Offshore Wind Planning in the New York Bight:

Marine Mammals and Sea Turtles Study

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Offshore Wind Planning in the New York Bight: Marine Mammals and Sea Turtles Study

Final Report

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Abstract

This study compiles existing information about the distribution, seasonal occurrence, and density of marine mammals and sea turtles in deepwater (>60 m) regions of the New York Bight that are potential sites for offshore wind (OSW) development. To account for species differences in sensitivity to OSW, marine mammal and sea turtle species known to occur in the Area of Analysis (AoA) were assigned to 11 receptor groups based on known, or expected susceptibility to OSW stressors, which vary with development phase and technology employed (e.g., fixed vs. floating turbines). Results indicate that species distribution in the AoA varies with receptor group, season, and habitat type. High densities of mid- and low-frequency cetaceans and deep- and shallow-diving cetaceans are predicted in waters above the continental slope. Species with coastal affinities, including the North Atlantic right whale and harbor porpoise, show heavy use of continental shelf habitat. High densities of both marine mammals and sea turtles are predicted above submarine canyons, which are known to be hotspots for biological productivity related to upwelling and nutrient mixing. Knowledge gaps regarding species distribution and potential impacts from OSW development are identified, and specific recommendations are offered to help fill these gaps.

Keywords

New York Bight, New Jersey Bight, deep water, offshore wind development, marine habitats, continental shelf, continental slope, marine canyons, marine mammals, sea turtles, protected species, abundance, density, seasonal occurrence, distribution, habitat use, receptors, stressors, risk assessment, sensitivity analysis, gap analysis, best management practices, mitigation, spatial planning

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Acronyms and Abbreviations

re 1 µPa rms	referenced to 1 microPascal
AC	alternating current
ADCP	acoustic doppler current profiler
AFTT	Atlantic Fleet Training and Testing
ALAN	artificial light at night
AMAPPS	Atlantic Marine Assessment Program for Protected Species
AMAR	Autonomous Multichannel Acoustic Recorder
AoA	Area of Analysis
BIA	Biologically Important Areas
BMP	Best Management Practices
BOEM	Bureau of Ocean Energy Management
CalTrans	California Department of Transportation
CFR	Code of Federal Regulations
CI	Confidence Interval
CV	coefficient of variation
dB	decibels
DC	direct current
DMON	digital acoustic monitoring instrument
DPS	Distinct Population Segment
E-TWG	Environmental Technical Working Group
EEZ	exclusive economic zone
EMF	electromagnetic field
ESA	Endangered Species Act
FAA	Federal Aviation Administration
ft	feet (foot)
FR	Federal Register
GIS	geographic information system
GW	gigawatt
HDD	horizontal directional drilling
HRG	high-resolution geophysical
HVDC	high-voltage direct current
Hz	hertz
IR	infra-red
kHz	kilohertz
km	kilometer(s)
m	meter(s)
MARU	Marine Autonomous Recording Unit

Master Plan	New York State Offshore Wind Master Plan
MBES	multibeam echo sounders
MDAT	Marine-life Data and Analysis Team
MMPA	Marine Mammal Protection Act
MW	megawatts
NARW	North Atlantic right whales
NEAq	New England Aquarium
NEFSC	Northeast Fisheries Science Center
NEPA	National Environmental Policy Act
NGO	non-government organization(s)
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NVD	night-vision devices
NYSDEC	New York State Department of Environmental Conservation
NYSERDA	New York State Energy Research and Development Authority
OBIS-SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OMMSCS	Other Marine Mammals of Special Conservation Status
OPA	Offshore Planning Area
OPR	Office of Protected Resources
OSW	offshore wind
PAC	Project Advisory Committee
PAM	passive acoustic monitoring
PEIS	Programmatic Environmental Impact Statement
PSO	protected species observer(s)
PTS	permanent threshold shift
SBES	split-beam echosounder
SBP	sub-bottom profilers
SE	standard error
SEER	Synthesis of Environmental Effects Research
SMA	Seasonal Management Area
sq mi	square mile(s)
TTS	temporary threshold shift
TWG	Technical Working Group(s)
UME	Unusual Mortality Event(s)

U.S.	United States
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
UXO	unexploded ordnance
VHF	very high frequency
WCS	Wildlife Conservation Society
WEA	Wind Energy Area

Summary

This Marine Mammal and Sea Turtle Study expands upon New York State Offshore Wind Master Plan (Master Plan; NYSERDA 2017) by (1) including deepwater areas, (2) reviewing information that has become available since the preparation of the Master Plan, and (3) considering the potential impacts of floating wind technology.

In 2019, New York's historic Climate Leadership and Community Protection Act (Climate Act) was signed into law, requiring the State to achieve 100% zero-emission electricity by 2040 and to reduce greenhouse gas emissions 85% below 1990 levels by 2050. The law specifically mandates the development of 9,000 megawatts (MW) of offshore wind energy by 2035, building upon its previous goal of 2,400 MW of offshore wind energy by 2030. The New York State Energy Research and Development Authority (NYSERDA) is charged with advancing these goals.

Since the early 2000s, offshore wind development off New York's coast has advanced in relatively shallow areas in the New York Bight, on the Outer Continental Shelf (OCS). As offshore wind (OSW) development continues to mature and offshore wind leases are developed in deeper waters, the size and type of the offshore wind components are likewise expected to grow, and the project footprint will change as the use of floating OSW technology begins to be deployed. This may result in changes in the types of potential effects and interactions seen to date for fixed-bottom offshore wind projects. NYSERDA is conducting studies to investigate the implications of developing floating offshore wind in deeper waters. Findings from the studies will be used to support the identification of areas that present the greatest opportunities and least risk for siting deepwater offshore wind projects, and other workstreams designed to help assure the continued responsible siting and development of offshore wind energy.

Five desktop environmental studies compile and analyze existing data on resources in the Area of Analysis (AoA) that may be sensitive to OSW development. Three zones comprise the AoA: Zone 1 is on the outer continental shelf (60–150 m deep), Zone 2 is at the shelf break and slope (150–2,000 m deep), and Zone 3 includes the area beyond the continental slope (2,000–3,000 m deep).

For this study, the most up-to-date, readily available data were included in a desktop study summarizing current knowledge of the distribution, density, and seasonal occurrence of these species groups. Marine mammal and sea turtle species known to occur in the AoA were assigned to 11 receptor groups based on susceptibility to specific “stressors” from OSW development. Results of the desktop analysis were then synthesized to assess data gaps and provide specific recommendations on how these gaps might be addressed.

Results from the desktop study indicate that the density and distribution of marine mammals and sea turtles in the AoA are dependent on season and habitat type. Several areas are predicted to have high densities of marine mammals and sea turtles, in particular, those above submarine canyons, which are known to be hotspots for biological productivity related to upwelling and nutrient mixing. Species with coastal affinities such as seals and harbor porpoise (high-frequency cetaceans) show heavy predicted use of the continental shelf (Zone 1). Zone 2, which includes the continental slope, shows high-predicted densities of mid- and low-frequency cetaceans and deep- and shallow-diving cetaceans, particularly in areas with steep bathymetric features that contribute to nutrient upwelling and mixing. North Atlantic right whales (NARW) show heavy use of continental shelf habitat northeast of Zone 1, which is adjacent to foraging habitat for this species and where the AoA overlaps with NARW critical foraging habitat. The density of sea turtles in the AoA is generally highest in the southwest portion of Zone 1 west of Hudson Canyon; however, variability exists on a seasonal basis. Sea turtles (mainly Leatherback) are also more likely to use the deepwater areas of Zone 3 than the continental slope (Zone 2).

The habitat-based density models used to predict the distribution, density, and seasonal occurrence of marine mammals and sea turtles had nearly complete spatial coverage in terms of spatial predictions for these species in the AoA. An exception was the lack of data for harbor porpoise in Zone 3 from December to May. The underlying uncertainty in these models should be taken into account and is also discussed. Other key data gaps also exist for marine mammals and sea turtles, which limit conclusive risk assessments, including a lack of empirical data on the hearing range of baleen whales and information on the distribution and habitat use of different age classes for sea turtles, such as post-hatchling versus non-hatching sea turtles. There is also limited data on effects (if any) to marine mammals and sea turtles as a result of heated effluent discharge from offshore high-voltage direct current (HVDC) power conversion stations used in some OSW farms; effects of electromagnetic fields (EMFs); potential effects of artificial light at night; effects of decommissioning activities; the potential effects of in-water structures on ocean hydraulic and nutrient dynamics, which can influence marine mammal and sea turtle prey distribution and availability; and the magnitude and effects of operational noise from the large, 12+ megawatt turbines currently planned for United States OSW farms.

Key uncertainties identified in fixed and floating OSW include cumulative impacts from multiple concurrent wind farm developments and uncertainties related to climate change, both in terms of shifting species distributions and the implications for spatially explicit risk assessments, such as this one, as well as potential confounding factors when attempting to parse out the effects of OSW development on marine mammals and sea turtles from those due to climate change.

Future considerations include the following:

- Prioritizing ongoing surveys for marine mammals and sea turtles, in particular, visual surveys where data are collected in accordance with established line-transect and distance sampling methods.
- Conducting telemetry (tagging) studies of marine mammals and sea turtles, which can provide information about animal use of submarine habitats, behavioral responses, and foraging behavior.
- Observing seasonal restrictions on OSW farm construction in shelf habitats to minimize impacts on NARW.
- Maintaining awareness that areas inshore of the AoA—even though not the focus of this analysis—are important habitat for marine mammals and sea turtles and will be subject to environmental stressors associated with OSW development.
- Protecting marine mammals and sea turtles in deep water by preventing accumulation of debris on floating turbine tether cables.
- Establishing long-term, purposeful monitoring programs to help assess the environmental impacts of fixed and floating OSW development in the AoA.
- Gathering data to fill knowledge gaps concerning baleen whale and sea turtle hearing and behavioral responses to OSW development.
- Recognizing that best management practices (BMPs) evolve with iterative OSW projects and as new information becomes available.

In order to further address data gaps related to OSW stressors on marine mammal and sea turtles, data being collected at fixed and floating OSW farms currently under construction should be widely shared, including information regarding animal sightings and acoustic detections, effective detection ranges, observed behavioral responses, and underwater noise levels generated during construction, operations, and decommissioning activities.

1 Introduction

For more than a decade, New York State has been conducting research, analysis, and outreach to evaluate the potential for offshore wind energy. New York State Energy Research and Development Authority (NYSERDA) led the development of the New York State Offshore Wind Master Plan (Master Plan), a comprehensive roadmap and suite of more than 20 studies for the first 2,400 megawatts (MW) of offshore wind energy. The Master Plan encourages the development of offshore wind in a manner that is sensitive to environmental, maritime, economic, and social issues while addressing market barriers and aiming to lower costs. The Master Plan included spatial studies to inform siting of offshore wind energy areas. Now, NYSERDA is undertaking new spatial studies to review the feasible potential for deepwater offshore wind development at or exceeding depths of 60 meters in the New York Bight and to support the future identification of additional lease areas in the region.

Planning processes considering the development of offshore wind in the deepwater areas examined in each of NYSERDA's spatial studies must consider these studies in the context of one another. Decision making must additionally consider different stakeholders and uses, and will require further adjusted approaches and offshore wind technologies to ensure the best outcome. Globally, deepwater wind technology is less mature and primarily concentrated on floating designs at the depth ranges assessed through these spatial studies, while deepwater fixed foundations are at their upper technical limit within the Area of Analysis (AoA). Therefore, floating designs were predominantly considered since most, if not all, of the AoA would likely feature floating offshore wind. NYSERDA, along with other state and federal agencies, is developing research and analysis necessary to take advantage of opportunities afforded by deepwater offshore wind energy by assessing available and emerging technologies and characterizing the cost drivers, benefits, and risks of floating offshore wind. Findings from these studies and available datasets will be used to support the identification of areas that present the greatest opportunities and least risk for siting deepwater offshore wind projects.

Offshore wind energy development is being introduced into a highly dynamic and human-influenced system. These reports seek to better understand the potential interaction of offshore wind development and marine wildlife and habitats; however, it is important to consider these within the broader context of climate change and existing land-based and marine activities. The State will continue to conduct research through its established Technical Working Groups (TWGs) concerning the key subjects of fishing, maritime commerce, the environment, jobs, environmental justice, and the supply chain. These TWGs were designed to inject expert views and the most recent information into future decision making.

Taken together, the information assembled in these spatial studies will help empower New York State and its partners to take the informed steps needed to capitalize on the unique opportunity presented by offshore wind energy.

1.1 Spatial Studies to Inform Lease Siting

- Benthic Habitat Study
- Birds and Bats Study
- Deepwater Wind Technologies – Technical Concepts Study
- Environmental Sensitivity Analysis
- Fish and Fisheries Data Aggregation Study
- Marine Mammals and Sea Turtles Study
- Maritime Assessment – Commercial and Recreational Uses Study
- Offshore Wind Resource Assessment Study Zones 1 and 3
- Technology Assessment and Cost Considerations Study

Each of the studies was prepared in support of a larger planning effort and shared with relevant experts and stakeholders for feedback. The State addressed comments and incorporated feedback received into the studies. Feedback from these diverse groups helps to strengthen the studies, and also helps ensure that these work products will have broader applicability and a comprehensive view. Please note that assumptions have been made to estimate offshore wind potential and impacts in various methodologies across the studies. NYSERDA does not necessarily endorse any underlying assumptions in the studies regarding technology and geography including but not limited to turbine location, turbine layout, project capacity, foundation type, and point of interconnection.

The Energy Policy Act of 2005 amended Section 8 of the Outer Continental Shelf Lands Act (OCSLA) to give BOEM the authority to identify offshore wind development sites within the Outer Continental Shelf (OCS) and to issue leases on the OCS for activities that are not otherwise authorized by the OCSLA, including wind development. The State recognizes that all development in the OCS is subject to review processes and decision-making by BOEM and other federal and State agencies. This collection of spatial studies is not intended to replace the BOEM wind energy area identification process and does not commit the State or any other agency or entity to any specific course of action with respect to offshore wind energy development. Rather, the State's intent is to facilitate the principled planning of future offshore development along the New York coast, provide a resource for the various stakeholders, and encourage the achievement of the State's offshore wind energy goals.

1.2 Study Area

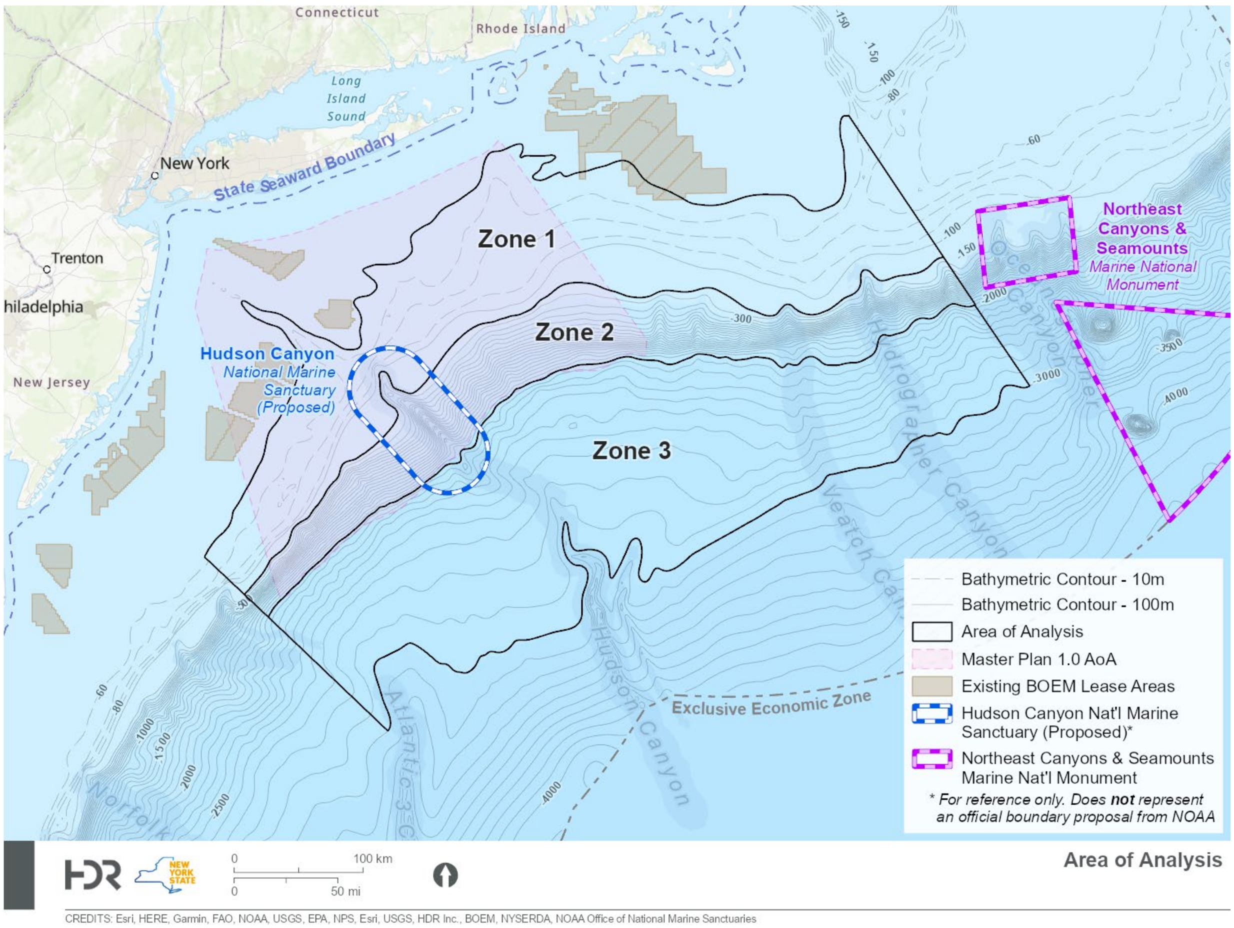
The spatial studies will evaluate potential areas for deepwater offshore wind development within a specific geographic Area of Analysis (AoA) of approximately 35,670 square miles of ocean area extending from the coast of Cape Cod south to the southern end of New Jersey (Figure 1). It includes three zones extending outward from the 60-meter depth contour, which ranges between 15 and 50 nautical miles (nm) from shore to the 3,000-meter contour, which ranges from 140 to 160 nm from shore.

The eastern edge of the AoA avoids Nantucket Shoals and portions of Georges Bank, since those areas are well known to be biologically and ecologically important for fish and wildlife, fisheries, and maritime activity. The AoA does include areas such as the Hudson Canyon, which is under consideration to be designated as a National Marine Sanctuary and thus unlikely to be suitable for BOEM site leases. While offshore wind infrastructure will not be built across the entire AoA, The spatial studies will analyze this broad expanse to provide a regional context for these resources and ocean uses. Zone 1 is closest to shore and includes a portion of the Outer Continental Shelf. It extends from the 60-meter contour out to the continental shelf break (60 meters [197 feet] to 150 meters [492 feet] deep). Zone 1 is approximately 12,040 square miles.

- Zone 2 spans the steeply sloped continental shelf break, with unique canyon geology and habitats (150 meters [492 feet] to 2,000 meters [6,561 feet] deep). Zone 2 is approximately 6,830 square miles.
- Zone 3 extends from the continental shelf break out to 3,000 meters (9,842 feet) depth. Zone 3 is approximately 16,800 square miles.

Zone 2, stretching across the steeply sloped continental shelf break with its distinctive canyon geology and unique habitats, is less likely to be suitable to host offshore wind turbines, but is still likely to be impacted by offshore wind development activities through maritime traffic and/or cabling and was therefore included in this study. The underwater canyons in this region are distinctive and ecologically significant, making Zone 2 an area of particular interest for scientific research, conservation efforts, and fish and benthic habitats. Another crucial factor prompting this analysis is the presence of electrical cabling in the area, which can have several environmental implications, including electromagnetic fields that might disrupt marine life and the physical disturbance of the seafloor during installation. Lastly, maritime vessel activities throughout the zone could involve shipping traffic, fishing, and other recreational activities related to the sea, which can introduce pollutants, noise, and physical disturbances such as vessel strikes that may have adverse effects on the surrounding environment.

Figure 1. Area of Analysis



1.3 Study Objectives

This study aims to build up on the information provided in the New York Offshore Wind Master Plan by aggregating available information on marine mammals and sea turtles in and near the AoA.

More specific objectives include:

1. Compile and analyze existing marine mammal and sea turtle studies and data sources.
2. Understand and synthesize marine mammal and sea turtle presence, distribution, and habitat use-patterns within, and in close proximity to the AoA. There is a specific focus on endangered species and deep-diving species, such as beaked whales and Sperm whales *(Physeter macrocephalus)*.
3. Identify and discuss gaps and uncertainties in marine mammal and sea turtle data, associated methods to address data gaps.
4. Identify existing marine mammal and sea turtle relevant research or workstreams within the AoA.
5. Analyze densities through a stressor and receptor matrix to evaluate seasonal and development stage risks (i.e., vessel collision, noise) to marine mammals and sea turtles as well as practices to avoid, minimize, or mitigate impacts.
6. Describe and characterize any additional aspects of uncertainty relating to potential impacts to marine mammals and sea turtles.

Results of this study are intended to inform the relative risk that potential wind energy areas pose to marine mammals and sea turtles and identify potential permitting risks, building on the information collected from previous tasks.

This identification process should help to provide detail on relative conflicts across the AoA, areas of least conflict, areas to consider avoiding based on high ecological or economic importance and any aspects of these that warrant further consideration to inform decision making. Further, these relative densities will be analyzed through a stressor and receptor matrix to evaluate seasonal and development stage risks. Analysis of data may help shape the spatial or temporal trends or identify data sources that require in-depth modeling to gather a better understanding of the identified AoA.

This study focuses on resources in the AoA. Section 1 describes the study area, study objectives, regulatory framework, stakeholder engagement process, and report organization. Section 2 discusses methods used for the literature review and data collection process, geospatial analysis, and gap analysis, and also provides a basic overview of the abundance and density models (developed as part of a separate effort) used to assess marine mammal and sea turtle distribution and density in the AoA. Section 3 describes the marine mammal and sea turtle species included in the analysis, summarizes key data sources, and presents a series of distribution and density maps for these species, organized by receptor group. Section 4 lists the potential stressors associated with each phase of deepwater OSW development and how they may affect marine mammals and sea turtles. Section 5 describes existing guidance for impact avoidance, minimization, and mitigation for marine mammals and sea turtles during each phase of OSW development. Section 6 identifies key uncertainties in assessing impacts of OSW development on marine mammals and sea turtles in the AoA, discusses data gaps identified in this study and summarizes future considerations to close these gaps and reduce sources of uncertainty in impact assessment.

This study is one of a series of environmental desktop studies that synthesize available and relevant existing data sets on four key resource groups: marine mammals and sea turtles; birds and bats; fish and fisheries, and benthic habitat. Each of these reports identifies potential stressors from all phases of OSW development for each resource group, with a focus on deepwater technology. A fifth report builds upon and compiles the results from the four studies into the single environmental sensitivity analysis and presents a series of maps showing areas of greatest (or least) risk from OSW development.

1.4 Regulatory Framework

The OCSLA (43 United States Code [U.S.C.] §1331 et seq.) defined submerged lands under federal jurisdiction as the outer continental shelf and assigned authority for leasing to the Secretary of the Interior. In 2005, the Energy Policy Act (42 U.S.C. §13201 et seq.) amended the OCSLA to clarify uncertainties about OSW and granted development authority to the Secretary of the Interior. The BOEM Office of Renewable Energy Programs facilitates the responsible development of renewable energy resources on the OCS. These regulations provide a framework for issuing leases, easements, and rights-of-way for OCS activities that support production and transmission of energy from sources other than oil and natural gas. BOEM is currently in the planning and analysis phase of identifying deepwater wind energy areas off the New York and New Jersey coasts. This phase is to collect information, reduce potential conflicts of use, and identify areas that are potentially suitable for lease sale. BOEM conducts an environmental assessment once the wind energy areas are established.

Several federal statutes, regulations, and policies are pertinent to the future development of OSW farms in the AoA. Specifically, those statutes relevant to the protection of marine mammals, sea turtles, and their habitats include the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), the Magnuson-Stevens Fishery Conservation Act, the OCSLA, the Coastal Zone Management Act, and the Inter-American Convention for the Protection and Conservation of Sea Turtles, under which the U.S. has agreed to reduce human activities that could potentially affect sea turtles. Understanding these statutes and the agency regulations and policies associated with their implementation is important to the development of OSW farms. As part of the

NEPA process, consultation with the U.S. Fish and Wildlife Service (USFWS) is required under Section 7 of the ESA for listed species. Although the AoA falls under federal jurisdiction, this study also takes into account high priority Species of Greatest Conservation Need, as listed by the New York State Department of Environmental Conservation (NYSDEC) and other neighboring state agencies. A detailed summary of these statutes, regulations, and policies is presented in the Master Plan (NYSERDA 2017).

1.5 Agency and Stakeholder Engagement

NYSERDA is committed to engaging with and incorporating stakeholder feedback in offshore wind planning processes. Stakeholder comments from the Master Plan were reviewed, and as practical, incorporated into this study. State agency partners were engaged in the development and review of this Mammal and Sea Turtle Study, consisting of New York State Department of State, New York State Office of Parks, Recreation, and Historic Preservation, New York State Department of Transportation, Empire State Development, New York Department of Public Service, New York State Office of General Services, and New York State Department of Labor.

To involve stakeholders in the development and analysis of this study, two stakeholder groups have been consulted. A Project Advisory Committee (PAC) comprised of marine mammal and sea turtle subject matter experts from State, federal, non-governmental groups and developers have been involved in assisting with identification of data sources, stressors (section 4) and species receptor groups (section 3.1.1) and have provided comments on the draft study.

Prior to the development of this study, information was shared with the Marine Mammals and Sea Turtles Study PAC, and virtual meetings were held to discuss technical details of this study as well as data and ranking criteria feeding into the environmental sensitivity analysis. Conference call dates for the Marine Mammals and Sea Turtles Study PAC were on 12 May 2023 and 5 June 2023. Additionally, NYSERDA's E-TWG provided a preliminary list of data sources used in the development of this report and also reviewed the draft report. Comments from both groups were addressed and, as practical, incorporated into this final report.

The State provided a first draft of this study for review by State and federal regulators, TWGs, and other stakeholders on 01 August 2023, and afforded these stakeholders the opportunity to submit written comments on the draft's contents. In addition, the E-TWG hosted meetings in September 2023, in which the study authors gave an overview of the document and fielded questions and concerns from participating organizations. In total, the State received over 100 written and verbal comments on the draft study from industry, the State, and non-governmental organizations. One of the major comments addressed was to better characterize the existing (ambient) underwater noise in the New York Bight to put noise associated with OSW development into context. Additionally, a more thorough discussion of noise levels from operational wind farms has been included based on stakeholder feedback. Additional results from passive acoustic monitoring studies have also been incorporated into this final study. The final study also includes more information about the uncertainty associated with the habitat-based density models used to predict species distribution in the AoA.

2 Methods

With the goal of building on, and expanding upon, the information contained in New York's Offshore Wind Master Plan, this study summarizes current knowledge about these species' use of the AoA, including shelf break, continental slope, and deepwater off-shelf areas. Also discussed are the various stressors (see section 4) associated with fixed and floating OSW farm development in the AoA. Specifically, this study expands upon the Master Plan by (1) including deepwater areas off the continental slope and areas farther east, roughly to Oceanographer Canyon (Figure 1); (2) reviewing species occurrence, abundance, and seasonal distribution information that has become available since the preparation of the Master Plan; and (3) considering the potential impacts of floating wind technology—more suited to deepwater regions—on these species, which was not addressed in the Master Plan. A variety of data sets were reviewed and analyzed for this effort, including vessel- and aerial-based surveys, passive acoustic monitoring (PAM) surveys, tagging (telemetry) surveys. Appendix A contains a comprehensive list of data sources used in this study.

2.1 Literature and Data Review

A detailed literature and data review was conducted for this study, utilizing standard methods for identifying, downloading, and reviewing available information about marine mammals, sea turtles, and their potential interaction with OSW. These methods included a review of relevant reports and publications, as well as survey data available on regional data portals (e.g., Northeast and Mid-Atlantic Ocean Data Portals), data from federal and State agency-specific data providers (e.g., National Oceanic and Atmospheric Administration [NOAA] Fisheries, NYSERDA), as well as from other known regional data providers (e.g., The Wildlife Conservation Society [WCS], the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations [OBIS-SEAMAP]). The information compiled during this process was used to determine marine mammal and sea turtle occurrence, distribution, abundance, and seasonal use of the AoA (section 3); conduct a detailed review of the stressors these species face from OSW development (section 4); and compile an updated list of approaches for avoidance and minimization and regulatory recommendations to mitigate the potential impacts of these stressors (section 5 and appendix C).

2.2 Geospatial Analysis

To maximize the utility of this study as a spatial planning exercise, publicly available data sets were obtained where possible and practical and added to a project-specific Geographical Information System (GIS) mapper in order to predict high-use areas for these species groups within the AoA. The primary data inputs for the geospatial analysis were the Habitat-Based Marine Mammal Density Models for the U.S. Atlantic[1] and the East Coast Turtle Density Models (DiMatteo et al. 2024). Both sets of density models are publicly available and hosted on the OBIS-SEAMAP Model Repository.[2] Both the marine mammal and sea turtle density models are based on visual detections of animals during systematic line-transect surveys. Where appropriate and recommended by the PAC, additional data sets were also included in the geospatial analysis (i.e., tag tracks) to assess the degree of agreement among data sets.

2.3 Gap Analysis

Once available information was identified, compiled, reviewed, and analyzed as described above, key data gaps were identified, including gaps in spatial and/or temporal survey coverage and data-poor species. Recommendations were also made regarding specific methods and research tools to address these gaps.

2.4 Density Modeling

2.4.1 Marine Mammals

Habitat-based Marine Mammal Density Models for the U.S. Atlantic used in this analysis were developed by the Duke University Marine Geospatial Ecology Lab and funded by the U.S. Navy.[3] Collectively, these models and density (i.e., number of animals per unit area) estimates are generally regarded as the best information currently available for marine mammals in the U.S. Atlantic for purposes of spatial planning and addressing spatiotemporally explicit management problems (Roberts et al. 2016a, 2016b). For example, the National Marine Fisheries Service Office of Protected Resources (NMFS OPR) requires that applicants for MMPA permits use these models to estimate marine mammal take for Incidental Take Authorizations. The density models were developed using available visual survey data collected in accordance with established line-transect and distance sampling methods (Buckland et al. 2001). Habitat-based density modeling has the advantage of predicting where marine mammals are likely to occur when survey effort is low or does not exist for a geographical area or species. These predictions are achieved in part using environmental covariates correlated with known marine mammal habitat (Roberts et al. 2023). The 95% and 5% Confidence Interval (CI), the coefficient of variation

(CV), and Standard Error (SE) grids are provided for each modeled species and species guild as supporting statistical measures of model uncertainty.[4] In 2022, there were major updates to the habitat-based models with substantial additional data and improved statistical methods, and the spatial resolution was increased to 5 kilometers (km) (Roberts et al. 2023). As part of these updates, the models were extended further inshore, from New York State through Maine. All environmental covariates were updated to newer products when available, and several covariates were added to the set of candidates. For models that incorporated dynamic covariates, model uncertainty was estimated using a new method that accounts for both model parameter error and temporal variability. In June 2023, another update to the models was conducted as part of a comprehensive update developed for the U.S. Navy's Atlantic Fleet Training and Testing (AFTT) Phase IV Environmental Impact Statement. All models were updated to include taxon-specific documentation; however, the update did not change any density, CV, or SE rasters. Seasonal predictions were included for all marine mammal species groups for which monthly abundance data was available. For some species (e.g., Blue whale [*Balaenoptera musculus musculus*]), only annual abundance estimates were available due to the limited temporal resolution of sightings data. Modeled species groups, temporal resolution of density surface models, and other model characteristics are shown in Table 1.

Table 1. Marine Mammal and Sea Turtle Density Model Characteristics

Source: Roberts et al. 2023; DiMatteo et al. 2024.

Species	Monthly Prediction (Yes or No)	Density = Zero in AoA (Yes or No)
North Atlantic right whale	Yes	No
Humpback whale	Yes	No
Fin whale	Yes	No
Sei whale	Yes	No
Common Minke whale	Yes	No
Blue whale	No	No
Sperm whale	Yes	No
Dwarf and pygmy sperm whale	No	Yes, except Zones 2 and 3
Northern bottlenose whale	No	No
Mesoplodont beaked whales	Yes	No
Cuvier's beaked whale	No	Yes, except Zones 2 and 3
Killer whale	No	No
Pygmy killer whale	N/A	Yes, except Zones 2 and 3
False killer whale	No	No
Melon-headed whale	No	Yes
Risso's dolphin	Yes	No
Pilot whales	Yes	No
Atlantic white-sided dolphin	Yes	No
White-beaked dolphin	No	Yes, except Zone 1
Short-beaked common dolphin	Yes	No
Atlantic spotted dolphin	Yes	No
Pantropical spotted dolphin	No	No
Striped dolphin	Yes	No
Fraser's dolphin	No	Yes
Rough-toothed dolphin	No	No
Clymene dolphin	No	Yes, except Zones 2 and 3
Spinner dolphin	No	No
Common bottlenose dolphin	Yes	No
Harbor porpoise	Yes	No
Seals	Yes	No
Green Sea Turtle	Yes	Yes, except Zones 1 and 2
Kemp's Ridley Sea Turtle	Yes	No
Leatherback Sea Turtle	Yes	No
Loggerhead Sea Turtle	Yes	No

2.4.2 Sea Turtles

Density surface models were developed and released in May 2023 for four species of sea turtles in the U.S. Atlantic.[5] In November 2023, the Leatherback Sea Turtle density predictions were updated to correct a problem where an incorrect perception bias estimate was used. This update resulted in a 60% decrease in density across the model range. Also funded by the U.S. Navy, these models estimate long-term monthly averages of density, abundance, and distribution for green (*Chelonia mydas*), Kemp's Ridley (*Lepidochelys kempii*), Leatherback (*Dermochelys coriacea*), and Loggerhead (*Caretta caretta*) Sea Turtles. These estimates represent the first broad-scale in-water estimates of abundance and distribution for these species off the U.S. east coast since 2003. Sea turtle sightings (n = 25,208) were recorded as Loggerhead, Green, Kemp's Ridley, Hawksbill (*Eretmochelys imbricata*), Leatherback, or unidentified turtle; however, because there were only six confirmed Hawksbill sightings, this species was not modeled. Density estimates were expressed as the number of individuals per square km within the study area, which extended from Maine to Florida throughout the U.S. Exclusive Economic Zone (EEZ). Survey effort covered approximately 1.2 million linear km (770,000 linear mi): 39,831 km (24,749 mi) of shipboard surveys and 1,151,880 km (715,745 mi) of aerial surveys conducted from 2003 to 2019. Surveys were conducted in all seasons, although effort was concentrated in the warmer months. The study area was gridded into 10 by 10 km (6.2 by 6.2 mi) blocks (see Table 3 in Sparks and DiMatteo 2023). Sea turtle density estimates represent the monthly mean for each block, averaged for the period 2003 to 2019, except for the green turtle model, which covered only 2010 to 2019. For most of the study area, density was estimated using a spatial density surface model that correlated local abundance observed during systematic line transect surveys with environmental conditions observed at that same location and time. For areas not surveyed and times, density was estimated by extrapolation.[6] Modeled species groups, temporal resolution of density surface models, and other model characteristics are shown in Table 1.

Estimates of the CV for each model were calculated, as were CIs for monthly and annual abundance estimates (see Figures 58–81 in Sparks and DiMatteo 2023). For Loggerhead Sea Turtles, uncertainty was highest in waters off the shelf, which were poorly sampled, and low on the continental shelf, where the majority of effort and sightings occurred. For Green Sea Turtles, uncertainty was highest in waters close to the shelf break, where there were fewer sightings. For Kemp's Ridley Turtles, uncertainty was higher farther from shore than the model predicted. For Leatherback Sea Turtles, uncertainty was higher offshore, where there was less survey effort and fewer sightings. Note that these spatial patterns of uncertainty apply to the entire U.S. East Coast and were not calculated for the AoA. Also note that relative uncertainty applies only to model parameters and not to other sources of uncertainty, such as detection function uncertainty and environmental variability.

3 Marine Mammals and Sea Turtles in the Area of Analysis

This section contains a summary of key data sources reviewed for the study, as well as results from the geospatial analysis.

3.1 Marine Mammal and Sea Turtle Species Included in this Study

Forty marine mammal and four sea turtle species are known to occur in the western North Atlantic Ocean (Table 2 and Table 3). Marine mammals found in this region include cetaceans (whales and dolphins) and pinnipeds (seals). Cetaceans with teeth are referred to as odontocetes, and cetaceans that instead use baleen to filter food from the water column are referred to as mysticetes. Table 2 summarizes the estimated abundance, federal and State conservation status, distribution, and seasonal occurrence of marine mammals in the Western North Atlantic, which includes the AoA. This list was compiled by reviewing relevant Stock Assessments prepared by NOAA Fisheries (Hayes et al. 2023) as well as recent data from visual and acoustic surveys performed in and near the AoA. The PAC also reviewed this species list and provided input. As a result, the occurrence designation for two baleen whale species (Sei [*Balaenoptera borealis borealis*] and Blue) in the AoA was changed from "rare" to "uncommon."

Table 3 summarizes the estimated abundance, federal and State conservation status, distribution, and seasonal and occurrence of sea turtles in the Western North Atlantic. This list was compiled by reviewing species status reports prepared by NMFS and USFWS for ESA-listed sea turtles.[7] The PAC also reviewed this species list and provided input. As a result, the Distinct Population Segment (DPS) information for Leatherback Sea Turtles was removed (there is in fact no DPS for Leatherbacks).

With the exception of harp (*Pagophilus groenlandicus*), hooded (*Cystophora cristata*), and ringed seals (*Pusa hipsida*), all of the marine mammal species shown in Table 2 were included in the habitat-based density models developed by Roberts et al.,[8] either as individual species or species groups (Table 4). Likewise, all four sea turtle species shown in Table 2 were included in the density models developed by DiMatteo et al. (2024). All modeled species groups were included in the study. In some cases, modeled density was zero in one or more zones of the AoA (Table 1 and Table 5) but were nevertheless included in the analysis for completeness.

Table 2. Marine Mammals that May Occur in or Near the Area of Analysis (AoA; Zones 1–3) from Georges Bank to Exclusive Economic Zone Waters Extending Off Delaware Bay

The Bryde's whale is not included here as multiple lines of evidence indicate this species is extremely rare in the U.S. waters of the North Atlantic (Rosel et al. 2021).

Species/Scientific Name	Stock Area	Estimated Abundance[a]	ESA / MMPA Status[b,c]	State Status[d]				Distribution and Seasonal Occurrence in the Western North Atlantic[e]
				NJ	NY	RI	MA	
Mysticetes								
North Atlantic right whale (*Eubalaena glacialis*)	Western North Atlantic	338	E; S	E	E	E	E	Coastal and Continental Shelf; Winter, Spring, and Fall (year-round)
Humpback whale (*Megaptera novaeangliae*)	Gulf of Maine	1,396	NL	E	E	NL	E	Coastal and Continental Shelf; Year-round, migratory in spring and fall, coastal feeding spring through fall)
Fin whale (*Balaenoptera physalus*)	Western North Atlantic	6,802	E; S	E	E	NL	E	Coastal and Continental Shelf; Year-round)
Sei whale (*Balaenoptera borealis borealis*)	Nova Scotia	6,292	E; S	E	E	NL	E	Continental Shelf; Spring and Summer (possibly year-round)
Common Minke whale (*Balaenoptera acutorostrata acutorostrata*)	Canadian East Coast	21,968	NL	NL	NL	NL	NL	Coastal and Continental Shelf; Spring, Summer, and Winter (possibly year-round)
Blue whale (*Balaenoptera musculus musculus*)	Western North Atlantic	402[f]	E; S	E	E	NL	E	Continental Slope and Oceanic; Spring and Summer
Odontocetes								
Sperm whale (*Physeter macrocephalus*)	North Atlantic	4,349	E; S	E	E	NL	E	Continental Slope and Oceanic; Year-round with peak in summer
Dwarf sperm whale (*Kogia sima*)	Western North Atlantic	7,750	NL	NL	NL	NL	NL	Continental Slope and Oceanic; Year-round
Pygmy sperm whale (*Kogia breviceps*)	Western North Atlantic		NL	NL	NL	NL	NL	Continental Slope and Oceanic; Year-round
Northern bottlenose whale (*Hyperoodon ampullatus*)	Western North Atlantic	Unknown	NL	NL	NL	NL	NL	Continental Slope and Oceanic; Not Expected
Cuvier's beaked whale (*Ziphius cavirostris*)	Western North Atlantic	5,744	NL	NL	NL	NL	NL	Continental Slope and Oceanic
Mesoplodont beaked whales (*Mesoplodon densitostris, M. europaeus, M. mirus, and M. bidens*)	Western North Atlantic	10,107	NL	NL	NL	NL	NL	Continental Slope and Oceanic
Killer whale (*Orcinus orca*)	Western North Atlantic	Unknown	NL	NL	NL	NL	NL	Oceanic; Spring, Rare[J]
Pygmy killer whale (*Feresa attenuata*)	Western North Atlantic	Unknown	NL	NL	NL	NL	NL	Continental Shelf and Oceanic; Not Expected
False killer whale (*Pseudorca crassidens*)	Western North Atlantic	1,791	NL	NL	NL	NL	NL	Continental Slope and Oceanic; Not Expected
Melon-headed whale (*Peponocephala electra*)	Western North Atlantic	Unknown	NL	NL	NL	NL	NL	Oceanic; Not Expected
Risso's dolphin (*Grampus griseus*)	Western North Atlantic	35,215	NL	NL	NL	NL	NL	Continental Slope and Oceanic (range contracts to Mid-Atlantic Bight in winter)
Pilot whale, long-finned (*Globicephala melas*)	Western North Atlantic	39,215	NL	NL	NL	NL	NL	Continental Shelf, Slope and Oceanic (northward along slope in late-winter and spring, more on shelf in late-summer and fall)
Pilot whale, short-finned (*Globicephala macrorhynchus*)	Western North Atlantic	28,924	NL	SI[h]	NL	NL	NL	Continental Shelf, Slope and Oceanic (northward along slope in late-winter and spring, more on shelf in late-summer and fall)
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	Western North Atlantic	93,233	NL	NL	NL	NL	NL	Coastal, Continental Shelf and Slope
White-beaked dolphin (*Lagenorhynchus albirostris*)	Western North Atlantic	536,016	NL	NL	NL	NL	NL	Continental Shelf
Common dolphin (*Delphinus delphis*)	Western North Atlantic	172,974	NL	NL	NL	NL	NL	Continental Shelf and Slope (shift north of AoA summer to fall)
Atlantic spotted dolphin (*Stenella frontalis*)	Western North Atlantic	39,921	NL	NL	NL	NL	NL	Continental Shelf and Slope
Pantropical spotted dolphin (*Stenella attenuata*)	Western North Atlantic	6,593	NL	NL	NL	NL	NL	Continental Slope and Oceanic; Not Expected
Striped dolphin (*Stenella coeruleoalba*)	Western North Atlantic	67,036	NL	SI[h]	NL	NL	NL	Continental Slope and Oceanic (spring concentration along shelf edge in Mid-Atlantic Bight)
Fraser's dolphin (*Lagenodelphis hosei*)	Western North Atlantic	Unknown	NL	NL	NL	NL	NL	Continental Slope and Oceanic; Not Expected
Rough-toothed dolphin (*Steno bredanensis*)	Western North Atlantic	136	NL	NL	NL	NL	NL	Continental Slope, Shelf, and Oceanic
Clymene dolphin (*Stenella clymene*)	Western North Atlantic	4,237	NL	NL	NL	NL	NL	Continental Slope and Oceanic; Not Expected
Spinner dolphin (*Stenella longirostris longiristris*)	Western North Atlantic	4,102	NL	NL	NL	NL	NL	Continental Slope and Oceanic; Not Expected
Common bottlenose dolphin (*Tursiops truncatus*)	Western North Atlantic, Offshore	62,851	NL	SI[h]	NL	NL	NL	Outer Continental Shelf and Slope (Year-round, mostly absent in winter when shift southward)

Table 2 continued

Species/Scientific Name	Stock Area	Estimated Abundance[a]	ESA / MMPA Status[b,c]	State Status[d]				Distribution and Seasonal Occurrence in the Western North Atlantic[e]
				NJ	NY	RI	MA	
Common bottlenose dolphin (*Tursiops truncatus*)	Western North Atlantic, Northern Migratory Coastal	6,639	NL; S	SI[h]	NL	NL	NL	Coastal, Year-round
Harbor porpoise (*Phocoena phocoena*)	Gulf of Maine, Bay of Fundy	95,543	NL	SI[h]	SC[i]	NL	NL	Coastal (Year-round) and Continental Shelf (Year-round but less abundant in summer)
Pinnipeds								
Harbor seal (*Phoca vitulina concolor*)	Western North Atlantic	61,336	NL	NL	NL	NL	NL	Coastal; Summer, Fall, and Winter
Gray seal (*Halichoerus grypus*)	Western North Atlantic	27,300	NL	NL	NL	NL	NL	Coastal; Spring and Fall
Harp seal (*Pagophilus groenlandicus*)	Western North Atlantic	7.6 million	NL	NL	NL	NL	NL	Coastal; Spring and Winter
Hooded seal (*Cystophora cristata*)	Western North Atlantic	Unknown[g]	NL	NL	NL	NL	NL	Coastal and Continental Shelf; Spring and Winter
Ringed seal (*Pusa hipsida*)	N/A	No SAR	N/A	NL	NL	NL	NL	Coastal and Continental Shelf

Key: E = endangered; ESA = Endangered Species Act; m = meter(s); MA = Massachusetts; MMPA = Marine Mammal Protection Act; NJ = New Jersey; NL = not listed; NY = New York; RI = Rhode Island; S = strategic; SAR = Stock Assessment Report; spp. = species.

* The Bryde's whale is not included here as multiple lines of evidence indicate this species is extremely rare in the U.S. waters of the North Atlantic (Rosel et al. 2021).

[a] Estimated abundance from the SARs (Hayes et al. 2023) generally consider only the portion of the population found in U.S. Exclusive Economic Zone (EEZ) waters and may not include the entire U.S. range, depending on available survey data. Most cetacean population estimates are based on the Atlantic Marine Assessment Program for Protected Species (AMAPPS) surveys (NOAA Northeast Fisheries Science Center [NEFSC] and SEFSC 2016, 2018, 2019, 2020, 2021, 2022; Palka 2020; Palka et al. 2021; Hayes et al. 2023), with the exceptions of the following: North Atlantic right whales (NARWs) are based on the maximum number of photo-identified individuals constructed from the recapture database as it existed in January 2021 and included photographic information up through November 2019 (Pace et al. 2017; Pace 2021; Hayes et al. 2023); however, based on data through 20 August 2022, the NARW population estimate for 2021 was 340 whales (Pettis et al. 2023); and Blue whales are based on photo-identified individuals, mainly in the St. Lawrence estuary and northwestern Gulf of St. Lawrence from 1980 to 2008 (Ramp and Sears 2013; Hayes et al. 2020). The harbor seal population estimate was updated in 2018 and is based on a Bayesian hierarchical analysis of abundance trends from 1993 to 2018 (Sigourney et al. 2021; Hayes et al. 2023), and the harp seal abundance is estimated by fitting age-structured population models to estimates of total pup production in Canada (DFO 2020; Hayes et al. 2023).

[b] In the MMPA, the term "strategic stock" is defined as a marine mammal stock—(a) for which the level of direct human-caused mortality exceeds the potential biological removal level; (b) which, based on the best available scientific information, is declining and is likely to be listed as a threatened species under the ESA [16 U.S.C. 1531 et seq.] within the foreseeable future; or (c) which is listed as a threatened species or endangered species under the ESA (16 U.S.C. 1531 et seq.), or is designated as depleted.

[c] In the ESA (16 U.S.C. 1531-1544), the term "endangered species" means any species that is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to humans. The term "threatened species" means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

[d] Source: NJ: New Jersey Department of Environmental Protection 2023; NY: New York State Department of Environmental Conservation 2015; RI: Earth's Endangered Creatures 2023; and MA: Commonwealth of Massachusetts 2023.

[e] The distribution of marine mammals tends to be coastal, along the continental shelf, continental slope, and/or oceanic (deep) waters. These are general distributions and do not preclude the occurrence of any species in any area within the AoA. Coastal stocks typically do not extend to the shelf break and are generally close to shore. Continental shelf stocks are not typically found on the shallow water plain extending to the slope area, where depth drops quickly to >1,000 meters (m). Determination of general distribution of marine mammals for purposes of this table was based on their occurrence in the Study Area, defined as Coastal (<200 m depth) and Oceanic (>200 m depth) (86 FR 58434; Braun et al. 2022).

[f] The minimum population estimate for the Blue whale is reported as the estimated abundance in the SAR.

[g] Hayes et al. (2023) reported the abundance estimates for hooded seals as "unknown" because surveys have not been conducted within the U.S. due to the northerly location of rookeries; however, they also reported that estimates based on surveys at pupping areas north of the U.S. have resulted in population estimates of 593,500 for hooded seals from 1984 to 2005 (Hammill and Stenson 2006).

[h] SI = Species of Interest are those with possible conservation concern based on data available in New Jersey and/or their status in surrounding states and/or species for which more information is needed in New Jersey. See below for the list of species of interest in New Jersey.

[i] SC = Species of special concern warrant attention and consideration, but current information collected by the department does not justify listing these species as either endangered or threatened.

[J] Based on the spring 2019 AMAPPS survey, killer whales could be encountered in small numbers (NEFSC and SEFSC 2020).

Table 3. Sea Turtles Known to Occur in or Near the Area of Analysis (AoA) from Georges Bank to Exclusive Economic Zone Waters Extending Off Delaware Bay

Species/Scientific Name	Distinct Population Segment (DPS)[a]	Estimated Abundance	ESA Status	State Status				Main Distribution in the Western North Atlantic
				NJ	NY	RI	MA	
Leatherback Turtle (*Dermochelys coriacea*)	N/A	20,659[b]; 1,694[c]	E	E	E	E	E	Coastal and Continental Shelf (Spring to fall with peak in summer)
Loggerhead Turtle (*Caretta caretta)*	Northwest Atlantic Ocean DPS	588,000[d]	T	E	T	NL	T	Coastal and Continental Shelf (Spring to fall with peak in summer)
Kemp's Ridley Turtle (*Lepidochelys kempii*)	N/A	248,307[e]	E	E	E	NL	E	Coastal and Continental Shelf (Spring to fall with peak in summer)
Green Turtle (*Chelonia mydas*)	North Atlantic DPS	167,424[f]; 8,393[g]	T	T	T	NL	T	Coastal and Continental Shelf (Spring to fall with peak in summer)

Key: E = Endangered; N/A = not applicable; NL = not listed; T = Threatened.

a DPS = Distinct Population Segment defined under the ESA (76 FR 58868).

b The total index of nesting female abundance for the Northwest Atlantic DPS is 20,659 females (NMFS and USFWS 2020).

c The total index of nesting female abundance for the United States to include Florida, North Carolina, South Carolina, Puerto Rico, and St. Croix is 1,694 females (NMFS and USFWS 2020).

d NMFS and USFWS 2023.

e NMFS and USFWS 2015.

f The total index of nesting female abundance for North Atlantic DPS to include Costa Rica (Tortuguero), Mexico (Campeche, Yucatan, and Quintana Roo), U.S. (Florida), and Cuba is 167,424 females (Seminoff et al. 2015).

g The total index of nesting female abundance for the United States is 8,393 females (Seminoff et al. 2015).

Table 4. Marine Mammal and Sea Turtle Receptor Groups Considered in This Study

Note: ESA = Endangered Species Act; UME = Unusual Mortality Event.

Receptor Group	Members of Receptor Group
High-Frequency Cetaceans	Harbor porpoise, dwarf and pygmy Sperm whales.
Mid-Frequency Cetaceans	Sperm whale, northern bottlenose whale, beaked whale spp., Pilot whale spp., , common dolphin, killer whale, pygmy killer whale, false killer whale, melon-headed whale, Risso's, Atlantic white-sided, white-beaked, Atlantic spotted, Pantropical spotted, striped, Fraser's, rough-toothed, Clymene, spinner, common bottlenose dolphin.
Low-Frequency Cetaceans	Baleen whales - Blue, Sei, Minke, Fin, Humpback.
North Atlantic Right Whale	North Atlantic right whale (NARW).
Other Marine Mammals of Special Conservation Status	ESA-listed cetaceans (Fin, Sei, Blue, Sperm whales) and any marine mammals under UME designation (Humpback whales, Gray and Harbor seals, Minke whales).
Deep-Diving Cetaceans	Sperm whale, pygmy and dwarf sperm whale, beaked whale spp., Pilot whale spp., northern bottlenose whale.
Shallow-Diving Cetaceans	Harbor porpoise, baleen whales (except NARW), common dolphin, killer whale, pygmy killer whale, false killer whale, melon-headed whale, Risso's, Atlantic white-sided dolphin, white-beaked, Atlantic spotted dolphin, Pantropical spotted dolphin, striped dolphin, Fraser's dolphin, rough-toothed, Clymene dolphin, spinner dolphin, common bottlenose dolphin.
Seals	Harbor, Gray, Hooded, Ringed, and Harp Seals.
Post-hatchling dispersal stage (all sea turtle species)	Post-hatchling Loggerhead, Leatherback, Kemp's Ridley, and Green Sea Turtles.
Juvenile, subadult, and adult hard-shelled sea turtles	Non-hatchling Loggerhead, Kemp's Ridley, and Green Sea Turtles (may include unidentified hardshell).
Juvenile, subadult, and adult Leatherback Sea Turtles	Non-hatchling Leatherback Sea Turtles.

Table 5. Marine Mammal and Sea Turtle Habitat Use and Occurrence in and Near the Area of Analysis

Species or Species Group/Scientific Name	Dive Profile/Vertical Habitat[a, c]		Occurrence Category[c]		Occurrence in Area of Analysis Zones[b]		
	0–200 meters (m)	>200 m	Coastal	Oceanic	Zone 1 60–150 m	Zone 2 150–2,000 m	Zone 3 2,000–3,000 m
North Atlantic right whale (*Eubalaena glacialis*)	X		X		X	X	X
Humpback whale (*Megaptera novaeangliae*)	X		X		X	X	X
Fin whale (*Balaenoptera physalus*)	X		X	X	X	X	X
Sei whale (*Balaenoptera borealis borealis*)	X		X	X	X	X	X
Common Minke whale (*Balaenoptera acutorostrata acutorostrata*)	X		X	X	X	X	X
Blue whale (*Balaenoptera musculus musculus*)	X		X	X	X	X	X
Sperm whale (*Physeter macrocephalus*)		X		X	X	X	X
Dwarf sperm whale (*Kogia sima*)		X		X	-	X	X
Pygmy sperm whale (*Kogia breviceps*)		X		X	-	X	X
Northern bottlenose whale (*Hyperoodon ampullatus*)		X		X	X	X	X
Cuvier's beaked whale (*Ziphius cavirostris*)		X		X	-	X	X
Mesoplodont beaked whales (*Mesoplodon densitostris, M. europaeus, M. mirus, and M. bidens*)		X		X	X	X	X
Killer whale (*Orcinus orca*)	X		X	X	X	X	X
Pygmy killer whale (*Feresa attenuata*)	X		X	X	-	X	X
False killer whale (*Pseudorca crassidens*)	X		X	X	X	X	X
Melon-headed whale (*Peponocephala electra*)	X		X	X	-	-	-
Risso's dolphin (*Grampus griseus*)	X		X	X	X	X	X
Pilot whales (*Globicephala* spp.)		X	X	X	X	X	X
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	X		X		X	X	X
White-beaked dolphin (*Lagenorhynchus albirostris*)	X		X		X	-	-
Short-beaked common dolphin (*Delphinus delphis*)	X		X	X	X	X	X
Atlantic spotted dolphin (*Stenella frontalis*)	X		X		X	X	X
Pantropical spotted dolphin (*Stenella attenuata*)	X		X	X	X	X	X
Striped dolphin (*Stenella coeruleoalba*)	X		X	X	X	X	X
Fraser's dolphin (*Lagenodelphis hosei*)	X		X	X	-	-	-
Rough-toothed dolphin (*Steno bredanensis*)	X		X	X	X	X	X
Clymene dolphin (*Stenella clymene*)	X		X	X	-	X	X
Spinner dolphin (*Stenella longirostris longiristris*)	X		X	X	X	X	X
Common bottlenose dolphin (*Tursiops truncatus*)	X		X		X	X	X
Harbor porpoise (*Phocoena phocoena*)	X		X		X	X	X
Seals (Phocidae)	X		X		X	X	X
Green Sea Turtle	X		X		X	X	-
Kemp's Ridley Sea Turtle	X		X		X	X	X
Leatherback Sea Turtle	X		X		X	X	X
Loggerhead Sea Turtle	X		X		X	X	X

[a] Shallow-diving cetaceans were defined as those inhabiting the coastal or epipelagic zone habitat (>200 meters [m] depth or 659 feet [(ft)] deep). Deep-diving cetaceans were defined as those inhabiting the mesopelagic zone (from 200 m to 1,000 m [3,300 ft]), and the bathypelagic zone (from >1,000 m to 4,000 m [13,000 ft]) (Braun et al. 2022; NOAA 2023a; 86 FR 58434).

[b] Occurrence in the AoA is based on the Roberts et al. (2023) habitat-based density surface models, See Table 8 and Table 9.

[c] Source: Table 12 in 86 FR 58434; Jefferson et al. 2015, X denotes primary range.

3.1.1 Receptor Groups

Marine mammals and sea turtles were assigned to eleven "receptor" groups (Table 4) based on susceptibility to specific "stressors" (Table 6) from OSW development in the AoA. These stressors are described in detail in section 4, and include underwater noise, vessel traffic, new structures, bottom disturbance, and others. Receptor groups were chosen based on the potential risk associated with these stressors: various cetacean species may have different risks associated with noise based on hearing range (i.e., high-, mid-, and low-frequency); marine mammals of special conservation status (including those that are ESA-listed as well as those experiencing unusual mortality events (UMEs); NOAA Fisheries 2023d) (Table 7) may be more sensitive due to population stress, and North Atlantic right whales (NARW) (*Eubalaena glacialis*) may be very sensitive to these stressors for similar reasons but to an even greater extent; shallow- and deep-diving cetaceans may have different likelihoods of vessel strikes, and various life stages and species of sea turtles may be more sensitive to different OSW stressors. Therefore, these receptor groups are evaluated as separate groups (Table 4). Because the purpose is to evaluate the sensitivity of these groups in the context of specific stressors, there is intentional redundancy among groups, and one species may fall into two or more groups. For example, Humpback whales are evaluated for potential risk in the context of (low frequency) noise, ship strikes, and overall sensitivity to OSW stressors because of their involvement in an ongoing UME. It should also be noted that the receptor groups as defined here are not absolute; for example, certain shallow-diving species such as striped dolphins can spend time at deeper depths and certain deep-diving cetaceans such as Pilot whales may forage at shallower depths. Likewise, our understanding of species distribution at various depths and distances from shore will evolve as new information is acquired.

Shallow versus deep diving cetaceans were defined as Coastal (<200 m depth) and Oceanic (>200 m depth) see Table 5. Generalized cetacean hearing groups: High-Frequency 275 hertz (Hz)–160 kilohertz (kHz); Mid-Frequency 150 Hz–160 kHz; and Low-Frequency 7 Hz–35 kHz; and Seals in water 50 Hz–86 kHz, see section 4.1.3. Sea Turtle generalized hearing range of 50 Hz–1200 kHz, see section 4.1.3.

Table 6. Key Stressors to Marine Mammals and Sea Turtles from Offshore Wind Development

Key: EMF = electromagnetic field; UXO = unexploded ordnance.

Pre-Construction	Construction	Post-Construction / Operation	Decommissioning
Noise-Generating Surveys	Noise-Generating Surveys; Construction Noise	Noise-Generating Surveys; Operational Noise	Noise-Generating Surveys; (De)construction Noise
Bottom Disturbance	Bottom Disturbance	Bottom Disturbance	Bottom Disturbance
Vessel Traffic	Vessel Traffic	Vessel Traffic	Vessel Traffic
UXO Detonation	Changes in Water Quality	Changes in Water Quality	Changes in Water Quality
	Artificial Lighting	Artificial Lighting	Artificial Lighting
		In-Water Structures (Includes Entanglement)	
		Seafloor Scouring	
		EMF	
		Changes to Oceanographic Dynamics	

Table 7. Marine Mammal Unusual Mortality Events in the Western North Atlantic Ocean

Source: https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events

Species	Minke Whale[b]	Humpback Whale	North Atlantic Right Whale	Harbor Seal	Gray Seal	Harp Seal	Harbor Seal and Gray Seal
Scientific Name	*Balaenoptera acutorostrata*	*Megaptera novaeangliae*	*Eubalaena glacialis*	*Phoca vitulina*	*Halichoerus grypus*	*Pagophilus groenlandicus*	*Phoca vitulina and Halichoerus grypus*
Date of UME Declared	January 2017	April 2017	June 2017	June 2022			July 2018
Date of Last Reported Case	August 2023	August 2023	July 2023	July 2023			May 2020
Name of UME[a]	Atlantic Minke Whale	Atlantic Humpback Whale	North Atlantic Right Whale	Northeast Pinniped			Northeast Pinniped[d]
Status of UME	Non-active, pending closure	Active	Active	Active			Non-active, pending closure
Body of Water (Location of the UME)	Atlantic Ocean (Atlantic coast from Maine through South Carolina)	Atlantic Ocean (Atlantic coast from Maine through Florida)	Atlantic Ocean (Canada and the United States)	Atlantic Ocean (Along the Maine Coast)			Atlantic Ocean (Maine, New Hampshire, and Massachusetts)
Cause of UME	Suspect Human Interaction (Entanglement)/Infectious Disease)	Suspect Human Interaction (Vessel Strike)	Human Interaction (Vessel Strike/Rope Entanglement)	Infectious Disease			Infectious Disease
Total Number Dead, Injured, or Sick Cases[b]	158	208	115[c]	379	65	6	3,152
Massachusetts Dead, Injured, or Sick Cases	55	41	7	N/A			1,010
Rhode Island Dead, Injured, or Sick Cases	11	10	0				No reported strandings
New York Dead, Injured, or Sick Cases	25	43	1				172
New Jersey Dead, Injured, or Sick Cases	11	29	1				101

[a] Although there is no active UME for Minke whales, the 2017–2023 Minke Whale Unusual Mortality Event along the Atlantic Coast is a Nonactive UME pending closure; however, with the recent mortalities (n = 17 as of August 2023), the UME may stay open. Prior mink whale UMEs have been declared in 2003, 2003–2004, 2004, and 2005. Since the inception of UMEs in 1991, there have been five UMEs declared for Northeast Pinnipeds: in 1991, 1992, 2006, 2011, 2018 and the present UME. The Northeast Large Whale or Gulf of Maine Large Whale UMEs were declared for Humpback whales in 2003, 2005, 2005–2006, and the present UME. North Atlantic right whale UMEs have been declared in 1996, and 2017 (the present UME).

[b] Stranding numbers as of August 2023.

[c] Most mortality, serious injury, and morbidity (sublethal injury and illness) cases have occurred in Canadian waters. Of the 115 documented dead, serious injuries, or sublethal injuries/illnesses, 36 have died, 34 were from serious injuries, and 45 from sublethal injuries or illnesses due to vessel strikes, entanglement, unknown causes, and perinatal mortality; however, only one-third of deaths are documented.

[d] Harp and hooded seals started stranding with clinical signs, not in elevated numbers, and the two seal species were added to the UME investigation.

3.2 Data Summary

Sources summarized in this section focus on information that has become available since the preparation of the Master Plan, as well as information about species distribution in areas not included in the Master Plan AoA (e.g., beyond the 2,000-m isobath). The survey datasets used to build the marine mammal and sea turtle density models include the NYSDEC Whale Monitoring Program Aerial Surveys 2017–2020 (e.g., Tetra Tech and LGL [2020]), as well as the New England Aquarium (NEAq) Northeast Canyons Marine National Monument Aerial Surveys 2017–2020 (e.g., Redfern et al. [2021]), are described in the respective technical reports for those models (Roberts et al. 2023; Sparks and DiMatteo 2023) and are therefore not summarized here. A comprehensive summary of historical species occurrence and distribution data in the Master Plan AoA (Figure 1) can be found in NYSERDA (2017). A complete list of data sources used in this study can be found in appendix A, and the data sets used to build the marine mammal and sea turtle density models can be found in appendix B.

3.2.1 Atlantic Marine Assessment Program for Protected Species Aerial and Vessel-Based Surveys

The Atlantic Marine Assessment Program for Protected Species (AMAPPS) is a comprehensive, multi-agency research program in the U.S. Atlantic Ocean. Since 2010, systematic surveys have been performed to assess the abundance, distribution, ecology, and behavior of a variety of marine species, including marine mammals and sea turtles. Data collected during these surveys was incorporated into the habitat-based density models for marine mammals developed by Roberts et al.,[9] as well as the density models for sea turtles developed by DiMatteo et al. (2024), the results from which are discussed in section 3.3.2. The most recent AMAPPS data included in these models are from 2019 (see appendix B, section B.1.1; Palka et al. 2021). More recent shipboard and aerial surveys were performed in fall 2019/2020 and summer 2021 (NEFSC and SEFSC 2020, 2021, 2022). Because these data are not reflected in the current versions of the density models and were not available at the time of writing for incorporation into the geospatial analysis, key findings are summarized here.

3.2.1.1 Marine Mammals

In fall 2019, Northeast Fisheries Science Center (NEFSC) conducted an aerial line-transect survey for purposes of animal abundance estimation. Surveys covered Atlantic waters from Nova Scotia to New Jersey, extending from the coastline to the outer continental slope at approximately the 2,000-m depth contour (NEFSC and SEFSC 2020, 2021). Marine mammal species observed in and near the AoA included bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), Cuvier's beaked whale (*Ziphius cavirostris*), Risso's dolphin (*Grampus griseus*), Pilot whales (*Globicephala* sp.), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), harbor porpoise (*Phocoena phocoena*), Fin whale (*Balaenoptera physalus*), Humpback whale (*Megaptera novaeanglie*), common Minke whale (*Balaenoptera acutorostrata acutorostrata*), Sperm whale, gray seal (*Halichoerus grypus*), and harbor seal (*Phoca vitulina concolor*) (NEFSC and SEFSC 2020).

Systematic aerial surveys were performed in summer 2021, from the coast out to the 200-m isobath. Marine mammal species observed in and near the AoA included common dolphin, bottlenose dolphin, Risso's dolphin, Pilot whales, Minke whale, Fin whale, and Humpback whale (NEFSC and SEFSC 2022).

Systematic vessel-based surveys were performed in summer 2021 in waters offshore of the 100-m depth contour. Marine mammal species observed in and near the AoA included Atlantic spotted dolphin (*Stenella frontalis*), bottlenose dolphin, short-beaked common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*), short-finned Pilot whale (*Globicephala macrorhynchus*), Blue whale, Atlantic white-sided dolphin, false killer whale[10] (*Pseudorca crassidens*), Cuvier's beaked whale, Risso's dolphin, Sperm whale, Humpback whale, and Fin whale. Sightings of taxa not identified to species included Pilot whales, unidentified beaked whale, and Fin/Sei whale (NEFSC and SEFSC 2022).

3.2.1.2 Sea Turtles

As described above, an aerial line-transect survey covering Atlantic waters from Nova Scotia to New Jersey and extending from the coastline to the outer continental slope at approximately the 2,000-m depth contour was conducted in fall 2019. Sea turtle species observed in or near the AoA included green, Leatherback, and Loggerhead Sea Turtles (NEFSC and SEFSC 2020).

Systematic aerial surveys were performed in summer 2021 from the coast out to the 200-m isobath. Sea turtle species observed in and near the AoA during these surveys included Loggerhead, Leatherback, Green, Kemp's Ridley Sea Turtles, and unidentified hardshell turtles. Sea turtle species observed in and near the AoA during the 2021 systematic vessel surveys included Loggerhead, Leatherback, and unidentified hardshell turtles (NEFSC and SEFSC 2022).

3.2.2 NYSERDA Offshore Planning Area Aerial Surveys

From summer 2016 through 2019, NYSERDA sponsored high-resolution aerial digital surveys in the New York Bight[11]. Surveys were conducted on a quarterly basis and covered the Offshore Planning Area (OPA), from Long Island southeast to the continental slope. The OPA corresponds roughly to the Master Plan study area but extends further inshore to the State seaward boundary (Figure 1). None of the waters in Zone 3 were included in these surveys.

3.2.2.1 Marine Mammals

Of the marine mammal species groups observed, dolphins were the most abundant, consisting of 97% of the observations, followed by 1% whales and 1% seals; unidentified mammals consisted of 1.5% of the total mammal observations. Dolphins were abundant in all seasons, particularly in spring and summer surveys. Except for unidentified dolphins, the common dolphin was the most abundant species in all but one seasonal survey (the summer 2016 survey had more Risso's dolphin encounters). Pilot whales, Risso's dolphin, striped dolphin, Atlantic white-sided dolphin, Atlantic spotted dolphin (*Stenella frontalis*), and rough-toothed dolphin (*Steno bredanensis*) were encountered in deeper water at the shelf break throughout the year. Dolphins were most frequently traveling in an east-southeast to west-northwest direction. Fin whales were the most abundant species during the summer, fall, and winter 2017–2018 surveys, while common Minke whales were the most abundant species during the winter 2016–2017 and spring surveys. Humpback whales had the same relative abundance as common Minke whales in spring 2017 and 2019 but were outnumbered by Minke and Sei whales in the spring 2018 survey. NARWs were observed during the winter 2016–2017 and spring 2017 surveys. Sperm whales were observed in the summer 2017, summer 2018, fall 2016, fall 2018, and winter 2018–2019 surveys. Whales were generally encountered more often in waters over the shelf break, although fin, Humpback, Minke, and NARWs were also found elsewhere in the OPA. No spatial distribution patterns by season were evident. Whales were most frequently observed traveling in an east-southeast to west-northwest direction (Normandeau Associates Inc. and APEM Ltd. 2021a).

3.2.2.2 Sea Turtles

Turtles were most frequently observed during summer surveys, with 97% of the observations occurring during this season. Loggerhead Sea Turtles were the species most frequently seen, representing 74% of the total observations. During the fall 2016 survey, the majority of sightings were Leatherback Sea Turtles, whereas in the fall 2017 survey, the majority were Loggerhead and Kemp's Ridley Sea Turtles. For the remaining surveys, Loggerhead Sea Turtles were the most abundant species. A single green turtle was observed during the summer 2016 survey. No turtles were observed during the winter 2017–2018, winter 2018–2019, or fall 2018 surveys. Most turtles observed during the summer, along with Leatherback Sea Turtles observed during the fall, occurred inside the 70-m isobath. Outside of these findings, there were no obvious spatial patterns among species or seasons. Turtle travel direction followed primarily a west-northwest to east-southeast direction (Normandeau Associates Inc. and APEM Ltd. 2021b).

3.2.3 Wildlife Conservation Society Vessel Surveys for Baleen Whales in the New York Bight

In order to study the distribution and behavior of baleen whales in the New York Bight, dedicated, non-systematic small vessel surveys were conducted from May to November 2017–2019 in nearshore (<10 km from shore) and mid-shelf (10 to 60 km from shore) waters (King et al. 2021). Over the three years of survey effort, 61 survey trips (n = 15 in 2017, n = 15 in 2018, and n = 31 in 2019) were conducted, consisting of just over 7,500 km of on-water survey effort. Roughly half of that distance was surveyed in 2019, with an almost equal distance covered in 2017 and 2018. A total of 195 sightings were recorded: 150 sightings of Humpback whales, 23 sightings of Fin whales, and 22 sightings of Minke whales. Humpback whales were observed throughout the nearshore region and in two distinct areas of the mid-shelf region (King et al. 2021). Fin and Minke whales were more often encountered in the mid-shelf region. Survey effort was concentrated in nearshore and mid-shelf waters and did not overlap with the AoA. Some surveys approached the 60-m isobath north of Hudson Canyon (King et al. 2021).

3.2.4 Mid-Atlantic Marine Mammal Tagging Studies

In order to examine the spatial use, diving, and foraging behavior of odontocetes in continental shelf and shelf slope waters, over 90 individuals of seven species were instrumented with satellite-tracked tags in the Low-Impact Minimally Percutaneous External-electronics Transmitter configuration off Cape Hatteras, North Carolina between 2014 and 2017.[12] Work was performed as part of a collaborative study between Cascadia Research Collective and Duke University and funded by the U.S. Navy. Tagged animals of two species [14 individual short-finned Pilot whales and one short-beaked common dolphin] had locations in the AoA (See section 3.3.1.1 for more details). Results demonstrated the importance of continental slope habitat for these species, including the use of steep bathymetric features as foraging habitat for deep-diving odontocetes, although given the distance of the AoA from the tagging site, tag tracks may show tag location bias and animal locations may therefore be underrepresented in the AoA (Hays et al. 2020).

In 2015, a multi-faceted study was initiated in order to characterize the movement patterns, dive behavior, and habitat use of cetaceans in the offshore Mid-Atlantic shelf and shelf break region (Engelhaupt et al. 2022). Between 2015 and 2023, 141 individuals of 6 species were instrumented with satellite-tracked tags off Virginia Beach, Virginia: 77 Humpback whales, 40 Sperm whales, 18 Fin whales, 3 NARW, 2 Blue whales, and 1 Sowerby's beaked whale (*Mesoplodon bidens*) (Engelhaupt et al. 2022). The tracks of 10 tagged Sperm whales, 3 Fin whales, and 1 Humpback whale overlapped with the AoA (a NARW was also tagged in spring 2022 as part of this project but its track did not overlap with the AoA—see section 3.3.1.4 for details). Given the duration of the satellite tags (weeks to months) locations recorded by the tags may reflect tag location bias, with areas distant to the tagging site (such as the AoA) potentially being underrepresented in space and time (Hays et al. 2020). Results confirmed findings from multiple studies (Kenney and Winn 1986, Palka 2023) that shelf edge habitat from Cape Hatteras to Georges Bank is important habitat for a wide range of mysticete and odontocete species. Work was performed by HDR and Amy Engelhaupt Consulting under contract to the U.S. Navy.

From 2018 to 2022, 14 harbor seals representing a variety of age classes (young-of-the-year, juvenile, and adult) were captured and instrumented with satellite tags at haul-out sites on the eastern shore of Virginia. The goal of the study was to examine the habitat use, movement, and haul-out patterns of tagged seals in the Hampton Roads region of Chesapeake Bay and coastal Atlantic Ocean (Ampela et al. 2023). All 14 tags (seven deployed in 2018, two in 2020, and five in 2022) recorded 29,554 locations over 1,566 tracking days. The mean number of tracking days was 112 (SD±26.88 days; range 62–159 days). Only three tag locations overlapped with the AoA (see section 3.3.1.8 for more details), demonstrating the importance of inshore and shelf habitat for this species. Although reflective of a small sample size, results are of interest as this study represents some of the only wild harbor seal tag data in the Mid-Atlantic. Work was performed as part of a collaborative study between the U.S. Navy, The Nature Conservancy, the Atlantic Marine Conservation Society, NOAA Fisheries, and HDR, Inc.

3.2.5 Robots4Whales Digital Acoustic Monitoring Buoy and Seaglider Detections in the New York Bight

Since 2016, autonomous platforms instrumented with digital acoustic monitoring (DMON) instruments have been deployed in the New York Bight and off the coast of Atlantic City, New Jersey. This project is a collaborative effort between the Woods Hole Oceanographic Institution (WHOI), WCS, Stony Brook University, and Rutgers University, with the goal of monitoring the presence of baleen whales in near real-time by automatically detecting and identifying their calls (WHOI 2023). Low-frequency detection and classification systems were implemented on the DMONs to identify marine mammal calls. The results from these deployments indicate that the presence of baleen whales can be determined using autonomous platforms equipped with DMONs.[13] Species that have been detected in near real-time include Fin whale, Sei whale, Humpback whale, and NARW (WHOI 2023). Results from acoustic monitoring performed from June 2016 to January 2020 indicated that NARWs were present in the Bight from November to April in every year, and were also detected in October, May, June, and/or July in various years (Murray et al. 2022). Findings from this study are relevant to marine mammals only, as PAM does not provide information about sea turtles.

3.2.6 Gray Seal Tagging Study

Satellite tags were deployed on 30 young-of-the-year gray seals in January 2019 and January 2020 at sites in coastal Maine and Massachusetts in order to investigate their post-weaning movements and habitat use.[14] Tags transmitted data for up to 287 days, and tagged seals traveled as far south as Delaware Bay and as far north as Sable Island, Canada.[15] Tagged gray seals utilized shelf and slope waters out to approximately the 200-m isobath, including portions of the AoA. Mid-Atlantic waters were used most heavily by tagged pups from January to June (Murray et al. 2021). Although this study focused on a single age class and does not provide insight into the habitat use of juvenile or adult gray seals in the AoA, it represents some of the only wild gray seal tag data in Mid-Atlantic waters.

3.3 Geospatial Analysis Results

The primary data inputs for the geospatial analysis were the Habitat-based Marine Mammal Density Models for the U.S. Atlantic[16] and the East Coast Turtle Density Models (DiMatteo et al. 2024) (see appendix B). These models are recognized by NMFS as the best available information for these species groups in the context of marine planning and protected species permitting[17]. However, there are several data sets applicable to the AoA that are not reflected in these density models, either because they were collected after the current versions of the models were developed, or because the survey methodology did not meet the criteria for inclusion in the modeling framework, that is, were not collected in accordance with distance sampling methodology (Roberts et al. 2023[18]). During the planning process for this study, the PAC recommended the inclusion of several additional datasets in the geospatial analysis including available animal telemetry (tagging) data, as well as data from recent visual surveys that were collected in a non-systematic manner or did not use the observer configuration required for distance sampling[19]. The goal of including these additional data sets in the spatial analysis was to better understand if there is general agreement (or lack thereof) among these models and data sets. This comparison was made with the understanding that various data sets were collected using different methodologies (i.e., sightings vs. telemetry data) at different spatial and temporal scales, and results should therefore be interpreted with these caveats in mind.

The following sections describe the distribution, density (i.e., number of animals predicted to occur per 100 square km [km^2]), and seasonal habitat use of marine mammals and sea turtles in and near the AoA. Results are organized by receptor group, which are listed in Table 4.

3.3.1 Marine Mammals

3.3.1.1 High-Frequency Cetaceans: Distribution, Density, and Seasonal Patterns

High-frequency cetaceans are defined as those that have a generalized hearing range of 275 Hz to 160 kHz (Table 4) and are, therefore, sensitive to high-frequency sounds. Three species of high-frequency cetaceans are found in the AoA: dwarf (*Kogia sima*) and pygmy sperm (*Kogia breviceps*) whales and harbor porpoise (Table 4). Habitat-based density models from Roberts et al. (2023) were used to predict seasonal density of this species group in the AoA. Roberts et al. (2023) modeled Dwarf and pygmy sperm whales together as a "guild" due to a paucity of confirmed sightings of each species. Monthly density estimates were not generated for this guild due to a lack of observations in certain seasons (particularly winter), and only annual density estimates were available for this analysis (Figure 2 and Figure 3). Therefore, harbor porpoise are the primary driver of the density patterns shown in these figures. It should also be noted that harbor porpoise model lacks spatial coverage in Zone 3 between December and May.

In the winter season, the highest predicted density region of high-frequency cetaceans straddles the 60-m isobath (which forms the inshore boundary of Zone 1), in the region south of Nantucket Sound, and reaches 37.77/100 km^2 (Figure 2). Relatively high densities are also predicted inshore of Zone 1, along the state's seaward boundary south of Long Island, east to the Hudson Shelf Valley. In winter, intermediate densities are predicted along the continental shelf in Zone 1, and comparatively low densities are predicted in the continental slope region, between the 60- and 150-m isobaths (Zone 2). In deep water, beyond the 2,000-m isobath (Zone 3), the predicted density of high-frequency cetaceans in winter is relatively low (Figure 2).

The predicted spring distribution of high-frequency cetaceans is similar to that in winter, but with a maximum of 48.46/100 km,^{2} concentrated inshore of Zone 1, but also extending into the AoA, northwest of Hydrographer Canyon (Figure 2). Intermediate densities of this species group are predicted along the continental shelf in Zone 1, and relatively low densities are predicted in Zone 2. As in winter, the predicted density of this species group in Zone 3 in spring (deep water) is also relatively low (Figure 2).

The summer (maximum 56.87/100 km^2) and fall (maximum 29.94/100 km^2) densities in and around the AoA differ from those in winter and spring, although broad-scale distribution patterns are similar, with the highest concentration of animals predicted inshore of Zone 1, southeast of Nantucket Island. A second cluster of intermediate density is predicted in summer and fall on the continental shelf in Zone 1 east of Hudson Canyon, and just beyond the shelf break in the upper continental slope (Figure 2). Density in this region is slightly higher in the fall compared to the summer. Intermediate to low densities are predicted elsewhere along the continental shelf in both seasons. Predicted densities are uniformly low in Zone 3 in both the summer and fall.

To better visualize the relationship between density levels across seasons, maps of density scaled to the annual highest density value are provided in Figure 3. When maps are scaled to the highest seasonal density value for each season, the same color on different seasonal maps does not represent the same density on these different maps; thus, scaling all seasonal maps for a receptor group to the highest annual density makes the densities represented by the colors match across the seasonal maps and better show changes in density among seasons. Seasons were defined as follows: winter (December–February), spring (March–May), summer (June–August), and fall (September–November). Overall, high-frequency cetaceans are predicted to be most common in the AoA in winter and spring (Figure 3).

This finding is consistent with the results from the NYSERDA OPA aerial surveys,[20] during which high-frequency cetaceans were observed in greatest numbers in the spring, followed by winter (Figure 4). Note that these aerial surveys did not cover all of the AoA. Effort in all seasons extended only to the 2,000-m isobath and covered roughly the western half of Zones 1 and 2 (Figure 4). Findings are also consistent with seasonal occurrence patterns observed in the New York Bight using PAM. For example, Rekdahl et al. (2023) reported that harbor porpoise were detected in the New York-New Jersey Harbor Estuary at low levels year-round, with seasonal peaks in presence in winter to spring (February to June).

Figure 2. High-Frequency Cetaceans: Scaled to Highest Seasonal Predicted Density

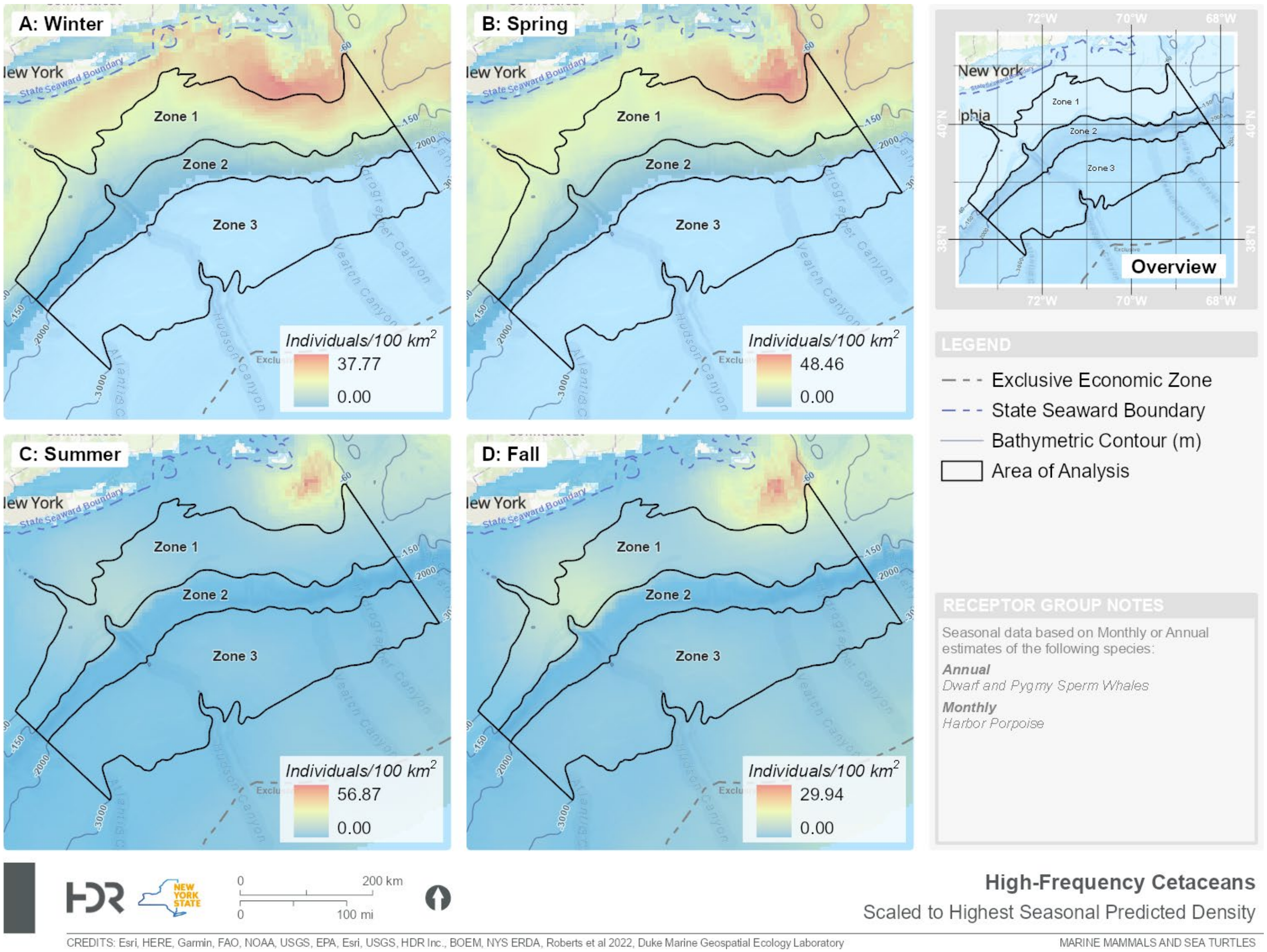


Figure 3. High-Frequency Cetaceans: Scaled to Highest Annual Predicted Density

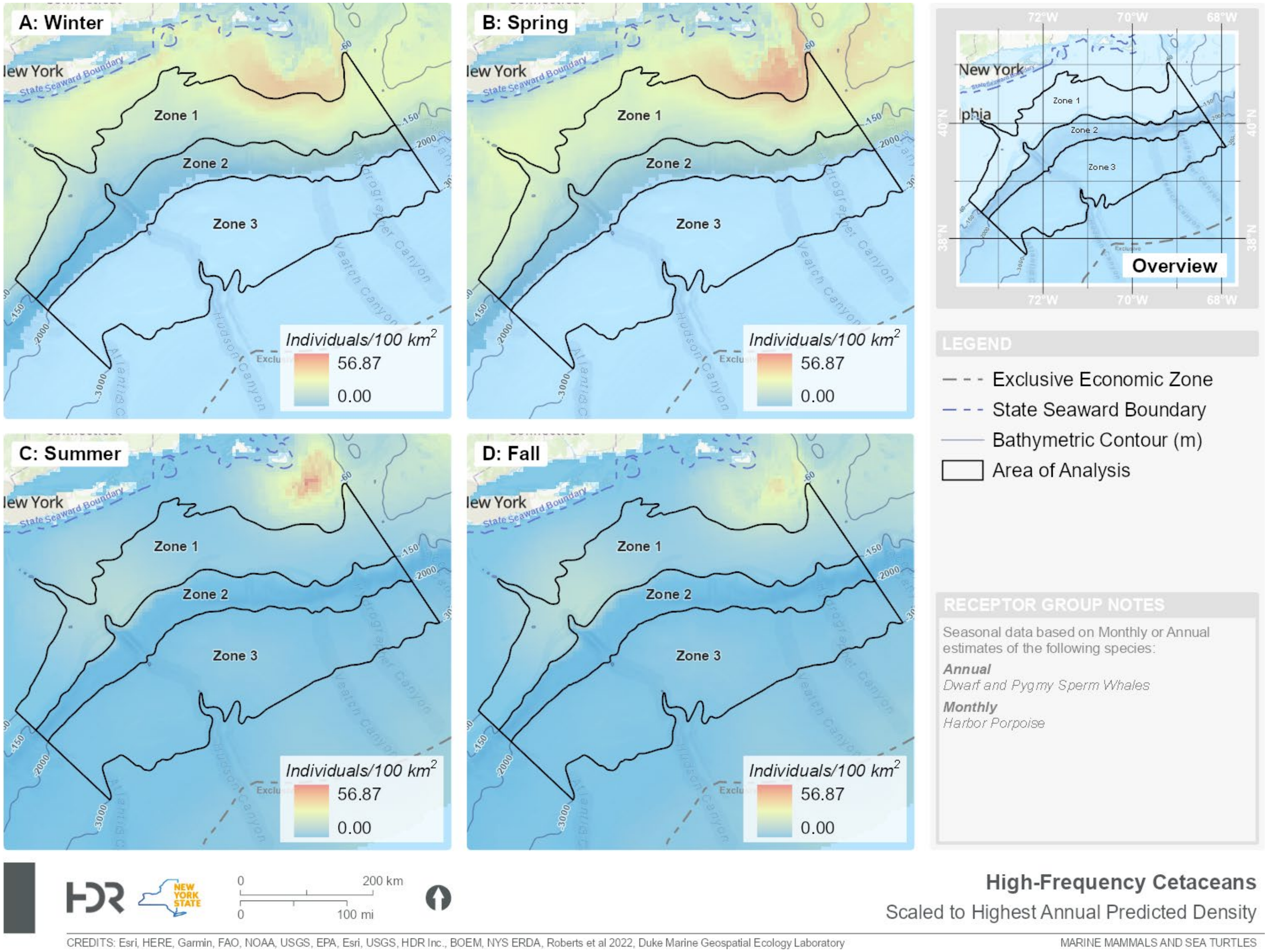
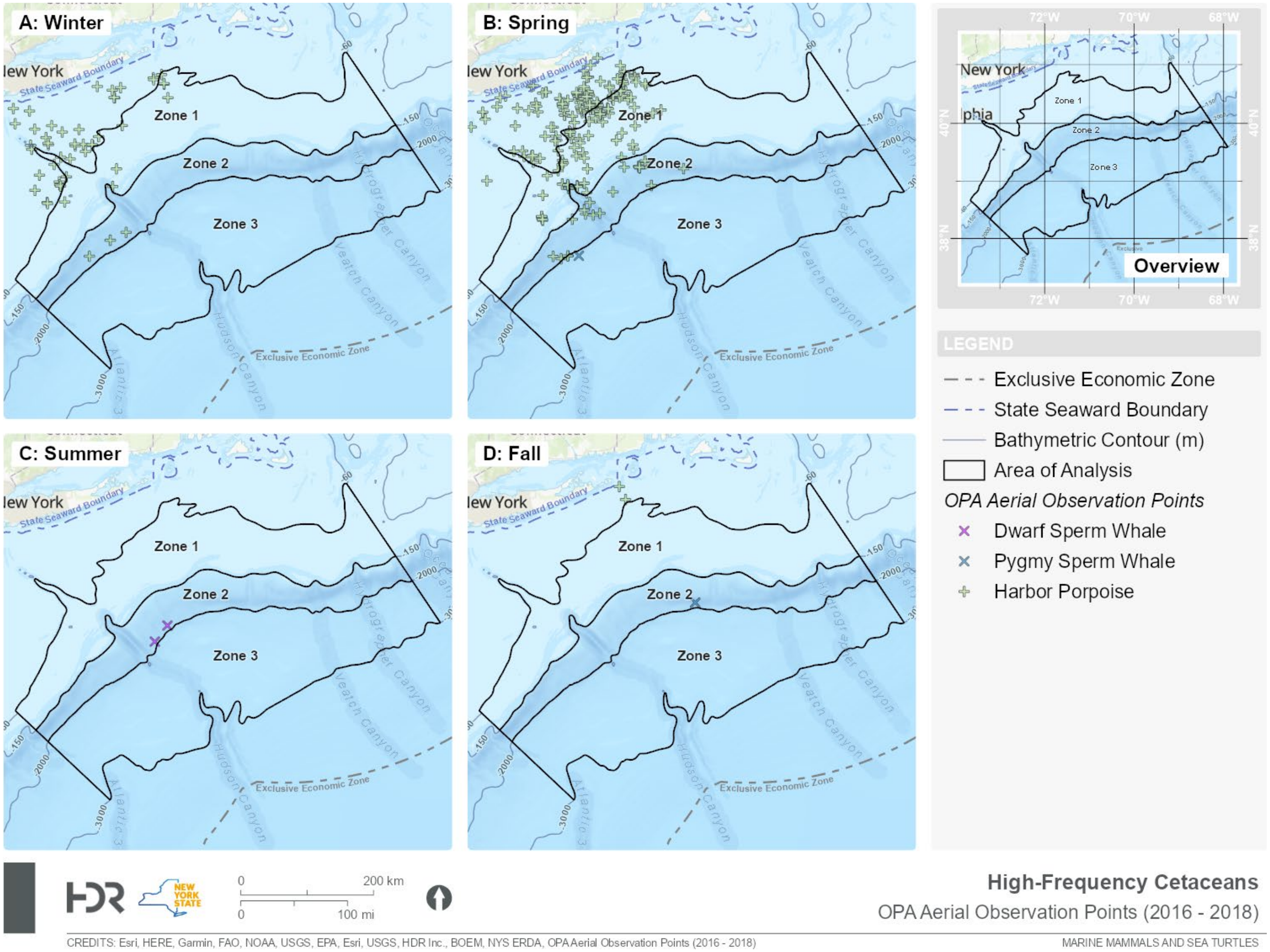


Figure 4. High-Frequency Cetaceans: Other Sighting Records



3.3.1.2 Mid-Frequency Cetaceans: Distribution, Density, and Seasonal Patterns

Mid-frequency cetaceans are defined as those that have a generalized hearing range of 150 Hz to 160 kHz (Table 4) and are, therefore, sensitive to mid-frequency sounds. Eighteen species of mid-frequency cetaceans are found in the AoA: Sperm whale, beaked whales, common dolphin, killer whale (*Orcinus orca*), northern bottlenose whale (*Hyperoodon ampullatus*), Pygmy killer whale, False killer whale, melon-headed whale[21] (*Peponocephala electra*), Risso's dolphin, Atlantic white-sided dolphin, white-beaked dolphin (*Lagenorhynchus albirostris*), Atlantic spotted dolphin, pantropical spotted dolphin (*Stenella attenuata*), striped dolphin, Fraser's dolphin (*Lagenodelphis hosei*), rough-toothed dolphin, Clymene dolphin (*Stenella clymene*), Spinner dolphin (*Stenella longirostris longiristris*), and common bottlenose dolphin (Table 4). Habitat-based density models from Roberts et al. (2023) were used to predict the seasonal density of this species group in the AoA. Monthly density estimates were available for only the Sperm whale and 5 species of dolphin (Figure 5 and Figure 6); therefore, these 6 species are the drivers of the seasonal patterns shown in the figures.

In the winter season, the highest predicted density of mid-frequency cetaceans (1,611.14/100 km^2) falls in the continental slope region (Zone 2, Figure 5), with a distinct concentration at the mouth of the Hudson Canyon. Intermediate densities are predicted fairly uniformly in winter throughout Zone 1, and relatively low densities are predicted throughout Zone 3.

In the spring season, the highest predicted density of mid-frequency cetaceans (1,320.74/100 km^2) likewise falls in the continental slope region (Zone 2), but with a more marked concentration of animals predicted at the mouth of the Hudson Canyon (Figure 5). Intermediate densities are predicted in the offshore region of Zone 1 in the spring, and very low densities of mid-frequency cetaceans are predicted throughout Zone 3.

Distribution patterns of mid-frequency cetaceans in summer and fall are similar to those expected in winter, although maximum density is slightly lower in summer (1,310.21/100 km^2) and fall (1,081.92/100 km^2). Slightly higher intermediate densities are predicted for this species group along the continental shelf (Zone 1) in fall, in contrast to other seasons. Very low densities of mid-frequency cetaceans are predicted in Zone 3 in the summer and fall seasons (Figure 5). Overall, mid-frequency cetaceans are predicted to be most common in Zone 2 in all seasons, although this pattern is most pronounced in winter and spring (Figure 6). This is generally consistent with the results from the NYSERDA OPA aerial surveys,[22] during which mid-frequency cetaceans were observed in greatest numbers along the continental slope in all seasons, particularly in spring and summer (Figure 7).

Comparing these findings to telemetry data from mid-frequency cetaceans instrumented with satellite-tracked tags off Cape Hatteras, North Carolina, between 2014 and 2017 (Baird et al. 2015, 2016, 2017, 2018; Foley et al. 2021), the tracks of Sperm whale, Pilot whale, and Cuvier's beaked whale are concentrated in outer continental shelf and slope habitat, although several tracks of sperm and Pilot whales also extend into Zone 3 and beyond, past the EEZ (Figure 8).

Findings from visual surveys and telemetry studies are generally consistent with available data for Sperm whales and bottlenose dolphins from regional PAM studies. For example, Estabrook et al. (2021) reported that Sperm whales were detected on autonomous multichannel acoustic recorders (AMAR) during every season in the New York Bight from October 2017 to October 2020, and Trabue et al. (2022) found that in and around the New York/New Jersey Harbor Estuary, bottlenose dolphins were acoustically present on passive acoustic archival recorders from April through October.

Figure 5. Mid-Frequency Cetaceans: Scaled to Highest Seasonal Predicted Density

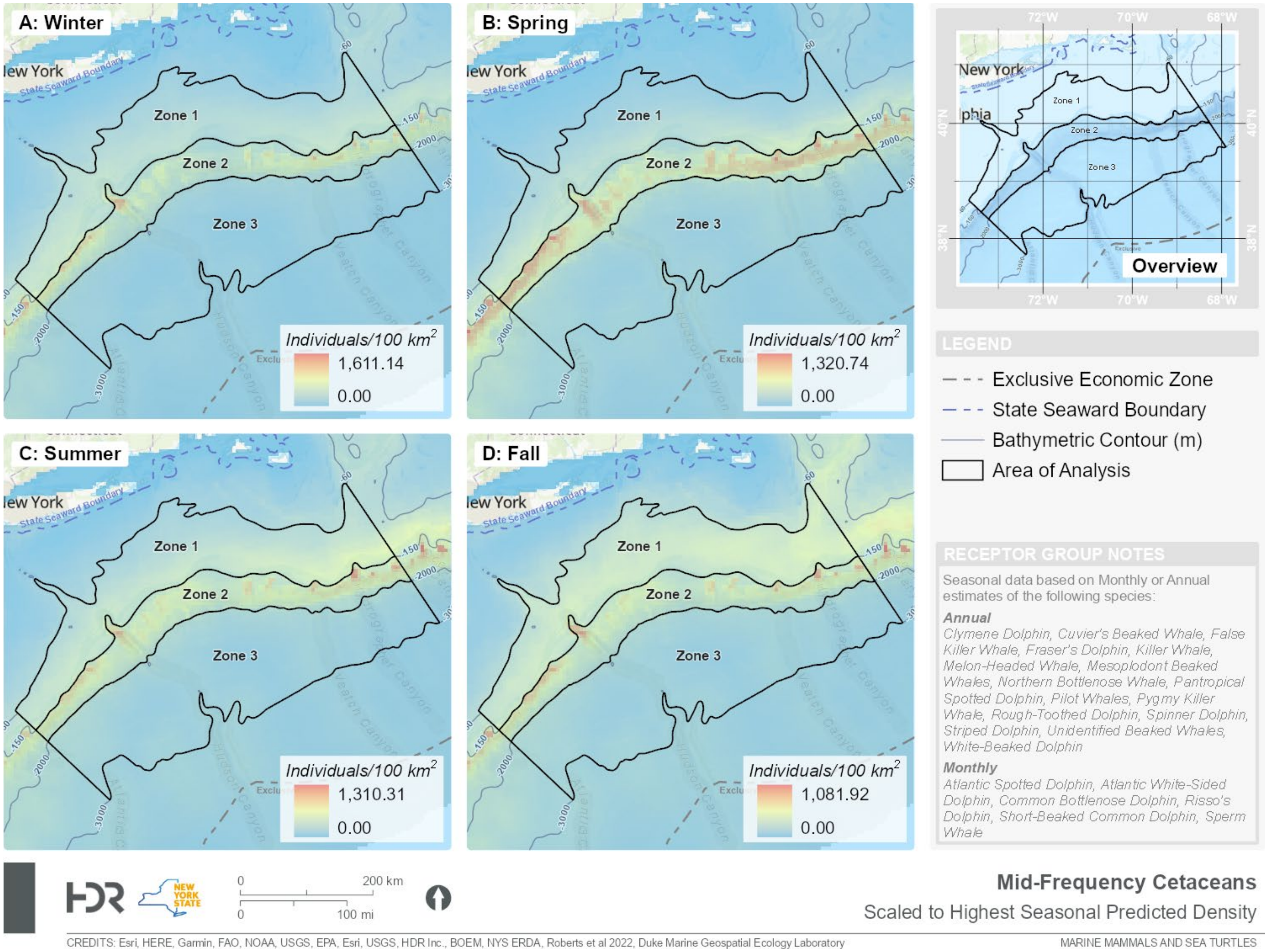


Figure 6. Mid-Frequency Cetaceans: Scaled to Highest Annual Predicted Density

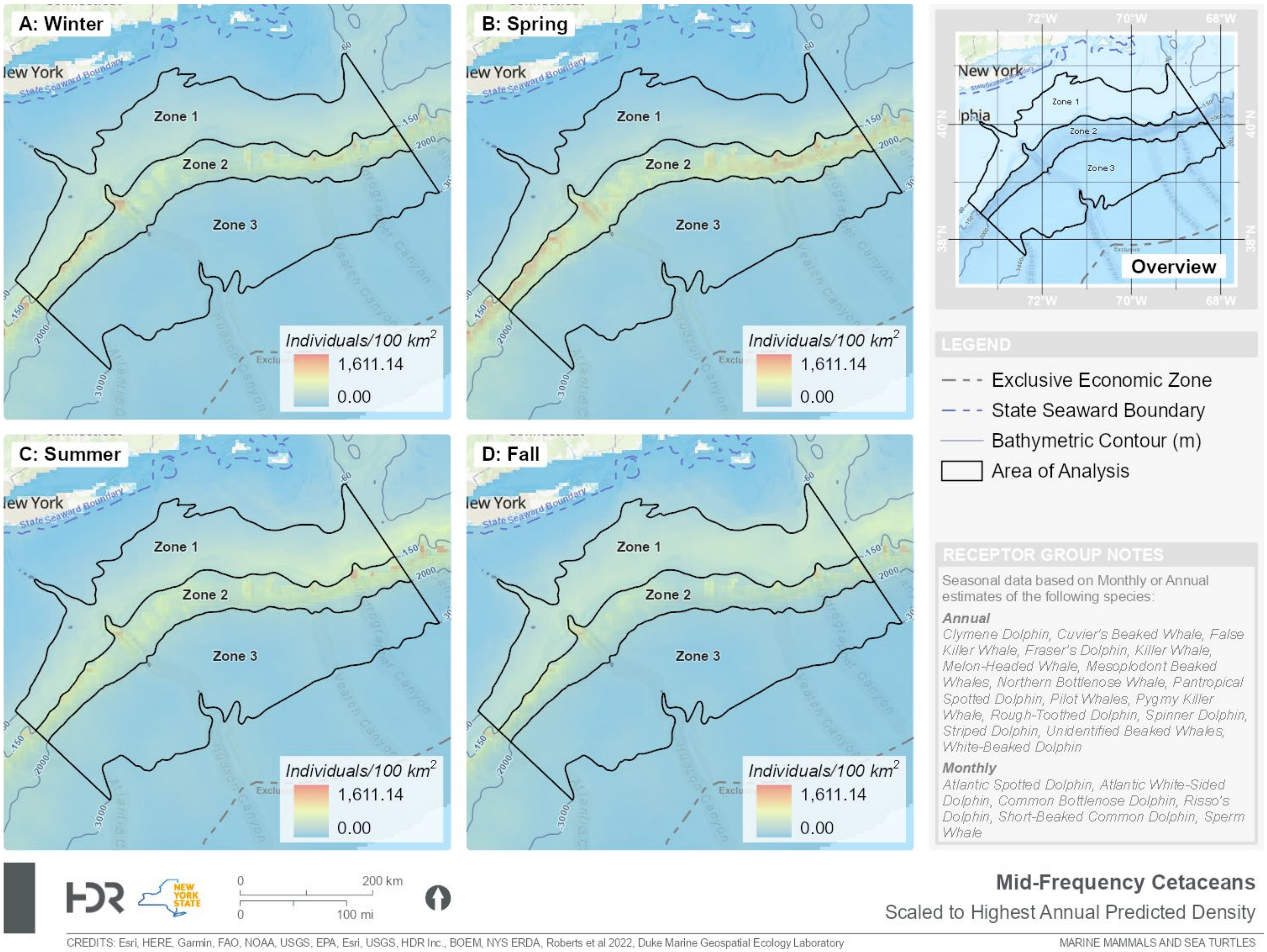
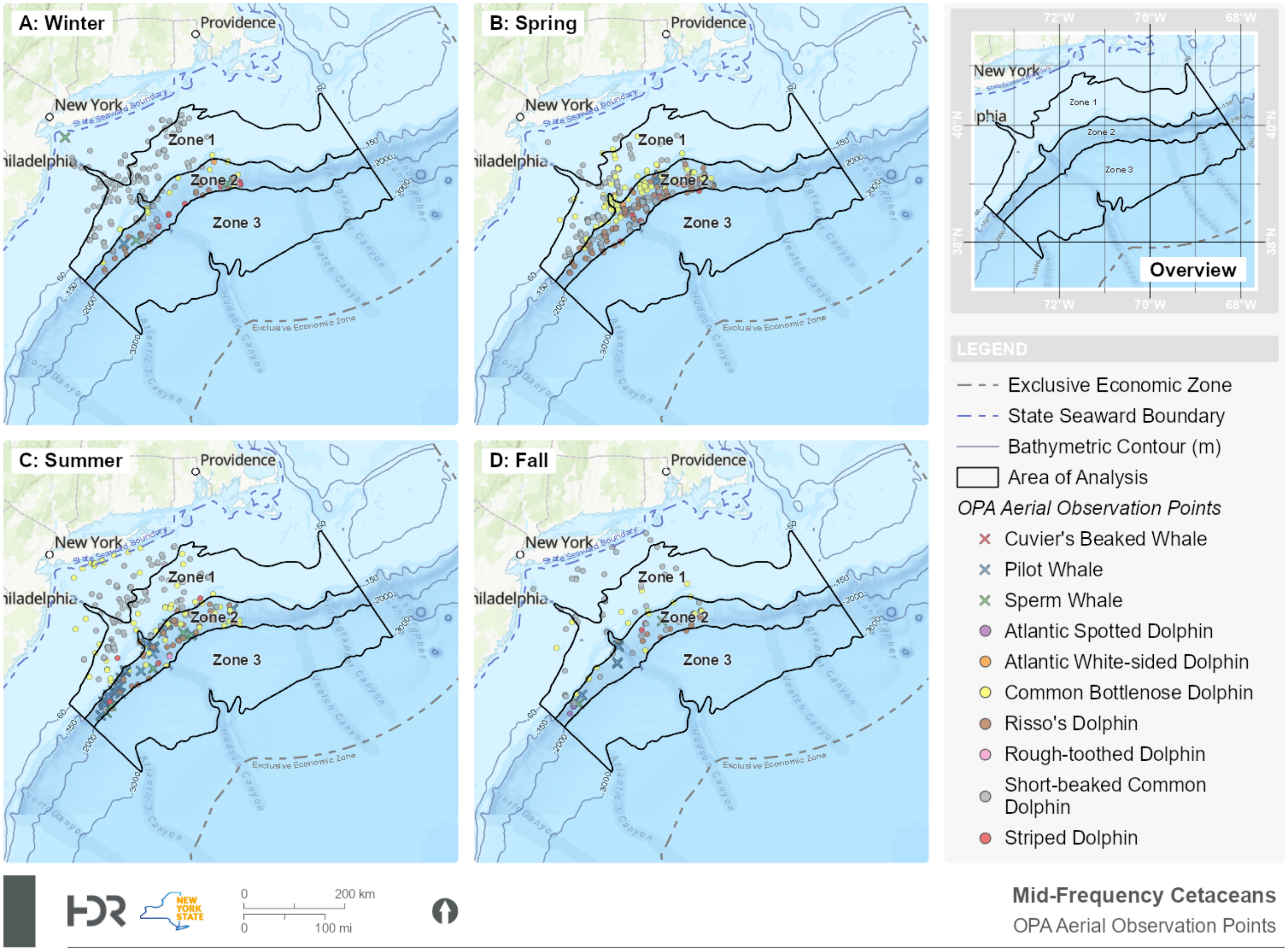


Figure 7. Mid-Frequency Cetaceans: Other Sighting Records

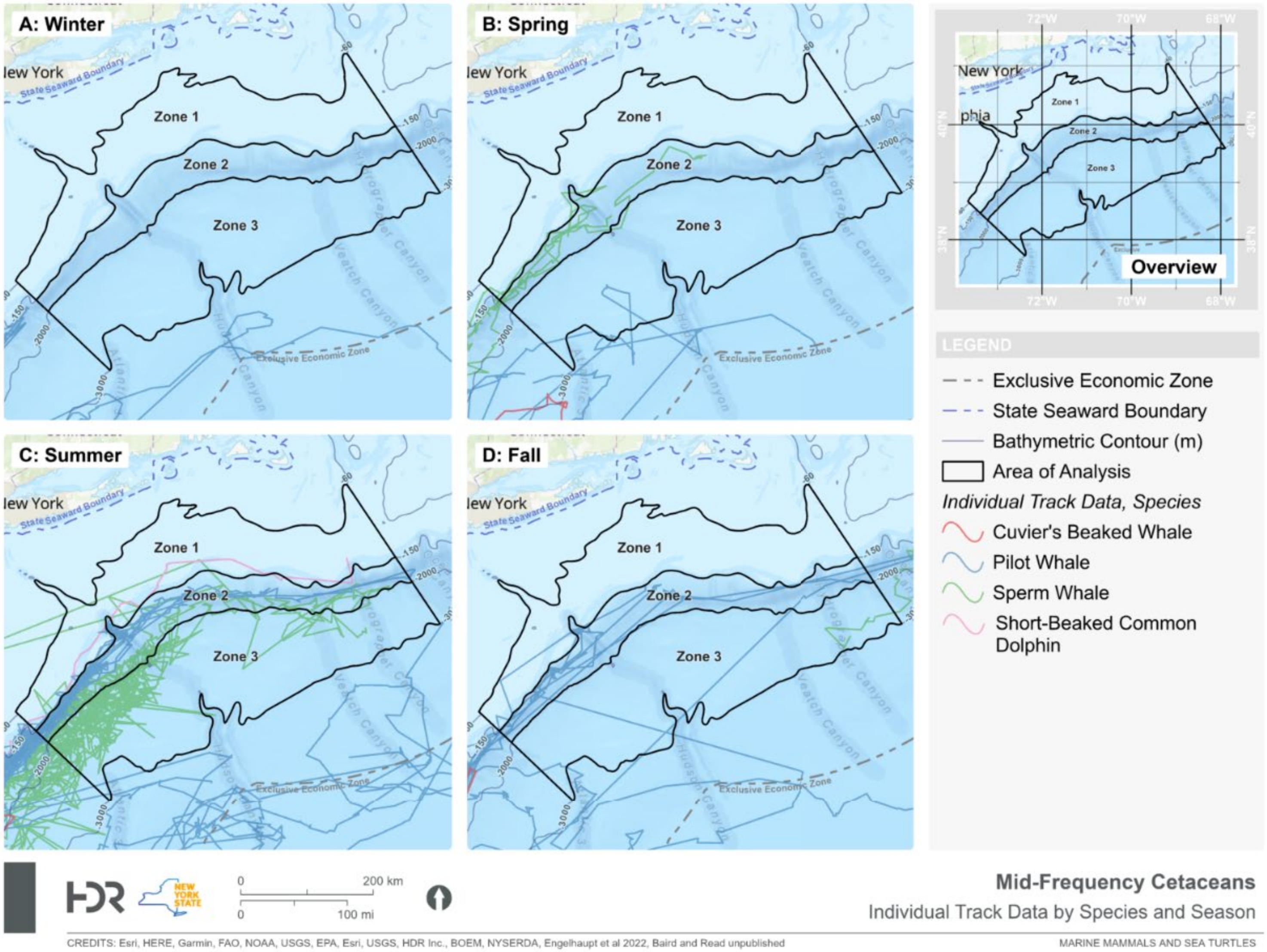


CREDITS: Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Esri, USGS, HDR Inc., BOEM, NYS ERDA, OPA Aerial Observation Points (2016 - 2018)

MARINE MAMMALS AND SEA TURTLES

Figure 8. Mid-Frequency Cetaceans: Tag Data

Note: Presence of tagged animals in the AoA may be underestimated due to location of tag deployments and duration of tag attachment. Location accuracy varies with tag type.



3.3.1.3 Low-Frequency Cetaceans: Distribution, Density, and Seasonal Patterns (excluding North Atlantic Right Whale)

Low-frequency cetaceans are defined as those that have a generalized hearing range of 7 Hz to 35 kHz (Table 4) and are therefore sensitive to low-frequency sounds (National Research Council [NRC] 1994, 2003; Croll et al. 2001). Other than the NARW, 5 species of low-frequency cetaceans are found in the AoA: Blue whale, common Minke whale, Fin whale, Humpback whale, and Sei whale (Table 4). Habitat-based density models from Roberts et al. (2023) were used to predict the seasonal density of this species group in the AoA. Given the generally low occurrence of Blue whales in the U.S. Atlantic, only annual density values were generated for this species. Therefore, the seasonal patterns shown in Figure 9 and Figure 10 are driven by Minke, fin, Humpback, and sei whale distributions.

In the winter season, the highest predicted density of low-frequency cetaceans (6.89/100 km^2) falls on the upper continental slope, in the inshore portion of Zone 2 (Figure 9). A region of relatively high density is also predicted in the Nantucket Shoals region, located northeast of the AoA and east of Nantucket Island. Intermediate densities are predicted along the continental shelf in winter, with slight concentrations at the mouths of the Hudson and Hydrographer Canyons. In winter, very low densities of low-frequency cetaceans are predicted in the outer portions of Zone 2 and throughout Zone 3.

In the spring season, the highest predicted density of low-frequency cetaceans (15.06/100 km^2) is located in the Nantucket Shoals region east of Nantucket Island and northeast of the AoA, with the highest concentration of animals occurring along the 60-m isobath (Figure 9). Within the AoA, the highest predicted densities of low-frequency cetaceans in Zone 1 in spring occur at the top of the Hudson Canyon, at the top of the Hydrographer Canyon, and eastward along the continental shelf (Figure 9). The highest predicted densities in Zone 2 in spring occur along upper slope habitat, with higher concentrations east of Veatch Canyon. The distribution of low-frequency cetaceans is very similar in summer and fall, but with differing densities. The highest concentration of animals in both seasons is located in the Nantucket Shoals region, northeast of the AoA (up to 23.97/100 km^2 in summer, and 15.71/100 km^2 in fall), and intermediate densities are predicted along the continental shelf in Zone 1 and the shallower portions of Zone 2. Low densities of low-frequency cetaceans are predicted in Zone 3 in all four seasons, although density in Zone 3 is slightly higher in the spring than in other seasons.

Overall, low-frequency cetaceans are expected to be most common in the AoA in summer, primarily in shelf and continental slope habitats, and least common in winter (Figure 10). Following recommendations from the PAC, additional data sets not included in the Roberts et al. (2023) models were considered in the geospatial analysis. These include the NYSERDA OPA aerial surveys,[23] as well as dedicated small-vessel surveys for baleen whales performed from 2017 to 2019 (King et al. 2021). Survey methods and results are described in more detail in section 3.2. It should be noted that vessel-based survey efforts varied from 10 to 60 km from shore and did not extend into the AoA. OPA aerial surveys covered only a portion of Zones 1 and 2. During the OPA aerial surveys, low-frequency cetaceans were most frequently observed in the AoA in spring, when they were observed exclusively on the continental shelf, followed by fall, when they were observed most often in Zone 2 (Figure 11).

Data was also examined from low-frequency cetaceans instrumented with satellite-tracked tags off Virginia Beach, Virginia, between 2015 and 2022 (Engelhaupt et al. 2022). Several fin and Humpback whale tracks overlapped with the AoA (Figure 12). In winter, the track of a tagged Humpback whale followed the outer continental shelf during its journey northward from the tagging location. This whale spent the majority of its time in the AoA in Zone 1 but crossed into Zone 2 (slope habitat) when over the Hudson Canyon, likely due to prey availability from nutrient upwelling (Figure 12). In spring, three Fin whale tracks overlapped with Zones 1, 2, and 3 in on- and off-shelf areas west of the Hudson Canyon. In summer, two Fin whale tracks overlapped with the AoA, primarily in on-shelf waters west of the Hudson Canyon, including deepwater areas beyond the 3,000-m isobath (Engelhaupt et al. 2022).

Figure 9. Low-Frequency Cetaceans: Scaled to Highest Seasonal Predicted Density

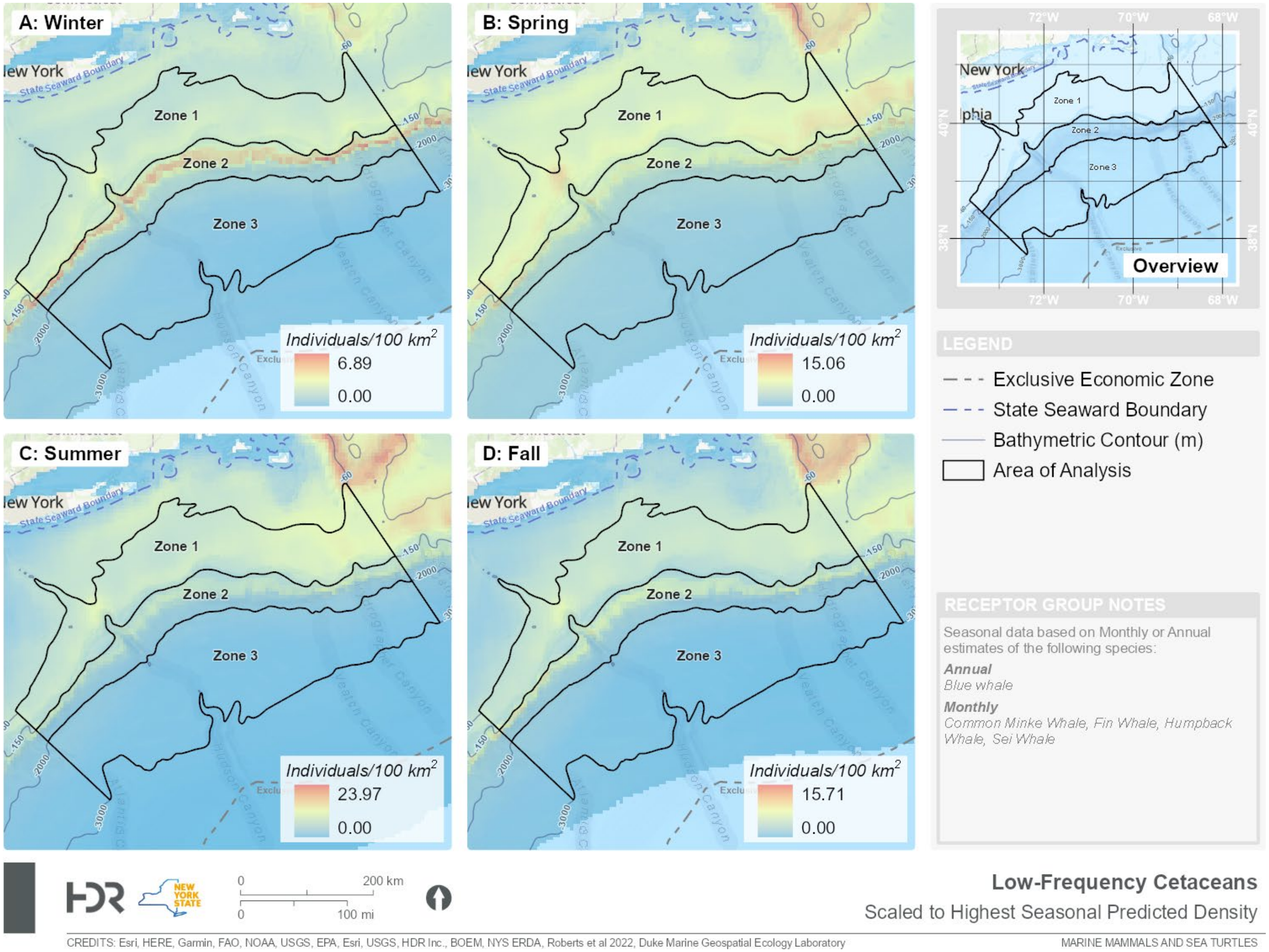


Figure 10. Low-Frequency Cetaceans: Scaled to Highest Annual Predicted Density

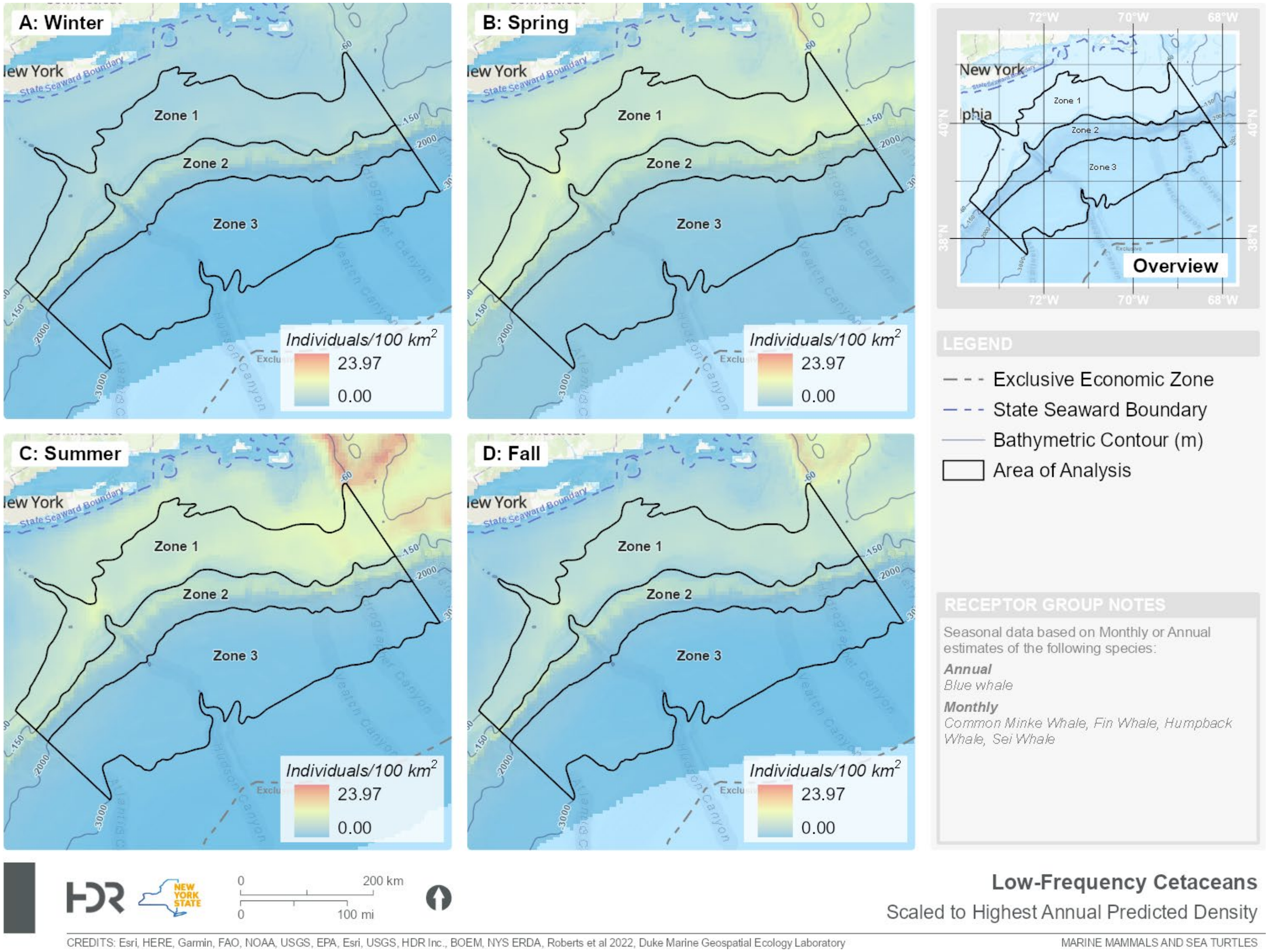


Figure 11. Low-Frequency Cetaceans: Other Sighting Records

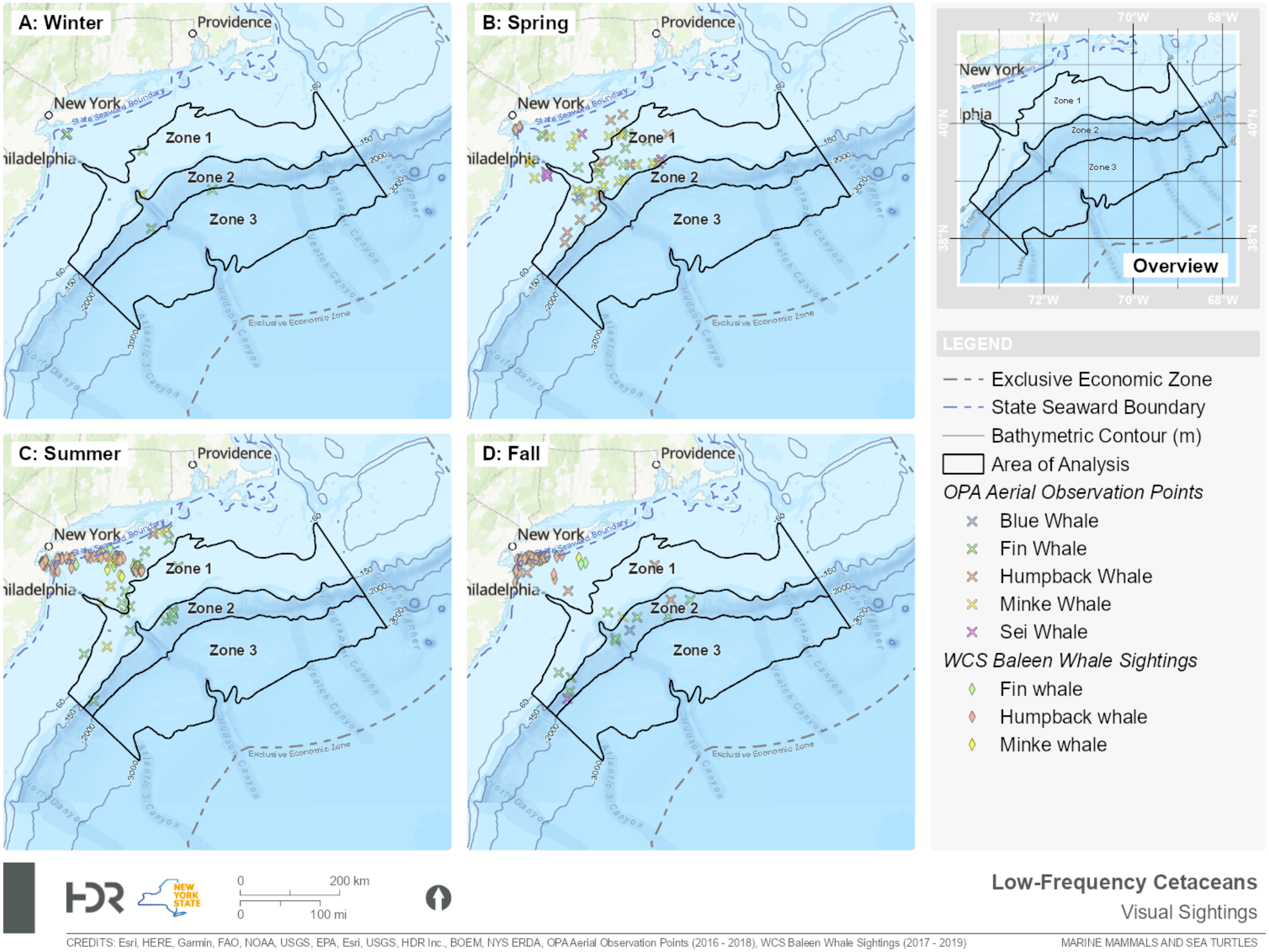
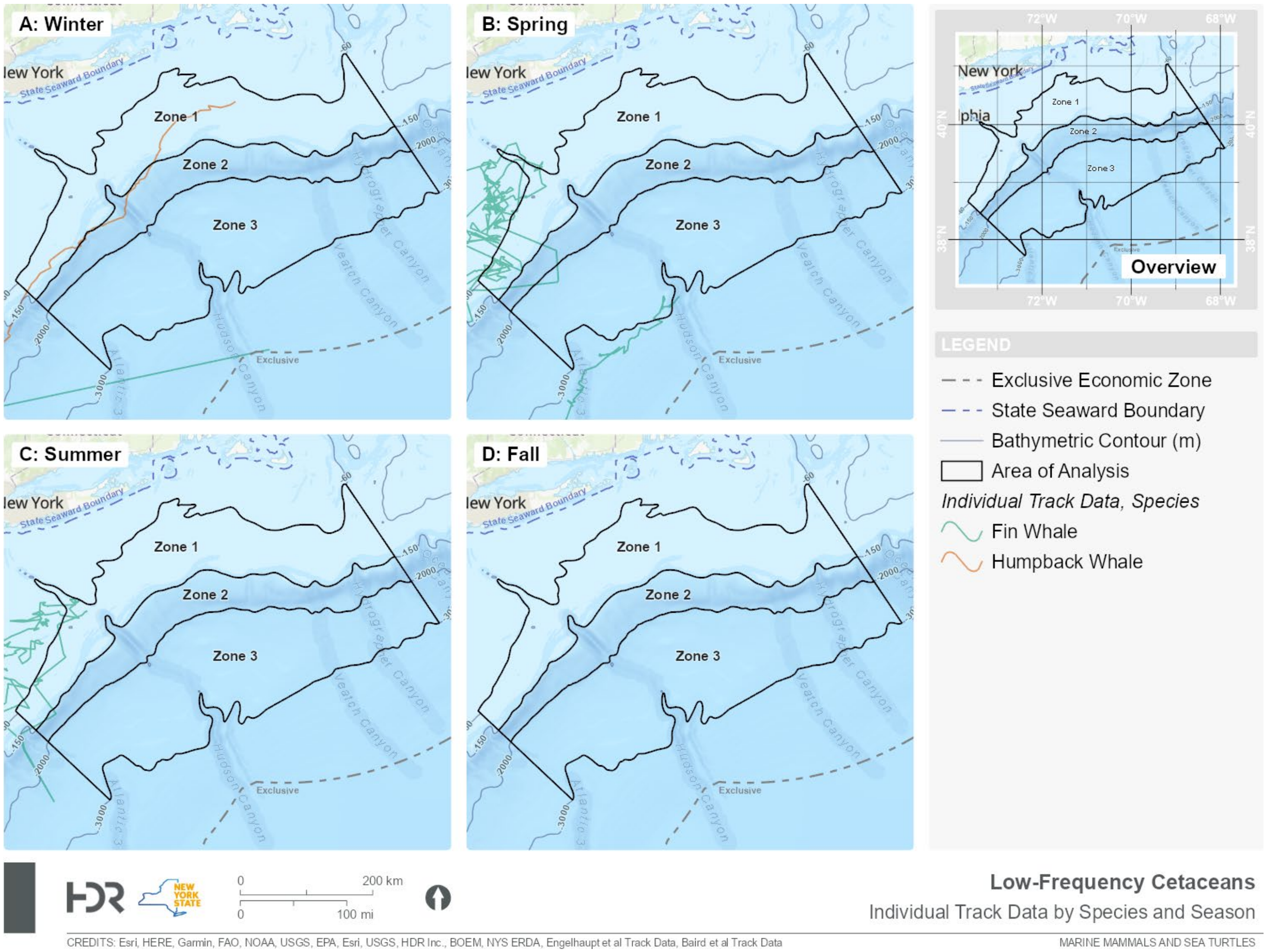


Figure 12. Low-Frequency Cetaceans: Tag Data

Note: Presence of tagged animals in the AoA may be underestimated due to location of tag deployments and duration of tag attachment. Location accuracy varies with tag type.



Findings from visual surveys and telemetry studies are generally consistent with seasonal occurrence patterns observed in the New York Bight for Blue, fin, and Humpback whales using PAM. Blue whales were detected offshore during January, February, and March. Fin whales were detected offshore every day for which recordings were available, and less often near-shore (Muirhead et al. 2018). Humpback whale songs were detected from March to May (2008) and December to February (2008–2009) (Zeh et al. 2021). Estabrook et al. (2021) reported that Fin whales and Humpback whales were detected during nearly every month in the New York Bight from October 2017 to October 2020.

3.3.1.4 North Atlantic Right Whale: Distribution, Density, and Seasonal Patterns

Recent estimates suggest that fewer than 338 NARW remain, and fewer than 70 of these individuals are breeding females (Hayes et al. 2023). Given the extremely small number of animals in the population, this species is particularly vulnerable to anthropogenic stressors, which, depending on the type and severity, have the potential to cause population-level effects (Southall et al. 2023). Given its critically endangered status, this species is considered here as a separate receptor group.

The U.S. range of the NARW extends from calving grounds in coastal waters of the southeastern U.S. to feeding grounds in New England waters (Hayes et al. 2023). NARWs exhibit partial migration, where a portion of the population winters in the calving grounds off Florida, Georgia, and South Carolina, and then travels north in the spring to feed in the waters off New England and Eastern Canada in the summer (Quintana-Rizzo et al. 2021). The AoA is located south of the designated critical foraging habitat for this species, located off the coast of New England, although the extreme northeastern portion of the AoA overlaps with critical habitat just south of Nantucket Shoals (Figure 13 and Figure 14).

In the winter months, the highest predicted density of NARW (18.84/100 km^2) is located northeast of Zone 1, just inshore of the 60-m isobath, between Nantucket Island and Hydrographer Canyon (Figure 13). Intermediate densities are predicted in winter on the outer continental shelf in the central region of Zone 1, south of Rhode Island, and inshore of the AoA south of Vineyard Sound (Figure 13), with some diffuse use of continental shelf and slope waters. Predicted density of NARW in Zone 3 in the winter is relatively low.

In spring, NARW distribution patterns are similar to those in winter, but with a slightly lower maximum density (13.44/100 km^2) and heavier predicted use of shelf waters (Figure 13). Likewise, NARW distribution patterns are similar in summer and fall, although with lower maximum densities (6.87/100 km^2 and 2.79/100 km^2).

Figure 13. North Atlantic Right Whale: Scaled to Highest Seasonal Predicted Density

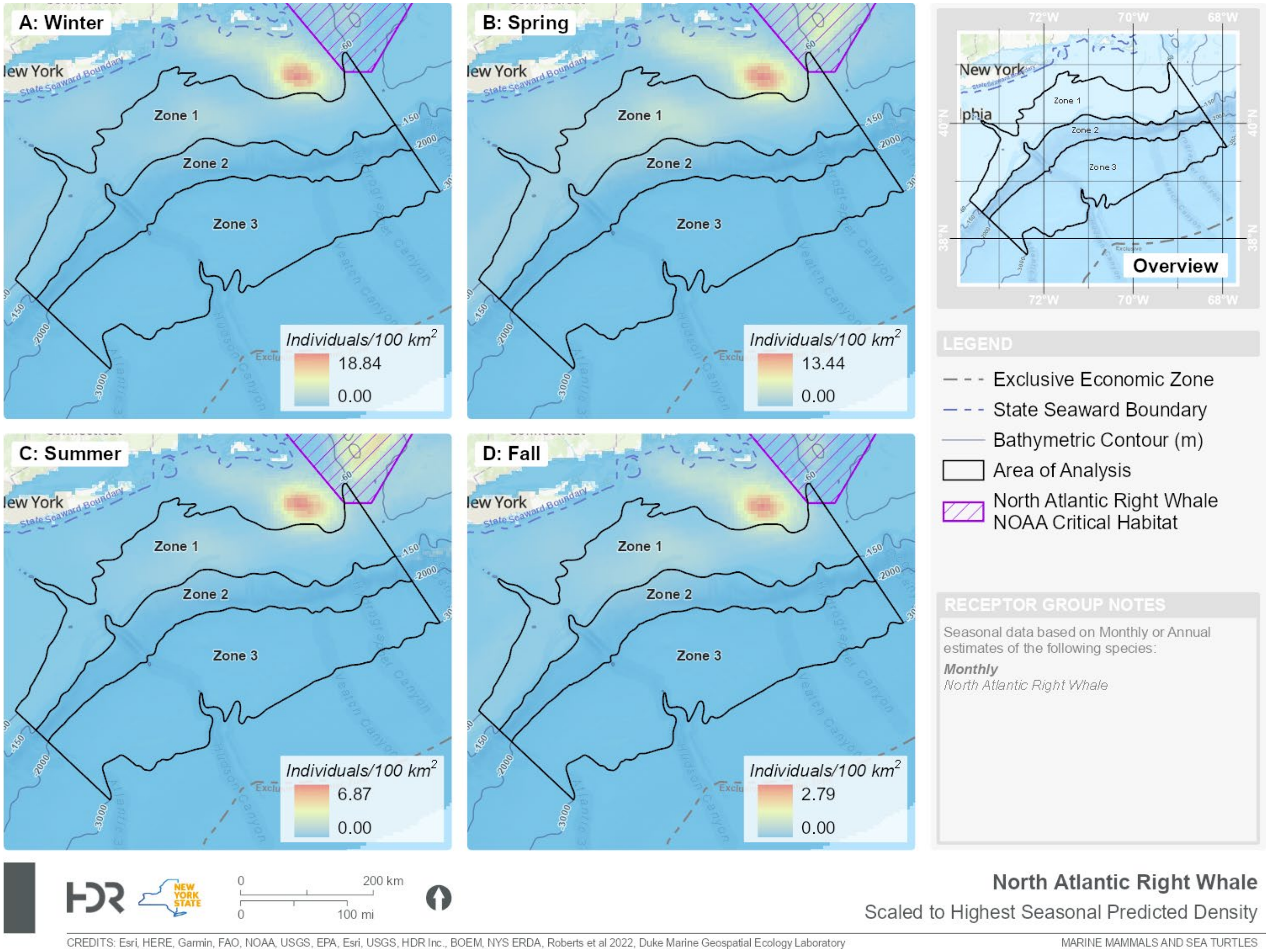
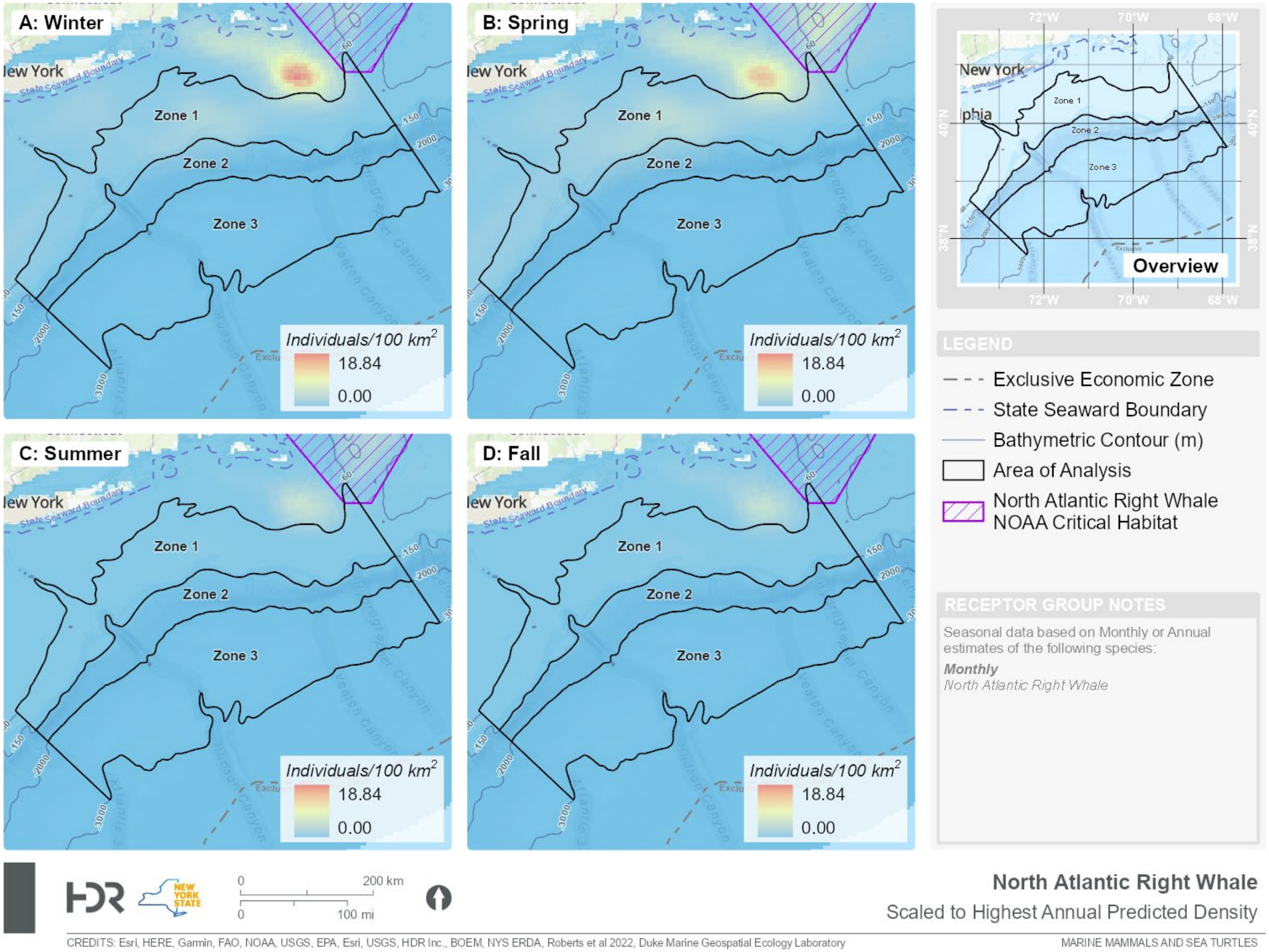


Figure 14. North Atlantic Right Whale: Scaled to Highest Annual Predicted Density



Overall, NARW are predicted to be most common in the AoA in winter and spring, and the area north of the AoA between Nantucket Island and Hydrographer Canyon is predicted to be a relatively high-density area for this species year-round (Figure 14). This finding generally aligns with results from the NYSERDA OPA aerial surveys, when NARW were observed only in winter (n = 6) and spring (n = 3) months[24]. The predicted use of shelf waters in spring, including areas inshore of the AoA, is supported by available telemetry data (Engelhaupt et al. 2022). A NARW tagged off Virginia Beach, Virginia, in spring 2022 traveled north to southern New England, generally staying close to the coast (inshore of the AoA) within, or just outside of, the state seaward boundary (Figure 16). This animal's track indicates heavy use of the area south of Nantucket Island, consistent with density predictions in this region (Figure 13 and Figure 14), although inferences that can be made from a single animal are limited.

Findings from PAM studies indicate the presence of NARW in the New York Bight throughout the year. For example, Muirhead et al. (2018) reported that NARWs were detected sporadically during every month of surveys (March–May 2008, August–December 2008, and December 2008–March 2009) but were most often detected between late February and mid-May. Results from real-time acoustic monitoring performed by Murray et al. (2022) between June 2016 and January 2020 indicated that NARWs were present in the Bight from November to April in every year, and were also detected in October, May, June, and/or July in various years.

3.3.1.5 Other Marine Mammals of Special Conservation Status: Distribution, Density, and Seasonal Patterns

Other than the NARW, several marine mammal species that occur in the AoA are listed as threatened or endangered under the ESA. These include the Sperm whale, Fin whale, Blue whale, and Sei whale,[25] Other marine mammal species, such as Humpback whales, Minke whales, gray seals, and harbor seals, although not listed as threatened or endangered, are currently experiencing significant die-offs known as UMEs (NOAA Fisheries 2023d). To the extent that they are understood, the causes of these UMEs vary, and may involve fishery interactions, vessel strikes, and disease outbreaks. In this analysis, ESA-listed species (other than the NARW) and those undergoing a current or recent UME are defined here as "Other Marine Mammals of Special Conservation Status"

Figure 15. North Atlantic Right Whale: Other Sighting Records

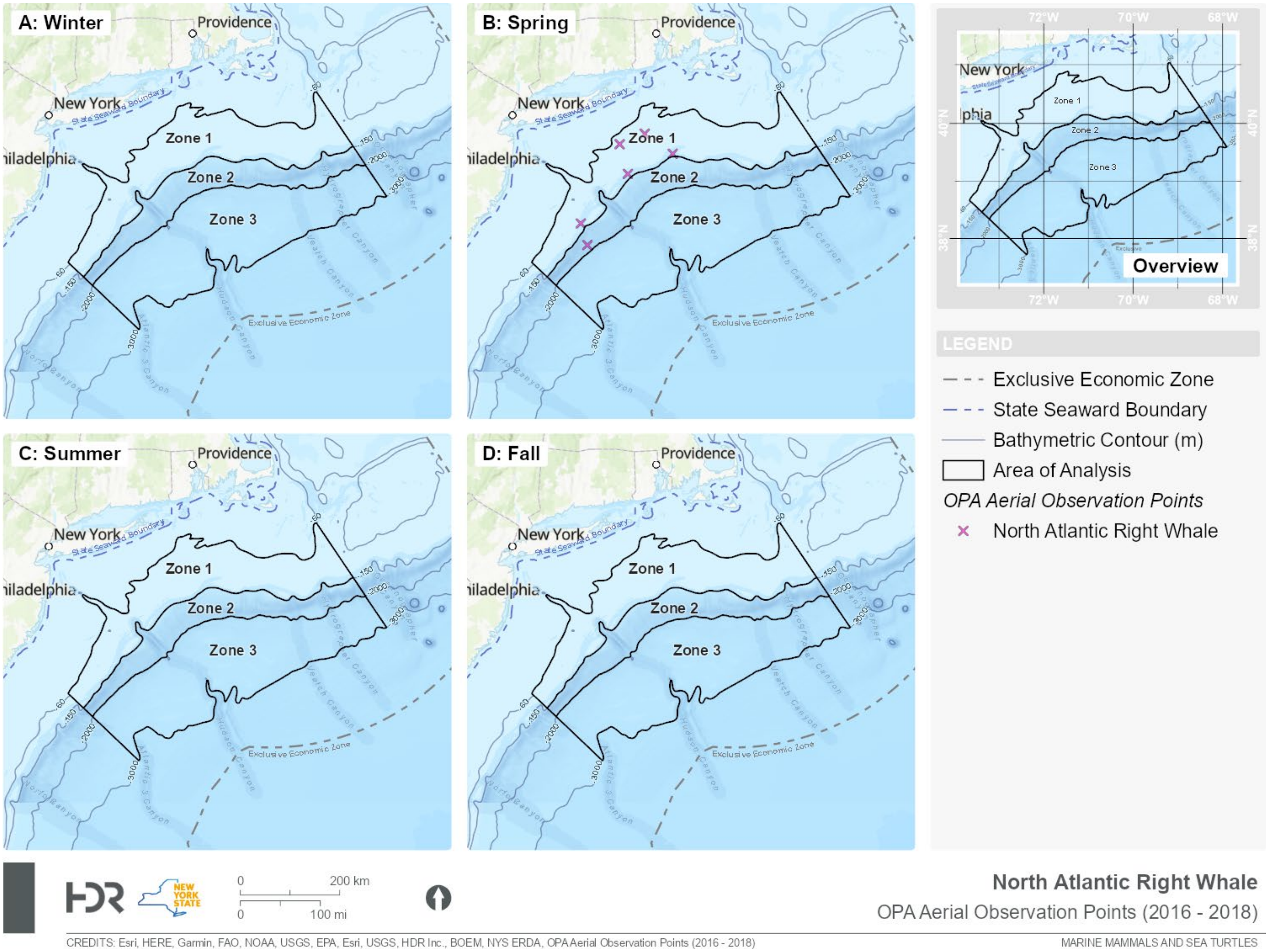
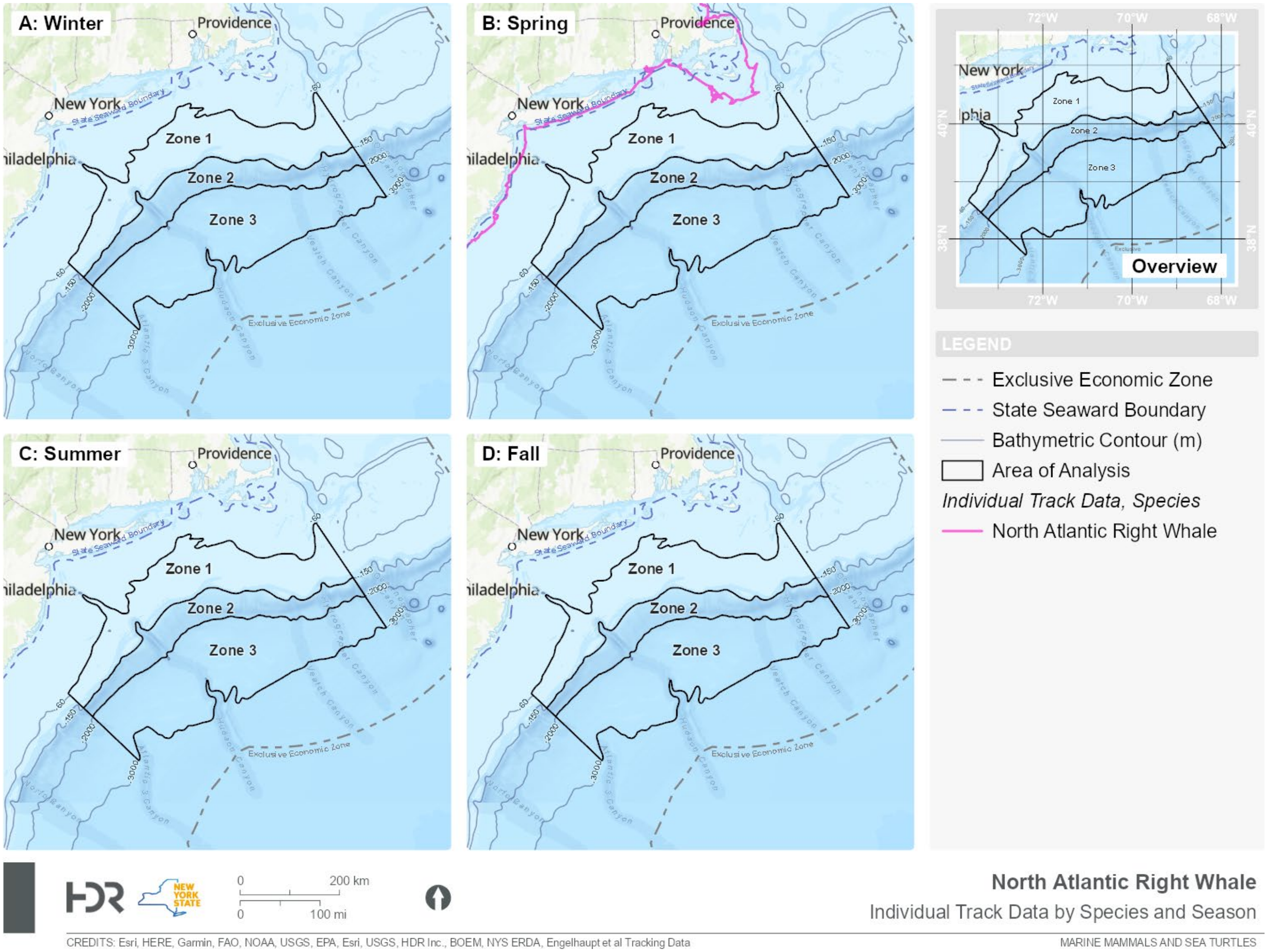


Figure 16. North Atlantic Right Whale: Tag Data

Note: Presence of tagged animals in the AoA may be underestimated due to location of tag deployments and duration of tag attachment. Location accuracy varies with tag type.



(OMMSCS) and considered a unique[26] receptor group. The rationale for this designation is similar to that for NARW: given existing stressors on these animals and already depleted populations, these species are particularly vulnerable to disturbance (Southall et al. 2023), including stressors from OSW development, which, depending on the type and severity, could have the potential to cause population-level effects.

In the winter season, the maximum density of OMMSCS is 234.19/100 km.^{2} The areas of highest density are located outside of the AoA and are centered around Nantucket Island, Martha's Vineyard, coastal Connecticut and Rhode Island, and eastern Long Island (Figure 17). Intermediate densities of OMMSCS are predicted in winter along the continental shelf, primarily inshore of the 60-m isobath but also in the northern and western regions of Zone 1. Predicted densities of OMMSCS in Zones 2 and 3 are relatively low.

In spring, the predicted distribution of OMMSCS is similar to that in winter, but with more than double the maximum estimated density (527.89/100 km^2), also centered around coastal islands in New York State, Connecticut, Rhode Island, and Massachusetts located outside the AoA (Figure 17). Intermediate densities are predicted in spring throughout the continental shelf, including Zone 1, although in lower numbers than in winter.

Predicted maximum densities of OMMSCS are slightly higher in summer (541.16/100 km^2) than in fall (313.26) and are also centered around coastal islands located north of the AoA. Diffuse use of Zone 1 is predicted in both seasons, with relatively low densities predicted in Zones 2 and 3.

Overall, OMMSCS are predicted to be most common in the AoA in winter and spring and are concentrated primarily in Zone 1 in all seasons (Figure 18). Although Sperm whales are included in this receptor group, the density and distribution patterns observed in Figure 17 and Figure 18 are driven by seals and baleen whales, likely due to the higher number of sighting records available for these species. Sperm whale density is predicted to be highest in the AoA in summer (16.37/100 km^2) and spring (11.26/100 km^2) as opposed to winter (8.07/100 km^2) and spring (7.56/100 km^2). In all seasons, Sperm whale distribution is concentrated in the deeper slope habitat of Zone 2 and beyond the 2,000-m isobath, including Zone 3 and deeper waters out to the EEZ.

Figure 17. Other Marine Mammals of Special Conservation Status: Scaled to Highest Seasonal Predicted Density

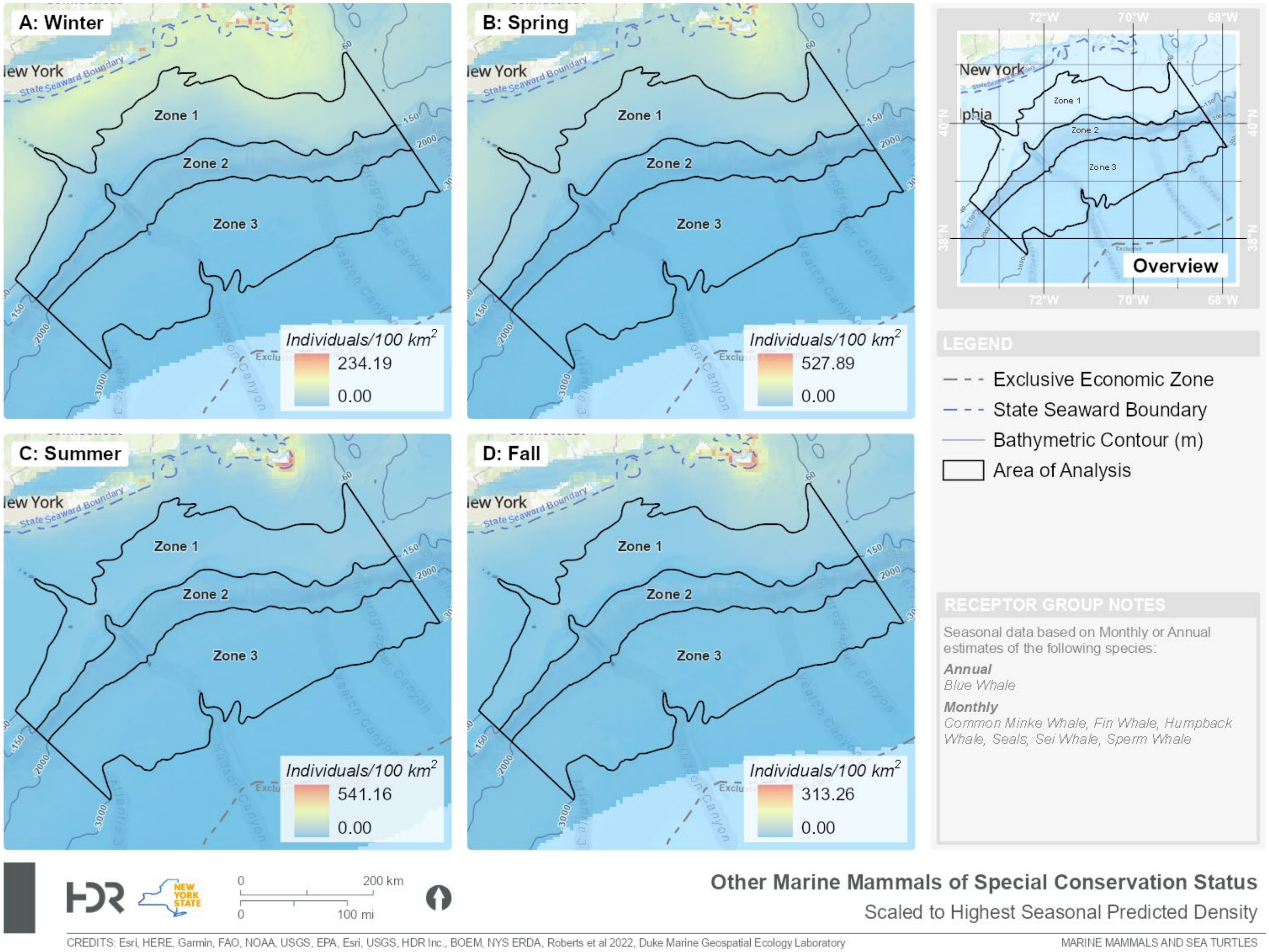
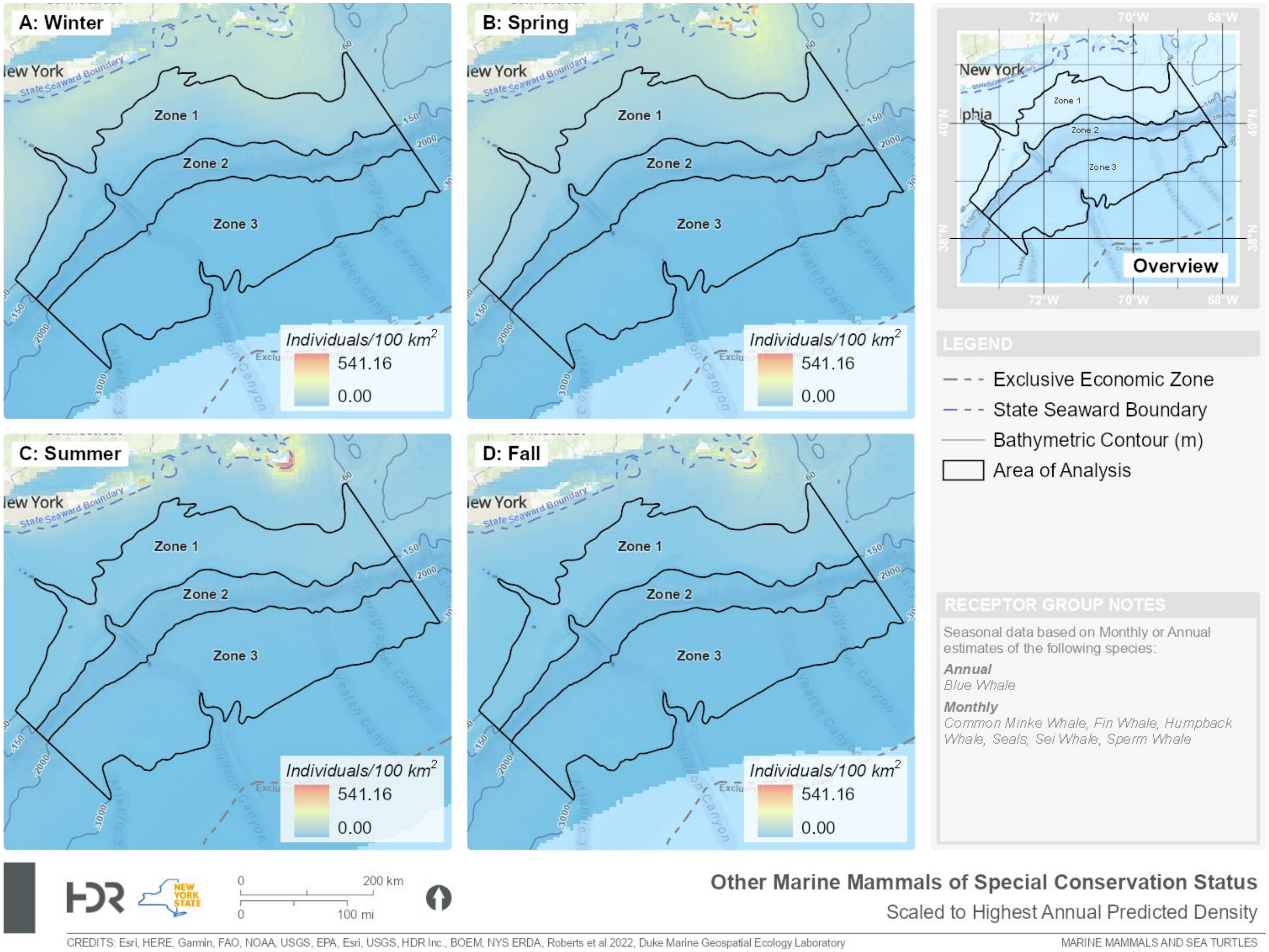


Figure 18. Other Marine Mammals of Special Conservation Status: Scaled to Highest Annual Predicted Density



As noted previously, following recommendations from the PAC, additional data sets not included in the Roberts et al. (2023) models were also considered in the geospatial analysis. These include the NYSERDA OPA aerial surveys,[27] as well as dedicated small-vessel surveys for baleen whales performed from 2017–2019 (King et al. 2021). During the OPA aerial surveys, OMMSCS were encountered most often in the AoA in spring, followed by fall and summer (Normandeau Associates Inc. and APEM Ltd. 2021a; Figure 19). During these aerial surveys, OMMSCS were encountered least often in winter months. In spring, this species group was observed exclusively on the continental shelf but was observed in both shelf and continental slope waters in other seasons (Figure 19) (note that these surveys did not cover Zone 3). All sightings of OMMSCS recorded during vessel-based surveys were occurred in the summer and fall and were located inshore of Zone 1 (King et al. 2021, Figure 19).

Data was also examined from OMMSCS instrumented with satellite-tracked tags in coastal Virginia between 2015 and 2023 (Engelhaupt et al. 2022; Ampela et al. 2023). Tagging study objectives, methods, and results are described in more detail in section 3.2.4. Tracks from tagged harbor seals, Fin whales, Humpback whales, and Sperm whales are shown in Figure 20. Harbor seal tracks approach the AoA only in spring months and are concentrated inshore of the AoA. This finding highlights the importance of shallow continental shelf habitat for this species. Fin whale tracks overlapped with the AoA in the spring and summer. In spring, tagged animals utilized habitat in all three zones, at various depths, all west of the Hudson Canyon. In summer, tagged Fin whales utilized shelf habitat, also west of the Hudson Valley Shelf, including southwestern portions of Zone 1. In winter, the track of a tagged Humpback whale followed the outer continental shelf during its journey northward from the tagging location. This whale spent the majority of its time in the AoA in Zone 1 but crossed into Zone 2 (slope habitat) when over the Hudson Canyon, likely due to prey availability from upwelling (Figure 20). A tagged Fin whale also traversed deepwater areas south of the AoA in winter (Figure 20). The tag stopped transmitting when the animal reached the EEZ boundary. Sperm whale tracks overlapped with the AoA in spring, summer, and fall. In spring, Sperm whale tracks were concentrated in continental slope habitat (Zone 2) but extended into Zones 1 and 2 over the Hudson Canyon (Figure 20). In summer, tagged sperm whales utilized all three zones of the AoA. Tag locations were concentrated in Zones 2 and 3 west of the Hudson Canyon but followed the 2,000-m isobath nearly to the eastern boundary of the AoA. In fall, tagged Sperm whale overlap with the AoA was minimal, although one tagged animal utilized the western portion of Zone 3, between Hydrographer and Oceanographer Canyons (Figure 20).

Figure 19. Other Marine Mammals of Special Conservation Status: Other Sighting Records

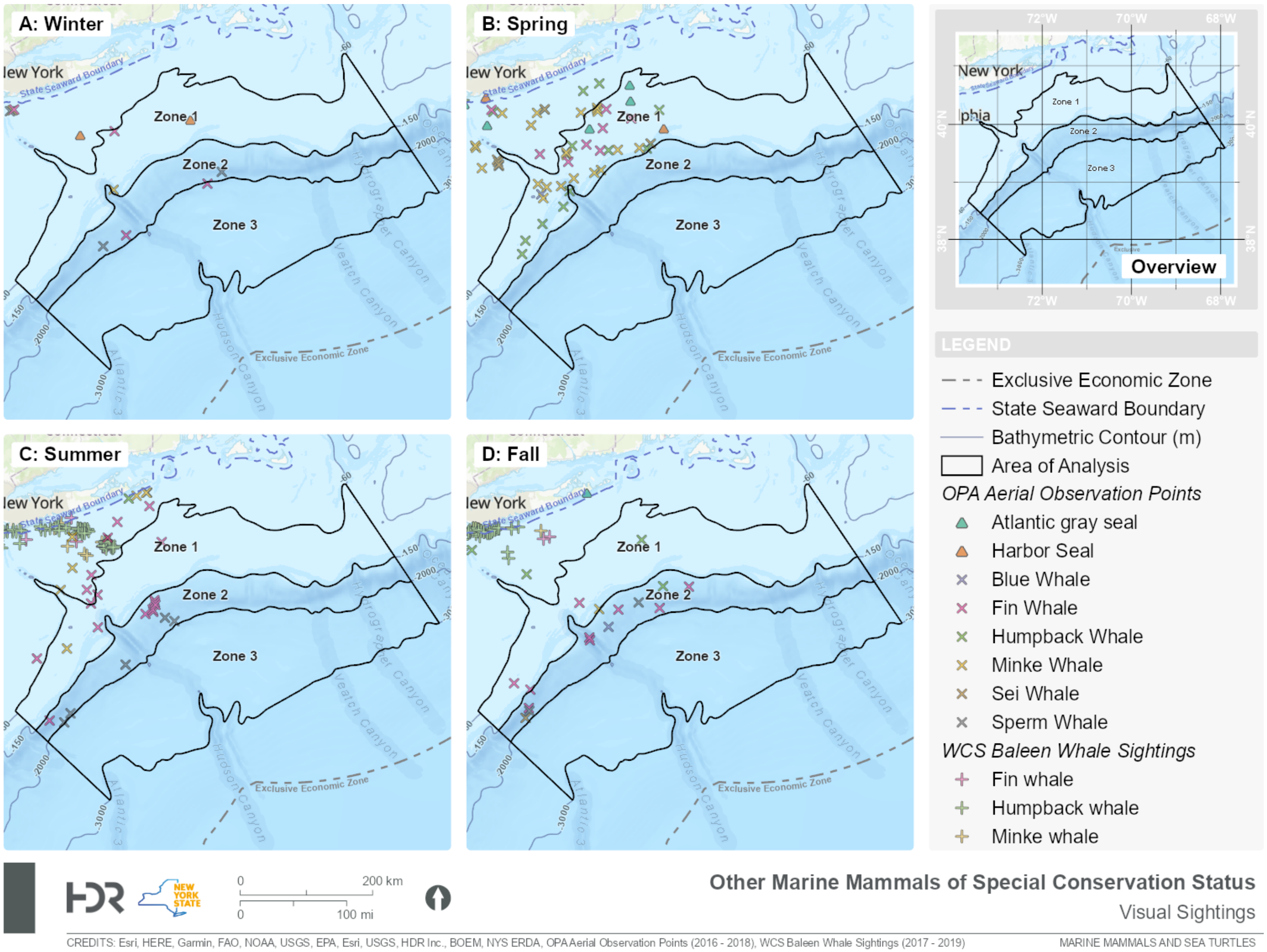
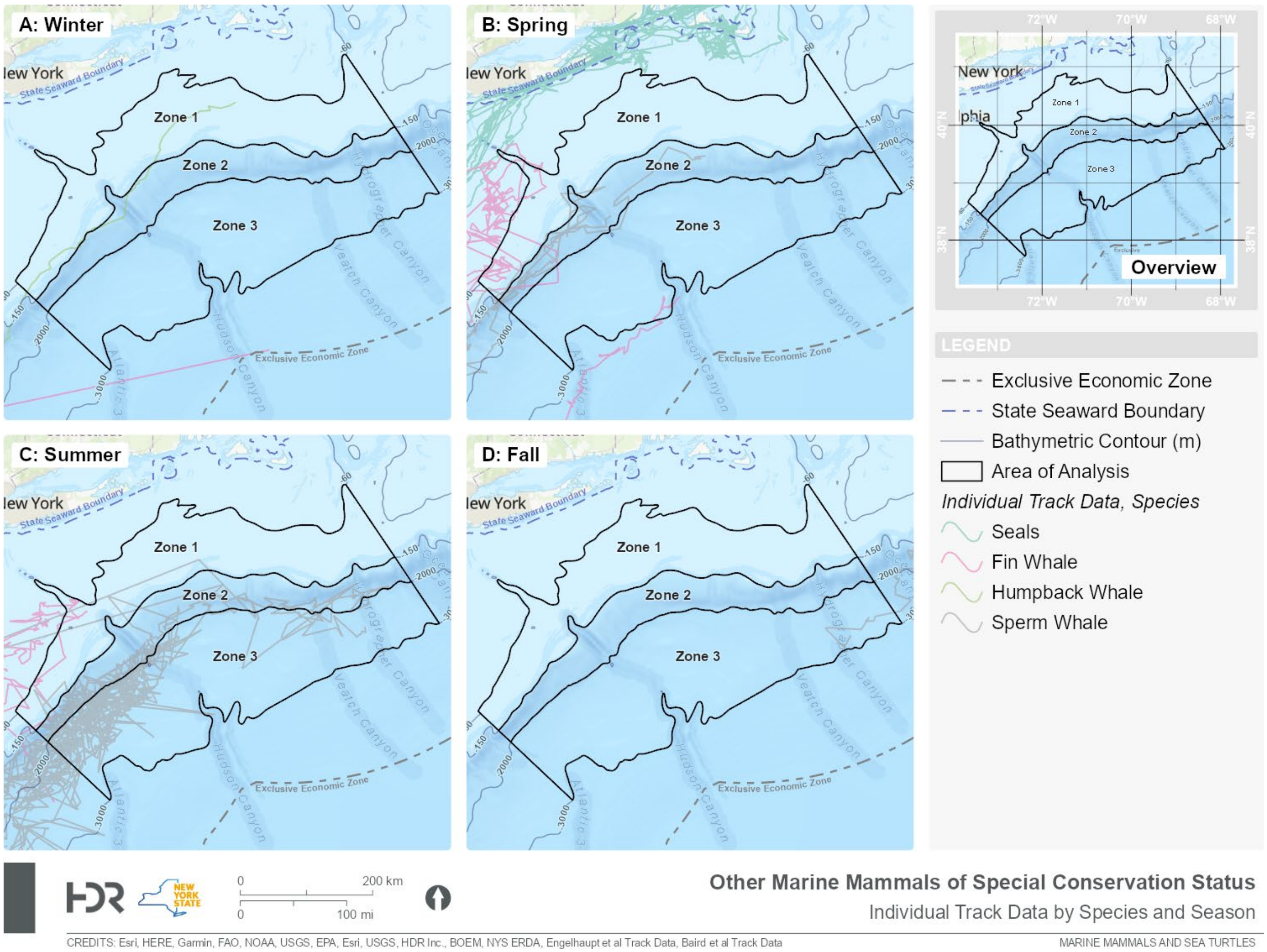


Figure 20. Other Marine Mammals of Special Conservation Status: Tag Data

Note: Presence of tagged animals in the AoA may be underestimated due to location of tag deployments and duration of tag attachment. Location accuracy varies with tag type.



3.3.1.6 Deep-Diving Cetaceans: Distribution, Density, and Seasonal Patterns

Along with generalized hearing groups and those of special conservation status, the distribution, density, and seasonal patterns of cetaceans were also analyzed in the context of the vertical habitat used by these species (i.e., dive depth, Table 5). Deep-diving cetaceans are defined here as those that spend significant time in the mesopelagic zone (from 200 to 1,000 m) and the bathypelagic zone (1,000 to 4,000 m).[28] The following deep-diving cetacean species are included in this analysis: Sperm whale, Dwarf and pygmy sperm whales, Cuvier's beaked whale, mesoplodon beaked whales, unidentified beaked whales, northern bottlenose whale, and Pilot whales (Table 4).

The maximum density of deep-diving cetaceans in the AoA is predicted to be remarkably similar across seasons: 51.24/100 km^2 in winter, 49.59/100 km^2 in spring, 59.45/100 km^2 in summer, and 50.04/100 km^2 in fall (Figure 21). Predicted distribution of deep-diving cetaceans in and around the AoA is likewise almost identical across seasons, with the highest concentrations of animals in continental slope habitat between the 150- and 2,000-m isobaths (Zone 2), particularly in Hudson Canyon and areas west, as well as in Veatch Canyon and areas east (Figure 22). Intermediate densities of deep-diving cetaceans are predicted in all seasons in Zone 3, beyond the 3,000-m isobath, as well as in deeper waters extending to the EEZ. Sightings recorded during the OPA aerial surveys are generally consistent with this pattern, with nearly all observations of deep-diving cetaceans occurring in Zone 2.[29] Tagged Pilot whales and sperm whales also show heavy use of continental slope habitat, as well as deeper waters beyond the 2,000-m isobath, out to the EEZ and beyond.[30] In summer, tagged Pilot whales showed heavy use of the top of the Hudson Canyon, in the extreme northwest portion of Zone 2. A Cuvier's beaked whale tagged off Cape Hatteras in spring traveled as far as Atlantic 3 Canyon and used deepwater habitat between the 2,000- and 3,000-m isobaths.[31]

Figure 21. Deep-Diving Cetaceans: Scaled to Highest Seasonal Predicted Density

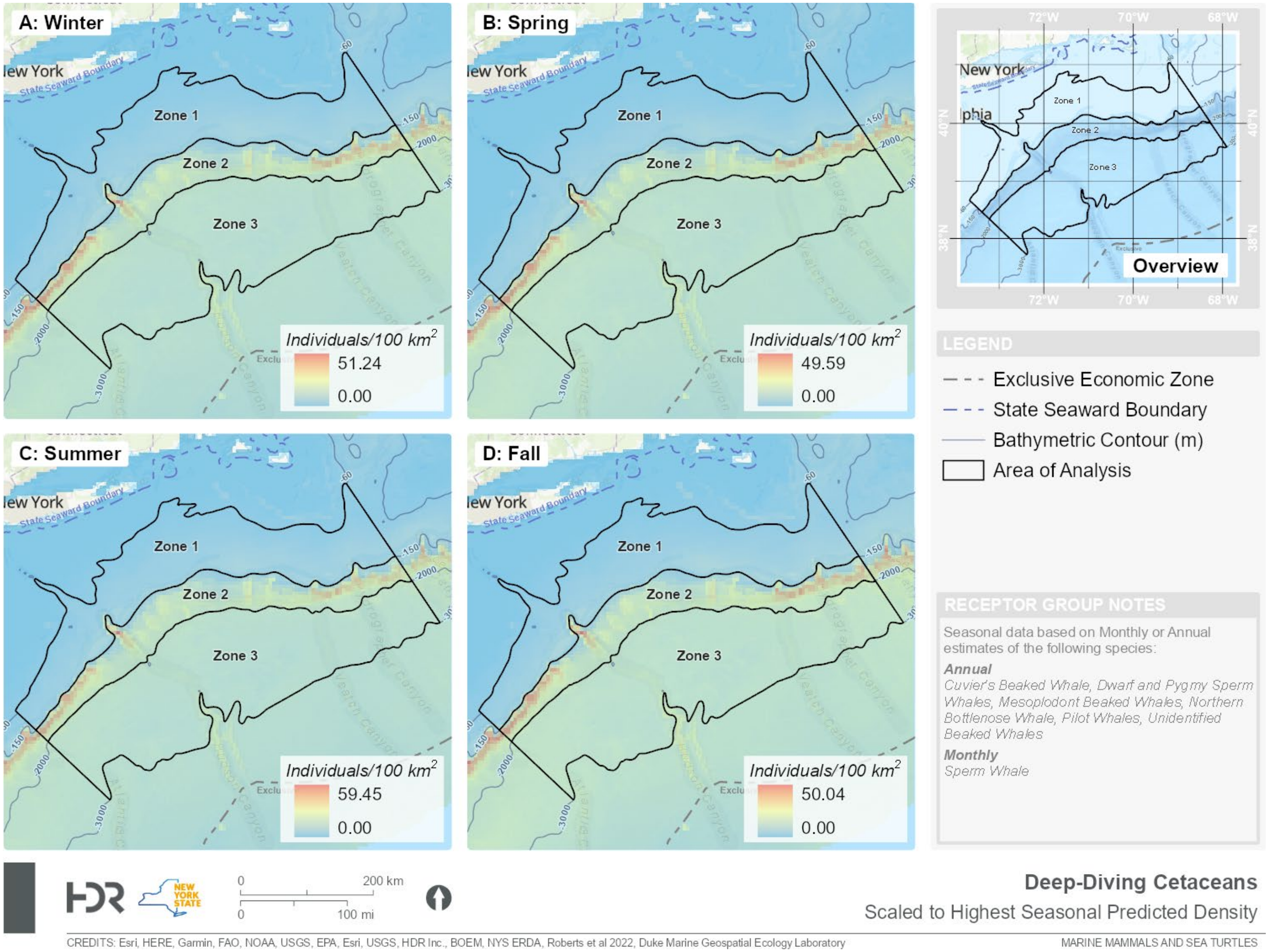


Figure 22. Deep-Diving Cetaceans: Scaled to Highest Annual Predicted Density

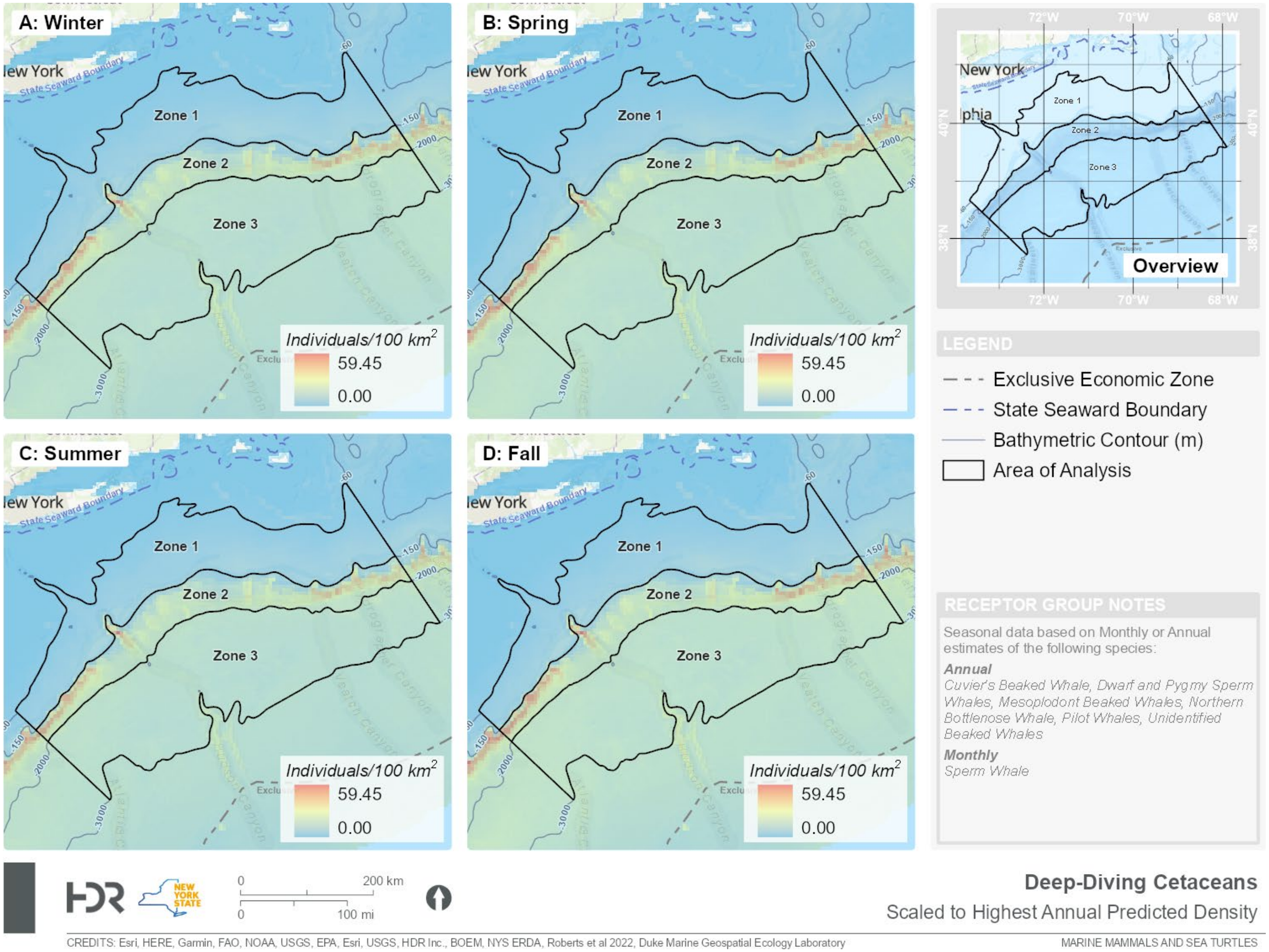


Figure 23. Deep-Diving Cetaceans: Other Sighting Records

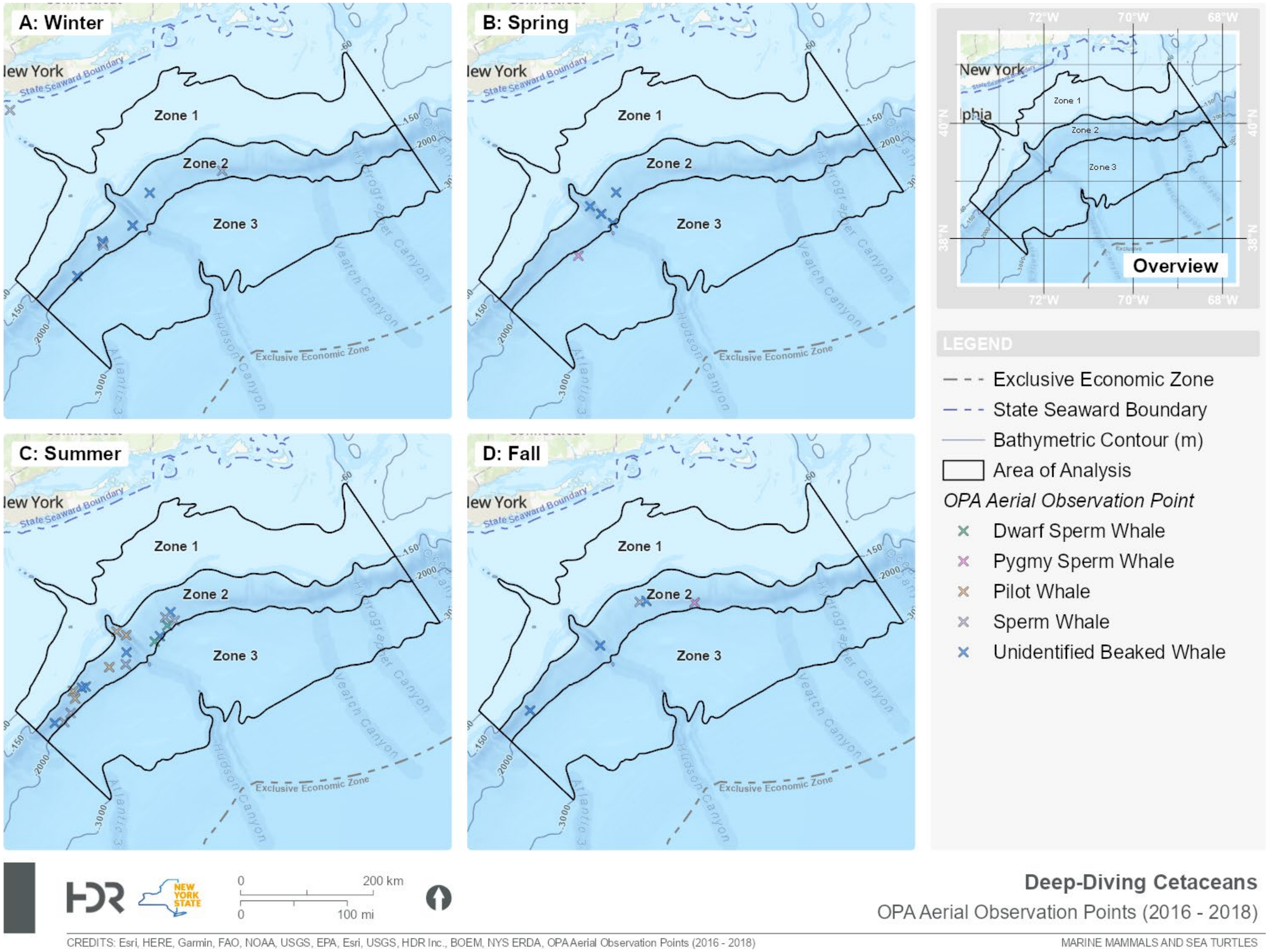
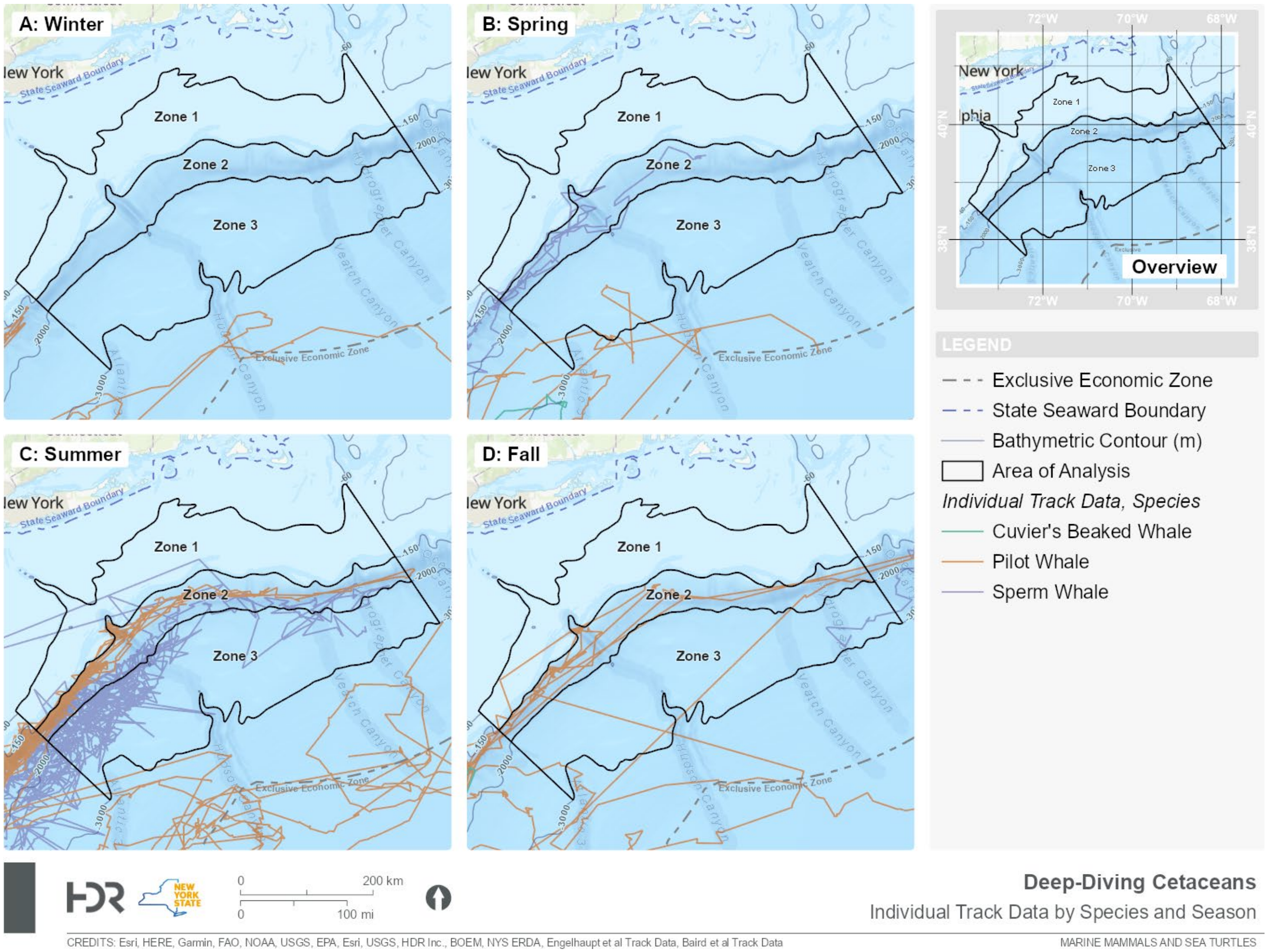


Figure 24. Deep-Diving Cetaceans: Tag Data

Note: Presence of tagged animals in the AoA may be underestimated due to location of tag deployments and duration of tag attachment. Location accuracy varies with tag type.



3.3.1.7 Shallow-Diving Cetaceans: Distribution, Density, and Seasonal Patterns

As described above, the distribution, density, and seasonal patterns of cetaceans were also analyzed in the context of the vertical habitat used by these species (i.e., dive depth, Table 5). Shallow-diving cetaceans are defined here as those that spend significant time in the epipelagic zone (from the surface to 200-m depth).[32] The following shallow-diving cetacean species are included in this analysis: harbor porpoise, baleen whales (except NARW), killer whale, pygmy killer whale, false killer whale, melon-headed whale, common dolphin, Risso's dolphin, Atlantic white-sided dolphin, white-beaked dolphin, Atlantic spotted dolphin, pantropical spotted dolphin, striped dolphin, Fraser's dolphin, rough-toothed, Clymene dolphin spinner dolphin, and common bottlenose dolphin (Table 4).

In winter, maximum densities of shallow-diving cetaceans (1,366.02/100 km^2) are predicted in the upper portions of the continental slope, particularly at the tops of the Hudson, Veatch, and Hydrographer Canyons. Intermediate densities of shallow-diving cetaceans are predicted in winter elsewhere along the upper slope, and throughout shelf habitat in Zone 1. Very low densities are predicted beyond the 2,000-m isobath in Zone 3 (Figure 25).

In spring, the maximum density of shallow-diving cetaceans in the AoA (1,276.12/100 km^2) is slightly lower than that predicted in winter. Distribution of these species is predicted to be similar in winter and spring, although higher concentrations of animals are predicted in the upper slope regions of Zone 2 in spring (Figure 25).

In summer, the maximum predicted density of shallow-diving cetaceans is nearly identical to that in spring (1,276.69/100 km^2), although the predicted distribution in the AoA is more diffuse, with the highest concentration of animals in upper slope waters but intermediate densities predicted in the remainder of Zone 2 and in Zone 1. Relatively low densities of shallow-diving cetaceans are predicted in Zone 3 in the summer, although the predicted density in this zone is higher than in the winter and spring months (Figure 25).

In fall, the maximum density of shallow-diving cetaceans is 1,050.00/100 km^2 and is likewise concentrated in Zone 2. Intermediate densities are predicted in the remainder of Zone 2 and throughout Zone 1, where slightly higher densities are predicted than in summer. As in summer, relatively low (but non-zero) densities of shallow-diving cetaceans are predicted in Zone 3 (Figure 25). Although the use of deepwater areas may seem incongruous for this receptor group, the 200-m depth cutoff is not meant to be an absolute delineation of habitat. Some shallow-diving species may utilize deeper habitats to some extent (and conversely, some deep-diving cetaceans may utilize shallow areas).

Overall, shallow-diving cetaceans are expected to be most common in the AoA in winter, followed by spring and summer. Predicted distribution is concentrated in slope habitats in all seasons, but with intermediate use of shelf waters as well, particularly in fall (Figure 26). During the OPA aerial surveys, 10 species of shallow-diving cetaceans were observed, with the majority of sightings, in spring, followed by summer.[33] Fin, Humpback, and Minke whales were sighted during small vessel surveys conducted between May and November in waters out to 60 km, corresponding with the region inshore of Zone 1.[34] The tracks of several tagged shallow-diving cetaceans overlapped with the AoA, including Humpback whale, Fin whale, and short-beaked common dolphin. In winter, the track of a tagged Humpback whale followed the outer continental shelf during its journey northward from the tagging location off Virginia. This whale spent the majority of its time in the AoA in Zone 1 but crossed into Zone 2 (slope habitat) when over the Hudson Canyon, likely due to prey availability from nutrient upwelling.[35] In spring, three Fin whale tracks overlapped with Zones 1, 2, and 3, in on- and off-shelf areas west of the Hudson Canyon, including deepwater areas beyond the 3,000-m isobath. In summer, two Fin whale tracks overlapped with the AoA, primarily in on-shelf waters west of the Hudson Canyon. In summer, a short-beaked common dolphin tagged off Cape Hatteras closely tracked the shelf edge on its journey northward, spending most of its time in the AoA in Zone 1 just inshore of the 150-m isobath.[36] A Clymene dolphin also tagged off Cape Hatteras in summer had a series of tag locations southwest of Zone 3 and west of Atlantic 3 Canyon, in waters deeper than 2,000 m (Baird et al. 2017; Engelhaupt et al. 2022; Figure 28).

Figure 25. Shallow-Diving Cetaceans: Scaled to Highest Seasonal Predicted Density

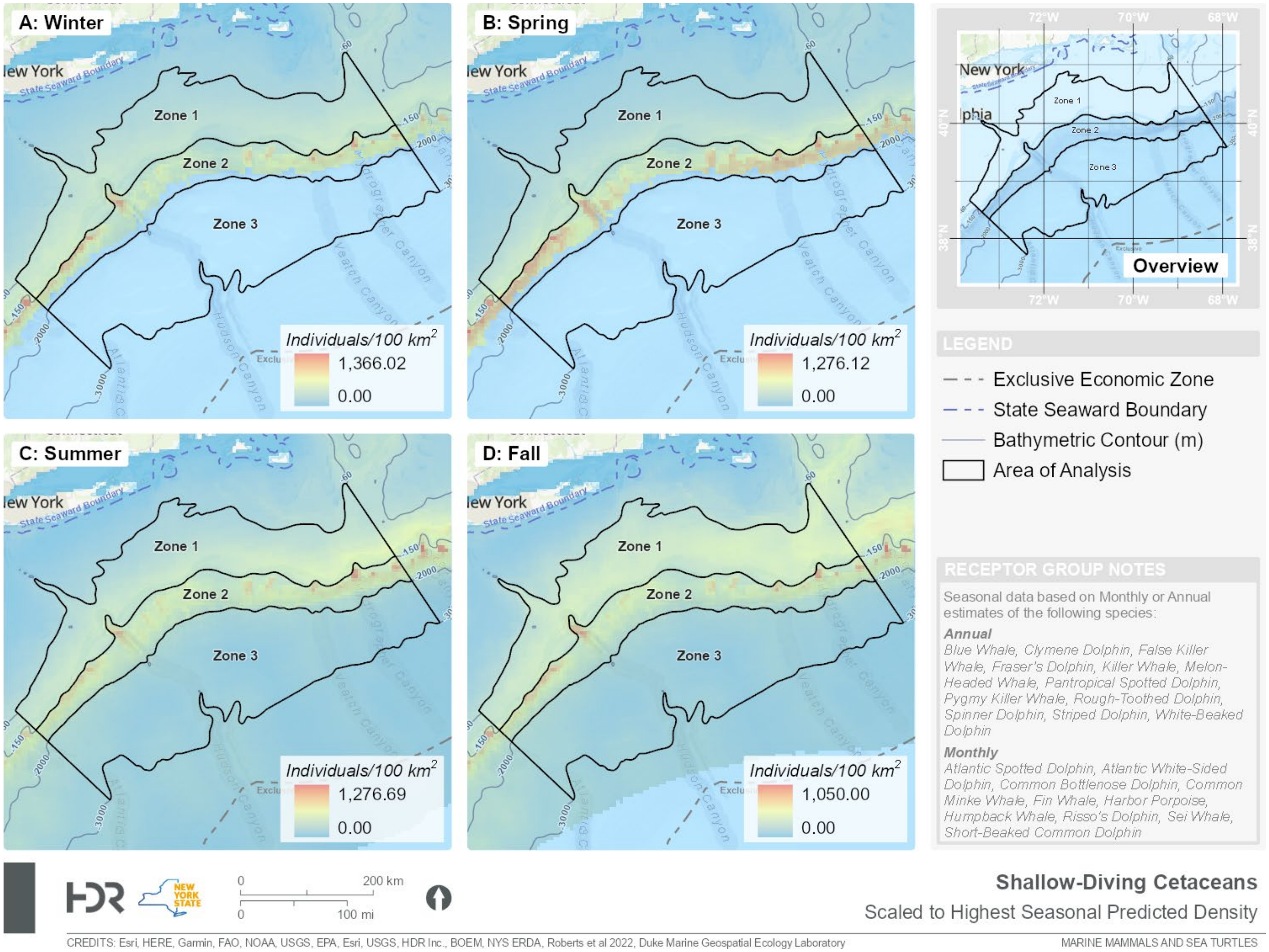


Figure 26. Shallow-Diving Cetaceans: Scaled to Highest Annual Predicted Density

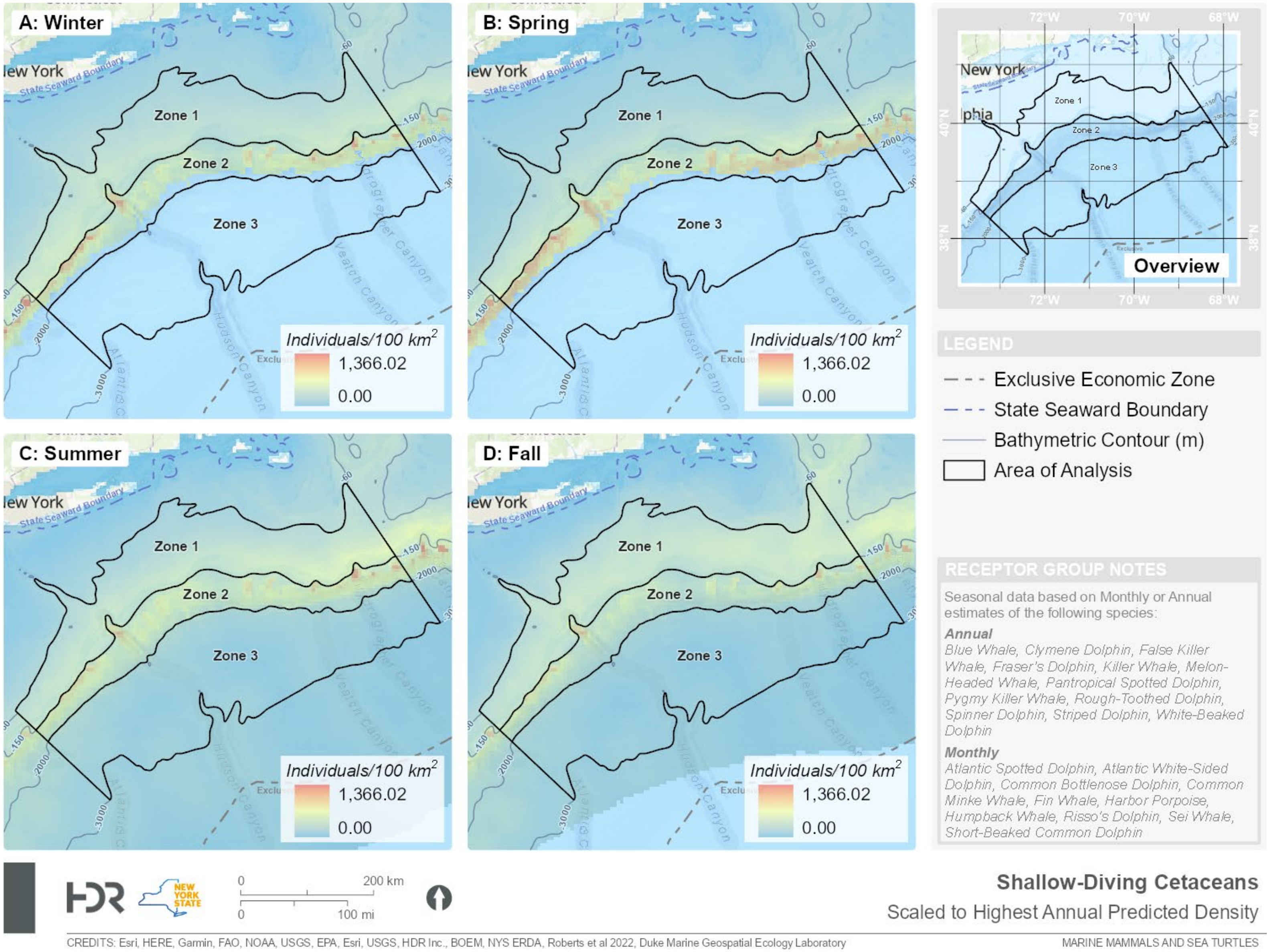


Figure 27. Shallow-Diving Cetaceans: Other Sighting Records

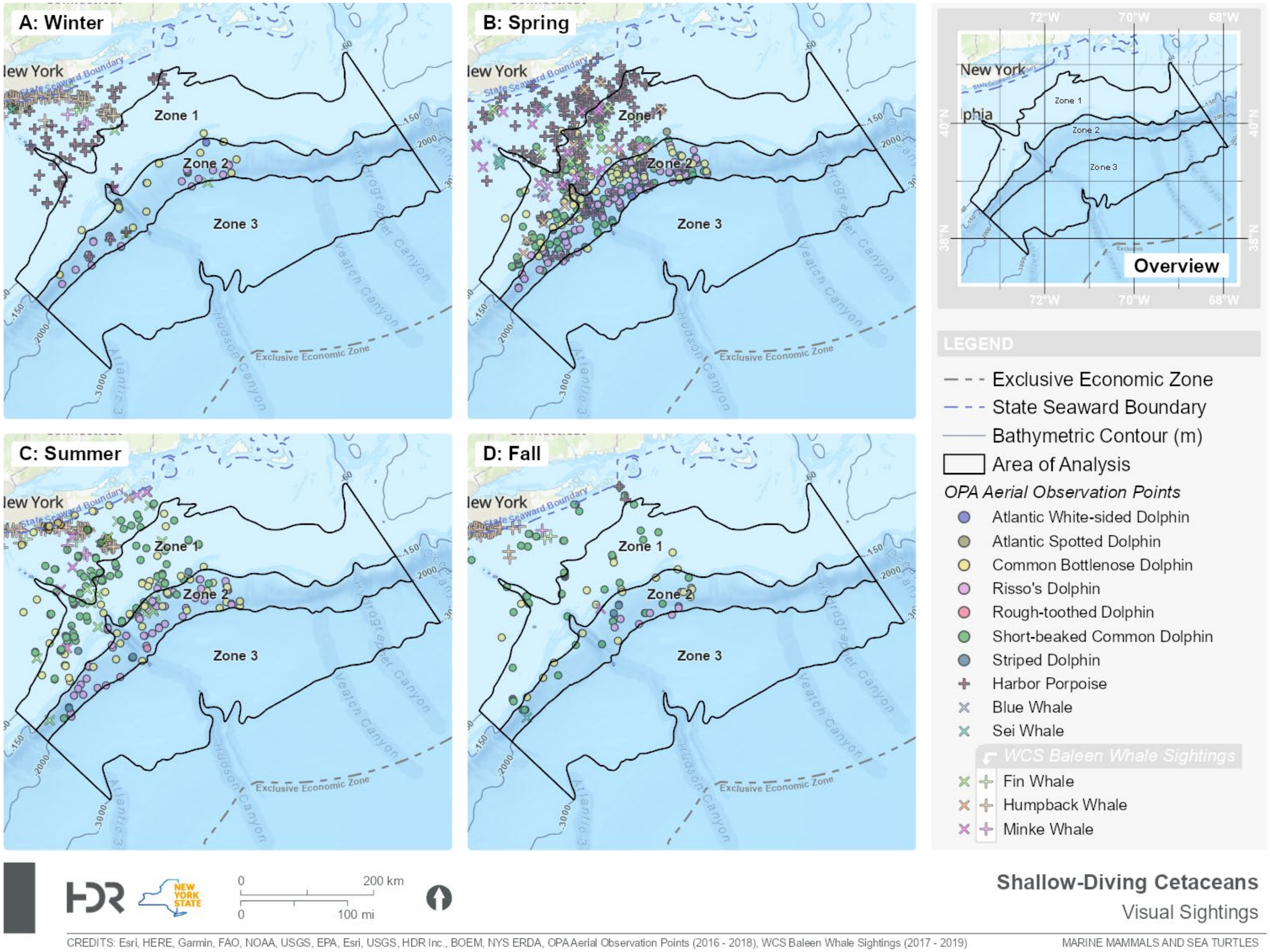
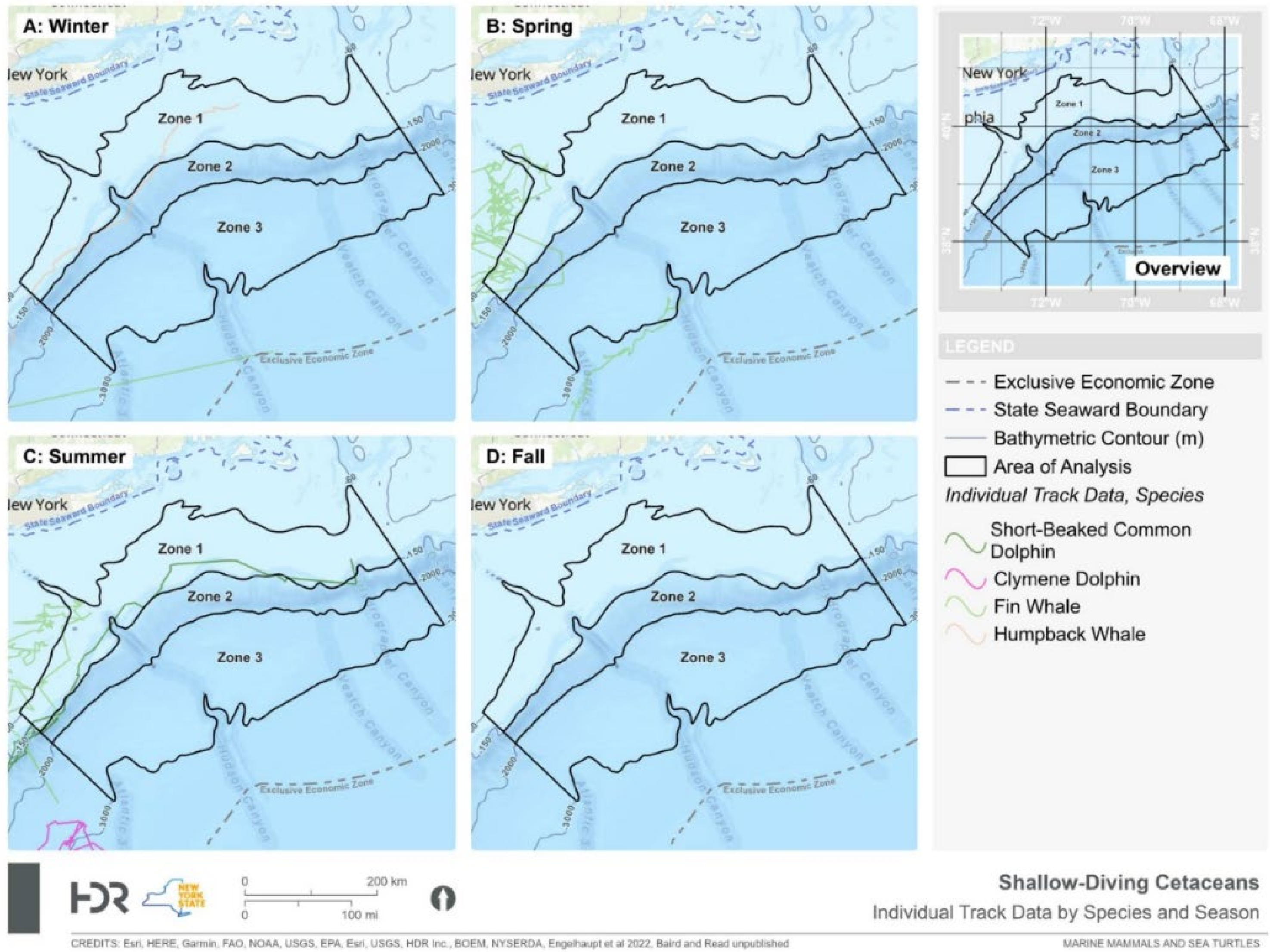


Figure 28. Shallow-Diving Cetaceans: Tag Data

Note: Presence of tagged animals in the AoA may be underestimated due to location of tag deployments and duration of tag attachment. Location accuracy varies with tag type.



3.3.1.8 Seals: Distribution, Density, and Seasonal Patterns

As with other marine mammal species groups, habitat-based density models developed by Roberts et al. (2023) were used to create maps of predicted density of seals in and near the AoA. Gray and harbor seals were modeled together as a guild called "seals." This guild did not include harp, hooded, or ringed seals in density predictions because these species occur only occasionally in the region (Roberts et al. 2023).

In winter, seal density in the AoA highest in Zone 1, inshore of the 150-m isobath. Maximum predicted density in winter (233.97/100 km^2) is centered at haul-out sites and breeding colonies located north of the AoA, around Nantucket, Martha's Vineyard, coastal Connecticut and Rhode Island, and eastern Long Island (Figure 29). Predicted densities of seals in Zones 2 and 3 in all seasons are relatively low. In spring, the distribution pattern is similar, but with more than double the maximum predicted density (527.68/100 km^2), which is also concentrated in the islands south of Cape Cod (Figure 29). In summer and fall, maximum predicted density is 540.55/100 km^2 and 313/100 km^2, respectively. In these seasons, seals are concentrated at haul-out and breeding sites north of the AoA, with lower densities predicted in Zone 1 (shelf waters).

Overall, seals are most common in the AoA in winter and spring and occur in the greatest numbers in shelf waters north of the AoA. This result generally aligns with sighting data from the NYSERDA OPA aerial surveys, when seals were observed most often in winter and spring (Normandeau Associates Inc. and APEM Ltd. 2021a; Figure 30). The majority of sightings were of harbor and gray seals, although one harp seal was observed in spring in Zone 2 (Figure 31).

Seals' heavy use of shelf waters in spring, particularly areas inshore of the AoA, is supported by available telemetry data from 14 harbor seals tagged in coastal Virginia (Ampela et al. 2023; Figure 32). These 14 tags (seven deployed in 2018, two in 2020, and five in 2022) recorded 29,554 locations over 1,566 tracking days. Only three of these locations overlapped with the AoA at the northern edges of Zone 1, and the remainder were inshore of the 60-m isobath, emphasizing the importance of inshore shelf habitat for this species (Figure 32).

Murray et al. (2021) tagged 30 gray seal pups in 2019 and 2020 at sites in coastal Maine and Massachusetts. Although the source data were not available for this analysis, several tag tracks appear to overlap with the AoA (Figure 33), and tagged gray seals utilized shelf and slope waters out to approximately the 200-m isobath. Mid-Atlantic waters were used most heavily by tagged pups from January to June (Murray et al. 2021).

Figure 29. Seals: Scaled to Highest Seasonal Predicted Density

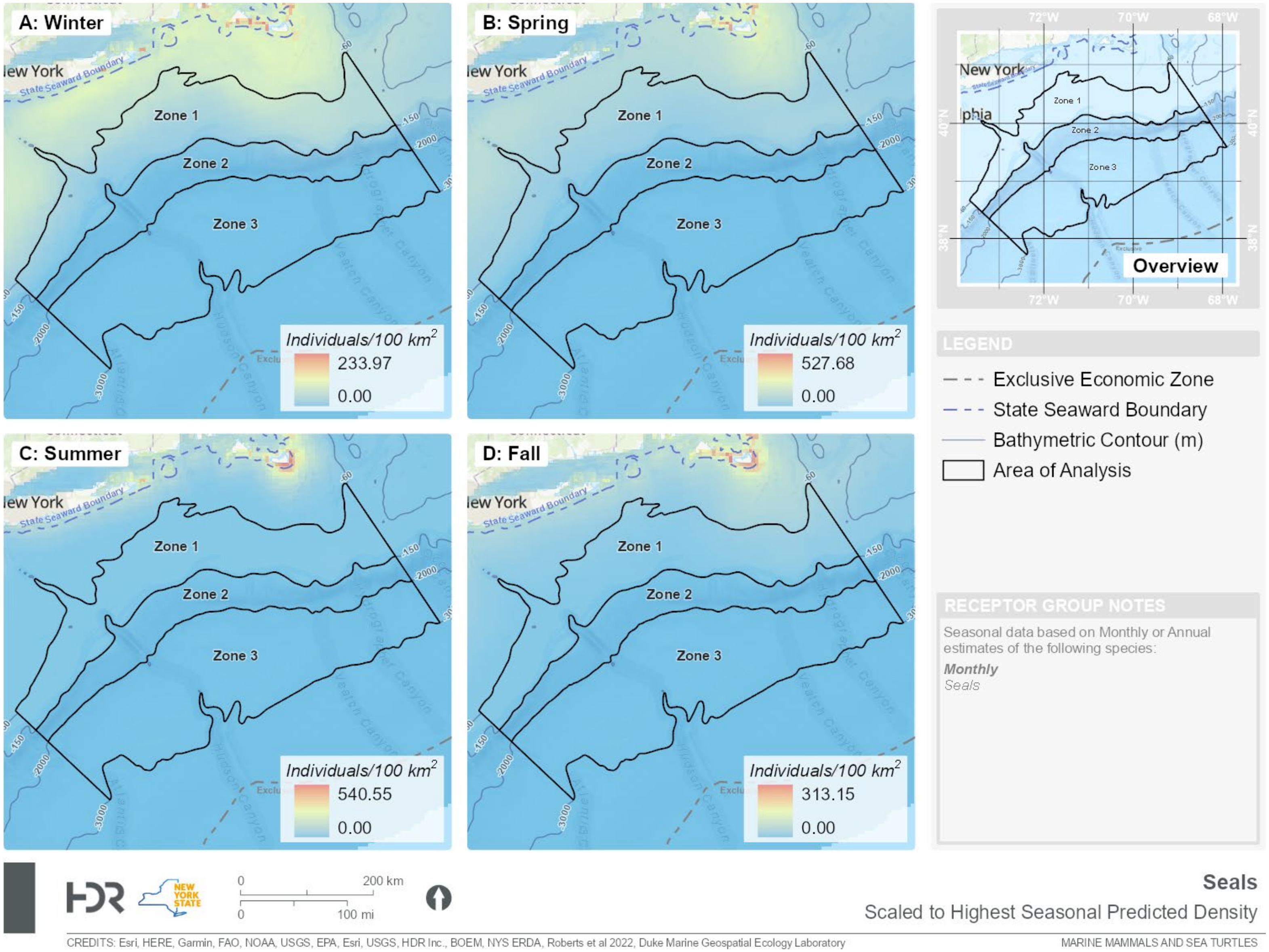


Figure 30. Seals: Scaled to Highest Annual Predicted Density

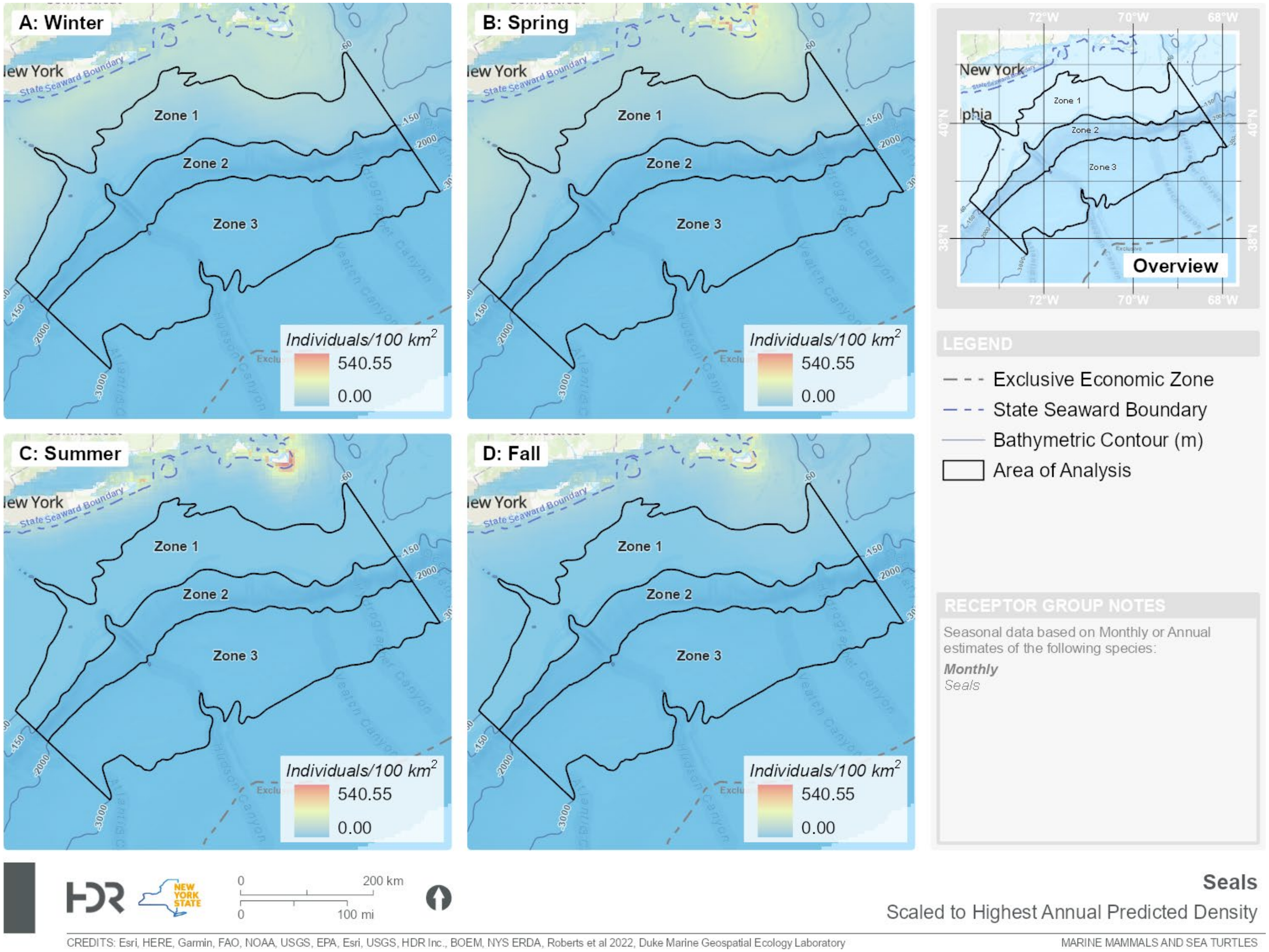


Figure 31. Seals: Other Sighting Records

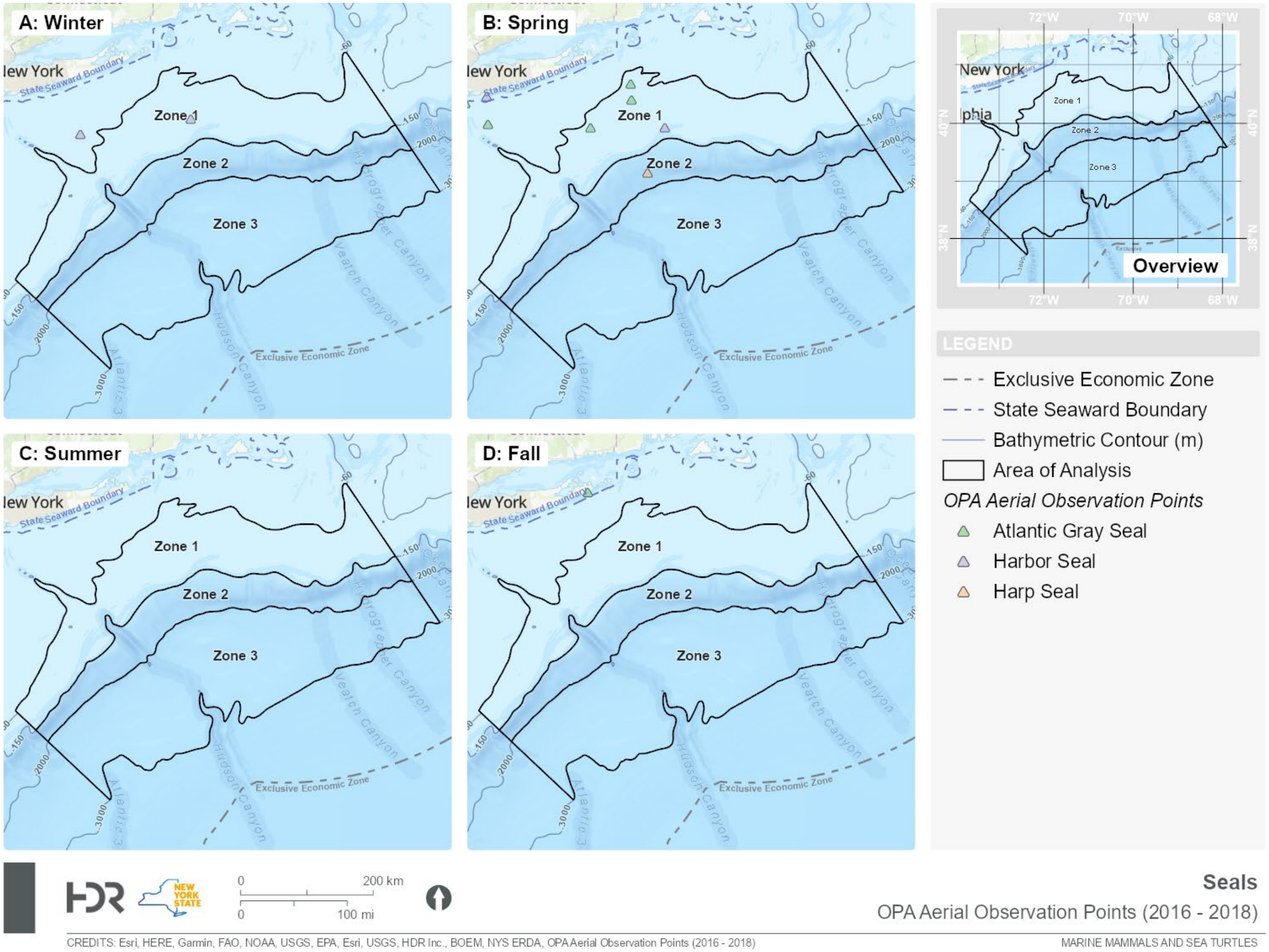


Figure 32. Seals: Tag Data

Note: Location accuracy varies with tag type.

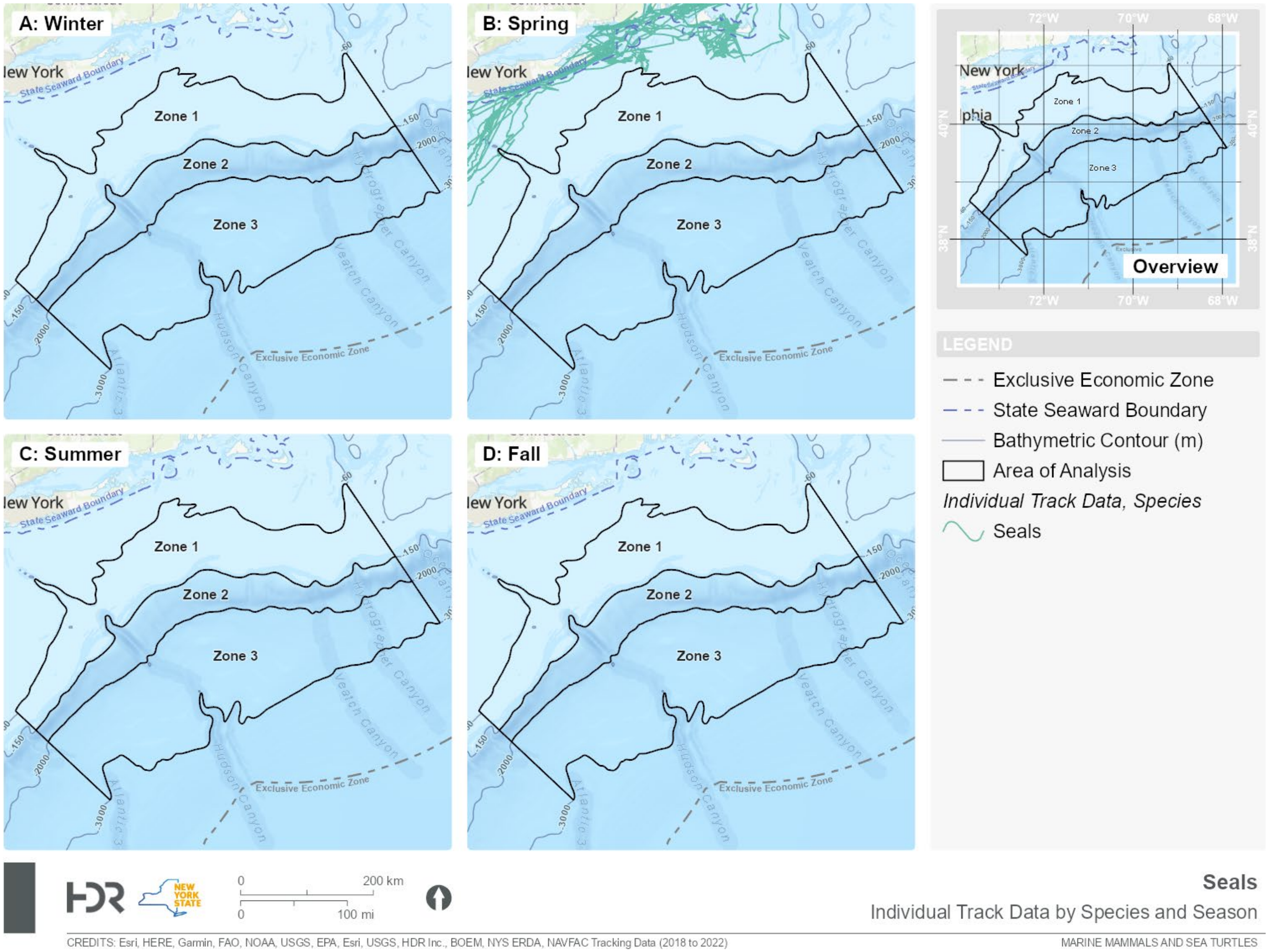
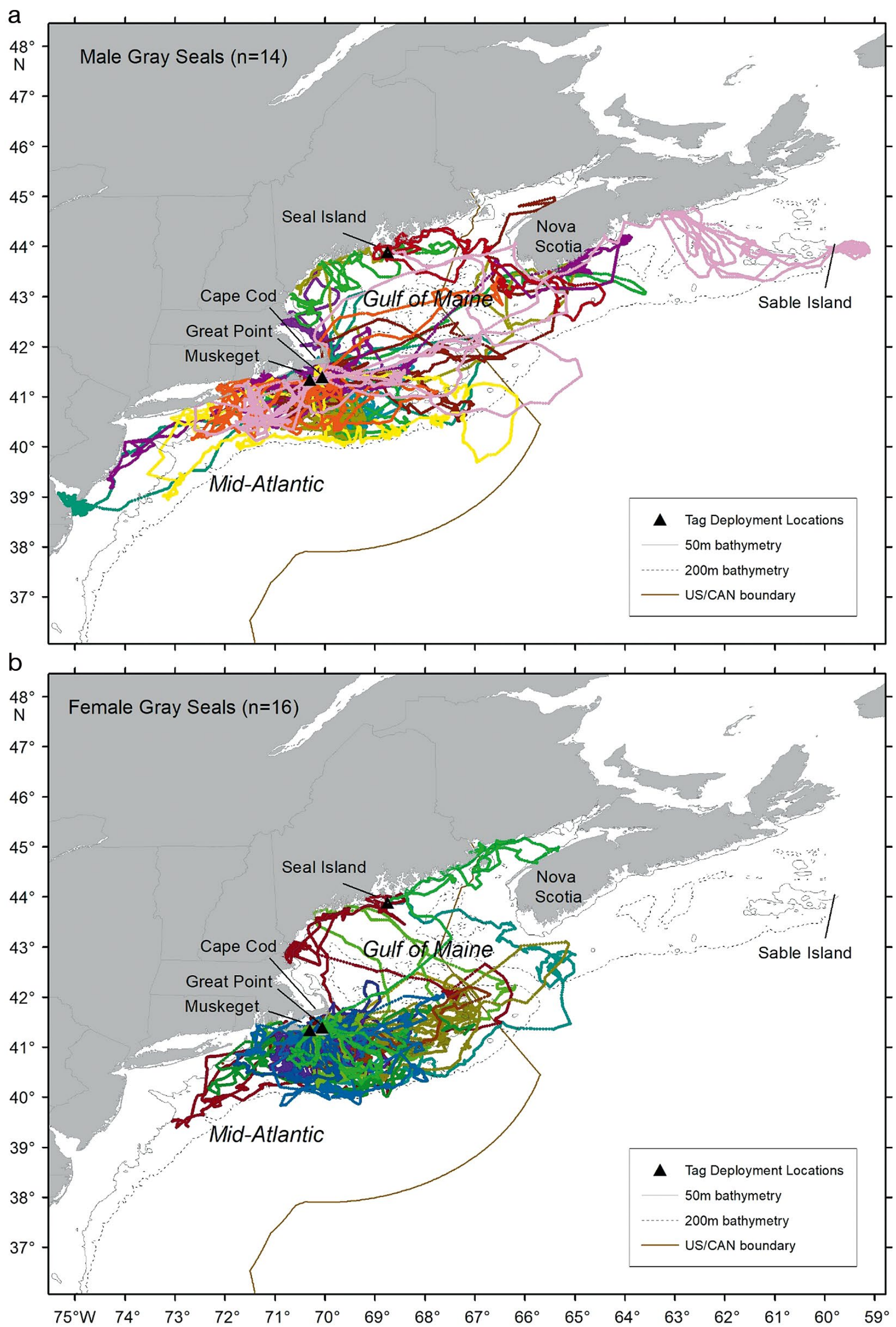


Figure 33. Seals: Interpolated Telemetry Tracks from (a) 14 Male Gray Seal Pups and (b) 16 Female Gray Seal Pups, 2019–2020

Source: Murray et al. 2021.



Seasonal estimates of the predicted number of marine mammals were calculated for each Zone, and for the entire AoA, based on the Roberts et al. (2023) habitat-based model data (Table 8). Also presented are the 90% CI around these population estimates (lower bound of 5% confidence and upper bound of 95% confidence).

Table 8. Seasonal Best Population Estimates for Marine Mammals (Species or Species Group) Known to Occur in or Near the Area of Analysis (AoA: Zones 1–3)

Estimates are derived from Roberts et al. (2023). Maps of the CV (an estimate of the uncertainty around these density estimates) for each modeled species/guild are available at https://seamap-dev.env.duke.edu/models/Duke/EC/

Common Name	Scientific Name	Period	Population Est. Zone 1	Zone 1 (5% – 95% CI)	Population Est. Zone 2	Zone 2 (5% – 95% CI)	Population Est. Zone 3	Zone 3 (5%/95% CI)	Population Est. All AoA	All AoA (5% – 95% CI)
Atlantic spotted dolphin	*Stenella frontalis*	Winter	106	36–114	1,822	209–5,781	8,174	943–26,470	10,101	1,188–32,364
		Spring	231	77–251	1,832	212–5,794	8,174	943–26,470	10,238	1,232–32,514
		Summer	1,093	375–1,144	1,872	223–5,838	8,174	943–26,470	11,139	1,540–33,452
		Fall	3,774	1,381–3,640	1,905	231–5,872	8,174	943–26,470	13,853	2,555–35,982
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	Winter	7,339	1,709–12,562	2,859	331–9,938	1,074	68–6,496	11,271	2,108–28,997
		Spring	6,972	1,632–11,173	3,068	372–9,639	1,315	90–7,756	11,354	2,094–28,568
		Summer	6,649	1,667–10,000	2,251	274–6,885	563	37–3,176	9,462	1,978–20,060
		Fall	3,788	652–9,020	384	28–1,918	46	3–291	4,219	683–11,229
Blue whale	*Balaenoptera musculusmusculus*	Year	1	0–1	1	0–3	5	1–15	8	1–19
Clymene dolphin	*Stenella clymene*	Year	0	0–2	1	0–7	23	1–153	24	1–162
Common bottlenose dolphin	*Tursiops truncatus*	Winter	6,756	2,068–8,107	12,813	4,448–13,080	10,064	3,794–9,718	29,633	10,310–30,906
		Spring	4,782	1,360–6,317	13,041	4,332–14,133	10,375	3,811–10,305	28,199	9,503–30,755
		Summer	9,852	3,586–9,557	15,917	6,160–14,410	9,457	3,694–8,802	35,227	13,441–32,770
		Fall	11,698	4,010–12,262	18,142	6,912–16,679	10,941	4,270–10,189	40,781	15,192–39,129

Table 8 continued

Common Name	Scientific Name	Period	Population Est. Zone 1	Zone 1 (5% – 95% CI)	Population Est. Zone 2	Zone 2 (5% – 95% CI)	Population Est. Zone 3	Zone 3 (5%/95% CI)	Population Est. All AoA	All AoA (5% – 95% CI)
Common Minke whale	*Balaenoptera acutorostrata acutorostrata*	Winter	185	75–158	36	12–37	27	6–43	248	93–238
		Spring	1,010	369–953	278	91–292	382	100–537	1,669	560–1,782
		Summer	956	307–1,025	119	33–146	113	24–193	1,188	365–1,364
		Fall	502	138–636	78	19–112	69	14–127	649	171–876
Cuvier's beaked whale	*Ziphius cavirostris*	Year	0	0–0	149	35–220	573	134–885	722	169–1,105
Dwarf and pygmy sperm whales	*Kogia* spp.	Year	0	0–0	43	6–110	618	92–1,525	661	98–1,635
False killer whale	*Pseudorca crassidens*	Year	5	1–7	15	4–21	36	9–52	56	14–80
Fin whale	*Balaenoptera physalus*	Winter	433	203–320	500	231–385	134	51–130	1,068	484–835
		Spring	711	341–518	508	235–386	202	76–195	1,420	652–1,099
		Summer	1,022	478–752	598	273–460	154	58–148	1,773	810–1,361
		Fall	592	274–446	559	253–438	111	41–108	1,262	567–992
Fraser's dolphin	*Lagenodelphis hosei*	Year	0	0–0	0	0–0	0	0–0	0	0–0
Harbor porpoise	*Phocoena phocoena*	Winter	5,685	1,505–8,124	622	95–1,480	0	0–0	6,307	1,600–9,603
		Spring	7,382	2,004–9,828	1,065	158–2,628	0	0–0	8,447	2,163–12,456
		Summer	976	176–1,964	65	9–130	1	0–8	1,043	185–2,101
		Fall	1,263	256–2,196	68	10–131	1	0–8	1,332	266–2,334
Humpback whale	*Megaptera novaeangliae*	Winter	93	37–83	44	16–42	4	1–8	142	54–133
		Spring	520	152–658	151	38–221	20	3–44	691	193–923
		Summer	589	174–720	88	14–185	7	1–27	685	189–931
		Fall	261	54–469	20	3–39	2	0–5	283	58–512
Killer whale	*Orcinus orca*	Year	3	1–5	6	1–10	15	4–24	25	6–38

Table 8 continued

Common Name	Scientific Name	Period	Population Est. Zone 1	Zone 1 (5% – 95% CI)	Population Est. Zone 2	Zone 2 (5% – 95% CI)	Population Est. Zone 3	Zone 3 (5%/95% CI)	Population Est. All AoA	All AoA (5% – 95% CI)
Melon-headed whale	*Peponocephala electra*	Year	0	0–0	0	0–0	0	0–0	0	0–0
Mesoplodont beaked whales	*Mesoplodon densitostris, M. europaeus, M. mirus, and M. bidens*	Year	1	0–3	155	33–254	524	109–915	681	143–1,172
North Atlantic right whale	*Eubalaena glacialis*	Winter	169	35–283	22	3–51	2	0–9	194	39–343
		Spring	286	64–443	36	6–71	4	0–14	325	71–529
		Summer	25	5–41	4	1–8	1	0–3	30	6–52
		Fall	32	7–53	6	1–11	1	0–4	39	8–68
Northern bottlenose whale	*Hyperoodon ampullatus*	Year	5	1–6	14	4–16	35	11–40	54	17–62
Pantropical spotted dolphin	*Stenella attenuata*	Year	4	1–9	6	1–13	30	6–51	40	8–73
Pilot whales	*Globicephala* spp.	Year	568	131–847	2,556	683–3,344	1,441	339–2,231	4,566	1,154–6,423
Pygmy killer whale	*Feresa attenuata*	Year	0	0–1	1	0–2	3	1–5	4	1–7
Risso's dolphin	*Grampus griseus*	Winter	1,687	670–1,471	10,975	4,650–8,988	8,376	3,297–7,669	21,039	8,617–18,129
		Spring	1,431	578–1,225	11,084	4,703–9,090	8,489	3,422–7,601	21,004	8,703–17,916
		Summer	5,480	2,370–4,384	28,792	13,058–22,154	17,052	7,321–14,501	51,324	22,749–41,038
		Fall	4,226	1,746–3,527	19,339	8,348–15,649	9,211	3,607–8,579	32,776	13,701–27,755
Rough-toothed dolphin	*Steno bredanensis*	Year	2	0–6	5	1–10	22	5–38	29	6–55

Table 8 continued

Common Name	Scientific Name	Period	Population Est. Zone 1	Zone 1 (5% – 95% CI)	Population Est. Zone 2	Zone 2 (5% – 95% CI)	Population Est. Zone 3	Zone 3 (5%/95% CI)	Population Est. All AoA	All AoA (5% – 95% CI)
Seals	*Phocidae*	Winter	7,980	1,970–11,683	512	75–1,257	179	18–682	8,672	2,063–13,622
		Spring	7,849	1,876–11,484	720	101–1,829	289	28–1,189	8,857	2,005–14,503
		Summer	541	130–811	151	23–341	41	5–128	733	158–1,280
		Fall	1,461	247–3,440	76	8–270	11	1–50	1,548	256–3,760
Sei whale	*Balaenoptera borealis borealis*	Winter	50	10–92	15	2–35	5	1–19	70	13–146
		Spring	315	78–464	153	29–291	66	8–214	534	115–969
		Summer	87	22–123	26	4–59	7	1–26	120	27–208
		Fall	67	13–126	11	1–31	2	0–9	80	15–166
Short-beaked common dolphin	*Delphinus delphis*	Winter	72,122	22,788–80,730	74,957	19,015–107,133	8,818	1,604 – 17,992	155,897	43,408–205,854
		Spring	50,949	13,896–66,555	106,708	28,848–140,757	24,310	6,415–33,327	181,967	49,159–240,639
		Summer	75,448	21,412–92,864	59,923	14,764–88,303	7,403	1,256–15,937	142,774	37,433–197,104
		Fall	89,505	22,227–130,881	41,829	7,986–84,602	3,306	524–7,936	134,641	30,737–223,420
Sperm whale	*Physeter macrocephalus*	Winter	133	47–131	969	428–782	2,737	1,227–2,219	3,839	1,701–3,132
		Spring	73	26–69	858	376–692	2,962	1,310–2,439	3,893	1,713–3,200
		Summer	210	78–195	1,436	657–1,111	3,573	1,671–2,782	5,219	2,406–4,088
		Fall	176	63–171	1,058	478–830	3,428	1,569–2,731	4,661	2,110–3,733
Spinner dolphin	*Stenella longirostris longiristris*	Year	18	3–36	54	9–105	129	23–259	201	36–399

Table 8 continued

Common Name	Scientific Name	Period	Population Est. Zone 1	Zone 1 (5% – 95% CI)	Population Est. Zone 2	Zone 2 (5% – 95% CI)	Population Est. Zone 3	Zone 3 (5%/95% CI)	Population Est. All AoA	All AoA (5% – 95% CI)
Striped dolphin	*Stenella coeruleoalba*	Year	41	4–144	2,286	454–4,062	18,296	3,597–34,147	20,623	4,055–38,352
Unidentified beaked whales	*Ziphiidae* spp.	Year	19	5–26	173	48–223	597	171–763	790	224–1,012
White-beaked dolphin	*Lagenorhynchus albirostris*	Year	1	0–1	0	0–0	0	0–0	1	0–1

Note: Zeroes represent predicted density versus lack of data. CI = confidence interval; Est. = estimate.

3.3.2 Sea Turtles

3.3.2.1 All Sea Turtle Species: Distribution, Density, and Seasonal Patterns

Four species of sea turtle are expected to occur in the AoA: three "hardshell" species (Green, Kemp's Ridley, and Loggerhead) and the Leatherback Sea Turtle. Kemp's Ridley and Leatherback Sea Turtles are listed as endangered under the ESA, and Green and Loggerhead Sea Turtles are considered threatened (Table 3). Density surface models for these species developed by DiMatteo et al. (2024) were used to predict the seasonal density of sea turtles in the AoA (Table 9). These models estimate long-term (2003–2019) monthly averages of density, abundance, and distribution for Kemp's Ridley, Leatherback, and Loggerhead Sea Turtles (the Green Sea Turtle models cover only 2010–2019). The modeled distribution of all four turtle species begins at the State Seaward Boundary and extends past the 3,000-m isobath.

As with marine mammals (section 3.3.1), maps of seasonal density are scaled to the annual highest density value to better visualize the relationship in density levels across seasons. When maps are scaled to the highest seasonal density value for each season, the same color on different seasonal maps does not represent the same density on these different maps. Therefore, scaling all seasonal maps for a species (or species group) to the highest annual density makes the densities represented by the colors match across the seasonal maps and better show changes in density among seasons.

As stated in section 3.3.2, the PAC recommended that sea turtles be divided into the following receptor groups for purposes of risk assessment: post-hatchling dispersal stage (all sea turtle species); non-hatchling Loggerhead, Kemp's Ridley, and Green Sea Turtles, and non-hatchling Leatherback Sea Turtles. Because the available sea turtle density models do not contain information about sea turtle life stages, the distribution maps shown in this section are organized by species only.

In winter, the highest predicted density (81.14/100 km^2) of turtles is found on the continental shelf in Zone 1, southwest of the Hudson Shelf Valley, and inshore of the 150-m isobath (Figure 34). Predicted turtle density in Zone 2 is relatively low in winter, with intermediate densities predicted in Zone 3, with slightly higher concentrations in the eastern portions of Zone 3 near the 3,000-m isobath (Figure 34). The predicted high values in Zone 1 appear to be driven by Loggerhead Sea Turtles, while the intermediate values in Zone 3 are driven by Leatherback Sea Turtles, as this is the only species with a regular occurrence in Zone 3.

Spring distribution of sea turtles is very similar to their winter distribution, but with slightly higher predicted densities (Figure 34). The highest predicted densities are in Zone 1, southwest of the Hudson Shelf Valley (83.44/100 km^2) and are driven mainly by Loggerhead densities. Predicted turtle density in Zone 2 is relatively low in spring except for a small area north of Atlantic 3 Canyon, just beyond the 150-m isobath. In spring, Zone 3 has intermediate predicted density values throughout (although slightly higher than those in winter), and turtle density in this zone is driven by Leatherback distribution.

Predicted sea turtle densities in summer are highest in waters shallower than 150 m, with a maximum of 588.02/100 km^2 inshore of Zone 1, southwest of the Hudson Shelf Valley. Intermediate densities are predicted along the continental shelf in the remainder of Zone 1 east of the Hudson Shelf Valley. As in spring, predicted turtle density in Zone 2 in summer is relatively low except for a small area north of Atlantic 3 Canyon, just beyond the 150-m isobath. In Zone 3. The high-predicted densities of sea turtles in summer in Zone 1 and inshore are driven mainly by the seasonal distribution of Green, Loggerhead, and Leatherback Sea Turtles. The low-to-intermediate turtle densities predicted in Zone 3 in summer are driven by Leatherback distribution.

The predicted distribution pattern for sea turtles in fall is similar to that in summer, but with slightly lower density values. The highest densities (479.54/100 km2, Figure 34) are likewise predicted to occur southwest of the Hudson Shelf Valley, inshore of Zone 1, and are driven mainly by the seasonal distribution of Green, Leatherback, and Loggerhead Sea Turtles. Intermediate densities of sea turtles are predicted along the continental shelf in fall, east of the Hudson Shelf Valley, and from the state seaward boundary through Zone 1. This pattern is driven primarily by the seasonal distribution of green and Leatherback Sea Turtles. The intermediate to low densities predicted throughout Zone 3 in the fall are driven by the seasonal distribution of Leatherback Sea Turtles.

Overall, sea turtles are expected to be most common in the AoA in summer and fall, with the highest densities in the southwest portion of Zone 1, and intermediate to low densities in Zone 3 (Figure 35). The maximum densities in summer and fall are approximately five times greater than those in winter and spring.

Table 9. Seasonal Best Population Estimates for Sea Turtles Known to Occur in or Near the Area of Analysis (AoA; Zones 1–3)

Note: Zeros represent predicted density versus a lack of data.

Estimates are derived from DiMatteo et al. (2024).

Common Name	Scientific Name	Period	Population Est. Zone 1	Population Est. Zone 2	Population Est. Zone 3	Population Est. All AoA
Green Sea Turtle	*Chelonia mydas*	Fall	13,748	157	0	13,905
		Spring	0	0	0	0
		Summer	28,090	440	0	28,530
		Winter	0	0	0	0
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Fall	88	18	35	141
		Spring	0	0	8	8
		Summer	191	49	110	349
		Winter	0	0	0	0
Leatherback Sea Turtle	*Dermochelys coriacea*	Fall	11,022	3,571	13,583	28,176
		Spring	191	402	3,537	4,130
		Summer	8,628	3,758	14,755	27,142
		Winter	275	369	2,308	2,953
Loggerhead Sea Turtle	*Caretta caretta*	Fall	26,131	2,938	4,440	33,509
		Spring	5,801	1,147	3,370	10,318
		Summer	24,367	2,579	3,176	30,122
		Winter	6,914	1,182	2,911	11,006

Figure 34. Sea Turtles (All Species): Scaled to Highest Seasonal Predicted Density

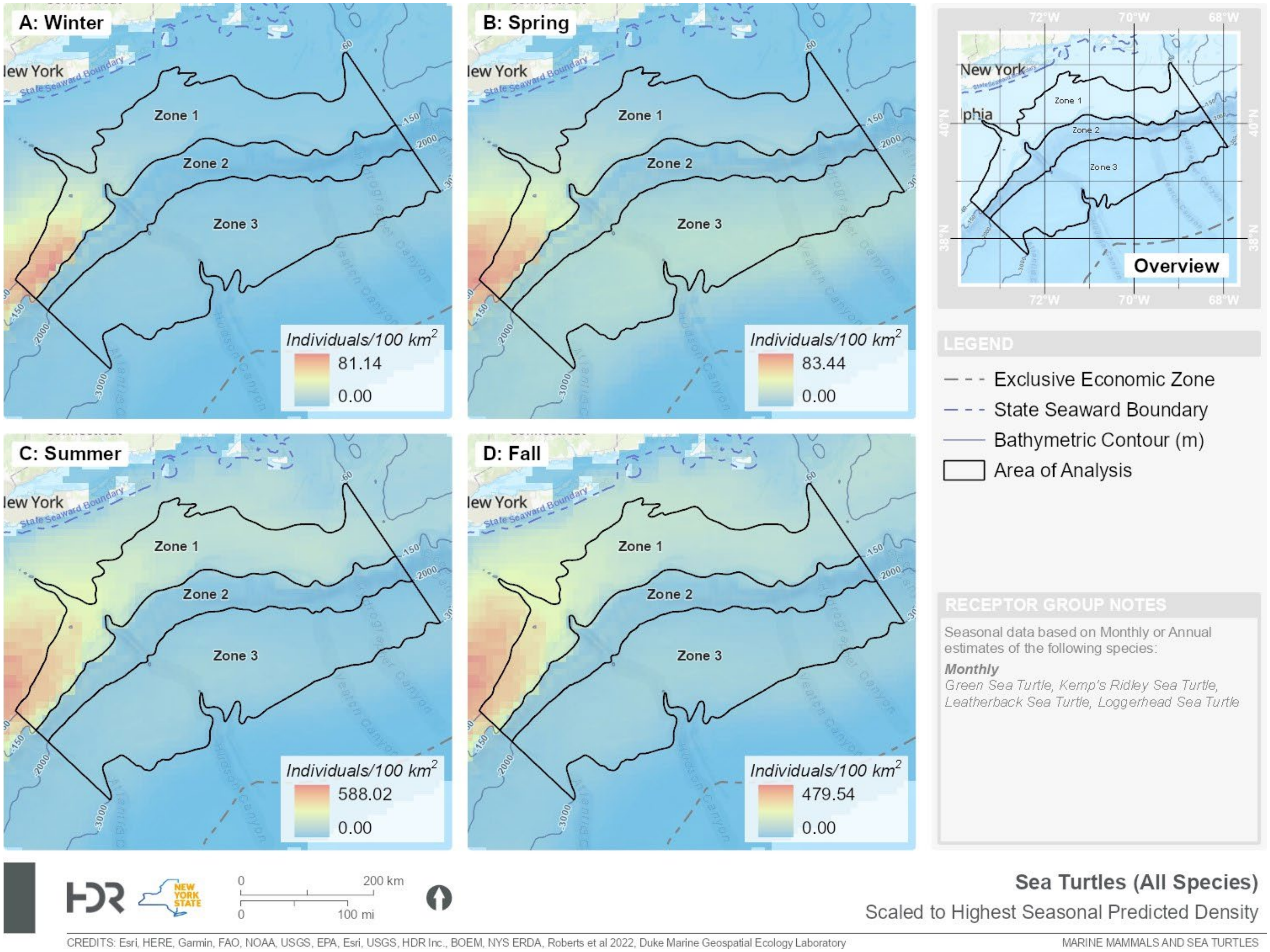
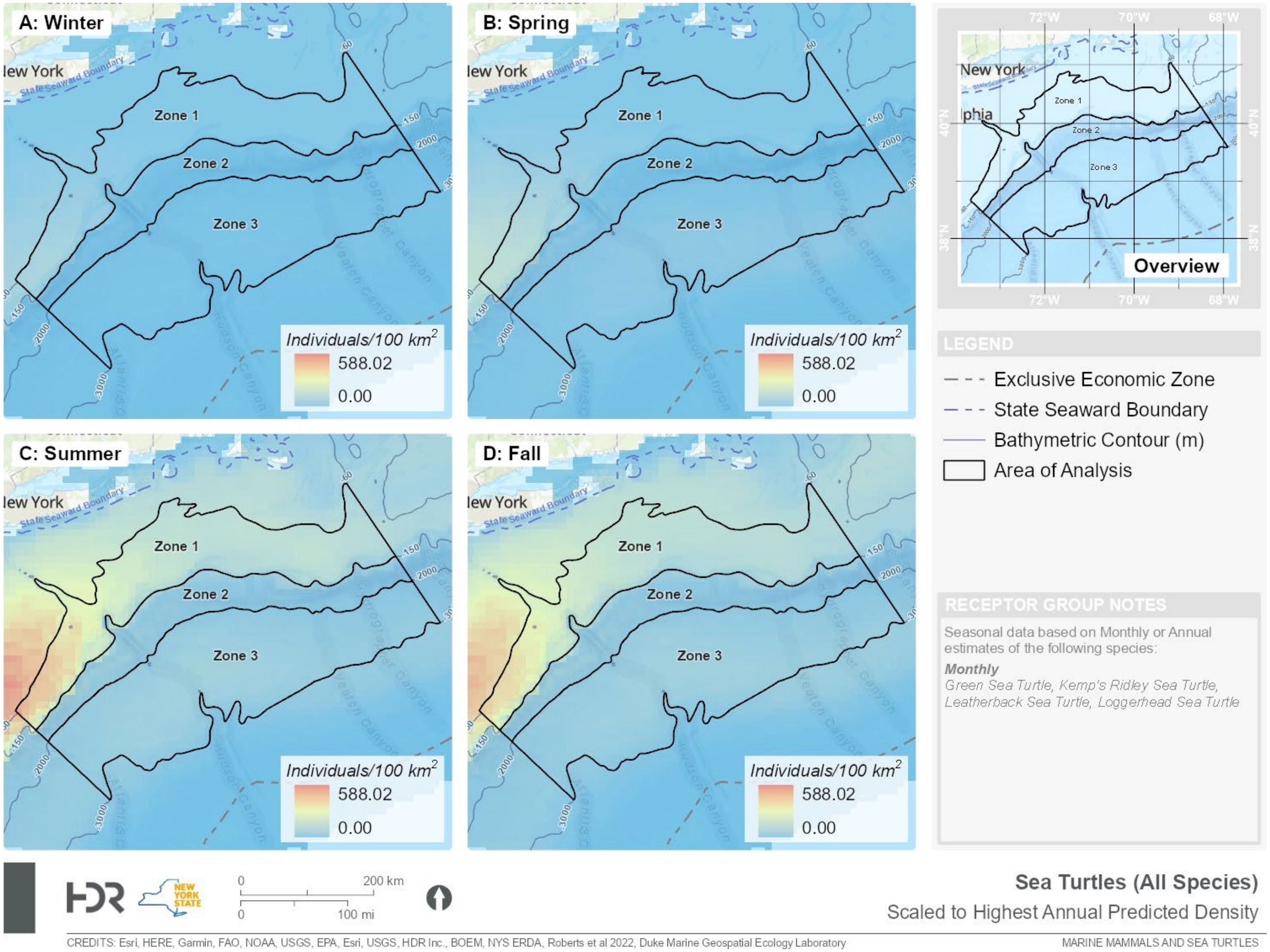


Figure 35. Sea Turtles (All Species): Scaled to Highest Annual Predicted Density



3.3.2.2 Green Sea Turtle: Distribution, Density, and Seasonal Patterns

The predicted density of Green Sea Turtles in the AoA is zero in the winter and spring seasons (Figure 36), although a small area of relatively high density (9.29 /100 km^2) is predicted on the continental shelf southwest of Zone 1, between the 60-m and 150-m isobath (Figure 36). The predicted density of green turtles in Zone 3 in all four seasons is zero (Table 9).

In summer, the highest density of Green Sea Turtles is predicted to occur outside of the AoA to the west of Zone 1 and reach a maximum of 228.89 /100 km.^{2}

Relatively high densities are also predicted to occur in the southwestern region of Zone 1, on the continental shelf west of Hudson Canyon (Figure 36). Intermediate densities are predicted throughout Zone 1 in the summer along the continental shelf to the east. Beyond the 150-m isobath, predicted densities of green turtles in summer extremely low.

Distribution patterns for this species in the fall season are similar to those predicted in summer, although maximum density reaches only 124.79/100 km^2 in fall (Figure 36). This peak density is predicted inshore of Zone 1, southwest, and northeast of the Hudson Shelf Valley. Relatively high densities of green turtles in fall are also predicted in the southwestern region of Zone 1, and intermediate densities are predicted in the remainder of Zone 1 along the continental shelf. As in summer, predicted density of green turtles beyond the 150-m isobath are extremely low. Overall, Green Sea Turtles are expected to be most common in the AoA on the continental shelf in summer and fall (Figure 37).

Figure 36. Green Sea Turtles: Scaled to Highest Seasonal Predicted Density

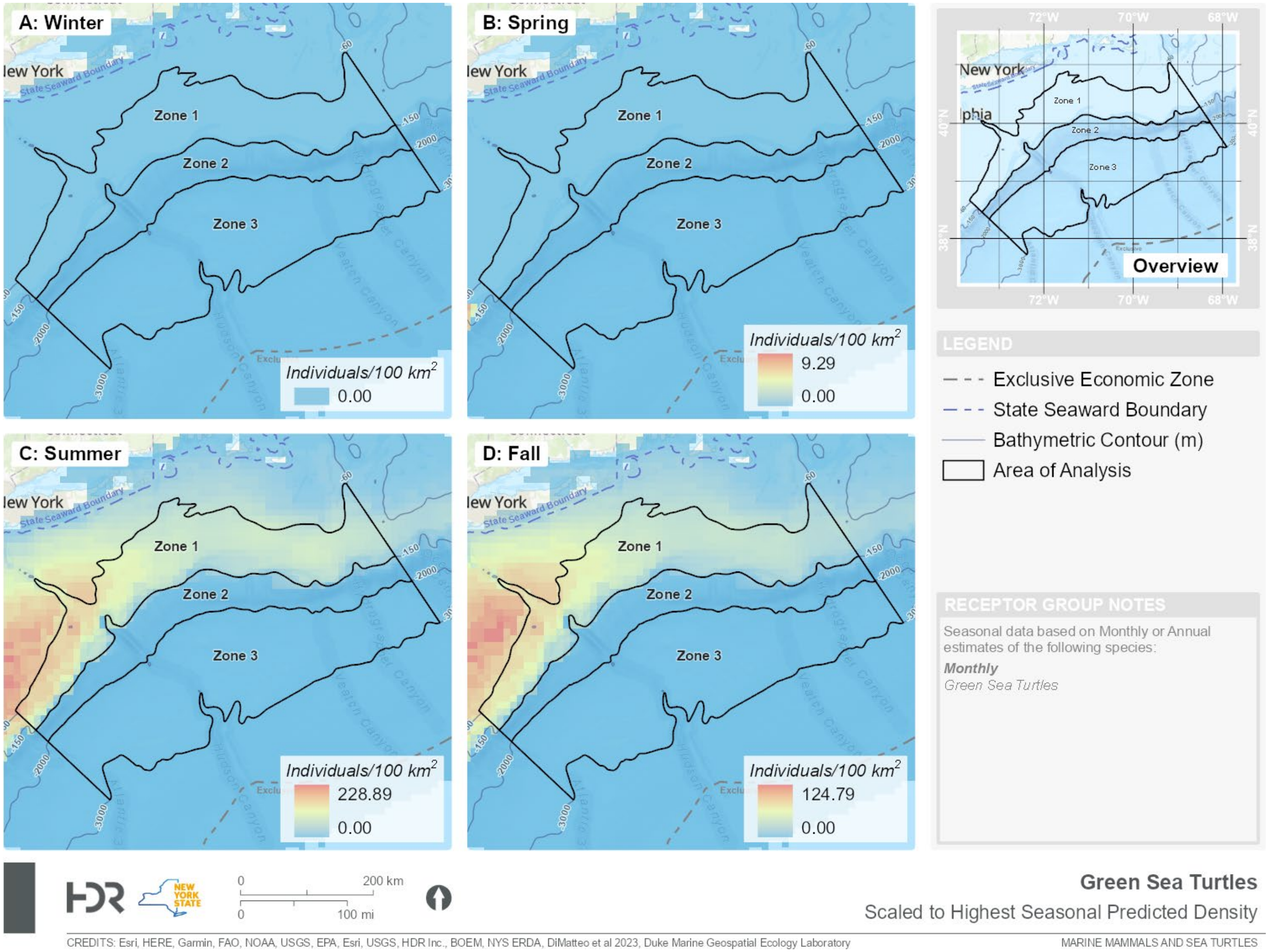
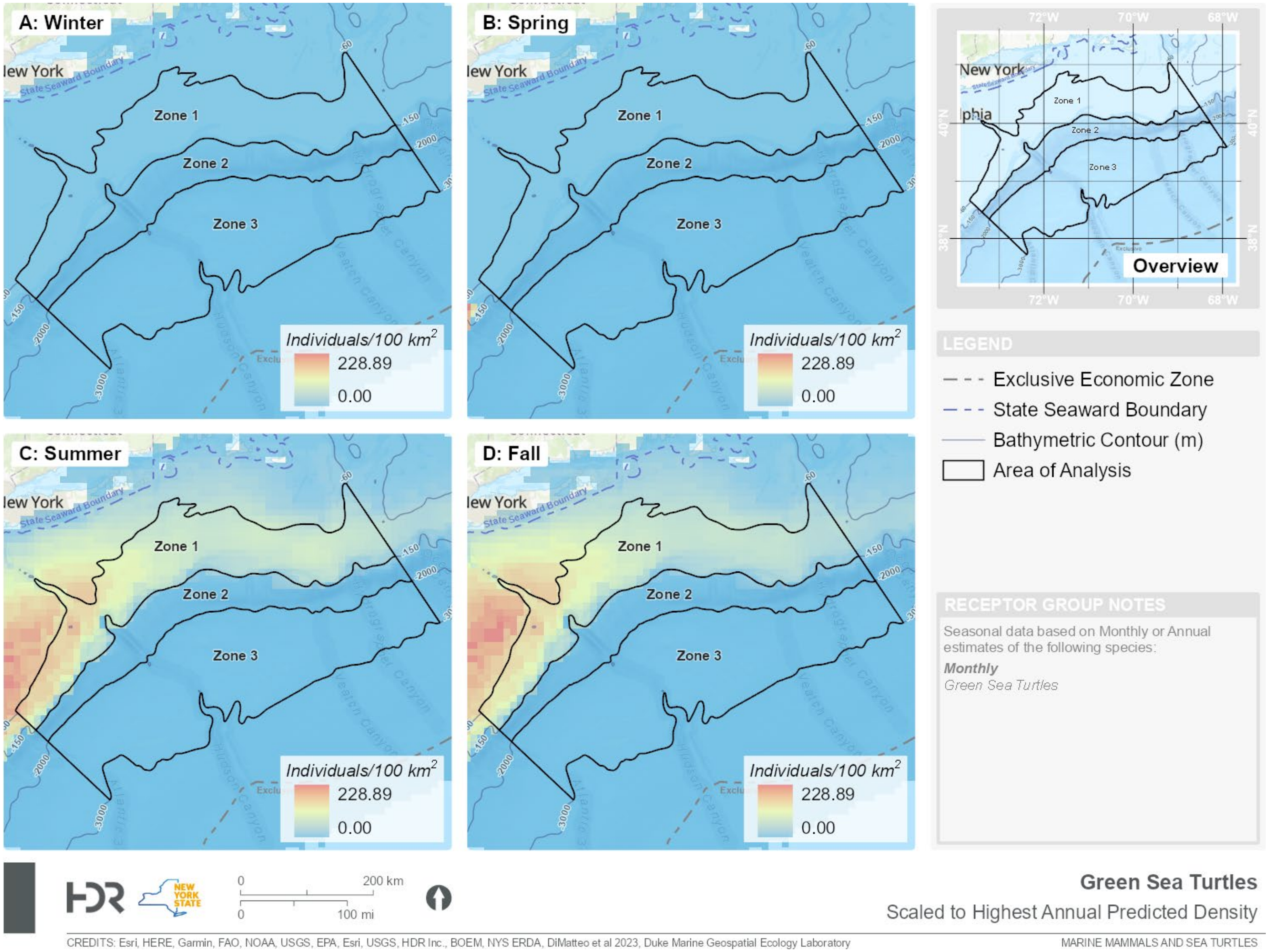


Figure 37. Green Sea Turtles: Scaled to Highest Annual Predicted Density



3.3.2.3 Kemp's Ridley Sea Turtle: Distribution, Density, and Seasonal Patterns

In the winter season, Kemp's Ridley Sea Turtles have a predicted density of zero in the AoA (Table 9, Figure 38). In spring, the maximum density of this species (0.34/100 km^2) is predicted to occur between the 2,000- and 3,000-m isobaths, just southwest of the western boundary of Zone 3. There is also a region of intermediate density in the southwest corners of Zones 2 and 3, north of Atlantic 3 Canyon (Figure 38). Predicted density of this species in Zone 1 in spring is relatively low.

The predicted distributions for this species are quite similar in summer and fall, although maximum densities in summer (9.22/100 km^2) are more than double those in fall (4.06/100 km^2). In both seasons, maximum densities occur outside the AoA, inshore of Zone 1, with intermediate densities predicted along the northern border of Zone 1 (Figure 38). Very low densities of this species are predicted in Zone 2 in summer and fall, with very slightly higher density predicted in the southwest portion of Zone 3 in these two seasons. Overall, Kemp's Ridley Sea Turtles are most likely to occur in the AoA in the summer and fall, but in low numbers (Figure 39).

3.3.2.4 Leatherback Sea Turtle: Distribution, Density, and Seasonal Patterns

In winter and spring, Leatherback Sea Turtles are predicted to occur in relatively low densities in shelf and continental slope waters. Highest density (10.12/100 km^2) in winter for this species is predicted to occur outside of the AoA, southeast of the eastern boundary of the AoA, in waters deeper than 3,000 m. High to intermediate density is predicted in the eastern half of Zone 3 in winter, tapering off to intermediate density further to the west at similar water depths. In spring, the maximum density for this species (9.92/100 km^2) is beyond the 2,000-m isobath in the eastern portion of Zone 3, east of the Hudson Canyon, but relatively high densities of Leatherbacks are expected throughout Zone 3 in this season.

In summer and fall, Leatherback distribution shifts to shelf waters, with maximum densities (63.22/100 km^2 and 65.88/100 km^2, respectively) mostly inshore of the AoA but overlapping with Zone 1, primarily in fall (Figure 40). In summer, density is concentrated on the continental shelf west of the Hudson Shelf Valley, with a second area of high density predicted to the east, inshore of Zone 1 and south of Nantucket Sound (Figure 40). In the fall, high densities of Leatherbacks are predicted fairly uniformly on the continental shelf inshore of Zone 1, south of the state seaward boundary, with some areas of high density predicted in the northern portions of Zone 1.

Figure 38. Kemp's Ridley Sea Turtles: Scaled to Highest Seasonal Predicted Density

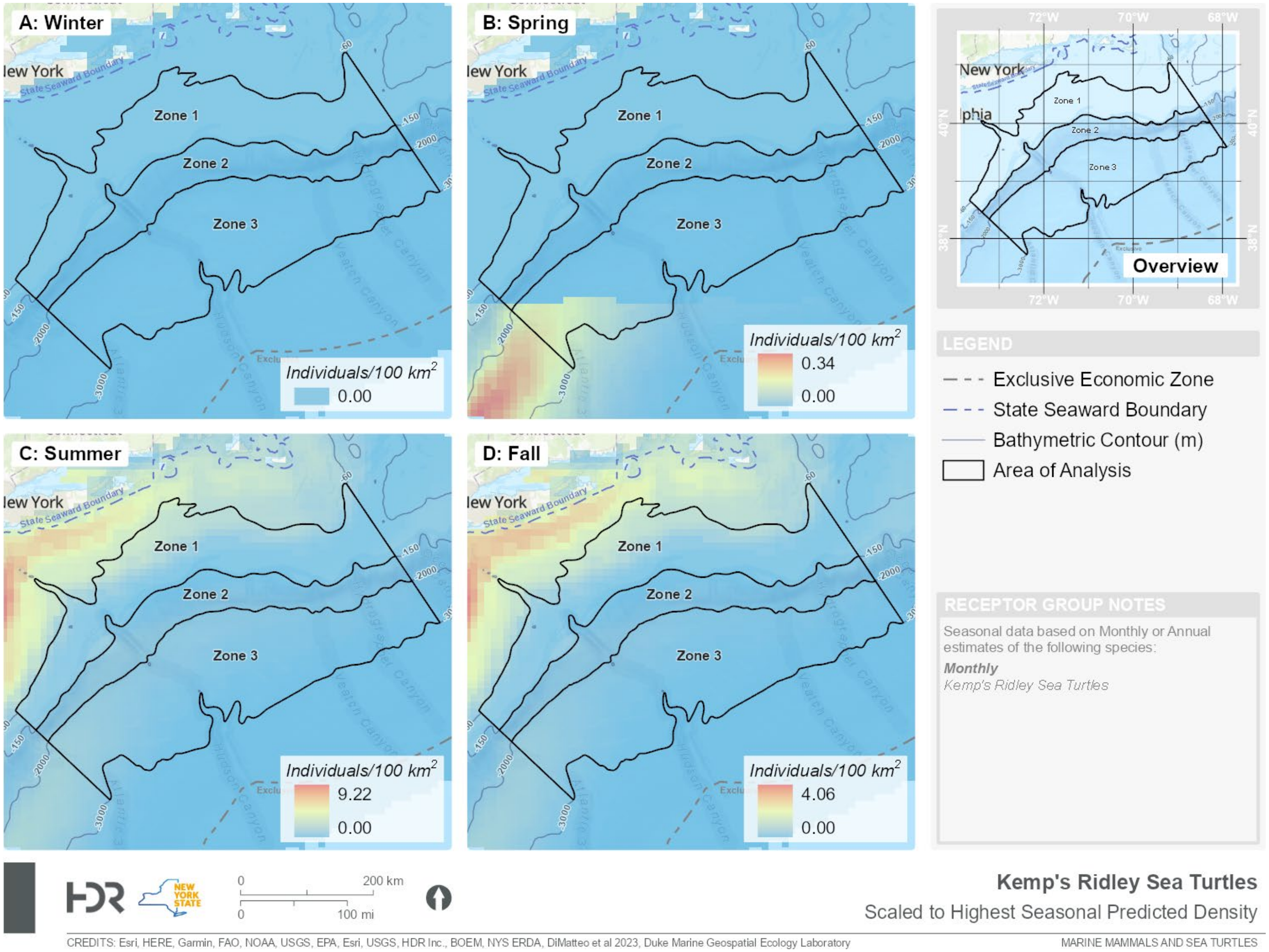


Figure 39. Kemp's Ridley Sea Turtles: Scaled to Highest Annual Predicted Density

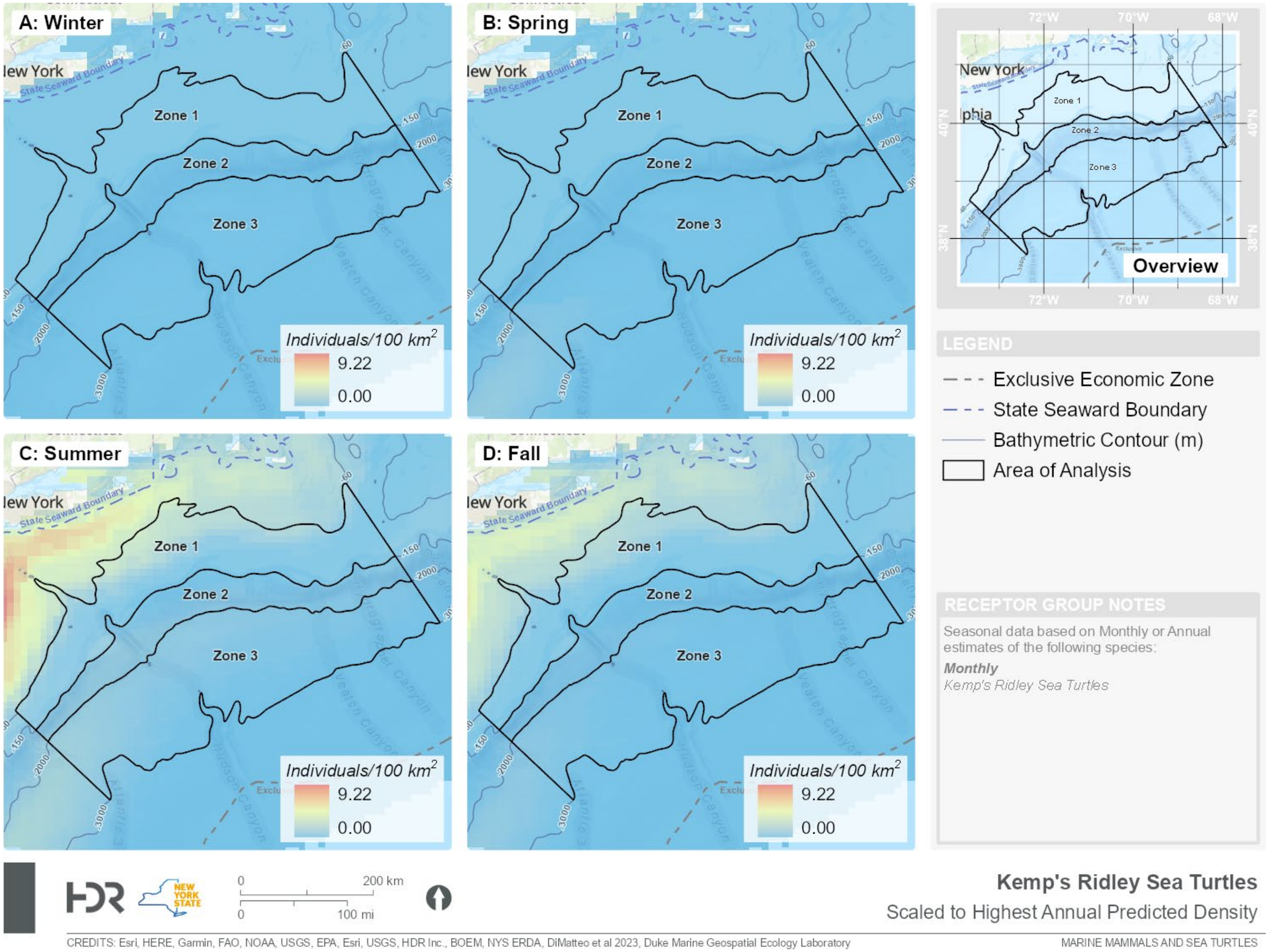
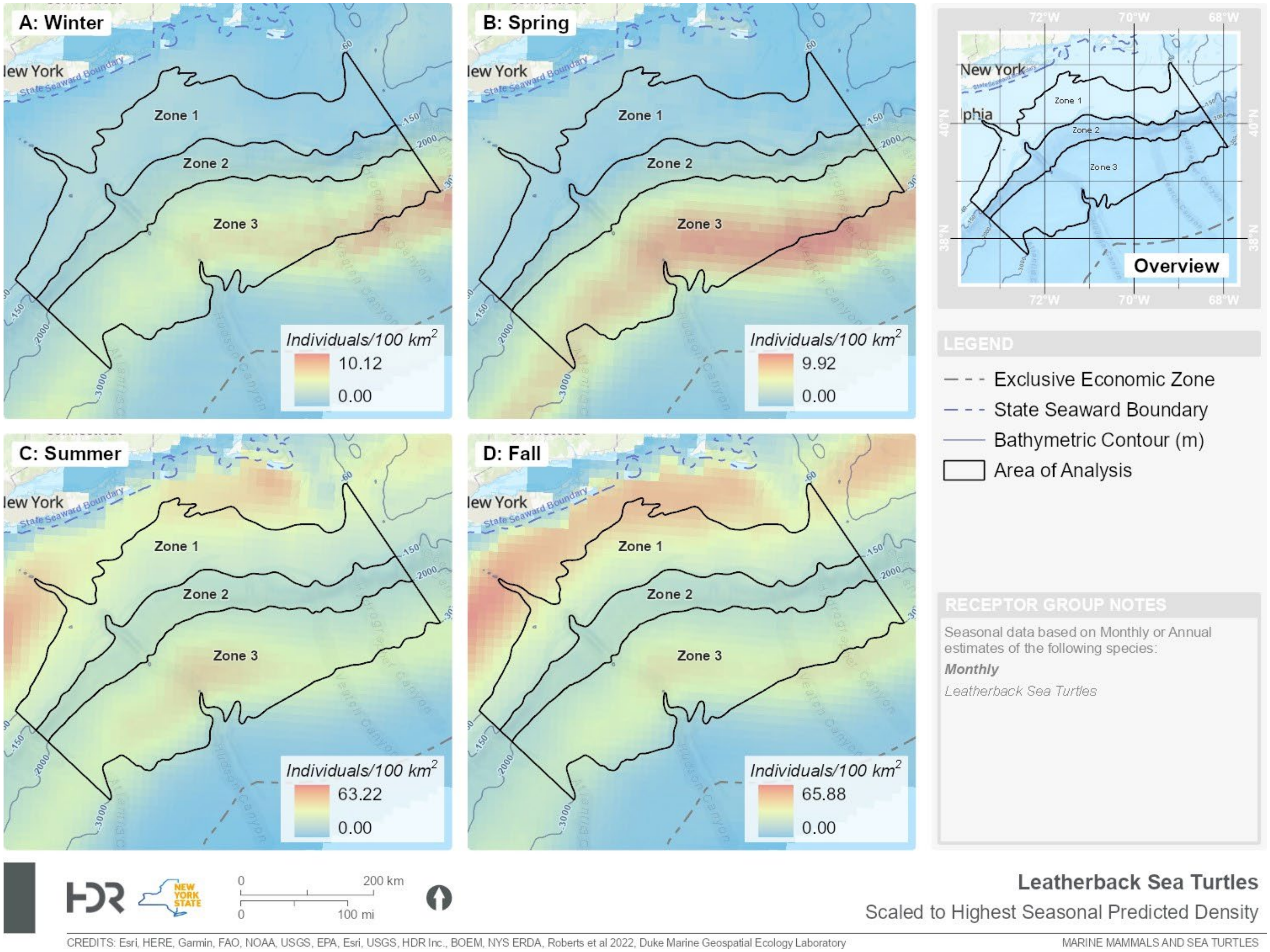


Figure 40. Leatherback Sea Turtles: Scaled to Highest Seasonal Predicted Density



Overall, Leatherback Sea Turtles are most common in the AoA in summer and fall months (Figure 41) and are expected to be more numerous in deepwater areas than any other sea turtle species.

3.3.2.5 Loggerhead Sea Turtle: Distribution, Density, and Seasonal Patterns

The predicted distribution of Loggerhead Sea Turtles in and near the AoA is similar across all four seasons (Figure 42) but with varying maximum densities (winter = 80.44/100 km^2, spring = 82.86/100 km^2, summer = 330.60/100 km^2, fall = 334.49/100 km^2). In all seasons, densities are highest in shelf waters south of the Hudson Shelf Valley and inshore of the 150-m isobath. Likewise, in all seasons, intermediate to low densities are predicted throughout Zone 1 east of the Hudson Canyon, as well as in portions of Zone 2. In Zone 3, expected density of Loggerhead Sea Turtles are relatively low in all seasons, but slightly higher in winter and spring (Figure 42). Overall, Loggerhead Sea Turtles are expected to be most common in the AoA in shelf waters in the summer and fall (Figure 43).

Seasonal best population estimates for sea turtles were calculated for each Zone and the entire AoA based on the DiMatteo et al. (2024) model data (Table 9).

Figure 41. Leatherback Sea Turtles: Scaled to Highest Annual Predicted Density

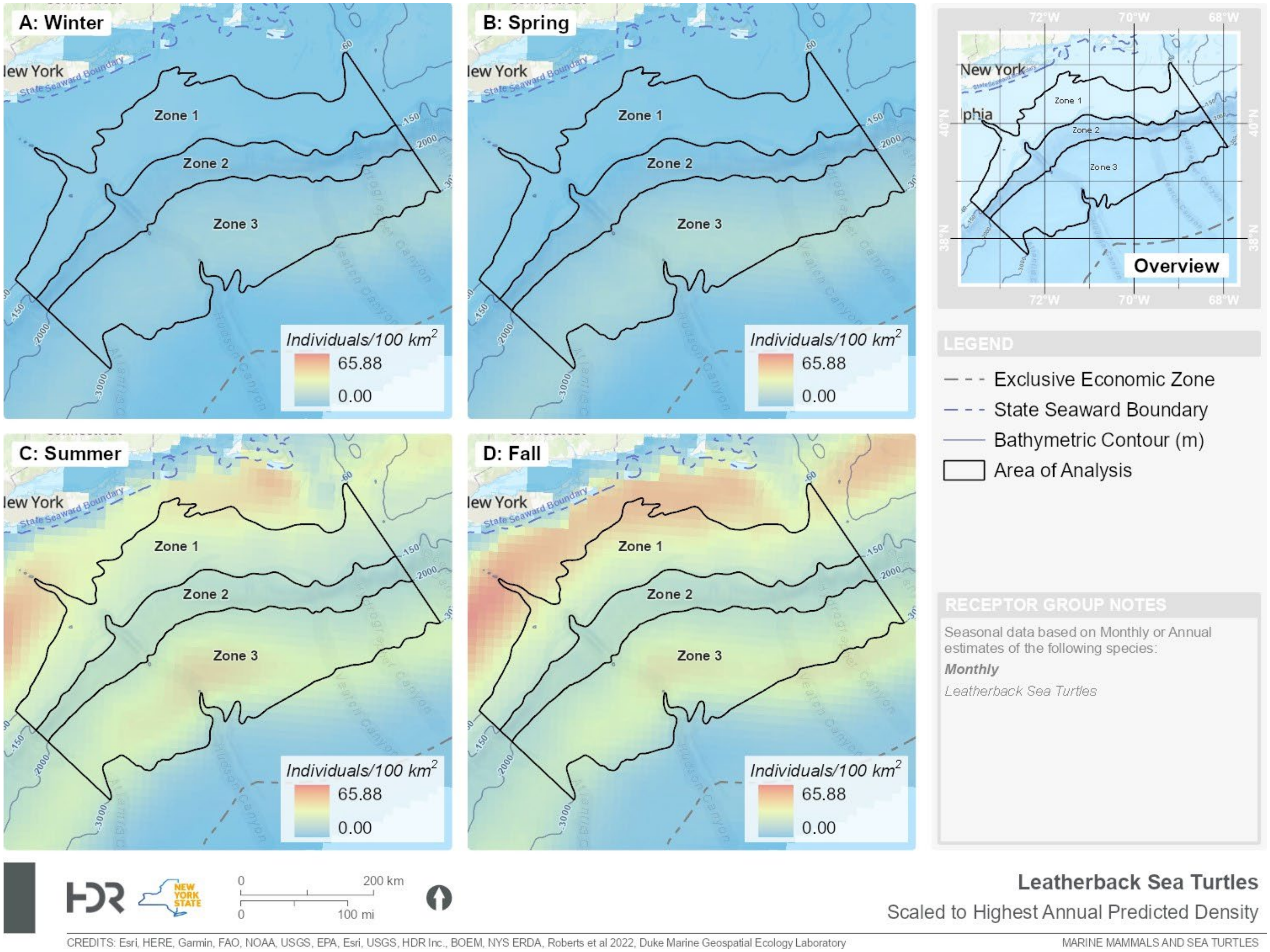


Figure 42. Loggerhead Sea Turtles: Scaled to Highest Seasonal Predicted Density

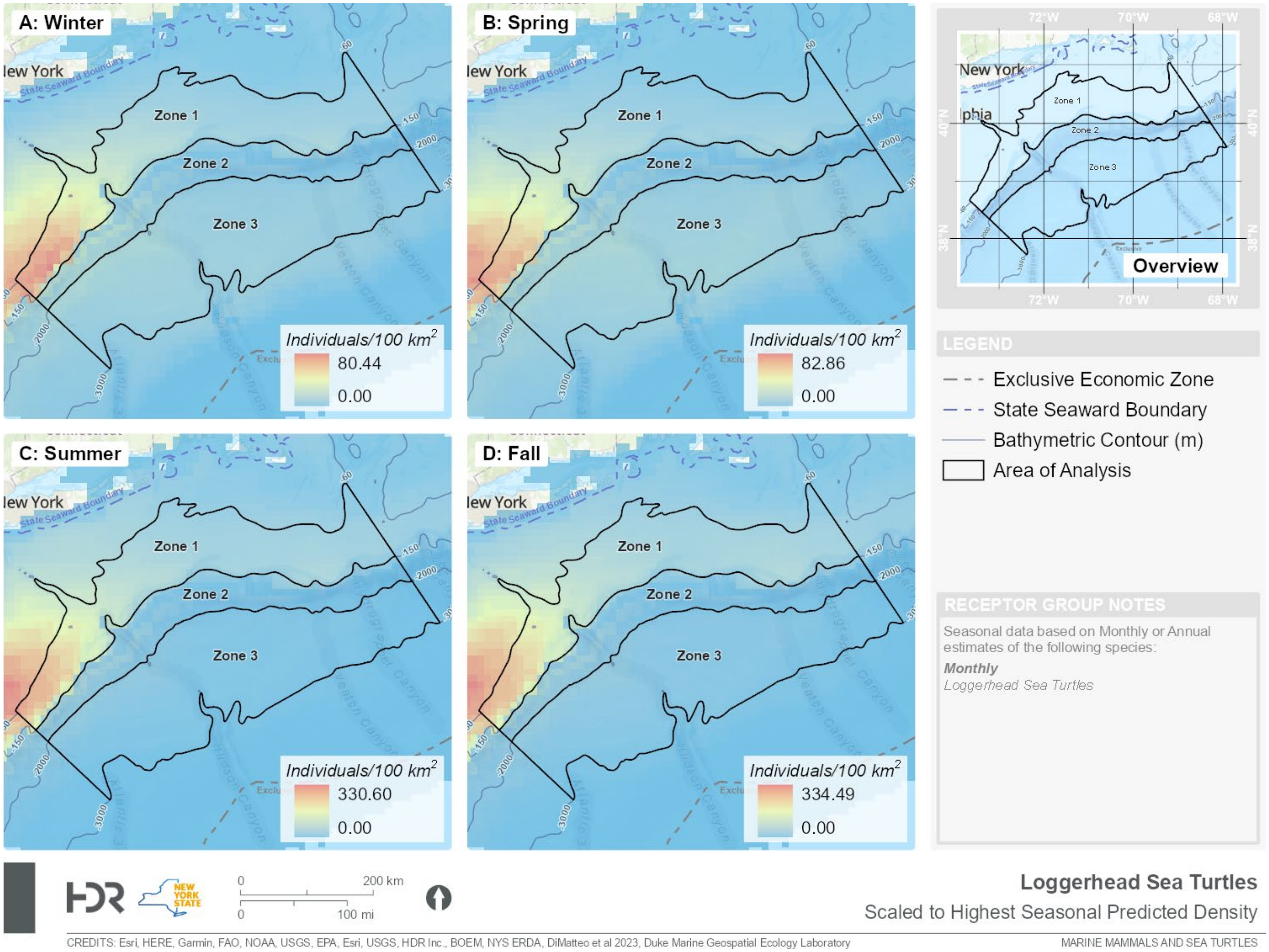
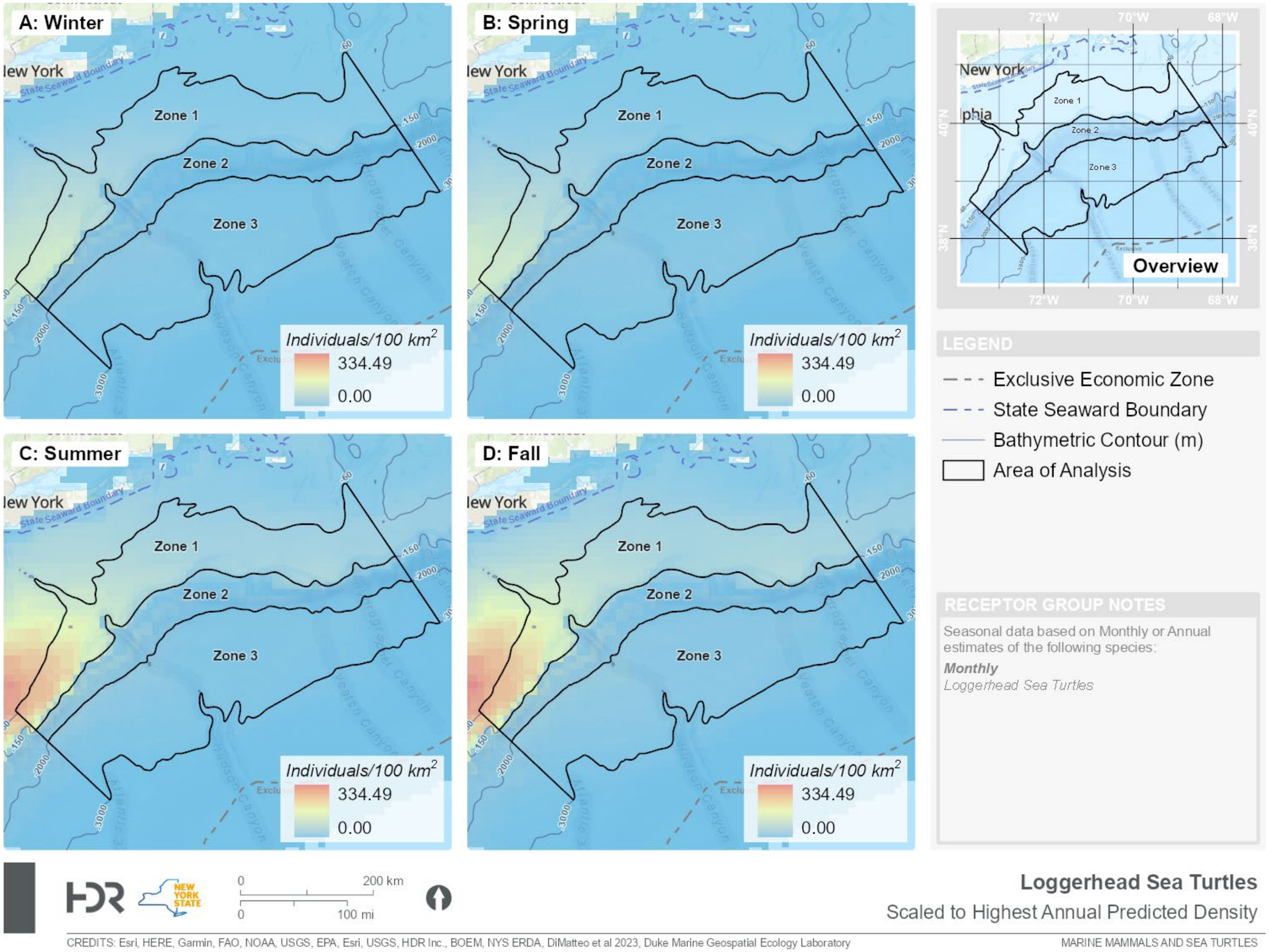


Figure 43. Loggerhead Sea Turtles: Scaled to Highest Annual Predicted Density



3.4 Conclusions

3.4.1 Marine Mammals

Several marine mammal receptor groups show heavy use of continental slope habitat between the 150 m and 200-m isobaths (Zone 2), including mid-frequency cetaceans and deep- and shallow-diving cetaceans. Animal concentration is predicted to be particularly high in areas associated with submarine canyons. Available tracking data from tagged Humpback, sperm, and Pilot whales confirmed this finding, showing distinct use of waters over the top of the Hudson Canyon. This is unsurprising, given that oceanic shelf break systems are often characterized by enhanced biological productivity due to steep bathymetric features that contribute to upwelling and nutrient mixing, and provide valuable food and energy resources to a variety of marine species (Levin and Dayton 2009). Shelf breaks are associated with high density of marine species of various trophic levels and are therefore regarded as ecologically important areas (Thorne et al. 2017).

In all seasons, NARW showed heavy use of continental shelf habitat northeast of Zone 1, between Nantucket Island and Hydrographer Canyon. This area is adjacent to critical foraging habitat for this species, and the extreme northeastern portion of the AoA overlaps with NARW critical habitat. Predicted use of the AoA by Other Marine Mammals of Special Conservation is concentrated in Zone 1 and inshore of the 60-m isobath, likely driven by the inclusion of seals in this category, which use coastal areas and islands for pupping and molting. High-frequency cetaceans show heavy use of the eastern portions of Zone 1, particularly in winter and spring. This pattern is likely driven by the inclusion of harbor porpoise in this receptor category, which are found in coastal areas.

3.4.2 Sea Turtles

Overall, sea turtles are predicted to be most common in shelf waters in the southwestern portion of Zone 1, west of the Hudson Canyon. Sea turtle density models predict intermediate use of the deepwater areas of Zone 3, and relatively light use of slope waters in Zone 2. Green Sea Turtles are expected to be most common on the continental shelf, in the western portions of Zone 1, in summer and fall. Kemp's Ridley Sea Turtles likewise show distinct seasonal differences in distribution, with a predicted density of zero in the AoA in winter, higher densities inshore of Zone 1 in summer and fall, and a shift in distribution in the spring to deeper waters between the 2,000-m and 3,000-m isobaths. Leatherback turtles show the strongest preference for deepwater areas of the AoA of any sea turtle species. The highest densities of Leatherbacks are predicted in shelf waters inshore of Zone 1 in summer and fall.

4 Stressors Associated with Each Phase of Deepwater Offshore Wind Development

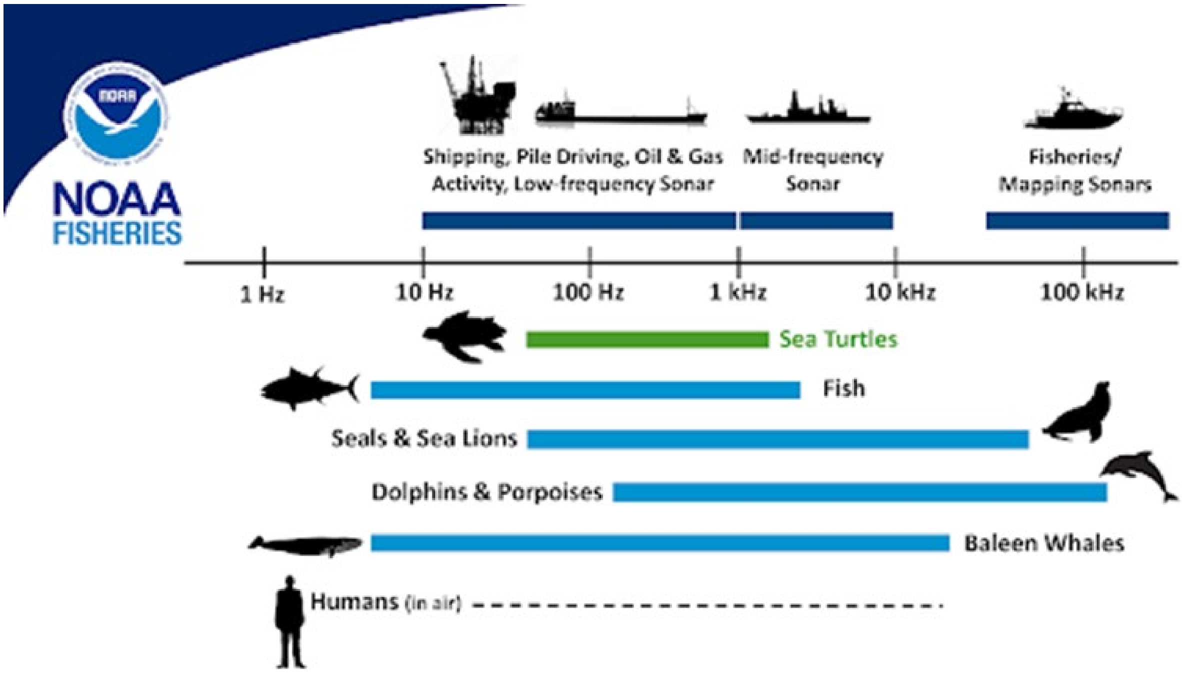
An objective of the Master Plan was to identify sensitive receptors and potential risks associated with potential stressors to marine mammals and sea turtles from future OSW farm development in the AoA. Stressors can be any "external abiotic or biotic factor that moves a biological system out of its normal operating range" (Segner et al. 2014). The following sections provide an overview of the Master Plan, as well as an expansion on these topics based on (1) more recent available science since the time that the Master Plan was completed in 2017; (2) consideration of an expanded AoA beyond the 60-m contour; and (3) development of OSW turbines using floating wind technologies. The primary OSW stressors (Table 6) outlined here include underwater noise, bottom disturbance, vessel traffic, artificial lighting, changes in water quality, unexploded ordnance (UXO) detonation, in-water structures, and changes to atmospheric/oceanographic dynamics. All of these stressors have the potential to affect both marine mammals and sea turtles. To some extent, the likely impacts of stressors associated with OSW development depend on the technology implemented. For example, underwater noise is more of a concern for fixed-foundation turbines versus floating turbines, because the latter technology is less likely to involve impact pile driving.

4.1 Noise

Popper et al. (2014) refer to noise as sound generated by "identifiable man-made sources such as individual ships or oil and gas platforms, or distant man-made sources that cannot be located or identified." Naturally occurring sounds such as those from biological sources, weather events, or natural physical movements are termed "ambient noise" or "background noise." Marine mammals are known for their production of sound for a variety of purposes, including mating, rearing, social interactions, group cohesion, and feeding (Erbe et al. 2016). Noise from certain anthropogenic sources, can result in the displacement or injury of marine organisms or otherwise effect their ability to communicate, forage, or interact with their environment.[37] Based on available data, primarily from behavioral and auditory evoked potential audiograms in captive animals, marine mammals and sea turtles are sensitive to sound at varying frequencies. These frequencies correspond to different anthropogenic (human-made) activities (Figure 44).

Figure 44. Hearing Frequency Ranges of Marine Species in Relation to Anthropogenic Sounds

Source: NOAA Fisheries



The following sections summarize the potential sources of excess noise during each phase of OSW development.

4.1.1 Types of Noise

The sound generated by the development and operation of an OSW farm can consist of transient or continuous sounds. Transient sounds are short-lived and can be impulsive or non-impulsive; impulsive sounds are typically abrupt, short, and contain a wide range of frequencies. Continuous sounds can be tonal, consisting of one or more frequencies, or broadband, containing a range of frequencies that can change in amplitude over time.

The sources of noise discussed in this study generally refer to sound pressure. Particle motion is another type of sound measuring; it measures the direction of a sound wave (vibratory energy) by displacement, velocity, or acceleration.[38] As opposed to teleost fishes, neither marine mammals (Nedelec et al. 2016) nor sea turtles[39] have hearing structures required for sensing particle motion; therefore, neither would be directly impacted by changes in particle motion. However, indirect effects on marine mammals and sea turtles could occur due to any changes in prey fish and invertebrate populations from this effect. See the Fish and Fisheries Data Aggregation Study (NYSERDA, 2025) for information regarding particle motion effects on fish and invertebrate species.

4.1.2 Sources of Noise in the Offshore Study Area

4.1.2.1 Pre-Construction

High-Resolution Geophysical and Geotechnical Surveys

Typically, acoustic sources are used to conduct pre-construction, high-resolution geophysical (HRG) surveys to evaluate and confirm geological, geotechnical, and benthic characteristics of the seafloor. These sources may include multibeam echo sounders (MBES), towed, and hull-mounted sub-bottom profilers (SBP), and other towed seismic sources such as boomers and sparkers (Ruppel et al. 2022). Oceanographic acoustic instrumentation may also be used, which would include the use of split-beam echosounders (SBES) and acoustic doppler current profilers (ADCPs). Using physical criteria of the sources such as source level, transmission frequency, directionality, beamwidth, and pulse repetition rate, Ruppel et al. (2022) categorized the acoustic sources into four tiers describing potential effects, ranging from "Tier 1" to "Tier 4" sources. Tier 1 and Tier 2 sources include high- and medium/ low- energy air guns, respectively. Tier 3 sources are non-air gun, impulsive HRG seismic sources that do not meet *de minimis* requirements either because they transmit at frequencies below 180 kHz (and are therefore audible to marine mammals) or for which insufficient data or modeling is available to support a Tier 4 categorization. Tier 4 sources are those that operate at a sound pressure level less than 150 dB re 1 μPa @ 1 m and transmit at frequencies higher than 180 kHz, which is outside the range of detection by marine mammals and thus unlikely to result in incidental take of marine mammals (i.e., *de minimis*).

Ruppel et al (2022) found that most non-seismic HRG, oceanographic, and communication/tracking acoustic sources are unlikely to result in incidental take of marine mammals and therefore qualify as Tier 4 *de minimis* sources. These sources include MBES, hull-mounted and shallow-towed SBPs, side-scan sonars, low-powered three-plate boomers, SBES, low-powered sparkers, ADCPs, acoustic releases, acoustic locators, and many systems used for underwater navigation and communication. Any equipment used for HRG survey work that emits sounds exceeding NOAA's injury or harassment thresholds and operates at frequencies below 180 kHz (e.g., higher energy boomers and sparkers) would be a potential risk and require consideration in mitigation and permitting of pre-construction activities.

In conjunction with HRG surveys, geotechnical surveys are needed to identify and/or confirm subsurface conditions and the potential presence of objects (e.g., abandoned anchors, pipelines, or lost casings from prior explorations) (Malhotra 2009). Geotechnical borings are a source of underwater noise, although current NMFS guidance is that noise produced during these surveys is minimal and does not rise to the level of injury or harassment of marine mammals or sea turtles (NMFS 2021). The number of geotechnical borings depends on the foundation type and size of the wind farm; however, in general, one boring per turbine foundation is typical.

Vessel Traffic

Any increase in vessel passage in an area that was not previously trafficked on a regular basis would contribute to noise from vessel operations (including surveying vessels). Vessels within the AoA and traveling to and from the site during the pre-construction phase generally consist of survey vessels completing geotechnical/geophysical studies. Vessel noise is predominantly in the low-frequency range (below 1 kHz) and is generated from onboard machinery, hydrodynamic flow around the hulls, and from propeller cavitation (Popper et al. 2014). However, noise levels and spectral content of this continuous sound depend on vessel size, speed, load, condition, age, engine type, and water depth. In the Sound Exposure Guidelines for Fishes and Sea Turtles, Popper et al. (2014) estimated that sound levels from vessels can range from less than 150 decibels (dB) to over 190 dB with a reference value of 1 micropascal (re 1 μPa) depending on the size and type of vessel. Recent studies have shown that even small reductions in vessel speed can substantially reduce underwater noise levels (ZoBell et al. 2021; Findlay et al. 2023). Survey vessels would move slowly (i.e., <10 kts) during surveying operations; however, higher-speed travel while transiting to and from the site would result in elevated noise levels. Vessels traveling at slower speeds would not only be quieter, but less likely to be involved a vessel strike (see section 4.2.1).

Helicopters, if used for service or other needs, would also generate a level of noise that marine mammals and sea turtles are not regularly exposed or accustomed to; however, effects would likely be minor (Hadden 1979; Patenaude et al. 2002). The angle at which the line from the aircraft to the receptor intersects the water's surface, and the characteristics of the aquatic environment (e.g., calm versus rough seas, depth, or reflective versus unreflective bottom) influence how much sound enters the marine environment with potential to effect marine mammals and sea turtles (Richardson et al. 1995). At angles less than 13° from the vertical, shallow waters, and areas with reflective seafloors are more likely to facilitate the propagation of underwater noise (Medwin 2005; Bevans 2018).

4.1.2.2 Construction

High-Resolution Geophysical Surveys

HRG surveys will be completed during the construction phase for placement of foundations and scour protection. See section 4.1.2.1 for information on this stressor.

Pile Driving

Pile driving, particularly impact pile driving, is one of the noisiest construction-related activities undertaken in marine environments today (Madsen et al. 2006; Erbe 2009). Piles for OSW turbine foundations (fixed-foundation OSW turbines) or anchors (floating OSW turbines; Maxwell et al. 2022) may be installed via impact hammer, vibratory hammer methods, or both. Pile driving installation is relatively short, usually less than 24 hours per monopile (Malhotra 2009).

The impulsive sounds generated by impact pile driving consist of a relatively rapid rise time to maximal pressure value, followed by diminishing, oscillating maximal or minimal pressures (Popper et al. 2014). California Department of Transportation (Caltrans) (2015) reports unattenuated pile strikes at 200 to 300 m to be 180 dB (referenced to 1 microPascal [re 1 µPa]); distances closer to the source would be elevated. Underwater noise measurements performed during installation of two monopiles as part of the Coastal Virginia Offshore Wind (CVOW) Pilot Project (WaterProof 2020) indicated that peak sound pressure levels from unattenuated impact piling reached 190 dB (re 1 µPa) at a distance of 750 m. Noise levels and sound propagation from impact piling vary by site and depend on a number of factors, including substrate and bedrock characteristics; water depth; pile shape, diameter, and length; surrounding bathymetry; water chemistry; and size and energy of impact hammer (Erbe 2009; Popper et al. 2014; Mooney et al. 2020). Construction would involve installation of wind turbine generators using monopile foundations (shallow water installation via impact or vibratory pile driver) or jacket foundations (deepwater installation via impact pile driver) attached to the seabed (U.S. Department of the Interior Minerals Management Service 2009). The average pile takes 4,000 to 6,000 hammer blows to install (Energinet.dk 2015), and jacket foundations require about 1.5 times more hammer blows and more than twice the time to install than monopiles (Norro et al. 2013).

Vibratory pile driving generates a continuous sound with peak sound pressures lower than those observed produced by impact pile driving (Nedwell et al. 2003; Popper et al. 2014). Although peak sound pressure associated with vibratory piling is less than for impact piling, the total energy imparted can be comparable due to the continuous nature of operation and time for installation, which is typically longer than impact piles, and the ensonified area (area affected by sound) can consequently be even larger than for impact piling (Caltrans 2015). Regardless, sound pressure levels generated from vibratory pile driving can be up to 15% lower than the sound emitted from impact pile driving (Matuschek and Betke 2009).

In most instances, floating OSW turbines do not require pile driving unless necessitated by the anchor type selection (such as pile anchors), which is dictated by the seabed sediment composition (Maxwell et al. 2022). Installation of the other types of anchors (i.e., drag-embedment, suction caisson, or gravity anchors) does not result in high-noise levels such as those emitted by pile driving (Diaz et al. 2016).

Trenching

Trenching for the purposes of cable installation may result in a mixture of broadband noise, tonal machinery noise, and transient noises (Nedwell et al. 2003). Nedwell et al. (2003) found trenching noise to be highly variable and dependent on the physical properties of the particular area of the seabed; they estimated sound pressure to be 178 dB at 1 m, which is within the range estimated for vessel traffic by Popper et al. (2014) (see section 4.1.2.1). Trenching for cable laying would be necessary for both floating OSW and fixed-foundation OSW turbines.

Vessel Traffic

Increased vessel traffic contributes to noise levels along the transit route from the coast to the AoA and within the AoA during the construction phase. Construction vessels often need to use dynamic positioning systems, which produce non-impulsive sounds (Denes et al. 2019) that can emit relatively high sound levels. However, the sounds generated from dynamic positioning are generally consistent with those from routine vessel traffic and are not anticipated to be a significant contributor to the overall acoustic footprint (JASCO and LGL 2019). A wide variety of vessel types, including survey vessels, installation vessels, feeder barges, jack-up barges, export cable laying vessels, trenching support vessels, various secondary support vessels, crew transfer vessels, and tugs in size up to approximately 400 feet, may be in the work area and traversing from the coast (see section 4.2). Many components of floating OSW turbines are able to be assembled on land and then shipped to the OSW farm area, potentially reducing the number of vessels needed and noise generation during the construction phase.

Helicopters may also be used during the construction phase. See section 4.1.2.1 for potential effects from helicopters on marine mammals and sea turtles.

4.1.2.3 Operation

Mechanical Noise

The operation of OSW facilities is unique in that the underwater noise produced, although essentially equivalent to that of a large commercial ship, is stationary with variable noise levels over a large area for many years (Mooney et al. 2020). Operational noise from OSW turbines is driven by the distance from the receptor to the turbine or turbines, the size of the turbine, wind speed, and technology (i.e., gearbox versus direct drive turbines) (Tougaard et al. 2020; Stöber and Thomsen 2021; Risch et al. 2023). Underwater noise generated from operational OSW turbines derives from aerodynamically produced noise (i.e., movement of the turbine blades) and turbine generators and gearboxes (if present) (Risch et al. 2023). Wind-induced vibrations of the tower at high wind speeds may also contribute as a potential source of noise (Elmer et al. [2007], as cited by Tougaard et al. 2020), though this is understudied. Aerodynamically produced noise does not generally influence underwater noise levels to any great extent due to the reflection of soundwaves off the water surface (Marmo et al. [2013] and Tougaard et al. [2020], as cited by Risch et al. 2023).

An empirical study by Holme et al. (2023) measured operational noise levels from three OSW farms over five weeks, with 6.3 MW and 8.3 MW turbines and wind farm sizes ranging from 250 MW to 450 MW. Empirical results were compared to modeled predictions by Tougaard et al. (2020). Holme et al. (2023) found that Tougaard et al. (2020) substantially overestimated underwater noise levels (as extrapolated from smaller turbines) anticipated during operation of larger turbines (125.4 SPL, dB re 1 μPa versus 117.3 dB at a distance of 70 m, a difference of 8 dB). Measured underwater noise levels were relatively low in the vicinity of the OSW farm (~116 dB 150 m).

As noted previously, the noise generated by operational OSW turbines is heavily influenced by the technology used, in particular, the use of gearbox versus direct drive technology (Marmo et al. [2013], as cited by Mooney et al. 2020; Stöber and Thomsen 2021). A study by Stöber and Thomsen (2021) evaluated the difference in noise levels emitted between these technologies and extrapolated underwater noise levels measured from ~6 MW turbines to those expected from 10 MW turbines. The 10 MW turbines were estimated to generate source levels of 170 to 177 dB re 1 μPa m. The change from gear boxes to direct drive technology was projected to reduce operational sound levels by 10 dB. Using the

NOAA Fisheries' criterion for behavioral harassment from continuous noise (120 dB, NMFS 2018), a single 10 MW direct drive turbine would be expected to cause behavioral harassment in marine mammals up to 1.4 km distance from the turbine, compared to 6.3 km for a turbine with a gear box (Stöber and Thomsen 2021).

Operational noise emitted from floating OSW turbines has been found to be comparable to fixed-foundation OSW turbines (Risch et al. 2023). Underwater noise generated by floating turbines at Kincardine and Hywind Scotland was concentrated below 200 Hz. Median one-third octave band levels below 200 Hz were between 95 and 100 dB re 1 μPa at about 600 m from the closest turbine for both wind farms, which is comparable to measured frequency and noise levels at fixed OSW farms. However, floating OSW turbines also require the use of mooring devices, which can contribute to an additional source of noise around the structures (Weissenberger 2019; Risch et al. 2023). Risch et al. (2023) reported that a study found these noises, described as impulsive "snaps" due to the steel cables, chains, or wire ropes, to potentially exceed 160 dB at a distance of 150 m.

Generally, studies that have modeled operational noise from OSW farms show that this noise extends several km before it is masked by ambient noise (Mooney et al. 2020). A study by Madsen et al. (2006) suggested that behavioral effects on marine mammals from operational noise are minor; however, the turbines evaluated in that study were smaller than those that would likely be constructed in the AoA. In the absence of empirical data for ≥10 MW turbines, such as those being planned for many commercial-scale OSW farms, several studies have attempted to extrapolate expected noise levels from data measured at ~6 MW turbines (Tougaard et al. 2020; Stöber and Thomsen 2021), but this extrapolation can be problematic (Holme 2023).

Vessel Traffic

Periodic vessel traffic for regular turbine maintenance would also contribute to noise levels in the OSW farm area; however, the frequency of visits depends on the maintenance approach (i.e., reactive, preventative, condition-based, or predictive maintenance; Ren et al. 2021), and need for maintenance may increase over the life of the OSW farm. Vessels required for standard operations and maintenance include crew transfer vessels, jack-up vessels, and supply vessels.

Helicopters may also be used during the construction phase. See section 4.1.2.1 for potential effects from helicopters on marine mammals and sea turtles.

4.1.2.4 Decommissioning

High-Resolution Geophysical Surveys

HRG surveys will be needed for safe and efficient deconstruction activities of the wind turbine farm. HRG surveys are described in section 4.1.2.1.

Deconstruction Activities

Decommissioning of OSW farms is in its infancy; therefore, little information is available regarding noise produced from deconstruction activities. The noise levels produced during this phase is dependent on the removal approach and type of structures in place (Hall et al. 2022). BOEM currently requires that all facilities, installations, and other devices attached to the seabed must be removed to a depth of 15 ft below the mudline within two years of termination of the lease (BOEM 2021a; Fernandez et al. 2021). Some structures may be left in place, similar to the gas industry's "rigs-to-reefs" practices (Mooney et al. 2020), which would substantially reduce noise-related effects from decommissioning. If fixed foundations are removed, noise levels can be high. Hinzmann et al. (2017), as reported by Mooney et al. (2020), measured the sound pressure levels of water jets used to cut a steel pile mast during the decommissioning of a British wind turbine. Peak noise levels were shown to reach high levels (198–199 dB re 1 μPa) at distances of 10 to 50 m from the source, with acoustic energy between 250 and 1,000 Hz. Pile extraction via impact or vibratory hammers would also have higher sound levels, albeit lower for vibratory extractions.

Decommissioning floating OSW turbines would produce substantially less noise as compared to fixed-foundation OSW turbines. Floating turbines would need to be deconstructed and cable ties removed. No piles would be required to be removed; even anchor piles would be left in place (Maxwell et al. 2022).

Vessel Traffic

As with wind farm construction, increased vessel traffic would also occur during the decommissioning phase and has the potential to increase noise levels above ambient conditions. The number and type of vessels would depend on the approach to decommissioning (i.e., complete versus partial removal) as well as the type of structures for deconstruction.

Helicopters may also be used during the construction phase. See section 4.1.2.1 for potential effects from helicopters on marine mammals and sea turtles.

4.1.3 Physical Effects of Noise

4.1.3.1 Hearing Effects

Whether or not a marine animal is affected by underwater sounds depends on the loudness of those sounds (measured in decibels, dB), their frequency (measured in Hz), and duration. Different marine species are sensitive to different sound frequencies (Table 10, Figure 44). The loudness of a sound is independent of a change in frequency. The cumulative sound exposure level (SEL_{cum}; measured in dB) is an important metric when assessing effects of underwater noise on marine life because it considers the duration and accumulation of sound energy from repeated impulsive sounds, such as pile driving. Noise has the potential to physically injure marine mammals and sea turtles when reaching loud enough levels within the frequency hearing range, for a certain amount of time to cause permanent threshold shift (PTS) or temporary effects from temporary threshold shift (TTS), if the animals are close enough to the source to experience these noise levels. PTS is an "irreversible elevation of the hearing threshold (i.e., a reduction in sensitivity) at a specific frequency" as a result of tissue damage (Southall et al. 2007). Conversely, TTS is a temporary condition resulting from the fatigue of cochlear hair cells and supporting structures.

Table 10. Summary of Generalized Hearing Ranges and Permanent Threshold Shifts of Marine Mammals

Source: NOAA NMFS 2016

Hearing Group	Example Species within the AoA[a]	Generalized Hearing Range	PTS Impulsive Noise[a]	PTS Non-impulsive Noise[b]
High-frequency cetaceans (HF)	Pygmy Whale Dwarf Sperm Whale Harbor Porpoise	275 Hz-160 kHz	$dB_{pk,flat}$: 202 dB $Sel_{cum,LF,24h}$: 155 dB	$Sel_{cum,LF,24h}$: 173 dB
Mid-frequency cetaceans (MF)	Sperm Whale Beaked Whale Dolphins	150 Hz-160 kHz	$dB_{pk,flat}$: 230 dB $Sel_{cum,LF,24h}$: 185 dB	$Sel_{cum,LF,24h}$: 198 dB
Low-frequency cetaceans (LF)	Baleen Whales	7 Hz-35 kHz	$dB_{pk,flat}$: 219 dB $Sel_{cum,LF,24h}$: 183 dB	$Sel_{cum,LF,24h}$: 199 dB
Seals (in water) (PW)	Harbor Seal	50 Hz-86 kHz	$dB_{pk,flat}$: 218 dB $Sel_{cum,LF,24h}$: 185 dB	$Sel_{cum,LF,24h}$: 201 dB

[a] For a complete list of species in each hearing category, please refer to Table 4.

[b] Peak sound pressure (dB_{pk}) has a reference value of 1 µPa, and cumulative sound exposure level (Sel_{cum}) has a reference value of 1 micropascal squared-seconds ($1\mu Pa^2s$). The subscript "flat" is included to indicate that peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with Sel_{cum} thresholds indicates the designated marine mammal auditory weighting function (low-, mid-, and high-frequency cetaceans and phocid seals in water) and that the recommended accumulation period is 24 hours.

Noise exposure thresholds for PTS and/or TTS and behavioral responses of marine mammals have been described by Southall et al. (2007, 2019), and Finneran (2016). These thresholds can be used to identify types of receptors, such as low-, mid-, and high-frequency cetaceans, that may be sensitive to certain types of underwater noise. NOAA Fisheries released guidance on TTS and PTS thresholds for marine mammals in July 2016 (NOAA NMFS 2016) (Table 10). PTS is considered “Level A harassment” under the MMPA. The guidance does not address “Level B harassment;” therefore, NOAA Fisheries uses an interim sound threshold guideline of 160 dB rms re 1µPa for pulsed sound and 120 dB rms re 1µPa received level for continuous sound. NOAA NMFS (2016) uses a dual metric of peak sound pressure and cumulative sound level to evaluate thresholds for PTS for impulsive noise (Table 10). Southall et al. (2019) recommended several updates to these noise exposure thresholds and functional hearing groups, including the addition of a Very High Frequency (VHF) group, which includes the harbor porpoise.

Popper et al. (2014), supported by numerous other researchers (NYSERDA 2017), reported that the general hearing range of sea turtles may be between 50 and 1,200 Hz with sensitivity to sound declining above 400 Hz. Popper et al. (2014) concluded that sea turtles may exhibit internal protection against pile driving and other impulsive noise due to their rigid carapace. The U.S. Navy developed thresholds for sea turtles with criteria for peak sound pressure and cumulative sound exposure levels, summarized in Table 11.

Table 11. Summary of Generalized Hearing Ranges and Permanent Threshold Shifts of Sea Turtles

Lpk: peak sound pressure (dB re 1 μPa); LE,24h: sound exposure level, cumulative 24h (dB re 1 μPa2·s)
Source: McCauley et al. 2000; Finneran et al. 2017; NMFS 2020

Hearing Group	Species within the AoA	Generalized Hearing Range	PTS	TTS
Sea Turtles	Leatherback Sea Turtle Loggerhead Sea Turtle Kemp’s Ridley Sea Turtle Green Sea Turtle	50 Hz-1200 kHz	L_{pk}: 232 dB $L_{E,24h}$: 204 dB	L_{pk}: 226 dB $L_{E,24h}$: 189 dB

Whether or not an animal experiences sound that rises to the level of injury (e.g., PTS) or behavioral disturbance from a given activity depends on a variety of factors, including distance from the noise source, behavioral avoidance, frequency content and duration of the sound, and the mitigation measures employed. Propagation of underwater noise is also dependent on oceanographic factors such as temperature and salinity. Therefore, no attempt is made here to assess the potential of specific activities to cause injury or behavioral disturbance to marine mammals or sea turtles, but only whether noise from a given activity is likely to be audible to a given species group.

4.1.3.2 Stress Response

Marine mammals and sea turtles sensitive to noise may exhibit a stress response to loud noises such as pile driving or deconstruction activities. Physical stressors for whales (e.g., entanglement events) have been shown to increase stress hormone levels as long as the stressor is present (Rolland et al. [2017]; Lysiak et al. [2018], as cited by Kraus et al. 2019). Right whales, as one of the world's most endangered species, likely experience chronic stress from continuous exposure to shipping noise; cumulative effects of added anthropogenic noise sources could increase the chronic physiological stress levels in this species (Kraus et al. 2019). Chronic stress reduces immune and endocrine function, negatively affecting health and reproductive fitness and leaving them vulnerable to disease (Schick et al. [2013] and Rolland et al. [2017], as cited by Kraus et al. 2019).

4.1.4 Behavioral Effects of Noise

4.1.4.1 Avoidance

Behavioral impacts may occur at further ranges and physical effects and may differ among individuals relative to received sound levels and behavior state (Wood et al. 2012). The behavioral response in marine mammals due to sound waves can vary in severity, including no response at all, mild aversion, or panic and flight (Southall et al. 2007). Short- and long-distance avoidance can occur in seals and cetaceans in response to noise (Morton and Symonds 2002; Verboom and Kastelein 2005; Bailey et al. 2010; Brandt et al. 2011; Dähne et al. 2013; Williams et al. 2014). Humpback whales, Green Sea Turtles, and Loggerhead sea turtles have been reported to travel away from underwater seismic noise (McCauley et al. 2000). In feeding areas, avoidance can lead to reduced foraging time or ability to find prey, resulting in reduced body condition and health (Kraus et al. 2019).

Avoidance may cause marine mammals and sea turtles to move more frequently into areas of higher vessel traffic, such as shipping corridors. Depending on where and how far an animal displaces, it may be more susceptible to vessel strikes (see section 4.2). The species that are at a higher risk of vessel collision, in general, include Humpback whales, which have undergone a UME in the North Atlantic since 2016 that appears to be related to larger than usual numbers of vessel collisions (NOAA Fisheries

2023b), and NARWs, for which vessel collision is considered a significant factor affecting the recovery of the species (Knowlton and Kraus 2001; Rolland et al. 2016). NOAA Fisheries has also declared a UME for NARWs since 2017, driven by entanglements or vessel strikes (NOAA Fisheries 2023c). Vessel noise has also been shown to affect the foraging behavior of low-frequency cetaceans such as Humpback whales, causing slower descent rates during foraging dives and fewer feeding events (Blair et al. 2016).

The state of the animal's behavior can affect the response to noise for some marine mammals, such as feeding location or migration (Ellison et al. 2012; Goldbogen et al. 2013; Southall et al. 2016). Goldbogen et al. (2013) found that Blue whales feeding on deep prey were more likely to change diving behavior when exposed to simulated sonar than those at shallower depths. Buck and Tyack (2000) observed gray whales avoid simulated low-frequency sonar during southward migration when it was within the migratory path, but not when it was located farther offshore, despite similar received sound levels. The studies of the relationship of response to behavior state and other factors have focused on sonar rather than noise anticipated from wind farms, but they provide some context for consideration of the influence of these factors. Anthropogenic noise may also trigger antipredator defenses in some cetacean species, leading to disruption in foraging behavior beyond that expected from hearing sensitivity alone (Miller et al. 2022).

4.1.4.2 Masking

Because marine mammals rely on sounds for communication and for sensing their environment, marine noise has the potential to interfere with their ability to send and receive acoustic signals, and thus their ability to communicate, interact socially, forage, navigate, find prey or mates, avoid predators, and identify appropriate nesting sites in the case of sea turtles (e.g., David 2006; Erbe et al. 2016; BOEM 2019). This interference is known as auditory masking. The susceptibility of a marine mammal to masking depends on the frequency at which they send and receive auditory signals and the frequency, loudness, and other attributes of the background noise (e.g., David 2006, Erbe et al. 2016). The extent to which anthropogenic noise interferes with an animal's ability to communicate with conspecifics has been referred to as the loss of "communication space" (Clark et al. 2009). Auditory masking in marine mammals is still poorly understood despite the potential effects of this phenomenon on marine mammal behavior and, consequently, on the health of individuals and populations.

Low-frequency cetaceans such as baleen whales are particularly vulnerable to masking by low-frequency noise such as vessel traffic noise (Clark et al. 2009; Hatch et al. 2012; Cholewiak et al. 2018; Southall et al. 2023). Humpback and right whale mother-calf pairs communicate quietly, potentially as an anti-predatory strategy, and are likely susceptible to masking (Videsen et al. [2017], as cited by Kraus et al. 2019). Pile-driving noise has been shown to mask communications in bottlenose dolphins up to 40 km from the source and cause a temporary decrease in harbor porpoise vocalizations up to an average of 17.8 km from the source (Brandt et al. 2011), with an increase in waiting times (the period between two consecutive encounters of echolocation activity) up to six times as long during OSW farm construction as compared to reference areas (Carstensen et al. 2006). Perceived changes in vocalizations or echolocation detection may be related to displacement or behavioral disturbance, but they may also reflect masking of sound, in that some species may choose not to use sound in an environment too noisy for sound to be effective. Auditory masking models may help predict the effects of anthropogenic noise on marine mammals given known parameters, such as distance to the noise source, sound levels, and call audibility range (Erbe et al. 2016).

4.1.5 Potential Risk of Noise-Related Injury or Behavioral Changes in Marine Mammals and Sea Turtles during Construction

The primary sources of noise related to OSW farms derive from turbine construction and long-term operations. Therefore, the following sections focus on the potential risk of injury or behavioral changes to marine mammals and sea turtles during the construction and operational phases.

4.1.5.1 High-Frequency Cetaceans

Although the majority of the energy emitted from impact pile-driving is relatively low-frequency (Risch et al. 2023), there are high-frequency components and high-frequency cetaceans are expected to have lower received energy thresholds for PTS than other marine mammal hearing groups (NMFS 2018).

Studies suggest that harbor porpoises may experience temporary displacement from impact pile-driving noise (Verboom and Kastelein 2005; Bailey et al. 2010; Brandt et al. 2011; Dähne et al. 2013), further supporting their potential sensitivity to this stressor. Brandt et al. (2011) reported reduced detections of harbor porpoise within 2 km of the piling sites for a mean of 20 hours.

Harbor porpoise hearing (e.g., Kastelein et al. 2012) and TTS (e.g., Lucke et al. 2009) has been directly studied in captivity, rather than estimated by proxy, and research has indicated that harbor porpoise may perceive pile-driving noise from wind farm construction at distances as much as tens of km from the construction site (e.g., Tougaard et al. 2009; Kastelein et al. 2013). These results suggest potential for a risk of construction noise-related disturbance to this receptor.

Noise emitted during turbine operations is typically low-frequency (Madsen et al. 2006; Lucke et al. 2007; Tougaard et al. 2020) and is therefore unlikely to substantially impact high-frequency cetaceans except at the low end of their hearing range. If detected by high-frequency cetaceans, impacts could include avoidance of the area (Palmer et al. 2021) or masking of communications (Lucke et al. 2007).

Vessel noise may be a source of disturbance for high-frequency cetaceans. Although noise from vessels is primarily in the low-frequency range, high-frequency cetaceans, such as harbor porpoise, have been shown to react to the mid- and high-frequency components of vessel noise, particularly in shallow-water environments where low-frequency sounds do not propagate well (Dyndo et al. 2015).

4.1.5.2 Mid-Frequency Cetaceans

Mid-frequency cetaceans, such as Sperm whales, beaked whales, and dolphins, are less likely to overlap in the most sensitive parts of their hearing range with the loudest sounds associated with impact pile driving. The loudest sounds produced during pile driving tend to be low-frequency sounds, usually below 1 kHz (Brandt et al. 2016). This is in the lower part of the generalized hearing range of mid-frequency cetaceans (150 Hz to 160 kHz; NOAA NMFS 2016) and not concentrated in the most sensitive range of hearing. They are also less likely to overlap with the low-frequency sounds associated with vessel traffic.

Studies of bottlenose dolphins suggest that they can detect impact pile-driving noise as far as 40 to 50 km away, but risks of masking may be limited, and changes in behavior are hard to attribute to sound versus other variables (David 2006; Bailey et al. 2010). Detection of sound does not necessarily equate to disturbance by sound, and mid-frequency cetaceans are known to approach and bow-ride on vessels conducting seismic surveys, which produce relatively loud sounds (e.g., Barkaszi 2012).

Like noise generated from pile driving, operational noise of OSW turbines may be detected by mid-frequency cetaceans at the lower end of their hearing range (Malinka et al. 2018). If detected, impacts could include avoidance of the area (Lossent et al. 2018) or masking of communications (Thomsen et al. 2006).

4.1.5.3 Low-Frequency Cetaceans

Low-frequency cetaceans (i.e., baleen whales) are at risk of masking by lower frequency construction-related vessel traffic, but vessel traffic is not uncommon in the AoA in general (U.S. Coast Guard Navigation Center 2016). Although classified as broadband, most energy produced by pile driving is low frequency, with impulses at frequencies less than 500 Hz (Laughlin 2006; Reyff [2008 and 2012] as cited by Popper et al 2014) The frequency range estimated to be the range of maximum sensitivity of Humpback whales is 2 to 6 kHz (Houser et al. 2001), but as mentioned above, sensitivity of low-frequency cetaceans has not yet been tested directly. Sound may be perceived by baleen whales at large distances from pile-driving activities, but shipping and other ambient low-frequency noise are also typically present in the environment (Risch et al. 2012; Rice et al. 2014). Given the already high ambient noise conditions measured in the New York Bight, further increase in these noise levels associated with OSW development (particularly in the low-frequency range) has the potential to further impinge upon the communication space of baleen whales.

Noise generated from the operation of OSW turbines is in the low-frequency range (Madsen et al. 2006; Lucke et al. 2007; Tougaard et al. 2020; Wang et al. 2022) and therefore could impact low-frequency cetaceans. No empirical information is currently available to determine the actual level of noise generated during the operation of >10 MW turbines at a commercial-scale OSW farm. Current estimates are based on models using empirical data evaluating smaller turbines, although these modeling efforts have inherent challenges (Holme et al. 2023). Furthermore, the mechanical noise of turbines is also driven by the technology used (see section 4.1.2.3). Effects of operational noise on low-frequency cetaceans could include avoidance of the area and/or auditory masking (Croll et al. 2001) (see section 4.1.4); however, the potential risks to this receptor group will be better understood once more accurate estimates of operational noise at commercial-scale OSW farms in the U.S. is available.

4.1.5.4 North Atlantic Right Whales

Given the extremely small number of NARW remaining (<350), this receptor group is particularly vulnerable to anthropogenic stressors, which, depending on the type and severity, have the potential to cause population-level effects. Although treated as a unique receptor group for the purposes of this analysis, NARW are low-frequency cetaceans and are also sensitive to noise from impact and vibratory pile driving, drilling, and vessel traffic (Clark et al. 2009; Rice et al. 2014). Even prior to the onset of OSW development activities in the New York Bight, Rice et al. (2014) reported that, of 10 acoustic monitoring sites located along the U.S. East Coast, the site in the New York Bight experienced the highest recorded sound levels, the majority of which were attributed to shipping noise. Most of these sounds were in low-frequency bands below 500 Hz, the communication range utilized by NARW, other baleen whales, and many fish species (Rice et al. 2014). Like other baleen whale species, NARW can be impacted by low-frequency noise sources, such as shipping noise from large vessels (20 to 200 Hz), which overlap acoustic signals used by this species (Clark et al. 2009; Hatch et al. 2012). Analyses of right whale fecal samples indicate that noise from large commercial vessels increases their stress levels (Rolland et al. 2012). Because right whale mother-calf pairs communicate quietly, which is likely an anti-predator strategy, they may be particularly susceptible to masking (Videsen et al. 2017; Kraus et al. 2019; Parks et al. 2019). Given the already high-ambient noise conditions measured in the New York Bight, a further increase in these noise levels associated with OSW development (particularly in the low-frequency range, such as shipping and operational noise from the rotating turbines) has the potential to further impinge upon the communication space of NARW and those of other baleen whale species.

Depending on the animals' distance from the sound source, oceanographic conditions, and other factors, underwater noise from construction associated with OSW development has the potential to cause injury or behavioral disturbance to NARW, although these impacts will likely be mitigated by the mandatory use of bubble curtains and other noise mitigation systems, as well as clearance and shutdown zones established around the noise source during construction. Displacement from foraging areas or migratory pathways due to noise generated by OSW activities could increase NARW overlap with vessel traffic and fishing activities, exposing them to increased risk from vessel strikes and fishery interactions (BOEM 2022). In feeding areas, displacement could lead to reduced foraging time, with reduced body condition and health as a consequence (Kraus et al. 2019). Overall, although the OSW stressors to which NARW will be exposed are not substantially different from those facing other low-frequency cetaceans, the resilience of this species is likely lower given their critically endangered status.

4.1.5.5 Seals

Seals are generally coastal, spend part of their time on land, and can lift their heads out of the water, reducing their vulnerability to in-water construction noise. Thompson et al. (2013) developed a framework for evaluating the risks of pile driving for wind farm development on harbor seals in Moray Firth and concluded that pile driving noise was not expected to result in a reduction in population-level fitness. Kastelein et al. (2013) reported that harbor seals may hear pile driving up to hundreds of km from pile-driving sites, but distance of audibility would be affected by actual sound propagation conditions and masking from ambient noise. A study of tagged harbor seals during construction of an OSW farm in the U.K. showed that during impact piling, seal abundance in the wind farm area was significantly reduced up to 25 km from the piling activity (Russell et al. 2016). However, displacement was limited to piling activity, and within 2 hours of cessation of pile driving, seals returned to non-piling distribution patterns (Russell et al. 2016). Seals may also detect the sound emitted by operational OSW turbines as the lower end of their hearing range overlaps with the expected frequency of OSW turbines (Wang et al. 2022, Figure 44).

4.1.5.6 Sea Turtles

Sea turtles are most sensitive to low-frequency sounds below 1,000 Hz (Figure 44), and their hearing range is comparable to that of fish but narrower than that of marine mammals (Piniak et al. 2016; NOAA 2022). It is difficult to determine the vulnerability of sea turtles to noise. Popper et al. (2014) speculated that the physiology of sea turtles (i.e., rigid carapace) may put them at lower risk of internal injury from pulsed sounds, like those associated with pile driving. Given their low-frequency hearing, auditory masking from pile driving may be a larger concern if auditory environmental cues are used for migration or feeding in the AoA. Likewise, continuous sounds generated by rotating turbines during the operational phase of OSW farms, as well as those generated by vessel traffic during all development phases, fall in the low-frequency category and would therefore likely be audible to in-water sea turtles.

A study by the U.S. Army Corps of Engineers (USACE 1997) evaluated the response of Loggerhead Sea Turtles to a fixed sound source designed to repel sea turtles from dredges and found there was no significant difference between avoidance and approach of the sound source by Loggerhead Sea Turtles. An additional study evaluated the response of 10 Loggerhead Sea Turtles to seismic sound, which initially showed significant avoidance response but did not continue, suggesting habituation to the sound. McCauley et al. (2000) conducted trials on captive and Loggerhead Sea Turtles, which resulted in observations of increased swimming activity at reception of seismic sources of 166 dB and above. Although seismic sound is not directly comparable to pile-driving noise, and seismic sources are typically part of moving towed arrays rather than stationary construction activities, the lack of experiments using pile-driving sound to evaluate sea turtle responses makes studies of seismic responses potentially informative.

Operations of turbines, while within the hearing range of sea turtles, may not result in a permanent avoidance of the area if the sea turtles become habituated to the sound, as indicated by the USACE (1997) study.

4.2 Vessel Traffic

4.2.1 Vessel Strikes

Vessel strikes are a threat to a number of marine mammal and sea turtle species. Vessel strikes are most likely to occur in areas with high numbers of ships, such as along established shipping routes, or in areas with higher concentrations of animals (e.g., Biologically Important Areas [BIAs]) (Douglas et al. 2008; Berman-Kowaleski et al. 2010).

Marine mammals and sea turtles are more likely to be struck and suffer mortality as a result of injuries when a vessel is large (i.e., 80 m or longer) (Laist et al. 2001), traveling at high speed (13 to 15 knots or higher for cetaceans [Laist et al. 2001; Jensen and Silber 2004; Kite-Powell et al. 2007] and 10 knots for sea turtles [Hazel et al. 2007]), or located in a geographic bottleneck such as a narrow strait (Williams and O’Hara 2010). Additionally, vessels less than 65 ft (19.8 m) in length accounted for five of the 12 documented lethal strike events in U.S. waters since 2008, demonstrating the significant risk this vessel size class can present to NARW (87 FR 46921). Travel speed restrictions of 10 knots or less have been shown to substantially reduce vessel strikes (Conn and Silber 2013; Crum et al. 2019), again indicating that speed is a major factor in the risk of vessel strikes. Small cetaceans, sea turtles, and seals also have potential to be struck by vessels; however, literature is primarily centered on small craft rather than types of ships associated with OSW farm development. Generally, the number of vessel strikes on marine mammals and sea turtles is underestimated due to underreporting and loss of carcasses related to predation, rapid deterioration, and water currents (Barkaszi et al. 2021; Pace et al. 2021).

The risk of vessel strikes is positively correlated with a marine animal's behavior; the more time a species spends at the water surface, the higher the risk that animal has of interacting with vessels. Therefore, shallow-diving cetaceans and sea turtles may be more vulnerable to strikes than deep-diving cetaceans, which spend less time at the surface. Whale calves and juveniles comprise a greater proportion of vessel strikes than adults, which may be caused by the relatively large amount of time that they are spending at the surface or in shallow coastal areas (Laist et al. 2001). Risk of vessel strikes can also be driven by migratory pathways and population spatial shifts over time that changes their susceptibility to interaction with vessels (e.g., population movement into or out of shipping routes).

Based on information compiled by Laist et al. (2001), the cetaceans most susceptible to vessel strike in the AoA are the Humpback whale, NARW, and Fin whale (Laist et al. 2001; NOAA Fisheries 2023b, 2023c). Humpback whales have undergone a UME in the North Atlantic since 2016 that appears to be related to larger than usual numbers of vessel strikes (NOAA Fisheries 2023b) and NARWs (NOAA Fisheries 2023c), for which vessel strikes are considered a significant factor affecting the recovery of the species (Knowlton and Kraus 2001; Rolland et al. 2016). Vessel strikes, along with entanglements, are a major cause of NARW mortality (Sharp et al. 2019; Meyer-Gutbrod et al. 2021; Moore 2023). Minke whales have experienced a UME along the Atlantic coast since 2017, and preliminary findings in several of the whales have shown evidence of human interactions, including vessel strikes (NOAA Fisheries 2023g). Increased vessel traffic is also considered a threat to Loggerhead, Kemp's Ridley, and Green Sea Turtles (NOAA NMFS 2008; NMFS et al. 2011; NMFS and USFWS 1991). The potential increase in vessel traffic to and from the port regions during all phases of OSW development therefore has the potential to elevate the risk of ship strikes in coastal regions, although this risk would be mitigated by vessel strike avoidance measures including mandatory vessel speed restrictions and species-specific vessel separation distances.

4.2.1.1 Changes in Numbers and Types of Vessels

Pre-construction

For fixed-foundation OSW turbines, HRG surveys would be necessary for understanding the ideal placement and type of fixed-foundation OSW turbines (e.g., piles, suction caissons, or gravity-based [Fugro Marine GeoServices Inc. 2017]), anchors for floating OSW turbines (e.g., drag-embedment, suction caissons, gravity anchor, and anchor piles [Maxwell et al. 2022]), and cable arrays. Vessels would move slowly during actual surveying; however, travel to and from the site and between sites poses a risk to marine animals due to increased speed. Vessels may also be deployed for seabed preparation, such as dredging or rock placement, which would require at least an additional two vessels.

Construction

Vessels used during construction of OSW farm foundations and turbines would depend on the water depth, type of installation (monopile, jacket, or floating), and port characteristics (American Bureau of Shipping 2021). A variety of vessels would be needed during the construction phase (see section 4.1.2.2), although some aspects of floating OSW turbines may allow for fewer vessels required (Maxwell et al. 2022). The risk of vessel collisions during the construction phase is inherently higher due to the increase in vessel traffic for this period of time.

Operation

Periodic visits to the OSW farm for inspections and maintenance would be required to ensure proper facility operations. The number of visits per year is dependent on the size and capacity of the wind farm, accessibility, wear/environmental conditions, and cost (Ren et al. 2021; McMorland et al. 2022) and will likely increase over the life of the OSW farm. Vessels needed for regular operations and maintenance may include jack-up vessels, crew transfer vessels, and supply vessels. In some OSW turbine configurations, larger platforms for helicopter landing would also reduce the number of vessels required (Maxwell et al. 2022).

Decommissioning

Vessels required during OSW farm decommissioning are likely similar to those needed during the construction phase for removal of substructures/foundations, cables, scour protection, and cable protection (Hall et al. 2022). However, the number and type of vessels will also depend on the approach to decommissioning as well as the type of structures for removal. In instances where fixed foundations are left in place as part of a “renewables-to-reefs” program (Smyth et al. 2015; similar to a “rigs-to-reefs” program), vessels would not be required for pile extraction and removal.

4.2.2 Fishery Interactions

Fisheries surveys will need to be conducted as part of pre-construction baseline data, during construction activities, and post-construction (i.e., during operations) to assess the potential effect of activities to fish populations in the AoA. Gears used for fish surveys may include otter trawls, sink gillnet, trammel net, beam trawl, fish traps/pots, and benthic physical sampling (e.g., Hamon grab, Van Veen grab, benthic sled, dredge) (BOEM 2023). While not targeted species, fisheries surveys have potential to elevate interaction risk to protected species, including marine mammals and sea turtles. BOEM (2023) states that to the maximum extent practicable, surveys should minimize the amount and duration of gear setting and towing and limit the spatial and temporal overlap with protected species. Surveys must comply with the Atlantic Large Whale Take Reduction Plan (50 [Code of Federal Regulations] CFR 229.32), Harbor Porpoise Take Reduction Plan (50 CFR 229.33 and 229.34), and Bottlenose Dolphin Take Reduction Plan (50 CFR 229.35) regulations. Despite regulatory protections, bycatch of marine mammals and sea turtles have been observed in the Mid-Atlantic by gillnet, trawl, and other gear types (Moore et al. 2008). Harbor porpoises and pinnipeds are the most common marine mammal bycatch in the Atlantic, specifically in the

New England coastal area, and bottlenose dolphins are bycaught in the Mid-Atlantic area. The most recent National Bycatch Report states that gillnet gear is the largest contributor to marine mammal bycatch, constituting up to 73% of marine mammal bycatch recorded in 2014 and 2015 (NOAA 2019). Marine stocks with the highest average annual bycatch estimate across all gear types included the gray seal, short-beaked common dolphin, harbor seal, and harbor porpoise.

Loggerhead Sea Turtles are the species of most concern for sea turtle bycatch, as the continental shelf provides critical ontogenetic habitats overlap with areas of high-fishing activity (Moore et al. 2008). Shrimp trawling vessels pose the greatest risk to sea turtles in the Atlantic (mainly, southeastern Atlantic), particularly before turtle excluder devices sizes were increased through federal regulations (68 *Federal Register* [FR]8456-8471). Sink gillnets are also a significant source of bycatch mortality to sea turtles; as reported in the NOAA (2019) report, up to 705 Loggerhead, 145 Kemp's Ridley, 27 Leatherback, and 112 unidentified hard-shelled sea turtles were caught between 2012 and 2018, with 781 turtles suffering mortality. Sea turtle mortality via bycatch may exceed that of all other U.S. fisheries, with Loggerhead Sea Turtles particularly impacted and experiencing population decline. More information, monitoring, and technology advancements are needed to reduce sea turtle mortality related to fisheries gear (Moore et al. 2008).

Fisheries surveys will be required before, during, and following construction activities for either fixed-foundation OSW or floating OSW turbine farms. Fisheries gear inherently presents bycatch risk to small marine mammals and sea turtles. Bycatch risk can be minimized by conducting surveys following guidelines provided by BOEM (2023) and implementing existing guidance for avoidance, minimization, and mitigation of impacts.

4.3 Unexploded Ordnance Detonation

UXO are defined as military munitions prepared for action but have been unexploded and remain in place, presenting a hazard to human safety and property. While the prevalence of UXOs in offshore waters of the U.S. Atlantic coast is a fraction of those found in Europe and the U.K. (Middleton et al. 2021), the identification and management of UXO remains a significant consideration in the planning and pre-construction phase of an OSW farm.

Identified UXO in the AoA could be left in place, relocated, or purposely detonated. Avoiding the UXO is the safest approach, with detonation as the option which carries the most risk (Middleton et al. 2021).

In-water explosions, such as the detonation of an UXO, produce a spherical shock wave that travels faster than the speed of sound in water (Popper et al. 2014). The extent of detonation and reach of effects depends on the size ("charge weight") of the UXO. The acoustic metrics and thresholds for effects depend on species and in some cases animal size and submersion depth (Hannay and Zykov 2022). No data is available regarding the effect of explosives on sea turtles; however, the death of a small number of sea turtles resulting from the deconstruction of oil and gas structures in the Gulf of Mexico was reported, potentially related to rapid pressure changes on the air-filled lungs and other air-filled cavities such as the middle ear (Popper et al. 2014). Marine mammals are shown to be at the greatest risk of injury when at the same depth or slightly elevated above the explosion (Brand 2021). Injuries from the shock wave can include a sudden increase in cerebrospinal fluid pressure, middle and inner ear damage, and/or lung and intestinal hemorrhaging.

Most UXO along the U.S. coast are small, and locations of UXO disposal areas have already been excluded from potential OSW development, significantly reducing the likelihood of identifying a UXO within the AoA (Middleton et al. 2021).

4.4 Permanent Structures

Permanent structures in place following construction (i.e., during operation) of an OSW farm are a potential stressor to marine animals in their natural environment and can include direct and indirect effects to these organisms. The following sections describe several potential effects and risks of the placement of permanent structures in the marine environment, and assumes effects take place during the operation phase of OSW farm life-cycle (unless otherwise noted).

4.4.1 Displacement

Data on the potential for habitat fragmentation or displacement caused by OSW structures themselves are generally lacking or contradictory. Highly mobile marine species, in theory, can use other suitable areas to compensate for habitat loss and fragmentation, but cautions that major barriers to migration or loss of critical habitat could affect species by requiring additional energy expenditures (Harwood 2001; Farr et all. 2021). Any known areas of concentrated feeding, breeding, and migration in the AoA for marine mammals and sea turtles may be considered sensitive to the risks associated with permanent structures. If displacement does occur, marine mammals or sea turtles could experience reduced body condition and health if foraging time is increased, potentially heighten risk of vessel strikes if marine mammals or sea turtles move into more trafficked areas, or effect migratory pathways (see section 4.1.4.1).

4.4.2 Artificial Reefs

Permanent structures in the water, such as fixed-foundation OSW turbines, scour protection, and floating OSW turbines, would provide additional complex substrate with which some marine organisms would colonize (Kaldellis et al. 2016; Degraer et al. 2020). "Reef effects" are well documented at OSW farms, oil and gas platforms, and subsea pipelines (Farr et al. 2021). Any structure placed in the marine environment has the potential to become an artificial reef through the colonization of marine biota, with colonization of some structures many times that of the surrounding, soft-bottomed area (Langhamer 2012; Smyth et al. 2015). The species composition colonizing the structures is dictated by vertical zonation, with different species present in the splash, intertidal, shallow, and deeper subtidal zones (Degraer et al. 2020). Generally, colonizing communities are dominated by mussels, macroalgae, and barnacles near the water surface; filter-feeding arthropods at intermediate depths, and anemones in deeper zones (De Mesel et al. [2015], as cited by Degraer et al. 2020). Apart from substrate-colonizing organisms, artificial reefs attract crabs and lobsters (Krone et al. [2017], as cited by Degraer et al. 2020) and a variety of fish species and life stages (Mote Marine Laboratory 2008), including piscivorous and zooplanktivorous fishes (Champion et al. 2015). In areas where fishing activity is restricted within and around OSW farms, these areas may act as de facto marine protected areas, creating refuges for marine species, increasing local species abundance, and generating spillover effects (Di Lorenzo et al. 2016) to adjacent areas (Farr et al. 2021). Increased resources around OSW farms would contribute to greater foraging resources for fish and zooplankton predators, attracting marine mammals and sea turtles (Barnette 2017; Fernandez-Betelu et al. 2022). While artificial reef effects are predictable at offshore structures, the exact influence of structure type on the degree of reef effect has not been quantified (Draeger et al. 2020).

Consideration for leaving foundations in place during decommissioning should be given to reduce impact of deconstruction activities, particularly if foundations are well colonized or if habitat created on the structure has conservation or commercial value (Topham et al. 2019).

4.4.3 Entanglement

Entanglement risks include primary, secondary, and tertiary entanglement (Maxwell et al. 2022). Primary entanglement occurs when animals are entangled in the lines or cables themselves, whereas secondary entanglement occurs when fishing gear becomes entangled in lines or cables, and this material subsequently entangles animals. Tertiary entanglement occurs when an animal is already entangled in gear, which becomes entangled on physical structures (Farr et al. 2021). Entanglement may result in the severe injury or mortality, starvation, or drowning of an animal (Cassoff et al. [2011], as cited by Farr et al. 2022), and is considered a leading cause of UMEs for Humpback and NARWs (in addition to vessel collisions) (NOAA Fisheries 2023b, 2023c). OSW farms functioning as hot spots of biological productivity (see section 4.4.2) can attract cetaceans, seals, and sea turtles for foraging, heightening risk of entanglement to these species if snagged materials are present. Sea turtles, particularly juvenile sea turtles, become entangled in discarded fishing materials much more often than land-based sources (Duncan et al. 2017).

The risk of marine mammal or sea turtle entanglement around fixed-foundation OSW turbines would consist of secondary or tertiary entanglement. As the fixed foundations are colonized with organisms (see section 4.4.2), there is greater surface area of rough cover (e.g., barnacles), which could snag derelict fishing gear and pose a risk to marine animals.

Entanglement risk of floating OSW turbines is a key potential risk difference compared to fixed-foundation OSW turbines (Maxwell et al. 2022). Since floating OSW turbines require mooring systems to keep the substructures stationary, marine animal entanglement risk will likely be influenced by the type of mooring system employed (i.e., catenary, taut, or semi-taut [Maxwell et al. 2022]), mooring materials (e.g., steel chain, steel wires, synthetic rope [Maxwell et al. 2022]) and characteristics (e.g., depth of the drape), turbine array configuration (Farr et al. 2021), and detection of mooring lines by animals (Maxwell et al. 2022), the abundance of derelict fishing gear or other materials in the region and proximity to fishing grounds (Maxwell et al. 2022). If cable arrays are developed as attachments to subsurface buoys as opposed to buried, this would also provide additional obstacles for marine mammals and avenues for entanglement (Farr et al. 2021). Studies show that baleen whales have the greatest risk of entanglement and toothed whales have the least risk due to their differing foraging habits; however, it is unlikely that any marine mammals would become directly entangled on the moorings themselves due to the large size of materials (Benjamins et al. [2014], as described by Farr et al. [2021] and Maxwell et al. [2022]). No primary entanglement in mooring lines or cables has been reported for floating turbines in Scotland at the largest floating OSW farm currently in operation, regardless of the high density of cetaceans and seals in the area (Maxwell et al. 2022).

Marine mammals and sea turtles would be at higher risk of secondary or tertiary entanglement. Species with large appendages such as Humpback whales or Leatherback Sea Turtles have a greater propensity for entanglement with ropes, lines, and cables that are used for fishing gear; increased biofouling of subsurface structures increases the likelihood of snagging of this fishing gear (Maxwell et al. 2022). Entanglement leading to mortality of marine mammals could pose a significant risk for population-level effects if highly endangered species are present in the areas around floating OSW farms. If floating wind farms were to have a larger spatial footprint than fixed wind farms, this could increase the likelihood of displacement of marine mammals and sea turtles, as well as secondary and tertiary entanglement risk.

4.4.4 Entrainment or Impingement

Some OSW farms include a high-voltage direct current (HVDC) system, which is needed to convert generated electricity from alternating current (AC) to direct current (DC) for the transmission of electricity from offshore to onshore (Middleton and Barnhart 2022) (Other OSW farms utilize offshore substations that to not produce warm water discharges). As the HVDC system makes this power conversion, a byproduct of heat during the process requires a cooling system to prevent overheating. The cooling system withdrawals seawater for circulation through the HVDC to counteract the heat generated by AC to DC conversion. Water withdrawals have potential to entrain organisms through the cooling system, or impingement organisms against the intake opening screens/bar racks. No information is available specifically regarding entrainment or impingement risks to marine organisms at OSW farms; however, some conclusions can be drawn from onshore water withdrawal practices and related regulations, and similar OSW projects.

The Sunrise Wind Farm Project, a joint venture between Orsted North America Inc. and Eversource Investment LLC conducted a study on the intake zone of influence and thermal discharge of the proposed converter station (Woods Hole Group 2021). The system was designed to withdraw water through three vertical intake pipes with 2.4-inch by 0.8-inch spaced bars and a through screen velocity of 0.43 ft per second. The water outside of the screened area (upstream) would have a lower velocity than that estimated through the screen. Organisms unable to swim independently out of the intake flow (e.g., early life-stage organisms such as eggs and larvae, zooplankton) or those with weaker swimming ability (e.g., juvenile fish) could be susceptible to entrainment or impingement if within the hydraulic zone of influence.

4.4.5 Impacts on Marine Resource Surveys

Aerial- and vessel-based marine resource surveys are performed regularly throughout the EEZ in order to gather data about marine mammal and sea turtle distribution (NEFSC and SEFSC 2020, 2021, 2022). The presence of wind turbines (fixed or floating) is likely to interfere with aerial surveys for marine mammals and sea turtles by requiring aircraft to fly at higher altitudes. This will require changes in existing survey methodology, such as changing strip width (area surveyed) and introducing the use of video cameras. The ships currently used for vessel-based marine resource surveys, such as the NOAA Ship *Henry B. Bigelow*, are not able to operate in wind farms due to safety concerns. The AoA has significant overlap with established AMAPPS shipboard survey tracklines, many of which have been surveyed since 2010, which has the potential to cause a disruption in a valuable long-term dataset. For these reasons, OSW development could have a significant impact on baseline data collection used to model marine mammal and sea turtle distribution in the region.

4.5 Benthic Disturbance

Studies have shown that introduction of solid structures onto the seafloor may temporarily or permanently alter seafloor characteristics, which may result in a loss of native benthic habitat and impact benthic community abundance and diversity (HDR 2020b). In areas such as the continental shelf, sea turtles can be found on the seafloor resting and foraging for crabs and mollusks (NOAA Fisheries 2023a). A study by Dodge et al. (2018) using a video recorder attached to a Loggerhead Sea Turtle showed it to spend most of its time diving and just above the seafloor where it would use silhouettes to target jellyfish prey; however, this behavior was also dependent on local stratification conditions and related jellyfish positioning (see section 4.8). Deep-diving cetaceans, such as Sperm whale, Pygmy and dwarf sperm whales, beaked whales, Pilot whales, and spinner dolphins may also be in the vicinity and can also be disturbed by benthic activities.

4.5.1 Pre-construction

Geotechnical investigations for seafloor surveys and mapping are required prior to construction of an OSW farm in order to confirm subsurface conditions and the potential presence of objects such as shipwrecks, abandoned anchors, existing pipelines, lost casings from prior explorations (Malhotra 2009) or boulders (Cahill 2016). Impacts to the benthic environment would likely be short-term and minor. Sea turtles and marine mammals that forage benthically, if in the vicinity of the activities, would likely have opportunities to move out of the area during the disturbance and overall effects to these taxa would be expected to be negligible.

4.5.2 Construction

Dredging during the early construction phase for seabed preparation would alter the benthic environment biologically and physically. Pile driving also results in benthic disturbance and encompasses space on the seafloor that would otherwise could be used by benthic organisms; however, the space used by the foundations generally consists of less than one percent of the overall area of the OSW farm (Synthesis of Environmental Effects Research [SEER] 2022a). While initial installation of turbine monopiles and scour protection have potential to crush or smother benthic organisms, some new habitats will be colonized over time (see section 4.4.2).

Anchors required for floating OSW turbines would result in a direct interaction with the seabed (SEER 2022a; Maxwell et al. 2022), although comprising a small percentage of benthic habitat (SEER 2022a). Additional benthic disturbance can be caused by mooring lines, depending on the mooring type selected. Taut mooring lines would not interact with the seabed; however, catenary moorings, which are draped chain, cable, or synthetic rope, have potential to regularly disrupt the seafloor as the floating turbine structure moves with ocean waves and the cables sweep along the bottom.

Cable arrays installed via plowing, jetting, other mechanical methods (SEER 2022a) or buried or covered by rock (Hernandez C et al. 2021) will cause benthic disturbance. For cables installed by horizontal directional drilling (HDD), minor benthic disturbance would occur at the entrance and exit boreholes, but overall would protect certain habitats and protect the cable from corrosion in near-coastal areas (Wright et al. 2002; Kraus and Carter 2018; Hernandez C et al. 2021). Recovery of the seabed following cable laying activities depends on the hydrogeomorphic conditions of the area, such as sediment supply and current velocities, and can take anywhere between weeks to several years (Kraus and Carter 2018). Cables that are left partially exposed (or exposed over time) are instead covered with other hard materials such as rocks, concrete mattresses, or half-shell pipes, and are likely to be colonized by benthic organisms (SEER 2022a).

While some benthic habitat would be disturbed during the construction process of OSW farms, new substrates introduced such as scour protection or cable protection (e.g., rocks, concrete mattresses, or half-shell pipes) are likely to be colonized by benthic organisms (SEER 2022a). The recovery (e.g., recolonization of microbenthic infauna) of the benthic environment depends on the hydrogeomorphic conditions of the general area and can range from months to years (Van der Veer 1985; Kraus and Carter 2018).

4.5.3 Operation

Following construction of OSW farms, the benthic environment would undergo various rates of recovery depending on water depth, existing sediment type, and prevailing current speeds, flow direction, and duration, which influences sediment transport and bedform creation, shifting, and migration (HDR 2020b). These factors result in high, medium, and low recovery zones, which determine the rate at which recovery can or will be achieved following disturbance.

In a seafloor disturbance and recovery study at the Block Island Wind Farm, researchers found that benthic disturbance within work area constituted a small portion of the overall wind farm (0.2% or less of the total work area), and of the area disturbed, the majority was considered temporary with complete recovery over time (HDR 2020b). Recovery was defined as complete if no evidence of disturbance was observed, and partial recovery if a section of a disturbance showed signs of recovery. Under the first construction phase, over 44% of the disturbed area had completely recovered within 36 months of construction completion, with the remaining 56%showing partial recovery. Under the second construction phase, 70%of the disturbance area had completely recovered with the remaining area exhibiting partial recovery.

4.5.4 Decommissioning

Unless authorized for partial removal, BOEM requires that structures and facilities must be completely removed within 2 years of the expiration of a lease, including piles, anchors, and cables, to a depth of 15 ft below the mudline (BOEM 2021a; Fernandez et al. 2021).

Removal of monopiles (fixed-foundation OSW turbines) and anchors (floating OSW turbines), scour protection, and cables would result in benthic disturbance. Some aspects of OSW components may reduce benthic disturbance, such as whether partial removal is authorized by BOEM (e.g., fixed-foundations would remain in place), cable depth or coverage (such as HDD conduit, coverage by rock or concrete mattress, etc.), or anchor type (floating OSW turbines), where some anchors can be removed simply (e.g., drag-embedded anchors) while others must be left in place (e.g., grouted-in anchor piles) (Maxwell et al. 2022). As stated previously, recovery of disturbed areas is likely to occur within months to several years of decommissioning; however, this inherently reduces benthic habitats and resources, as well as causes another major disturbance to the area (apart from construction). Marine mammals and sea turtles would likely avoid the area due to benthic activities.

4.6 Structure Scouring of the Seafloor

The installation of permanent structures on the seafloor has the potential to interrupt the flow of currents and natural deposition of substrates, which can lead to local scour around foundations, anchors, and cables; scouring over the larger area wind farm area, creating a basin; and altering overall seafloor movements, including sand waves, ridges, and shoals (Malhotra 2009; Hernandez C et al. 2021). Shifting erosion and deposition patterns in the wind farm area results in changes to benthic habitats and organisms occupying those habitats. To prevent scour issues, scour protection materials are installed around turbine bases or cables to limit impacts to the area (SEER 2022a). Benthic organisms are likely to colonize these materials, using them as new habitat often in areas where hard structure was not previously available. This may attract sea turtles, which could use this area for foraging resources. Scour protection would be removed during decommissioning activities, unless authorized by BOEM to leave in place (BOEM 2021a; Fernandez et al. 2021).

4.7 Water Quality Effects

Risk to water quality exist due to construction and operation of OSW farms, which could affect marine mammals and sea turtles. The following sections discuss the risks to water quality per life-cycle phase of an OSW farm.

4.7.1 Pre-construction

4.7.1.1 Vessel Traffic

During pre-construction surveys, vessels used for surveys or crew transport could cause contamination in the surrounding area from accidental ship waste releases such as garbage or oil (Kaldellis et al. 2016). Gas and oil spills can restrict sea turtle movements causing exhaustion, expose them to harsh temperatures, increase vulnerability to predators, and ingest toxic chemicals (NOAA Fisheries 2021). For marine mammals, spills can cause injuries and impacts to populations from reproductive failure and other health effects. If trash is accidentally discarded from vessels, sea turtles and marine mammals may experience entanglement or ingest the materials, leading to injuries and mortality (NOAA 2023b).

4.7.1.2 Suspended Sediments

Surveying techniques that disturb the seafloor or pre-construction seabed preparation (e.g., dredging or rock placement [American Clean Power 2021]) could also affect water quality by suspending sediments and increasing turbidity, as well as mixing hypoxic or anoxic bottom layers. Chemical contaminants that make their way to the ocean eventually accumulate in sediments (Lamberson et al. 1992) and suspension of these contaminants can be toxic to organisms in the local area.

Suspended sediments also cause increased turbidity in the localized area of disturbance. Limited information is available regarding the sensitivity of sea turtles and marine mammals to total suspended sediment concentrations. Increased turbidity may cause sea turtles and marine mammals to alter their normal movements, but effects are not likely to be significant (NOAA Fisheries 2023f). Both organisms are air breathing and mobile and would be able to swim through sediment plumes uninhibited.

4.7.2 Construction

As stated in section 4.2.1.1, up to 19 or more vessels may be needed for the construction phase for component transfers, cable laying, and development, construction, and commissioning, although fewer vessels may be required for the construction of floating OSW turbines (American Clean Power 2021). An increase in vessel traffic inherently increases the risk for inadvertent releases. Actions which disturb the seabed, such as pile driving or installation of mooring anchors, could suspend sediments, potentially releasing toxin and increasing turbidity. Floating OSW turbines may have less seabed disturbance as compared to fixed-foundation OSW turbines depending on the anchor type used, which would reduce risk water quality effects related to suspended sediments. Effects to marine mammals and sea turtles due to inadvertent releases or suspended sediments is discussed in section 4.7.1.

4.7.3 Operation

4.7.3.1 Anti-Biofouling Measures

Seawater is highly corrosive, and maintenance of offshore structures can be difficult and expensive (Farr et al. 2021). Preemptive measures to prevent corrosion and biofouling often include epoxy-based coatings, polyurethan topcoat, and cathodic protection (Price and Figueira [2017], as cited by Farr et al. 2021). These measures are a source of chemical emissions such as organic compounds (e.g., bisphenol A) and metals (e.g., aluminum, zinc, and indium); however, there is currently no clear evidence of negative impact on the marine environment from these sources (Kirchgeorg et al. [2018], as cited by Farr et al. 2021).

4.7.3.2 Vessel Traffic

Periodic visits to the OSW farm for inspections and maintenance would be required to ensure proper facility operations. Four or more vessels would be needed (American Clean Power 2021), though the number of visits per year is dependent on the size and capacity of the wind farm, accessibility, wear/environmental conditions, and cost (Ren et al. 2021; McMorland et al. 2022). The presence of OSW farms increases the risk of collision by vessel traffic, with ship size and proximity to commonly used shipping routes also important considerations (Biehl and Lehmann 2006). Biehl and Lehmann (2006) found that effects of collisions (i.e., level of hazard) may depend on vessel type (e.g., container ship, bulker, single hull) and turbine foundation type (e.g., monopile, jacket). Overall, the likelihood of vessel collision with turbines leading to chemical spills is low.

4.7.3.3 High-Voltage Direct Current Effluent Temperature Effects

As discussed in section 4.4.4, for some OSW farms, a HVDC station may be necessary for power conversion for onshore transmission. A byproduct of this power conversion is heat; in order for the station to operate continually, the system that is regularly generating heat must be cooled (Middleton and Barnhart 2022). The most effective cooling system is an open-loop system, which withdrawals seawater and pumps it through a heat exchanger, then discharges back to the sea. This creates a plume of water at the discharge location that has elevated water temperature above the ambient seawater.

Heated effluent has been regulated at onshore and inland powerplants under Section 316(a) of the Clean Water Act since the 1970s due to its effect on aquatic organisms. In coastal areas, heated effluent has shown to alter sea turtle movements (Crear et al. 2016) and growth rates (Eguchi et al. 2012). No information is available on the effect of heated effluent on marine mammals other than manatee, which are known to be found near powerplant discharges. Manatees are not found in the AoA.

4.7.4 Decommissioning

Water quality effects during decommissioning would be similar to the construction phase (see section 4.7.2). Vessels would be required for the deconstruction of the OSW farm, which presents a risk of accidental chemical or waste contamination (Kaldellis et al. 2016). Deconstruction of structures could also present a risk of inadvertent releases of oils or other chemicals. Actions that disrupt the seabed (e.g., fixed foundation or buried cable removal) would resuspend sediments and potentially affect water quality. Effects to marine mammals and sea turtles due to inadvertent releases or suspended sediments is discussed in section 4.7.1.

4.8 Changes to Atmospheric and Oceanic Conditions

The emergence of wide-spread OSW farm clusters has potential to result in structural changes of atmospheric and oceanic conditions (Daewel et al. 2022). A physical-biogeochemical modeling study completed by Daewel et al. (2022) suggested that increasing the amount of OSW farms may substantially impact and restructure the marine ecosystem of the southern and central North Sea by changing atmospheric conditions and stratification intensities and patterns, slowing down circulation and decreasing bottom shear stress. The model showed that energy extracted from the lower atmosphere (i.e., reduced wind forces) may result in reduced water column mixing, leading to a mixed layer higher (elevated) in the water column than previously observed. OSW farm clusters wind wake effects may cause local changes in net primary productivity of up to 10% and decrease in organic sediment resuspension through the water column due to reduced shear stress, and locations of benthic hypoxia if depressional areas are not sufficiently circulated.

Closer to shore, changes in wind and wave patterns can result in altered upwelling dynamics (Raghukumar et al. 2023). Water brought to the surface by upwelling is typically colder, nutrient rich, and biologically productive (Kämpf and Chapman 2016; NOAA 2023c). The effects of OSW farms on upwelling have not been well studied; however, modeling completed by Raghukumar et al. (2023) suggests that wind speed changes may result in reduced upwelling on the inshore side of a wind farm, and increased upwelling on the offshore side. These potential changes could cause considerable changes in the spatial distribution of highly productive areas.

The changes to surface waves, vertical mixing and stratification, upwelling, and sediment dynamics may result in cascading effects to the biological (carbon) processes (Farr et al. 2021). Alterations to the spatial distribution of primary production can disrupt zooplankton and fish aggregations, which could further affect marine animals dependent on these sources for food, including sea turtles and marine mammals. In addition to changes in primary productivity, a study by Dodge et al. (2018) indicated that sea turtle position in the water column is strongly related to jellyfish distribution, which is driven by stratification dynamics. If vertical mixing and stratification are altered, this could redistribute jellyfish congregations and attract sea turtle predators.

4.9 Electromagnetic Fields

EMFs are a type of low-frequency electromagnetic radiation generated from natural and anthropogenic sources, such as the Earth’s geomagnetic field, thunderstorms, power cables, and electronics (SEER 2022b). In the context of OSW, the major source of EMFs is from power export cables carrying electricity to shore (Copping et al. 2020). Electric field emissions into the surrounding environment can be mitigated by shielding and grounding cables; however, magnetic fields cannot be eliminated through cable design. EMFs are strongest immediately adjacent to the cable and decreases with distance from the cable; nevertheless, the strength of EMFs can depend on the type of cable used. Several marine species groups are known to be sensitive to electric and/or magnetic fields, such as elasmobranchs (skates, rays, and sharks), crustaceans, teleost (bony) fish, and sea turtles (Farr et al. 2021). These species use natural EMFs to support essential life functions such as locating predators or prey and migration. Responses to EMF are species-dependent and may include avoidance of or attraction to the EMF source (Copping et al. 2020). Some laboratory studies have examined the interactions between benthic fish and invertebrates, but there is limited empirical data regarding the interactions of pelagic species such as marine mammals and sea turtles with EMFs (Copping et al. 2020). The probability of a marine animal encountering an EMF source depends on factors such as animal movement patterns and habitat use (Copping et al. 2020). Therefore, effects to marine mammals and sea turtles from EMFs are likely limited due to the pelagic nature of these species and high mobility (Morandi et al. 2018).

4.10 Artificial Lighting

Artificial light at night (ALAN) is a widespread and expanding form of pollution, particularly in coastal regions where light is sufficient to cause changes in biological responses of animals in adjacent habitats such as altering migration patterns (Marangoni et al. 2022). Lights in pelagic environments, such as from oil and gas platforms or ships, may cause attraction or avoidance responses depending on the taxa and life stage. For example, certain species of fish are known to be attracted to or avoid lights, and ichthyoplankton diel vertical migrations have also been shown to be interrupted in the presence of continuous lights (Marangoni et al. 2022). Effects of ALAN on pelagic marine mammals or sea turtles (as opposed to coastal and beach juvenile and adult turtles) is not well studied (Orr et al. 2013).

Lights on temporary structures during construction, or on permanent wind farm structures (both, fixed-foundation OSW turbines or floating OSW turbines) are required by law for safe navigation; however, effects of long-term, flashing lights atop wind turbines is unknown. More literature is available regarding the effects of artificial lighting on fish, invertebrates, and zooplankton. Impacts to these taxa include changes in vertical and lateral movements (i.e., fish attracted to lighting sources, zooplankton not exhibiting diel vertical migration), which can alter local community composition and abundances. As discussed in section 4.8, changes to these sources of productivity can have a cascading affect to predators relying on these organisms, including sea turtles and marine mammals. Overall, artificial lighting at night needs to be studied with respect to the pelagic environment.

5 Existing Guidance for Avoiding, Minimizing, and Mitigating Impacts

This section summarizes a literature review of the best practices for avoiding, minimizing, and mitigating impacts from a variety of sources and consultations. Guidelines summarized from regulatory guidance documents are subject to change over time, and new guidance or regulations may also arise after publication of this study. This section focuses on guidance published since the Master Plan in 2017 (NYSERDA 2017). This study does not intend to propose changes to existing guidance or to develop new guidance.

Section 6 of the Master Plan summarizes potential guidelines and best management practices (BMPs) from a variety of sources, which are provided in appendix C (Table C-1). The Master Plan also provides specific mitigation measures for the NARW described in agreements between OSW developers and NGOs for site characterization and assessment activities (Grybowski et al. [2012 and 2014], as cited in NYSERDA 2017).

In addition to general best practices, BOEM consults with NMFS under the ESA for species under NMFS jurisdiction that may be affected by OSW development. These species include the NARW, Blue, Fin, Sperm, and Sei whales as well as sea turtles. During these project-specific consultations, NMFS proposes measures to avoid, minimize, and mitigate impacts to marine mammals and sea turtles that are specific to each project, in addition to reinforcing measures that are general best practices. For example, NMFS has issued ESA Section 7 Consultation Biological Opinions for the Vineyard Wind Project (2021), South Fork Wind Project (2021), and Ocean Wind 1 Project (2023). NMFS provides reasonable and prudent measures, terms and conditions, and conservation recommendations in these consultation documents. Best practices and project-specific avoidance, minimization, and mitigation measures are also proposed by NMFS during the Incidental Take Authorizations process under the MMPA required for OSW activities that may result in take of marine mammals (e.g., HRG surveys, impact pile driving).

The following sections and appendix C summarize best practices for avoiding, minimizing, and mitigating impacts to marine mammals and sea turtles, divided by project phases (general best practices, pre-construction, construction, post-construction, and decommissioning) and stressors described in section 6 of this report. Much of the guidance specific to benthic resources and fisheries also provide benefits to marine mammals and sea turtles, but are not discussed here (e.g., best practices related to bottom disturbance, artificial lighting, reduced water quality, scouring around seafloor structures, EMF, and changes to atmospheric/oceanographic dynamics). See the Benthic Habitat Study (NYSERDA, 2025) and Fish and Fisheries Data Aggregation Study (NYSERDA, 2025) for a summary of those approaches to impact avoidance and minimization.

Some best practices span across all project phases of development or include recommendations for long-term and/or regional monitoring. These general best practices are summarized in appendix C, Table C-2. As described in section 6, stressors associated with pre-construction activities include noise-generating surveys, bottom-disturbing surveys, vessel traffic, and UXO detonation. Table C-3 in appendix C summarizes best practices to reduce impacts to marine mammals and sea turtles from these stressors. Stressors associated with construction activities include construction noise, vessel traffic, bottom disturbance, artificial lighting, and reduced water quality. Table C-4 in appendix C summarizes best practices to reduce impacts to marine mammals and sea turtles from these stressors. Guidelines and best practices related to vessel traffic are covered in appendix C, Table C-3 and are the same for construction as pre-construction. Guidelines and best practices related to bottom disturbance, artificial lighting, and reduced water quality are discussed in the Benthic Habitat Study and Fish and Fisheries Data Aggregation Study (NYSERDA, 2025) and would also provide benefits to marine mammals and sea turtles. Stressors associated with post-construction activities include noise-generating surveys, bottom-disturbing surveys, scouring around seafloor structures, new in-water structures, EMF, vessel traffic, artificial lighting, changes to atmospheric and oceanographic dynamics, and reduced water quality. Table C-5 in appendix C summarizes best practices to reduce impacts to marine mammals and sea turtles from these stressors.

Guidelines and best practices related to vessel traffic, noise-generating surveys, bottom-disturbing surveys are covered in Table C-3 in appendix C and are the same for post-construction as pre-construction. Guidelines and best practices related to scouring around seafloor structures, artificial lighting, EMF, reduced water quality, and changes to atmospheric and oceanographic dynamics are discussed in the Benthic Habitat Study and Fish and Fisheries Data Aggregation Study (NYSERDA, 2025) and would also provide benefits to marine mammals and sea turtles.

Stressors associated with decommissioning activities include construction noise, vessel traffic, reduced water quality, and artificial lighting. Best practices for the decommissioning phase will generally follow those outlined above. However, certain activities and best practices are not relevant to decommissioning, such as impact pile driving or possible mooring entanglement from floating turbines. It is anticipated that additional or revised guidance and best practices will have been published at the time projects are decommissioned (30+ years). It is also expected that ESA and MMPA consultations will be re-opened at the time of each project decommissioning.

5.1 Summary of Changes Since the Master Plan

Since the Master Plan was released in 2017, there have been several additional guidance documents and recommendations published by federal and state agencies, as well as NGOs. Some of the guidance and best practices proposed in the Master Plan have been revised, refined, or have become obsolete, which are shaded in appendix C, Table C-1. In addition, measures for activities related to wind development in deep water (floating wind technology) were not reviewed or included in the Master Plan but are summarized here.

On August 1, 2022, NOAA published the proposed rule amending the North Atlantic Right Whale Vessel Strike Reduction Rule (50 CFR § 224.105). The proposed rule (87 FR 46921) would: (1) modify the spatial and temporal boundaries of current speed restriction areas referred to as Seasonal Management Areas (SMAs), (2) include most vessels greater than or equal to 35 ft (10.7 m) and less than 65 ft (19.8 m) in length in the size class subject to speed restriction, (3) create a dynamic speed zone framework to implement mandatory speed restrictions when whales are known to be present outside active SMAs, and (4) update the speed rule's safety deviation provision. Changes to the speed regulations are proposed to reduce vessel strike risk based on a coast-wide collision mortality risk assessment and updated information on right whale distribution, vessel traffic patterns, and vessel strike mortality and serious injury events. Changes to the existing vessel speed regulation are essential to stabilize the ongoing right whale population decline and prevent the species' extinction. NOAA is currently reviewing public comments on the proposed rule.

In addition, while used in European countries as a best practice to avoid impacts to marine mammals, NMFS generally does not recommend "pinger" or "seal scarers" as a means to displace marine mammals from areas of high noise levels associated with OSW development. Instead, soft starts or ramp ups are generally recommended by NMFS and BOEM. However, guidelines for deterrence of marine mammals, largely related to fisheries, is outlined in NMFS's proposed rule on the guidelines for safely deterring marine mammals (August 31, 2020; 85 FR 53763).

In the context of floating wind technology, some existing approaches to impact avoidance and minimization may be challenging to implement in the deepwater environment. For example, increased depth may make anchoring construction and monitoring vessels difficult or impossible, which may make permit compliance challenging in cases where vessel spacing and at-sea vessel monitoring configurations are specified in MMPA and ESA permits. Increased water depth may also complicate deployment and retrieval of any bottom-mounted PAM sensors needed for purposes of construction mitigation, sound field verification, and long-term PAM. Likewise, increased distance from shore will likely increase vessel transit times, potentially increasing the likelihood of ship strikes as a consequence. Longer transit times and longer hours on the water may also increase the number of protected species observers (PSOs) required for a given activity, since existing guidelines typically restrict PSO shifts to four hours or less.

5.2 Monitoring and Mitigation Technologies

Key technologies for at-sea marine mammal and sea turtle monitoring and mitigation include underwater PAM and visual monitoring tools such as high-powered ("big-eye") binoculars, infra-red (IR) cameras, night-vision devices (NVDs), laser range finders, data collection software, and informational tools. PAM has a number of applications for long-term monitoring of marine mammals, as well as for real-time mitigation during construction activities (Van Parijs et al. 2021). PAM sensors (hydrophones) may be mounted to the seafloor, towed behind a vessel, or attached to uncrewed vehicles such as autonomous underwater vehicles or autonomous surface vehicles. Long-term PAM across seasons and years in a given location, such as a wind farm area, is generally best accomplished using fixed, bottom-mounted sensors. Mobile sensors are well suited to real-time mitigation and shorter-term PAM for ecological monitoring. PAM has the advantage of being non-invasive and can detect the presence and distribution of marine mammals in poor conditions when visual monitoring is not possible and is also an important source of information for cryptic marine mammal species that are difficult to detect visually even in favorable conditions. One disadvantage of PAM is that marine mammals will only be detected when they are vocalizing (Van Parijs et al. 2021). Likewise, PAM is not generally informative about group size of vocalizing animals. PAM is not useful for detecting sea turtles, as they are not known to use sound to communicate with conspecifics and find prey, as marine mammals do.

Combining PAM and visual monitoring techniques typically provides the most complete information about marine mammals, both during ecological monitoring and real-time mitigation for construction and vessel strike avoidance (Baille and Zitterbart 2022). While visual monitoring can be accomplished fairly effectively using traditional methods (unaided eye, binoculars) in good visibility conditions and calm sea states, visual detection of marine mammals in fog, rain, and low light conditions requires the use of alternative monitoring technologies such as IR cameras and NVDs (Verfuss et al. 2018, 2019). Substantial advancements have been made in IR camera technologies in recent years, and some systems have considerable detection ranges even in darkness. IR cameras have been proven effective for detecting (endothermic) marine mammals at sea due to their bodies' heat signature. IR cameras are not effective for detecting (ectothermic) sea turtles at sea as their heat signature is less easily distinguished. NVDs are somewhat effective in detecting marine mammals and sea turtles at night and in low-light conditions, but their ranges tend to be relatively short and therefore not useful for covering large areas of ocean, which is often necessary during at-sea construction and aboard transiting vessels for purposes of strike avoidance. The potential for using IR imaging to detect marine mammals in low-visibility conditions is limited (Verfuss et al. 2018). IR and NVDs are not very effective in weather with precipitation (Smith et al. 2020).

6 Uncertainties, Knowledge Gaps and Future Considerations

6.1 Uncertainties and Knowledge Gaps

The commitment by BOEM to deploy 30 gigawatts (GW) of OSW energy by the year 2030 and 15 GW of floating OSW capacity by 2035 has triggered rapid succession of OSW energy development in U.S. waters. As of early 2023, there existed two demonstration-scale projects operating in federal and state U.S. waters (offshore Virginia and Rhode Island), and two utility-scale projects in federal waters approved by BOEM (offshore Massachusetts and Rhode Island). With recent OSW energy auctions, over two dozen lease areas are planned for the Atlantic. This rapid advancement has led BOEM to prepare its first draft Programmatic Environmental Impact Statement (PEIS) for the six proposed lease areas in the New York Bight. A focused, regional cumulative analysis is part of this PEIS and will likely be central to future regional planning processes. To address cumulative impacts, The Vineyard Wind Final Environmental Impact Statement assessed “impacts that could result from the incremental impact of the Proposed Action and action alternatives when combined with past, present, or reasonably foreseeable activities, including other future offshore wind activities” (BOEM 2021b). The cumulative effects of development come with a high level of uncertainty generated from incomplete information in the past, present, and future. Uncertainty is defined as lack of confidence in results often due to missing data and unreliable information, low sample sizes, or high variability (Walker et al. 2003; Masden et al. 2015).

Another type of uncertainty in this study arises from the habitat-based density models used to assess marine mammal distribution in section 4.2.1. Due to the nature of these models, which use available sightings, effort, and environmental data to predict animal distribution and abundance in areas that have not been surveyed, there is typically some level of uncertainty associated with model parameters and environmental covariates. The 95% and 5% CI, the CV, and SE grids are provided for each modeled species and species guild as supporting statistical measures of model uncertainty.[40]

A key source of uncertainty in this and any other assessment of risk associated with OSW development is the role of climate change. Both marine mammals and sea turtles are vulnerable to the oceanographic and atmospheric shifts associated with climate change, which, depending on the species, can affect reproductive rates, body condition, distribution and habitat use, access to prey and prey selection, predation risk, exposure to human activities, and frequency of disease (Patel et al. 2021; Gulland et al.

2022). Such changes are already being documented in a number of marine mammal species that occur in the AoA, including NARWs, Humpback whales, Blue whales, Fin whales, Minke whales, and Pilot whales (Gulland et al. 2022). Climate change contributes to uncertainty in OSW impact assessment in several ways. Distributional shifts in marine mammals and sea turtles make spatially explicit environmental risk assessments a moving target, and analyses of marine mammal and sea turtle density and distribution such as the one presented here may be outdated by the time OSW farms in the AoA are sited, built, and operational. Additionally, any studies of the effects of OSW development on marine mammals and sea turtles may be confounded by the effects of climate change. For example, long-term monitoring programs are currently being required of OSW developers in the U.S. by federal and state agencies, which involve collecting data before, during, and after construction. The assumption is that these data will provide information specific to impacts from OSW development, but many of the metrics measured such as animal distribution, density, habitat use, and population health, may also be affected by climate change in ways that are difficult to parse. Even semi-controlled experimental designs such as the Before-After Control-Impact approach, which relies on the use of control sites to measure changes in the area of interest, may not be conclusive because the impacts of climate change in the marine environment are not uniform and may affect experimental and control sites in different ways. In order to gather useful data informing OSW impact assessments, these issues must be carefully considered prior to implementing any long-term data collection efforts.

6.1.1 Marine Mammal Knowledge Gaps

The habitat-based density models used in this analysis to predict marine mammal distribution, density, and seasonal occurrence in the AoA have, with a few exceptions, spatial coverage throughout the EEZ. These models predict where marine mammals are likely to occur when survey effort is low or does not exist for a geographical area or species. These predictions are achieved by using environmental covariates correlated with known marine mammal habitat (Roberts et al. 2023). The majority of marine mammal species and guilds modeled by Roberts et al. have density predictions in all three zones of the AoA. An exception is the harbor porpoise, which lacks data coverage in Zone 3 at some times of the year (December–May). In other cases, predicted density for a species or species guild in a given zone of the AoA was zero, but this does not necessarily indicate a data gap (i.e., a zero value does not indicate a lack of data). The density models for individual species and guilds contain detailed information about the level of uncertainty associated with model parameters (Roberts et al. 2023). That said, generally speaking, the more empirical survey data that are available for a given species or guild in a given area and season, the lower the uncertainty associated with those model predictions will be.

In terms of temporal resolution, certain marine mammal species modeled by Roberts et al. (2023) have only annual density estimates versus monthly estimates. In some cases, this is due to low numbers of sightings for species that are relatively rare in the region, such as Blue whales. In other cases, sighting records may be limited because of an animal's behavior, such as deep-diving and cryptic marine mammals that surface relatively infrequently (e.g., Dwarf and pygmy sperm whales, northern bottlenose whales, and Cuvier's beaked whales) or due to their size, such as small-bodied cetaceans that are difficult to detect visually in high sea state conditions (e.g., harbor porpoise). Some of the density models lack resolution to species and are modeled as a guild. This is the case with Pilot whales, since the two species that make up this guild (long- and short-finned Pilot whales) can be difficult to distinguish in the field.

Aside from information about animal distribution, important species-specific data gaps do exist for marine mammals in the context of OSW development. For example, there is no empirical data on the hearing range of baleen whales, as this species group is difficult to study in captivity. Hearing ranges are extrapolated from the frequencies at which baleen whales are known to communicate and predicted based on inner ear morphology. Behavioral reactions of baleen whales to impact pile driving are also largely unknown, as most of the studies performed at existing wind farms are in Northern Europe, where baleen whales do not regularly occur.

Other key stressors associated with OSW development are not well understood in the context of their effects on marine mammals that occur in the AoA, including the potential effects of heated effluent from offshore HVDC power conversion stations (for OSW farms that utilize these), effects (if any) from interactions with EMFs from undersea and suspended in-water electrical cables; potential effects of artificial light at night in the marine environment; the effects of OSW decommissioning activities, and the potential effects of in-water structures to affect mixing of the water column and associated potential changes in upwelling, primary productivity, and hypoxic/anoxic conditions in the benthos. The latter may affect the distribution and availability of marine mammal prey. Another key knowledge gap is the level of operational noise that will be generated by the commercial-scale OSW farms currently planned for U.S. waters. Most of the available information about operational noise and its impacts on marine life comes from older wind farms, such as those in Northern Europe, which are comprised of smaller turbines than those planned for use in the U.S. For example, the newly developed 12+ MW GE Haliade-X turbines reach up to 260 m (over two football fields) in height and have a blade diameter of 220 m. The environmental effects of these turbines are not fully understood, particularly when built to scale in commercial windfarms that may comprise 100+ turbines, such as those being planned in the Mid-Atlantic region. Operational noise falls in the low-frequency range and would be audible to baleen whales.

6.1.2 Sea Turtle Knowledge Gaps

Until recently, the only sea turtle density models available for U.S. east coast waters were developed in 2007 and are therefore outdated (Department of the Navy 2007). In July 2023, these models were updated to incorporate recent survey data for all four sea turtle species that occur in the AoA, with spatial coverage throughout the EEZ (DiMatteo et al. 2024). This update filled an important regional data gap identified by other study efforts (e.g., Bonacci-Sullivan 2018). Similar to marine mammals, these models predict the distribution, density, and seasonal occurrence of sea turtles in the AoA throughout the EEZ. The sea turtle modeling approach correlated local distribution and abundance observed on systematic line transect surveys with environmental conditions observed at that same location and time, and density was estimated in areas that were not surveyed and times using extrapolation. Therefore, no clear spatial data gaps emerged from the analysis. Likewise, monthly density estimates were available for all four sea turtle species, which represent the monthly mean for each spatial grid cell averaged across multiple years. Estimates of the CV for each model were calculated, as were CIs for monthly and annual abundance estimates (Sparks and DiMatteo 2023); see section 2.4.2. However, other major sources of uncertainty are not addressed in the current version of the models, including detection function uncertainty, uncertainty in the underlying environment, dive variability, and assignment of unclassified sightings, although this is being prioritized for future iterations of the models (DiMatteo et al. 2024). We also note that, at the time of writing, the peer-reviewed publication associated with these models were not available and were therefore not reviewed for this study.

One important data gap in the context of this study is the lack of knowledge of the distribution and habitat use of different age classes of sea turtles, that is, post-hatchling versus non-hatching turtles. It was suggested by the PAC that different age classes of hardshell versus Leatherback Sea Turtles may have different vulnerabilities to various OSW stressors, such as bottom disturbance, entanglement, and in-water structures. To the extent that these stressors vary for fixed and floating wind, it is important to understand the spatial distribution by age class within species in order to fully assess risks to sea turtles in deepwater versus shelf regions. The models used to predict sea turtle distribution in this study did not have age class information, so it was not possible to perform a spatial risk assessment for the three sea turtle receptor groups identified in section 3.1.1: Post-hatchling dispersal stage (all sea turtle species); non-hatchling Loggerhead, Kemp's Ridley; and Green Sea Turtles, and non-hatchling Leatherback Sea Turtles.

Aside from questions of species distribution, there are numerous gaps in our knowledge of sea turtles in the context of OSW development. Although sea turtles are known to perceive sounds in the low-frequency hearing range, more research is needed to understand the biological significance of these findings and better understand how sea turtles perceive and respond to sound in their environment. Like baleen whales, most OSW environmental studies to date have been performed in Northern Europe, where sea turtles do not occur. Therefore, there is little direct evidence of the effects of any phase of OSW development, using either fixed or floating technology, on this species group.

Specific data gaps identified in this study include the lack of information about the effects (if any) from sea turtle interactions with EMFs from undersea and suspended in-water electrical cables; potential effects on sea turtles of artificial light at night in the marine environment; the effects of OSW decommissioning activities on sea turtles; and the potential effects of in-water structures to affect mixing of the water column and associated potential changes in upwelling, primary productivity, and hypoxic/anoxic conditions in the benthos. The latter may affect the distribution and availability of sea turtle prey. As mentioned above, another key knowledge gap is the level of operational noise that will be generated by the commercial-scale OSW farms currently planned for U.S. waters, which will utilize larger turbines than most existing wind farms. The operational noise from these turbines falls into the low-frequency range and would be audible to sea turtles.

6.2 Future Considerations

The following recommendations are proposed to help address the data gaps and uncertainties identified in this analysis, and minimize overall impacts of OSW development on marine mammals and sea turtles in the AoA:

- Prioritizing seasonal surveys for marine mammals and sea turtles in the AoA, particularly visual surveys that use established line-transect and distance sampling methods (Buckland et al. 2001). Data from these surveys are used to model marine species density and distribution in the AoA and throughout the EEZ and are regarded by NMFS as the best available information for this purpose. Ongoing distributional shifts of marine mammals, sea turtles, and their prey, due to climate change and other factors, necessitate regular updates to these models to ensure they are accurate and informative, particularly in offshore areas that may be under-surveyed due to logistical considerations.
- To complement these visual surveys, telemetry (tagging) studies of marine mammals and sea turtles are recommended. These studies can provide information about animal movements, use of marine habitats, behavioral responses, and foraging behavior. Tagging studies are also useful to fill in data gaps for species not easily detected during traditional vessel-based and aerial surveys. Examples are cryptic, deep-diving marine mammals, seals, and sea turtles.
- Observing seasonal restrictions on OSW farm construction in shelf habitats to minimize impacts on NARW.
- Maintaining awareness that areas inshore of the AoA—even though not the focus of this analysis—are important habitat for marine mammals (including NARW) and sea turtles. These areas will necessarily be subject to environmental stressors associated with OSW development, such as export cable emplacement, landfall works, and increased vessel traffic.
- Protecting marine mammals and sea turtles in deep water by preventing accumulation of marine debris on floating turbine tether cables. Such debris (e.g., ghost fishing gear) should be removed from tether cables on a regular basis in order to reduce the likelihood of secondary and tertiary entanglement of marine mammals and sea turtles.
- Establishing long-term monitoring programs to help assess the environmental impacts of fixed and floating OSW development in the AoA. These programs should be developed in the context of regional science initiatives, such as the Regional Wildlife Science Collaborative, in order to maximize the utility of data collected and avoid "silo-ing" of information specific to individual OSW projects. Before-during-after survey design should be thought out carefully before any monitoring efforts are initiated in order to minimize confounding factors from climate change and make conclusions as robust as possible. Any marine mammal/sea turtle monitoring program that also includes collection of oceanographic data would improve our understanding.
- Recognizing that BMPs evolve with iterative OSW projects and as new information becomes available. BMPs are also driven by the permitting process and may change with updated agency guidelines.
- Data being collected at fixed and floating OSW farms currently under construction should be widely shared, including information regarding animal sightings and acoustic detections, effective detection ranges, observed behavioral responses, and underwater noise levels generated during construction, operations, and decommissioning activities.

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Appendix A. Data Sources

Table A-1. Data Sources Reviewed for this Study

Category	Name	Description	Why using it?	How data will be used?	Resource Type	Resource
Bureau of Ocean Energy Management (BOEM)	**Whale Detection Buoy Accuracy**	Baumgartner et al. 2020, 2021. Evaluating the Accuracy and Detection Range of a Moored Whale Detection Buoy near the Massachusetts Wind Energy Area.	To show how species are using the Area of Analysis (AoA). Identifies TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Species distribution and seasonal occurrence.	Non-Spatial/Report	https://espis.boem.gov/final%20reports/BOEM_2019-061.pdf
BOEM	**Endangered Species Act (ESA) Consultations (NMFS)**	BOEM. 2018. Data Collection and Site Survey Activities for Renewable Energy on the Atlantic Outer Continental Shelf.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA.	Species diversity, abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report	https://www.boem.gov/renewable-energy/state-activities/nmfs-esa-consultations
BOEM	**Whale and Sea Turtle Risk Assessment**	BOEMs Risk Assessment to Model Encounter Rates Between Large Whales and Sea Turtles and Vessel Traffic from Offshore Wind Energy on the Atlantic OCS (Barkaszi et al. 2021; Malhorta et al. 2021).	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA.	Species abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report	https://tethys.pnnl.gov/publications/risk-assessment-model-encounter-rates-between-large-whales-sea-turtles-vessel-traffic
BOEM	**New York Bight Wind Lease Site Assessment**	BOEM. 2021. Commercial and Research Wind Lease and Grant Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf of the New York Bight - Draft Environmental Assessment.	To show how species are using the AoA. Identifies TES present and where concentrated in AoA.	Species diversity, abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report	https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/NY-Bight-Draft-EA-2021.pdf
BOEM	**North Atlantic Right Whale Offshore Wind**	BOEM. 2022. Protecting North Atlantic Right Whales During Offshore Wind Energy Development.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA.	Species abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report Portal	https://www.boem.gov/environment/protecting-north-atlantic-right-whales-during-offshore-wind-energy-development
BOEM	**ESA Consultations (NMFS)**	BOEM. 2023. Empire Offshore Wind: Empire Wind Project.	To show how species are using the AoA. Identifies TES present and where concentrated in AoA.	Species diversity, abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report Portal	https://www.boem.gov/renewable-energy/state-activities/nmfs-esa-consultations
BOEM	**ESA Consultations (FWS)**	BOEM. 2023. FWS ESA consultations. Bureau of Ocean Energy Management. US Department of Interior.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA.	Species diversity, distribution, habitat use.	Non-Spatial/Report Portal	https://www.boem.gov/renewable-energy/state-activities/fws-esa-consultations
BOEM	**Protected Species Surveys**	BOEM. 2023. Protected Species Observer reports from Offshore Wind Farm Site Characterization Surveys.	To show how species are using the AoA. Identifies TES present and where concentrated in AoA or how using AOA (time of year or life stage).	Species diversity, abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report	https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/App-N-Protected-Species-Observer-Report-2.pdf

Table A-1 continued

Category	Name	Description	Why using it?	How data will be used?	Resource Type	Resource
BOEM	**Whale and Sea Turtle Pelagic Survey**	Kraus et al. 2016; Stone et al. 2017; Leiter et al. 2017; Estabrook et al. 2022. Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA.	Species diversity, abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report	https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Renewable-Energy/Northeast-Large-Pelagic-Survey-Collaborative-Aerial-and-Acoustic-Surveys-for-Large-Whales-and-Sea-Turtles.pdf
BOEM	**Megafauna Aerial Surveys**	Quintana et al. 2019; Quintana-Rizzo et al. 2021; O'Brien et al. 2021a, 2021b, 2022. Megafauna Aerial Surveys in the Wind Energy Areas of Massachusetts and Rhode Island with Emphasis on Large Whales.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA.	Species diversity, abundance and distribution, seasonal occurrence, habitat use.	Spatial/Various Sighting Reports	https://espis.boem.gov/Final%20reports/BOEM_2021-054.pdf
BOEM	**RODEO**	Realtime Opportunity for Development Environmental Observations (RODEO).			Non-Spatial/Report Portal	https://www.boem.gov/rodeo
Duke University	**MDAT Data**	Curtice et al. 2019. Duke University Marine-life Data and Analysis Team (MDAT) Marine-life data.	Identifies TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Species densities, diversity, distribution, and seasonal occurrence.	Spatial/Several Layers	https://seamap.env.duke.edu/models/mdat/
Duke University	**Sea Turtle Models**	Kot et al. 2023. Duke University / State of the World's Sea Turtles Models in OBIS-SEAMAP.	Identifies TES present and where concentrated in AOA or how using AoA (time of year or life stage).	Species densities, diversity, distribution, and seasonal occurrence.	Spatial/Several Layers	https://seamap.env.duke.edu/swot
Duke University	**Marine Mammal Density Models**	Roberts et al. 2015, 2016, 2018, 2022, 2023; Roberts and Halpin 2022. Duke University /Habitat-based Marine Mammal Density Models for the U.S. Atlantic.	Identifies TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Species densities, diversity, distribution, and seasonal occurrence.	Spatial/Several Layers	https://seamap.env.duke.edu/models/Duke/EC/
Misc. Marine Mammals Surveys	**Aerial Survey of Marine Wildlife – Offshore Wind**	Normandeau Associates, Inc. and APEM, Inc. 2021a, 2021b. Digital Aerial Baseline Survey of Marine Wildlife in Support of Offshore Wind Energy Taxonomic Analysis Summary Reports.	To show how species are using the AoA. Identifies TES present and where concentrated in AoA.	Compiling species list, species diversity, abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report	https://remote.normandeau.com/aer_docs.php?pj=6
Misc. Marine Mammals surveys	**Marine Mammals Survey**	Rhode Island Natural History Survey Marine Mammals of Rhode Island (Kenney et al. 2020, 2022)	To show how species are using the AoA.	Species diversity, presence, and habitat use.	Non-Spatial/Report	https://rinhs.org/category/animals/
Misc. Marine Mammals Surveys	**Acoustic Monitoring of Marine Mammals**	Woods Hole Oceanographic Institution (WHOI) and Wildlife Conservation Society Autonomous Real-time Marine Mammal Detections Moored Buoys and Gliders Ecosystem and Passive Acoustic Monitoring (ECO-PAM) (Johnson et al. 2022; Murray et al. 2022; WHOI 2023)	To show how species are using the AoA. Identifies TES present and where concentrated in AoA.	Species distribution, and seasonal occurrence.	Spatial/Monitoring Points	http://dcs.whoi.edu/

Table A-1 continued

Category	Name	Description	Why using it?	How data will be used?	Resource Type	Resource
NOAA	**North Atlantic Right Whale**	Gatzke et al. 2017; Khan et al. 2018. North Atlantic Right Whale Sighting Surveys (NARWSS) aerial surveys from New Jersey to Canada.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA.	Species abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report	https://www.researchgate.net/publication/298761422_North_Atlantic_Right_Whale_Sighting_Survey_NARWSS_and_Right_Whale_Sighting_Advisory_System_RWSAS_2014_Results_Summary
NOAA	**Marine Mammal Stock Assessments**	Hayes et al. 2023. NOAA Fisheries U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA.	Compiling species list, species diversity, distribution, seasonal occurrence, and habitat use.	Non-Spatial/Report	https://media.fisheries.noaa.gov/2023-08/Final-Atlantic-and-Gulf-of-Mexico-SAR.pdf
NOAA	**Animal Telemetry Network**	Animal Telemetry Network.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA.	Species distribution, seasonal occurrence, habitat use.	Spatial/Animal Tracking Portal	https://ioos.noaa.gov/project/atn/
NYS DEC	**Large whale Acoustic Survey**	Estabrook et al. 2019, 2020, 2021. Passive Acoustic Survey. Cornell University and JASCO, Cetacean Studies using Passive Acoustic Monitoring (PAM).	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA.	Species distribution, seasonal occurrence, and habitat use.	Spatial/Various Sighting Reports	https://www.dec.ny.gov/lands/113828.html
NYS DEC	**Sea Turtle Monitoring**	Monitoring Survey for Sea Turtles in the New York Bight. New York State Department of Environmental Conservation.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Species diversity, abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report	https://www.dec.ny.gov/animals/112355.html
NYS DEC	**Large Whale Monitoring Survey**	New York State Department of Environmental Conservation (NYDEC) Monitoring Survey for Large Whales in the New York Bight.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Species diversity, abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report	https://www.dec.state.ny.us/lands/113647.html
NYS DEC	**Large Whale Aerial Survey**	Tetra Tech and SES 2018; Tech and LGL 2019, 2020; Zoidis et al. 2021; Lomac-MacNair et al. 2022. New York Bight Whale Monitoring Aerial Surveys 2017-2020.	To show how species are using the AoA. Identifies unique habitat Identifies TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Species diversity, abundance and distribution, seasonal occurrence, habitat use.	Spatial/Various Sighting Reports	https://www.dec.ny.gov/lands/113818.html
NMFS	**Marine Mammal and Turtle Abundance/Spatial Distribution**	NEFSC and SEFSC 2020, 2021, 2022; Palka 2020; Palka et al. 2021. AMAPPS II and III -- Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US waters of the Western North Atlantic Ocean.	To show how species are using the AoA. Identifies TES present and where concentrated in AoA.	Species abundance and distribution, seasonal occurrence.	Spatial/Various Sighting Reports	https://www.fisheries.noaa.gov/resource/publication-database/atlantic-marine-assessment-program-protected-species-annual-reports

Table A-1 continued

Category	Name	Description	Why using it?	How data will be used?	Resource Type	Resource
NYSERDA	**2017 Offshore Wind Master Plan**	NYSERDA. 2017. New York State Offshore Wind Master Plan: Marine Mammals and Sea Turtles Study. Ecology and Environment Engineering, P.C., Report 17-25.	To show how species are using the AoA. Identifies unique habitat Identifies potential use conflicts Identifies TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Compiling species list, species diversity, abundance and distribution, seasonal occurrence, habitat use.	Non-Spatial/Report	New York State Offshore Wind Master Plan: Marine Mammals and Sea Turtles Study | Tethys (pnnl.gov)
NYSERDA	**NYSERDA E-TWG**	New York State Environmental Technical Working Group (NYSERDA E-TWG) (Atlantic Shores Offshore Wind, Shell New Energy, Equinor Wind US, Ørsted, Avangrid, and Vineyard Wind).	To show how species are using the AoA.	Compiling species list and species diversity.	Non-Spatial/Report	New York Environmental Technical Working Group (nyetwg.com)
Data Portals	**ADEON Data**	Atlantic Deepwater Ecosystem Observatory Network (ADEON) data portal.	To show how species are using the AoA. Identifies TES present and where concentrated in AoA.	Species abundance and distribution, seasonal occurrence.	Spatial/Various Sighting Reports	https://adeon.unh.edu/data_portal
Data Portals	**MARCO Data**	MARCO. 2023. Mid-Atlantic Regional Council on the Ocean.	To show how species are using the AoA. Identifies TES present and where concentrated in AoA.	Species abundance and distribution, seasonal occurrence.	Spatial/GIS Portal	https://portal.midatlanticocean.org/visualize/#
Data Portals	**Movebank**	Movebank 2023	To show how species are using the AoA. Identifies TES present and where concentrated in AoA.	Species abundance and distribution, seasonal occurrence.	Spatial/Animal Tracking Portal	https://www.movebank.org/cms/movebank-main
Data Portals	**NROC Data**	NROC. 2023. Northeast Regional Ocean Council.	To show how species are using the AoA. Identifies TES present and where concentrated in AoA.	Species abundance and distribution, seasonal occurrence.	Spatial/GIS Portal	https://northeastoceandata.org/data-explorer/
Data Portals	**NYOPD Data**	Geographic Information Gateway.	Identifies TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Species densities, distribution, and seasonal occurrence.	Spatial/Office of Planning & Development GIS Portal	http://opdgig.dos.ny.gov/#/search/browse
Seal Surveys	**Harbor and Gray Seal Surveys**	Harbor and Gray Seal Surveys in New York. Atlantic marine conservation society.	To show how species are using the AoA Identifies unique habitat.	Species abundance and distribution, seasonal occurrence.	Non-Spatial/Report	https://www.amseas.org/harbor-gray-seal-surveys
Seal Surveys	**Seal Walks And Cruises**	The Coastal Research and Education Society of Long Island Seal Walks and Cruises	To show how species are using the AoA. Identifies unique habitat.	Species abundance and distribution, seasonal occurrence.	Non-Spatial/Report	https://www.cresli.org/common/news/articles/article_detail.cfm?QID=11251&clientID=12000&topicID=0&subsection=sidebar
U.S. Navy	**Marine Mammal Tagging**	Ampela et al. 2021, 2023. Seal Tagging and Tracking in Virginia.	To show how species are using the AoA.	Species abundance and distribution.	Spatial/Various Sighting Reports	
U.S. Navy	**Marine Mammal Tagging**	Engelhaupt et al. 2017, 2018, 2019, 2020, 2021, 2022, 2023. VACAPES Outer Continental Shelf Cetacean Study. Naval Fisheries Engineering Command. Virginia Beach, Virginia.	To show how species are using the AoA. Identifies TES present and where concentrated in AOA or how using AoA (time of year or life stage).	Species abundance and distribution.	Spatial/Various Sighting Reports	https://www.navymarinespeciesmonitoring.us/files/5415/8698/1777/Engelhaupt_et_al._2020_-_VACAPES_OCS_2019.pdf

Table A-1 continued

Category	Name	Description	Why using it?	How data will be used?	Resource Type	Resource
U.S. Navy	**Marine Species Density**	Roberts et al. 2020, 2021. U.S. Navy Marine Species Density Database Phase III for the Atlantic Fleet Training and Testing Study Area.	Identifies TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Species densities, distribution, and seasonal occurrence.	Spatial/GIS Portal	https://goaeis.com/portals/goaeis/files/eis/draft_seis_2020/supporting_technical/GOA_Marine_Species_Density_Technical_Report_Amended_Nov_2021.pdf
Other Whale Surveys	**Marine Mammal Detection Buoy and Acoustic Monitoring**	Murray et al. 2022; WHOI 2023. Woods Hole Oceanographic Institution (WHOI) and Wildlife Conservation Society Autonomous Real-time Marine Mammal Detections Moored Buoys and Gliders Ecosystem and Passive Acoustic Monitoring (ECO-PAM).	Identifies TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Species distribution, and seasonal occurrence.	Spatial/Monitoring Points	http://dcs.whoi.edu/
Other Whale Surveys	**NY Harbor Monitoring Project**	Muirhead et al. 2018; WCS 2021; Chou et al. 2022; Trabue et al. 2022; King et al. 2021; Zeh et al. 2021; Rosenbaum et al. 2021; Alter et al. 2022; Rekdahl et al. 2023. Wildlife Conservation Society (WCS) New York Harbor Monitoring Project.	To show how species are using the AoA. Identifies unique habitat TES present and where concentrated in AoA or how using AoA (time of year or life stage).	Species abundance and distribution, seasonal occurrence, habitat use.	Spatial/Various Sighting Reports	https://whalesofnewyork.wcs.org/New-York-Harbor-Acoustics

A.1. Appendix A References

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Appendix B. Density Model Inputs

B.1 Data Sources Used in Marine Mammal Habitat-Based Density Models[41]

B.1.1 Aerial Surveys

- Southeast Fisheries Science Center (SEFSC) Southeast Cetacean Aerial Survey (SECAS) 1992–1995.
- Northeast Fisheries Science Center (NEFSC) Pre-AMAPPS Aerial Surveys 1995–2008.
- SEFSC Mid-Atlantic Tursiops Surveys (MATS) 1995–2005.
- University of North Carolina at Wilmington (UNCW) MidA Bottlenose Onshore/Offshore Surveys for Bottlenose Dolphins 2002–2002.
- NEFSC North Atlantic Right Whale Sighting Survey (NARWSS) Aerial Surveys 2003–2020.
- Fish and Wildlife Research Institute (FWRI) North Atlantic Right Whale Early Warning System (NARW EWS) 2003–2020.
- New England Aquarium (NEAq) NARW EWS 2003–2010.
- Wildlife Trust/Sea to Shore Alliance/Clearwater Marine Aquarium Research Institute Aerial Surveys NARW EWS (Skymaster) 2003–2020.
- UNCW Southeast United States (SEUS) NARW EWS Right Whale Aerial Surveys 2005–2008.
- UNCW Onslow Navy Monitoring Aerial Surveys 2007–2011.
- New Jersey Department of Environmental Protection (NJDEP) Ecological Baseline Study (EBS) Aerial Surveys 2008–2009.
- UNCW Jacksonville Navy Monitoring Aerial Surveys 2009–2017.
- NEFSC and SEFSC AMAPPS Aerial Surveys 2010–2020.
- NEAq Northeast Large Pelagic Survey Collaborative Aerial Surveys 2011–2015.
- UNCW Cape Hatteras Navy Monitoring Aerial Surveys 2011–2017.
- Virginia Aquarium & Marine Science Center (VAMSC) Virginia Coastal Zone Management (CZM) Wind Energy Areas (WEA) Aerial Surveys 2012–2015.
- VAMSC Maryland Department of Natural Resources (MD DNR) WEA Surveys Aerial Surveys 2013–2015.
- UNCW Norfolk Canyon Navy Monitoring Aerial Surveys 2015–2017.
- VAMSC Navy Monitoring: Virginia Capes (VACAPES) 2016–2017.
- New York State Department of Environmental Conservation (NYSDEC) New York Bight Whale Monitoring (NYBWM) Aerial Surveys 2017–2020.
- NEAq Marine Mammal Surveys of the Wind Energy Areas (MMS-WEA) 2017–2020.
- NEAq Northeast Canyons Marine National Monument Aerial Surveys 2017–2020.
- HDR Navy Monitoring Aerial Surveys: Norfolk Canyon 2018–2019.

B.1.2 Shipboard Surveys

- SEFSC Pre-AMAPSS Shipboard Surveys 1992–2006.
- NEFSC Pre-AMAPSS Shipboard Surveys 1995–2007.
- Wildlife Trust/Sea to Shore Alliance/Clearwater Marine Aquarium Research Institute Aerial Surveys NARW EWS (Twin Otter) 2003/04–2018/19.
- NJDEP EBS Shipboard Surveys 2008–2009.
- NEFSC and SEFSC AMAPSS Shipboard Surveys 2011–2016.
- Marine Conservation Research (MCR) Song of the Whale Surveys (SOTW) Visual Shipboard Surveys 2012–2019.
- MCR SOTW Acoustical Shipboard Surveys 2019–2019.

Table B-1 lists the publications documenting each survey program that was used in the density analysis.

Table B-1. Publications Documenting the Survey Programs Used in the Marine Mammal Density Analysis*

Organization	Program	Publications
FWRI	NARW EWS	Gowan and Ortega-Ortiz 2014
MCR	R/V SOTW Surveys	Ryan et al. 2013
NEAq	NARW EWS	Gowan and Ortega-Ortiz 2014
	NLPSC	Leiter et al. 2017; Stone et al. 2017
	MMS-WEA	Quintana-Rizzo et al. 2021; O'Brien et al. 2022
	CNM	Redfern et al. 2021
NEFSC	Pre-AMAPPS	Mullin and Fulling 2003; Palka 2006; Garrison et al. 2010
	AMAPPS	Palka et al. 2017, 2021
	NARWSS	Cole et al. 2007
NJDEP	EBS	Geo-Marine 2010; Whitt et al. 2015
NYSDEC	NYBWM	Zoidis et al. 2021
SEFSC	MATS	None available
	Pre-AMAPPS (shipboard)	Mullin and Fulling 2003; Palka 2006; Garrison et al. 2010
	AMAPPS	Palka et al. 2017, 2021
	SECAS	Blaylock and Hoggard 1994
UNCW	Aerial Surveys of the Navy's Cape Hatteras Study Area	McLellan et al. 2018
	MidA Bottlenose	Torres et al. 2005
	Aerial Surveys of the Navy's Jacksonville Study Area	Foley et al. 2019
	Aerial Surveys of the Navy's Norfolk Canyon Study Area	McAlarney et al. 2018; Cotter 2019
	Aerial Surveys of the Navy's Onslow Bay Study Area	Read et al. 2014
	Right Whale Surveys	Torres et al. 2005
VAMSC	MD DNR WEA	Barco et al. 2015
	VA CZM	Mallette et al. 2014, 2015
	Aerial Survey Baseline Monitoring in the Continental Shelf Region of the VACAPES OPAREA	Mallette et al. 2017
WLT/SSA/CMARI	NARW EWS (both aircraft)	Gowan and Ortega-Ortiz 2014

Table notes are on the next page.

Key: AMAPPS = Atlantic Marine Assessment Program for Protected Species; CNM = Northeast Canyons Marine National Monument Aerial Surveys; EBS = Ecological Baseline Study; FWRI = Fish and Wildlife Research Institute; MATS = Mid-Atlantic Tursiops Survey; MCR = Marine Conservation Research; MD DNR = Maryland Department of Natural Resources; MMS-WEA = Marine Mammal Surveys of the Wind Energy Areas; NARW EWS = North Atlantic Right Whale Early Warning System; NARWSS = North Atlantic Right Whale Sighting Surveys; NEAq = New England Aquarium; NEFSC = Northeast Fisheries Science Center; NJDEP = New Jersey Department of Environmental Protection; NLPSC = Northeast Large Pelagic Survey Collaborative; NYBWM = New York Bight Whale Monitoring; NYSDEC = New York State Department of Environmental Conservation; SECAS = Southeast Cetacean Aerial Survey; SEFSC = Southeast Fisheries Science Center; SOTW = Song of the Whale; UNCW = University of North Carolina Wilmington; VA CZM = Virginia Coastal Zone Management; VACAPES = Virgnia Capes; VAMSC = Virginia Aquarium & Marine Science Center; WEA = Wind Energy Areas; WLT/SSA/CMARI = Wildlife Trust/Sea to Shore Alliance/Clearwater Marine Aquarium Research Institute.

* Source: Roberts et al. 2023.

B.2 Data Sources Used for Sea Turtle Density Analysis

Table B-2. Survey Programs Used in the Sea Turtle Density Analysis*

Survey Provider	Program	Platform	Effort (km)	Years	Months
SEFSC	AMAPPS	Boat	16,892	2011, 2013, 2016	June–September
NEFSC	AMAPPS	Boat	16,522	2011, 2013, 2014, 2016	March–April, June–August
NEFSC	Pre-AMAPPS	Boat	4,011	2004, 2007	June–August
SEFSC	AMAPPS	Plane	110,876	2010–2019	January–December
SEFSC	MATS	Plane	13,505	2004–2005	January–March, July–August
NEFSC	AMAPPS	Plane	90,564	2010–2012, 2014–2019	January–December
NEFSC	Pre-AMAPPS	Plane	34,558	2004, 2006–2008	June–August
NEFSC	NARWSS	Plane	471,722	2003–2017	January-December
HDR Inc.	Navy Marine Species Monitoring Program	Plane	6,374	2018	April–August, October–December
NEAq	NLPSC	Plane	43,309	2011–2015	January–December
TT-NYSDEC	NYBWM	Plane	57,303	2017–2018	January–December
UNCW	Navy OPAREA Surveys (VACAPES, Cherry Point and Jacksonville)	Plane	195,497	2009–2017	January–December
UNCW	Right Whale Surveys	Plane	114,646	2005–2008	January–June, October–December
VAMSC	Miscellaneous in the Mid-Atlantic	Plane	56,942	2010, 2012–2017	January–December

Key: AMAPPS = Atlantic Marine Assessment Program for Protected Species; MATS = Mid-Atlantic Tursiops Survey; NARWSS = North Atlantic Right Whale Sighting Surveys; NEAq = New England Aquarium; NEFSC = Northeast Fisheries Science Center; NYBWM = New York Bight Whale Monitoring; NYSDEC = New York State Department of Environmental Conservation; SEFSC = Southeast Fisheries Science Center; UNCW = University of North Carolina Wilmington; VACAPES = Virgnia Capes; VAMSC = Virginia Aquarium & Marine Science Center.

* Source: Sparks and DiMatteo 2023.

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Appendix C. Summary of Potential Guidelines for Avoiding, Minimizing, and Mitigating Impacts Related to General Project Activities

Table C-1. Summary of Potential Guidelines and BMPs from the Master Plan

Receptor (Species/Group)	Potential Guideline/BMP	References
Stressor: Increased Vessel Presence/Change in Types of Vessels Present in AoA **Risks: Vessel-collision, displacement**		
All cetacean receptor groups[a], seals, and sea turtles	Vessel operators and crews keep vigilant watch for all marine mammals and sea turtles.	NOAA 2008 (Vessel Strike Avoidance Measures); BOEM 2014a; NOAA GARFO n.d. (GARFO Section 7 Guidance)
All cetacean receptor groups[a], seals, and sea turtles	Train vessel crews in protected species identification, laws, regulations, vessel collision information, and behavior and distribution information	NOAA 2008
All cetacean receptor groups[a], seals, and sea turtles	Establish designated traffic lanes for construction, maintenance, and decommissioning vessels.	DOI MMS 2009
All cetacean receptor groups[a], seals, and sea turtles	Keep vessel traffic to a minimum during construction and decommissioning.	DOI MMS 2009
All cetacean receptor groups[a], seals, and sea turtles	Year-round, the vessel maintains a predetermined minimum separation distance to all other marine mammals and sea turtles.	NOAA 2008; BOEM 2014a
All cetacean receptor groups[a], seals, and sea turtles	Establish seasonal restrictions for construction schedules when appropriate.	USACE 2014; NOAA GARFO n.d.
All cetacean receptor groups[a], seals, and sea turtles	Speed limits for vessels	NYSERDA 2015; NOAA GARFO n.d.
All cetacean receptor groups[a], seals, and sea turtles	Minimize changes in vessel traffic where at-risk species are likely to occur in area	NOAA GARFO n.d.
All cetacean receptor groups[a]	Vessel operators and crew familiarize themselves with NOAA's regional viewing guidelines and ways to minimize encounters with cetaceans.	DOI MMS 2009
Shallow-diving cetaceans	If small cetaceans are sighted (e.g., bow riding) attempt to remain parallel to animals' course and avoid excessive speed or abrupt changes in direction.	NOAA 2008
Endangered cetaceans	Year-round, when ESA-listed whales are sighted, vessels maintain a predetermined minimum separation distance.	NOAA 2008; BOEM 2014a

Table C-1 continued

Receptor (Species/Group)	Potential Guideline/BMP	References
Endangered cetaceans	If an ESA-listed whale is observed in the path of the vessel, the operator reduces speed and shifts engines to neutral.	NOAA 2008; BOEM 2014a
North Atlantic Right Whale	Maintain a distance of 500 m away from NARW[b]	50 CFR § 224.103 (c)(1)(i)
North Atlantic Right Whale	If within 500 m of a right whale and underway, avoid the whale and immediately leave the area at a slow safe speed[b]	50 CFR § 224.103 (c)(2)(i)
North Atlantic Right Whale	Vessels 65 ft or larger are restricted to traveling at 10 knots or less in the period of November 1 to April 30 each year in SMAs, including Ports of New York/New Jersey[b]	50 CFR § 224.105
Stressor: Noise Risks: Physical injury, displacement, behavior alteration		
All cetacean receptor groups[a], seals, and sea turtles	Establish a predetermined exclusion and monitoring zone radius around acoustically active project components[c]	DOI MMS 2009; USACE 2014; NYSERDA 2015; Carduner 2017; Morin 2017; BOEM 2017
All cetacean receptor groups[a], seals, and sea turtles	A third party Protected Species Observer monitors the exclusion zone for a designated length of time prior and subsequent to each pile-driving event, and during the entirety of the pile-driving activity.	USACE 2014; NYSERDA 2015
All cetacean receptor groups[a], seals, and sea turtles	Under safe conditions, apply ramp up/soft-start procedures for noise-producing equipment used in pile driving.	USACE 2014; NOAA GARFO n.d.; Carduner 2017
All cetacean receptor groups[a], seals, and sea turtles	Pile-driving start avoided during periods of low visibility (i.e., during fog conditions or at night).	JNCC 2010; NYSERDA 2015
All cetacean receptor groups[a], seals, and sea turtles	Establish seasonal restrictions for construction schedules when appropriate.	USACE 2014; NYSERDA 2015; NOAA GARFO n.d.
All cetacean receptor groups[a], seals, and sea turtles	Use noise reduction technologies during pile driving to reduce the sound levels in water.	Lucke et al. 2011; NYSERDA 2015; NOAA GARFO n.d.; Carduner 2017; Philipp 2017; Dähne et al. 2017
All cetacean receptor groups[a], seals, and sea turtles	Limit amount of time spent pile driving in a 24-hour period.	NOAA GARFO n.d.
All cetacean receptor groups[a], seals, and sea turtles	Adequate zone of passage maintained throughout action area.	NOAA GARFO n.d.
All cetacean receptor groups[a], seals, and sea turtles	Noise remains below relevant species thresholds.	NOAA GARFO n.d.
All cetacean receptor groups[a], seals, and sea turtles	Geographic and/or seasonal restrictions to limit exposure and reduce behavioral harassment.	Carduner 2017

Table C-1 continued

Receptor (Species/Group)	Potential Guideline/BMP	References
All cetacean receptor groups[a], seals, and sea turtles	Displace animals from areas of high noise levels by means of soft start or deterrence devices, i.e., Pinger, Seal Scarer.	Philipp 2017
All cetacean receptor groups[a]	Conduct passive acoustic monitoring baseline study for ambient noise and cetacean vocalizations during pre-construction surveys to assist in siting.	Kraus et al. 2016; BOEM 2017; Van Parijs 2017
All cetacean receptor groups[a]	Designate passive acoustic monitoring operators during the piling process to assist in detecting cetaceans in the area.	JNCC 2010; NYSERDA 2015
North Atlantic Right Whale	Prohibition on pile driving (MET tower) in the period of November 1 to April 30	Morin 2017; BOEM 2017
North Atlantic Right Whale	All sub-bottom profiling and pile driving stops within 24 hours of Dynamic Management Area establishment.	Morin 2017; BOEM 2017
Sea turtles	To the extent practicable, restrict human activities that could seriously affect sea turtles, especially during the periods of reproduction, nesting, and migration.	IAC 2001
Stressor: Permanent Structures in the Water Risks: Displacement, Avoidance		
All cetacean receptor groups[a], seals, and sea turtles.	Careful siting to avoid biological hotspots and areas that might displace animals into shipping lanes.	NYSERDA 2015
All cetacean receptor groups[a], seals, and sea turtles.	Structures do not create any impairment of normal behaviors or block passage.	NOAA GARFO n.d.

[a] Cetacean receptor groups include high-, mid-, and low-frequency, shallow- and deep-diving, and endangered cetaceans (Table 4).

[b] This BMP represents a published federal regulation and must be followed as written.

[c] Permits often require exclusion and monitoring zones. Any mitigation included as a permit condition becomes a requirement rather than a voluntary BMP.

Note: gray shading denotes a recommendation or best practice that has changed since the Master Plan was published.

TableC-2. Summary of Potential Guidance for Avoiding, Minimizing, and Mitigating Impacts Guidelines Related to General Project Activities

Receptor (Species/Group)	Potential Guideline	References
Funding		
All cetacean receptor groups, seals, and sea turtles.	Commitment to provide funding to develop and deploy technologies to help ensure heightened protections for NARWs and other marine mammals as the U.S. offshore wind industry continues to grow.	Vineyard Wind 2019
Long-term or regional monitoring		
All cetacean receptor groups, seals, and sea turtles.	Conduct a coordinated effort to monitor ambient noise in regional areas.	MMO 2014; WSDOT 2015
North Atlantic Right Whale	Ensure all environmental reviews are informed by robust baseline data on the use of the project area by NARWs, to include at least 3 years of baseline data. Implement continued monitoring during the construction period and for at least 3 years post-construction to assess impact of the project on NARWs and their habitat. Establish long-term monitoring for the duration of construction and operations to evaluate the potential impacts on key components of the ecosystem (e.g., NARWs and their prey). Conduct monitoring using rigorous scientific designs with the intent of measuring the impact of OSW development on NARWs, their habitat and habitat use, and the effectiveness of measures.	BOEM and NOAA 2022; CLF et al. 2019
All cetacean receptor groups, seals, and sea turtles.	Conduct acoustic monitoring of construction and of operational noise and substrate vibrations with the goal of developing a robust database of construction and operational noise to inform the development of mitigation measures.	BOEM and NOAA 2022
All cetacean receptor groups, seals, and sea turtles.	Conduct monitoring for changes to fishing operations and displacement of fishing effort into other areas. Monitor changes in fishing activity to detect changes in bycatch or entanglement rates of protected species, particularly NARWs.	BOEM and NOAA 2022
All cetacean receptor groups, seals, and sea turtles.	Long-term pre- and post-construction monitoring (for both marine mammals and sea turtles) is required to understand potential displacement effects, and whether any observed changes are a result of climate change, offshore wind development, or other factors. This information would also improve impact assessments and help advise monitoring and mitigation strategies.	NRDC et al. 2023
All cetacean receptor groups.	Conduct continuous archival PAM in and around lease areas to collect baseline information on the presence, distribution, and seasonality of NARWs (and other sound-producing marine animals) and to establish noise levels before and during construction and operation. Additionally, use both archival and real-time PAM to collect baseline information on the presence, distribution, and seasonality of NARWs in transit routes and to minimize risk of vessel strike of transiting vessels. Plans should follow recommendations in Van Parijs et al. (2021), which suggests a minimum of 3 to 5 years of monitoring using continuous PAM archival recorders immediately prior to construction.	BOEM and NOAA 2022; Van Parijs et al. 2021

Table C-2 continued

Receptor (Species/Group)	Potential Guideline	References
All cetacean receptor groups.	Coordinate a regional PAM approach (in addition to project-specific PAM) that follows the recommendations in Van Parijs et al. (2021) and considers adequate array/hydrophone design, equipment, and data evaluation to understand changes over spatial scales relevant to NARWs for the duration of the projects, as well as the storage and dissemination of these data.	BOEM and NOAA 2022; Van Parijs et al. 2021
All cetacean receptor groups.	Project-specific PAM Plans, developed by project proponents and approved by Federal agencies, should include descriptions of equipment, procedures (deployment, retrieval, detection, and analyses), ISO data quality standards and protocols that will be used for monitoring and mitigation. In the U.S., PAM specifications for inclusion in a PAM Plan will need to be developed in consultation with NOAA and other permitting agencies, such as BOEM. To design a PAM Plan, the following six topics need to be included and addressed: species of interest, PAM system types, PAM recording technologies, PAM study design, PAM system requirements, and PAM data archiving and reporting.	Van Parijs et al. 2021; NMFS 2023; 88 FR 22696
All cetacean receptor groups.	Development of a NYB (and ultimately regional) PAM network with standardized data collection and reporting standards and with the potential for real-time sensors to inform best-practices and mitigation, so that long-term, broad-scale questions could be answered and provide information necessary for species protection in the region.	WCS 2021
Data review and sharing		
All cetacean receptor groups, seals, and sea turtles.	Prompt analysis and publication of results of survey monitoring and mitigation programs. Ensure that analysis is completed promptly, and results published to inform future risk assessments and mitigation and monitoring actions.	Broker et al. 2015; Nowacek et al. 2013
North Atlantic right whale	Report right whale data in a timely manner and make publicly available.	BOEM and NOAA 2022; CLF et al. 2019
All cetacean receptor groups.	Local and/or regional PAM data standards and a shared data repository are key aspects and would provide a foundation for collaboration across both local and regional projects	WCS 2021
Adaptive management		
All cetacean receptor groups, seals, and sea turtles.	A commitment to considering other mitigation approaches aimed at overall species protection.	Vineyard Wind et al. 2019; BOEM and BSEE 2012a
All cetacean receptor groups, seals, and sea turtles.	Consider changes in habitat use by protected species. Site characterizations or assessments may need to be updated or evaluated. Consider the entire range of a population when evaluating geographic differences in impacts. For example, harbor porpoises are considered a northern species, but their geographic range is quite broad and occurs as far south as North Carolina.	BOEM 2018
All cetacean receptor groups, seals, and sea turtles.	Develop and implement plans for research and monitoring to address new and emerging issues and technology in a scientifically rigorous and systematic way. Include requirements that OSW infrastructure (e.g., turbine foundations, submarine cables, substations, and other equipment) be instrumented to meet project and regional monitoring objectives.	BOEM and NOAA 2022

Table C-2 continued

Receptor (Species/Group)	Potential Guideline	References
All cetacean receptor groups, seals, and sea turtles.	Monitor to implement mitigation and identify the effectiveness of mitigation measures.	BOEM and NOAA 2022
All cetacean receptor groups, seals, and sea turtles.	Understanding the location and extent of large whale foraging areas, including multi-species aggregations that may also involve birds, dolphins, fish and how they overlap with wind development areas will enable detection of changes in habitat use/ foraging behavior during and post-construction	NRDC et al. 2023
Other general best practices		
All cetacean receptor groups, seals, and sea turtles.	Exclusion zones should focus on areas where large whales are more persistent rather than moving through	BOEM 2018
All cetacean receptor groups, seals, and sea turtles.	BOEM guidelines for providing information on marine mammals and sea turtles–while not specific to minimizing or mitigating impacts to marine mammals during project activities, a solid understanding of species occurrence in each project area is important to categorize impacts and determine appropriate measures to reduce impacts.	BOEM 2019
North Atlantic Right Whale	Prior to and when conducting any in-water construction activities and vessel operations, the lessee (e.g., vessel operators, PSOs) must use available sources of information on NARW presence in or near the project area including daily monitoring of the Right Whale Sightings Advisory System, and monitoring of Coast Guard VHF Channel 16 throughout the day to receive notification of any sightings and/or information associated with any Slow Zones (i.e., Dynamic Management Areas (DMAs) and/or acoustically-triggered slow zones) to provide situational awareness for both vessel operators and PSOs.	NMFS 2023; 88 FR 22696; BOEM 2023; 87 FR 64868
North Atlantic Right Whale	Any large whale sighted by a PSO or acoustically detected by a PAM operator that cannot be identified as a non-NARW must be treated as if it were a NARW.	NMFS 2023; 88 FR 22696; BOEM 2023; 87 FR 64868

Table C-3. Summary of Potential Guidelines for Avoiding, Minimizing, and Mitigating Impacts Related to Pre-Construction Activities

Receptor (Species/Group)	Potential Guideline	References
General Pre-Construction		
All cetacean receptor groups, seals, and sea turtles.	The Lessee must ensure that monthly reporting of survey activities is submitted to BOEM by the PSO provider on the 15th of each month for each vessel conducting survey work.	BOEM 2021
All cetacean receptor groups.	Conduct passive acoustic monitoring baseline study for ambient noise and cetacean vocalizations during preconstruction surveys to assist in siting.	Bailey et al. 2014; BOEM 2017; Kraus et al. 2016; Van Parijs 2017; BOEM 2016b; BOEM 2018
All cetacean receptor groups, seals, and sea turtles.	Collect baseline environmental and biological data prior to survey activity. In situ measurements of the biological environment with sufficient characterization of sources of natural variability Key parameters include ecosystem features and their influence on spatial and temporal variability in density, distribution, and behavior of key species.	Nowacek et al. 2013; Broker et al. 2015; Cerchio et al. 2010; BOEM 2018
All cetacean receptor groups, seals, and sea turtles.	Evaluate risks of proposed development actions and alternatives. Conduct a quantitative risk assessment based on information from the baseline assessment and the sound propagation modeling, including extrapolation and/or models derived from other species/areas if required. This should be precautionary but practical in the potential impacts formally assessed.	Nowacek et al. 2013; NOAA OPR 2018
All cetacean receptor groups, seals, and sea turtles.	Throughout all survey operations, vessel operators will monitor the NMFS NARW reporting systems for the establishment of a DMA. If NMFS should establish a DMA in the area under survey, the vessels will abide by speed restrictions in the DMA per the lease condition.	Bay State Wind 2018; Deepwater Wind 2017; Dominion Energy 2018; DONG Energy 2017; Skipjack Windfarm 2018; ION 2017; USDOC and NOAA 2018a
All cetacean receptor groups, seals, and sea turtles.	Conduct multiple years of successive baseline monitoring before construction to determine spatial distribution and temporal variability of marine mammals and sea turtles, as well as the area's ecological importance by means of aircraft and ship transect surveys.	BSH 2008; BSH 2014; DONG Energy 2013; DONG Energy and Vattenfall 2005; Macleod et al. 2011; Tetra Tech and Smultea Sciences 2018
All cetacean receptor groups, seals, and sea turtles.	Evaluate effectiveness of monitoring program for surveys. Determine if monitoring results were sufficient to adequately address mitigation measures and identify any residual risk to species of concern.	Broker et al. 2015; Nowacek et al. 2013
North Atlantic Right Whale	Developers should evaluate multiple project design options such as the type, number, size (physical dimensions and power output), location, and orientation of wind turbines and offshore substations, with a focus on identifying design options that avoid and minimize impacts to NARWs and their habitat within and with adjacent projects; tradeoffs for other resources need to be evaluated during project planning.	BOEM and NOAA 2022

Table C-3 Continued

Receptor (Species/Group)	Potential Guideline	References
Stressor: Noise-Generating Surveys **Risk: Physical injury, displacement, behavior alteration**		
All cetacean receptor groups, seals, and sea turtles.	Evaluate effectiveness of mitigation measures for seismic surveys. Evaluation of monitoring result to determine if mitigation measures as implemented were adequate to meet agreed objective in the mitigation actions.	Broker et al. 2015; Nowacek et al. 2013
All cetacean receptor groups, seals, and sea turtles.	Implement mitigation and monitoring for surveys. Systems must be in place in the field to ensure that agreed mitigation measures and agreed monitoring actions are correctly and effectively implements in a timely manner. Written protocol, based on anticipated scenarios, must be understood, and practiced ahead of time by all involved parties. Clear chains of command and communication are essential as is honest assessment of the value and limitation of all observing systems.	Broker et al. 2015; Nowacek et al. 2013; SEIC 2010
All cetacean receptor groups, seals, and sea turtles.	During night operations, night-vision equipment and infrared technology will be used to monitor shutdown zones.	DONG Energy 2017; Johnson 2009
All cetacean receptor groups, seals, and sea turtles.	Establish a predetermined exclusion/clearance and monitoring zone and/or shut-down zone radius around acoustically active project components.	Ainslie and von Benda-Beckmann 2012; Alaska LNG 2016; Alaska LNG 2018; Andersson et al. 2017; AOCSR 2017; Bailey et al. 2014; Bay State Wind 2018; BOEM 2017; BOEM 2016a; BOEM 2016b; BOEM 2016c; BOEM and BSEE 2012b; CTJV 2018; Deepwater Wind 2017; Deepwater Wind 2018; DOI MMS 2009; Dominion Energy 2018; BOEM 2021; NMFS 2023; 87 FR 64868; 88 FR 22696; BOEM 2023
All cetacean receptor groups, seals, and sea turtles.	Under safe conditions, apply ramp-up/soft-start procedures for noise-producing equipment used in HRG and/or G & G equipment used in surveys.	Ainslie and von Benda-Beckmann 2012; Alaska LNG 2016; Alaska LNG 2018; Andersson et al. 2017; AOCSR 2017; Bay State Wind 2018; BOEM 2016b; BOEM 2016c; BOEM 2017; BOEM and BSEE 2012b; BSH 2014; CTJV 2018; Danish Maritime Authority 2015; Deepwater Wind 2017; Deepwater Wind 2018; Dominion Energy 2018; WSDOT 2019; BOEM 2021; CLF et al. 2019; NMFS 2023; 87 FR 64868; 88 FR 22696

Table C-3 continued

Receptor (Species/Group)	Potential Guideline	References
All cetacean receptor groups, seals, and sea turtles.	A third party and/or qualified PSO monitors the exclusion zone and/or shut-down zone for a designated length of time prior and subsequent to each acoustically active event, and during the entirety of the acoustically active event.	Ainslie and von Benda-Beckmann 2012; Alaska LNG 2016; Alaska LNG 2018; AOCSR 2017; Bay State Wind 2018; BOEM 2016b; BOEM 2016c; BOEM and BSEE 2012b; CTJV 2018; Danish Maritime Authority 2015; Deepwater Wind 2017; Deepwater Wind 2018; Dominion Energy 2018; DONG Energy 2017; Skipjack Windfarm 2018; BOEM 2021; BOEM and NOAA 2022; CLF et al. 2019; NMFS 2023; 87 FR 64868; 88 FR 22696
All cetacean receptor groups, seals, and sea turtles.	If a marine mammal is sighted during vessel-based surveys by a PSO and there is potential for it to enter the Level A zone (based on position and motion relative to the vessel actions), the PSO will direct the vessel operator to alter vessel speed or direction.	Alaska LNG 2016; AOCSR 2017; Deepwater Wind 2017; NMFS 2023; 87 FR 64868; 88 FR 22696
All cetacean receptor groups, seals, and sea turtles.	While no surveying at night is the default, most developers have developed an alternative monitoring plan. Evaluating these plans and PSO reports may help BOEM develop standardized mitigation measures for night operations so that developers do not have to submit alternative monitoring plans for each survey. Standardizing these requirements would help developers conduct work at night. In order for geophysical surveys to be conducted at night or during low-visibility conditions, PSOs must be able to effectively monitor the Clearance and Shutdown Zone(s). No surveys may occur if the Clearance and Shutdown Zone(s) cannot be reliably monitored for the presence of ESA-listed species.	BOEM 2018; BOEM 2021
All cetacean receptor groups.	For alternative monitoring plans, BOEM has required passive acoustic monitoring (PAM) (towed) and visual monitoring (cameras, night vision, etc.). BOEM may want to consider expanding accepted PAM methods to include gliders, buoys, etc.	BOEM 2018
All cetacean receptor groups, seals, and sea turtles.	Data sharing between developers to find the best technology to use.	BOEM 2018
ESA-listed species	For situational awareness, a Monitoring Zone (500 m in all directions) for ESA-listed species must be monitored around all vessels operating boomer, sparkers, or bubble gun equipment.	BOEM 2021
ESA-listed species; unidentified whales.	To minimize exposure to noise that could be disturbing, a 500 m Shutdown Zone for NARWs and unidentified whales, and a 100 m Shutdown Zone for all other ESA-listed whales visible at the surface must be established around each vessel operating boomer, sparker, or bubble gun equipment.	BOEM 2021

Table C-3 continued

Receptor (Species/Group)	Potential Guideline	References
Non-ESA-listed marine mammals.	For non-ESA-listed marine mammals, the Lessee must comply with NMFS permit conditions of any applicable Incidental Take Authorization (ITA) received under the MMPA. If an ITA is not required, the Lessee must adhere to the measures outlined by BOEM (2021; BMP 4.3) for non-ESA-listed marine mammals for which incidental take has not been authorized.	BOEM 2021; NMFS 2023
All cetacean receptor groups, seals, and sea turtles.	Before any noise-producing survey equipment is deployed, the Monitoring Zones (500 m for all ESA-listed species and 200 m for non-ESA-listed marine mammals) must be monitored for 30 minutes of pre-clearance observation. If any protected species is observed within the respective Monitoring Zone during the 30-minute pre-clearance period, the 30-minute clock must be paused. If the PSO confirms the animal has exited the zone and headed away from the survey vessel, the 30-minute clock that was paused may resume. The pre-clearance clock will reset to 30 minutes if the animal dives or visual contact is otherwise lost.	BOEM 2021
All cetacean receptor groups, seals, and sea turtles.	A “ramp up” of the boomer, sparker, or bubble gun survey equipment must occur at the start or re-start of geophysical survey activities when technically feasible. A ramp up must begin with the power for the geophysical survey ramped up half power for 5 minutes, and then to full power.	BOEM 2021; CLF et al. 2019
All cetacean receptor groups, seals, and sea turtles.	At times when multiple survey vessels using boomer, sparker, or bubble gun categories of equipment are operating within a lease, adjacent lease areas, or exploratory cable routes, a minimum separation distance must be maintained between survey vessels to ensure that sound sources do not overlap.	BOEM 2021
All cetacean receptor groups, seals, and sea turtles.	Any visual observations of listed species by crew or project personnel must be communicated to PSOs on-duty.	BOEM 2021; NMFS 2023; 87 FR 64868; 88 FR 22696
All cetacean receptor groups, seals, and sea turtles.	During good conditions (e.g., daylight hours; Beaufort scale 3 or less) when survey equipment is not operating, to the maximum extent practicable, PSOs must conduct observations for listed species for comparison of sighting rates and behavior with and without use of active geophysical survey equipment. Any observed listed species must be recorded regardless of any mitigation actions required.	BOEM 2021
North Atlantic Right Whale	Do not use airguns and avoid unnecessary use of acoustic sources below 180kHz, specifically boomers and sparkers. Where boomers and sparkers cannot be avoided, implement project design criteria and best management practices such as those outlined in NOAA Fisheries ESA programmatic consultation (issued June 2021, as amended September 2021) (or any updated versions of this document or similar guidance issued by the agencies) for all geophysical and geotechnical surveys carried out over the life of the leases. Examples include use of lowest practicable sound source levels.	BOEM and NOAA 2022

Table C-3 continued

Receptor (Species/Group)	Potential Guideline	References
All cetacean receptor groups, seals, and sea turtles.	Deactivate acoustic source when not acquiring data or preparing to acquire data, except as necessary for testing.	BOEM and NOAA 2022; NMFS 2023; 87 FR 64868; 88 FR 22696
North Atlantic right whale; unidentified large whales.	Any large whale sighted by a PSO within 1 km of the boomer, sparker, or Compressed High-Intensity Radiated Pulse (CHIRP) that cannot be identified as a non-NARW must be treated as if it were a NARW.	NMFS 2023; 87 FR 64868; 88 FR 22696
Stressor: Bottom-Disturbing Surveys **Risk: Physical injury, behavior alteration**		
ESA-listed Species	The Lessee must ensure any mooring systems used during survey activities must be designed to prevent potential entanglement or entrainment of listed species, and in the unlikely event that entanglement does occur, ensure proper reporting of entanglement events according to the measures specified below.	BOEM 2021
All cetacean receptor groups, seals.	For fisheries monitoring trawl surveys, marine mammal monitoring must occur prior to, during, and after haul-back, and gear must not be deployed if a marine mammal is observed in the area. Trawl operations must only start after 15 minutes of no marine mammal sightings within 1 nm of the sampling station. During daytime sampling for the research trawl surveys, the lessee must maintain visual monitoring efforts during the entire period of time that trawl gear is in the water from deployment to retrieval. If a marine mammal is sighted before the gear is removed from the water, the vessel must slow its speed and steer away from the observed animal(s).	NMFS 2023; 87 FR 64868; 88 FR 22696
All cetacean receptor groups, seals.	Baited remote underwater video (BRUV) sampling and chevron trap usage, for example, would utilize specific mitigation measures to reduce impacts to marine mammals. These specifically include the breaking strength of all lines being less than 1,700 pounds (771 kg), limited soak durations of 90 minutes or less, no gear being left without a vessel nearby, and a delayed deployment of gear if a marine mammal is sighted nearby.	NMFS 2023; 87 FR 64868; 88 FR 22696
All cetacean receptor groups, seals.	Limit tow time to 20 minutes and monitor for marine mammals throughout gear deployment, fishing, and retrieval.	88 FR 22696
Sea Turtles	Any sea turtle disentanglement would occur consistent with the Northeast Atlantic Coast STDN Disentanglement Guidelines at https://www.reginfo.gov/public/do/DownloadDocument?objectID=102486501 and the procedures described in “Careful Release Protocols for Sea Turtle Release with Minimal Injury” (NOAA Technical Memorandum 580; https://repository.library.noaa.gov/view/noaa/3773)	NMFS 2023
Sea Turtles	Any sea turtles caught and/or retrieved in any fisheries survey gear would first be identified to species or species group. Each sea turtle species caught and/or retrieved would then be properly documented using appropriate equipment and data collection forms. Biological data, samples, and tagging would occur as outlined in NMFS Sturgeon and Sea Turtle Take Standard Operating Procedures. Live, uninjured animals should be returned to the water as quickly as possible after completing the required handling and documentation.	NMFS 2023

Table C-3 continued

Receptor (Species/Group)	Potential Guideline	References
Sea Turtles	Any sea turtles or Atlantic sturgeon caught and retrieved in gear used in fisheries surveys would be handled and resuscitated (if unresponsive) according to established protocols and whenever at-sea conditions are safe for those handling and resuscitating the animal(s) to do so.	NMFS 2023
Stressor: Vessel Traffic Risk: Vessel collision, physical injury, displacement, behavior alteration, avoidance.		
North Atlantic Right Whale	Timely reporting of NARW sightings to the NMFS or the Coast Guard within two hours of occurrence when feasible.	Vineyard Wind et al. 2019; USDOC and NOAA 2018a
	All vessels will maintain a separation distance of 330 ft. (100 m) or greater from any sighted non-delphinid cetacean (or Sperm whales and baleen whales other than NARW). If sighted, the vessel underway must reduce speed and shift the engine to neutral, and it must not engage the engines until the non-delphinid cetacean has moved outside of the vessel's path and beyond 330 ft. (100 m). If a survey vessel is stationary, the vessel will not engage engines until the non-delphinid cetacean has moved out of the vessel's path and beyond 330 ft.(100 m).	Bay State Wind 2018; Deepwater Wind 2018; Dominion Energy 2018; DONG Energy 2017; Statoil Wind 2018; USDOC and NOAA 2018a; NMFS 2023; 87 FR 64868; 88 FR 22696
Delphinid Cetacean, Seals	All vessels will maintain a separation distance of 164 ft. (50 m) or greater from any sighted delphinid cetacean or pinniped. Any vessel underway will remain parallel to a sighted delphinid cetacean's or pinniped's course whenever possible and avoid excessive speed or abrupt changes in direction. Any vessel underway will reduce vessel speed to 10 knots or less when pods (including mother/calf pairs) or large assemblages of delphinid cetaceans or pinnipeds are observed. Vessels may not adjust course and speed until the delphinid cetaceans or pinnipeds have moved beyond 164 ft. (50 m) and/or the abeam of the underway vessel.	BOEM and BSEE 2012a; Bay State Wind 2018; Deepwater Wind 2018; Dominion Energy 2018; DONG Energy 2017; Skipjack Windfarm 2018; Statoil Wind 2018; USDOC and NOAA 2018a; NMFS 2023; 87 FR 64868; 88 FR 22696
North Atlantic Right Whale	Between November 1st and April 30th, all vessels, regardless of size, must operate at 10 kts or less when traveling between ports in New Jersey, New York, Maryland, Delaware, and Virginia.	NMFS 2023; 88 FR 22696, BOEM 2023
Sea Turtles	All vessels will maintain a separation distance of 50 m (164 ft.) or greater from any sighted sea turtle.	BOEM and BSEE 2012a; Dominion Energy 2018; DONG Energy 2017; Deepwater Wind 2017, BOEM 2023
North Atlantic Right Whale	Additional monitoring measures are required of crew transfer vessels from November 1st through May 14th and within Dynamic Management Areas designated by the National Marine Fisheries Service (NMFS), including real-time passive acoustics, visual observers, and aerial surveys within Dynamic Management Areas.	Besnard et al. 2013; NOAA GARFO n.d.

Table C-3 continued

Receptor (Species/Group)	Potential Guideline	References
All cetacean receptor groups, seals, and sea turtles.	Ensure that vessel operators, employees, and contractors engaged in offshore activities complete marine trash and debris awareness training annually. Implement BOEM's training compliance reporting.	BOEM 2021; BOEM and NOAA 2022; NMFS 2023
All cetacean receptor groups, seals, and sea turtles.	Materials, equipment, tools, containers, and other items used in OCS activities, which are of such shape or configuration that they are likely to snag or damage fishing devices, and could be lost or discarded overboard, must be clearly marked with the vessel or facility identification and properly secured to prevent loss overboard. All markings must clearly identify the owner and must be durable enough to resist the effects of the environmental conditions to which they may be exposed.	BOEM 2021; BOEM and NOAA 2022; NMFS 2023
All cetacean receptor groups, seals, and sea turtles.	The Lessee must recover marine trash and debris that is lost or discarded in the marine environment while performing OCS activities when such incident is likely to cause undue harm or damage to natural resources, including their physical, atmospheric, and biological components, with particular attention to marine trash or debris that could entangle or be ingested by marine protected species. Recovery of the marine trash and debris should be completed as soon as practicable, but no later than 30 calendar days from the date on which the incident occurred. If the Lessee is not able to recover the marine trash or debris within 48 hours, the Lessee must submit a recovery plan to DOI explaining the recovery activities to recover the marine trash or debris (Recovery Plan). The Lessee must report to DOI (using the email address listed on DOI's most recent incident reporting guidance) all lost or discarded marine trash and debris.	BOEM 2021; BOEM and NOAA 2022
ESA-Listed Species	Anytime a survey vessel is underway (transiting or surveying), the vessel must maintain a 500 m minimum separation distance from ESA-listed species and a PSO must monitor a Vessel Strike Avoidance Zone (500 m or greater from any sighted ESA-listed species or other unidentified large marine mammal visible at the surface) to ensure detection of that animal in time to take necessary measures to avoid striking the animal.	BOEM 2021
Sea Turtles	If a sea turtle is sighted at any distance within the operating vessel's forward path, the vessel operator must slow down to 4 knots and steer away (unless unsafe to do so). The vessel may resume normal vessel operations once the vessel has passed the individual.	BOEM 2021
Sea Turtles	During times of year when sea turtles are known to occur in the survey area, vessels must avoid transiting through areas of visible jellyfish aggregations or floating vegetation (e.g., sargassum lines or mats). In the event that operational safety prevents avoidance of such areas, vessels must slow to 4 knots while transiting through such areas	BOEM 2021
ESA-Listed Species	The Lessee must ensure a PSO, or crew lookout is posted during all times to avoid interactions with ESA-listed species when a vessel is underway (transiting or surveying) by monitoring in all direction.	BOEM 2021; CLF et al. 2019; NMFS 2023; 87 FR 64868; 88 FR 22696
North Atlantic Right Whale	Regardless of vessel size, vessel operators must reduce vessel speed to 10 knots (18.5 mph) or less while operating in any Seasonal Management Area (SMA) and Dynamic Management Area (DMA) or Slow Zone triggered by visual detections of NARWs.	BOEM 2021; CLF et al. 2019; BOEM 2023

Table C-3 continued

Receptor (Species/Group)	Potential Guideline	References
North Atlantic Right Whale	The Lessee must ensure all vessel operators check for information regarding mandatory or voluntary ship strike avoidance (SMAs and DMAs or Slow Zones that are also designated as DMAs) and daily information regarding NARW sighting locations. These media may include, but are not limited to: NOAA weather radio, U.S. Coast Guard NAVTEX and channel 16 broadcasts, Notices to Mariners, the Whale Alert app, or WhaleMap website.	BOEM 2021; CLF et al. 2019
North Atlantic Right Whale	Vessels 35 ft or larger are restricted to traveling at 10 knots or less in the period of November 1 to May 30 each year in SMAs, including Ports of New York/New Jersey.	87 FR 46921
	Prior to the start of construction activities, all vessel operators and crew must receive a protected species identification training.	NMFS 2023; 87 FR 64868; 88 FR 22696; BOEM 2023
All cetacean receptor groups, seals, and sea turtles.	All vessels must have a visual observer on board who is responsible for monitoring the vessel strike avoidance zone for marine mammals. Visual observers may be PSO or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena and must be able to identify a marine mammal as a NARW, other whale (defined in this context as Sperm whales or baleen whales other than NARWs), or other marine mammal. Crew members serving as visual observers must not have duties other than observing for marine mammals while the vessel is operating over 10 kts.	NMFS 2023; 87 FR 64868; 88 FR 22696; BOEM 2023
North Atlantic Right Whale	Year-round, all vessel operators must monitor, the project's Situational Awareness System, WhaleAlert, US Coast Guard VHF Channel 16, and the Right Whale Sighting Advisory System (RWSAS) for the presence of NARWs once every 4-hour shift during project-related activities. The PSO and PAM operator monitoring teams for all activities must also monitor these systems no less than every 12 hours. If a vessel operator is alerted to a NARW detection within the project area, they must immediately convey this information to the PSO and PAM teams.	NMFS 2023; 87 FR 64868; 88 FR 22696, BOEM 2023
North Atlantic Right Whale	All vessels, regardless of size, must immediately reduce speed to 10 kts or less when a NARW is sighted, at any distance, by anyone on the vessel.	NMFS 2023; 87 FR 64868; BOEM 2023
North Atlantic Right Whale	If a vessel is traveling at greater than 10 knots, in addition to the required dedicated visual observer, the lessee must monitor the transit corridor in real-time with PAM prior to and during transits. If a NARW is detected via visual observation or PAM within or approaching the transit corridor, all crew transfer vessels must travel at 10 kts or less for 12 hours following the detection. Each subsequent detection shall trigger a 12-hour reset. A slowdown in the transit corridor expires when there has been no further visual or acoustic detection in the transit corridor in the past 12 hours.	NMFS 2023; 87 FR 64868; BEOM 2023
Sea Turtles	For all vessels operating north of the Virginia/North Carolina border, between June 1 and November 30, the lessee would have a trained lookout posted on all vessel transits during all phases of the project to observe for sea turtles. The trained lookout would communicate any sightings, in real-time, to the captain so that the requirements in I below can be implemented.	NMFS 2023; 87 FR 64868; 88 FR 22696; BOEM 2023

Table C-3 continued

Receptor (Species/Group)	Potential Guideline	References
Stressor: UXO Detonation **Risk: Physical injury, behavior alteration, displacement.**		
North Atlantic Right Whale	Develop and implement standard protocols for addressing unexploded ordinances, including implementation of best available technology to avoid or minimize exposure of NARWs and their sensitive habitats to low order (e.g., deflagration) or high order detonations or chemical release.	BOEM and NOAA 2022
North Atlantic Right Whale	Establish Clearance and Shutdown Zones that must be monitored to avoid exposure to noise or other conditions that could result in the mortality, serious injury, or non-auditory injury or auditory injury (i.e., permanent threshold shift) of individual NARWs and to minimize the amount and severity of behavioral disturbance.	BOEM and NOAA 2022
All cetacean receptor groups, seals, and sea turtles.	Upon encountering a UXO/MEC of concern, the lessee may only resort to high-order removal (i.e., detonation) after all other means by which to remove the UXO/MEC have been exhausted. The lessee must not detonate a UXO/MEC if another means of removal is practicable.	NMFS 2023
All cetacean receptor groups, seals, and sea turtles.	Utilize a noise abatement system (e.g., bubble curtain or similar noise abatement device) around all UXO/MEC detonations and operate that system in a manner that achieves maximum noise attenuation levels practicable.	NMFS 2023
All cetacean receptor groups, seals, and sea turtles.	The lessee must not detonate UXOs/MECs from November 1st through April 31st, annually and the lessee must only detonate UXO/MECs during daylight hours.	NMFS 2023
All cetacean receptor groups, seals, and sea turtles.	Establish and implement clearance zones using both visual and acoustic monitoring. PSOs and PAM operators must clear the area prior to detonation.	NMFS 2023
All cetacean receptor groups, seals, and sea turtles.	During each UXO/MEC detonation, the lessee must empirically determine source levels (peak and cumulative sound exposure level), the ranges to the isopleths corresponding to the Level A harassment and Level B harassment thresholds, and estimated transmission loss coefficient(s). If SFV measurements on any of the detonations indicate that the ranges to Level A harassment and Level B harassment thresholds are larger than those modeled, assuming 10-dB attenuation, the lessee must modify the ranges, with approval from NMFS, and/or apply additional noise attenuation measures (e.g., improve efficiency of bubble curtain(s), install an additional noise attenuation device) before the next detonation event.	NMFS 2023

TableC-4. Summary of Potential Guidelines for Avoiding, Minimizing, and Mitigating Impacts Related to Construction Activities

Receptor (Species/Group)	Potential Guideline	Reference
General Construction		
All cetacean receptor groups, seals, and sea turtles.	During construction, assess impacts of the construction work in the project area.	BSH 2008; BSH 2014; Macleod et al. 2011; Chen et al. 2017
All cetacean receptor groups, seals, and sea turtles.	Establish seasonal restrictions for construction schedules when appropriate.	BOEM 2017; Dähne et al. 2017; Danish Maritime Authority 2015; Deepwater Wind 2017; Lucke et al. 2011; NOAA GARFO n.d.; NYSERDA 2015; USACE 2014; Weir and Dolman 2007; Hilcorp 2019; IMR n.d.; ION 2017; Spectrum 2017; TGS 2017; WECO 2017
North Atlantic right whale.	Develop an adaptive framework to quickly resolve unanticipated issues so that impacts to NARWs are minimized quickly and efficiently.	BOEM and NOAA 2022
All cetacean receptor groups, seals.	Conduct briefings between construction supervisors, construction crews, and the PSO/PAM team prior to the start of all construction activities, and when new personnel join the work, in order to explain responsibilities, communication procedures, marine mammal monitoring and reporting protocols, and operational procedures. An informal guide must be included with the Marine Mammal Monitoring Plan to aid personnel in identifying species if they are observed in the vicinity of the project area.	NMFS 2023; 87 FR 64868; 88 FR 22696
All cetacean receptor groups, seals.	If an individual from a species for which authorization has not been granted, or a species for which authorization has been granted but the authorized take number has been met, is observed entering or within the relevant Level B harassment zone for each specified activity (e.g., pile driving, HRG surveys, UXO detonation), the activity must be shut down immediately, unless shutdown is not practicable, or be delayed if the activity has not commenced. The activity should not resume or commence until the animal(s) have been confirmed to have left the relevant clearance zone, or the observation time has elapsed with no further sightings.	NMFS 2023; 87 FR 64868; 88 FR 22696
All cetacean receptor groups, seals.	Any marine mammals observed within a clearance or shutdown zone must be allowed to remain in the area (i.e., must leave of their own volition) prior to commencing pile driving activities or construction surveys.	NMFS 2023; 87 FR 64868; 88 FR 22696; BOEM 2023
All cetacean receptor groups, seals, and sea turtles.	Develop and implement mitigation/monitoring plans for each specific project activity (e.g., pile driving, UXO detonation, sound field verification, vessel strike avoidance).	NMFS 2023; 87 FR 64868; 88 FR 22696; BOEM 2023

Table C-4 continued

Receptor (Species/Group)	Potential Guideline	Reference
Stressor: Construction Noise **Risk: Physical injury, displacement, avoidance, behavior alteration**		
All cetacean receptor groups, seals, and sea turtles.	Sound Exposure Level (SEL) must not exceed 160 dB (re 1 μPa) outside of a circle of 750 m radius, and the Peak Level (L_{peak}) must not exceed 190 dB (threshold formulated by Federal Environmental Agency [UBA]) – achieve through use of noise mitigation methods.	BSH 2014; BOEM 2014b; Merck 2018
All cetacean receptor groups, seals, and sea turtles.	For construction activities other than pile driving that cause underwater noise, the accumulated SEL from each construction activity must not exceed a threshold value of 190 dB.	Danish Energy Authority n.d.
All cetacean receptor groups, seals, and sea turtles.	Underwater noise reduction measures to reduce sound levels by a target of 12 dB.	BOEM 2014b; Vineyard Wind et al. 2019
Sea Turtles	Ensure that the lessee monitors the full extent of the area where noise would exceed the 175 dB rms threshold for turtles for the full duration of all pile driving activities and for 30 minutes following the cessation of pile driving activities and record all observations in order to ensure that all take that occurs is documented.	NMFS 2023
All cetacean receptor groups, seals, and sea turtles.	Use noise-reduction technologies during pile driving to reduce sound levels in water, such as dampening technologies (cushion blocks, mattresses), single or double bubble curtains, or shell noise reduction technologies (double piles and cofferdams). Note that effectiveness is dependent upon environmental conditions and that the appropriate noise-reduction technology should be implemented for the specific environmental conditions of a project and site to ensure effectiveness.	Andersson et al. 2017; Bellmann 2014; BOEM 2014b; CalTrans 2015; CTJV 2018; Elmer and Savery 2014; NOAA GARFO n.d.; NYSERDA 2015; Reyff 2009; Dahl et al. 2017; Reinhall et al. 2016
All cetacean receptor groups, seals, and sea turtles.	Incorporate the use of sound-reduction technologies in construction, such as soft-start methods during pile driving.	BOEM 2016a; BOEM 2016c; Caltrans 2015; Deepwater Wind 2012; Gartman et al. 2016; USACE 2014; Weilgart 2018; Wilhelmsson et al. 2010; NMFS 2023; 88 FR 22696
All cetacean receptor groups, seals, and sea turtles.	Develop noise emission forecasts for the construction period.	BSH 2014; USDOC and NOAA 2018b
All cetacean receptor groups, seals, and sea turtles.	Avoid the use of explosives during construction.	BOEM 2016a; BOEM 2016c

Table C-4 continued

Receptor (Species/Group)	Potential Guideline	Reference
North Atlantic Right Whale	Seasonal prohibition on pile driving activities from January 1st through April 30th, the period when North Atlantic right whales are most likely to be present in the Project Area.	BOEM 2014a; Vineyard Wind et al. 2019; NMFS 2023; 88 FR 22696
All cetacean receptor groups, seals, and sea turtles.	Restrictions on parallel piling.	Danish Energy Authority n.d.; Danish Maritime Authority 2015
All cetacean receptor groups, seals, and sea turtles.	No more than two foundation monopiles may be installed per day.	NMFS 2023; 88 FR 22696
All cetacean receptor groups, seals, and sea turtles.	Comprehensive monitoring protocols during the construction window (i.e., May 15th through October 31st), including, but not limited to, a restriction on initiating pile driving at night or during periods of poor visibility and the establishment of a minimum 1,000-m clearance zone that will be monitored by real-time passive acoustics and visual observers.	Vineyard Wind 2019; CLF et al. 2019
All cetacean receptor groups, seals, and sea turtles.	Report on background noise in the construction area.	BSH 2014; Marine Management Organization 2014; WSDOT 2016
All cetacean receptor groups, seals, and sea turtles.	Use of Sound Source (Field) Verification during initial noise-generating activities to determine whether modeled acoustic exposure area is consistent with measured acoustic exposure area.	Alaska LNG 2018; AOCSR 2017; BOEM 2016c; CalTrans 2015; BOEM and NOAA 2022; NMFS 2023; 88 FR 22696
All cetacean receptor groups, seals, and sea turtles.	Under safe conditions, apply ramp-up/soft-start procedures for noise-producing equipment used in pile driving.	Ainslie and von Benda-Beckmann 2012; Alaska LNG 2016; Alaska LNG 2018; Andersson et al. 2017; AOCSR 2017; Bay State Wind 2018; BOEM 2016b; BOEM 2016c; BOEM 2017; BOEM and BSEE 2012b; BSH 2014; CTJV 2018; Danish Maritime Authority 2015; Deepwater Wind 2017; Deepwater Wind 2018; Dominion Energy 2018; WSDOT 2019; CLF et al. 2019; NMFS 2023; 87 FR 64868; 88 FR 22696
All cetacean receptor groups, seals, and sea turtles.	Current data should be used to improve noise models and validate these models. Sound propagation models to assess the sound levels produced over an area may be useful to assess the likelihood of exposing protected species to certain impacts. Exposure analysis leads to risk assessment, which can then be used to decide which tools are needed.	BOEM 2018

Table C-4 continued

Receptor (Species/Group)	Potential Guideline	Reference
North Atlantic Right Whale	Develop and implement project schedules that avoid pile driving and high-vessel use activities during the time of year when NARWs are most likely to occur in the lease areas and along vessel routes. Avoid foundation installation within identified time periods and known areas of higher NARW density and persistence. Include extended seasonal restrictions for particular activities or restrictions on surface occupancy. Implement measures that prevent pile driving when monitoring of NARWs is not effective and NARWs are predicted to be present.	BOEM and NOAA 2022; CLF et al. 2019
	Establish Clearance and Shutdown Zones that must be monitored to avoid exposure to noise or other conditions that could result in the mortality, serious injury, or non-auditory injury or auditory injury (i.e., permanent threshold shift) of individual NARWs (and other marine mammals and sea turtles) and to minimize the amount and severity of behavioral disturbance.	BOEM and NOAA 2022; NMFS 2023; 87 FR 64868; 88 FR 22696
North Atlantic Right Whale	The lessee must not initiate pile driving later than 1.5 hours after civil sunset or 1 hour before civil sunrise unless the lessee submits an Alternative Monitoring Plan to NMFS for approval that proves the efficacy of their night vision devices.	NMFS 2023; 87 FR 64868; 88 FR 22696
All cetacean receptor groups, seals, and sea turtles.	Deploy dual noise abatement systems that are capable of achieving, at a minimum, 10 dB of sound attenuation, during all impact pile driving of foundation piles.	NMFS 2023; 87 FR 64868; 88 FR 22696

Table C-5. Summary of Potential Guidelines for Avoiding, Minimizing, and Mitigating Impacts Related to Post-Construction Activities

Receptor (Species/Group)	Potential Guideline	Reference
General Post-Construction		
All cetacean receptor groups, seals, and sea turtles.	During operation, monitor and assess impacts for multiple years in the project area.	BSH 2008; BSH 2014; Macleod et al. 2011; Marine Management Organization 2014; Teilmann et al. 2006
All cetacean receptor groups, seals, and sea turtles.	Consistent measuring of noise from marine energy converters should be employed. Measurements should include consideration of the frequency range of the equipment and procedures used. Specifically, this should be in relation to the hearing ranges of the marine species present. Methods of measurement are presented including boat-based systems, static systems (moored and bottom-mounted hydrophones) and drifting systems.	Lepper et al. 2014
Stressor: New In-Water Structures **Risk: Displacement, behavior alteration, avoidance.**		
North Atlantic right whale.	Conduct monitoring to assess the impacts of the physical presence and operation of the turbines. Monitoring should assess changes in the atmospheric and oceanographic environment—including benthic and pelagic habitats and oceanographic features (e.g., stratification and fronts)—particularly as these environments relate to NARW feeding behavior and ecology.	BOEM and NOAA 2022
All cetacean receptor groups, seals, and sea turtles.	Continuous monitoring for strains on mooring lines and inter-array cables resulting from ensnarement of marine debris or entanglement of an animal (e.g., using load cells or other appropriate sensor-types with proven sufficient sensitivity to model line and cable movements under normal conditions and to detect abnormal movement caused by a marine debris ensnarement or entanglement event).	NRDC 2022; Benjamins et al. 2014; Harnois et al. 2015
All cetacean receptor groups, seals, and sea turtles.	Daily remote visual inspection of infrastructure for ensnarement of marine debris or entanglement of an animal at depths where marine debris is most likely to occur (e.g., using cameras, remote aerial surveys, or other appropriate techniques).	NRDC et al. 2022; Benjamins et al. 2014; Harnois et al. 2015
All cetacean receptor groups, seals, and sea turtles.	Monthly inspection of the full length of submerged infrastructure (including platforms, substations, mooring lines, inter-array cables, and anchors, as well as monitoring technology docking stations or other infrastructure, as appropriate) for ensnared marine debris or entanglement of an animal (e.g., using side-scan sonar, and/or underwater autonomous vehicles or remotely operated vehicles (ROV) designed specifically for surveys of offshore energy infrastructure).	NRDC et al. 2022; Benjamins et al. 2014; Harnois et al. 2015

Table C-5 continued

Receptor (Species/Group)	Potential Guideline	Reference
All cetacean receptor groups, seals, and sea turtles.	Mooring lines and inter-array cables should be designed and maintained in configurations that minimize the potential for entanglement of marine species (e.g., lines and cables should remain under tension).	NRDC 2022
All cetacean receptor groups, seals, and sea turtles.	Infrastructure should be designed to facilitate visual or acoustic detection of ensnared marine debris at depths where marine debris is most likely to occur (e.g., by using lighter coloration or, for acoustic detection, textures to contrast with marine debris at depths where light is limited).	NRDC 2022
All cetacean receptor groups, seals, and sea turtles.	If monitoring shows that marine mammals or sea turtles are entangled in marine debris ensnared on any project structure, the lessee shall immediately follow the Reporting Protocol for Injured or Stranded Marine Mammals or the sea turtle reporting protocol developed by the Sea Turtle Disentanglement Network; and provide the federal and relevant state agencies with all available information on the incident.	NRDC 2022
All cetacean receptor groups, seals, and sea turtles.	All incidences of observed ensnarement of marine debris on floating offshore wind infrastructure and entanglements of marine life shall promptly be made publicly available.	NRDC 2022
All cetacean receptor groups, seals, and sea turtles.	Recommendations to reduce impacts of mooring structure to large marine mammals include relative risk assessments, routine inspections of moorings and for developers to report to regulators any significant changes to mooring and installations. Also recommended is an official process for developers to report any marine animal entanglement and an associated formal accident investigation procedure.	Benjamins et al. 2014
All cetacean receptor groups, seals, and sea turtles.	Bury cables if possible; use low footprint configurations (taut/ semi-taut moorings).	Davis et al. 2016; Harris 2014; Hutchison et al. 2020; James and Costa Ros 2015; Miller et al. 2013; Benjamins et al. 2014

C.1 Appendix C References

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Endnotes

1 Roberts et al. 2015, 2016a, 2016b, 2017, 2018, 2020, 2021, 2022, 2023; Roberts 2020; Roberts and Halpin 2022 serve as the resources that provide context within this section.

2 The public repository, which serves as resource for modeling efforts of protected marine species, can be found at https://seamap.env.duke.edu/models

3 Roberts et al. 2015, 2016a, 2016b, 2017, 2018, 2020, 2021, 2022, 2023; Roberts 2020; Roberts and Halpin 2022 serve as the resources that provide context within this section.

4 Supporting data reference. https://seamap.env.duke.edu/models/mdat/Mammal/MDAT_Mammal_Model_Metadata.pdf. Note that these uncertainty estimates are not directly related to survey effort in a given region, but to variability in dynamic covariates and other model parameters used to extrapolate density in areas with low survey coverage

5 An overview of the East Coast Turtle Density Models. Based upon DiMatteo et al. 2024, density surface models were developed and released in May 2023 for four species of sea turtles in the U.S. Atlantic. https://seamap.env.duke.edu/models/NUWC/EC/

6 An overview of the East Coast Turtle Density Models. https://seamap.env.duke.edu/models/NUWC/EC/

7 Status species reports were provided by the National Marine Fisheries Service and the United States Fish and Wildlife Service, 2023.

8 Habitat-based density models had been conducted by Roberts et al. 2015, 2016a, 2016b, 2017, 2018, 2020, 2021, 2022, 2023; Roberts 2020; Roberts and Halpin 2022 serve as the resources that provide context within this section.

9 Habitat-based density models for marine mammals had been conducted by Robert et al 2015, 2016a, 2016b, 2017, 2018, 2020, 2021, 2022, 2023.

10 False killer whales were sighted adjacent and to the west of the AoA.

11 Data referenced from Normandeau Associates Inc. and APEM Ltd. 2021a, 2021b.

12 Data referenced from Baird et al. 2015, 2016, 2017, 2018, 2019; Foley et al. 2021.

13 Data referenced from Baumgartner et al. 2020, 2021; Johnson et al. 2022; Murray et al. 2022.

14 Data referenced from Murray et al. 2021.

15 Data referenced from Murray et al. 2021.

16 Data referenced from Roberts et al. 2015, 2016a, 2016b, 2017, 2018, 2020, 2021, 2022, 2023; Roberts 2020; Roberts and Halpin 2022.

17 Takes of marine mammals incidental to specified activities and marine site characterization surveys offshore of New Jersey. https://www.federalregister.gov/d/2023-15817/p-13

18 Please see appendix A for a list of survey datasets that were used as model inputs.

19 Data is referenced from Baird et al. 2015, 2016, 2017, 2018, 2019; Normandeau Associates Inc. and APEM Ltd. 2021a, 2021b; Foley et al. 2021; King et al. 2021; Engelhaupt et al. 2022; Ampela et al. 2023.

20 Data is referenced from Normandeau Associates, Inc. and APEM, Ltd. 2021.

21 The seasonal and annual densities are zero in all zones for melon-headed whales and Fraser's dolphins, please see Table 7.

22 Data is referenced from Normandeau Associates Inc. and APEM Ltd. 2021a.

23 Data referenced from Normandeau Associates Inc. and APEM Ltd. 2021a.

24 Data is referenced from Normandeau Associates Inc. and APEM Ltd. 2021a; Figure 15.

25 Data is referenced from Hayes et al. 2023; NOAA Fisheries 2023e.

26 As the purpose of this study is to evaluate the sensitivity of receptor groups in the context of specific OSW stressors, there is intentional redundancy among these groups, and one species may fall into two or more receptor groups. For example, Humpback whales are evaluated for potential risk in the context of (low frequency) noise, ship strikes as shallow divers, and overall sensitivity to offshore wind stressors because of their involvement in an ongoing unusual mortality events.

[27] Data is referenced from Normandeau Associates Inc. and APEM Ltd. 2021a.

[28] Data is referenced from Braun et al. 2022; NOAA 2023a.

[29] Data is referenced from Normandeau Associates Inc. and APEM Ltd. 2021a, Figure 23.

[30] Data is referenced from Baird et al. 2015, 2016, 2017, 2018, 2019; Foley et al. 2021; Engelhaupt et al. 2022; Figure 24.

[31] Data is referenced from Baird et al. 2018; Figure 24.

[32] Data is referenced from Braun et al. 2022; NOAA 2023a.

[33] Data is referenced from Normandeau Associates Inc. and APEM Ltd. 2021a, Figure 27.

[34] Data is referenced from King et al. 2021, Figure 28.

[35] Data is referenced from Baird et al. 2015, 2016, 2017, 2018, 2019; Foley et al. 2021; Engelhaupt et al. 2022; Figure 28.

[36] Data is referenced from Baird et al. 2018; Engelhaupt et al. 2022; Figure 28.

[37] Data is referenced from Croll et al. 2001; NRC 1994; 2003; Götz et al. 2009, as cited in Farr et al. 2021.

[38] Data is referenced from Nedelec et al. 2016; Popper and Hawkins 2018.

[39] Data is referenced from Christensen-Dalsgaard et al. 2012.

[40] Supporting data reference. https://seamap.env.duke.edu/models/mdat/Mammal/MDAT_Mammal_Model_Metadata.pdf. Note that these uncertainty estimates are not directly related to survey effort in a given region, but to variability in dynamic covariates and other model parameters used to extrapolate density in areas with low survey coverage.

[41] Data is referenced from Sparks and DiMatteo 2023; DiMatteo et al. 2024.

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