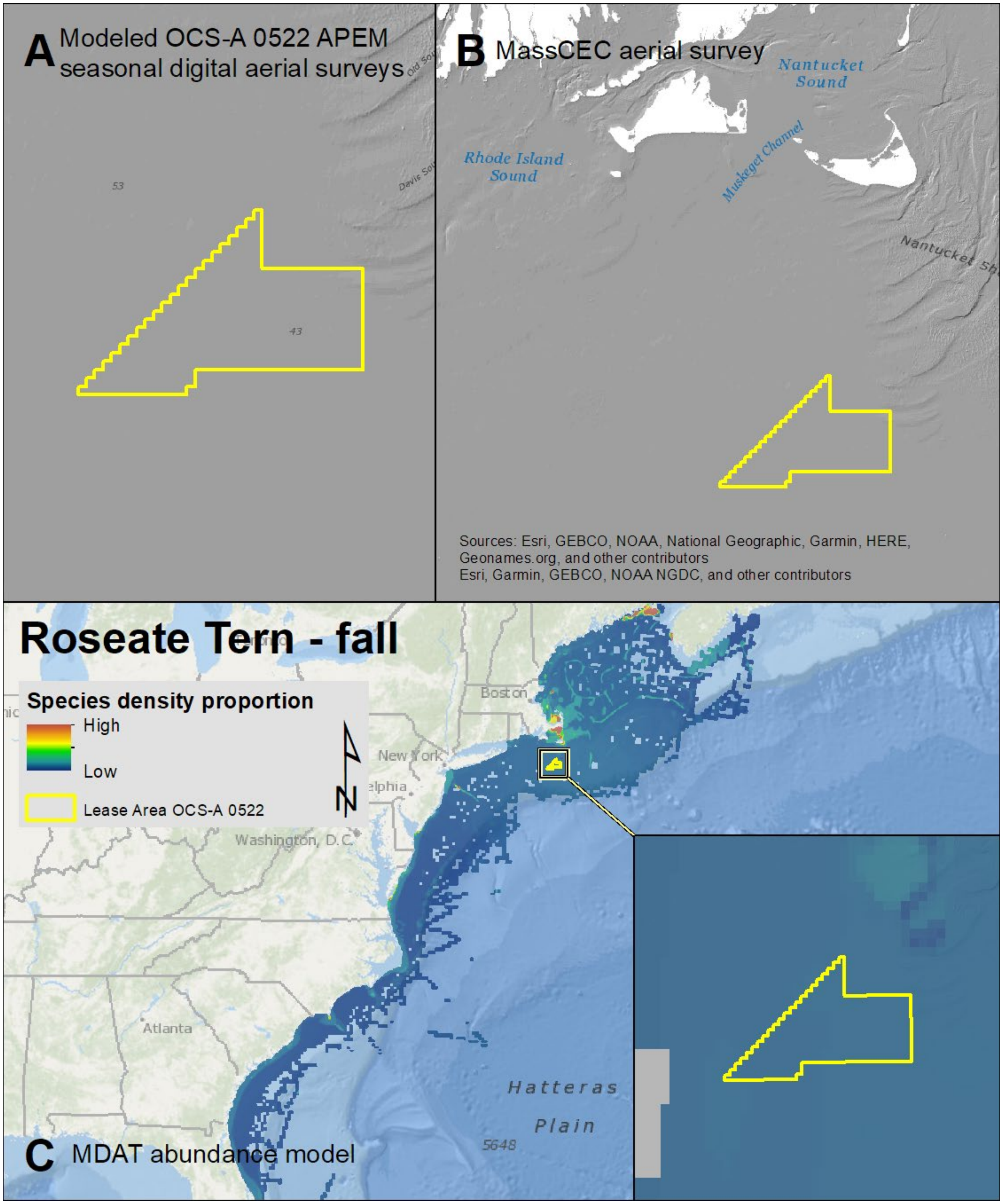
Map 102. Spring Roseate Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



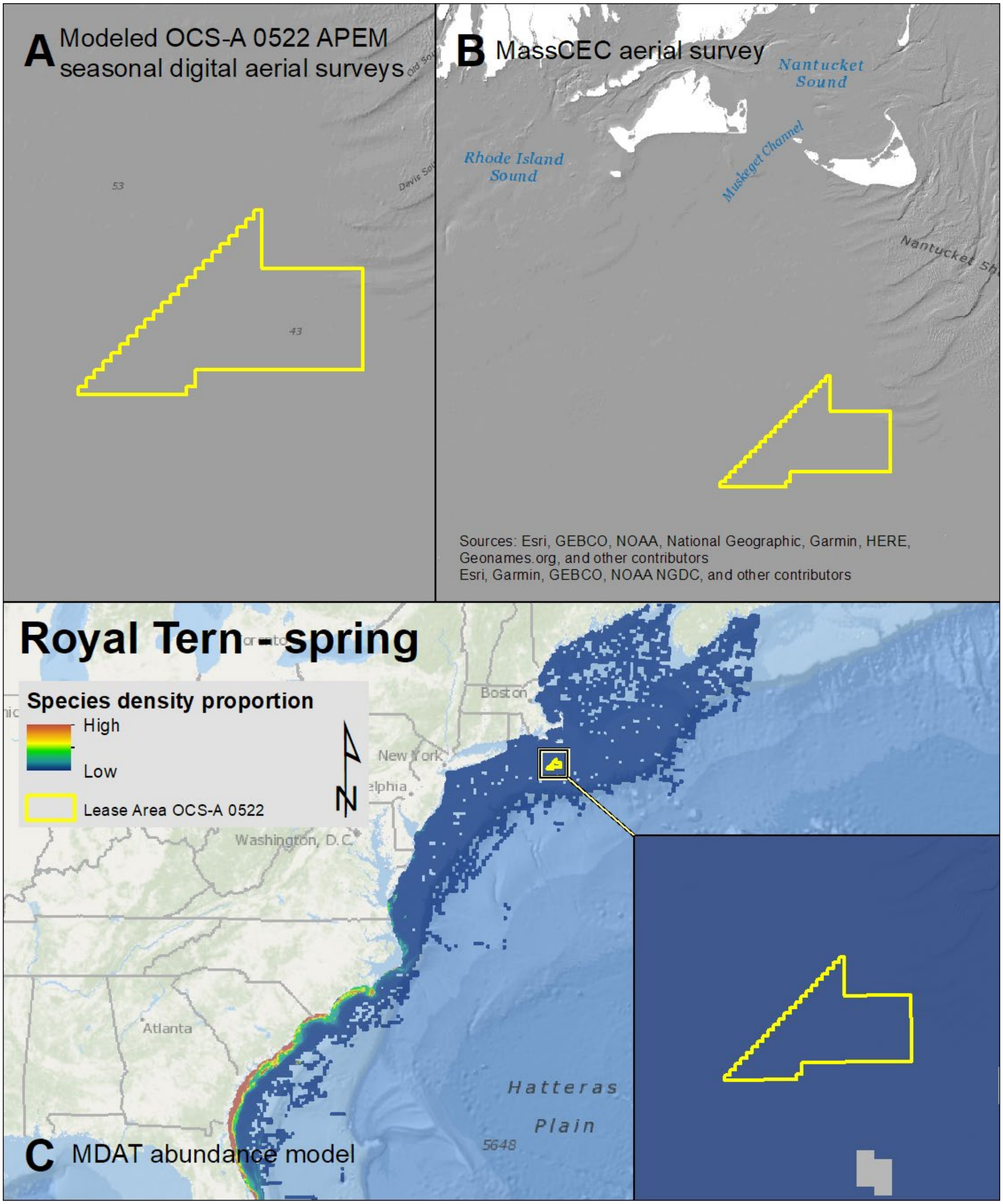
Map 103. Spring Roseate Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



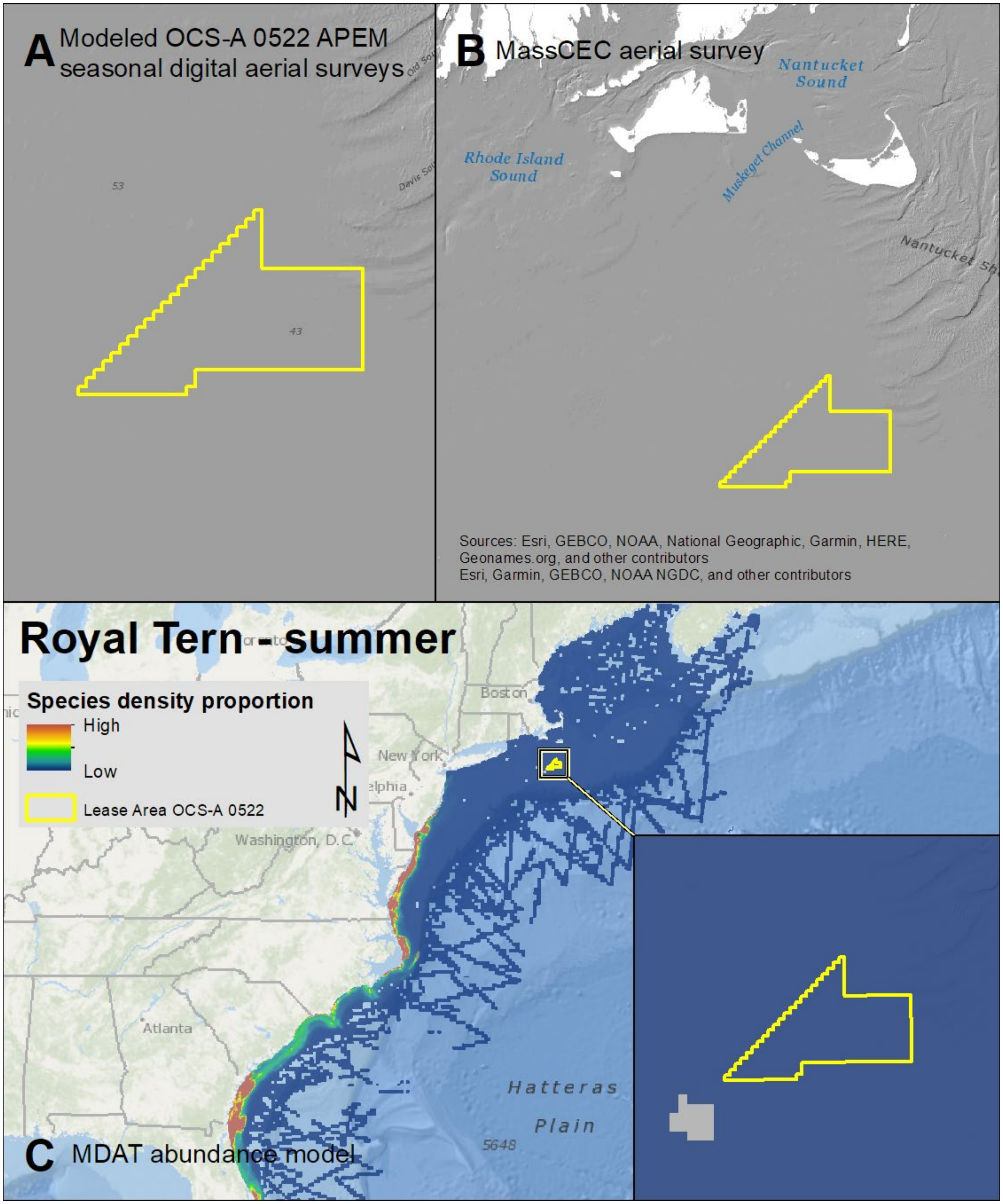
Map 104. Summer Roseate Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



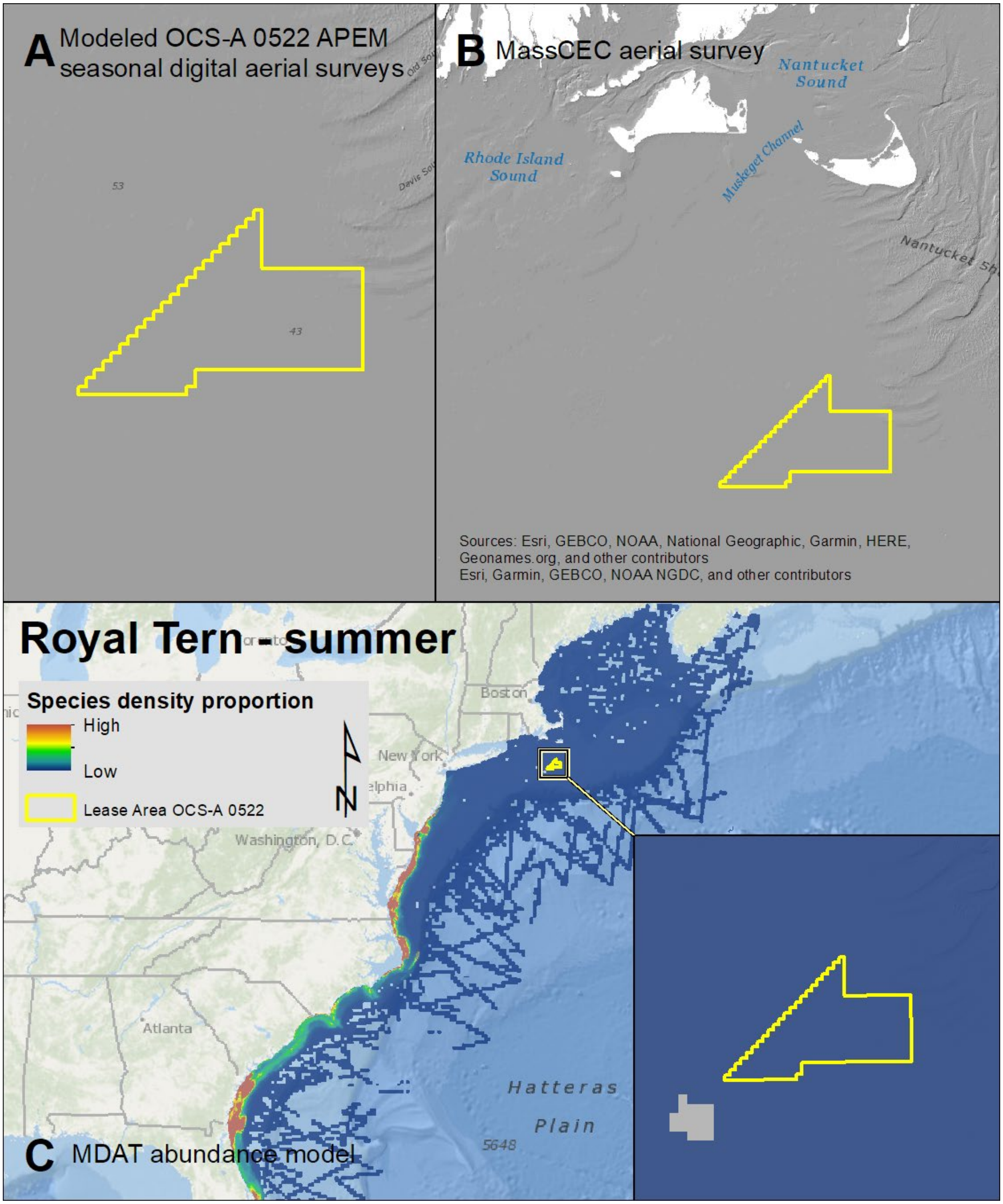
Map 105. Fall Roseate Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



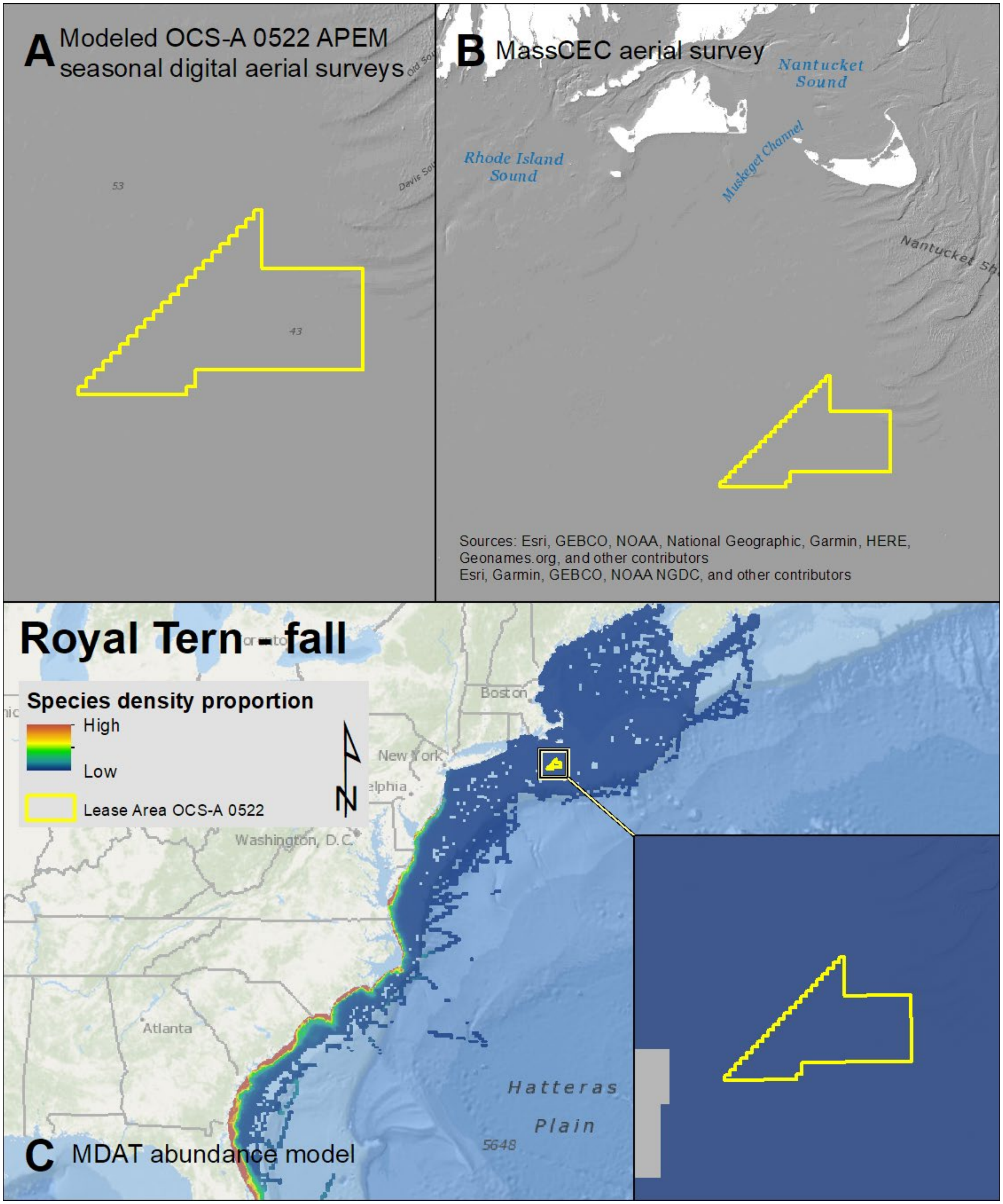
Map 106. Spring Royal Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



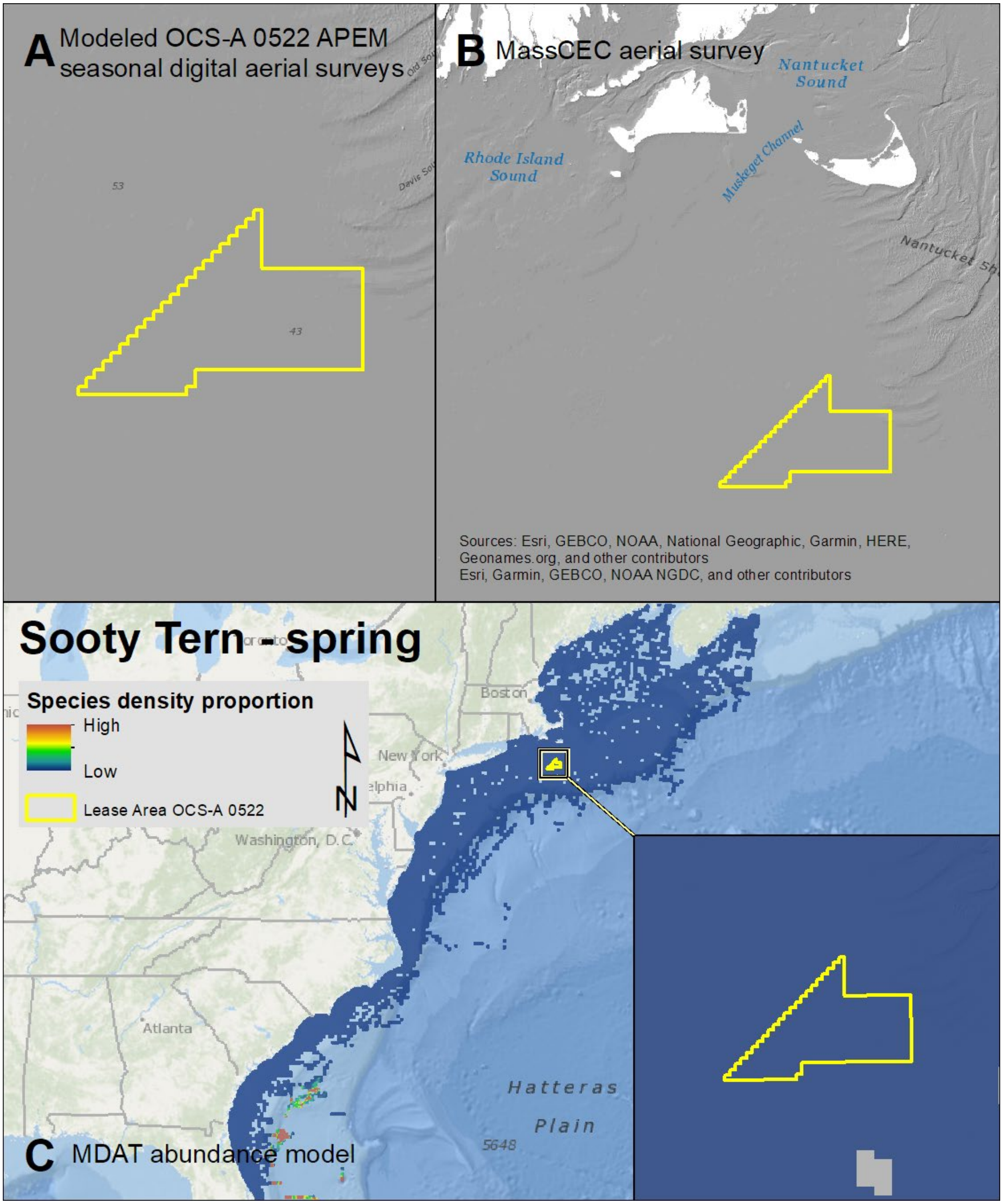
Map 107. Summer Royal Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



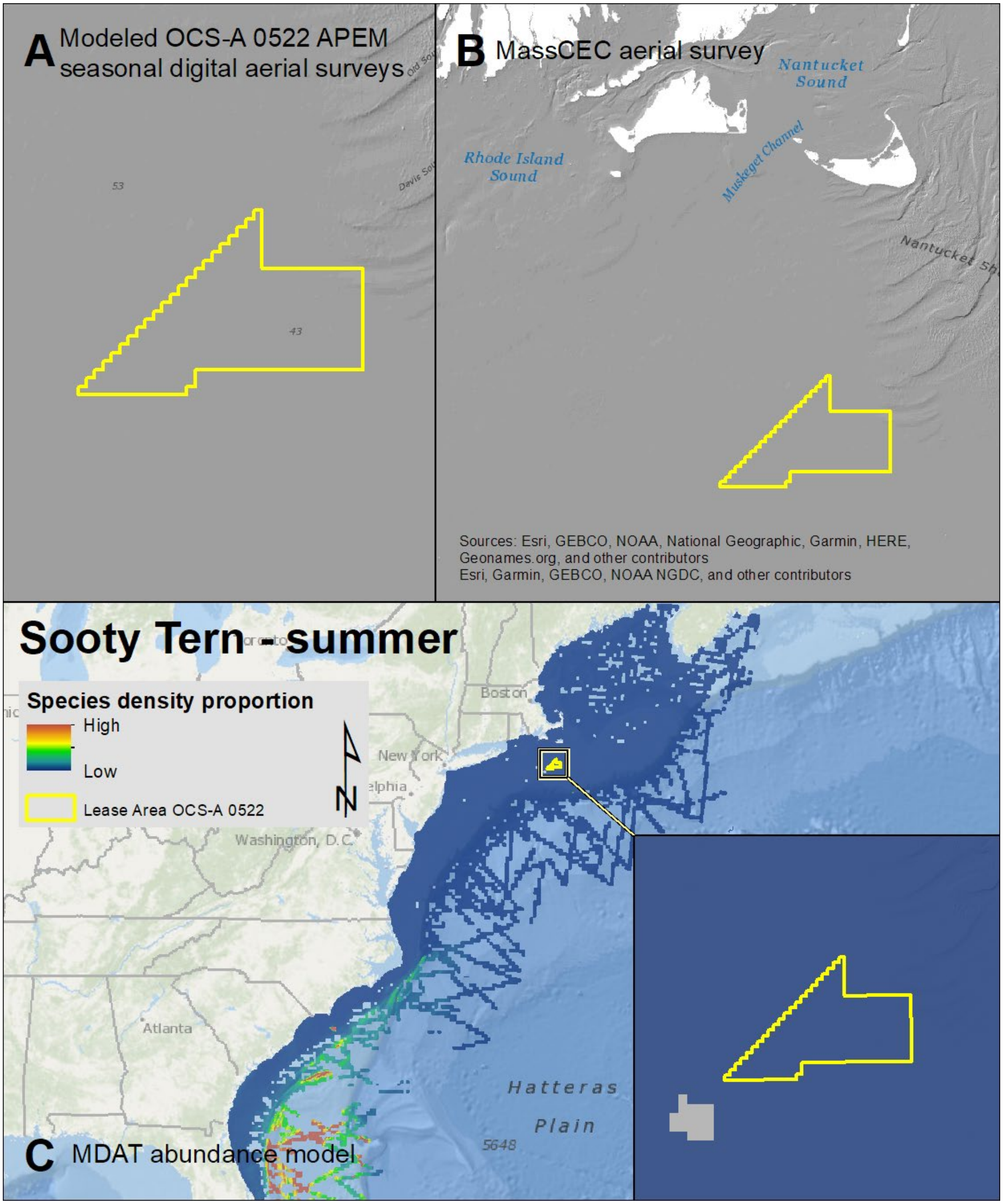
Map 108. Summer Royal Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



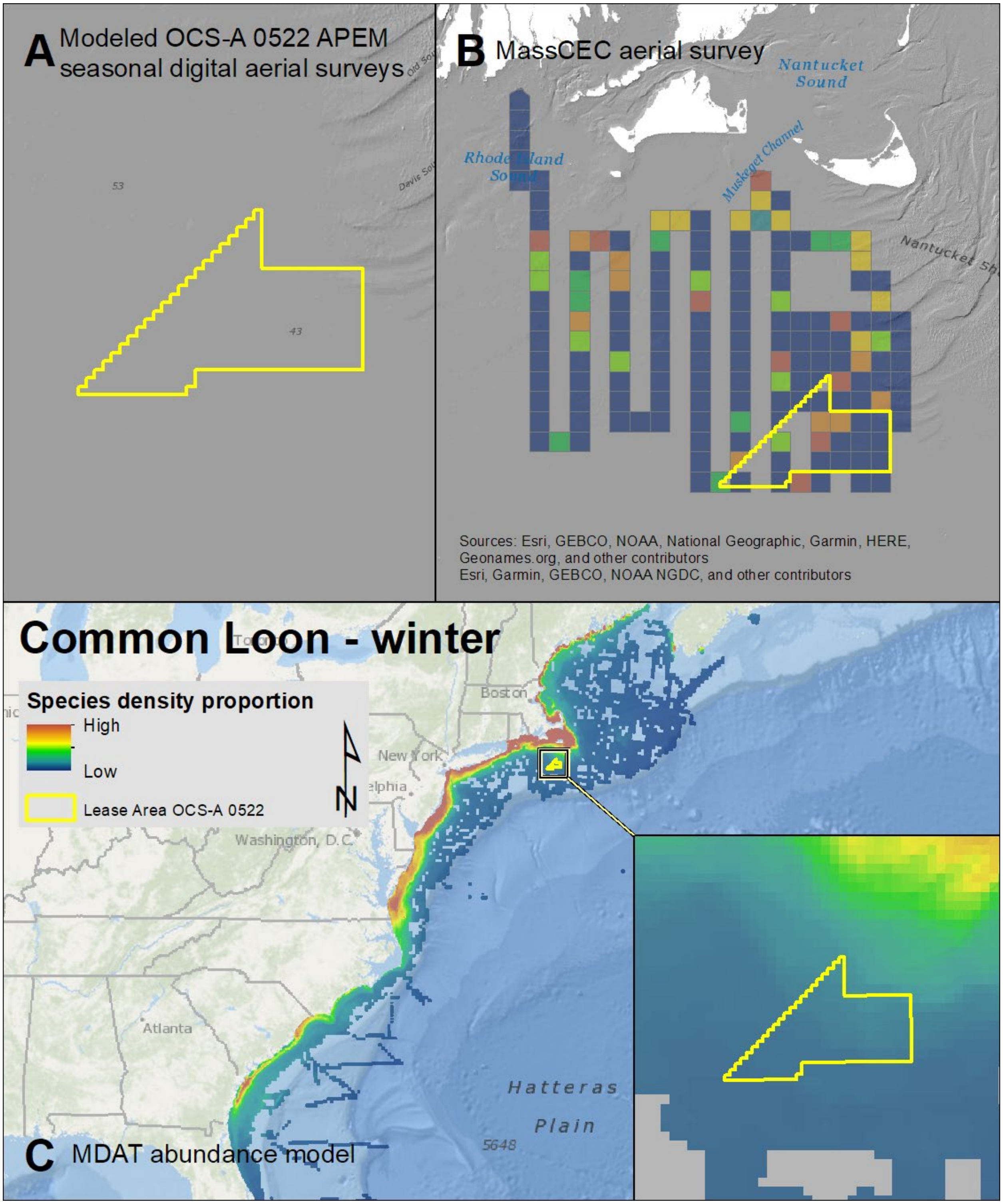
Map 109. Fall Royal Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



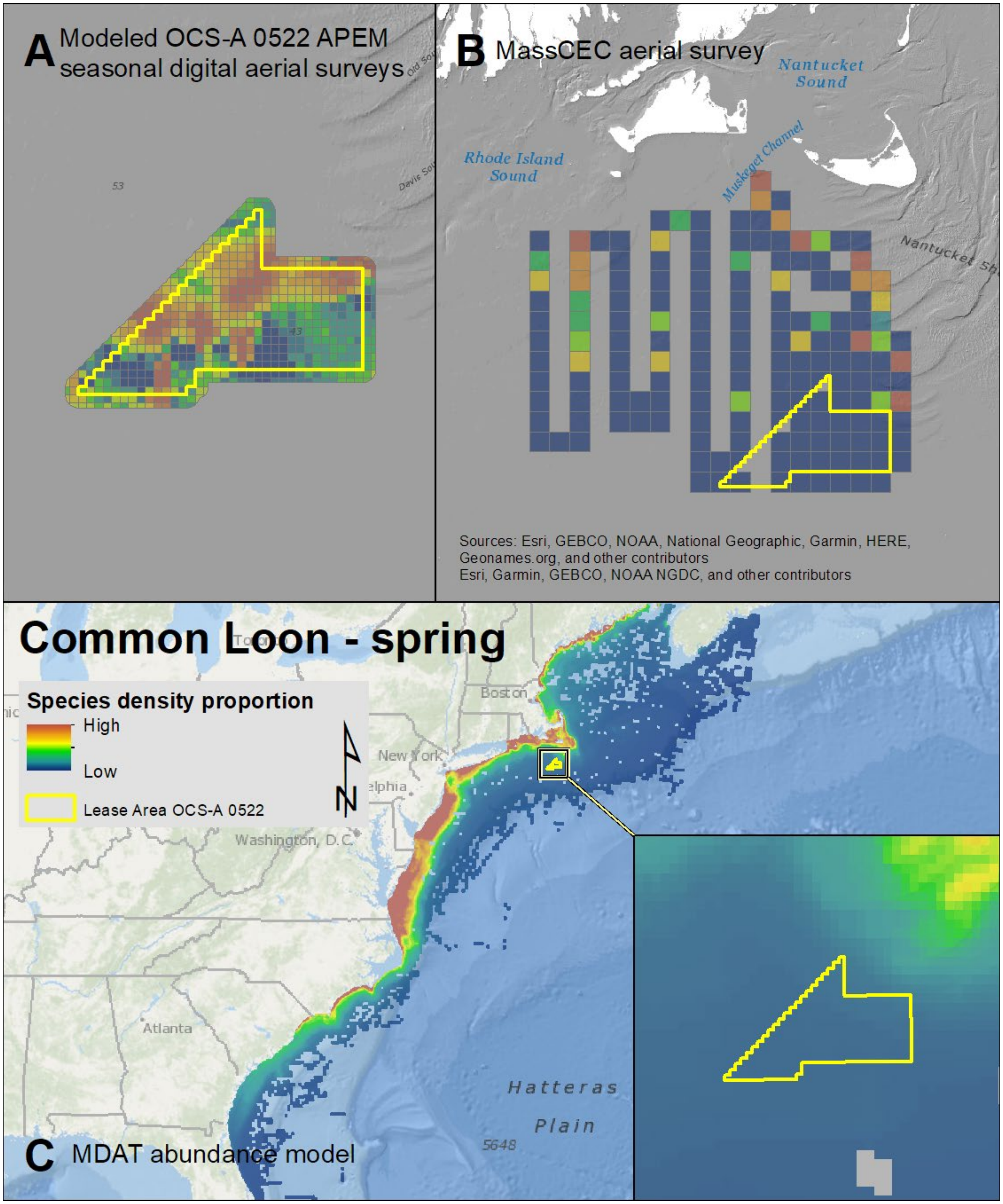
Map 110. Spring Sooty Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



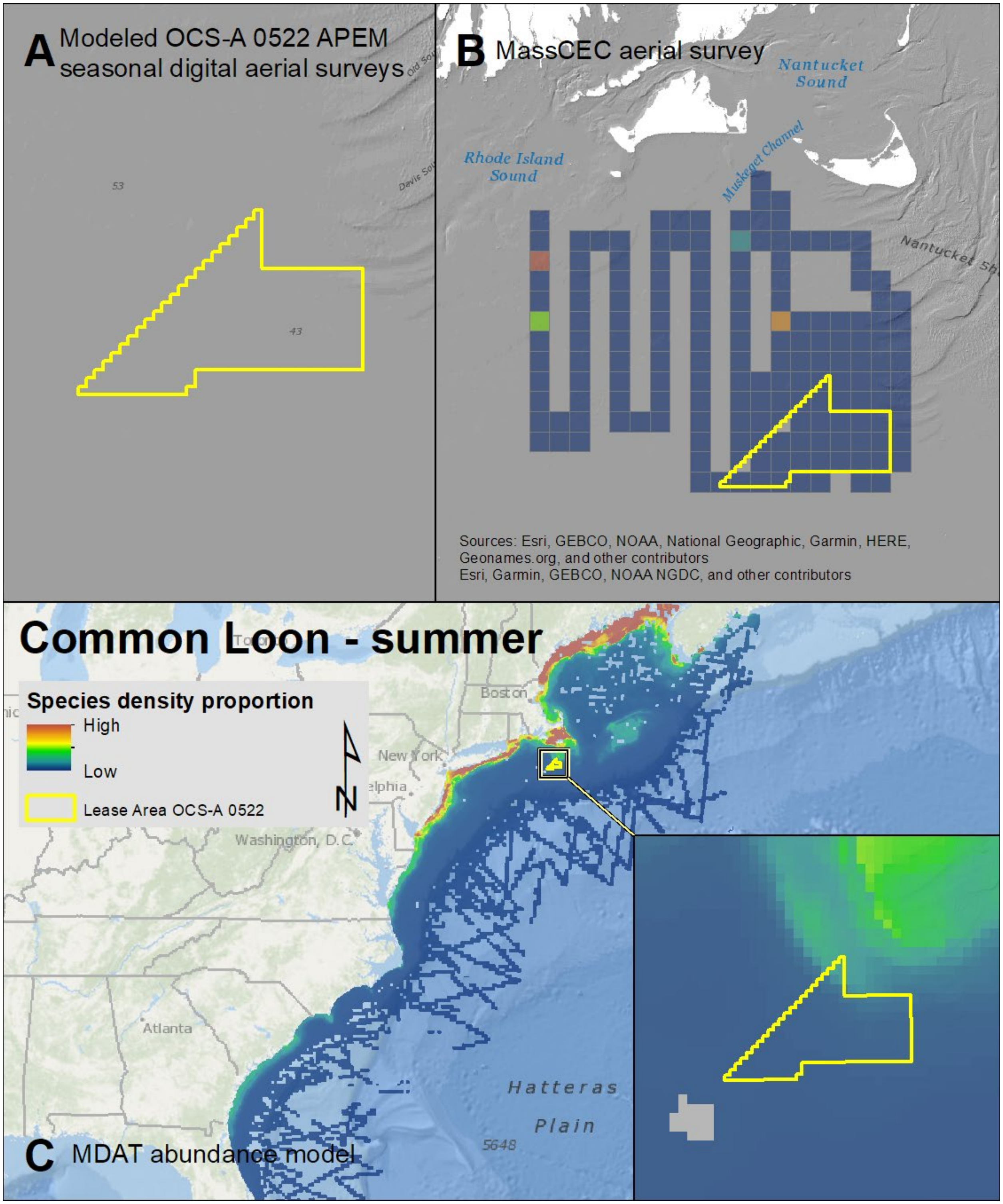
Map 111. Summer Sooty Tern modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



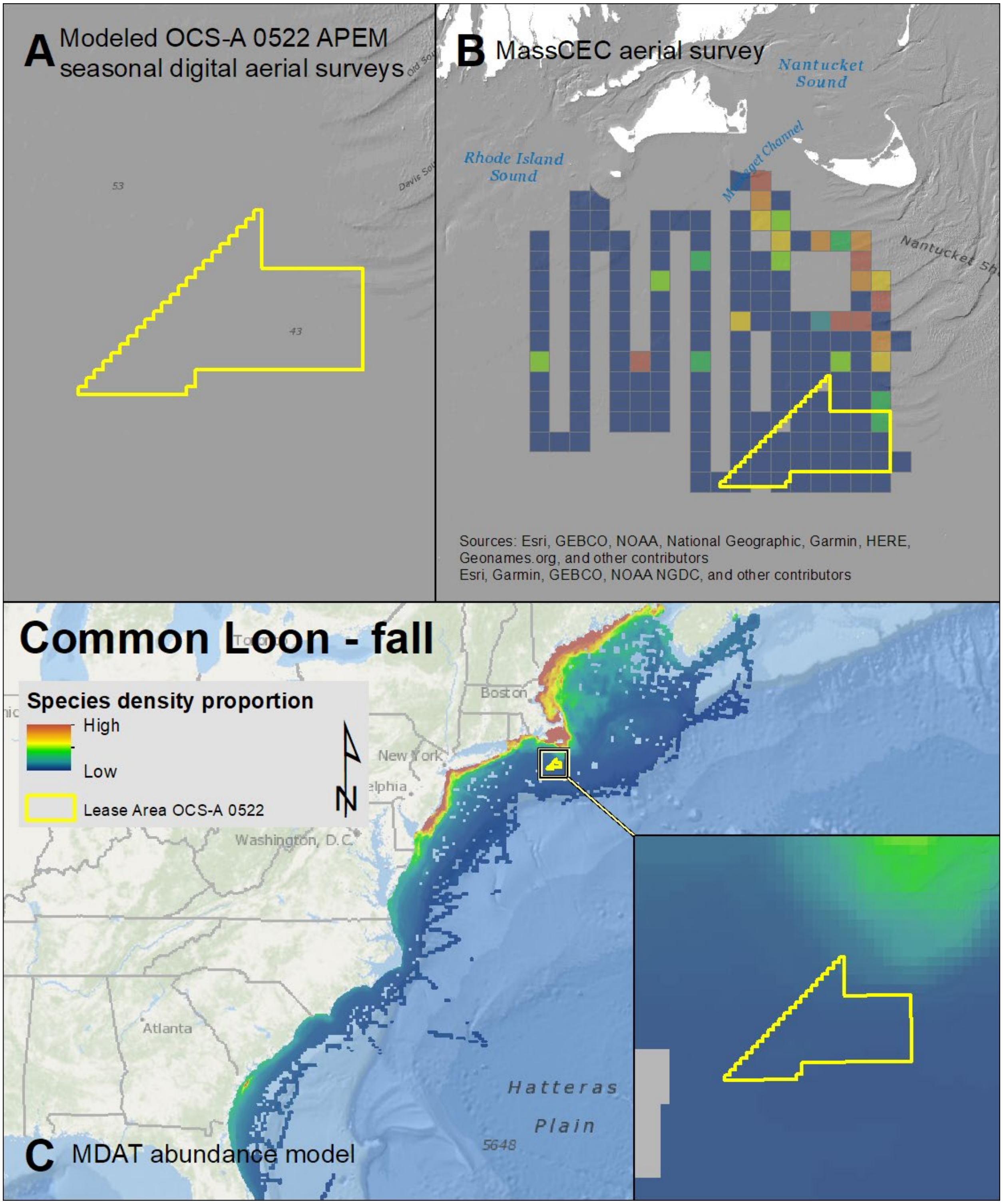
Map 112. Winter Common Loon modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



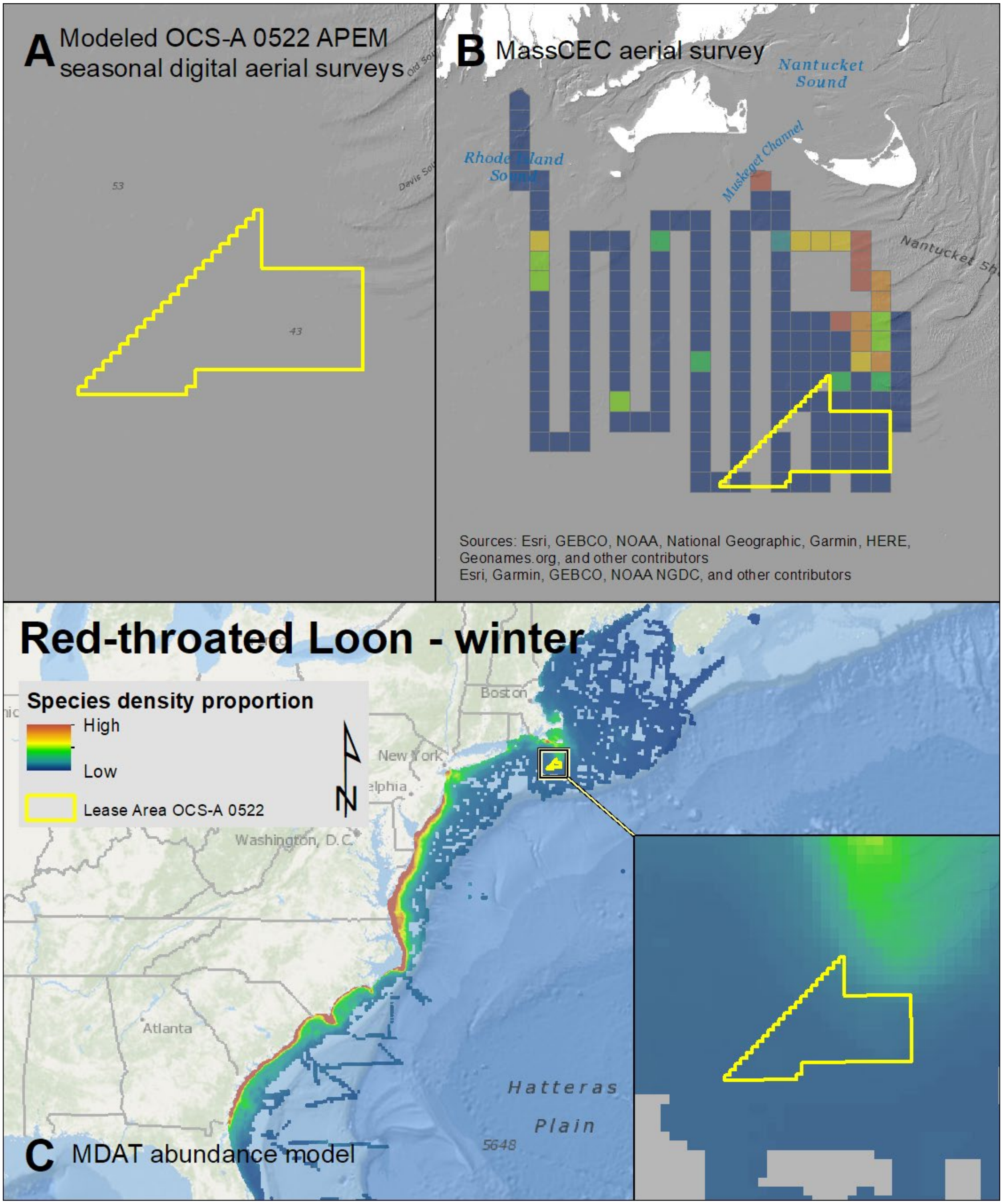
Map 113. Spring Common Loon modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



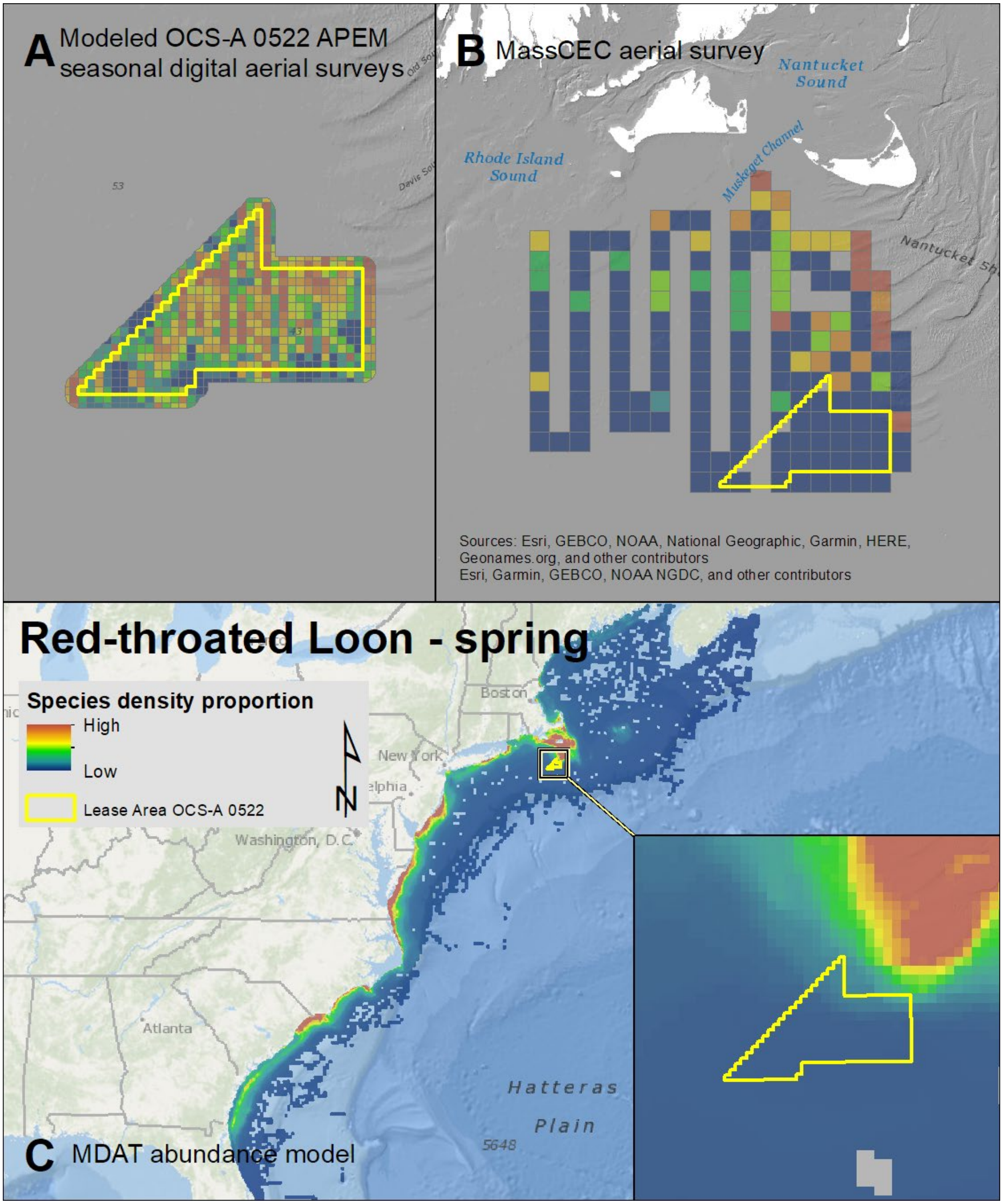
Map 114. Summer Common Loon modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



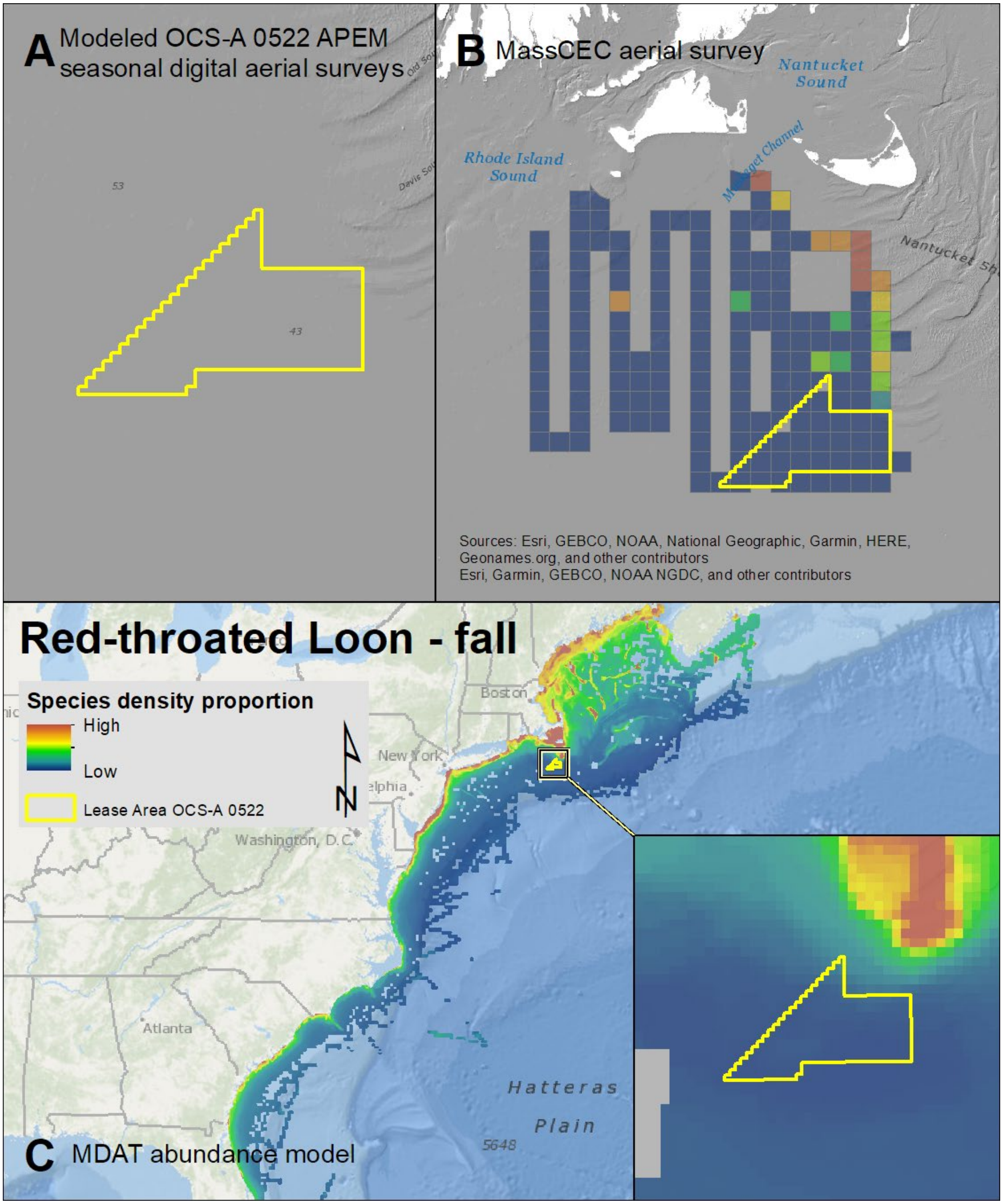
Map 115. Fall Common Loon modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



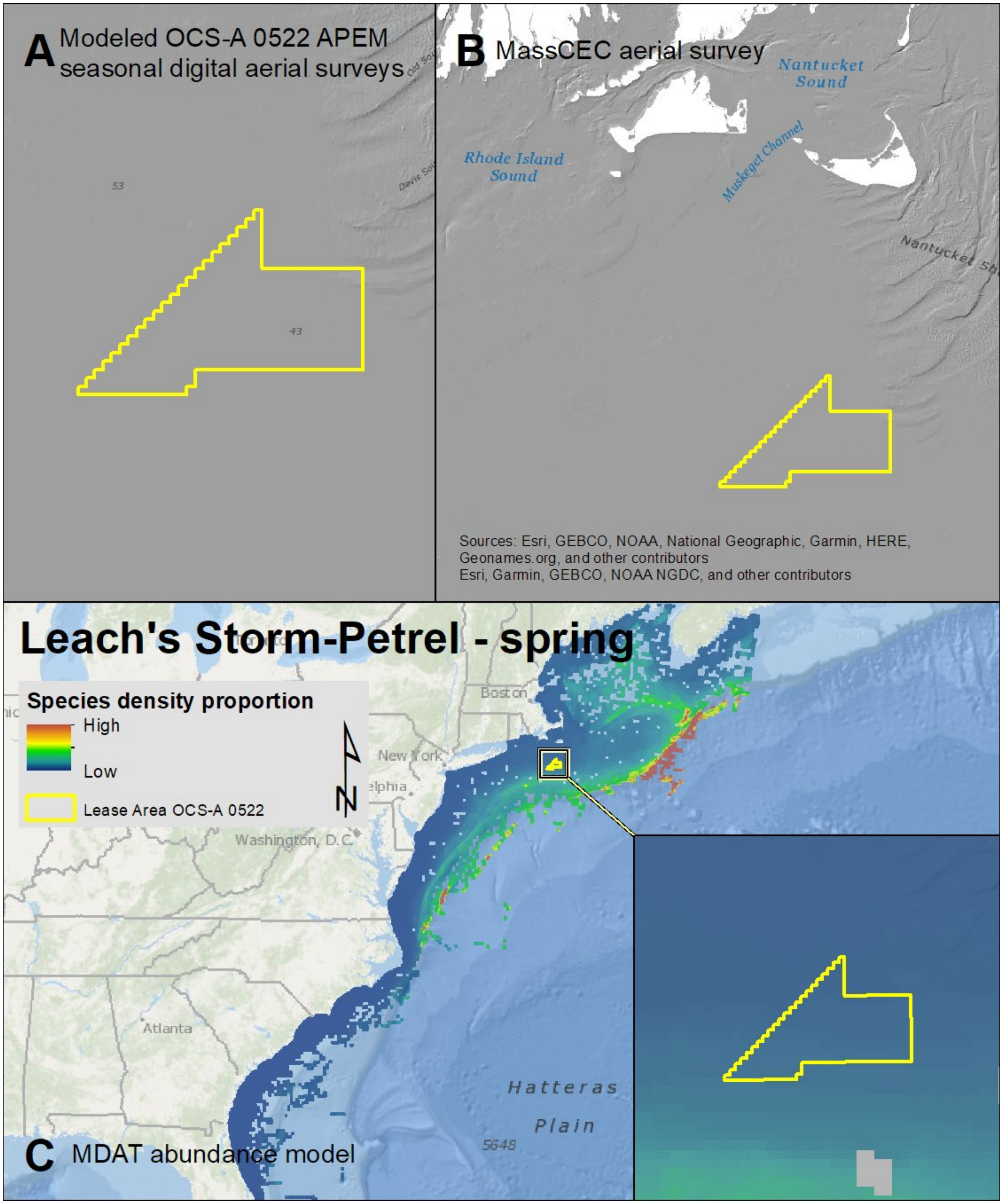
Map 116. Winter Red-throated Loon modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



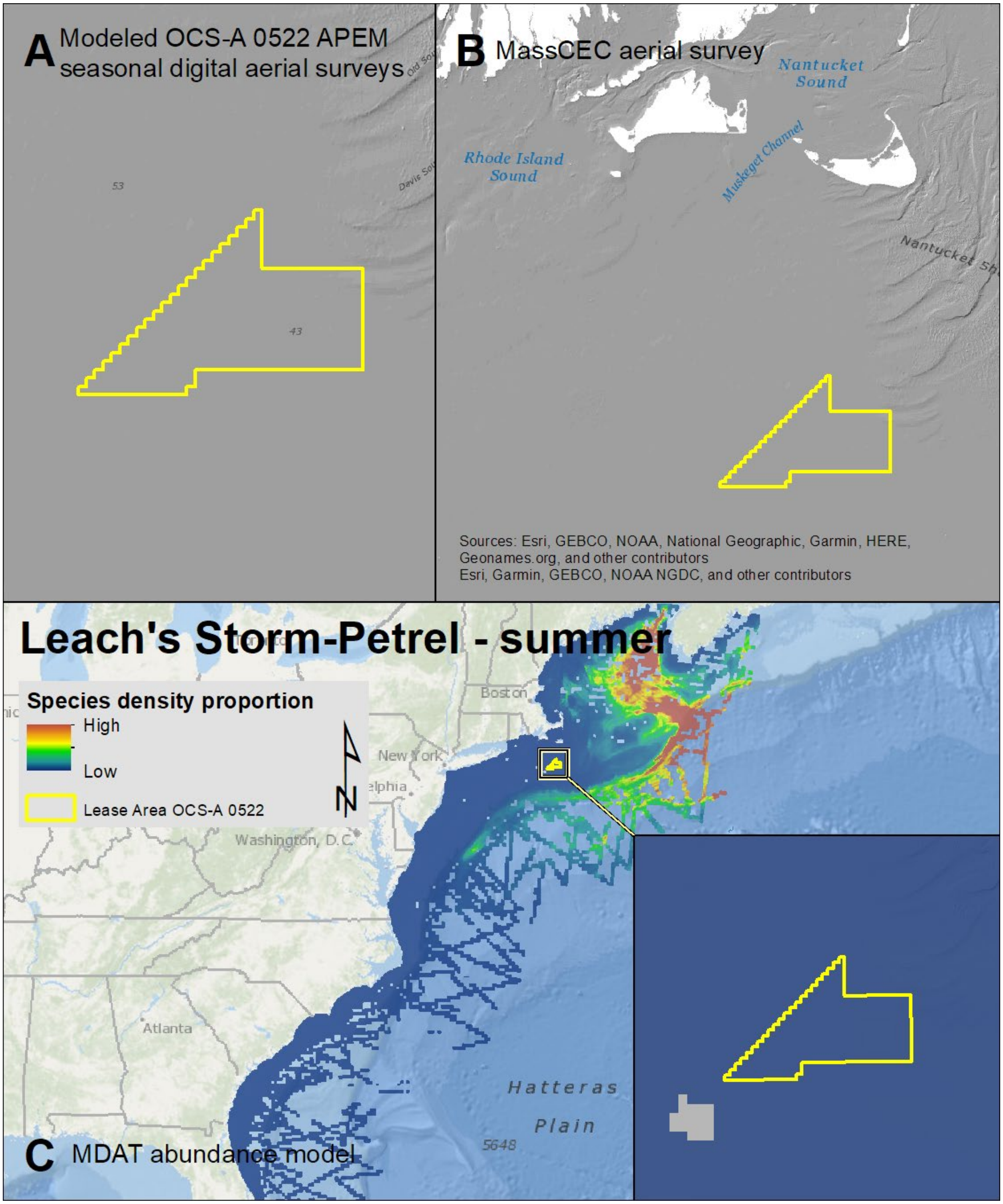
Map 117. Spring Red-throated Loon modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



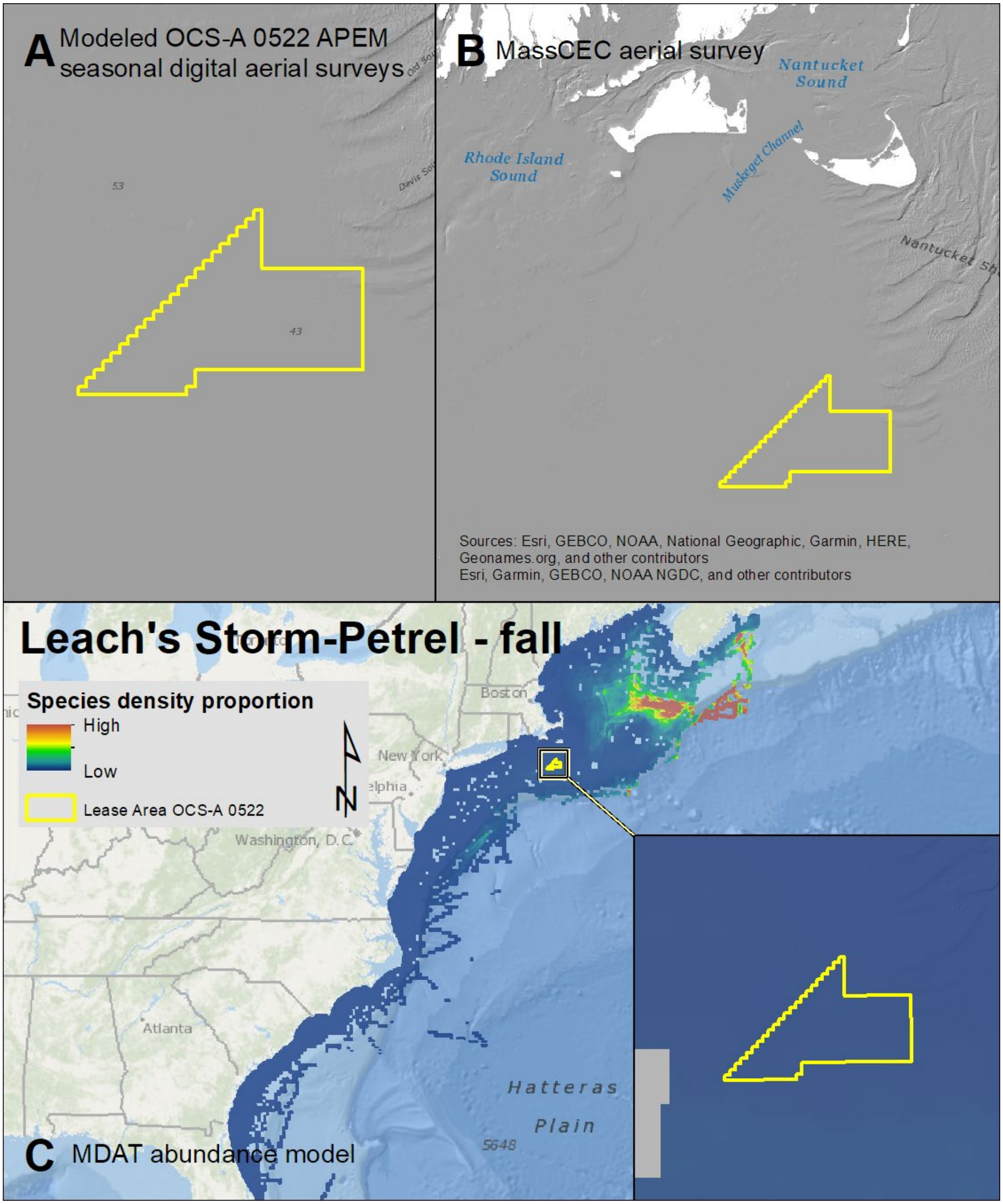
Map 118. Fall Red-throated Loon modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



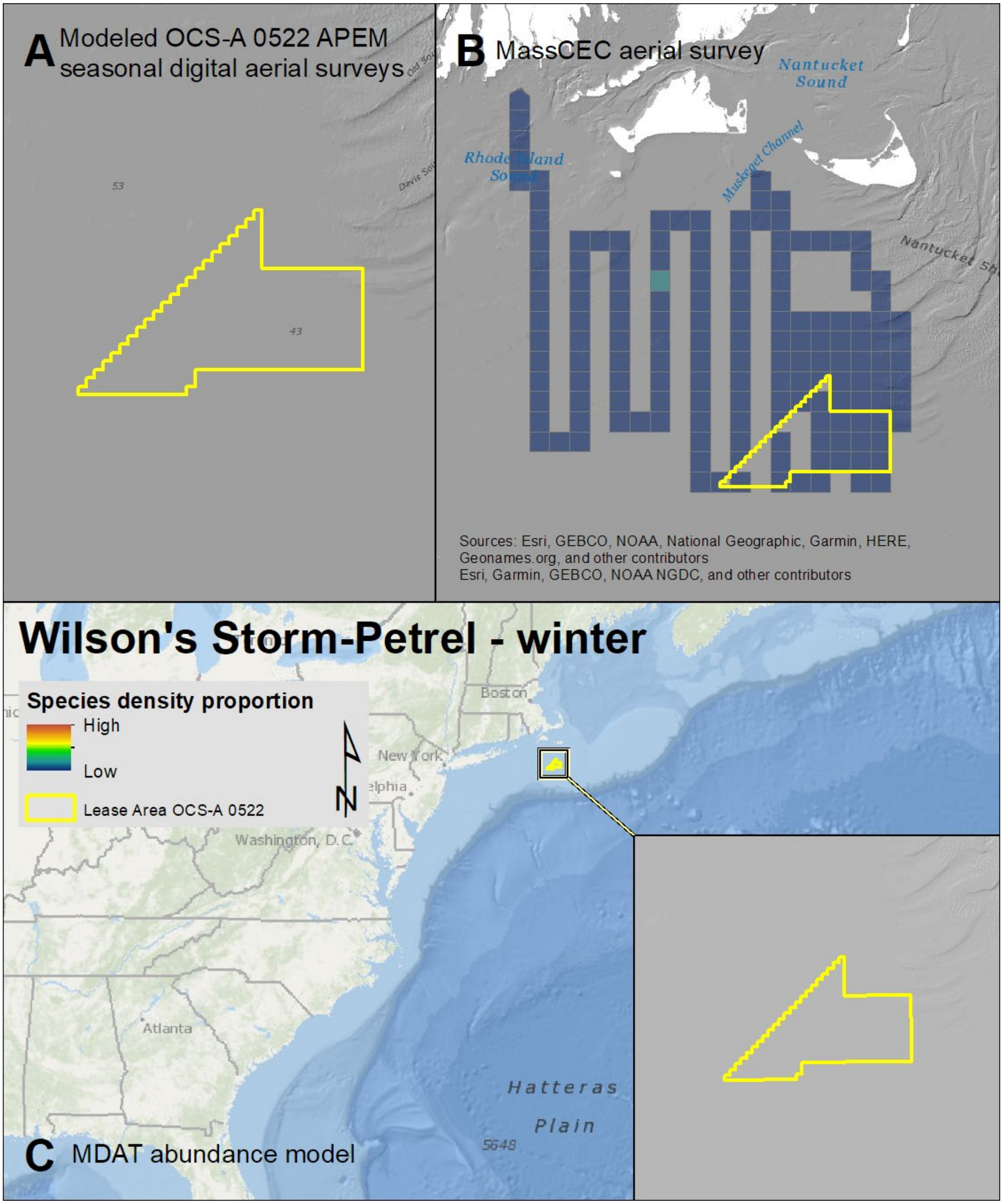
Map 119. Spring Leach's Storm-Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



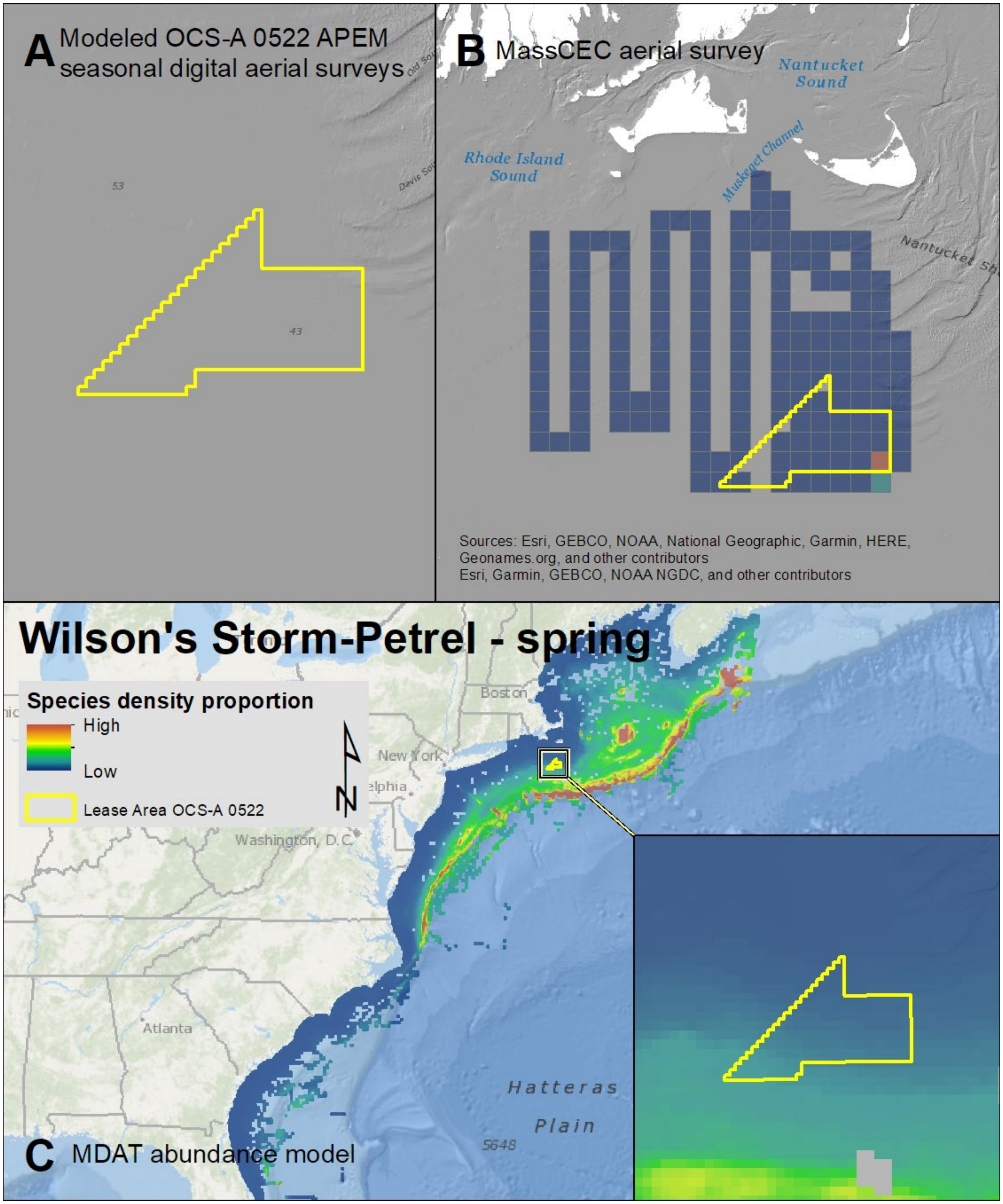
Map 120. Summer Leach's Storm-Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



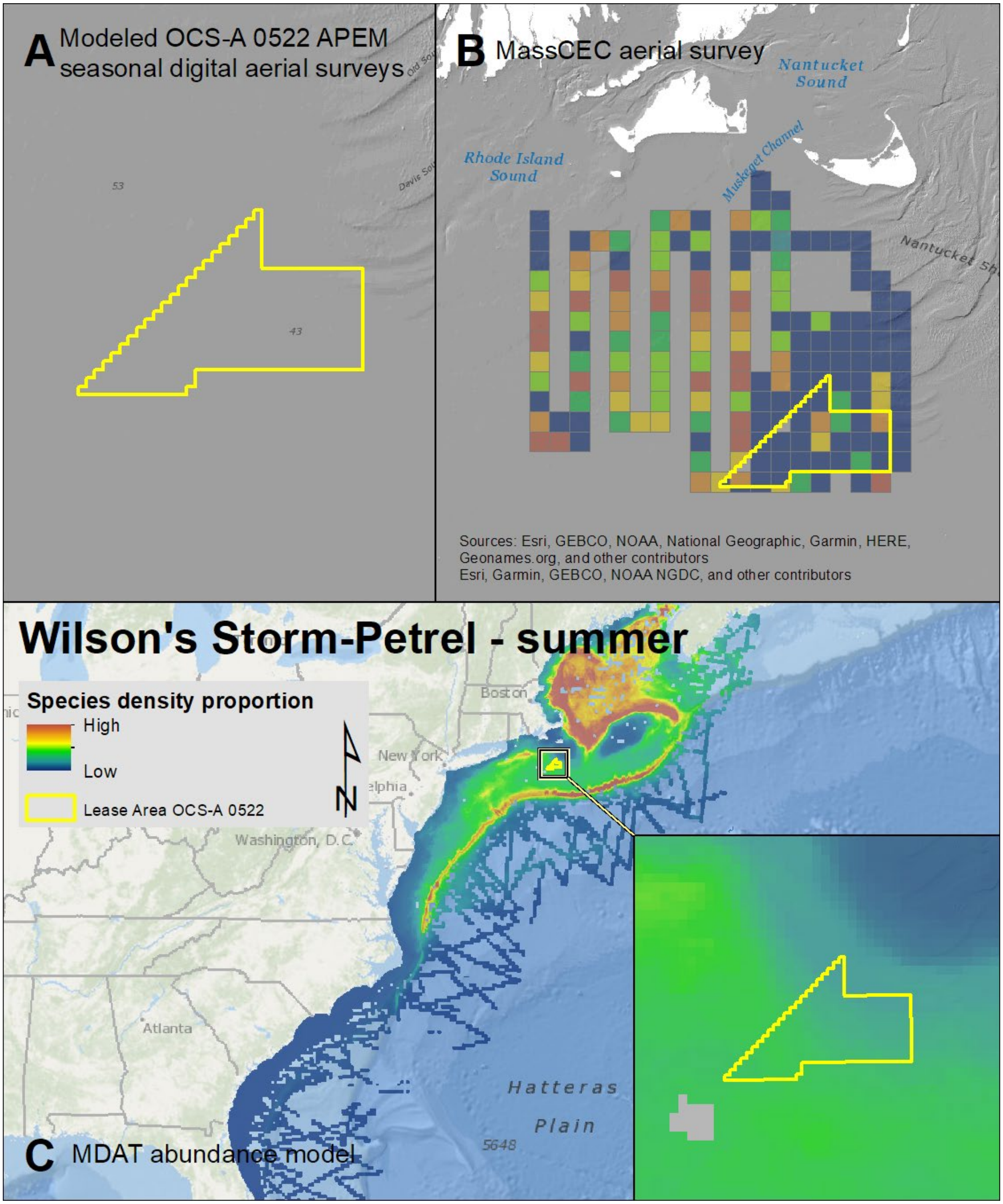
Map 121. Fall Leach's Storm-Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



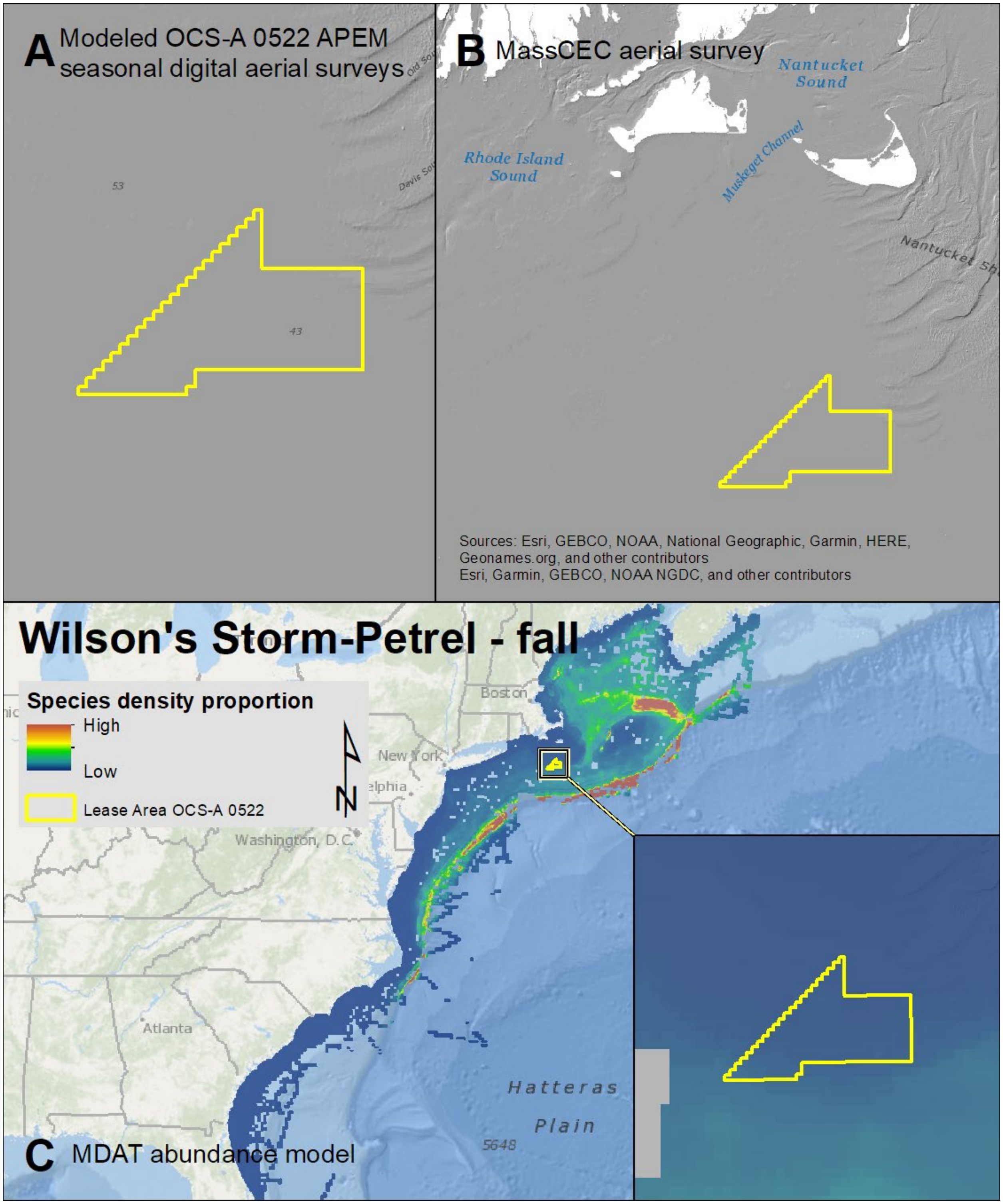
Map 122. Winter Wilson's Storm-Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



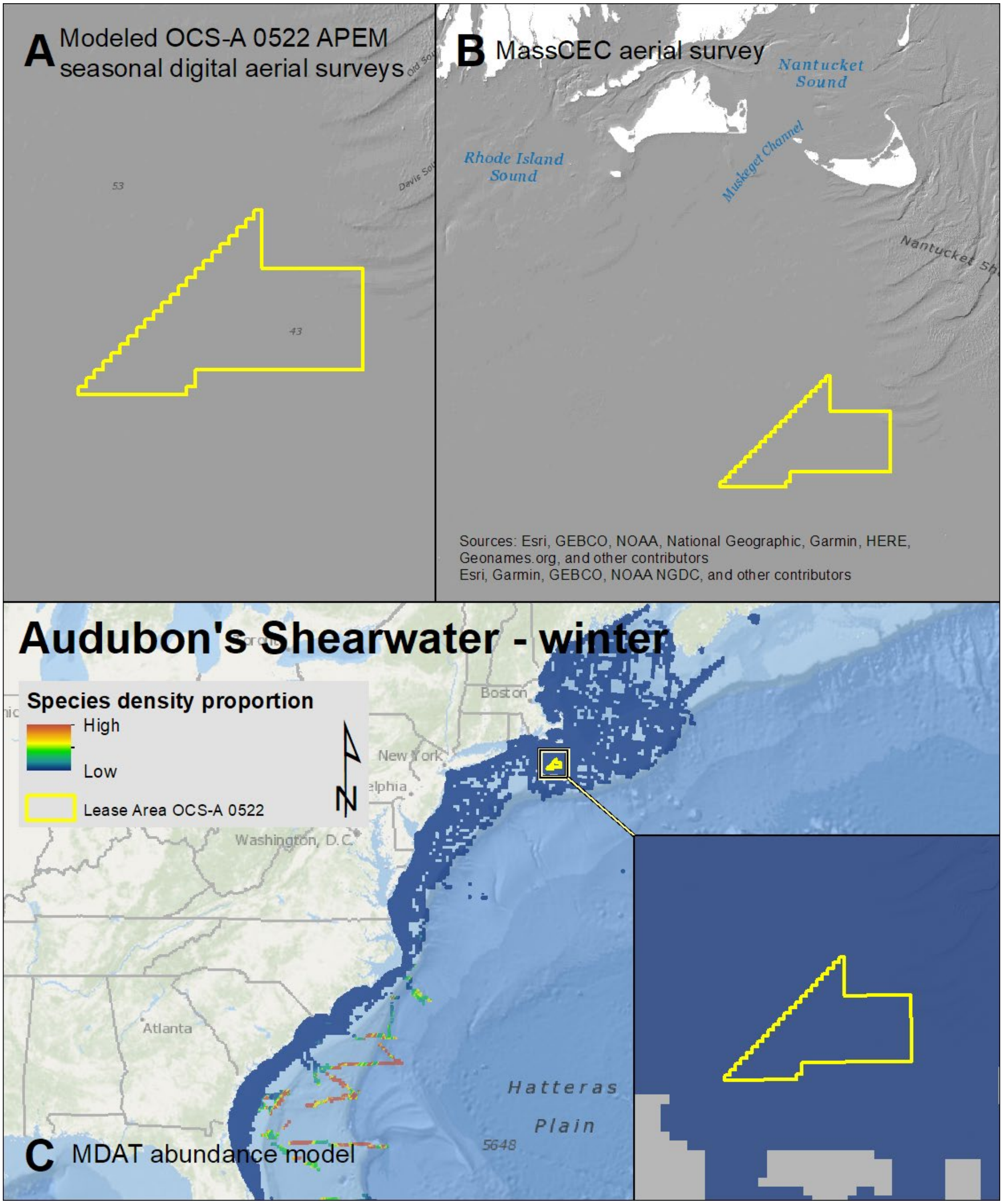
Map 123. Spring Wilson's Storm-Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



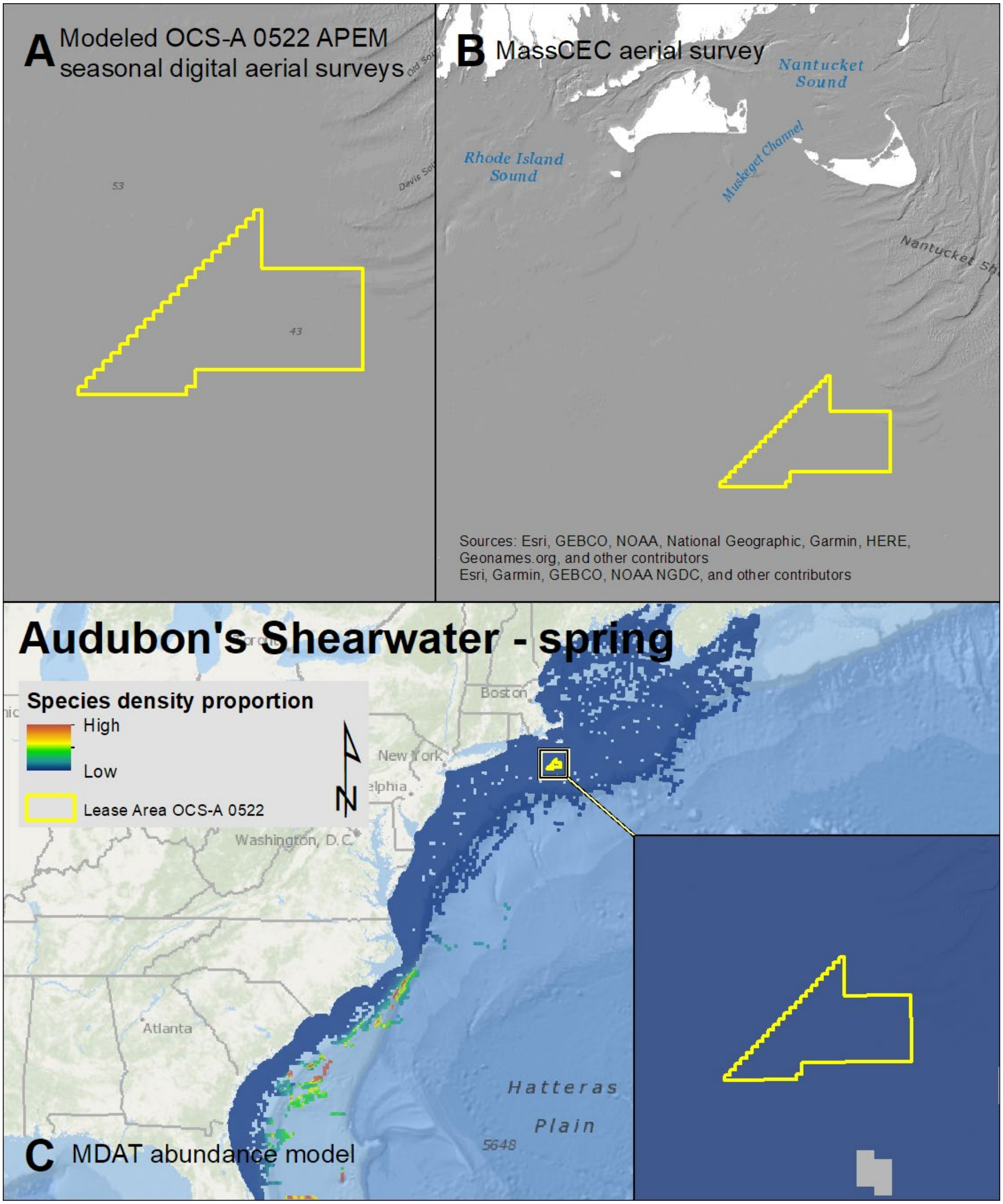
Map 124. Summer Wilson's Storm-Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



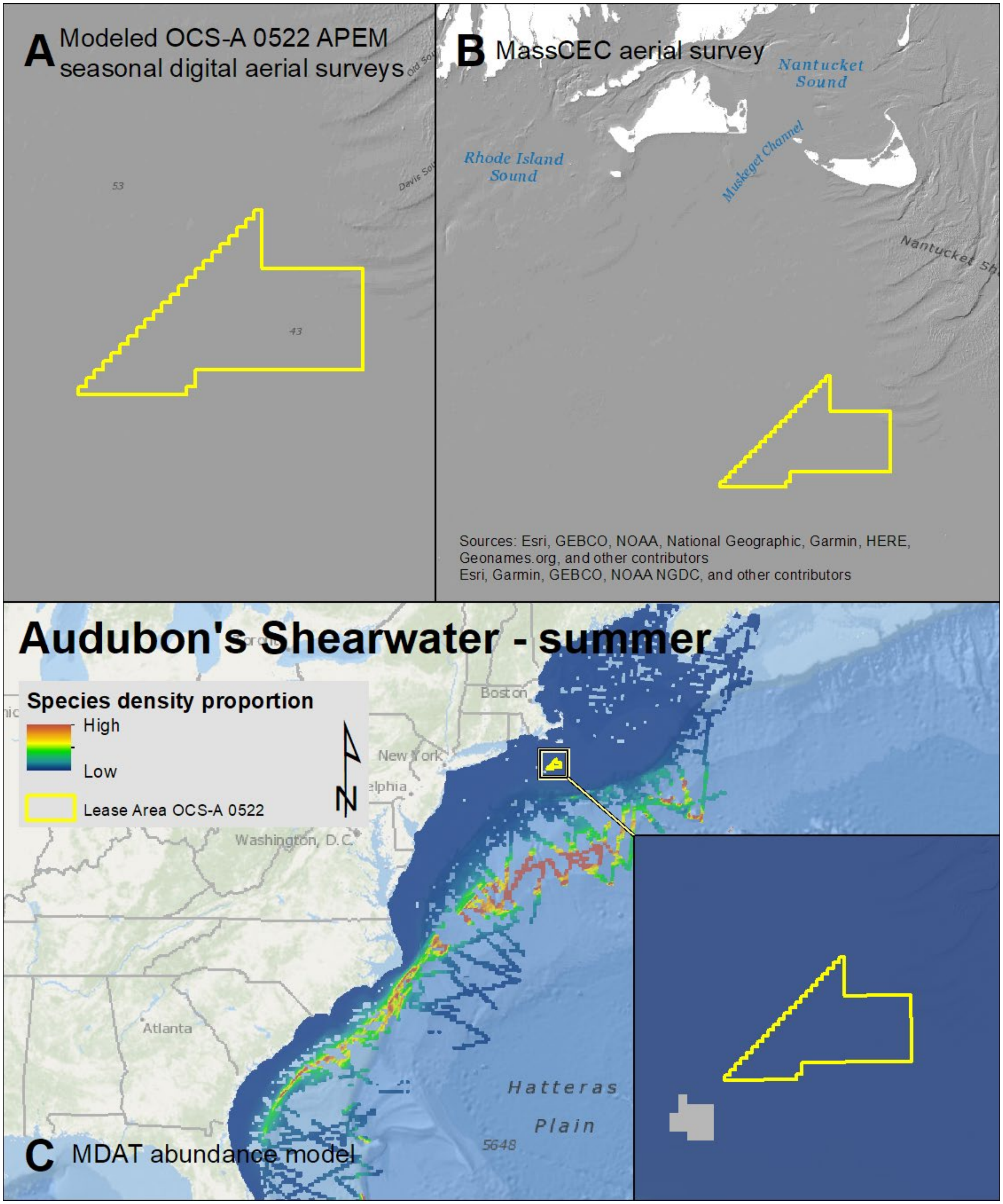
Map 125. Fall Wilson's Storm-Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



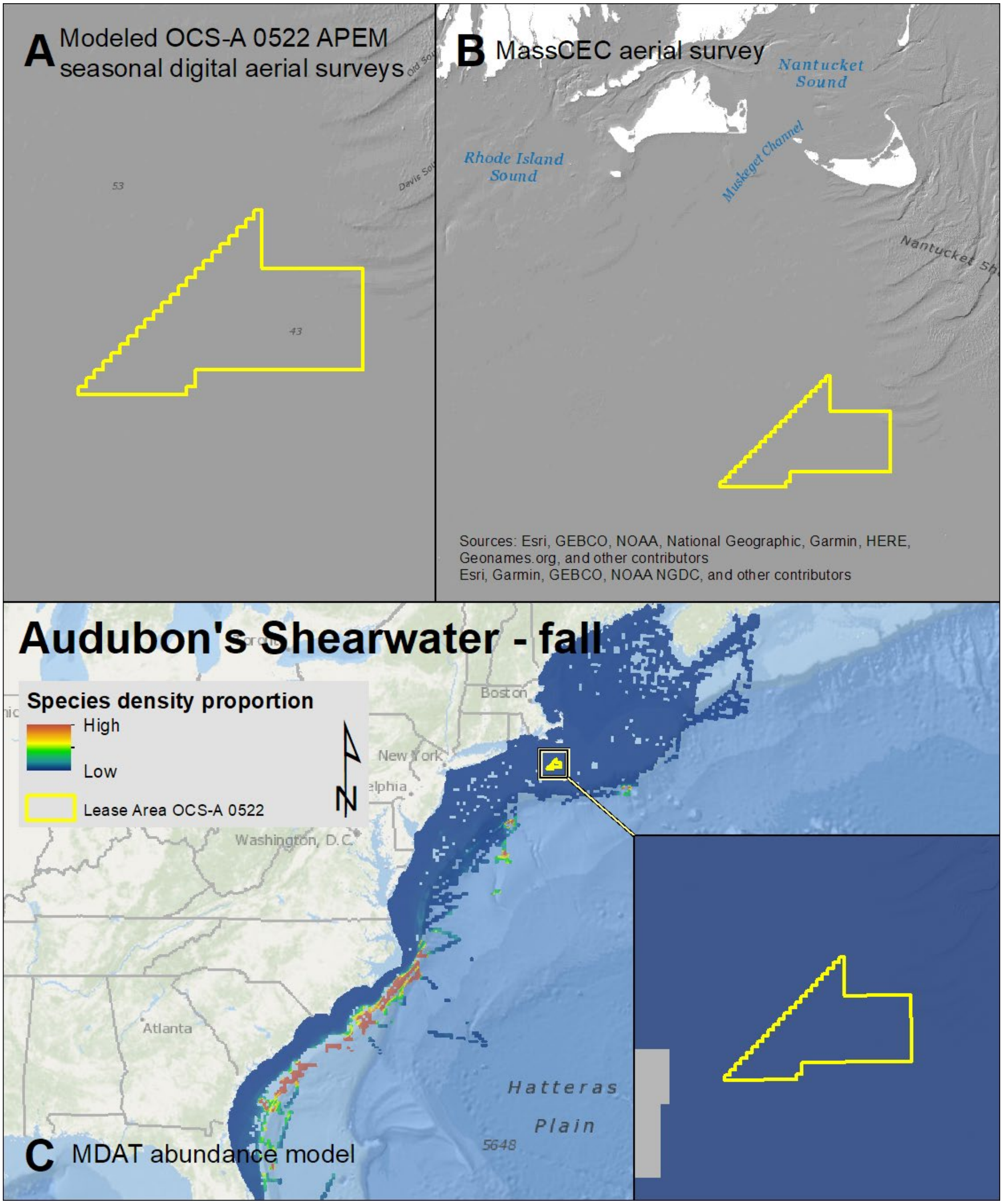
Map 126. Winter Audubon's Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



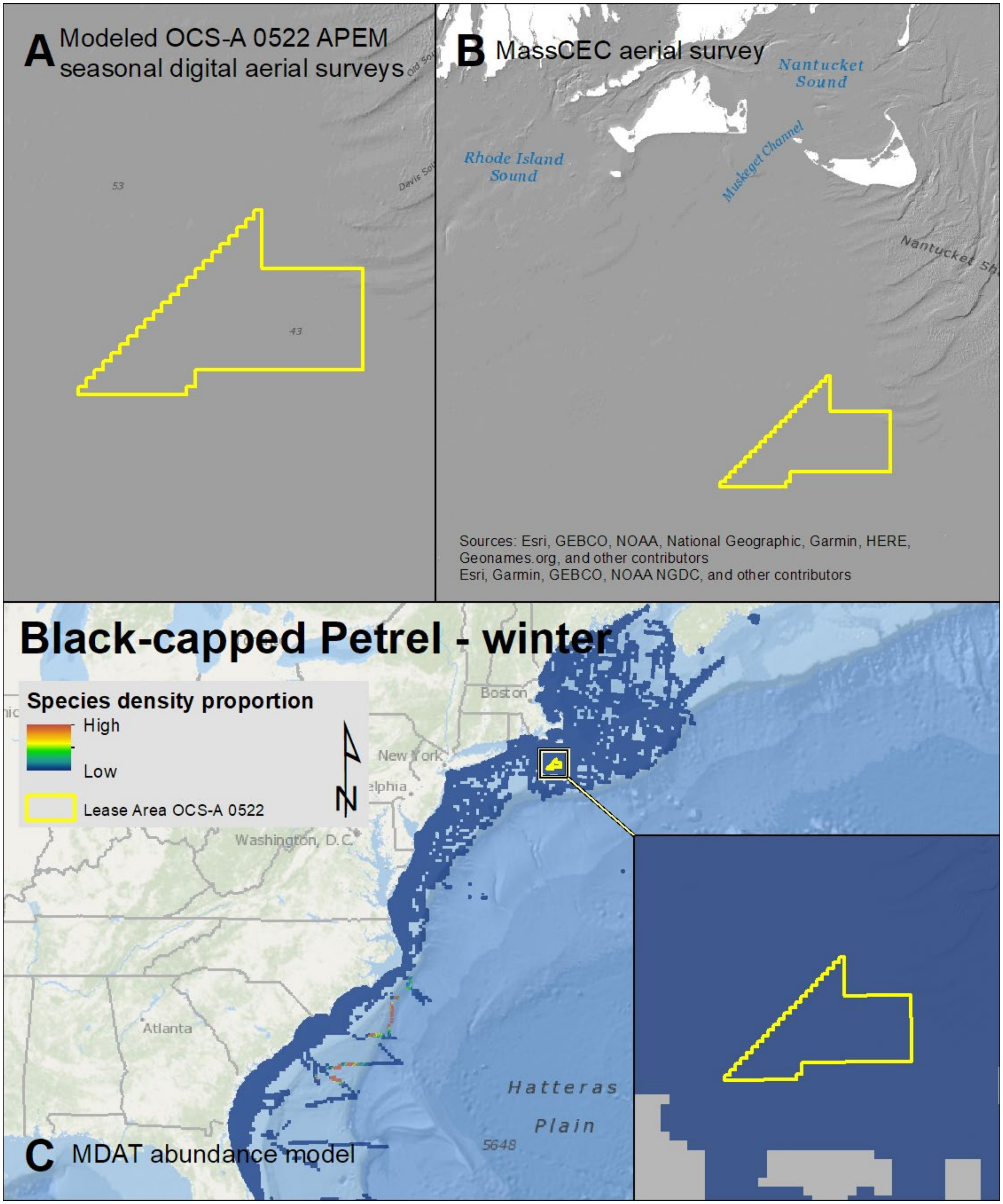
Map 127. Spring Audubon's Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



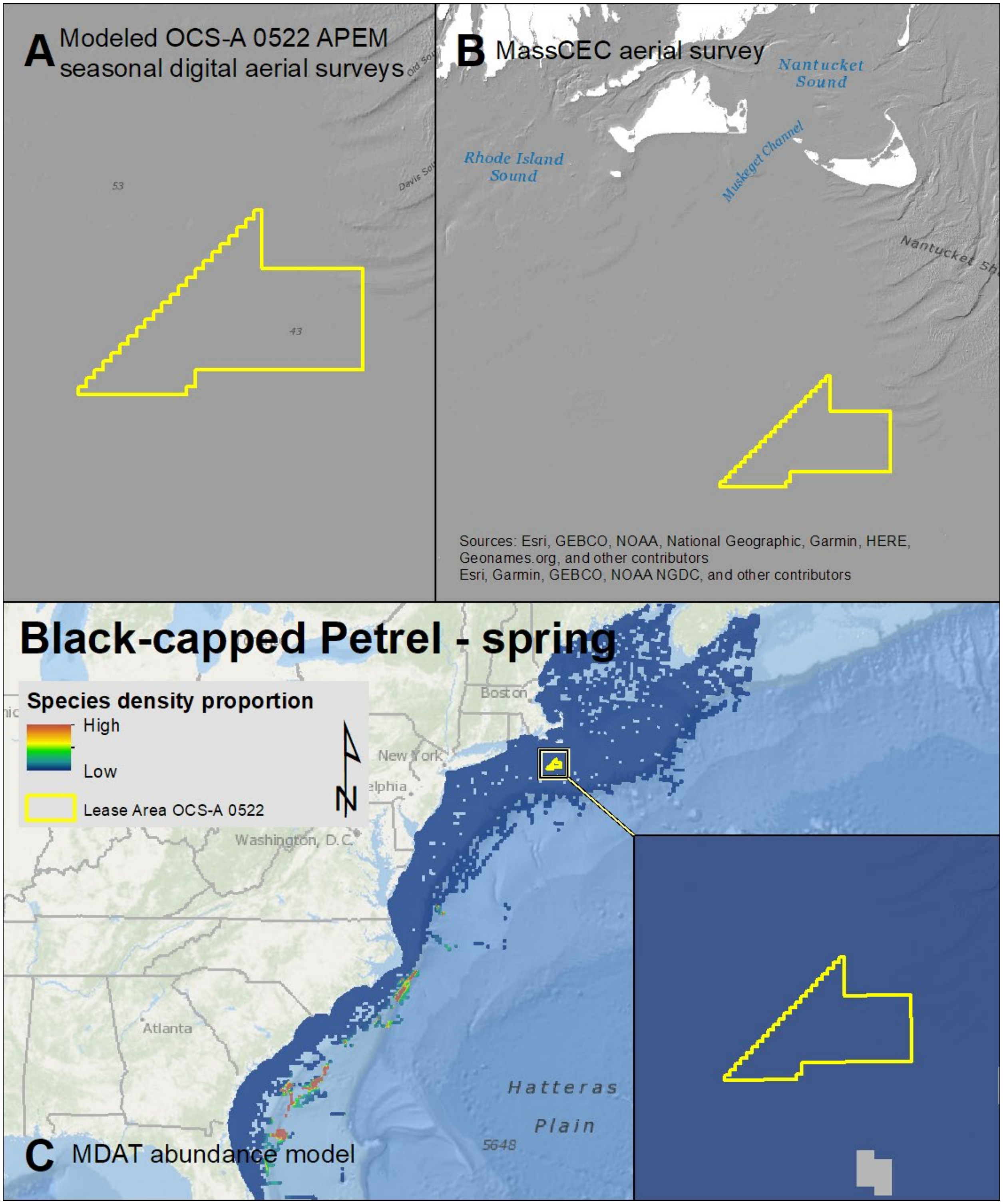
Map 128. Summer Audubon's Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



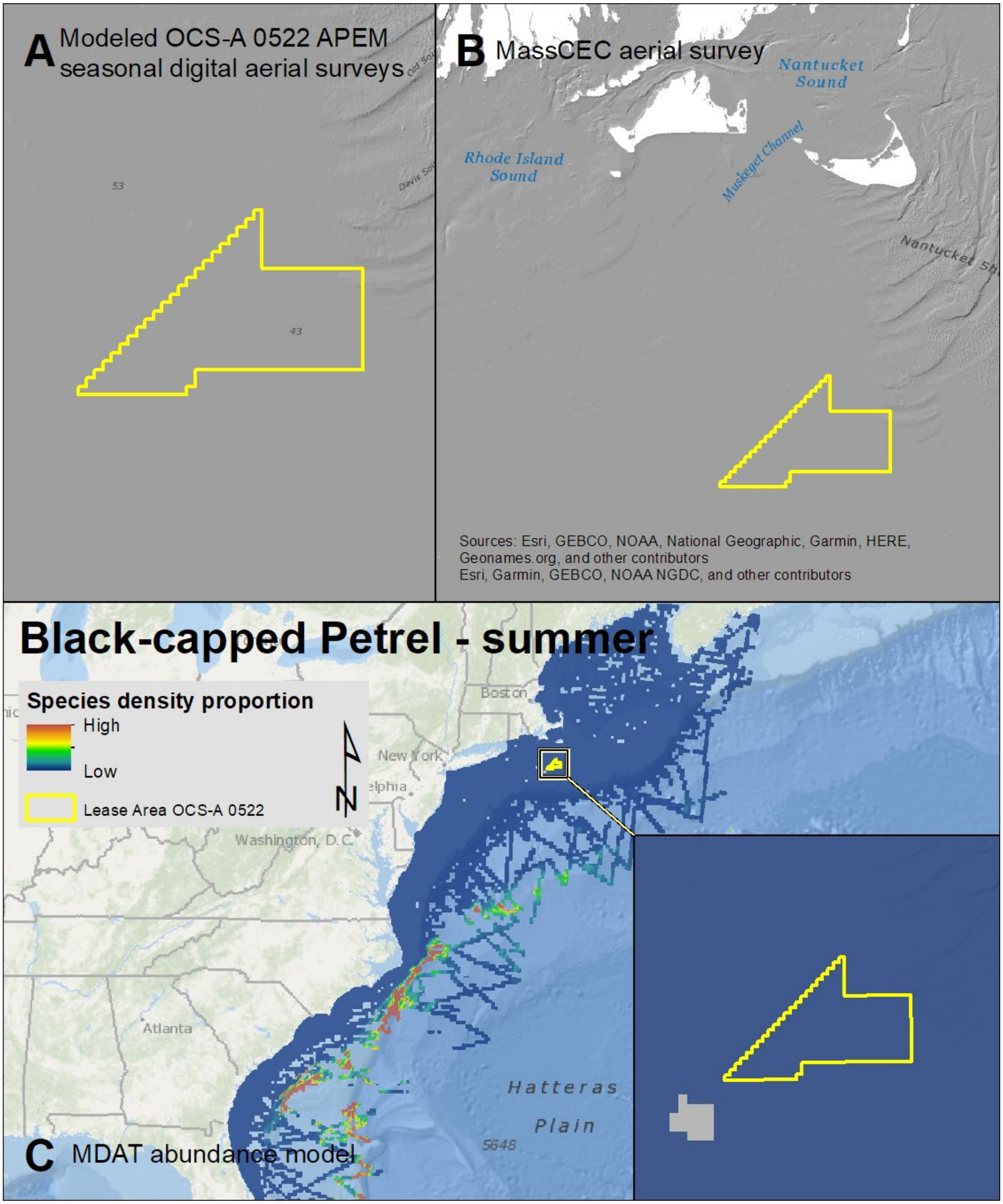
Map 129. Fall Audubon's Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



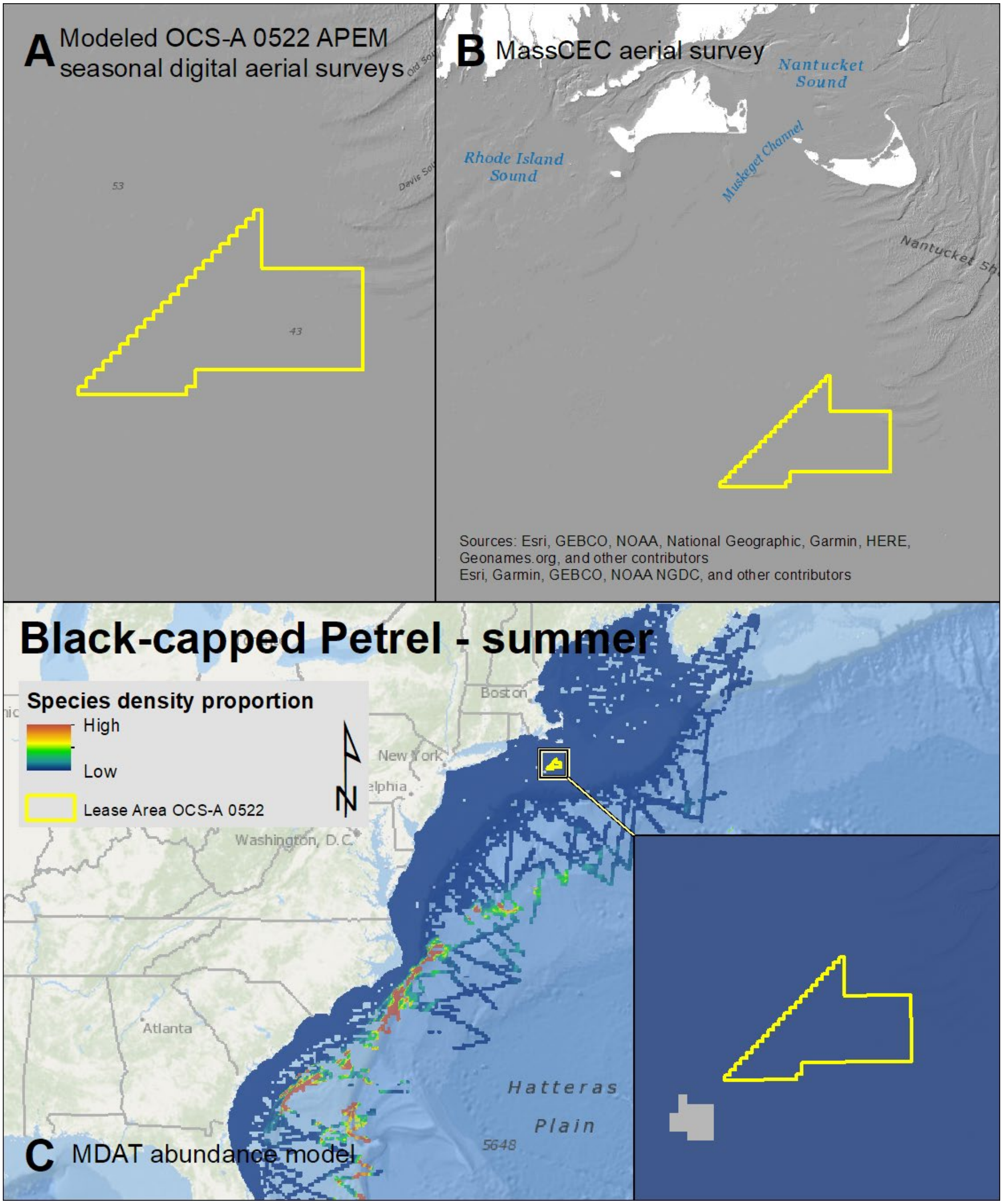
Map 130. Winter Black-capped Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



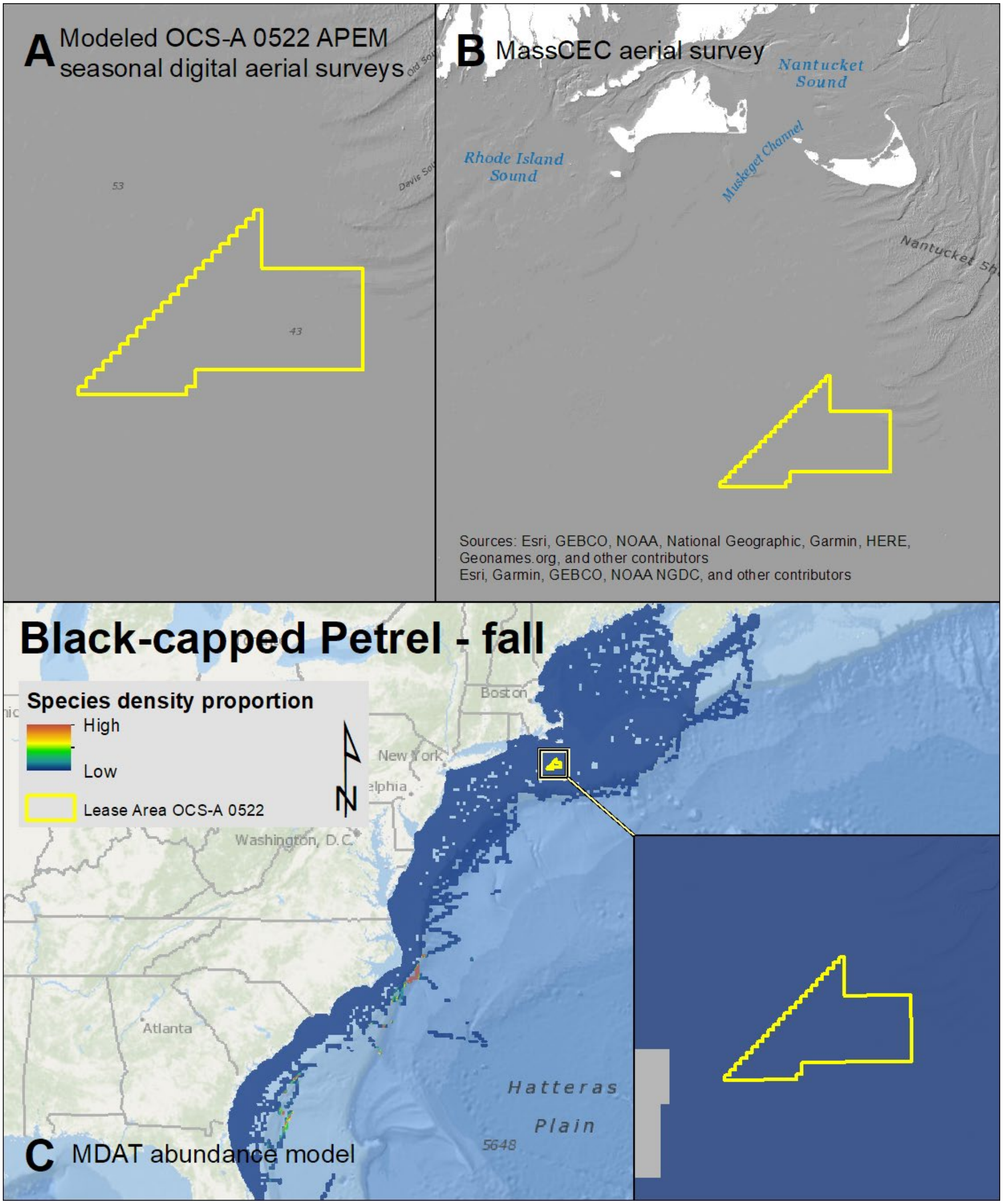
Map 131. Spring Black-capped Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



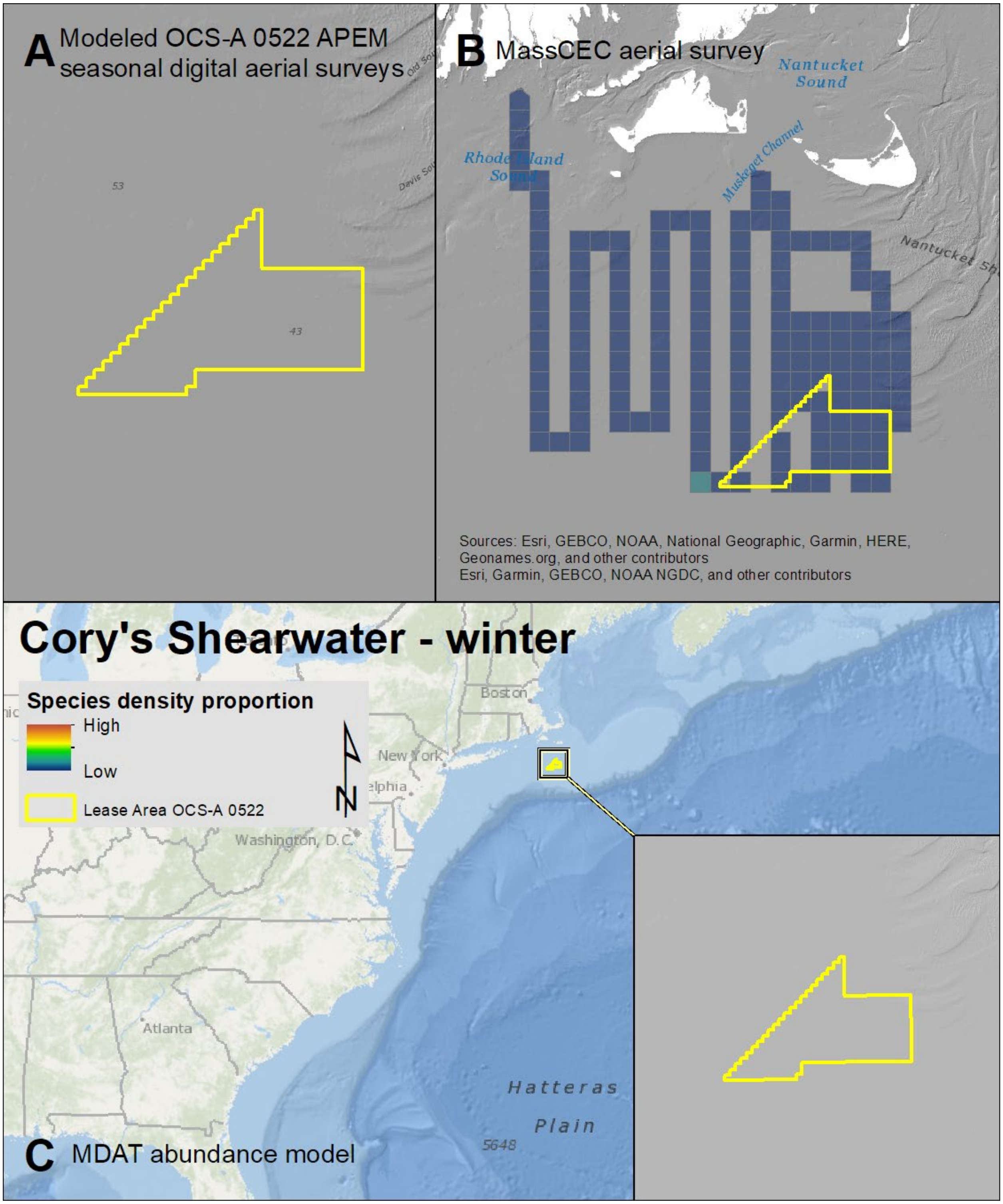
Map 132. Summer Black-capped Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



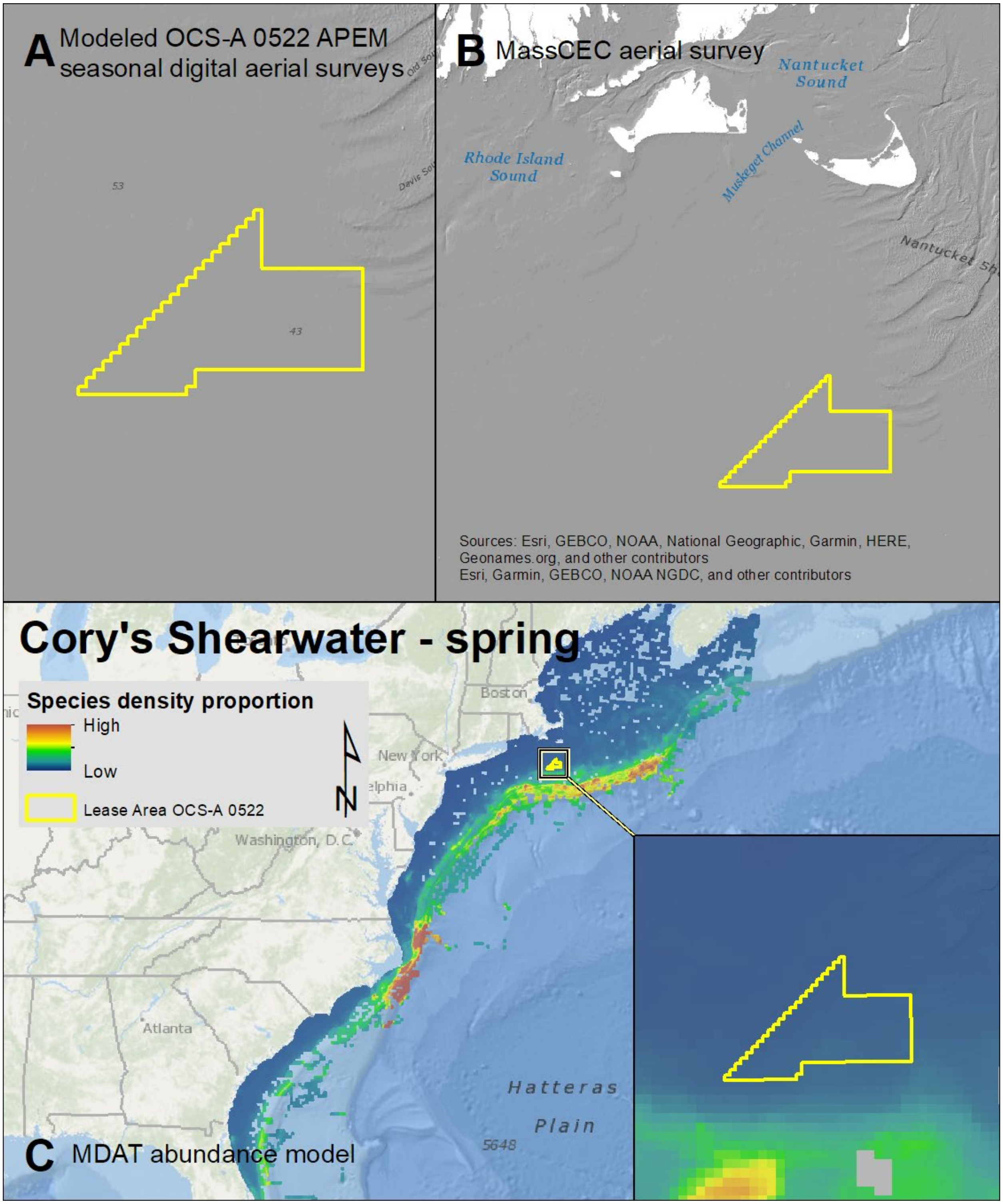
Map 133. Summer Black-capped Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



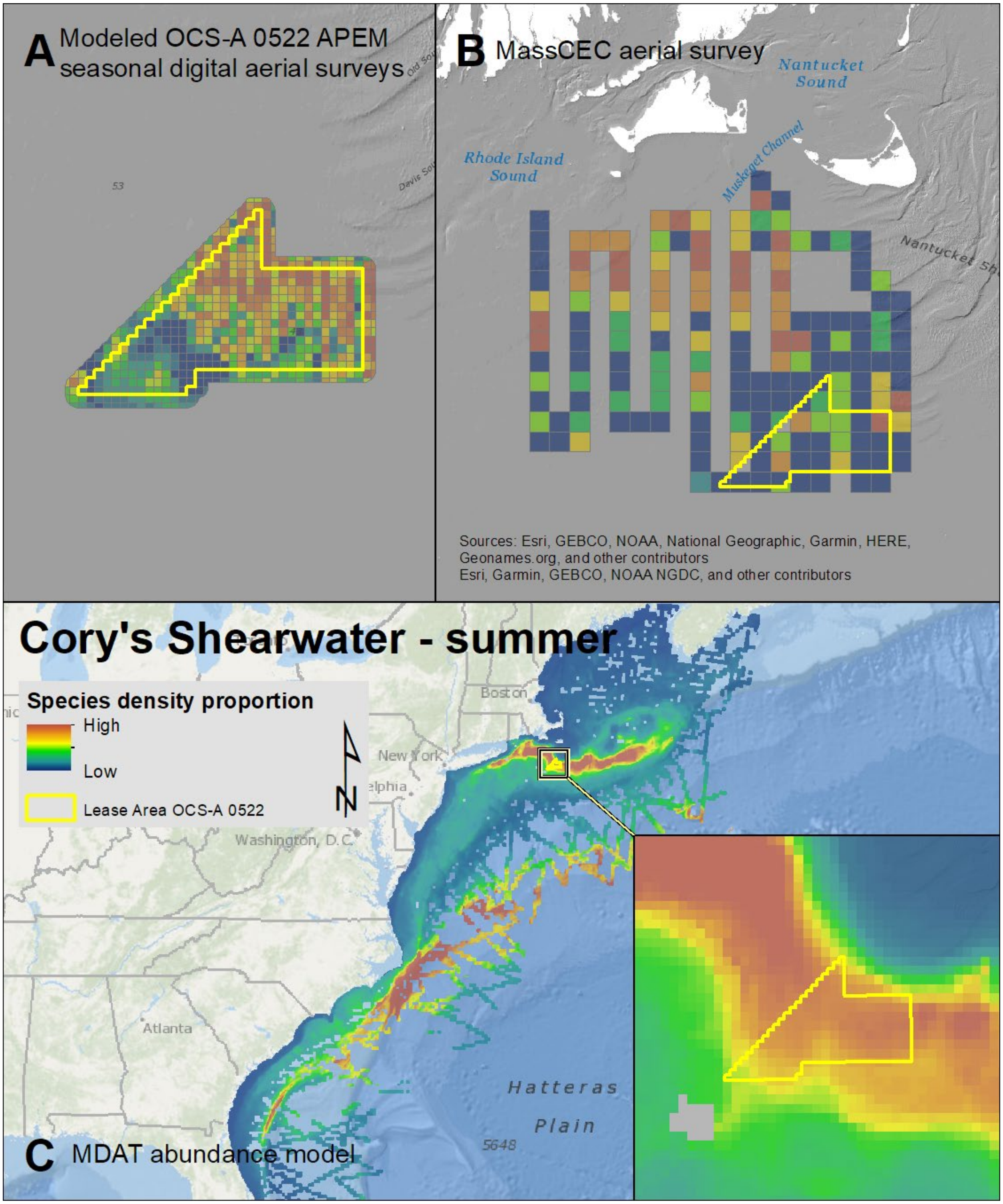
Map 134. Fall Black-capped Petrel modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



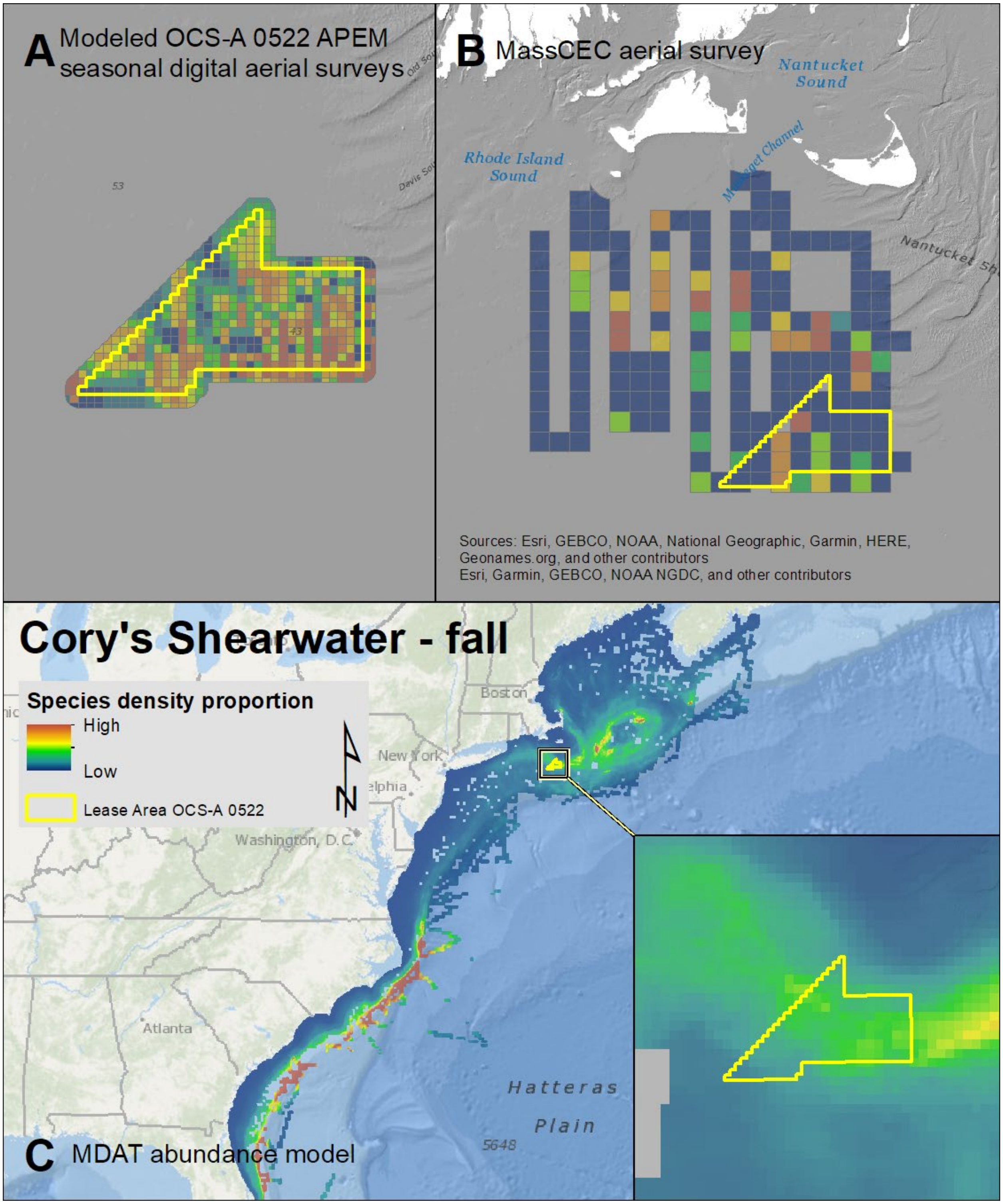
Map 135. Winter Cory's Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



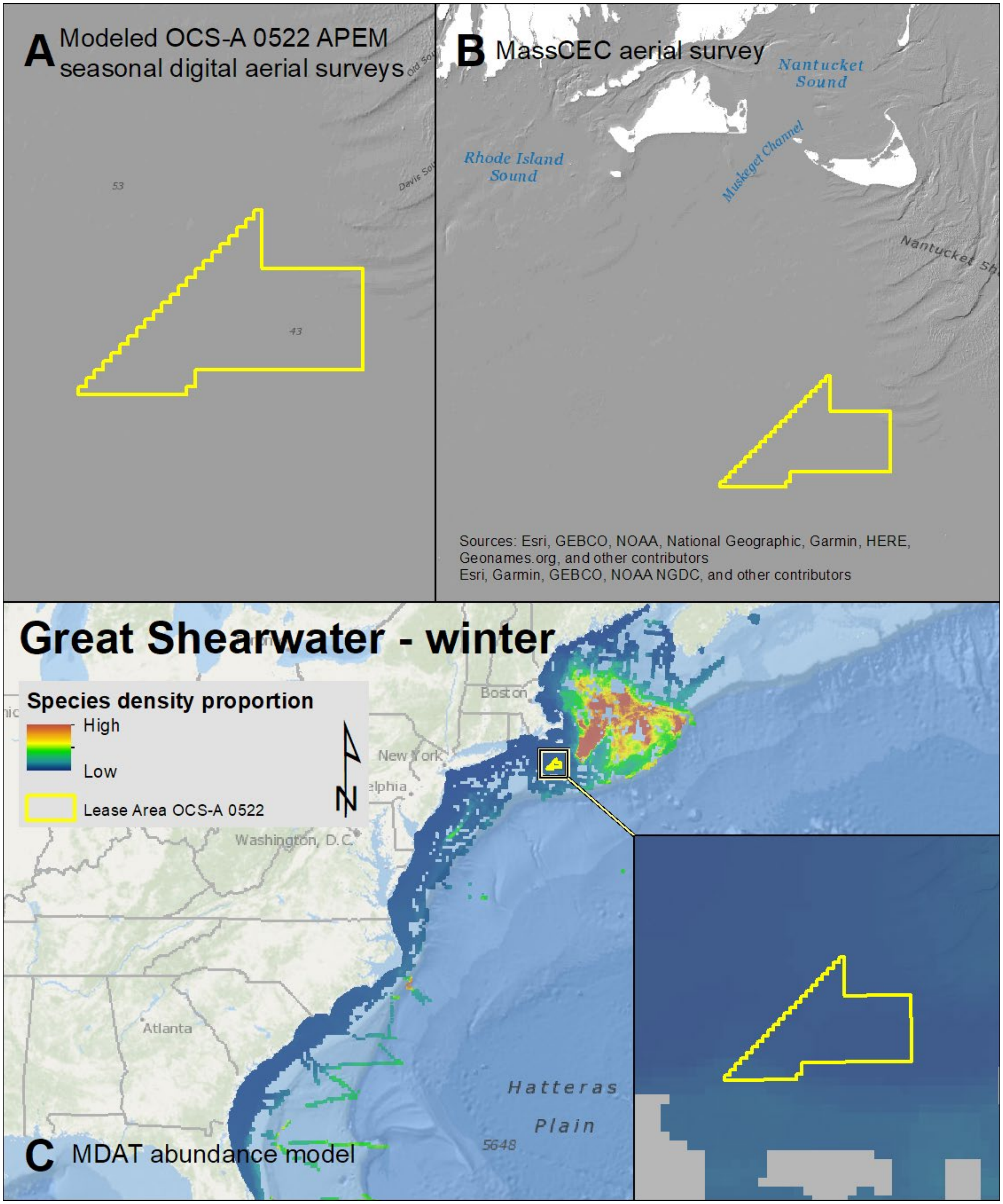
Map 136. Spring Cory's Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



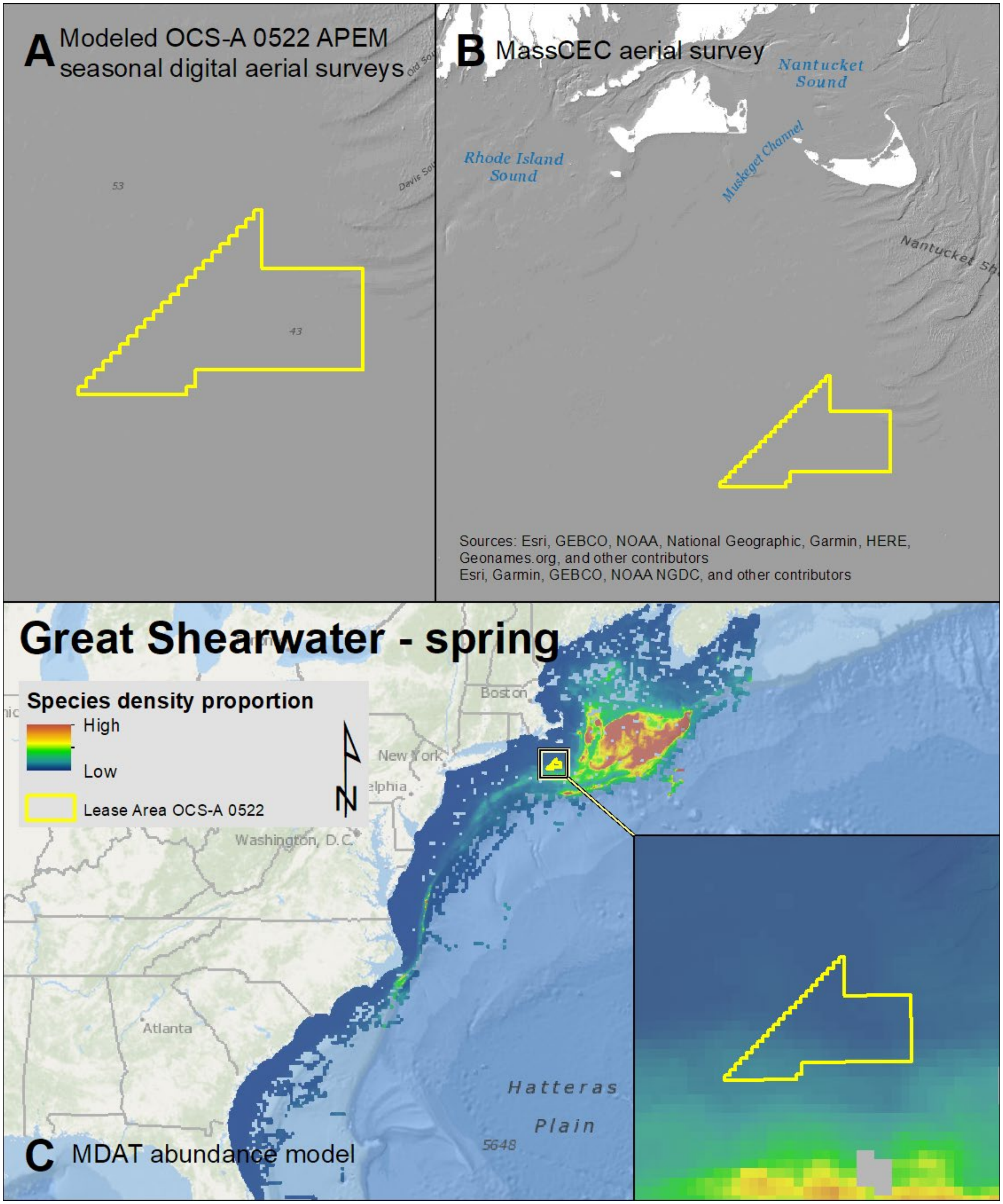
Map 137. Summer Cory's Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



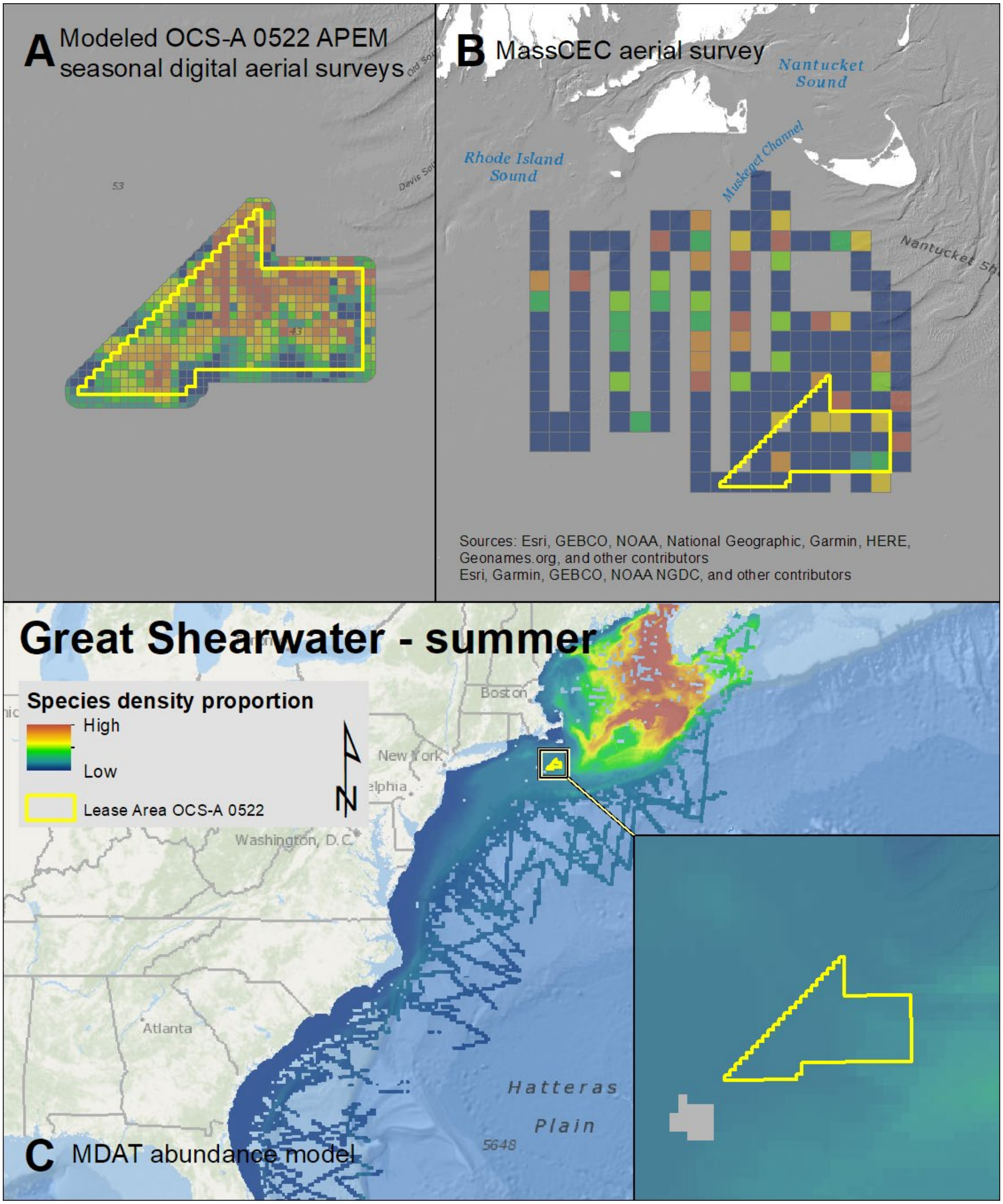
Map 138. Fall Cory's Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



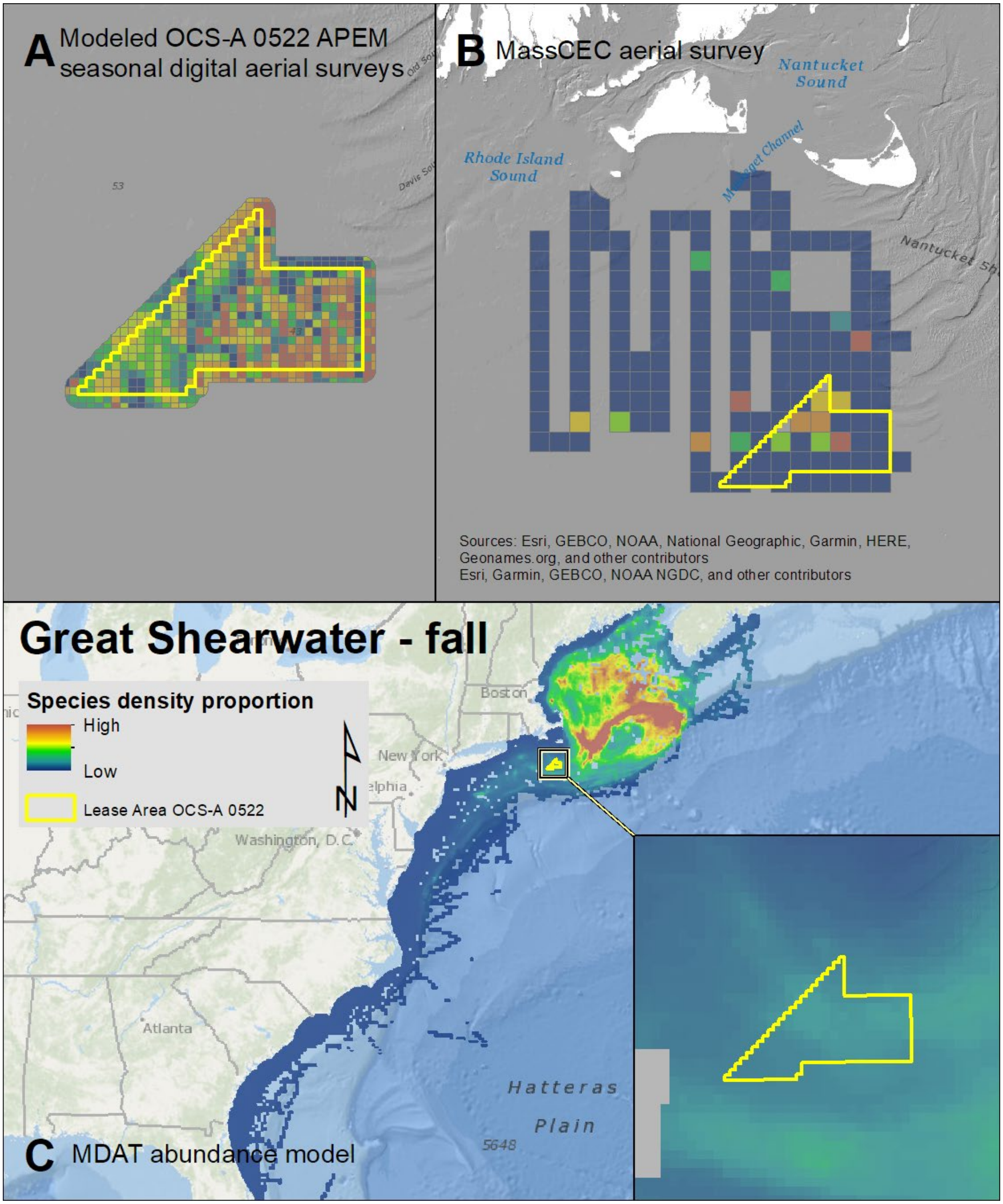
Map 139. Winter Great Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



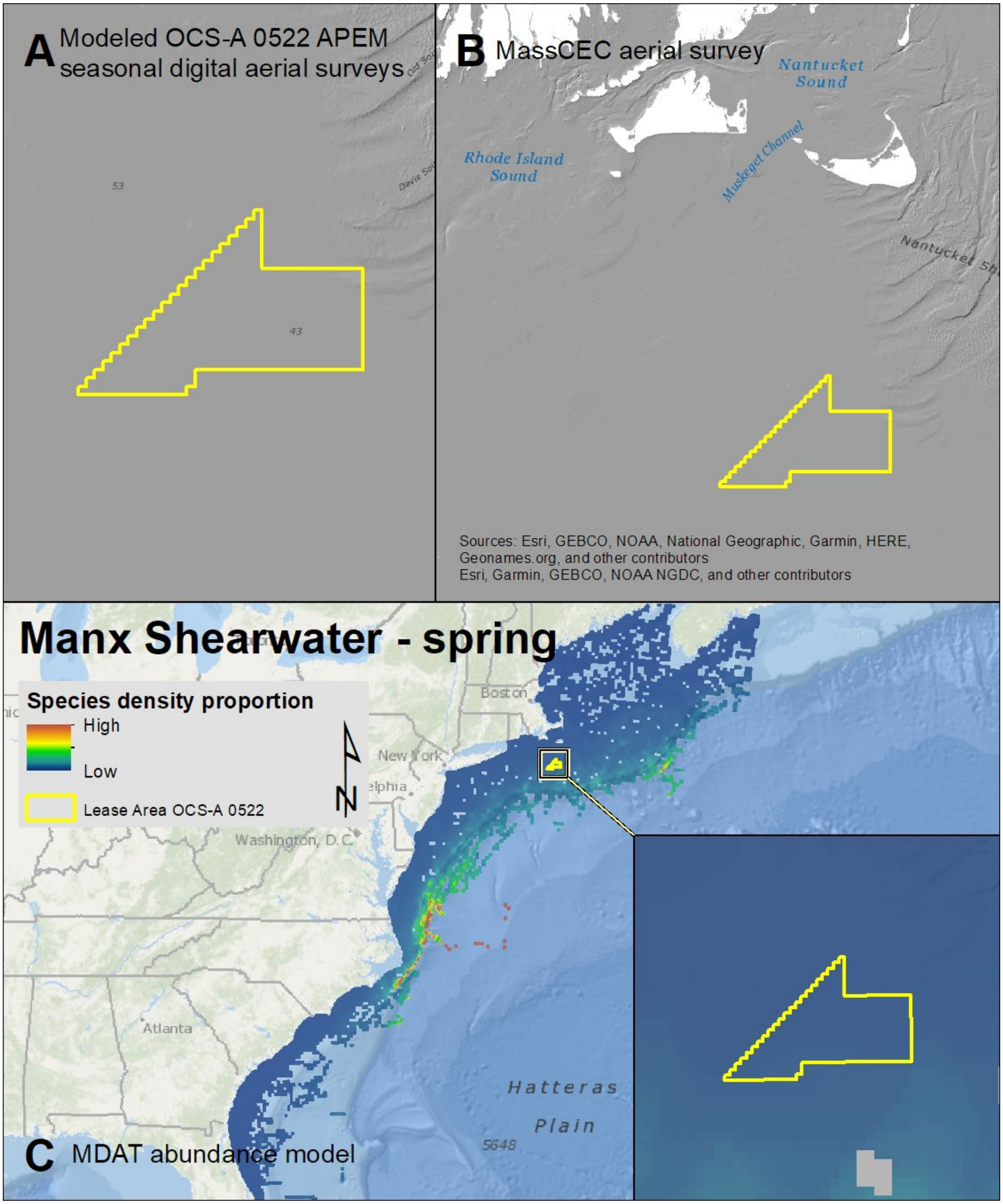
Map 140. Spring Great Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



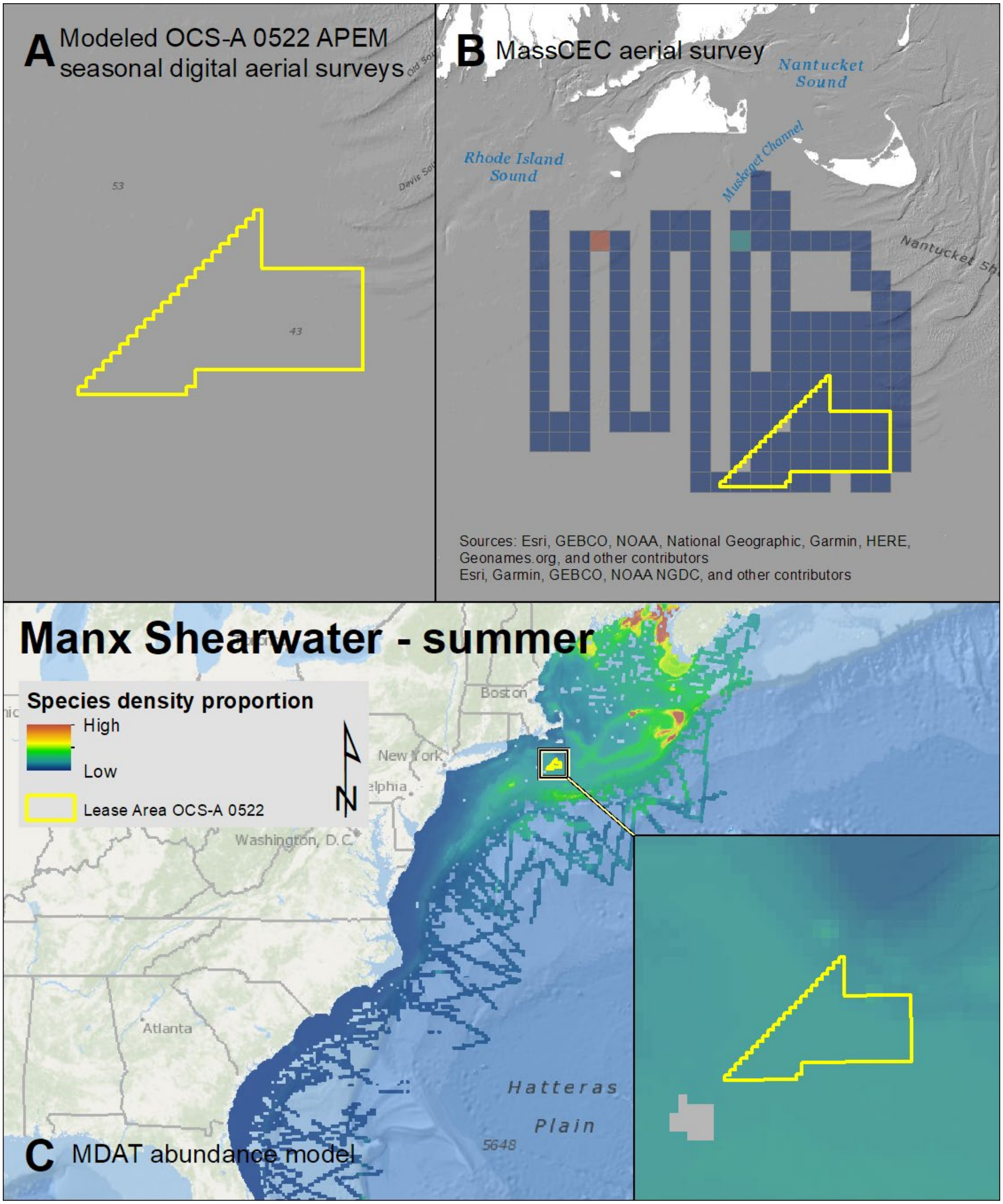
Map 141. Summer Great Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



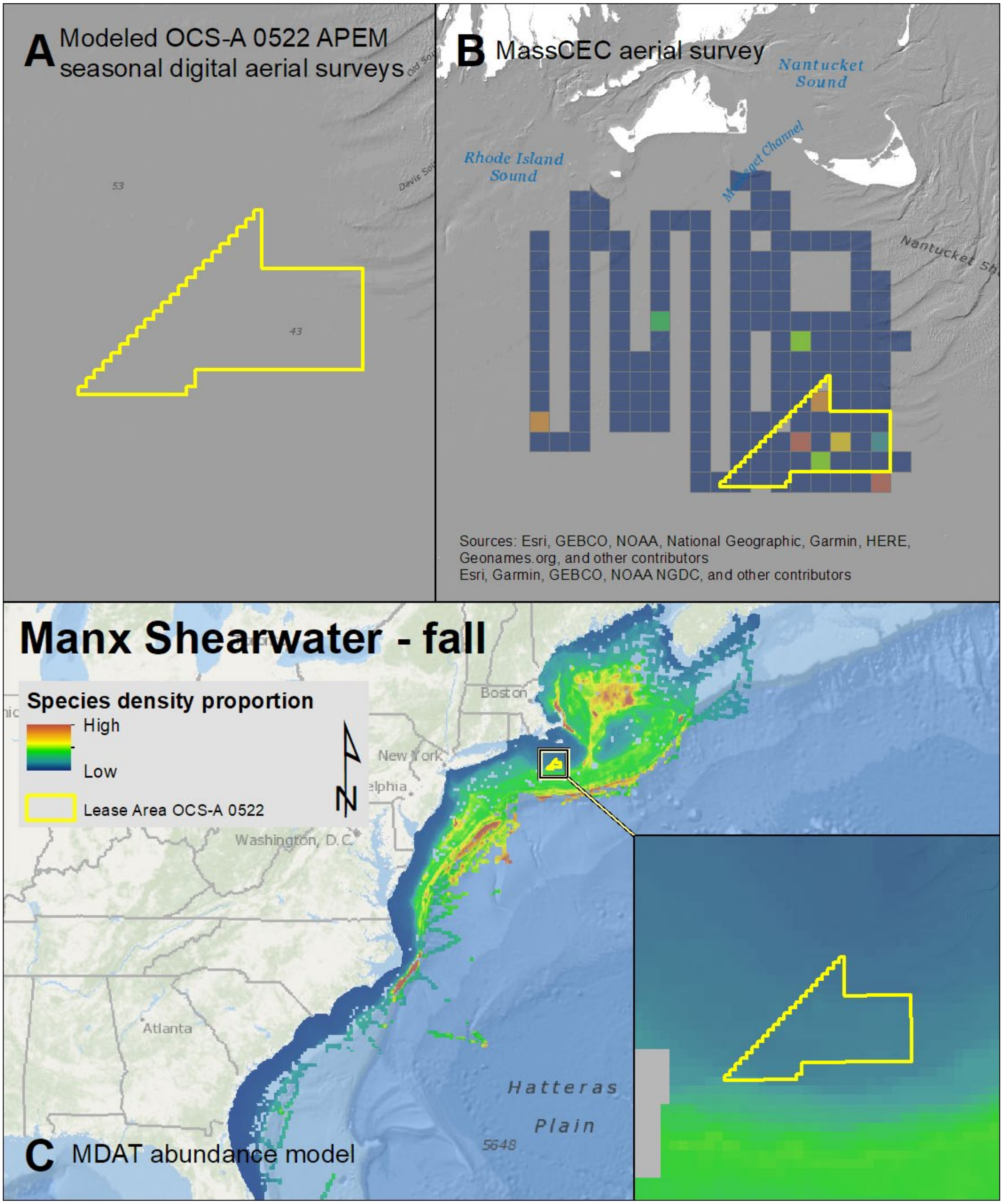
Map 142. Fall Great Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



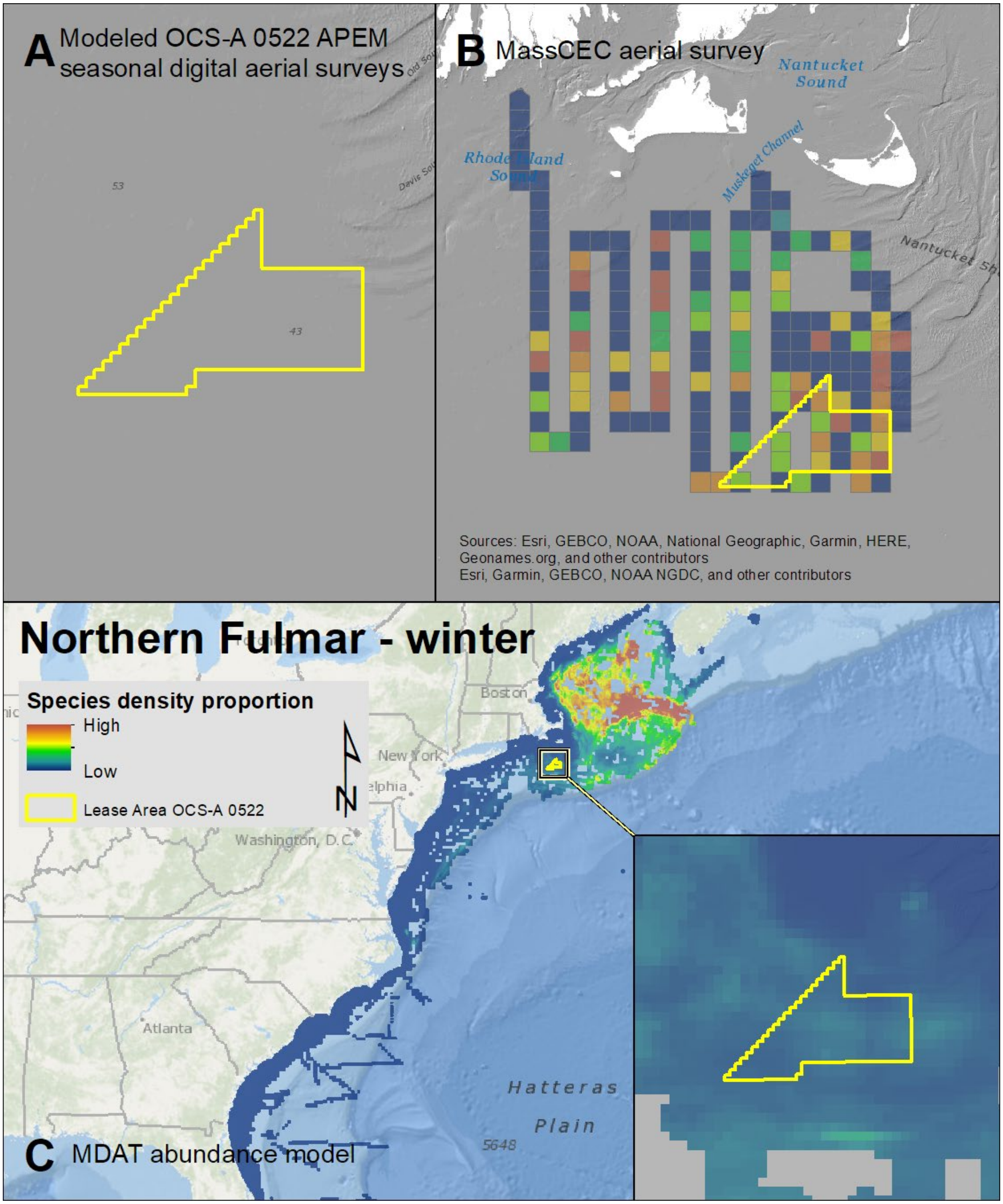
Map 143. Spring Manx Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



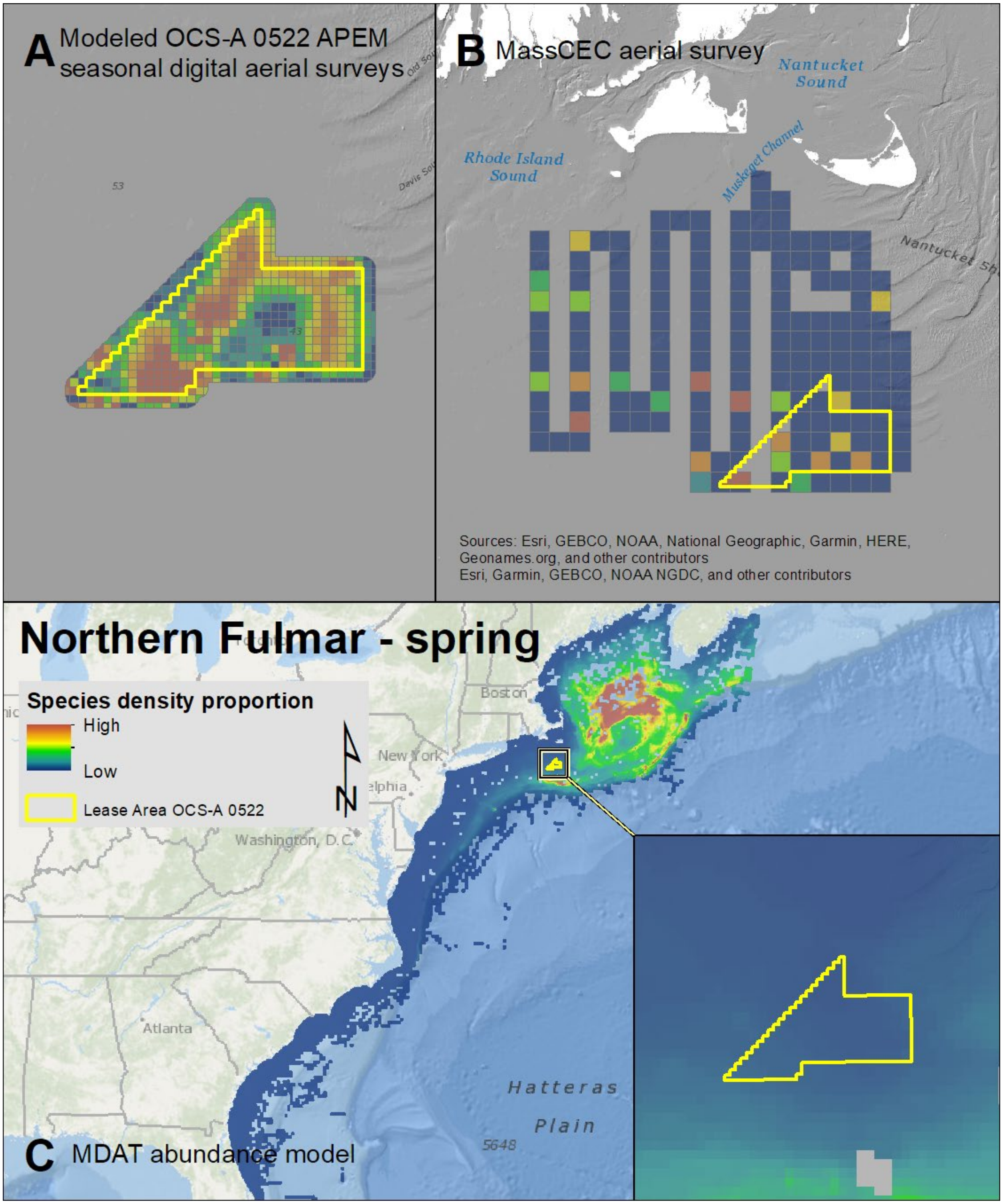
Map 144. Summer Manx Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



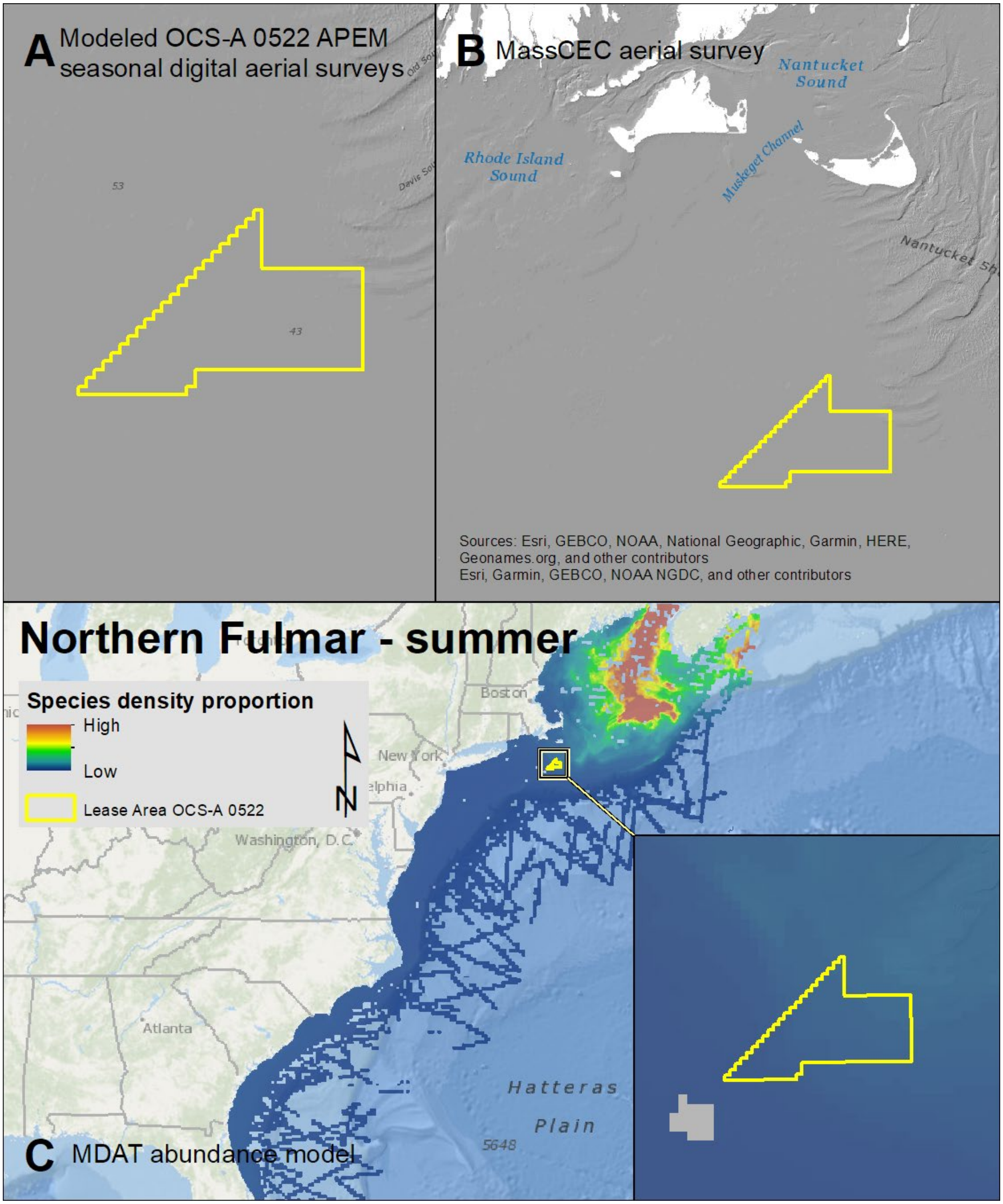
Map 145. Fall Manx Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



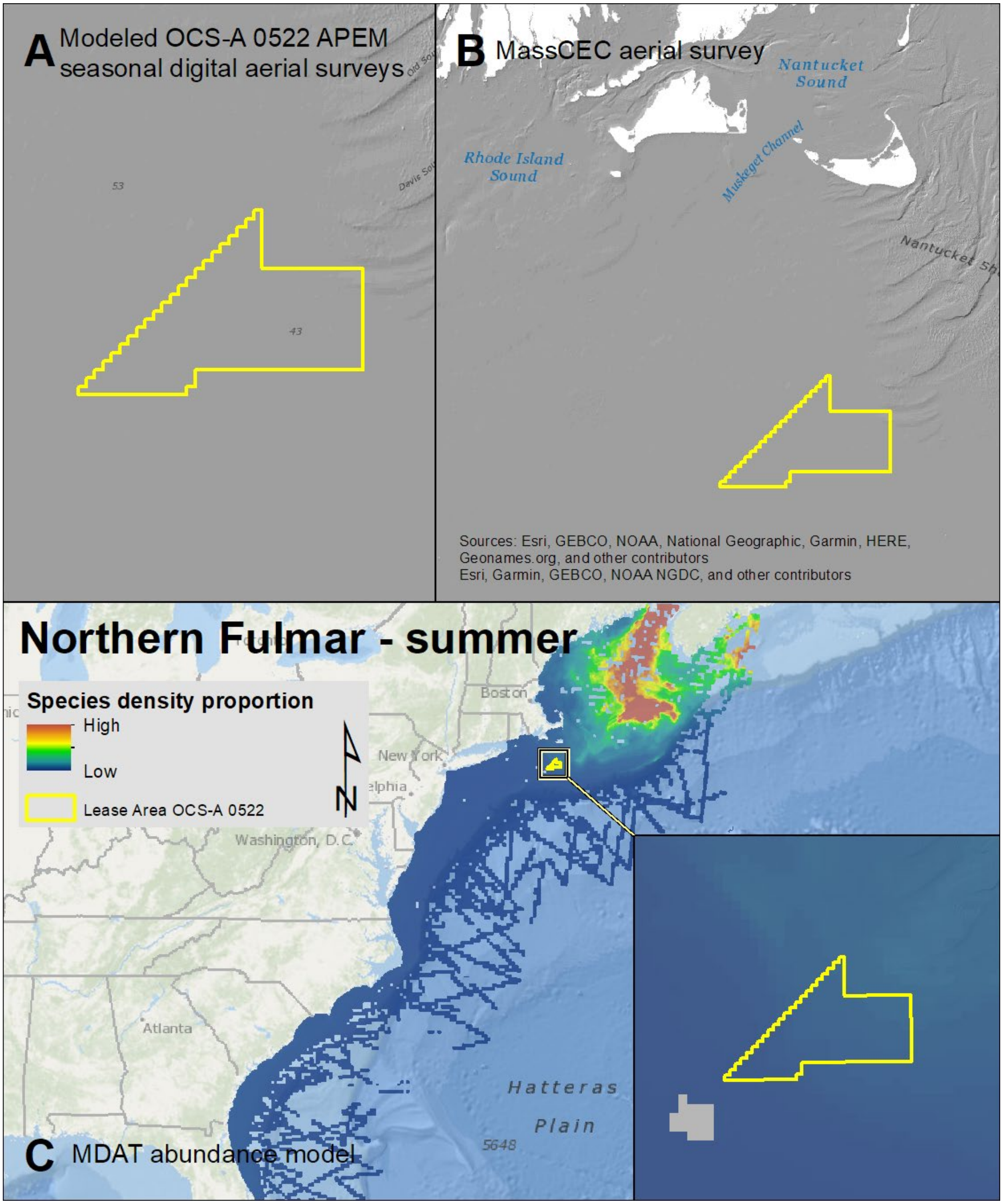
Map 146. Winter Northern Fulmar modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



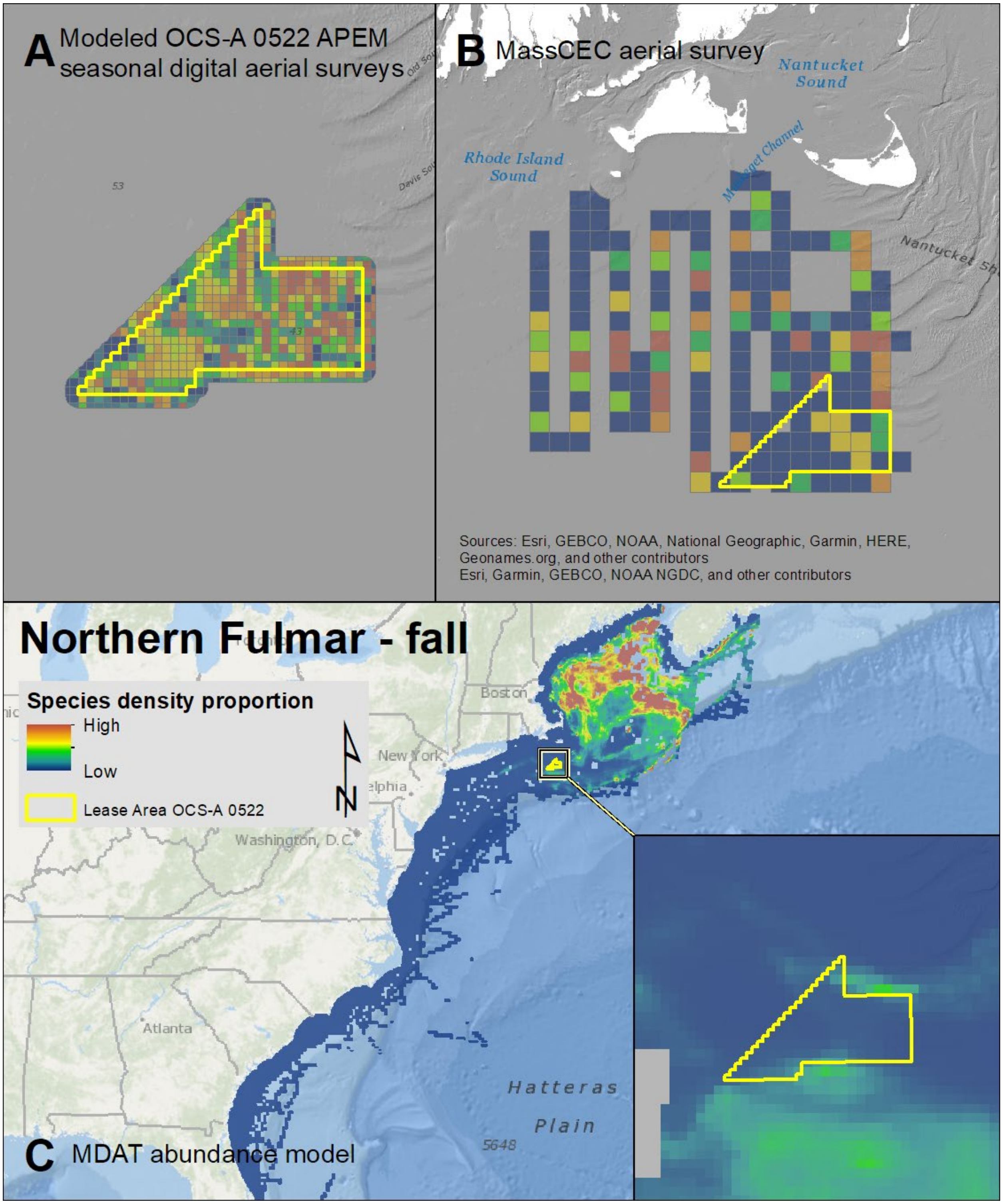
Map 147. Spring Northern Fulmar modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



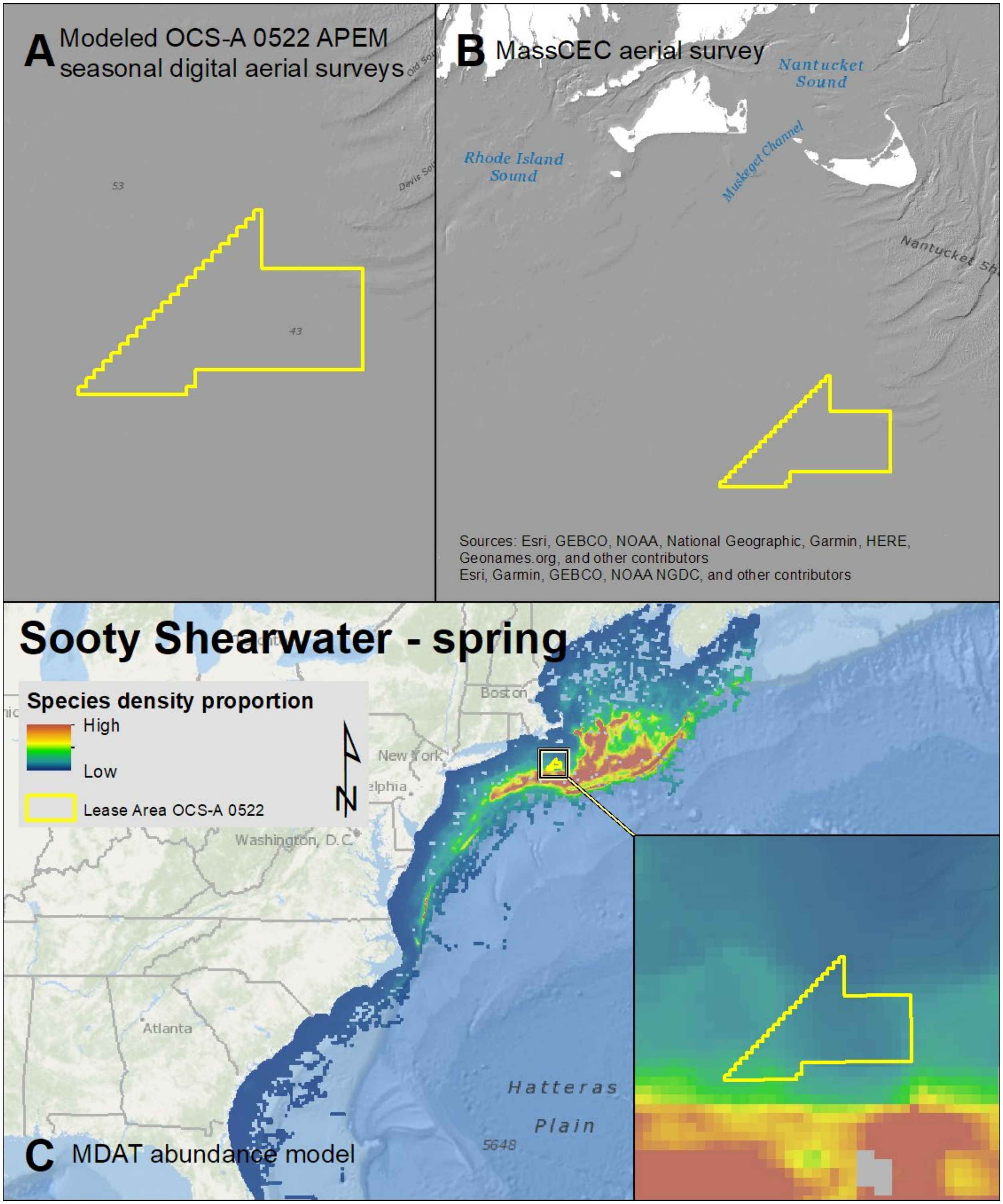
Map 148. Summer Northern Fulmar modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



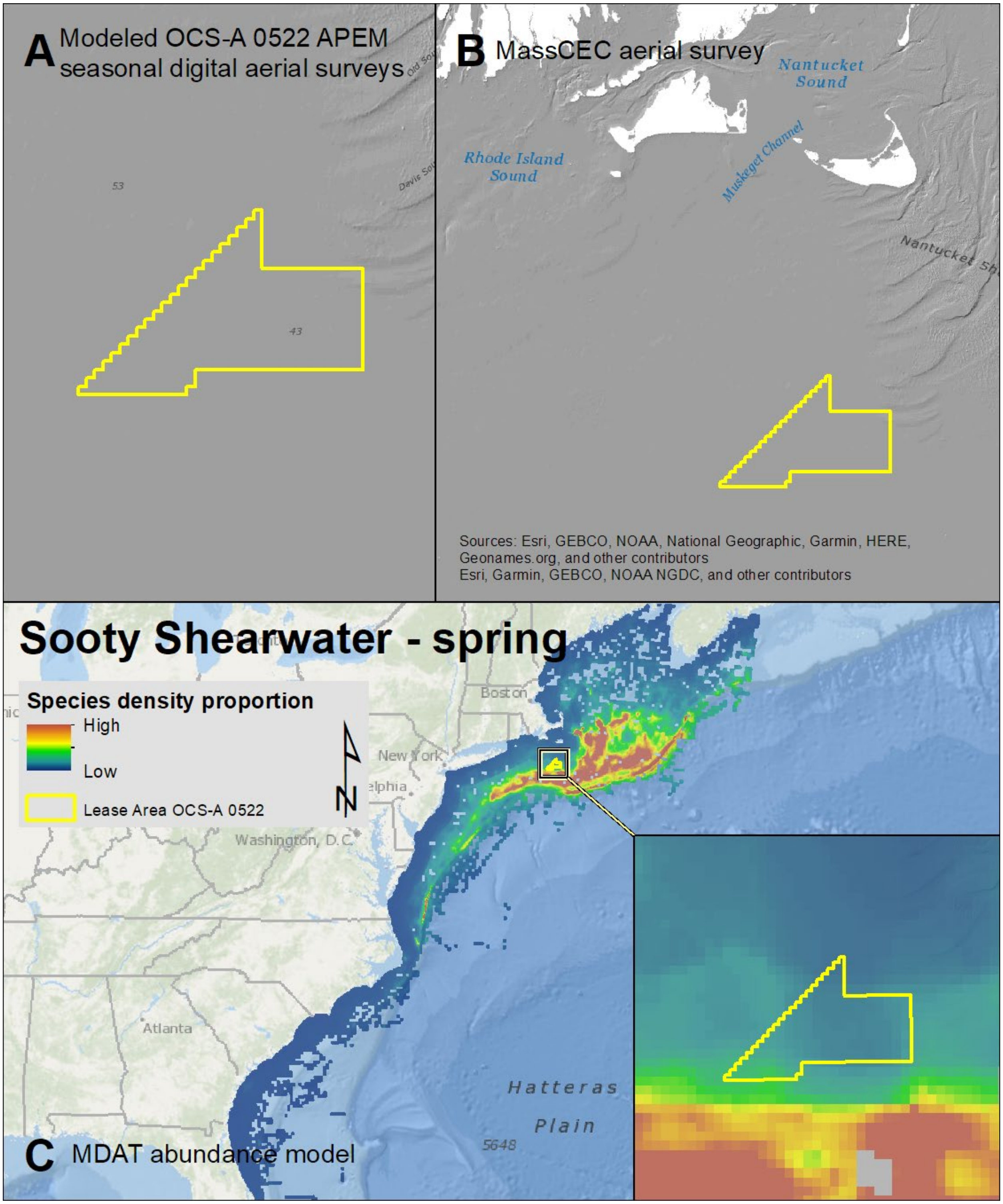
Map 149. Summer Northern Fulmar modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



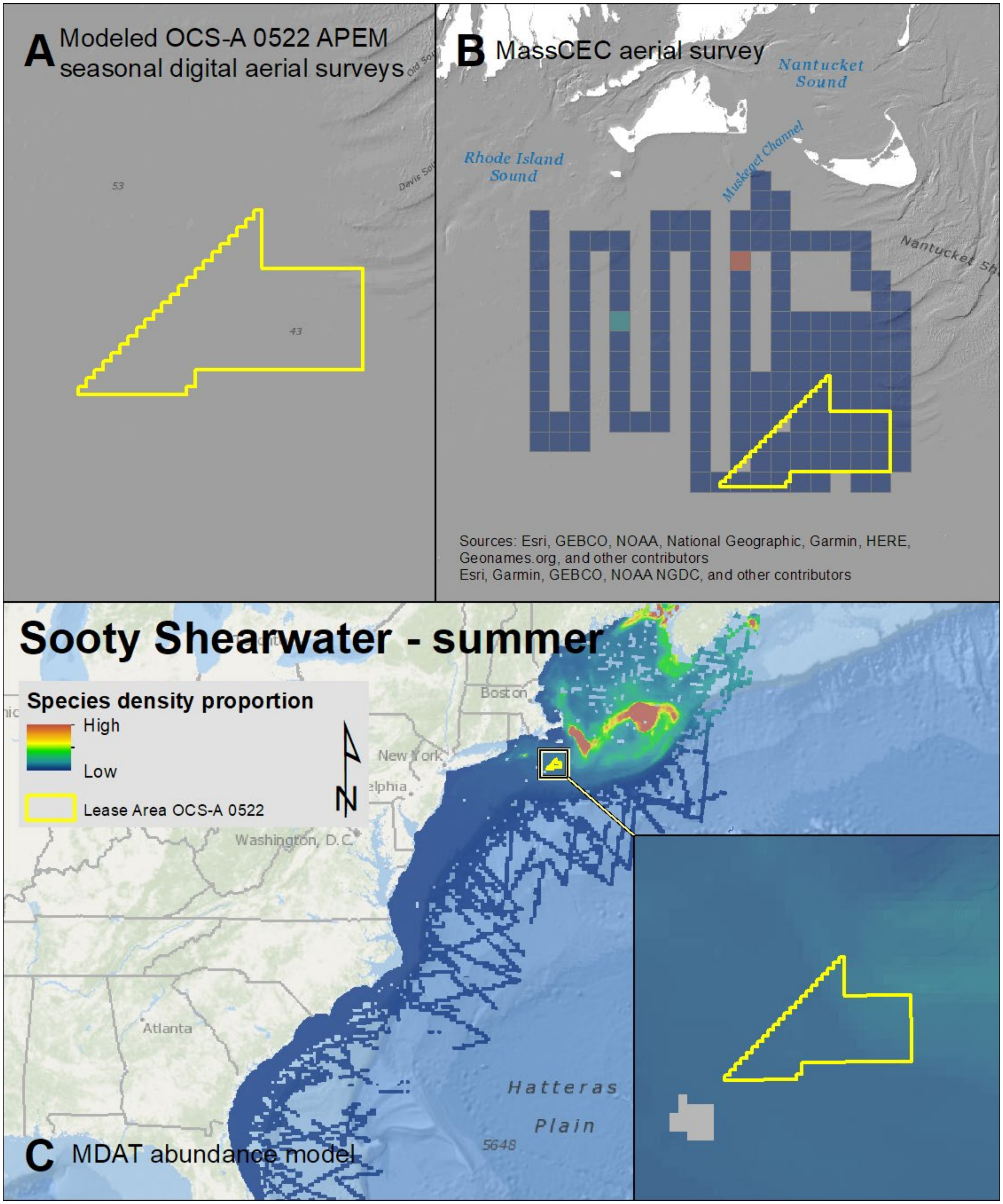
Map 150. Fall Northern Fulmar modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



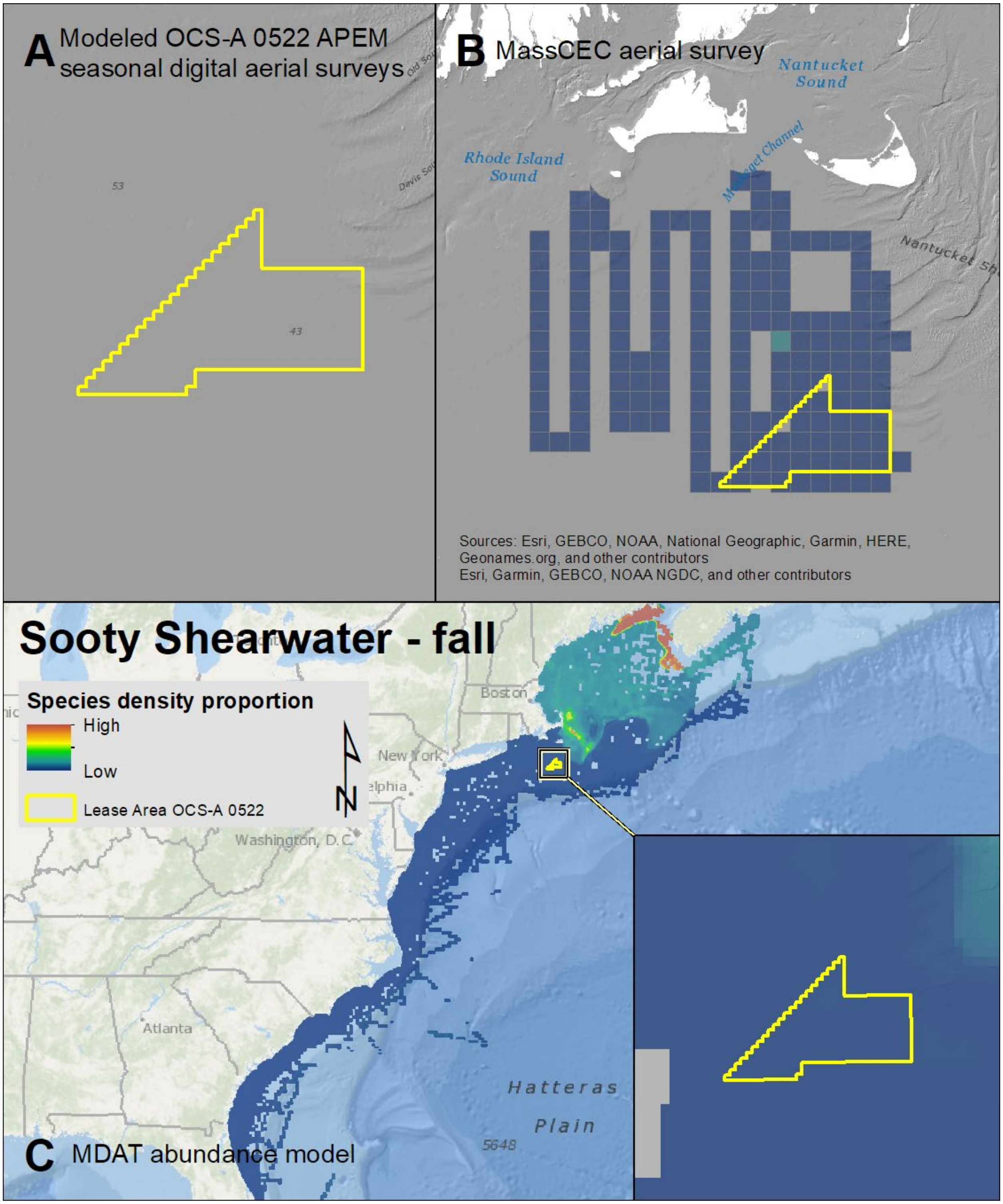
Map 151. Spring Sooty Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



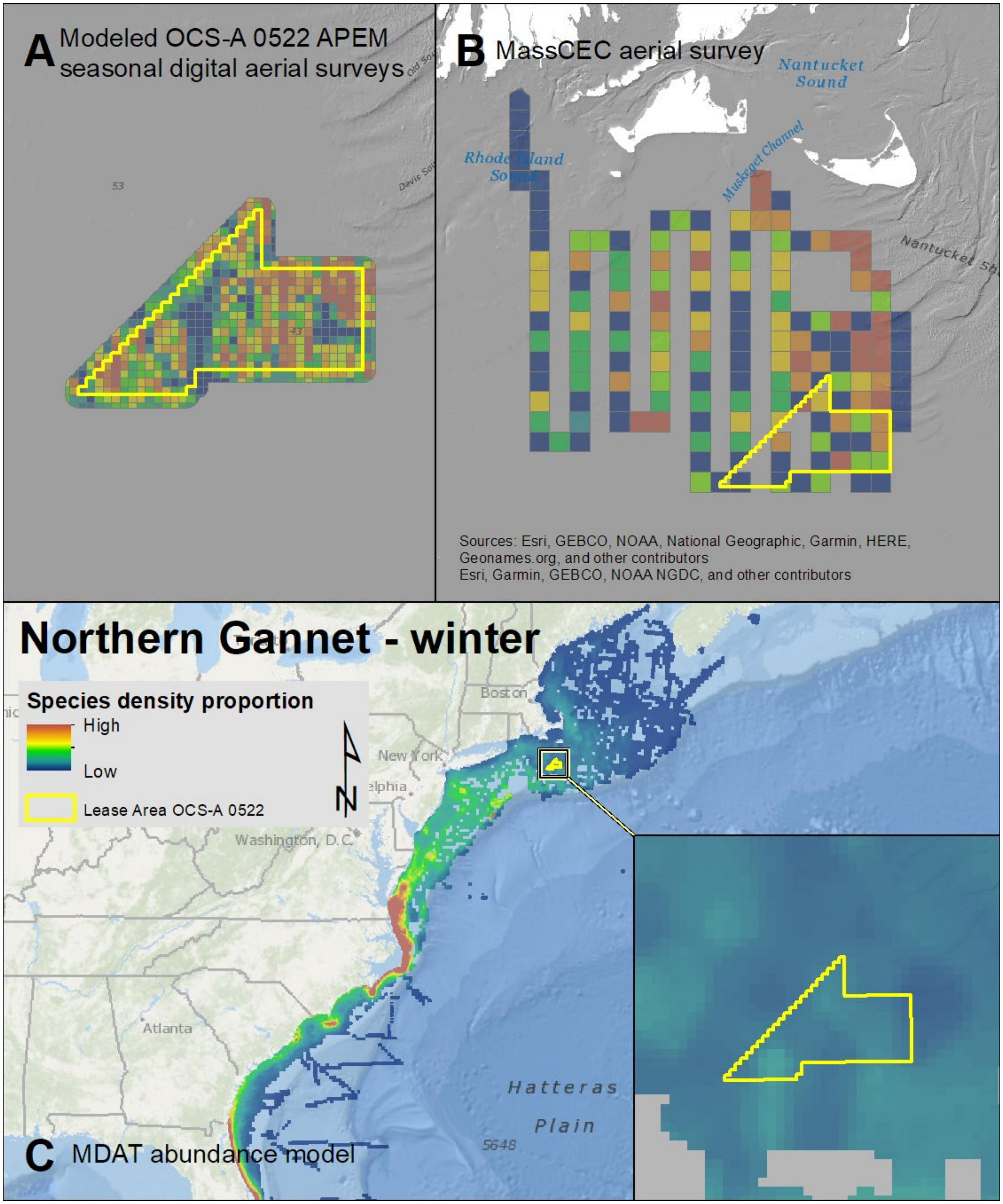
Map 152. Spring Sooty Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



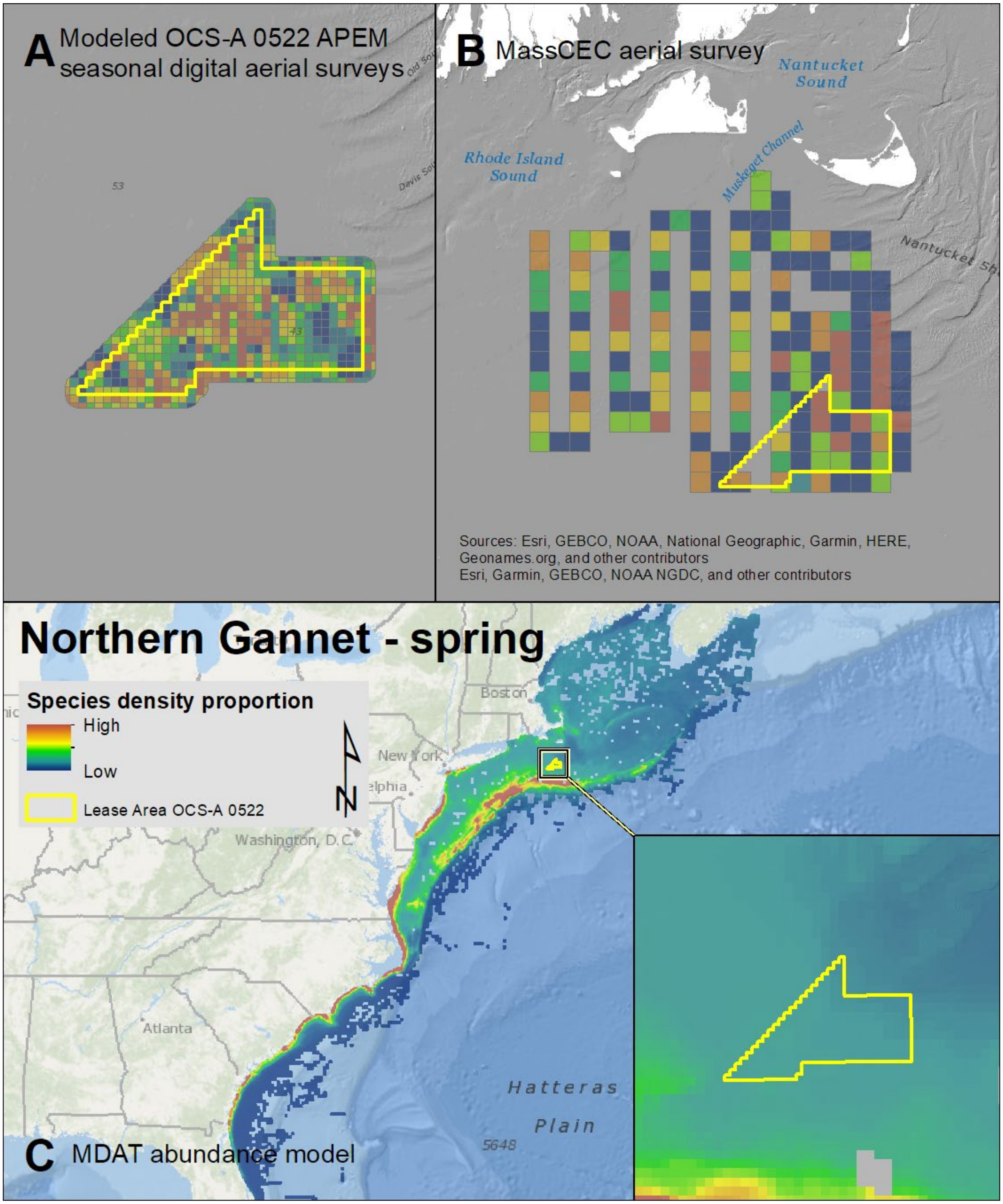
Map 153. Summer Sooty Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



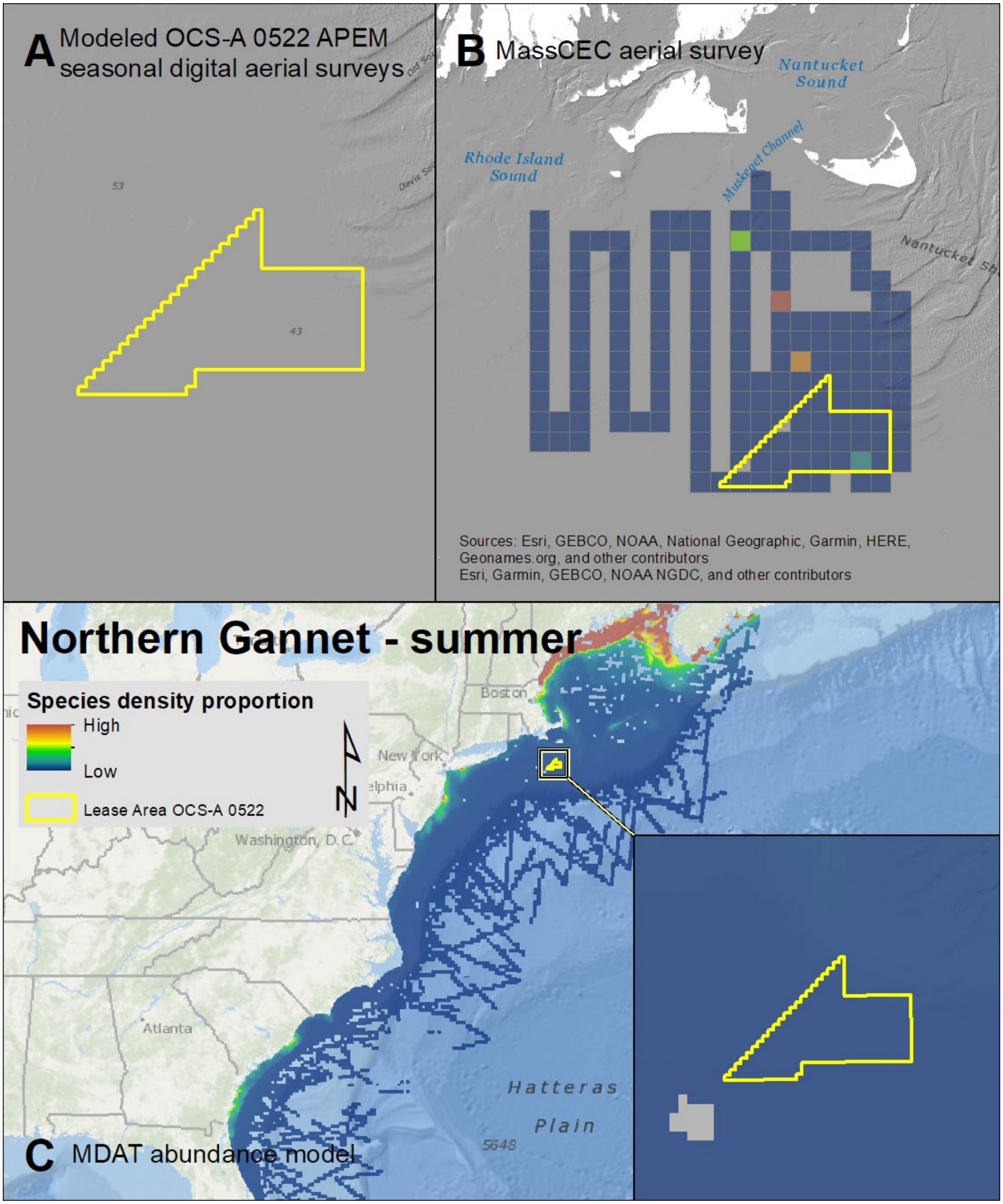
Map 154. Fall Sooty Shearwater modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



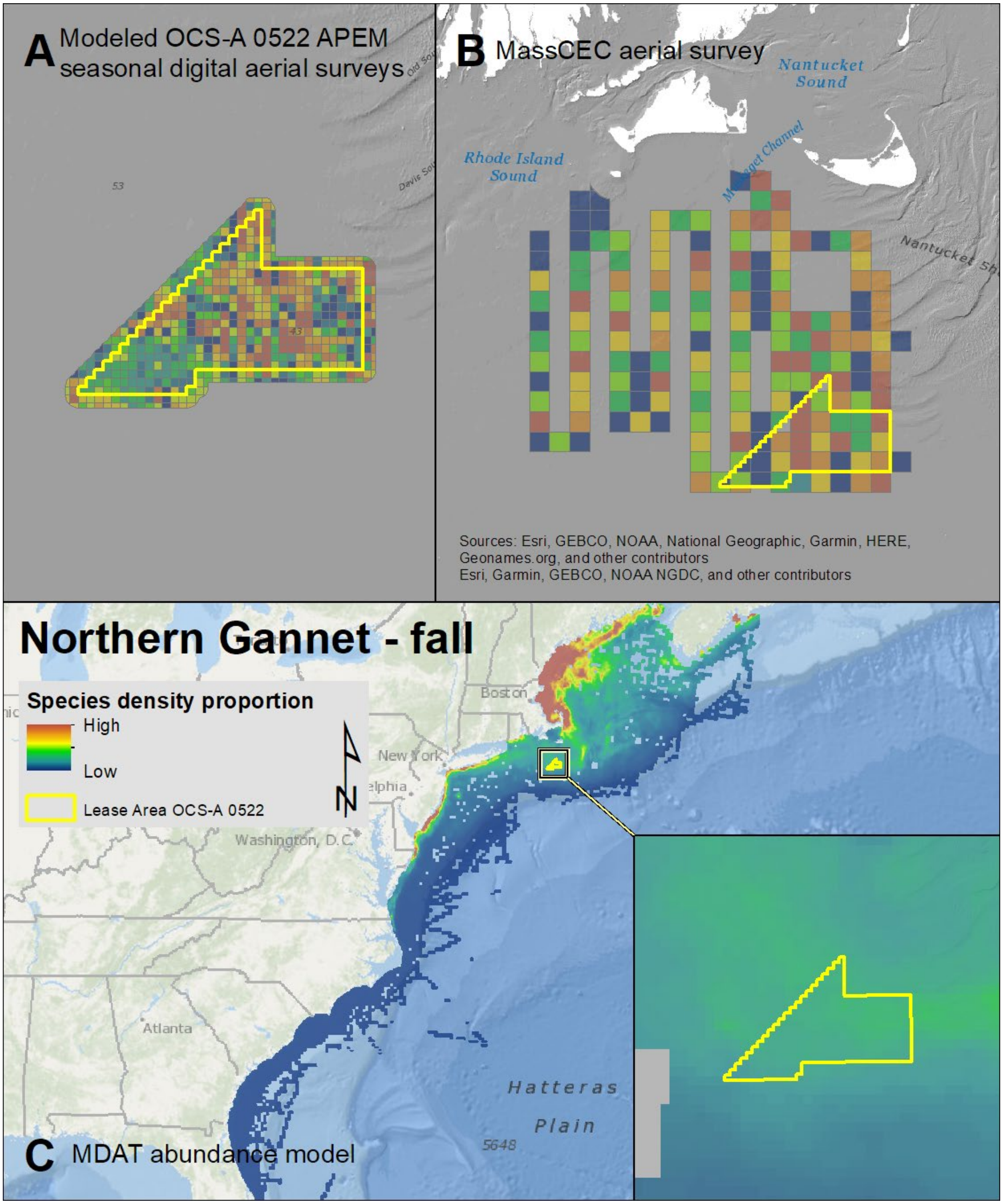
Map 155. Winter Northern Gannet modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



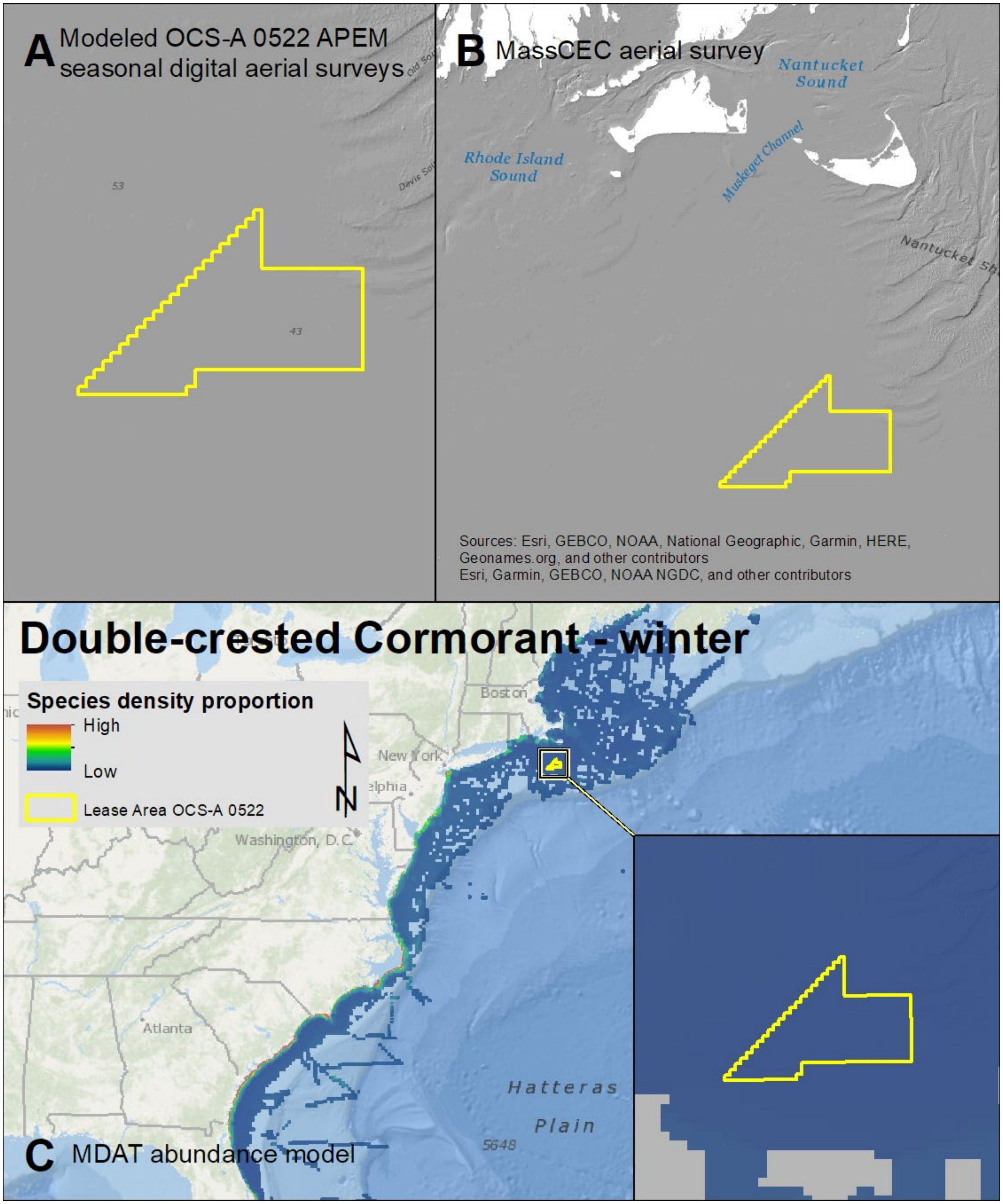
Map 156. Spring Northern Gannet modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



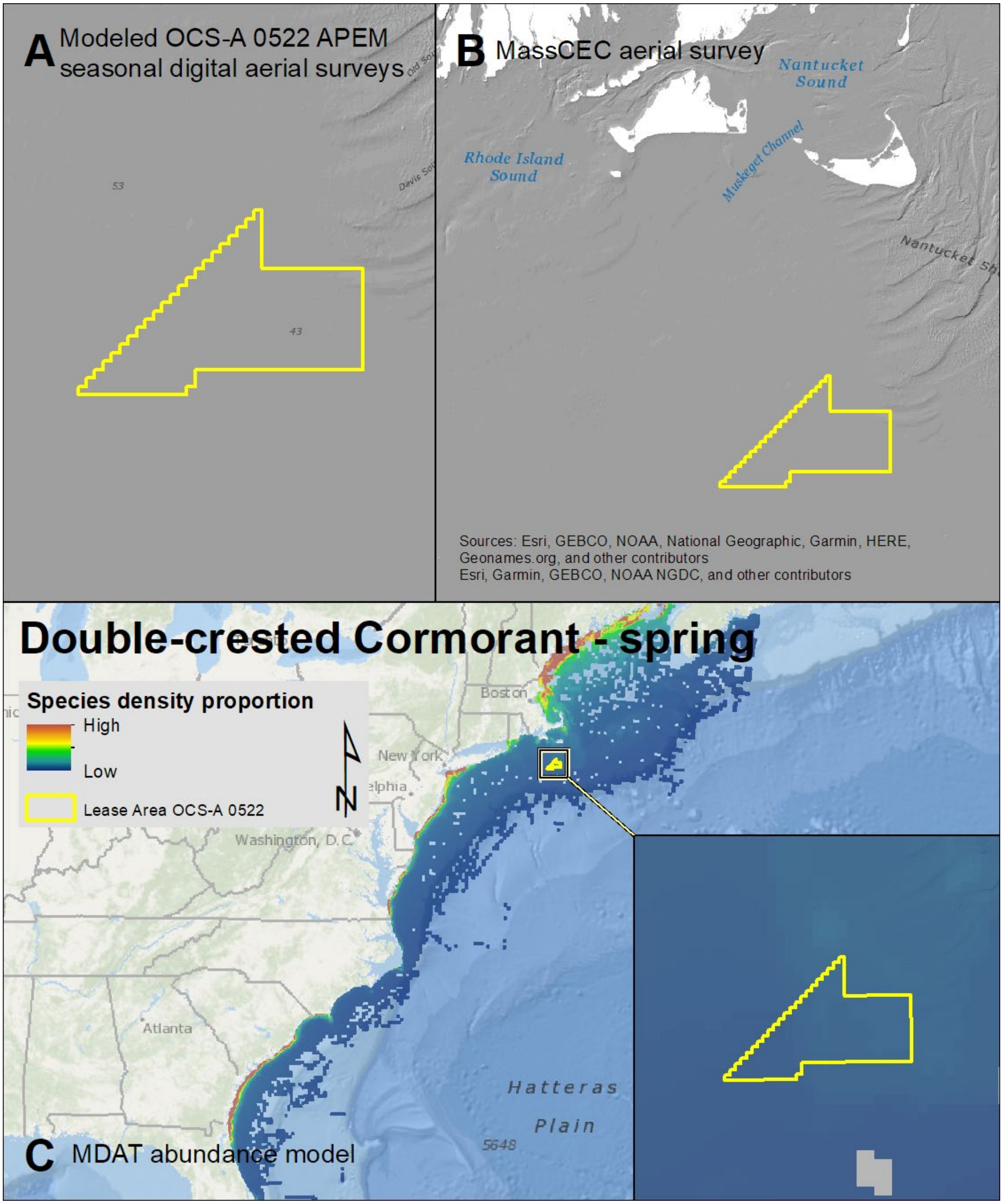
Map 157. Summer Northern Gannet modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



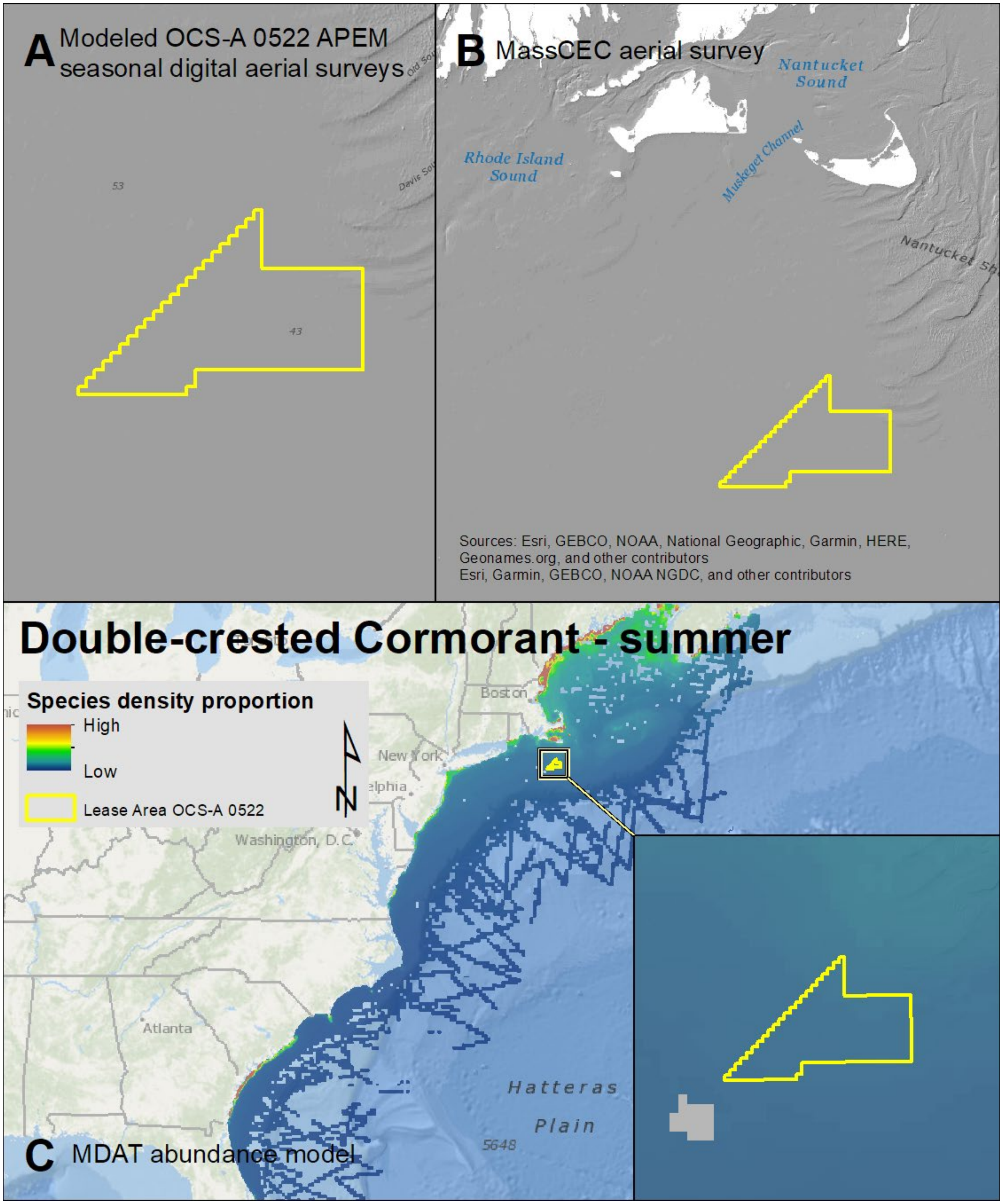
Map 158. Fall Northern Gannet modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



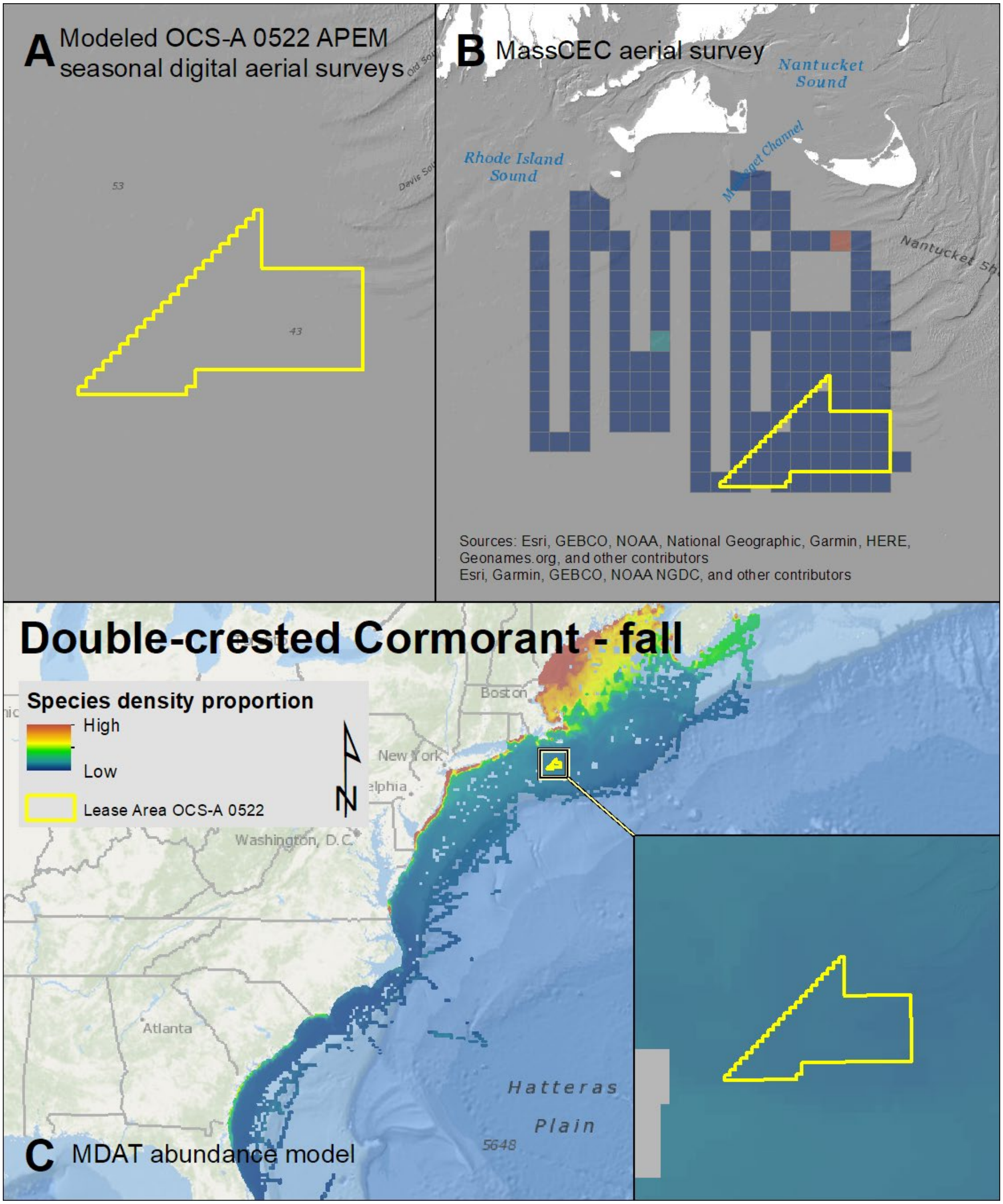
Map 159. Winter Double-crested Cormorant modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



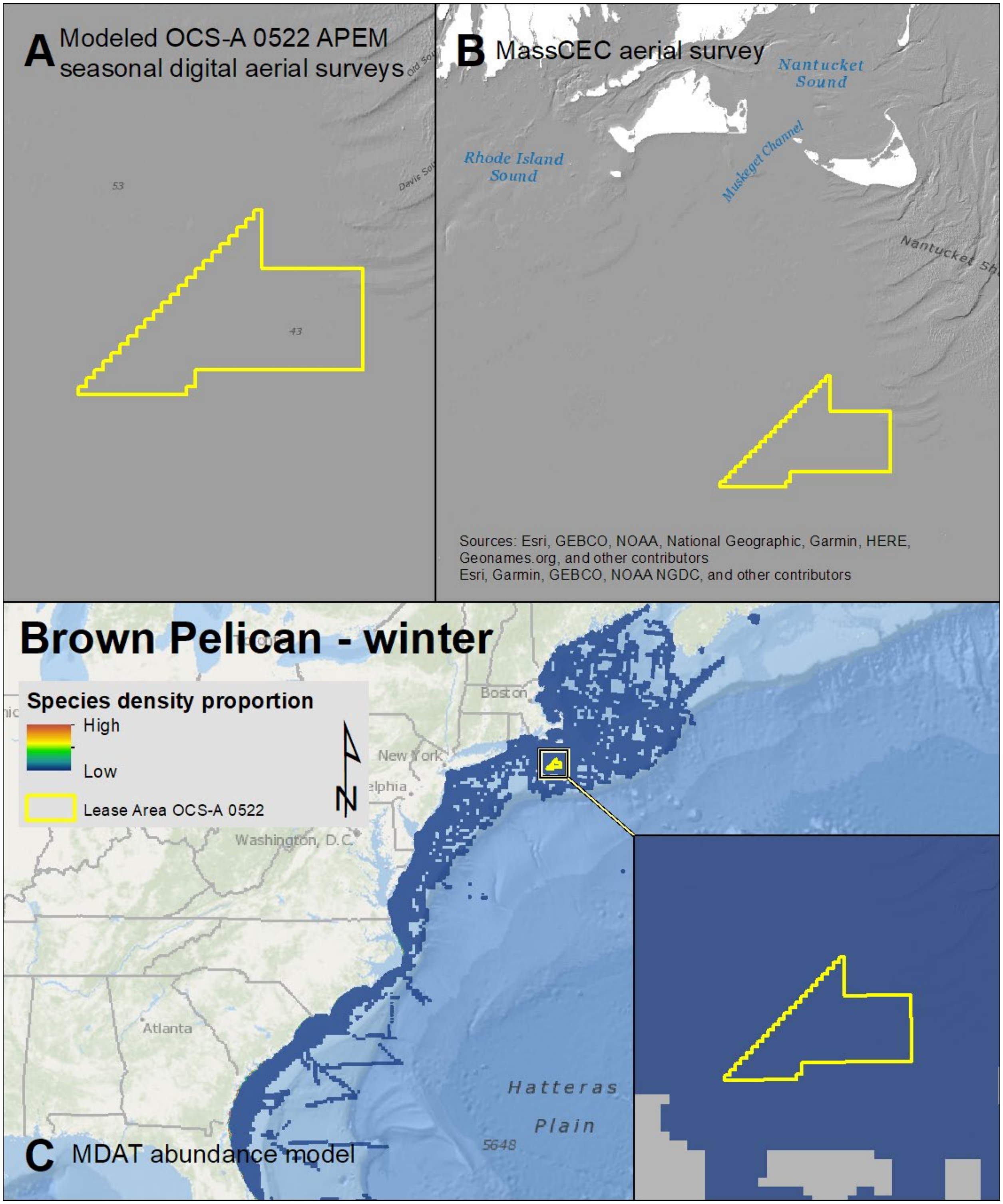
Map 160. Spring Double-crested Cormorant modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



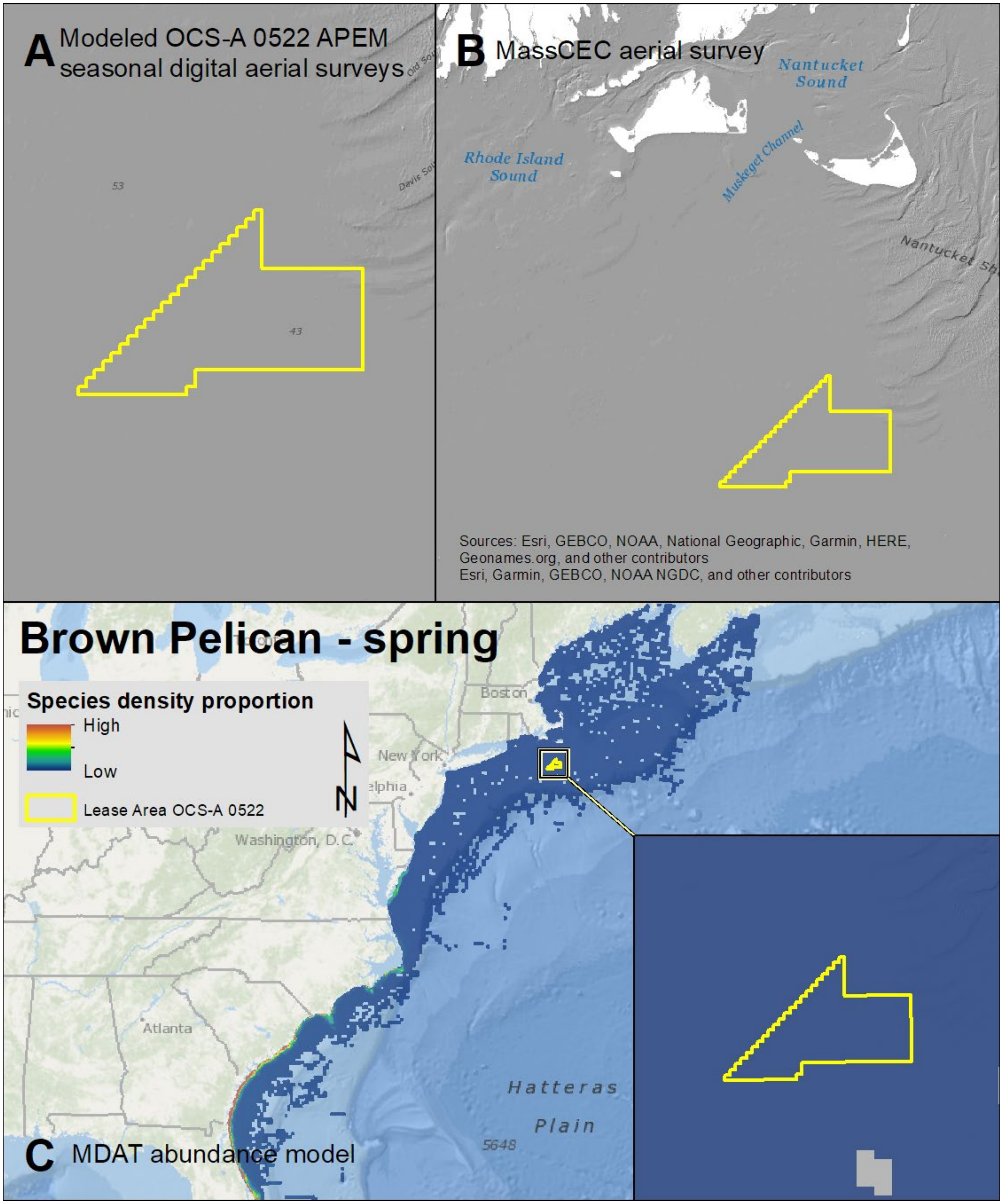
Map 161. Summer Double-crested Cormorant modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



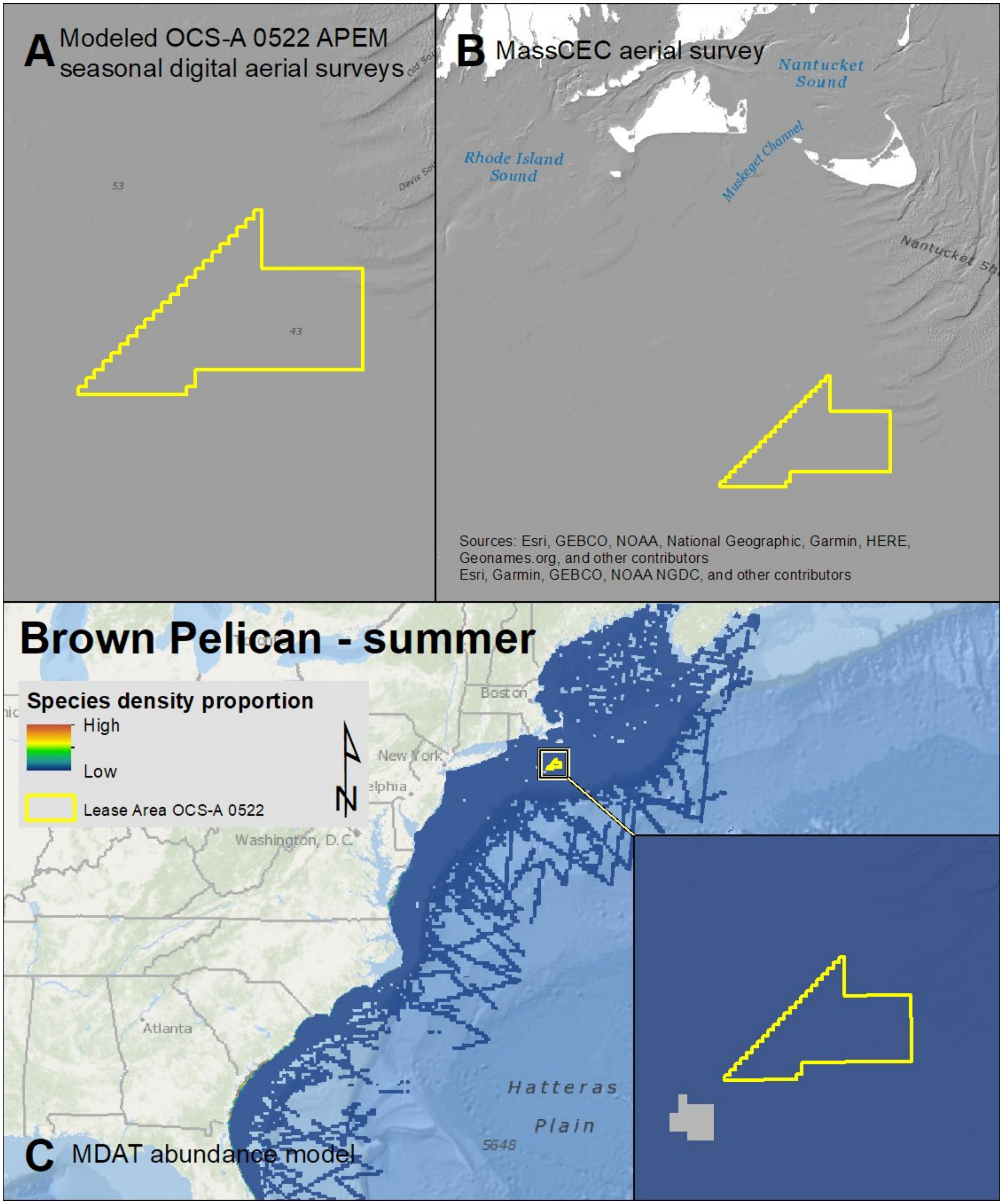
Map 162. Fall Double-crested Cormorant modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



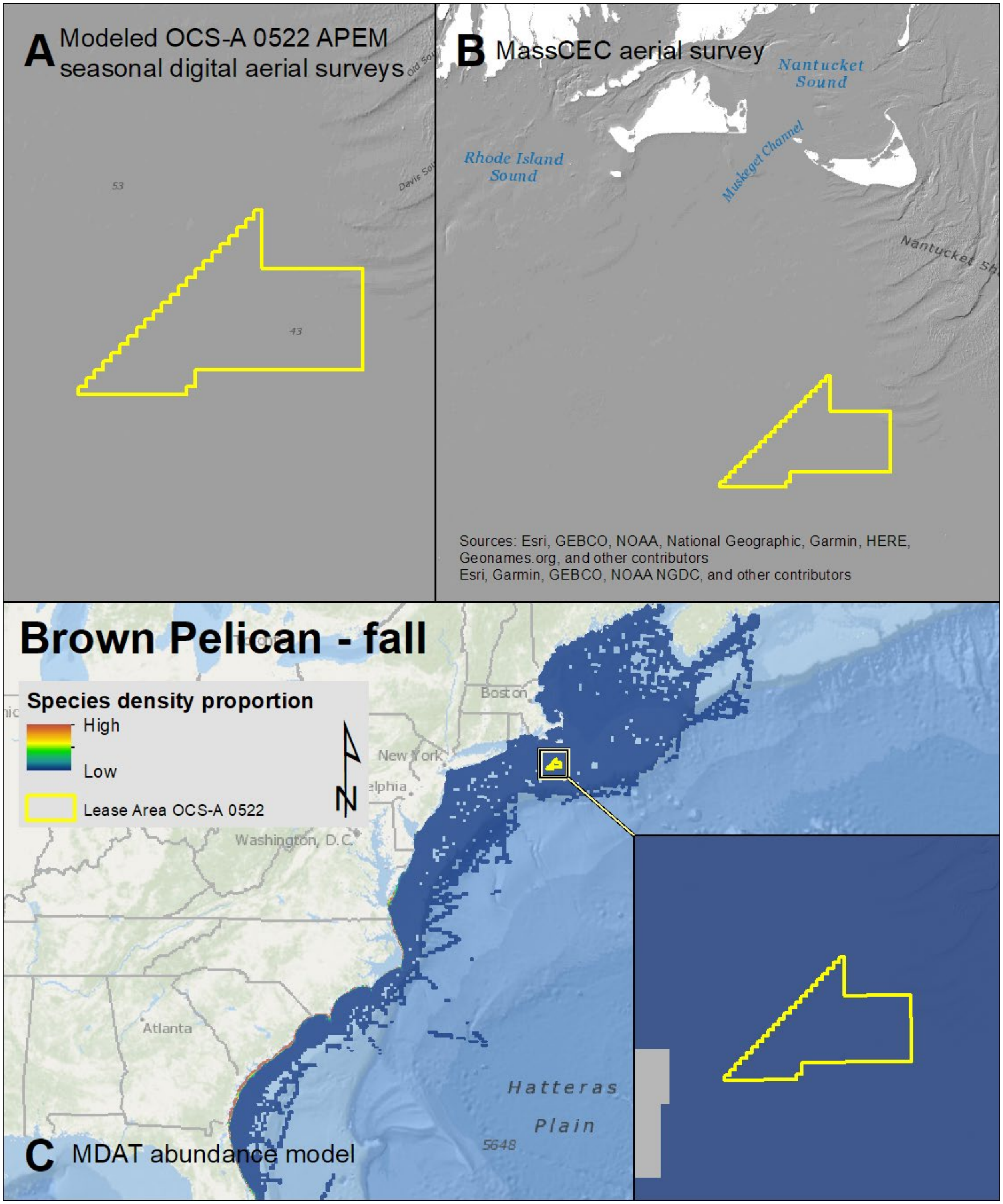
Map 163. Winter Brown Pelican modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



Map 164. Spring Brown Pelican modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



Map 165. Summer Brown Pelican modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.



Map 166. Fall Brown Pelican modeled density proportions in the OCS-A 0522 Lease Area seasonal digital aerial surveys (A), density proportions in the MassCEC baseline survey data (B), and the MDAT data at local and regional scales (C). The scale for all maps is representative of relative spatial variation in the sites within the season for each data source.