Regional Wildlife Science Collaborative for Offshore Wind

Introduction to:

An Integrated Science Plan for Wildlife, Habitat, and Offshore Wind Energy in U.S. Atlantic Waters

The RWSC Science Plan is a living document. It compiles information about ongoing and planned offshore wind and wildlife data collection and research, sourced from the four RWSC Sectors, including U.S. Atlantic states, federal agencies, environmental NGOs, offshore wind companies, and the research community. From this information and with these experts, RWSC is identifying opportunities for collaboration and research gaps and needs.

The purpose of this Science Plan is to assist the RWSC Steering Committee in implementing the RWSC Mission – To collaboratively and effectively conduct and coordinate relevant, credible, and efficient regional monitoring and research of wildlife and marine ecosystems that supports the advancement of environmentally responsible and cost-efficient offshore wind power development activities in U.S. Atlantic waters – by:

- **Understanding ongoing and planned data collection and active research**
- **Building on prior efforts and collaboration**
- **Identifying data and research gaps and needs**
- **Standardizing new data collection and facilitating data sharing**
- **Aligning and leveraging funding from multiple sources**

Introduction

There are currently 27 renewable energy lease areas in the Atlantic Outer Continental Shelf (OCS) and 42 megawatts of installed offshore wind capacity. The total area of these existing leases and those areas being considered for additional leasing in the Atlantic OCS covers over 22 million acres. The fixed-bottom offshore wind infrastructure currently proposed for installation by 2030 would cover about 2.3 million acres[1]. Future additional lease sales are expected in the Gulf of Maine and the Central Atlantic, and over this time, floating technologies will increase as a proposed method of installation in various locations.

In U.S. Atlantic waters, the federal agencies and states are requiring and funding wildlife monitoring, data collection, and research in response to this scale of proposed and planned offshore wind development and in response to several federal and state renewable energy initiatives.

The Biden Administration through the U.S. Departments of the Interior, Energy, and Commerce announced a national goal in 2021 to deploy 30 gigawatts of offshore wind by 2030 and 15 gigawatts of floating offshore wind by 2035 while protecting biodiversity and promoting ocean co-use[2]. In addition, the first-ever U.S. Ocean Climate Action Plan (OCAP) directs responsible departments and agencies to integrate and coordinate across the Federal Government, and to engage with states, local governments, and Tribes on near-term actions to create a carbon-neutral future, including expanding offshore wind energy in an environmentally responsible manner, supporting innovation, and continuing to monitor potential environmental impacts[3]. Specific OCAP actions to expand offshore wind development include improving data sharing and access, identifying gaps in ocean mapping data requirements, and increasing scientific research and knowledge on the potential effects of offshore wind development and production on ocean and coastal resources (e.g., seabirds, marine mammals, habitats) and processes (e.g., currents, temperature stratification), to inform policy decisions through Tribal, academic, and public-private partnerships.

In addition to federal-level action, several states have administratively and legislatively committed to procure electricity from offshore wind facilities, and some states have moved forward with specific procurements. Collectively, and as of mid-2022, offshore wind energy policies in eight states call for deploying at least 39,322 MW of offshore wind energy capacity by 2040[4]. Many procurements for power purchase agreements have identified environmental considerations (e.g., baseline studies, ongoing monitoring and approaches to mitigation) to be included in bid packages from prospective bidders.

[1] Draft BOEM and NOAA Fisheries North Atlantic Right Whale Strategy (October 2022); accessed via https://www.regulations.gov/document/BOEM-2022-0066-0003.

[2] http://www.doi.gov/news/interior-joins-government-wide-effort-advance-offshore-wind

[3] https://www.whitehouse.gov/wp-content/uploads/2023/03/Ocean-Climate-Action-Plan_Final.pdf

[4] Musial, W. et al. 2022: Offshore Wind Market Report: 2022 Edition. U.S. Department of Energy Office of Energy Efficiency and Renewable Energy; accessed via https://www.energy.gov/sites/default/files/2022-08/offshore_wind_market_report_2022.pdf

Offshore wind companies leasing or developing projects in U.S. Atlantic waters are also funding additional wildlife monitoring, data collection, and research beyond regulatory requirements. Over the past several years, companies have developed partnerships with universities along the Atlantic coast to bolster their existing programs and to develop new research programs focused on offshore wind[5,6,7,8].

In response to these ongoing initiatives and activities, U.S. federal agencies, Atlantic coast states, offshore wind companies, and eNGOs created the Regional Wildlife Science Collaborative for Offshore Wind (RWSC) as a venue to coordinate with each other and engage with the research community. In July 2021, a Steering Committee with equal representation from those four Sectors officially launched RWSC with the mission to collaboratively and effectively conduct and coordinate relevant, credible, and efficient regional monitoring and research of wildlife and marine ecosystems that supports the advancement of environmentally responsible and cost-effective offshore wind power development activities in U.S. Atlantic waters.

RWSC is hosted by the Northeast Regional Ocean Council[9] (NROC) and Mid-Atlantic Regional Council on the Ocean[10] (MARCO), the two Regional Ocean Partnerships on the U.S. Atlantic coast who have convened government agencies, industry, environmental groups, researchers, and others around shared priorities for ocean planning and management for more than a decade. NROC's and MARCO's work to identify and address data and science needs, including for marine wildlife and offshore wind through many expert work groups, and in collaboration with the Regional Associations of the Integrated Ocean Observing System, the Northeast Ocean Data Portal[11] and Mid-Atlantic Ocean Data Portal[12] lays the foundation for advancing RWSC's objectives.

To further guide this mission, the RWSC Steering Committee convened expert Subcommittees—Marine Mammal, Bird & Bat, Sea Turtle, Habitat & Ecosystem, Protected Fish Species, and Technology ("the Subcommittees")—and experts throughout the region to develop the first *Integrated Science Plan for Wildlife, Habitat, and Offshore Wind Energy in U.S. Atlantic Waters* ("Science Plan"). This Science Plan represents thousands of hours of input and work from hundreds of volunteer experts in wildlife, habitats, and ocean ecosystems since December 2021 captured through 50 public Subcommittee meetings, as well as through dedicated working sessions on certain topics and one-on-one discussions.

RWSC Subcommittee meetings are forums where the research community and scientific experts coordinate with the agencies and industry to identify the methods, data, and analyses needed to answer questions about potential effects from offshore wind development on wildlife and the ecosystem. Participants share information about ongoing research and provide review of others' methods and approaches (occasionally at agencies' request).

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[5] https://rucool.marine.rutgers.edu/orsted-us-offshore-wind-partners-with-rutgers-university/
[6] https://www.umassd.edu/smast/news/marine-science-key-factor-in-record-of-decision.html
[7] https://www.vineyardwind.com/press-releases/2022/4/20/vineyard-wind-and-the-university-of-new-hampshire-partner-on-acoustic-monitoring-for-marine-mammals
[8] https://www.umces.edu/news/us-wind-umces-launch-offshore-wind-research-partnership
[9] https://www.northeastoceancouncil.org
[10] https://midatlanticocean.org
[11] https://www.northeastoceandata.org
[12] https://portal.midatlanticocean.org

The resounding conclusions from the Subcommittees over the last 18 months are that the volume of data that has been and will be collected is vast, future data collection activities could be better integrated, and there is an urgent need to ensure that the data are shared, managed, and accessible.

Purpose

RWSC will use the Science Plan to coordinate and fund future offshore wind and wildlife data collection and data management.

Understand ongoing and planned data collection and active research

The Science Plan aggregates information about ongoing and pending offshore wind and wildlife data collection and research activities occurring in U.S. Atlantic waters. To capture this information dynamically, the Subcommittees are supporting the **RWSC Offshore Wind & Wildlife Research Database**[13], which is continually updated as new projects and data collection efforts begin. The Database is focused on recent and active projects in U.S. Atlantic waters that were funded to address offshore wind and wildlife or habitat interactions, and it compiles information about each project's overall goal(s), geographic area of focus, methods used, funders, principal investigators, and other details.

The Database was compiled from publicly available information and from information shared during Subcommittee meetings since late 2021. Many of these initiatives do not involve field research or data collection, but improve the collective ability of RWSC to address research questions (e.g., development of data management best practices). Each taxa-based chapter of the Science Plan will summarize these activities and connect them to the research topics that they address.

This Science Plan provides a snapshot in time of these ongoing activities and initiatives as of June 2023. The RWSC Offshore Wind & Wildlife Research Database will serve as the most current source for research and data collection activities in U.S. Atlantic waters.

Build on prior efforts and collaboration

The Science Plan builds on several efforts over the past decade to identify research needs and priorities. In September 2022, the NYSERDA's Environmental Technical Working Group (E-TWG), in collaboration with the National Renewable Energy Lab's and Pacific Northwest National Lab's U.S. Offshore Wind Synthesis of Environmental Effects Research (SEER) team, released a synthesis of 806 offshore wind and wildlife research topics from 60 sources[14]. The resulting synthesized topics broadly relate to identifying, assessing, and avoiding impacts to wildlife distribution, abundance, and behavior, and to habitat and ecosystem quality and function. These synthesized research topics are incorporated into the Science Plan by reference, and many of them are described in the taxon-specific chapters of this Plan.

In addition, the Science Plan builds on the recent and ongoing work of many partners who have articulated the need for coordinated and collaborative research and data collection related to offshore wind, including but not limited to:

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[13] https://database.rwsc.org

[14] https://www.nyetwg.com/regional-synthesis-workgroup

- The federal agencies, Atlantic coast states, eNGOs, and offshore wind industry members and other stakeholders who participated in the visioning process for a regional wildlife science entity and who developed the *2020 Stakeholder Driven Vision*[15]
- March 2017 Best Management Practices Workshop for Atlantic Offshore Wind Facilities and Marine Protected Species, hosted by BOEM[16]
- May 2018 *Workshop on Marine Mammal Research Priorities*[17] convened by Massachusetts, BOEM and New England Aquarium
- A Framework for Studying the Effects of Offshore Wind Development on Marine Mammals and Turtles Report prepared for the Massachusetts Clean Energy Center and the Bureau of Ocean Energy Management, May 2019[18]
- NYSERDA E-TWG State of the Science Workshop on Wildlife and Offshore Wind Energy 2020: *Cumulative Impacts Workgroup Reports*[19]
- Responsible Offshore Science Alliance (ROSA) *Offshore Wind Project Monitoring Framework and Guidelines*[20], which provides a set of recommendations for how to design and implement valid scientific studies of offshore wind farms
- *Monitoring of Marine Life During Offshore Wind Energy Development - Guidelines and Recommendations*[21] contributed by more than 20 environmental organizations
- Priorities identified by the New Jersey Offshore Wind Research and Monitoring Initiative[22]
- *Fisheries and Offshore Wind Interactions: Synthesis of the Science*[23] - focused on five topics collectively identified by the project partners as critical for consideration in relation to offshore wind: ecosystem effects, fisheries socioeconomics, fisheries management and data collection, methods and approaches, and regional science planning
- Others?

Identify data and research gaps and needs

The Subcommittees used the [RWSC Offshore Wind & Wildlife Research Database] and information shared during Subcommittee meetings to understand where key data and information are being collected, which entities are funding and implementing other non-field activities that advance

[15] https://neoceanplanning.org/wp-content/uploads/2021/08/RWSE_Vision_2020.pdf
[16] https://www.boem.gov/renewable-energy/best-management-practices-workshop-atlantic-offshore-wind-facilities-and-marine
[17] https://www.masscec.com/resources/related-wildlife-analyses
[18] https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Renewable-Energy/A-Framework-for-Studying-the-Effects.pdf
[19] https://www.nyetwg.com/2020-workgroups
[20] https://www.rosascience.org/_files/ugd/99421e_b8932042e6e140ee84c5f8531c2530ab.pdf
[21] https://www.nrdc.org/sites/default/files/ow_marine-life_monitoring_guidelines.pdf
[22] https://dep.nj.gov/offshorewind/rmi/
[23] Hogan F et al. 2023. Fisheries and Offshore Wind Interactions: Synthesis of Science. https://doi.org/10.25923/tcjt-3a69. https://repository.library.noaa.gov/view/noaa/49151.

research, and finally, where gaps and needs exist. Each taxon-specific chapter of this Science Plan identifies the additional activities needed to address active research topics more fully, and to begin to address additional research topics.

Standardize new data collection and facilitate data sharing

To ensure that wildlife, habitat, and ecosystem data collected in U.S. Atlantic waters can be synthesized and included in future regional scale meta-analyses, species or habitat modeling, and other studies, the standardization of data and methods for providing access to data are critical. For many monitoring methods and analysis approaches, the Subcommittees are identifying existing best practices or have begun developing their own. The Data Standardization & Management chapter compiles information about existing data standardization, management, and sharing best practices and for which data these protocols and infrastructure still need to be developed. Each taxon-specific chapter of the Science Plan includes descriptions and more detailed recommendations specific to the data, methods, and tools relevant to each taxon.

Align and leverage funding from multiple sources

The Steering Committee intends to develop collaborative funding plans to address the data gaps and research needs in this Science Plan as opportunities arise.

The RWSC Steering Committee expects that the information in this Science Plan may be useful to and draw interest from multiple funders. The Steering Committee encourages interested funders to engage with RWSC to coordinate and collaborate on projects that together may have a greater impact than any single funder may achieve. The success of regional scale studies will require coordinated funding and data sharing.

This Science Plan recognizes that each funding source may have its own set of criteria for selecting projects, requirements or conditions for providing funding, and/or specific desired deliverables and outputs. Furthermore, projects or initiatives for prospective funding will need to be responsive to and be driven by the current mix of ongoing and planned data collection and research activities. Therefore, the elements of each collaborative funding plan are expected to be customized by the Steering Committee at the time when funding is committed or available. The Steering Committee may request additional information from Subcommittees and additional input from stakeholders to inform funding plans.

Chapter 2- Science Plan Organization

The RWSC Subcommittees are using several categories to organize information about ongoing, pending, and recommended data collection and research.

Chapters: Marine wildlife taxa, habitats, and cross-taxa issues

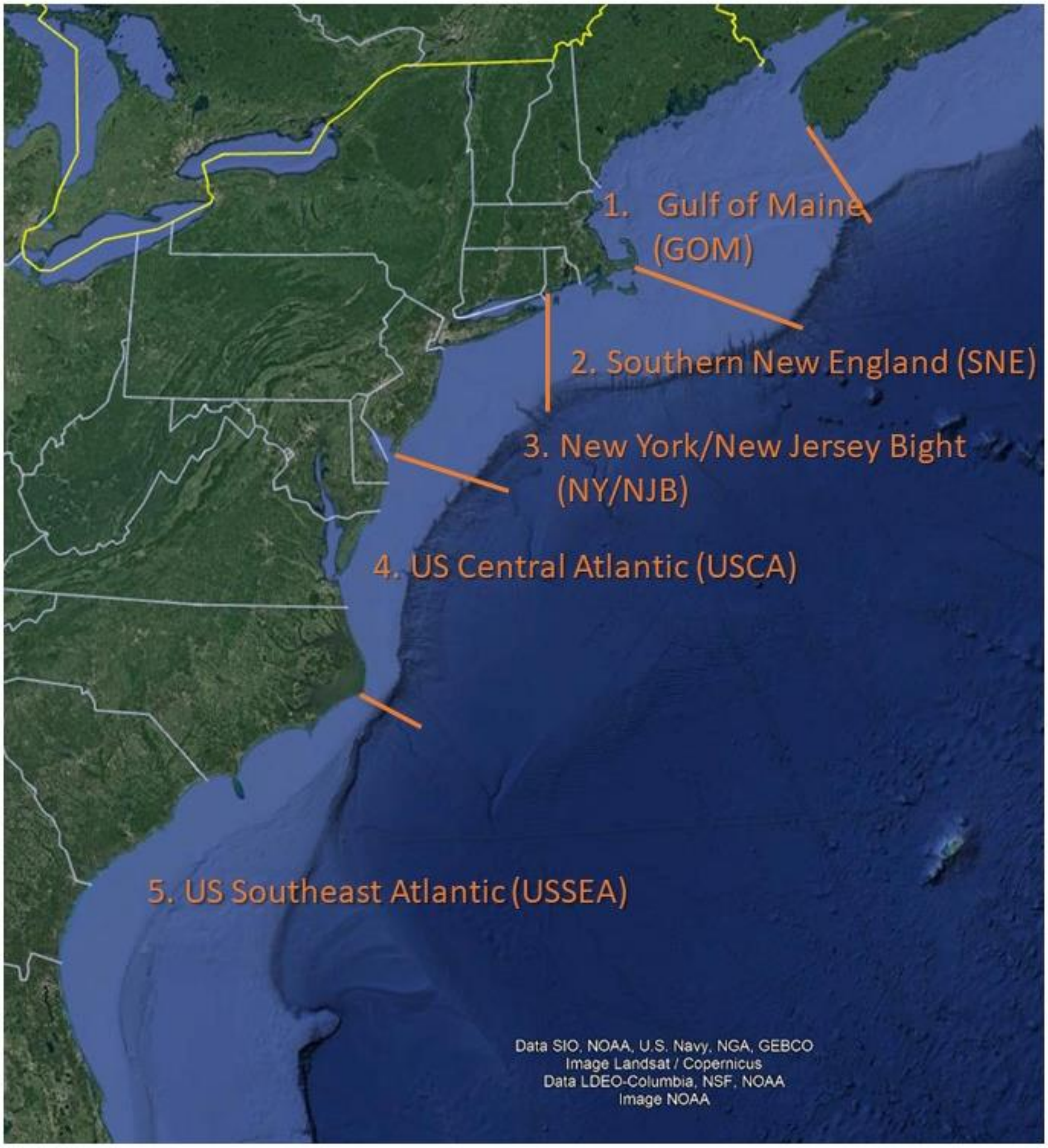
First, the Science Plan is separated into chapters that align with each RWSC taxa-based Subcommittee: Marine Mammals, Birds & Bats, Sea Turtles, Protected Fish Species, and Habitat & Ecosystem. The Habitat & Ecosystem Subcommittee wrote two chapters: Oceanography and Seafloor Habitat. There are additional chapters for issues that relate to all taxa and habitats, including Science Plan Actions, Data Standardization & Management, Data Governance, and Technology.

There are many data collection activities that explicitly target or incidentally gather information on multiple taxa. Those multi-taxa activities are described in the RWSC Offshore Wind & Wildlife Research Database and in the pertinent sections of the Science Plan. Opportunities for additional coordinated data collection across taxa are also described in each section where relevant.

Subregions

Each taxa-based chapter of the Science Plan groups information about ongoing, pending, and recommended research activities by whether they occur at the regional scale (U.S. Atlantic waters) or at subregional scales. The Subcommittees identified Subregions roughly aligned with the current federal offshore wind development planning and lease areas (see figure below). This alignment stems from the reality that many data collection activities are funded to examine a particular project overall, a project phase, lease area, or group of contiguous lease areas.

The use of subregions in the Science Plan is limited to organizing information and highlighting place-based gaps and needs. It is not the intent of the Science Plan to suggest geographic boundaries for data collection and research activities. In many cases, biogeographic considerations may drive data collection and research planning, including study design, analysis, and interpretation.



Map of subregions in U.S. Atlantic waters that are aligned with federal offshore wind planning and leasing areas.

Research Themes

For the purposes of organizing hundreds of ongoing, pending, and recommended research activities along the Atlantic coast, the Subcommittees used five broad Research Themes to organize their chapters. There are more specific research topics, questions, and recommendations that nest within each theme. Some research topics and recommendations relate to more than one Research Theme.

In the RWSC Offshore Wind & Wildlife Research Database, users can filter ongoing data collection and research activities by Research Theme.

1. Mitigating negative impacts that are likely to occur and/or are severe in magnitude

Several Subcommittee members identified this research theme as a high priority overall, particularly for highly vulnerable and/or protected species that are data limited. Research within this theme would test the efficacy of existing mitigation methods or develop new methods for high-risk species for which there is high confidence in negative impacts.

2. Detecting and quantifying changes to wildlife and habitats

This theme encompasses the work required to detect and quantify changes to wildlife distribution, abundance, behavior, and health as well as changes to habitat characteristics and quality. The Subcommittees recognize that not all observed changes are ecologically meaningful, and that consideration should be given to determining and defining levels of change that are meaningful for various ecosystem components or species. Activities within this theme include but are not limited to:

- Collecting baseline wildlife and habitat data
- Assessing whether sufficient wildlife, habitat, and ecosystem data exist to detect change
- Designing and conducting assessments of effects or impacts to wildlife and habitats
- Developing and testing new technologies and tools to improve wildlife- and habitat-observational capacity
- Other approaches to reduce uncertainty in observed wildlife/habitat patterns
- Identifying thresholds of ecologically meaningful change

3. Understanding the environmental context around changes to wildlife and habitats

When paired with the activities associated with the previous research theme, characterizations of the environmental context including anthropogenic stressors, will be critical for understanding drivers of wildlife, habitat, and ecosystem change. Activities within this theme include characterizations of oceanographic and meteorological properties, prey fields, ocean noise, and human activities in the ocean other than offshore wind that may affect wildlife and habitat. An important component of this research theme is controlling for impacts induced by climate change during the assessment of potential offshore wind effects.

4. Determining causality for observed changes to wildlife and habitats

Ideally, research activities result in the ability to determine the causes of any observed changes to wildlife distribution, abundance, and/or behavior, and to habitats. Given the natural variability in the ocean ecosystem and new patterns and variations attributed to climate change, Subcommittee members have cautioned that determining causality with high confidence will be challenging.

5. Enhancing data sharing and access

This theme is a catalyst for addressing all the previous themes. Activities within this theme include:

- Identifying and supporting existing data systems or building and maintaining new data systems that accommodate the volumes of wildlife and environmental data to be collected over the next several decades
- Developing the institutional support for and frameworks needed to facilitate timely data sharing
- Developing standards for data sharing, management, storage, and access for various data types and methods/tools

Why these themes?

The Subcommittees quickly encountered challenges when organizing and coordinating across hundreds of ongoing, pending, and recommended research activities. Some ongoing data collection activities focus on baseline data collection for wildlife whereas other focus solely on oceanographic data. To organize data and research such that multiple individual efforts could eventually contribute to answering broader science questions, the Subcommittees developed several themes that assist with placing ongoing efforts generally along a continuum of scientific inquiry. The first theme relates to the most urgent science questions, whereas themes 2-4 build toward an ability to examine potential causes of change, with theme 5 facilitating a collaborative understanding of all data collection and results. The five RWSC Research Themes can be related to other research frameworks currently in use, including for example the "Occurrence, Exposure, Response, Consequences" framework used by the U.S. Navy and other federal agencies in the identification of science objectives for marine species monitoring[1]:

- Occurrence – RWSC Research Theme 2
- Exposure – RWSC Research Theme 3
- Response – RWSC Research Theme 4
- Consequences – RWSC Research Theme 2

[1]Chief of Naval Operations Energy & Environmental Readiness Division. 2013. U.S. Navy Strategic Planning Process for Marine Species Monitoring. 14 pp. Available at: https://www.navymarinespeciesmonitoring.us/files/8013/8454/0231/NAVY_STRATEGIC_PLANNING_PROCESS_FOR_MONITORING_11152013.pdf

Chapter 3 - Science Plan Actions

Science Plan Actions are the specific categories of activities that collectively address Research Themes.

There are two categories of Science Plan Actions – Field Data Collection & Analysis Actions and Non-field Actions. Within the Field Data Collection & Analysis Actions category, there are many specific methods and approaches being used.

Within each taxa-based chapter, the ongoing, pending, and recommended research and data collection activities are grouped by Science Plan Actions.

In the RWSC Offshore Wind & Wildlife Research Database, users can filter ongoing data collection and research activities by field and non-field Science Plan Actions.

Field Data Collection & Analysis Actions

For the purposes of further organizing ongoing, pending, and recommended research, the Subcommittees developed a list of methods and tools that are used to collect wildlife and environment data offshore. These are collectively referred to as "Field data collection & analysis actions". Often, these methods are paired with Non-field Actions (described in the next section).

Field Data Collection & Analysis Actions	Method Description	Possible Platforms
Aerial visual - strip transect	Standard survey technique to count individuals/species	Aerial
Opportunistic visual	Non-standard and unstructured surveys to quantify individuals/species	Aerial, Boat-based
Aerial high def imagery	High-resolution/definition photography or video for quantifying animals, nests, colonies, and/or characterizing habitat	Aerial
Aerial visual - distance sampling	Standard survey technique to quantify abundance	Aerial
Boat-based - distance sampling	Standard survey technique to quantify abundance	Boat-based
Boat-based - strip transect	Standard survey technique to count individuals/species	Boat-based
Stationary visual	Visual observations made from a stationary platform (e.g., turbine) or shore	Stationary
Nest/colony counts	Manual counts of nests/colonies	Stationary, Aerial
Thermal camera	Thermal cameras mounted to turbines or buoys for bird/bat detection	Stationary
Infrared camera	Infrared cameras mounted to turbines or buoys for bird/bat detection; boat-based infrared for marine mammal detection	Stationary, Boat-based

Field Data Collection & Analysis Actions	Method Description	Possible Platforms
Visual range	Sensor to quantify range of detected birds/bats	Stationary
NEXRAD		Stationary
Marine RADAR		Stationary, Boat-based
Passive acoustic monitoring - real-time	Hydrophones deployed to record sounds produced by animals and the environment with real-time reporting. Can be stationary bottom-mounted (buoys) or mobile (gliders).	Glider, buoy
Passive acoustic monitoring - archival	Hydrophones deployed to record and archive sounds produced by animals and the environment; can be stationary bottom-mounted (buoys) or mobile (gliders)	Stationary, Glider
Carcass counts	Manual counts and assessments of carcasses	Stationary, Aerial
LIDAR	Wind speed profiles	Stationary, Realtime data
Satellite tagging	Includes deploying tags on animals; e.g., ARGOS	Animal telemetry
Acoustic tagging	Includes deploying tags on animals and deploying receivers; e.g. Vemco	Animal telemetry
VHF tagging	Includes deploying tags on animals and deploying receivers; e.g. Motus	Animal telemetry
GPS tagging	Includes deploying tags on animals and deploying receivers	Animal telemetry
Other tagging	Includes deploying tags on animals and deploying receivers	Animal telemetry
eDNA	Environmental DNA collection and analysis for species detection; could be collected at stations via discrete water samples or via mobile flow-through systems?	Stationary, Glider
Diet analysis	Stomach content analyses; chemical analyses; stable isotope analyses	Boat-based
Animal physiology	Physiological measurements including stress hormones from blood, blow, mucus, tissue, fecal samples, etc.	Boat-based
Focal follow		Glider, ROV, AUV, Drone
Satellite remote sensing	Surface measurements of winds, temperature, height, ocean color (chlorophyll, dissolved organic matter, suspended particles) and other ocean and atmosphere variables collected remotely via satellite	
Water quality and oceanography	In-situ measurements properties including salinity, dissolved oxygen, temperature, etc.	Stationary, Realtime data, Glider
Nets and tows	Zooplankton and small fish sampling	Boat-based
High frequency RADAR	Measurements of ocean surface currents	Stationary
Seafloor imagery	Photographs (sediment profile and plan-view) or video of seafloor geology and biology	Boat-based, ROV, AUV, Drop Camera, SCUBA divers/snorkelers

Field Data Collection & Analysis Actions	Method Description	Possible Platforms
Sediment grabs	Physical samples of seafloor sediment; size and type of grab sampler may influence the composition of the sample	Boat-based
Seafloor acoustics - geophysical	Multibeam bathymetry, backscatter, side scan sonar	Boat-based, ROV, AUV
Echosounders	Acoustic instrumentation used to characterize prey fields in the water column; can also be directed at the seafloor for bottom characterization	Boat-based, Stationary

Non-field Actions

In addition to field data collection, wildlife and environment research includes other types of activities that advance the use of the data in multiple ways. A range of Non-field Actions that correspond to all phase of research planning, implementation, and dissemination have been defined by the Subcommittees:

Coordination and planning - coordination among the four RWSC Sectors and the research community through the operation of the RWSC, but also other multisector coordination activities led by federal agencies and individual states; deconflicting research activities; coordination around an issue or species, such as the North Atlantic right whale.

Standardizing data collection, analysis, and reporting – development and maintenance of informal "best practices" as well as formal guidance from government entities on the specific protocols and methods that should be used for specific data types and/or studies to ensure alignment with advances in technologies and practices.

Historical data collection/compilation – adding existing data to modern databases so that historical data can be used in long-term/time-series analyses and studies.

Study optimization – implementation of statistical frameworks and analyses to determine optimal study designs given a set of data conditions and research goals.

Manipulative experiments – in manipulative experiments, multiple replicate experimental units are created and an experimental manipulation (a "treatment") is applied to a random set of these units, with the remaining units being left as controls. A measured difference in average response between the manipulated and control units can then be inferred to be due to the treatment. Manipulative experiments are different from observational studies and can help researchers "diagnose" the cause(s) of any observed change.

Model development and statistical frameworks – development and maintenance of species distribution models, habitat suitability models, risk assessment frameworks, Population Consequences of Disturbance (PCoD) models, cumulative impact assessments, etc.

Technology advancement – includes the development and testing of new field research tools/methods or mitigation options; can also include development of and improvements to data systems.

Meta-analysis and literature review – examples include compilations of research priorities, impacts literature, assessments of data availability, life history parameters to inform models.

Outreach and platforms to provide data products and results to stakeholders – includes the work that RWSC does to summarize and convey findings and results to stakeholders and decision-makers, including through regional data portals and other web-based platforms that display interpretive maps with exploratory tools and links to the underlying data as appropriate.

Chapter 4: Data Governance

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Summary

- This chapter and the Data Management & Standardization chapter address cross-cutting data and information issues in the Science Plan and the RWSC's ongoing work. During the Science Plan review, the authors will host discussion sessions with the RWSC and update this chapter to reflect those conversations.
- Data governance encompasses the purpose and processes for collecting and using data, the legal and licensing frameworks, and the supporting technical implementation. It is foundational to successful collaborative data efforts and it requires active effort throughout the life of the program.

In order to achieve its mission, we recommend that the RWSC:

- Establish a Data Governance Subcommittee to oversee ongoing governance, maintain the data management and sharing policies, and support data partners in implementing data standards and best practices.
- Fully map out the RWSC Data Ecosystem, including data sources, owners, and means of data access.
- Develop RWSC data sharing and management policies, incorporating best practices and standards identified by RWSC expert Subcommittees.
- Create a data catalog to enable the discovery and sharing of data in the RWSC Data Ecosystem.
- Hold workshops with RWSC partners to discuss data governance, develop the above actions and review other potential data governance needs.

Introduction

The RWSC's mission is:

> "To collaboratively and effectively conduct and coordinate relevant, credible, and efficient regional monitoring and research of wildlife and marine ecosystems that supports the advancement of environmentally responsible and cost-efficient offshore wind power development activities in U.S. Atlantic waters."

Achieving this mission requires attention to the way monitoring is carried out, by whom, and how results are validated and shared. The expert Subcommittee Chapters of the RWSC Science Plan describe opportunities for efficiencies across projects and identify relevant research. Delivering these efficiencies and coordinating data from collection to research products, across diverse and widespread efforts, will require data governance. Well-planned data governance will also help position the RWSC as a trusted resource for scientific guidance and information.

Data governance encompasses the people, processes, policies, and standards around data, as well as the supporting technical infrastructure. Data governance can be created through international agreements, national laws, or implemented at an organizational or project level.[1,2] Data management is part of data governance, but data management often refers to the nuts and bolts of delivering data while governance also encompasses decision-making, strategy, and resource allocation. Well-designed data governance supports effective, privacy-protecting data sharing and increases the value and impact of data through access and reuse.[3] This is particularly important for environmental data efforts,[4] like the RWSC, where analyses could involve data from a wide range of sources, such as compliance data shared with government agencies, data collected by wind energy companies and their contractors, independent and academic researchers, nonprofit organizations, and other future collaborators. Each of these contributors needs to be confident in how their data will be used and have the capacity to make informed decisions about data sharing, understanding both the potential benefits and risks.

Data governance is important to consider at every step of the data lifecycle.[5] The Science Plan lays out research goals which rely on collaboration across a network of partners and projects. Each of these

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[1] Steve MacFeely et al., "Towards an International Data Governance Framework," *Statistical Journal of the IAOS* 38, no. 3 (January 1, 2022): 703–10, https://doi.org/10.3233/SJI-220038.mac

[2] Paul Brous, Marijn Janssen, and Riikka Vilminko-Heikkinen, "Coordinating Decision-Making in Data Management Activities: A Systematic Review of Data Governance Principles," in *Electronic Government*, ed. Hans Jochen Scholl et al., Lecture Notes in Computer Science (Cham: Springer International Publishing, 2016), 115–25, https://doi.org/10.1007/978-3-319-44421-5_9.brous

[3] Rene Abraham, Johannes Schneider, and Jan vom Brocke, "Data Governance: A Conceptual Framework, Structured Review, and Research Agenda," *International Journal of Information Management* 49 (December 1, 2019): 424–38, https://doi.org/10.1016/j.ijinfomgt.2019.07.008.

[4] Jörn Fritzenkötter et al., "Governing the Environment-Related Data Space," *SSRN Electronic Journal*, 2022, https://doi.org/10.2139/ssrn.4250166.f

[5] We're using a version of the data lifecycle from the International Oceanographic Commission's Data Management training. There are many versions of the data lifecycle, with varying levels of detail, and we

partnerships and projects may be at a different stage of their data lifecycle. In our conversations with Science Plan participants, we heard about data flows where there was a lack of clarity about how data would be structured or transmitted (Plan), inconsistent documentation of data practices (Collect), and questions about whether partners had the right MOUs in place to share data (Share). These are the types of questions data governance can answer, and the ideal time to discuss data governance is before data collection starts, rather than risk generating data that gets hung up in negotiating licenses or can't interoperate due to incompatible formats.

In its role as a coordinator, the RWSC can provide guidance and support for contributors. This can include templates, standards, and staff time to help data and projects connect to the Science Plan. In some cases, such as when the RWSC funds a project, the RWSC may be able to apply data governance during the planning phase, before data collection starts. The RWSC will also be engaging with projects already underway, helping participants to navigate requirements set by other entities and working to harmonize their data workflows with the Science Plan.

Collaboration takes time and resources, and it is essential to the success of the Science Plan. Every project needs to invest in data governance and data management, as does the RWSC in its role as coordinator. By thinking about data governance at the RWSC level, not just at the individual research project level, the RWSC can identify where best to invest time and resources. It can also continue the RWSC's current approach of operating transparently by documenting how tools were chosen, how often templates or protocols will be revised, and other data governance decisions. Being open about how these decisions are made builds trust in the data systems used by the RWSC and the data products produced by this collaborative.[6]

Because data governance is an ongoing effort, we recommend the RWSC establish a Data Governance Subcommittee to oversee these decisions, policies, and processes, implement data management, and support data contributors. One of the first tasks of the Subcommittee would be mapping the Data Ecosystem to better understand gaps, participant needs, and the full scope of data and information sources.

The RWSC Data Ecosystem

The RWSC's Data Ecosystem encompasses: all the data necessary to answer the questions in the Science Plan; the agencies, organizations, and individuals that created the data; the data hosts or locations; and the networks that connect them. Figure 1 provides a high-level concept of the Data Ecosystem and how elements could be connected to deliver Science Plan products, with a focus on data sources, ownership, and control. Each chapter of the RWSC Science Plan has begun the process of more detailed Data Ecosystem mapping, and the RWSC Data Governance Subcommittee should integrate these initial lists of data sources into a comprehensive map.

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recommend the RWSC choose one to help guide the development of common terms across the group. Other frameworks include USGS, the NOAA Environmental Data Management Framework, and DataOne.

[6] Dawei Lin et al., "The TRUST Principles for Digital Repositories," *Scientific Data* 7, no. 1 (May 14, 2020): 144, https://doi.org/10.1038/s41597-020-0486-7.lin

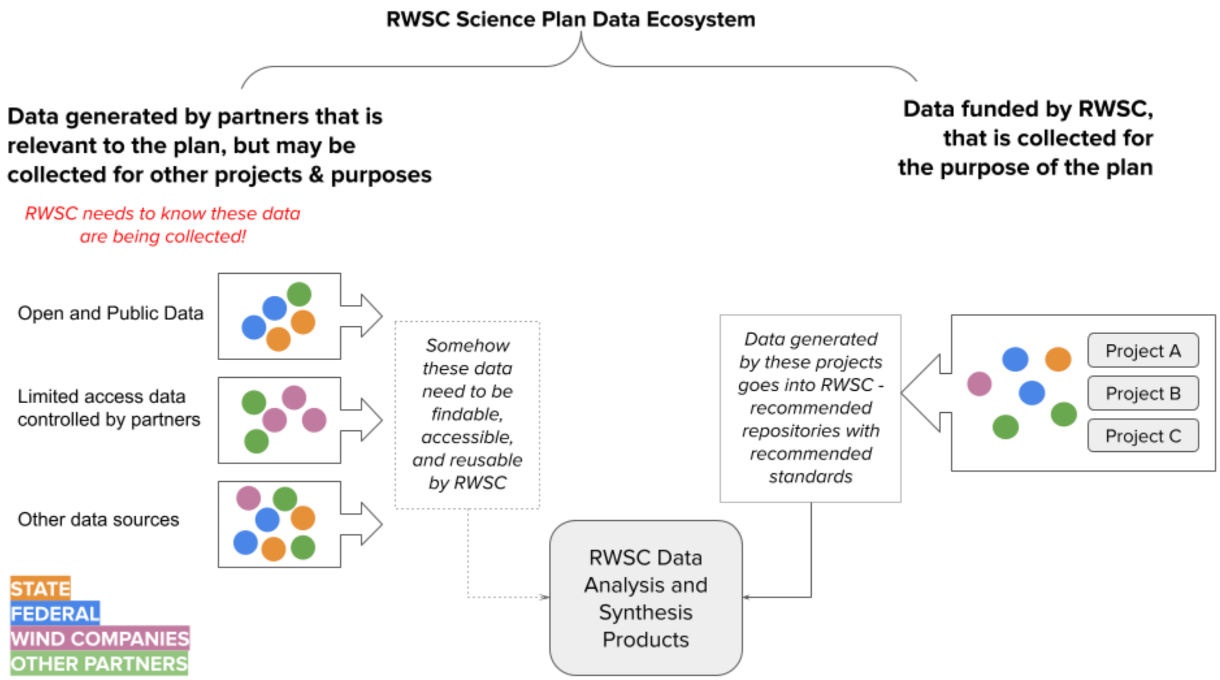

Figure 1: Conceptual diagram of major components of the RWSC Data Ecosystem, organized by data contributors. A full map would detail data streams and the entities responsible for connecting those data streams to the Science Plan.

A Data Ecosystem's interconnections are core to its value. If data discovery is difficult or data cannot move from one node to another, the Data Ecosystem will not be as effective or efficient. The RWSC could consider guidelines and standards for elements of the Data Ecosystem to support FAIR principles — making that data more Findable, Accessible, Interoperable, and Reusable by the RWSC community.[7] Because Transparency, Accessibility, and Collaboration are core values for the RWSC, the group should consider governing data not only for the Science Plan but also for future re-use by new partners, for questions not yet imagined.[8] While not all data in the RWSC's Data Ecosystem will be appropriate for this level of stewardship, there may be some data sources and data products the RWSC is best suited to govern and preserve so they can have impact beyond their initial research questions.

One way to think about a Data Ecosystem is by purpose, as the topical chapters in this Plan start to do in describing the data needed for each research recommendation. From a data governance standpoint, it is useful to think about a data ecosystem by data ownership and control. We go through four general categories of data below and suggest some governance considerations for each. In each category there

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[7] Toste Tanhua et al., "Ocean FAIR Data Services," *Frontiers in Marine Science* 6 (2019), https://www.frontiersin.org/articles/10.3389/fmars.2019.00440.

[8] Katie Hoeberling, "Opportunity Brief | Beyond Original Intent: Environmental Data Stewardship for Diverse Uses" (Open Environmental Data Project (OEDP), December 7, 2022), https://doi.org/10.15868/socialsector.41283.

are issues that should be addressed by the RWSC Data Governance Subcommittee in developing data standards and policies.

Data Governance Considerations by Ownership Category

Open and Public Data

Open data is free to access by anyone, with no use restrictions, while public data may be accessible to anyone but have use restrictions or fees for certain levels of use.[9] Data published by the Integrated Ocean Observing System (IOOS) and many other datasets released by government agencies fall in this category. Open data does not include restricted data held by public agencies, such as compliance reports that may contain trade secrets (see the Limited Access category). Governance considerations around open and public data include:

- **Monitoring data location and access.** As websites and information architecture change, so do URLs and links to data. Unless data has a persistent identifier, such as a Digital Object Identifier (DOI), it may be hard to find and reuse in the future. How will the RWSC keep track of core public datasets to make sure they remain accessible?
- **Data retention.** States and the federal government have document retention policies that cover datasets as well. While many scientific datasets are held in perpetuity, or for 70 years (per National Archives standards), not all datasets are. Are there key datasets that RWSC may need to take on if they are scheduled for deletion?
- **Provenance**. Provenance is "the documentation of where a piece of data comes from and the processes and methodology by which it was produced."[10] Documentation can vary for public datasets, making provenance unclear and introducing uncertainties in combining them with other datasets. What does the RWSC need to do to secure provenance for public data for its analyses?

Limited access data controlled by partners

This data is one of RWSC's greatest assets, as it may not be public or open but partners may choose to share it for the purpose of Science Plan analyses. Examples include: site assessment data generated by consultants for energy companies that is not published in an Final Environmental Impact Statement (FEIS) or Construction and Operations Plan (COP), observations from state wildlife agencies that need obfuscation to protect sensitive resources, or research data shared pre-publication by an academic institution. RWSC partners can use the Science Plan to identify where they have relevant data and provide a data description, if not full metadata, about what they would be willing to share, under what conditions. The RWSC Data Governance Subcommittee could then work with potential data contributors on data governance for the datasets, including:

- Where will the data be stored? Will the partner hold it on their systems or does the RWSC need to arrange for secure hosting?

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[9] For example, NCEI's Climate Data Online provides data for free (open) and charges a fee for ordering specific, large datasets (public, but not open). Images may be publicly discoverable but have Creative Commons licenses requiring attribution or restricting commercial use.

[10] "Data Provenance | Australian Research Data Commons | ARDC," *Https://Ardc.Edu.Au/* (blog), May 14, 2022, https://ardc.edu.au/resource/data-provenance/.

- Defining access restrictions. This can include things like: data being made available only to specific, named researchers; no external access but researchers can submit queries and receive modeled results; access that is unlocked at a certain time or expires after a certain time (Figure 2); download limitations; keeping access logs, etc.
- Data documentation: Will the partner provide descriptive metadata or collection protocols? How should data be cited?
- What are the acceptable data products?
- Consequences for data misuse. Keep in mind that for some data types, especially Personally Identifiable Information (PII), there can be legal and financial implications for disclosure.

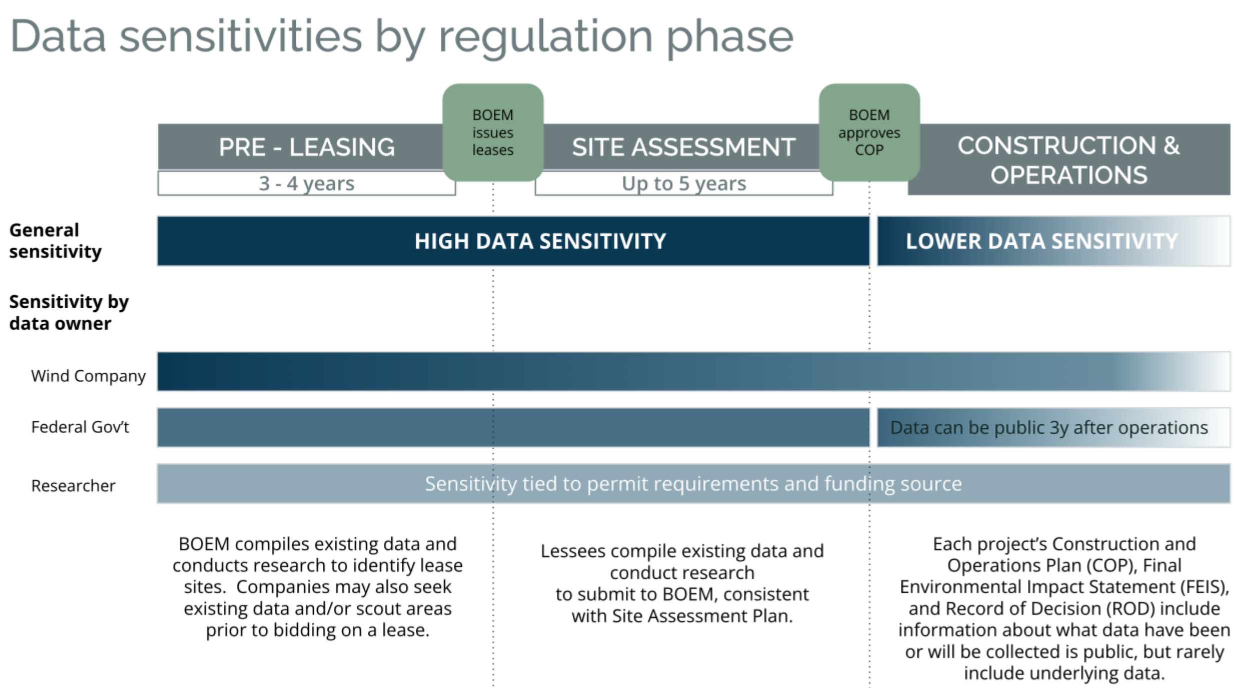

Figure 2: Sensitivity of data collected by the offshore wind industry and their consultants across the regulatory phases.

Data funded or otherwise 'controlled' by the RWSC

When the RWSC funds data collection or analysis there is an opportunity to set terms for data sharing. The RWSC could add data licensing and sharing language to funding agreements in addition to any requirements from a funding source, such as a foundation that mandates open data. Some RWSC partners already apply data disclosure requirements to contracts with developers or consultants and the RWSC Data Governance Subcommittee may want to review these documents for guidance. It will be important for the RWSC to clearly communicate with grantees how data are expected to be collected, stored, and provided to the RWSC for the grant purposes, as well as what will happen to the data afterwards. Similarly, once the RWSC receives data from grantees, the RWSC will need to apply those access and preservation rules and store the data accordingly.

Other data sources

Once the Science Plan is released, a wide range of contributors may seek to connect to the RWSC Data Ecosystem. The RWSC Data Governance Subcommittee should consider both requirements and incentives for contributors, as well as what expectations it sets around data usage and preservation. For example, IOOS and its regional associations have partner certification programs which impose a set of national data standards developed by NOAA for data to be incorporated into their portals. This type of formal process could be valuable for a new partner seeking to collaborate on a restricted access project. A more informal approach would be developing data management best practices through the RWSC expert Subcommittees, making those practices public, and eventually providing funding or data coaching to independent researchers and small organizations who need help with data preparation. These approaches are not mutually exclusive, and in both examples the ultimate goal is to support standard practices that improve data interoperability, reliability, and use.

Data Governance Components & Context

We divide data governance into three main components that work together:

A. **Purpose and Process**, aka "the people layer". This includes decision-making processes, setting and adapting the project goals, staffing and funding, partnership expectations, and culture.
B. **Legal & Contractual:** Data licenses, MOUs, and funding terms. These should outline roles, responsibilities, constraints, and consequences.
C. **Technical Implementation**: Data storage and access infrastructure, as well as workflows, collaboration and code tools, and security protections.

Purpose & Process

The RWSC's Purpose is laid out in the Mission and further articulated through this Science Plan. The RWSC has already created a strong culture of transparency by making its governance structure public, including describing a consensus-based decision-making process for the Steering Committee and Sector Caucuses, and holding open meetings. The governance structure will need to be updated to reflect the existence of the Science Plan and the processes around its implementation.

Purpose & Process Discussion Topics

- Who needs to be involved in decisions about allocating resources to research and data collection activities in the Science Plan?
    - What will be the role of the sector caucuses in this process, including identifying opportunities for funding and collaboration?
    - How will those decisions be documented?
- How will the RWSC report on Science Plan progress, and what data infrastructure is needed to make that possible?
    - Who decides if data are 'good enough to use' and how are those decisions made?

- If the RWSC publishes data guidelines or standards, does the RWSC want to keep track of how those are applied or cited? For example, will the RWSC be comfortable with people using and citing an RWSC data protocol in work unrelated to the Science Plan.
- Who makes decisions about providing access to sensitive or restricted datasets?
- Will funded projects be required to implement certain metadata standards and/or data sharing requirements?
- What is the dispute resolution process and how will disputes be documented?
- When and how will the Science Plan be updated?

Legal & Contractual

Data sharing agreements will be essential for the success of the Science Plan. In order to address the research recommendations in the Plan, the RWSC and/or its partners may need access to data that is not fully public or open. Even if the RWSC does not handle data directly, collaborators working to execute Science Plan projects will need support and guidance to navigate bottlenecks in the Data Ecosystem. The RWSC could provide guidance for research collaborators or model agreements. Below are two key concepts related to data sharing that could be incorporated into legal agreements, and can inform the RWSC when reviewing data agreements from other partners and developing RWSC policies.

Authorized Uses & Users

Limiting how data can be used and who can see and use it can make data contributors comfortable sharing data. This requires not only that the contract specify allowed data uses and users but also that the parties have the capacity to uphold the use restrictions. While Memoranda of Agreement and Understanding (MOAs and MOUs) may talk about high level data purposes, licensing agreements and contracts can be much more specific about:

- Exactly who can access the data: any researcher working on a project at a specific institution, a named individual, or anyone authorized by the data holder
- Time periods for access
- Shareable data products, such as maps or summary analyses, that synthesize data without sharing the underlying datasets. These can be specified in the contract, or they could require approval from the contributor before being released, or be required to include a certain level of anonymization
- Data retention: where data can be stored, for how long
- Ownership and attribution of data products

Risks & Consequences

Once the RWSC has defined its role in supporting the Science Plan implementation, it should develop a Risk Register, or a list of things that could go wrong and what to do if that happens. This is not strictly a legal issue, but some of the risks and mitigations will relate to data sharing. For example, if partners do not keep up data documentation then departures of key technical staff could mean losing access to datasets or servers as well as a loss of institutional knowledge. When data contributors sign an agreement for authorized uses and users, they are saying they will protect against unauthorized access and data misuse. If data are released due to a security breach, that may be a reputational issue for the RWSC. If data are inappropriately released, or used for an unapproved purpose, that may be an issue for the RWSC if it jeopardizes other RWSC work. An inappropriate release could be due to a lack of capacity or a simple mistake by a researcher, such as not understanding a requirement to get prior approval before re-using data in a new journal article. The RWSC should consider how it will handle data risks generally and how it could support data partners in upholding data sharing agreements.

Technical Implementation

Technical implementation of data governance includes data storage and access infrastructure as well as workflows, collaboration and code tools, and information security protections. Technical implementation should support the purpose and legal aspects of governance, not drive them. For the RWSC, which does not plan to host large amounts of data itself, technical implementation will likely focus on tools, processes, and protocols to coordinate data across infrastructure built and maintained by others.

Current Data Infrastructure

The RWSC currently maintains a public database of relevant research activities. The database, an organized set of data structured around data relationships that is stored electronically, includes URLs of research projects, PDFs of reports, data summaries, and other data products. The RWSC is also a partner with the Northeast and Mid-Atlantic Regional Ocean Councils who maintain Ocean Data Portals that provide online visualization and analysis tools. The Data Portals are platforms that house a mix of internally and externally hosted map layers but they generally do not store the underlying data that generated the map layer. This means that many raw datasets cannot be accessed or re-used via the Portals. The Portals have limited access control functionality to support co-development and partner review of draft data products.

Both of these efforts will likely continue for the life of the RWSC, and they provide value for tracking partner research activities and displaying location-specific research results as map layers. However, neither is set up to guarantee quality and re-usability of the data collected to answer the research recommendations in this Science Plan, nor can they fully implement access controls to protect sensitive data over the course of the full data life cycle.

Future Data Infrastructure

Our initial sketch of the Data Ecosystem shows a network of datasets, databases, and repositories. Repositories are centralized data storage and access entities that publish, document, and make data available for use. They are composed of managed and curated databases, datasets, and data products and the associated metadata. For the RWSC to be easily able to connect, use, and re-use data housed in repositories, it should provide guidance on choosing repositories for storing and publishing data for each data type. We provide some general criteria below and the next chapter, on Data Management & Standardization, builds on these, also including specific repository criteria considered by the expert Subcommittees.

Technical Implementation Discussion Topics

- Metadata standards
    - Are data and metadata stored in non-proprietary file formats?

  - Does your metadata enable someone outside your field to reuse your data?
  - Does your metadata meet domain-appropriate standards?
  - How is data provenance documented in the metadata?
- Choosing a repository
  - Will the repository aid in discovering the data by being federated with other repositories, or being the go-to place for that type of data?
  - Does the repository follow the FAIR and CARE principles?
  - Does the repository provide Persistent IDs (ex: DOIs) for published datasets?
  - Does the repository provide clear data reuse guidelines, encourage broadest reuse possible, and measure citation, downloads, and attribution?
  - Is the repository managed for long-term sustainability and availability of data?
- Controlling access to data
  - Will the RWSC data catalog provide restricted access, and is this enough to address data sharing concerns from data partners?
  - If data are published in a repository with embargo capabilities, could RWSC partners access the data before the end of the embargo period?
- Collaboration
  - What tools, methods, and workflows will be used to ensure collaborative work on Science Plan research?
  - Where will code, models and other analytic methods be documented and shared among collaborators?

Recommendations for Governing the RWSC Data Ecosystem in the Future

Create an RWSC Data Governance Subcommittee

This subcommittee would play an essential role in decision making for data governance among RWSC partners. This would be the group that develops the Data Ecosystem map, leads discussions of the concepts in the Purpose & Process, Legal & Contractual, and Technical Implementation sections above. It would also serve as the body that defines the purposes of data sharing, what data is relevant to include in the data catalog (see below), the expected outputs of data sharing among RWSC partners, access to shared data, and sets data standards and management policies (see below).

Standards & Policies

The RWSC does not have the capacity to review and certify all the data sources needed by the Science Plan. However, The Data Governance Subcommittee can build on the recommendations in the Data Management chapter to develop more complete recommendations for existing metadata standards and repositories for each data type being collected. As an incentive for following the recommendations, the RWSC could note in its data catalog or research database whether a project is attesting that it is using one of the RWSC's recommended standards, and could also possibly utilize the built-in standards checking provided by some data catalog or repository service providers such as DataONE[11]. Standardized guidance could also be developed for sensor deployment methods and protocols including detailed information on how to collect and record data (Example: Long-term and Archival Passive Acoustic Monitoring (PAM) Data Management & Storage Best Practices[12]), study design practices and recommendations on statistical power to detect change, and development of standardized data collection sheets that are freely available and domain-specific.

Data Management and Sharing Plans

RWSC standards should include the requirement to create a data management and sharing plan (DMSP) for RWSC-funded projects, and a recommendation to create this plan for projects funded by other sources. Both these efforts would benefit from being informed by a detailed template that would walk a researcher through the general and specific parts of creating this plan. Alternatively, DMSPs mandated by other funders could be shared with RWSC. A DMSP would serve many purposes, such as letting RWSC know that certain data are going to be collected and in what time frame, what methods will be used to collect the data, where those data will be available and when, and how those data might relate to other data in the RWSC Data Ecosystem. In addition, DMSPs outline the steps that will be taken to secure sensitive data throughout the data lifecycle. DMSPs are living documents, and should be updated throughout the research process as personnel, situations, and conditions may change.

Create a data catalog

Data catalogs are detailed collections of metadata that make up a searchable inventory of datasets and products and facilitate data discovery. A data catalog could connect the components of the RWSC Data Ecosystem and enable the discovery and sharing of data funded by the RWSC and/or collected in support of the Science Plan. This would enable RWSC to function as an information hub without having to store data or serve as a data repository. RWSC's current database of associated projects on the website contains information at the project level, but a data catalog would operate at the dataset level. It would display the metadata describing each dataset that is part of the RWSC Data Ecosystem but published in external repositories. For example, an acoustic dataset collected by a government agency might be published in NCEI while a habitat dataset collected by an academic researcher might be published in Dryad, but metadata from both would be included in the RWSC data catalog so that anyone looking for these data could discover them and understand their context within the RWSC Data Ecosystem.

In order for the data catalog to function, RWSC will need to mandate the sharing of metadata for all datasets under its control, as well as provide guidance on metadata standards and formats that should be followed for each data type collected (see above section on Standards & Policy). This guidance should align with the standards and practices already in place in any particular field, domain, or scientific community (ex: using Ecological Metadata Language standards for documenting ecological data). Finally, decisions about which datasets will be made accessible through an RWSC data catalog would follow

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[11] https://www.dataone.org/hosted-repo/

[12] RWSC Marine Mammal Subcommittee, "Data Management & Storage Best Practices for Long-Term and Archival Passive Acoustic Monitoring (PAM) Data - Long-Term and Archival Passive Acoustic Monitoring (PAM) Data," December 14, 2022, https://rwscollab.github.io/pam-data-mgmt/.

from the governance decisions outlined above on data sensitivity and quality, RWSC approval, and Science Plan importance, and would be made by the Data Governance Subcommittee. For further discussion of an RWSC data catalog, please see the chapter on Data Management & Standardization.

Focus on pooling select datasets

A few topics could be selected from the Science Plan where both data sensitivities and the impact of greater data access are likely to be high. This might include site assessment data or construction data collected by developers and consultants that would be valuable for multiple Science Plan analyses. The RWSC could set data sharing agreements for specific set of analyses, with a limited set of researchers, and use a commercial data compliance platform to manage access. The remainder of the Data Ecosystem would be designed by individual data owners, each setting their own infrastructure. This allows the RWSC to leverage its trusted role to enable research and monitoring that may not be possible otherwise.[13]

Project WOW (Wildlife and Offshore Wind), a multi-institutional project led by Duke University and including RWSC, could provide an appropriate case study. As of June 2023, Project WOW is planning to collect wildlife observations and contextual data (e.g., oceanographic variables, recordings of underwater sound) in Wind Energy Areas (WEAs) in southern New England and the New York Bight. Many other entities, including private offshore wind companies, are collecting data in the same timeframe, potentially including additional relevant variables (e.g. additional species, different contextual data) and additional locations. All parties' interpretation of those data could be enhanced by some form of data sharing among all entities. This could take the form of a structured data pool, governed by the RWSC's data policies and those of the contributing data partners, and hosted at by one of the partners or a mutually acceptable third-party host with strong access controls. RWSC could be instructed by the data providers to guide and oversee an independent analysis of the pool of data to help address topics in the Science Plan, creating synthetic data products but not releasing any of the pooled data. Regardless of the outcome of this particular case study, RWSC's role is to identify opportunities for collaborations like this and to provide participants with the forum to discuss and advance options that would further its own mission to coordinate "relevant, credible, and efficient regional monitoring."

Intertidal Agency Bios

Kate Wing, Executive Director

Kate founded Intertidal Agency to work at the intersection of technology, design strategy, and ocean issues. She has more than 20 years of experience in the social sector as an advisor, grantmaker,

[13] Sage Bioneworks offers one example of an organization managing pools of sensitive data. They make their tools for biomedical research data collaborative platforms and programs open and discuss their governance framework in Mangravite et al (2020) *Mechanisms to Govern Responsible Sharing of Open Data: A Progress Report*. https://sage-bionetworks.github.io/governanceGreenPaper/v/3c2a648b892d8c672a3043c4bacda65505947921/

advocate, and consultant. She served as PI on an ocean data sharing research project for the NSF Convergence Accelerator for a Networked Blue Economy. She co-founded the Net Gains Alliance, a coalition supporting data modernization in U.S. fisheries, and helped launch Fishnet.ai, the first open training library of commercial fishing images. She is the co-chair of the Data Committee for the UN Decade of Ocean Science and Sustainability and regularly serves as a mentor for ocean tech accelerators and early career ocean professionals.

Dr. Rachael E. Blake, Director of Data Science

Rachael brings broad experience in marine science, data science, and technical problem solving to Intertidal Agency. She has engaged with diverse stakeholders and interdisciplinary teams while leading data-intensive projects at non-profits and academic research centers. As part of her commitment to continuous learning and open research, she has contributed to software packages that improve reproducibility and developed lessons on data documentation. In addition to her work at Intertidal Agency, she maintains active research collaborations including a long-term analysis of intertidal data from Alaska and studies of global insect biodiversity and invasions, and serves on the Media Committee of the Society for Open, Reliable, and Transparent Ecology and Evolutionary Biology (SORTEE).

Chapter 5: Data Management & Standardization

Summary

Many entities are individually funding and managing data collection and research projects with respect to offshore wind, wildlife, and the ocean ecosystem. To ensure that wildlife and ecosystem data collected in and around offshore wind energy areas (WEAs) can one day be compiled and analyzed holistically to examine patterns and trends across U.S. Atlantic waters, data need to be collected in a standardized way and managed consistently. Data standardization, management, sharing, and storage all need to be funded and implemented intentionally to be effective.

Each RWSC expert Subcommittee compiled information and recommended the use of specific existing repositories and data standards relevant to the methods and data types associated with their focal taxa/topics. There are many existing repositories where scientists can store data and where scientists and the public can access data. These repositories are different from the web mapping interfaces and data portals where users can visualize synthesized and interpreted data products (e.g., regional ocean data portals). Subcommittee members have also expressed the need to develop recommendations around deployment practices, study design, and data collection considerations for several methods and data types where none currently exist.

Recommendations

- Data management plans (DMPs) should be developed for all research and data collection activities related to offshore wind, wildlife, and the environment. DMPs should use the existing repositories and data standards in the RWSC Science Plan identified for each relevant data type. Data management, sharing, and storage, including for both raw data and data products, should be funded components of all research. Experts recommend that these components should make up 10-20% of project budgets.
- Existing repositories should develop and use an Atlantic offshore wind "identifier" to associate with data collected in and around Atlantic WEAs to facilitate data searches.
- RWSC should develop a list of acceptable and trusted digital repositories for offshore wind and wildlife/environment data (similar to this USGS list) for partners and eventual recipients of RWSC funding.
- Stronger recommendations around which repositories should be used for each data type could be made, but most of these recommended existing repositories will need additional funding, capacity, and/or new workflows to accommodate the volume of data being collected with respect to offshore wind, wildlife, and the ocean ecosystem. Specifically:

    - The robust existing data management, storage, and access systems associated with the U.S. IOOS program and IOOS Regional Associations should be leveraged for all oceanographic and meteorological datasets being collected for offshore wind projects and research.
    - NOAA NCEI should consider streamlining the appraisal and approval process for incorporating data collected in WEAs that are funded by entities other than NOAA to ensure that data collection funded by states, offshore wind developers, and other federal agencies can be quickly and efficiently stored at NCEI. This is especially important for the following data types, for which no similar alternative repository was identified:
        - Deep sea coral observations
        - Marine trackline geophysical data (single beam bathymetry, subbottom profiles, magnetic, gravity, side scan sonar)
        - Other hydrographic data (multibeam bathymetry, National Ocean Service hydrographic data, water column sonar data)
        - Marine geology data (surficial sediment grain size and other seabed data)
    - RWSC and the Responsible Offshore Science Alliances (ROSA) should work with the Animal Telemetry Network and the associated regional nodes (ACT, MATOS, FACT) to support coordination and data sharing/access around offshore wind-related animal telemetry projects.
    - OBIS-SEAMAP needs additional capacity to support continued repository/database management and personnel to organize and manage offshore wind-related data.
    - The Northwest Atlantic Seabird Catalog needs additional capacity to build a publicly accessible front-end and digital exploration, access, and submission tools.
    - There are no existing repositories for storing large image files from aerial high-definition cameras, thermal cameras, etc. RWSC should work with partners to develop a solution to enable documentation, sharing, and reuse of imagery data.
- To ensure that all offshore wind and wildlife/environment data are findable and can be re-used, RWSC should adopt metadata standards for each relevant data type, many of which are already in use by partners and within the scientific community.
- RWSC should develop and adopt standards for study design and deployment specific to offshore wind studies for methods and data types where none yet exist. Specific recommendations on this topic are described in each taxa-based chapter of the Science Plan.

Why Data Standardization & Management for this Science Plan?

The U.S. federal agencies, Atlantic coast states, and offshore wind companies are each funding many individual data collection and research activities. A few of those activities are funded collaboratively but the majority are funded, scoped, and managed under the purview of a single funder/entity.

Recognizing that as RWSC and others fund research collaboratively, many will continue to fund data collection and research individually, and these entities requested that the RWSC Science Plan compile resources and information that they can then share with their grantees and contractors about where and how wildlife and environmental data should be collected consistently and stored efficiently. The New York State Energy Research and Development Authority Environmental Technical Working Group (NYSERDA E-TWG) developed Wildlife Data Standardization and Sharing: Environmental Data Transparency for New York State Offshore Wind Energy for a similar purpose. This chapter builds on that work.

Requiring a common set of standards ensures that data collected by disparate entities across U.S. Atlantic waters could one day be collectively analyzed to understand any potential broad-scale changes to wildlife and the ocean ecosystem due to offshore wind development.

To address this request, each RWSC expert Subcommittee made recommendations for existing standards and repositories that funders should require and that researchers should use. When RWSC begins funding research and data collection activities, it will require the development of a Data Management Plan (DMP) that will specify the types of data being collected, any standards used to collect and/or analyze the data, metadata standards,

Benefits of Data Standardization & Sharing

Aside from enabling future pooled regional scale analyses, there are multiple benefits of data standardization and data sharing to individual funders and collaborative efforts.

If data are standardized…	**Benefits individual entities**	**Benefits the collaborative**
Reduced cost for funders of research: funders can refer to standard practices rather than spending time detailing a scope of work, or updating study requirements as science and research technologies advance	✓	✓
Reduced cost/time for data collectors: researchers can use and cite standard practices rather than developing new protocols, and avoid collecting unnecessary or incompatible data	✓	✓
Ensures a standard product: funders can be sure that they paid for "good" data that met a set of community-developed criteria; data can be used in future analyses	✓	✓

More efficient science and management decision-making: access and analyses are faster which streamlines interpretation and use	✓	✓
If data are standardized AND shared openly…	**Benefits individual entities**	**Benefits the collaborative**
Improved data accessibility: data are easily discoverable; funders get visible "credit" for generating data;	✓	✓
Reduction in duplicative research: since all stakeholders have access to the range of studies conducted, it is less likely that redundant data would be collected.	✓	✓

Considerations for Data Repositories

A digital data repository is a location online where data are stored with metadata. As contributors to and users of digital repositories, the Subcommittees identified the following useful characteristics of repositories. Not all existing repositories have all characteristics.

- **Publicly accessible:** Makes the data freely accessible to the public.
- **Public interface:** Has a straightforward public interface that allows users to identify where and what data exist. The interface is also used to upload and/or download data.
- **Funded:** Has a long-term or steady source of funding.
- **Updated frequently:** Is regularly updated.
- **Searchable:** Is easily searchable; robust and relational.
- **Ability to embargo:** Allows contributors to specify embargo periods where data may be discoverable but not downloadable to allow the author(s) time to publish analyses and results, for example; this functionality may also include provider-defined terms of use and citation.
- **Metadata standards:** Provides explicit instructions for the metadata that needs to be conveyed and stored with the data.
- **Contextual data:** Accommodates, incorporates, or links to relevant associated data (e.g., effort data, environmental and meteorological data).
- **Offshore wind identifier:** Provides or can provide a specific data entry identifier for data collected in associations with offshore wind research.
- **QA/QC services:** Has access to a repository/database manager who conducts effective Quality Assurance/Quality Control practices as part of routine data maintenance.

- **Data visualizations:** Provides basic data product/visualization development features so that those without an in-depth statistical background can understand basic results/outcomes.

Initial Review of Repositories Relevant to RWSC

The following digital data repositories are being considered for long-term archival storage and sharing of the various datasets being collected with respect to offshore wind, wildlife, and the ocean ecosystem based on their existing functionality and user-base.

Prior to preparing and sending data to one of these repositories for long-term/archival storage and sharing, researchers may require an interim solution for internal or limited data sharing and use before projects are completed and while data collection and analysis is ongoing.

For its eventual grantees, RWSC should consider establishing a dedicated hosted repository to store work plans, scopes of work, raw data, draft data products, metadata, and all interim/draft deliverables produced with RWSC funding for ongoing projects. Once the projects are completed, the data could stay in the hosted repository and/or be uploaded to one of relevant repositories below for permanent archiving and storage with other like datasets.

One option for an RWSC dedicated hosted repository is DataONE, which is a network of data repositories operated by research centers, universities, non-profit organizations, citizen science initiatives, government and non-government organizations, etc. Member institutions share data and infrastructure with DataONE and in return, DataONE facilitates user access to data and interoperability between members. Data access can be controlled based on the needs of the data provider and collaborative, and digital object identifiers can be assigned to each datasets and product to facilitate proper use and citation. The NOAA National Centers for Environmental Information (NCEI) and USGS Science Data Catalog are notable government members of the DataONE network.

Relevant taxa/topics -------------------- **Method(s) and data type(s)**	**Repository**	**Features** ● yes ◗ partially ○ no
Habitat & ecosystem Satellite remote sensing, water quality and oceanography, seafloor acoustics, active acoustics and echosounders, sediment grabs	**NOAA National Centers for Environmental Information (NCEI)**: NCEI provides archive services for much of the data collected by NOAA scientists, observing systems, and research initiatives. Stored data products include coastal elevation models, coastal water temperature and sea surface temperature, global ocean currents, water column sonar, multibeam bathymetry, trackline geophysical and National Ocean Service hydrographic data, seafloor sediment grain size data, deep sea corals, and passive acoustic data (see next entry). Data collected without NOAA funding or support must go through a scientific appraisal process to be considered for	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ◗ Ability to embargo ● Metadata standards ● Contextual data ○ Offshore wind identifier ◗ QA/QC services

Relevant taxa/topics ------------------ Method(s) and data type(s)	Repository	Features ● yes ◗ partially ○ no
	the archive, and is subject to the NESDIS non-NOAA data policy upon approval.	● Data visualizations
Marine mammals, fish, habitat & ecosystem Raw passive acoustic data and passive acoustic data products (ambient noise metrics, species detections)	**NOAA NCEI Passive Acoustic Data Archive:** Archived passive acoustic datasets are made publicly available for search, discovery, and access through a web-based map viewer. The PassivePacker software tool simplifies data submission to the archive. The software packages the data into standardized structures and creates machine-parsable JavaScript Object Notation (JSON) metadata records. Data providers then send these data packages to NCEI. There is a ~$145/TB cost associated with archiving data at NCEI to support long-term data stewardship that meets the National Archives and Records Administration standards. The PassivePacker webpage includes a manual found under 'Help' for comprehensive data submission guidance specific to passive acoustic data. It is requested that data be sent to NCEI within a year of retrieval. If an embargo is needed past that time to delay public access until after publication, NCEI may be able to provide that service.	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards ○ Contextual data ○ Offshore wind identifier ◗ QA/QC services ○ Data visualizations
Marine mammals, fish Passive acoustic data products (e.g., ambient noise metrics and species detections)	**NOAA Passive Acoustics Reporting System**: All confirmed passive acoustic detections of target species/species, whether from archival or real-time data, are archived in a publicly accessible location. For the U.S. East Coast, all species detection data and ambient noise metrics should be reported to the Northeast Passive Acoustic Reporting System via nmfs.pacmdata@noaa.gov. Formatted spreadsheets that follow ISO standards with required detection, measurement, and metadata information are available for submission purposes. When PAM is used for long-term monitoring, all data (detection data, metadata, GPS data, and ambient noise data) should be provided via the formatted spreadsheets and uploaded within 90 days of the retrieval of the recorder or data collection. The data will be displayed on the Passive Acoustic Cetacean Map. Recorder locations will be shared with the RWSC Marine Mammal Subcommittee, Northeast Ocean Data Portal, and Mid-Atlantic Ocean Data Portal.	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ○ Ability to embargo ● Metadata standards ○ Contextual data ○ Offshore wind identifier ○ QA/QC services ● Data visualizations
Marine mammals, sea turtles, birds, fish Observational surveys; telemetry data; acoustic	**OBIS-SEAMAP** (Ocean Biogeographic Information System – Spatial Ecological Analysis of Megavertebrate Populations): A thematic node of the Ocean Biodiversity Information System (OBIS), OBIS-SEAMAP is a spatially, temporally interactive online database for marine mammal, sea turtle, seabird and ray & shark observation data. The website includes mapping tools, data extraction / data download, visualization tools, and	● Publicly accessible ● Public interface ◗ Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards

Relevant taxa/topics ------------------- Method(s) and data type(s)	Repository	Features ● yes ◗ partially ○ no
monitoring; photo identification; oceanographic data products; model outputs	quantification of effort data. BOEM recommends that survey data for marine mammals are shared via OBIS-SEAMAP. OBIS-SEAMAP Model Repository is the host for marine mammal and sea turtle individual species models covering U.S. Atlantic waters produced by Duke University and the U.S. Navy, respectively. It also hosts several other protected species model collections covering other geographies around the world (e.g., Arctic, Mediterranean). OBIS-SEAMAP website also hosts instructions for minimum required data fields, acceptable formats, a data sharing policy with multiple sharing options, and methods for submitting data to the archive.	● Contextual data ○ Offshore wind identifier ○ QA/QC services ● Data visualizations
Habitat & ecosystem Water quality and oceanography	**U.S. Integrated Ocean Observing System Regional Data Assembly Centers (IOOS Regional DACs):** There are three IOOS Regional DACs in the RWSC Study Area associated with each IOOS Regional Association - NERACOOS, MARACOOS, and SECOORA. The Regional DACs provide data assembly, quality control, discovery and access services for marine data collected by State, Local, Tribal governments, academia, and industry in each region. Inclusion of an observing asset in a Regional DAC is not limited to assets funded through IOOS RAs cooperative agreements or the federal government. For example, MARACOOS has served data from offshore wind companies' metocean buoys. All Data Management and Communications (DMAC) services in use in each region and all the data sets they publish are registered in the IOOS Catalog/Service Registry. Data served are collected from platforms such as buoys, gliders, radar, and satellites, and include oceanographic and meteorological variables like surface currents and waves, sea surface temperature, wind speed, chlorophyll-a fluorescence, and climatologies, forecasts, hindcasts, and other models of oceanographic variables.	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ? Ability to embargo ● Metadata standards ● Contextual data ○ Offshore wind identifier ● QA/QC services ● Data visualizations
Habitat & ecosystem Water quality and oceanography	**Glider Data Assembly Center (DAC):** The Glider DAC is a "Functional DAC" within the U.S. IOOS program. Its purpose is to provide glider operators with a simple process for submitting glider datasets to a centralized location, enabling the data to be visualized, analyzed, widely distributed via existing web services and the Global Telecommunications System (GTS) and archived at the National Centers for Environmental Information (NCEI). Currently, the IOOS Regional Associations (RAs), which conduct a combination of routine, sustained, and event driven monitoring, are the main contributors to the IOOS glider DAC. The gliders displayed have	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ? Ability to embargo ● Metadata standards ● Contextual data ○ Offshore wind identifier ● QA/QC services

Relevant taxa/topics -------------------- Method(s) and data type(s)	Repository	Features ● yes ◗ partially ○ no
	been funded by U.S. IOOS, NOAA, ONR, NSF, EPA, various universities, state agencies and industries. Gliders collect oceanographic information and may also be outfitted with biological sensors such as echosounders for prey field data collection or hydrophones for passive acoustic monitoring.	● Data visualizations
Habitat & ecosystem -------------------- Water quality and oceanography	**High Frequency Radar Data Assembly Center (DAC):** The HF Radar DAC is a "Functional DAC" within the U.S. IOOS Program. IOOS operates the nation's only HF radar network, providing real-time information on the speed and direction of surface currents. This network supports search and rescue operations, response to oil spills, marine shipping navigation, monitoring and tracking harmful algal blooms and coastal water quality monitoring. The data are also routinely ingested into oceanographic models. The network currently consists of approximately 140 radars in nearly every coastal state plus Puerto Rico. MARACOOS coordinates data management for the Mid-Atlantic HF Radar Network which consists of 40 radars operated by eight separate organizations. SECOORA coordinates data management for approximately a dozen HF radar site in the southeastern U.S. Atlantic coast.	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ? Ability to embargo ● Metadata standards ● Contextual data ○ Offshore wind identifier ● QA/QC services ● Data visualizations
Marine mammals, sea turtles, birds, fish -------------------- Satellite tagging data; acoustic tagging data through the regional nodes ACT-MATOS and FACT	**Animal Telemetry Network** (ATN): The Animal Telemetry Network Data Assembly Center (ATN DAC) is a "Functional DAC" within the U.S. IOOS program. It is designed to serve as an access point to search, discover and access animal telemetry data, and associated oceanographic datasets, from a wide variety of species and platforms. ATN has implemented a multi-year program funded by the Office of Naval Research which will pay for the cost of Argos satellite tracking services for marine animal telemetry researchers who agree to submit their data and metadata to ATN's DAC. The DAC provides a secure data access and analysis space for researchers, while offering public visualizations of tracks and data archiving following user-specified embargo periods. Visit https://portal.atn.ioos.us/ to access the map-based inventories. The ATN website includes instructions for how to submit data and metadata to the ATN DAC.	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards ● Contextual data ○ Offshore wind identifier ○ QA/QC services ● Data visualizations
Marine mammals, sea turtles, birds, fish -------------------- Acoustic tagging data	**FACT Network:** The FACT Network includes state and federal wildlife agencies, universities, not-for-profit and private marine research organizations operating throughout east Florida, Georgia, the Bahamas and Caribbean. FACT partners have acoustic receivers deployed along a continuum of habitats including tidal rivers, estuaries, ocean inlets, the surf zone, as well as offshore coral reefs and wrecks. The FACT Network uses a cloud-based data sharing platform called the	○ Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards

Relevant taxa/topics ------------------- Method(s) and data type(s)	Repository	Features ● yes ◗ partially ○ no
	FACT Node. Designed by the Ocean Tracking Network and supported by SECOORA, the FACT Node operates independently but is connected to other OTN-designed nodes to allow for cross-matching of tags to receiver detections. Thus, if you already report your data to an OTN-designed node (e.g. the ACT Network, OTN, Migramar, Pirat) you do not need to submit your data to the FACT Node. You are still considered a scientific member of FACT if you submit your data to another node as long as you have registered with FACT. The FACT Data Team processes uploaded datasets files semi-annually through the FACT Node and deposits detection extracts back into the folder. FACT accepts data from current projects and historic projects. FACT maintains instructions and best practices for uploading data and metadata, and provides a number of data templates.	○ Contextual data ○ Offshore wind identifier ○ QA/QC services ● Data visualizations
Marine mammals, sea turtles, birds, fish ------------------- Acoustic tagging data	**Atlantic Cooperative Telemetry Network (ACT Network):** The ACT Network has a data portal called ACT-MATOS. This database is a secured way to archive acoustic telemetry data and match transmitter detections between researchers. This database is an Ocean Tracking Network (OTN) affiliated node meaning it is connected with other OTN nodes, such as OTN and the FACT Network. Researchers create a publicly available project page where they have the ability to set visibility permissions regarding the raw data uploaded to their project page. To upload metadata to the network, members are provided a standardized template with specific required fields (downloaded from the database portal website). MATOS allows telemetry researchers to store and share data on acoustic receiver deployments, tag detections, and tag deployments with individuals of their choosing. MATOS users who have uploaded tag deployment data can search the MATOS receiver database to find out where their tags have been detected. The system's mapping capabilities allows users to visualize animal movement.	○ Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards ○ Contextual data ○ Offshore wind identifier ○ QA/QC services ● Data visualizations
Birds ------------------- Aerial visual, boat-based visual, stationary visual, imagery	**Northwest Atlantic Seabird Catalog:** Several bureaus within the Department of Interior compiled available information from seabird observation datasets from the Atlantic Outer Continental Shelf into a single database, the Northwest Atlantic Seabird Catalog, with the goal of conducting research and informing coastal and offshore planning activities. Currently, NOAA NCCOS is maintaining the database with support from BOEM. As of September 2022, the database contains 285 datasets from Maine to Florida from 1906-2020 with over 1 million records of seabird observations. Each observation record has a unique point location, date and time,	○ Publicly accessible ○ Public interface ◗ Funded ● Updated frequently ○ Searchable ? Ability to embargo ○ Metadata standards ○ Contextual data ○ Offshore wind identifier ○ QA/QC services

Relevant taxa/topics ------------------- Method(s) and data type(s)	Repository	Features ● yes ◗ partially ○ no
	species, and count. There may also be biological information related to sightings, such as animal age or behavior. The survey conditions (e.g., weather variables) may have been recorded for each individual observation but was more often recorded at the transect (line along which the plane or boat traveled) level. The dataset contains data primarily for seabirds, but some accompanying submissions were not discarded: marine mammals, turtles, fish, boats, fishing gear, and trash.	○ Data visualizations
Marine mammals, sea turtles, fish ------------------- Observational data; Photography	**North Atlantic Right Whale Consortium** (NARWC): The Sightings Database houses North Atlantic right whale and other marine mammal, sea turtle, and large fish/shark sightings data (opportunistic and structured survey data) from the 1970s-present. The North Atlantic Right Whale Catalog (Identification Database) houses photographs of right whales from 1935-present. Data and metadata submission guidelines are available on the website. BOEM recommends that all right whale data are shared via NARWC databases.	○ Publicly accessible ○ Public interface ● Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards ○ Contextual data ○ Offshore wind identifier ● QA/QC services ○ Data visualizations
Marine mammals, birds, bats, sea turtles, fish ------------------- Satellite tagging, Acoustic tagging, VHF tagging, other tagging	**Movebank**: A free, online database of animal tracking data and other data collected by sensors on animals meant to help animal tracking researchers to manage, share, analyze and archive their data. Researchers can use Movebank to share their animal tracking data with the public or with other registered users. Data providers can add data to one or more studies, which can be set up to ingest near real-time feeds or archived data. Users can link remotely sensed environmental data from multiple sources to tracking data in the interface. There are several documents to explain and guide decisions around adding and sharing data and metadata.	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards ● Contextual data ○ Offshore wind identifier ● QA/QC services ● Data visualizations
Sea turtles ------------------- Stranding data, incidental capture, nesting	**Sea Turtle Stranding and Salvage Network (STSSN):** Formally established by NOAA Fisheries in 1980 to document strandings of sea turtles along the coastal areas from Maine to Texas and in portions of the U.S. Caribbean. The Network is a cooperative effort comprised of federal, state, and permitted private partners working to inform causes of morbidity and mortality in sea turtles by responding to and documenting sea turtles, found either dead or alive (but compromised), in a manner sufficient to inform conservation management and recovery. The STSSN accomplishes this through the following: • Collection of data in accordance with STSSN protocols	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards ○ Contextual data ○ Offshore wind identifier ○ QA/QC services

Relevant taxa/topics **------------------** **Method(s) and data type(s)**	**Repository**	**Features** ● yes ◗ partially ○ no
	• Improved understanding of causes of death and threats to sea turtles in the marine environment. • Monitoring of stranding trends. • Provision of initial aid to live stranded sea turtles. • Provision of sea turtle samples and parts for conservation-related research. • Availability of timely data for conservation management purposes. Each state's Sea Turtle Stranding and Salvage Network collects and contributes data to a centralized database. Summarized stranding data from the last 10 years that have been verified by STSSN personnel are available via the Sea Turtle Stranding and Salvage Network Data Summary and Visualization Application.	● Data visualizations
Birds and bats VHF tagging	**Motus – Atlantic Offshore Wind:** The Motus Wildlife Tracking System is an international collaborative network of researchers that use automated radio telemetry to simultaneously track hundreds of individuals of numerous species of birds, bats, and insects. The system enables a community of researchers, educators, organizations, and citizens to undertake impactful research and education on the ecology and conservation of migratory animals. When compared to other technologies, automated radio telemetry currently allows researchers to track the smallest animals possible, with high temporal and geographic precision, over great distances. A project team from the U.S. Fish & Wildlife Service, Biodiversity Research Institute, University of Rhode Island, Applied Physics Systems LLC, and Birds Canada, with funding from the New York State Energy Research and Development Authority (NYSERDA) developed a series of interrelated products to guide and inform the deployment of automated radio telemetry technology in relation to offshore wind energy development in the U.S. Atlantic.	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards ● Contextual data ● Offshore wind identifier ● QA/QC services ● Data visualizations
Bats Colony counts, acoustic detection data, captures	**NABat (North American Bat Monitoring Program):** NABat is a multi-national, multi-agency coordinated bat monitoring program across North America. This collaborative bat monitoring program is made up of an extensive community of partners across the continent who use standardized protocols to gather data that allow us to assess population status and trends, inform responses to stressors, and sustain viable populations. Most if not all of the standards relate to onshore bat data collection and would need to be adapted for offshore monitoring. NABat maintains a database and Partner Portal that enables users to upload, archive, and access their own	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards ● Contextual data ○ Offshore wind identifier ● QA/QC services

Relevant taxa/topics ------------------ Method(s) and data type(s)	Repository	Features ● yes ◗ partially ○ no
	data or request data from other NABat partners. The Partner Portal also features a variety of web-based tools to assist users in project planning and mapping. The NABat Coordinating Office publicly shares the inventory of database holdings on the Partner Portal. The data summaries on the Partner Portal convey the volume and type of data housed in the database and available to request. These summaries include the number of cells sampled and species detections each year by survey type and by species within a filtered area of interest, delineating between ambiguous detections and confirmed detections. The summaries do not include or give access to project specific details, specific location details, or row level data. The purpose of these data summaries is to allow users to explore the diversity and volume of data available by request in the NABat database.	● Data visualizations
Bats ------------------ Acoustic detection data	**BatAMP (Bat Acoustic Monitoring Portal):** provides a centralized, web-based system that allows users to upload, visualize, share, and aggregate data derived from acoustic monitoring projects. BatAMP builds upon the core capabilities of the Data Basin platform, which allows users to upload spatial datasets across a variety of formats, including spreadsheets with spatial coordinates; participate in the BatAMP group and other groups, as well as create your own group workspace; use feature-rich mapping and data visualization tools; and aggregate datasets from multiple contributors to create a growing database of bat monitoring data. These data are then compiled for visualization in the companion Bat Acoustic Monitoring Visualization Tool.	● Publicly accessible ● Public interface ● Funded ● Updated frequently ● Searchable ● Ability to embargo ● Metadata standards ○ Contextual data ○ Offshore wind identifier ○ QA/QC services ● Data visualizations

The role of regional portals

Northeast & Mid-Atlantic Regional Ocean Data Portals

Two regional ocean data portals "Portals" overlap the RWSC study area – the Northeast and Mid-Atlantic Regional Ocean Data Portals – and are operated by RWSC co-host entities the Northeast Regional Ocean Council and the Mid-Atlantic Regional Council on the Ocean.

The Portals have hosted thousands of marine life and habitat data products covering much of U.S. Atlantic waters for nearly a decade. The products were developed in collaboration with expert working groups and decision-makers in both regions. Most of the membership of these working groups is now captured in the RWSC expert Subcommittees (which have expanded to include experts in additional species and geographies). The products available via the Portals have been used to inform a range of ocean planning and management issues including but not limited to offshore wind.

The Portals are platforms where marine life and habitat data products can be viewed along with thousands of additional layers that show the footprint of ocean uses over time (including offshore wind planning and project level data) or downloaded and used by anyone in analyses or other studies. The Portals do not store, archive, or provide access to the underlying data that produce the map layers (i.e., model outputs) displayed on Portal maps or available in the Portal for download. Instead, the underlying data have been stored in several of the repositories listed in the previous section (e.g., OBIS-SEAMAP [observations and model repositories], Northwest Atlantic Seabird Catalog, IOOS RAs).

For all data products that can be viewed and downloaded from the Portals, the Portals provide metadata and other relevant documentation (e.g., published papers or reports) that describe the source data, methods used to produce the products, how products were reviewed and by whom, and any recommended limitations to the use of the data products.

The Portals will continue to provide and maintain data products depicting the footprint of ocean resources and uses for scientists, decision-makers, and the public, including for marine life, habitats, and offshore wind. For RWSC participants, the Portals can be leveraged by accessing up-to-date offshore wind planning and lease areas as well as project-level design data provided by the Bureau of Ocean Energy Management (BOEM) for the purposes of research planning. RWSC also expects that participants may use the Portals to review draft data products and results on password-protected versions of each website with each other and with experts, and eventually to disseminate the results of research and data collection activities that are ready to be shared with decision-makers and the public.

U.S. Integrated Ocean Observing System Regional Associations

Three IOOS Regional Associations (RAs) overlap with the RWSC study area: NERACOOS, MARACOOS, and SECOORA. The RAs have strong ties to the research community and are leaders in collecting, standardizing, managing, and disseminating real- and near-real time data. Each maintains a data portal that focuses on the RAs' specific strengths and local partnerships.

The East Coast RA's websites and portals provide access to dynamic ocean/coastal data and products, including model predictions. Behind the RAs' websites, the U.S. IOOS Program maintains a robust Data Management and Cyberinfrastructure core capability with requirements and specifications related to open data sharing, storage and archiving, registration, and publishing. In addition to data collection spearheaded by the RAs, many additional data sets from other sources are leveraged, quality controlled to meet federal standards, and served in standard formats to the wider community.

Some of the IOOS RAs have been collaborating with offshore wind developers to collect, store, and serve oceanographic and meteorological data being collected in WEAs.

Existing standards for metadata, data collection, and analysis

The Subcommittees compiled specific existing standards related to their taxon/topic of expertise, some of which have been specifically developed for offshore wind and wildlife/environment research. All of the protocols below provide metadata standards, and some provide additional standards for study design, data collection, and/or analysis.

Relevant taxa/topics -------------------- **Method(s) and data type(s)**	**Standard**
Marine mammals Passive acoustic monitoring - archival	RWSC Data Management and Storage Best Practices for Long-term and Archival Passive Acoustic Monitoring Data, RWSC Marine Mammal Subcommittee
Birds & bats VHF tagging	Monitoring Protocols and Guidance for Automated Radio Telemetry Studies at Offshore Wind Farms: includes deployment guidance, station calibration tool, study design tool, workflows to archive and serve tag detection data, station data, standardized metadata, and summary reports; U.S. Fish and Wildlife Service, Biodiversity Research Institute, University of Rhode Island, Applied Physics Systems, LLC, Birds Canada
Marine mammals, Birds & bats, Sea turtles, Fish Animal telemetry data (primarily)	Archiving in the Movebank Data Repository: archiving, DOI assignment, licensing, submission guidelines
Bats Acoustics, counts, capture data	North American Bat Monitoring Program (NABat) Metadata templates, USGS
Birds Visual - boat-based and Visual – aerial	Guidance for Pre- and Post-Construction Monitoring to Detect Changes in Marine Bird Distributions and Habitat Use Related to Offshore Wind Development (in development), New York State Energy Research & Development Authority Environmental Technical Working Group (NYSERDA E-TWG), U.S. Fish and Wildlife Service, Bureau of Ocean Energy Management
Marine mammals, Birds & bats, Sea turtles, Fish Observational surveys; telemetry data; acoustic monitoring; photo identification; oceanographic data	OBIS-SEAMAP minimum data fields and acceptable formats, Duke Marine Geospatial Ecology Lab

Relevant taxa/topics -------------------- Method(s) and data type(s)	Standard
products; model outputs	
Marine mammals, Birds & bats, Sea turtles, Fish Animal telemetry, passive acoustic monitoring, active acoustics, imagery, optics	Marine Biodiversity Observation Network (MBON) Data and File Formatting Recommendations, U.S. IOOS / MBON
Marine mammals, Birds & bats, Sea turtles, Fish Satellite telemetry data (primarily)	Animal Telemetry Network DAC Data Management Policy Guidance: includes data submission requirements and instructions for submitting project-level metadata and deployment records via an app and by using Research Workspace.
Marine mammals, Birds & bats, Sea turtles, Fish Acoustic telemetry data (primarily)	FACT Network Metadata Template, SECOORA
Habitat & ecosystem Satellite remote sensing, water quality and oceanography, seafloor acoustics, active acoustics and echosounders, sediment grabs	ISO 19115 XML Metadata standard, required by NOAA National Centers for Environmental Information (NCEI) and U.S. Integrated Ocean Observing System (IOOS)
Habitat & ecosystem Seafloor geophysical data	(Draft) Standard Ocean Mapping Protocol, Interagency Working Group on Ocean and Coastal Mapping for the National Ocean Mapping, Exploration, and Characterization Council

Other relevant metadata standards that were not specifically identified by expert Subcommittees:

EML (Ecological Metadata Language)

- Required by the Environmental Data Initiative, which is a member repository of DataONE
- Standard for documenting ecological and environmental data in many ecosystems

Darwin Core

- Used by MBON and IOOS communities
- A specification of Dublin Core for biodiversity data
- https://github.com/tdwg/dwc

Chapter 6: Technology

Authors: RWSC Technology Subcommittee (← click to view roster)

Introduction

The RWSC Steering Committee identified the need for a Technology Subcommittee to provide a forum for wildlife and marine science experts to discuss potential applications, key questions, and challenges related to the use of technology in wildlife/environment monitoring with members of the tech-startup, marine technology, and ocean engineering communities.

This Subcommittee, first convened in April 2023, is building off and includes membership from existing groups and efforts to test and advance technology with respect to offshore wind and wildlife/environment monitoring:

> **National Offshore Wind Research & Development Consortium (NOWRDC):** a nationally focused, not-for-profit organization collaborating with industry on prioritized R&D activities to reduce the levelized cost of energy of offshore wind in the U.S. while maximizing other economic and social benefits. The Consortium is focused on, but not limited to, technology advancement in each of three initial research pillars: Offshore Wind Farm Technology Advancement; Offshore Wind Power Resource and Physical Site Characterization; and Installation, Operations and Maintenance, and Supply Chain.
>
>> **Technology needs for scientifically robust wildlife monitoring and adaptive management:** A project conducted by Advisian and the Biodiversity Research Institute, funded by NOWRDC. This project, which culminates in August 2023, will make targeted recommendations for technology development around priority questions with respect to marine mammals and birds in the Atlantic, Pacific, and Great Lakes for fixed and floating offshore wind projects.
>
> **Tethys Wind Energy Monitoring and Mitigation Technologies Tool:** A free, online tool to catalog monitoring and mitigating technologies developed to assess and reduce potential wildlife impacts resulting from land-based and offshore wind energy development. WREN (Working Together to Resolve Environmental Effects of Wind Energy) will continuously maintain and update the research status of technologies to ensure the international community has access to current, publicly available information on monitoring and mitigation solutions, their state of development, and related research on their effectiveness. Reviewed on an annual basis.
>
> **Offshore Wind Innovation Hub:** The New York-based Offshore Wind Innovation Hub was launched by Equinor, together with its partner bp. The hub will facilitate partnerships with start-ups that bring new technological solutions to the rapidly growing US offshore wind industry. The initiative will begin as a three-year partnership between Equinor, the Urban Future Lab at the NY Tandon School of Engineering, and NOWRDC, supported by New York City Economic Development Corporation.

Greentown Labs Go Energize 2023: Greentown Labs, the largest climate tech incubator in North America, and Vineyard Wind, developer of the first utility-scale offshore wind farm in the United States, are collaborating on Greentown Go Energize 2023, a program supported by the Massachusetts Clean Energy Center, aimed at startups that are innovating solutions for offshore turbine monitoring and ecological data collection, as well as digital solutions to improve turbine efficiency and longevity.

Technology Subcommittee members representing these existing initiatives and others from states, federal agencies, eNGOs, offshore wind companies, consulting companies, and the research community, identified the following high-level themes for their future work. The purpose of this chapter is to further frame these themes and identify near-term actions to advance them.

1. Technology advancements provide the potential to accelerate multiple phases of offshore wind development by improving our ability to anticipate, detect, and mitigate potential impacts to wildlife and the ecosystem.
2. There are three categories of interest to the Subcommittee where new technologies need to be tested and applied: monitoring, mitigation, and data management. Many projects are already being funded to test and/or advance new technologies for the purposes of offshore wind and wildlife/environment within these categories, and the Subcommittee should continue to track the implementation and results of such projects.
3. There is a need to develop criteria to evaluate the effectiveness of new technology with respect to "traditional methods" or other new technologies.

1. Technology advancements to accelerate offshore wind development while ensuring minimal impacts to wildlife and the ecosystem

Several members of the Subcommittee felt strongly that the testing and advancement of new technologies should be focused on enabling faster timelines for multiple phases of offshore wind development, including permitting and mitigation during construction. Technologies that would address this goal include:

- Predictive modeling
- Systems that improve wildlife detection rates in both space and time, allowing for more rapid mitigation responses
- Tools and systems that deter wildlife or mitigate potential stressors such as noise, electromagnetic fields, entanglement, and physical disturbance

Other applications of technology that are of interest to the Subcommittee include the advancement of long-term monitoring methods and streamlining research data collection. Given the scale of proposed offshore wind development, experts noted that consistent data collection across the RWSC study area will be more attainable with the adoption of new technologies. Already, tools like gliders and un-crewed systems (air and water) are covering more ground offshore than would be possible with traditional ship-based sampling or fixed-bottom sensors. The Subcommittee emphasized the need to continue employing both traditional methods and new technologies for validation purposes and when the traditional methods provide additional context or data that new technologies cannot provide.

The Technology Subcommittee acknowledges that as investments in new technologies continue, there is a need for new approaches to be objectively tested for their efficacy and value over traditional methods. The Subcommittee expressed a goal to advance a multi-sector discussion and development of criteria for technology evaluation. The next section of this chapter describes ongoing, pending, and recommended projects that are advancing and testing new monitoring, mitigation, and data management technologies. Following that inventory, the Subcommittee presents high-level categories under which specific metrics for technology performance evaluation could be developed.

2. Ongoing, pending, and recommended activities within the three categories of technology applications

The Technology Subcommittee identified three categories of new technology where testing and evaluation may be needed: monitoring, mitigation, and data management. Many projects are already being funded to test and/or advance new technologies with respect to offshore wind and wildlife/environment within these categories. This section summarizes those efforts and presents recommendations from the Subcommittee for additional work.

The applications of accepted technologies and methods for monitoring, mitigation, and data management (e.g., add examples here, like gliders) are described in each of the taxa-based chapters that follow in this Science Plan. This Technology chapter describes only those tools and methods that are still undergoing evaluation for usefulness and efficacy.

Monitoring

Monitoring activities include the required and voluntary data collection activities that seek to characterize wildlife presence, distribution, abundance, behavior, movement, and health, as well as benthic and pelagic habitat features that could be affected by offshore wind development or drive changes in species presence, distribution, abundance, behavior, movement, and health.

Ongoing and pending projects testing new monitoring technologies

Technology being advanced	**Project name**
Use of UAVs to apply tags	Digital acoustic tagging of sei whales (a component of a larger BOEM study into the Spatial and Acoustic Behavior of Endangered Large Whales)
Machine learning/AI image classification	Automated Detection and Classification of Wildlife Targets in Digital Aerial Imagery – Phase II (BOEM, USGS, USFWS, UC Berkeley)

Technology being advanced	Project name
	Using Artificial Intelligence to Study Protected Species in the Northeast
Automated classification of thermal images	Thermal camera marine mammal automated detection project (Stony Brook University)
3D real-time flight track imaging with remote data transfer	ThermalTracker-3D (PNNL; CA report)
Radar that can be deployed on unstable platforms like buoys	Offshore Biological Radar Project (PNNL/USGS)
eDNA	Developing Best Practices and Applying Environmental DNA (eDNA) Tools and in Support of Assessing and Managing Living Marine Species in an Ecosystem-based Context (BOEM, NOAA NEFSC, Smithsonian) Developing and testing sea turtle specific eDNA assays Contribution to validate environmental DNA (eDNA) to identify the presence of certain marine species Maine eDNA
Use of UAVs to collect biological samples	Project WOW Integrated Regional Ecosystem Studies: Opportunistic behavioral research study
Uncrewed systems to conduct seafloor mapping	Gulf of Maine Seafloor Mapping to Inform Wind Energy Planning, Habitat Characterization, and Fisheries Management (NOAA Uncrewed Systems Operations Center)
Autonomous technology/platforms	Developing next-generation autonomous robotic technology (WHOI)
Real-time marine monitoring	Float-and-fly drones (LevantaTech)

Recommended projects for testing new monitoring technologies

The following recommendations have been compiled from each taxa-based chapter in this Science Plan. For more detail around the ongoing, pending, and recommended technology advancements associated with each wildlife taxon or habitat topic, review the "Technology advancement" sections in each chapter.

- Cross-taxa
  - Improve analysis of monitoring data through artificial intelligence, automated acoustic, and image processing, and near real-time data availability.
- Marine mammal-specific
  - Develop integrated monitoring and mitigation systems within wind facilities that leverage and advance new technologies. This includes "smart" mitigation methods triggered by marine mammal presence, quieting technologies, and potentially sharing real-time observations online.
  - Explore and expand the use of satellite data, unmanned systems (gliders or autonomous underwater vehicles) and emerging technologies (e.g., eDNA) for marine mammal distribution and habitat use; Develop and deploy safe long

duration satellite tagging telemetry technology for tracking high-resolution movements of marine mammals in and around offshore wind structures.
    - Advance, evaluate, and apply new technologies to better detect marine mammals where they occur, including using infrared cameras or laser detection (on ships or other platforms).
- Sea turtle-specific
    - Develop and test safe long term external attachment and/or internal insertion methods for acoustic tags on sea turtles
    - Develop and test smaller tags with depth sensors capable of surface time calculations for availability bias calculations in small juvenile turtles
    - Develop and test longer term (non-archival) tags and/or tag attachment techniques with low drag for capture/release in difficult (offshore) environments
    - Develop and test remote tag attachment techniques for in water work, especially for hard-shelled turtles
- Bird-specific
    - Test and validate turbine-scale detection systems including radar quantification of passage rates, passive acoustic detection of nocturnal migrants, and cameras to record behavior in the rotor-swept zone
    - Pilot studies that test similar detection technologies at multiple facilities should be coordinated and results should be shared.

Mitigation

Mitigation measures for wildlife in offshore wind energy development encompass the entire project lifecycle including site selection, construction noise reduction, collision risk mitigation, and habitat restoration.

Advancements in monitoring technologies can facilitate improvements to mitigation measures by better predicting where species may be distributed in space and time, improving real-time species detection, and by dampening potential impacts when they are unavoidable. For example, integrating passive acoustic monitoring, radar systems, and unmanned aerial vehicles could enable an above-and-below water 3D real-time monitoring capability, which could lead to faster adaptive management. Artificial intelligence and machine learning techniques offer the potential to enhance species detection and identification, potentially improving the speed of mitigation applications.

While progress has been made in mitigating the impact of offshore wind farms on wildlife, challenges remain. Standardization of mitigation practices, stakeholder engagement, and continuous research are vital for further improvements. Additionally, the cost-effectiveness of mitigation measures needs to be carefully evaluated to ensure their feasibility in large-scale projects.

Ongoing and pending efforts to apply and test mitigation technologies

Mitigation measure	Technologies	Projects or efforts applying and/or testing these technologies
Enhanced species detection	Thermal cameras; artificial intelligence	Thermal camera marine mammal automated detection project (Stony Brook University) AI whale detection technology at Vineyard Wind 1
Noise reduction	Bubble curtains - reduces the sound energy transmitted to marine organisms	CVOW-Pilot; Vineyard Wind 1, South Fork? Double bubble curtain tested at Vineyard Wind 1
Collision avoidance (e.g., curtailment/smart-stop systems)	1. Curtailment- reducing speed or stopping operations 2. Smart-Stop Infrared/Radar/Sonar initiates shutdown of system. 3. Sensory deterrents (can be visual or acoustic)	
Collision avoidance (e.g., noise, lights, etc.)	1. Radar and Thermal Imaging. 2. Acoustic monitoring and deterrents. 3. Curtailment and Smart-Stop Systems. 4. Blade and Tower modifications	CVOW-Pilot ATOM System
High Voltage Direct Current cooling systems	HVDC systems are primarily used for long-distance transmission of electricity, and their cooling systems are designed to dissipate heat generated during the transmission process. Both the heat and the cooling system could have effects on the ecosystem that could be mitigated (e.g., entrainment)	
Entanglement mitigation	1. Cable Design and Installation 2. Noise and Vibration Mitigation 3. Visual Deterrents 4. Environmental Monitoring and Surveillance	

Mitigation measure	Technologies	Projects or efforts applying and/or testing these technologies
Habitat enhancement	The implementation of measures to offset habitat loss or degradation: 1. Artificial reefs and habitats. 2. Seabed Restoration. 3. Fish Aggregating Devices. 4. Marine Protected Areas (MPA). 5. Habitat Connectivity. 6. Longterm Monitoring and Adaptive Management.	
Turbine siting and layout	1. Turbine siting and Layout: WindFarm and WindPro. 2. Avian Collision Risk: DTBird, BCAS. 3. Marine Mammal Risk Assessment: MARMAM. 4. Noise Propagation Modeling: CadnaA, Predictor, LimA 5. Habitat Modeling and Connectivity Analysis: MARXAN, Zonation. 6. Environmental Data Analysis: R and Python (along with other statistical packages).	Software Tools for the Mitigation of Wind Turbine Interference in the U.S. IOOS Network

Recommended projects for testing new mitigation technologies

The following recommendations have been compiled from each taxa-based chapter in this Science Plan. For more detail around the ongoing, pending, and recommended technology advancements associated with each wildlife taxon or habitat topic, review the "Technology advancement" sections in each chapter.

- Cross-taxa
  - Technologies to monitor, detect, and remove marine debris snagged on subsurface structures associated with floating and fixed-bottom offshore wind
- Marine mammal-specific
  - Develop integrated monitoring and mitigation systems within wind facilities that leverage and advance new technologies. This includes "smart" mitigation methods triggered by marine mammal presence, quieting technologies, and potentially sharing real-time observations online.

    - Advance, evaluate, and apply new technologies to better detect marine mammals where they occur, including using infrared cameras or laser detection (on ships or other platforms).
- Bird-specific
    - Validate collision detection technologies using carcass surveys (as has been done onshore, recognizing the challenges of implementing this offshore).

Data Management

The effective collection, storage, and security of data play a crucial role in wildlife monitoring and mitigation efforts in offshore wind environments. Data management platforms provide a centralized system for storing, organizing, and managing the collected data. These platforms often include features for data entry, storage, retrieval, and metadata management. Examples of data management platforms used in offshore wind projects include environmental data management systems (EDMS) or project-specific databases.

Data Management Systems

(This is distinct from data repositories, which are covered elsewhere in the Science Plan)

- Technologies to transfer data to onshore analysts (fiber optic cables, satellites?)
- Secure platforms for data QA/QC and review
- Scalability: Assess the scalability of the technology to cover large offshore areas and handle increasing data volumes effectively.
- Integration and Compatibility: Evaluate the compatibility and integration potential of the technology with existing monitoring systems, data management platforms, and mitigation protocols.
- Data Quality and Interpretation: Assess the quality of data generated by the technology, including resolution, data formats, and compatibility with existing analytical tools. Evaluate the ease of interpretation and extraction of meaningful insights.

Data Transfer Technologies:

- Wireless Networks: The LoRaWAN® specification enables wireless connectivity for battery-operated devices in regional or global networks, supporting IoT requirements. The LoRaWAN® specification is a Low Power Wide Area (LPWA) networking protocol designed to wirelessly connect battery-operated to the Internet in regional, national, or global networks. It targets critical Internet of Things (IoT) requirements such as bi-directional communication, end-to-end security, mobility, and localization services. In some cases, offshore wind installations may utilize subsea cables that connect monitoring devices to onshore data centers or monitoring stations. These cables provide a reliable and high-bandwidth connection for continuous data transfer.
- Subsea Cables: Offshore wind installations may utilize subsea cables to connect monitoring devices with onshore data centers or monitoring stations, providing reliable and high-bandwidth data transfer.

- Remote Sensing Technologies: Remote sensing techniques, such as HF Radar, satellite imagery, and aerial surveys, rely on satellite communication networks to transmit collected data.

Data Storage Devices:

- Data storage devices like data loggers, memory cards, or hard drives collect data from monitoring devices, which can then be transported back to onshore facilities for analysis.
- Where real-time transmission is not required or feasible, data storage devices such as data loggers, memory cards, or hard drives collect data from monitoring devices. These devices are then physically transported back to onshore facilities for data retrieval and analysis.
- Acoustic or optical modems can transfer data from the collection device to another storage device for transportation to shore, eliminating the need to remove the device.

Data Buoys and Underwater Acoustic Communication Systems:

- Data buoys equipped with sensors are deployed at sea to collect and transmit environmental data, utilizing wireless or satellite communications. Data buoys equipped with data logging and transmission capabilities are deployed at sea to collect and transmit environmental data. These buoys can be equipped with various sensors, such as oceanographic and meteorological sensors and hydrophones for acoustic monitoring, and use wireless or satellite communications to relay the collected data.
- Underwater acoustic communication systems employ acoustic modems and hydrophones to establish a real-time data transmission between underwater monitoring devices and onshore facilities. Aquatic acoustic communication systems are utilized for real-time data transmission between underwater monitoring devices and onshore facilities. Acoustic modems and hydrophones are used to establish communication links, enabling the transfer of acoustic recordings or other collected data.

Secure Platforms for QA/QC and Review:

- QA/QC Processes: Standard operating procedures, automated data validation algorithms, and manual review ensure the quality and accuracy of collected data.
- QARTOD Quality Assurance of Real-Time Oceanographic Data. QA/QC processes are implemented to validate and ensure the quality and accuracy of collected data. This includes establishing standard operating procedures (SOPs) for data collection, entry, and validation. QA/QC checks can involve automated data validation algorithms, manual data review, and cross-validation with reference data sources.
- Data Validation Tools: Software applications or scripts automate checks to identify errors or inconsistencies in the data. Data validation tools are software applications or scripts that perform automated checks on the collected data to identify potential errors, inconsistencies, or outliers. These tools can help ensure data quality and flag any

anomalies that require further investigation or correction. IOOS supports the QARTOD program.

- Data Review and Auditing: Independent experts or internal review teams systematically examine collected data for accuracy, completeness, and compliance with standards. Data review and auditing involve systematically analyzing the collected data to verify its accuracy, completeness, and compliance with defined standards. This process may involve independent experts or internal review teams assessing the data against specific criteria or industry guidelines.

Secure Data Transfer, Access Control, and Backup:

- Secure Data Transfer: Encrypted connections and secure file transfer protocols ensure data confidentiality and integrity during transmission. Secure data transfer protocols are used to ensure the confidentiality and integrity of data during transmission between offshore platforms and onshore facilities. Encrypted connections and secure file transfer protocols (e.g., SFTP, FTPS) are commonly employed to protect data during transit.
- Access Control and User Permissions: User authentication, role-based access control, and data segregation strategies manage user permissions and data security. Access control mechanisms are implemented to manage user permissions and control who can access, modify, or retrieve specific datasets. User authentication, role-based access control (RBAC), and data segregation strategies are employed to ensure data security and privacy.
- Data Backup and Disaster Recovery: Regular backup procedures and disaster recovery plan to safeguard against data loss and ensure data resilience.
- Regular data backup procedures are essential to prevent data loss due to technical failures, system malfunctions, or unforeseen events. Offshore wind data management systems often include backup strategies and disaster recovery plans to ensure data resilience and continuity.

Other:

- Data Management Tools: Cloud-native data management architecture and tools enhance data management and accessibility. Reaching for the Cloud is a collaboration between IOOS and RPS Group Ocean Science. This project aims to identify the technological and process shifts needed to develop a cloud-native architecture that will serve the current and future needs of the IOOS community.
- Collaborative Projects: Projects such as Reaching for the Cloud and "SoundCoop" focus on developing cloud-native architectures and promoting improved accessibility and applications for data management. Sound Coop, or Passive Acoustic Monitoring National Cyberinfrastructure Center is a project that is Piloting a community-focused, national cyberinfrastructure capability for passive acoustic monitoring data, technology, and best practices to promote improved, scalable, and sustainable accessibility and applications for management and science.

3. Potential criteria for evaluating the performance of new technologies for monitoring and mitigation

As new technologies and innovations develop on multiple fronts related to offshore wind and wildlife (monitoring, mitigation, data management), the Technology Subcommittee recognizes the need to consistently evaluate any new tools and approaches against traditional methods and alternative technologies.

Technology Subcommittee members recommend developing a mutually agreed-upon set of criteria that decision makers, funders, and users of technology can apply and interpret to evaluate the performance of the technology, potential appropriate uses of the technology, and any potential risks associated with applying the new technology.

A set of evaluation criteria would ensure that new methods and tools are evaluated consistently, fairly, and more efficiently than if custom performance evaluations are conducted each time a new technology emerges. The criteria should be evaluated every few years to ensure that they continue to be relevant and responsive to the needs of decision makers, funders, and users.

There are several existing technology evaluation frameworks that the Subcommittee may refer to as it advances its work on this topic:

- Technology Readiness Assessment Guide, U.S. Department of Energy, DOE G 413.3-4A
- Guidance notes on qualifying new technologies, American Bureau of Shipping
- Technology Assessment Design Handbook, U.S. Government Accountability Office

Below, the Subcommittee presents draft categories of evaluation criteria for new technologies with respect to offshore wind and wildlife/environment. The Subcommittee recommends convening smaller multi-sector expert work groups to guide and participate in the evaluation of specific tools as the needs arise.

Potential categories of technology evaluation criteria

Accuracy and Precision

Advanced technologies could provide higher accuracy and precision in detecting, identifying, and tracking wildlife species than traditional methods. Technology also allows more consistent and reliable data collection and monitoring, leading to more high-quality data. Potential metrics include false/true positive/negative rates.

Efficiency and Scalability

Technology advancements enable more efficient data collection, processing, and storage, allowing for the collection and handling of large volumes of data. This scalability is essential given the extent of proposed offshore wind development in U.S. Atlantic waters.

Cost Efficiency

As technology advances, costs associated with monitoring, mitigation, and data management can be reduced. This allows for more cost-effective implementation of monitoring programs, making it feasible to adopt advanced technologies and sustain long-term monitoring efforts. A potential metric in this category is cost savings over time.

Faster Data Analysis and Interpretation

Technology advancements like machine learning and artificial intelligence enhance data analysis and interpretation capabilities. These technologies automate data processing, enabling extracting meaningful insights, identifying patterns, and detecting potential risks or impacts. Potential metrics include

Safety

New technologies may provide safer mechanisms for data collection than traditional or manual methods, especially in potentially dangerous conditions offshore. Technology advancements could result in increased deployment and data collection success if humans aren't required to wait for safe conditions or work in suboptimal conditions.

Real-Time Capabilities

Advanced technologies offer real-time monitoring capabilities, enabling prompt notification of wildlife presence, behavior changes, or other characteristics. Real-time data can be used to trigger mitigation measures and/or adaptive management promptly, which may result in an overall reduced risk of wildlife interactions and minimized disturbances to sensitive species.

Mitigation Effectiveness

Technology advancements contribute to developing innovative mitigation measures by developing deterrent systems or shutdown protocols that effectively reduce collision risks and minimize wildlife disturbance.

Data Integration and Collaboration

Advanced technologies promote data integration from multiple sources and platforms, enabling a holistic view of the offshore wind/wildlife/environment system. This integration facilitates collaboration among researchers, wind farm operators, regulators, and conservation organizations, fostering knowledge sharing and effective conservation strategies.

Data Management and Security

Technology advancements enhance data management and security, ensuring the integrity, accessibility, and privacy of collected data. Robust data storage infrastructure, encryption protocols, and access control mechanisms safeguard sensitive information while facilitating data sharing and compliance with data protection regulations.

Public Awareness and Engagement

Technology advancements in data visualization and communication tools enable effective dissemination of monitoring results and engage the public in wildlife and ecosystem monitoring. Accessible and engaging communication can raise awareness about the importance of offshore wind/wildlife/environment monitoring and keep the public informed of ongoing data collection and research.

RWSC Technology Subcommittee

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Chapter 7: Marine Mammals

Authors: RWSC Marine Mammal Subcommittee (← click to view roster)

Executive Summary

This chapter describes around 70 individual ongoing data collection and research initiatives related to offshore wind and marine mammals funded by a variety of partners (states, federal agencies, industry). For an always up-to-date list of active projects, visit the RWSC Offshore Wind & Wildlife Research Database.

Given this ongoing work, the Marine Mammal Subcommittee is making recommendations for additional research that is both aligned with existing efforts and that fills important gaps. Those recommendations are described in detail throughout each section of this chapter. The recommendations are also summarized below:

RWSC Research Theme	Research Topic	Recommendations
Mitigating negative impacts that are likely to occur and/or are severe in magnitude	Understand increases in vessel traffic from construction and maintenance of offshore wind projects and develop or update existing vessel & marine mammal co-occurrence models	• Inform models with information from the offshore wind industry regarding vessel types and numbers. Validate models with AIS and effort-corrected whale sightings data. • Continue the existing collaboration between Project WOW and the RWSC Marine Mammal Subcommittee to inform and be informed by the development and maintenance of research/risk frameworks as applied to marine mammals in the RWSC study area.
	Advance quieting technologies	• Develop new and advance existing technologies that can mitigate potential impacts including noise (e.g., bubble curtains). • Develop integrated monitoring and mitigation systems within wind facilities that leverage and advance new technologies. This includes “smart” mitigation methods triggered by marine mammal presence, quieting technologies, and potentially sharing real-time observations online.
	Assess entanglement risks associated with floating offshore wind; monitor entanglement with subsea structure	• Build off of existing simulation modeling funded by BOEM and other efforts to better understand entanglement risk.

RWSC Research Theme	Research Topic	Recommendations
	of floating offshore wind structures; monitor secondary entanglement where derelict fishing gear/marine debris may attach to subsurface offshore wind structures	• Facilitate transfer of lessons learned from investigations of ropeless gear and reduction in right whale entanglements (e.g., in the Gulf of Maine) to offshore wind monitoring and mitigation efforts.
	Advance Population Consequences of Disturbance (PCoD) and Population Consequences of Multiple Stressors modeling	• Continue to advance PCoD modeling and other frameworks, through Project WOW, projects funded by BOEM and others.
	Mitigate impacts on regional scientific surveys	• NMFS Long-term protected species, fisheries, and ecosystem surveys form the backbone of the scientific monitoring system needed for the management of wildlife, fisheries, habitats, and ecosystems. In order to understand potential changes in wildlife and habitats from offshore wind energy development--it is critical that long-term standardized surveys continue to provide timely, accurate, and precise data on wildlife, habitats, and ecosystems. The need to fully implement the NMFS and BOEM Survey Mitigation Strategy is critical to putting site and regional level studies in the context of population trends and ecosystem conditions. The Strategy calls for the development of a Northeast Survey Mitigation Program. This is largely unfunded but it is highlighted as a significant priority for the region.
Detecting and quantifying changes to wildlife and habitats	Collect information on distribution, abundance, behavior, health, reproduction, and movement patterns of marine mammals and integrate new data types into species distribution models (e.g., PAM) and/or develop new models and data products	• Continue regional scale protected species data collection through AMAPPS or similar programs and supplement AMAPPS data with methods that detect smaller species and juveniles. • Advance and/or adopt recommendations related to the use of aerial visual and aerial digital survey techniques for certain species, life history stages, or geographies. • Develop integrated monitoring and mitigation systems within wind facilities that leverage and advance new technologies. This includes "smart" mitigation methods triggered by marine mammal presence, quieting technologies,

RWSC Research Theme	Research Topic	Recommendations
		and potentially sharing real-time observations online. • Explore and expand the use of satellite data, unmanned systems (gliders or autonomous underwater vehicles) and emerging technologies (e.g., eDNA) for marine mammal distribution and habitat use; Develop and deploy safe long duration satellite tagging telemetry technology for tracking high-resolution movements of marine mammals in and around offshore wind structures. • Advance, evaluate, and apply new technologies to better detect marine mammals where they occur, including using infrared cameras or laser detection (on ships or other platforms). • Improve analysis of monitoring data through artificial intelligence, automated acoustic, and image processing, and near real-time data availability. • Continue to update marine mammal density models with new observational and environmental covariate data every 2-3 years or as is practical. For North Atlantic right whale models, updates should be more frequent. Incorporate passive acoustic data and other data types as practical into future versions of cetacean density models so that model outputs reflect more types of observational effort. • Periodically validate and evaluate the performance of models and statistical frameworks. Use validation and evaluation results to continually inform and advance model/framework development and application. • In collaboration with the Massachusetts Habitat Working Group on Offshore Wind and other partners, continue supporting the development of collaborative funding plans for Southern New England megafauna aerial surveys that have occurred consistently since 2011.

RWSC Research Theme	Research Topic	Recommendations
	Implement a regional long-term archival passive acoustic monitoring network in the U.S. Atlantic Ocean	• Use the results of the RWSC Marine Mammal Subcommittee's power analysis to support initial design of a regional long-term archival passive acoustic monitoring network in the Atlantic Ocean and guide future research including: o Improve estimates of acoustic detection rates and cue rates of baleen whales during non-construction conditions o Improve dose-response curves by obtaining in-situ behavioral data at offshore wind construction sites on baleen whale responses to pile driving noise. This would require collecting a range of data types including PAM and visual observations (aerial or ship-based) o Expand passive acoustic monitoring outside of wind energy areas, especially along the shelf break, including through the use of gliders and real-time systems • Repeat a power analysis/optimization analysis every 3-5 years to ensure that new monitoring assets are accounted for in the optimal design and that existing or new hypotheses and questions can be addressed by the regional network. • Use the RWSC Marine Mammal Subcommittee as a forum to strategize and guide future deployments of passive acoustic recorders. Include the Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS), Mid-Atlantic Regional Association of Coastal Ocean Observing Systems (MARACOOS), and Southeastern Coastal Ocean Observing Regional Association (SECOORA), given that the network may also leverage existing or add new ocean observing assets maintained by these groups. The RWSC Marine Mammal Subcommittee will be used as a forum for information exchange and coordination related to developing collaborative funding models for optimizing PAM deployments.

RWSC Research Theme	Research Topic	Recommendations
		• Incorporate elements of the ECO-PAM Project (ended 12/31/22) into the regional-scale PAM network.
	Expand analysis and synthesis of rates of marine mammal strandings and mortality events in the U.S. Atlantic Ocean over time	• Continue and expand stranding data collection and analysis, as well as strandings and mortality data time series analysis for the U.S. Atlantic Ocean.
Understanding the environmental context around changes to wildlife and habitats	Work with the Habitat & Ecosystem Subcommittee to ensure that key oceanographic and habitat data are collected and available as data products for use in marine mammal studies	• View relevant research topics and recommendations in the Habitat & Ecosystem Chapter
	Work with the Habitat & Ecosystem Subcommittee to determine whether offshore wind structures alter hydrodynamics, stratification, and mixing	• View relevant research topics and recommendations in the Habitat & Ecosystem Chapter
	Develop a coordinated regional scale zooplankton (marine mammal prey) monitoring and mapping effort, building off existing programs and studies	• Continue to collect data across the region that allows analysis and synthesis of prey fields; expand upon existing prey field sampling (including EcoMon, Continuous Plankton Recorder, the Gulf of Maine MBON, Center for Coastal Studies, Northeast U.S. Shelf LTER, and projects conducted by Stony Brook University and Rutgers University). • In coordination with NERACOOS, MARACOOS, and the RWSC Habitat & Ecosystem Subcommittee, expand upon and link existing studies of zooplankton prey led by Rutgers University and Stony Brook University in southern New England and the NY Bight with those in the Gulf of Maine (Gulf of Maine MBON, BOEM-funded Zooplankton Ecology study, Canadian AZMP, Center for Coastal Studies) to establish a broader ecosystem observing system. Synthesize patterns to identify trends and linkages across trophic levels.
	Monitor ambient noise levels in the ocean for historic conditions, present day, and predicted future scenarios	• Embed these activities in the regional passive acoustic monitoring network.

RWSC Research Theme	Research Topic	Recommendations
Determining causality for observed changes to wildlife and habitats	Conduct a synthetic baseline assessment of marine mammals over the past several decades that integrates density modeling and/or visual survey data, passive acoustic monitoring data, tagging data, oceanography/habitat data, and climate data to characterize pre-development levels of spatial and temporal variability in marine mammal distribution and abundance patterns	• Use the results of this analysis to characterize pre-development levels of spatial and temporal variability in marine mammal distribution and abundance patterns, from which to measure and assess any potential changes after the onset of offshore wind construction and regional-scale operation activities.
	Determine whether construction activities displace or attract marine mammals	• Use the RWSC Marine Mammal Subcommittee's Data Management and Best Practices for Long-term Archival Passive Acoustic Monitoring Data to guide consistent data collection, storage, and analysis such that regional scale questions related to marine mammal displacement can be addressed. The RWSC Marine Mammal Subcommittee will be used as a forum for information exchange and coordination related to developing collaborative funding models for PAM data analysis strategies. • Build off of Project WOW IRES and apply lessons learned to studies in and around other lease areas outside Southern New England and NY/NJ Bight • Use Project WOW Frameworks to identify stressors, species, and geographic areas to conduct assessments of displacement, attraction, or other changes to wildlife abundance, distribution, behavior, and/or health
	Determine whether offshore wind structures displace or attract marine mammals	
	Determine whether marine mammal feeding is altered due to changes to hydrodynamics or prey distribution/abundances caused by offshore wind structures	
	Distinguish between climate change-driven shifts in marine mammal distribution, abundance, and behavior and changes that may be driven by offshore wind construction and operation	
	Study how species detect/receive EMF, whether they respond to EMF (from both AC and DC cables) with changes in distributions or behavior, and whether those responses vary with factors such as EMF strength, cable burial depth, and floating/fixed technology	• Scope studies of EMF and marine mammals
Enhancing data sharing and access	Continue to maintain the inventory of all ongoing data collection and research projects for marine	• Develop data products that reflect the results of data collection and research activities throughout the RWSC study area

RWSC Research Theme	Research Topic	Recommendations
	mammals and offshore wind to encourage a coordinated approach to regional-scale analysis and planning future work	and encourage or require projects to include funding for data product development, hosting, and maintenance/updates in their budgets. Data could be hosted and maintained by individual providers but should be shared in formats compatible with existing platforms described above.
	Coordinate data collection and synthesis of existing data efforts at a regional scale including baseline data, population monitoring, and data collected at individual OSW project sites (e.g., post-construction monitoring data) and facilitate pooling of data to obtain the statistical power to examine regional-scale effects	• Continue to lead or participate in the ongoing and pending coordination and planning activities, using the RWSC Marine Mammal Subcommittee as a forum for information exchange and coordination among federal agencies, states, offshore wind industry, eNGOs, and the research community. • Coordinate and initiate collaborations with additional partners to facilitate data and information sharing, including the Marine Mammal Health and Stranding Response Program, regional stranding coordinators, the National Marine Mammal Tissue Bank, and others.
	Make all data publicly available, including data collected for Environmental Impact Statements and post-construction monitoring to aid in the assessment of broad-scale questions, ecosystem-level research, and potential cumulative impacts	• Ensure that existing data repositories for marine mammal data have resources and personnel to integrate and provide access to offshore wind and wildlife monitoring datasets as they are collected. Include a minimum budget threshold that must be allocated to data management and access in all project budgets (e.g., 20%). • Require that marine mammal observations (opportunistic data, structured survey data, passive acoustic detections, other detections) be submitted to OBIS-SEAMAP with any associated effort data. North Atlantic right whale observations should also be submitted to the North Atlantic Right Whale Consortium. • Require that raw acoustic data and deployment metadata be submitted for archiving at the NCEI Passive Acoustic Data Archive. Species detection data and ambient noise metrics data should be submitted to the NOAA Passive Acoustics Reporting System with the appropriate

RWSC Research Theme	Research Topic	Recommendations
		metadata and detector performance metrics. • Require that raw tagging data and deployment metadata be submitted for storage, management, and visualization to the Animal Telemetry Network and/or its regional nodes (ACT, FACT, MATOS) according to the guidance provided by these entities. • Continue work with BOEM and partners on the development and use of a Master Protected Species Observer (PSO) Sightings Database. With the RWSC Subcommittee, review, require, and disseminate the resulting best practices and data standards that are currently under development. • Work with BOEM, the U.S. Fish & Wildlife Service, USGS, and others as they develop the infrastructure and guidelines around the use of a repository for aerial digital imagery.

1 Marine mammal species in the RWSC study area

Marine mammals include baleen whales and toothed whales (together, cetaceans), seals (pinnipeds), and manatees (sirenians). Distributions of marine mammals have been shifting in response to changes in their environment, including human activities, climate change, and conservation measures.

All marine mammal species are protected under the Marine Mammal Protection Act (MMPA) which prohibits intentional or incidental killing, injuring, or harassment of marine mammals and specifies the circumstances and rules under which permits may be issued for such activities. Under the MMPA, NOAA Fisheries has developed stock assessment reports for all marine mammals in U.S. waters since 1994. These reports contain estimates of current species population sizes and population trends. Six marine mammal species are also listed as endangered or threatened under the Endangered Species Act (ESA), which prohibits "take" of these species and requires conservation of their habitat.

Table 1. Marine mammal species in the RWSC study area. Source: NOAA Fisheries Species Directory, https://www.fisheries.noaa.gov/species-directory/

Species	Status	NOAA Fisheries Region
Blue whale	ESA Endangered; MMPA Protected; MMPA Depleted	New England/Mid-Atlantic; Southeast
Fin whale	ESA Endangered; MMPA Protected; MMPA Depleted	New England/Mid-Atlantic; Southeast
North Atlantic right whale	ESA Endangered; MMPA Protected; MMPA Depleted	New England/Mid-Atlantic; Southeast
Sei whale	ESA Endangered; MMPA Protected; MMPA Depleted	New England/Mid-Atlantic; Southeast
Sperm whale	ESA Endangered; MMPA Protected; MMPA Depleted	New England/Mid-Atlantic; Southeast
West Indian manatee	ESA Threatened; MMPA Protected; MMPA Depleted	Assessed by U.S. Fish & Wildlife Service; Southeast Region
Atlantic spotted dolphin	MMPA Protected	New England/Mid-Atlantic; Southeast
Atlantic white-sided dolphin	MMPA Protected	New England/Mid-Atlantic; Southeast
Blainville's beaked whale	MMPA Protected	New England/Mid-Atlantic; Southeast
Bryde's whale	MMPA Protected	New England/Mid-Atlantic; Southeast
Clymene dolphin	MMPA Protected	New England/Mid-Atlantic; Southeast
Common bottlenose dolphin	MMPA Protected; MMPA Depleted (Western North Atlantic Northern	New England/Mid-Atlantic; Southeast

Species	Status	NOAA Fisheries Region
	Florida Coastal stock, Western North Atlantic Central Florida Coastal stock, Western North Atlantic Northern Migratory Coastal stock, Western North Atlantic South Carolina-Georgia Coastal stock, Western North Atlantic Southern Migratory Coastal stock)	
Cuvier's beaked whale	MMPA Protected	New England/Mid-Atlantic; Southeast
Dwarf sperm whale	MMPA Protected	New England/Mid-Atlantic; Southeast
False killer whale	MMPA Protected; MMPA Depleted	Southeast
Fraser's dolphin	MMPA Protected	Southeast
Gervais' beaked whale	MMPA Protected	New England/Mid-Atlantic; Southeast
Gray seal	MMPA Protected	New England/Mid-Atlantic
Harbor porpoise	MMPA Protected	New England/Mid-Atlantic; Southeast
Harbor seal	MMPA Protected	New England/Mid-Atlantic; Southeast
Harp seal	MMPA Protected	New England/Mid-Atlantic
Hooded seal	MMPA Protected	New England/Mid-Atlantic
Humpback whale	MMPA Protected; MMPA Depleted (Western North Pacific stock, Centras North Pacific stock, California, Oregon, Washington stock)	New England/Mid-Atlantic; Southeast
Killer whale	MMPA Protected; MMPA Depleted (AT1 Transient stock)	New England/Mid-Atlantic; Southeast
Long-finned pilot whale	MMPA Protected	New England/Mid-Atlantic; Southeast
Melon-headed whale	MMPA Protected	New England/Mid-Atlantic; Southeast
Minke whale	MMPA Protected	New England/Mid-Atlantic; Southeast
Northern bottlenose whale	MMPA Protected	New England/Mid-Atlantic
Pantropical spotted dolphin	MMPA Protected; MMPA Depleted (Pacific northeastern offshore spotted stock)	New England/Mid-Atlantic; Southeast
Pygmy killer whale	MMPA Protected	New England/Mid-Atlantic; Southeast

Species	Status	NOAA Fisheries Region
Pygmy sperm whale	MMPA Protected	New England/Mid-Atlantic; Southeast
Risso's dolphin	MMPA Protected	New England/Mid-Atlantic; Southeast
Rough-toothed dolphin	MMPA Protected	New England/Mid-Atlantic; Southeast
Short-finned pilot whale	MMPA Protected	New England/Mid-Atlantic; Southeast
Sowerby's beaked whale	MMPA Protected	New England/Mid-Atlantic
Spinner dolphin	MMPA Protected; MMPA Depleted	New England/Mid-Atlantic; Southeast
Striped dolphin	MMPA Protected	New England/Mid-Atlantic; Southeast
True's beaked whale	MMPA Protected	New England/Mid-Atlantic; Southeast
White-beaked dolphin	MMPA Protected	New England/Mid-Atlantic

1.1 Focal species and notable recent trends

Table 1 indicates that the marine mammal species of greatest concern in the RWSC study area are large whales due to their designation as "Endangered" under the ESA.

It is important to understand the recent and projected trends in whale populations prior to the planning and implementation of any new offshore activity. Environmental Impact Statements (EISs) associated with the U.S. National Environmental Policy Act (NEPA) review of new human activities that may impact whales (including offshore wind projects) provide detailed assessment of the species known or expected to occur in the region and their likelihood and timing of occurrence in the area of the proposed activity. EISs describe population status, trends, expected impact-producing factors, and the estimated duration of effects (both positive and negative) on each species. Finally, EISs estimate cumulative impacts (both positive and negative) on each species group ranging from negligible to major. Each proposed offshore wind project's Final EIS contains or will contain this information.

From a regional and global perspective, natural and anthropogenic climate change are recognized as major drivers of changes in whale distribution, and in some cases, abundance as well[1,2,3]. Baleen whales' prey in particular–which include zooplankton and small fish species–are susceptible to ocean warming and changes in ocean circulation. In response to climate-driven shifts in their prey, baleen whales have shifted foraging locations into places where fewer protections are available[4], or where conflicts with more human uses are likely. NOAA's 2023 State of the Ecosystem New England report[5] describes the slow movement of several marine mammal species to the northeast and into generally deeper water (see figure below).

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[1] Pendelton DE, Tingley MW, Ganley LC, Friedland KD, Mayo C, Brown MW, McKenna BE, Jordaan A, Staudinger MD. 2022. Decadal-scale phenology and seasonal climate drivers of migratory baleen whales in a rapidly warming marine ecosystem. Global Change Biology 28: 4989-5005. https://doi.org/10.1111/gcb.16225.

[2] Meyer-Gutbrod EL, Davies KTA, Johnson CL, Plourde S, Sorochan KA, Kenney RD, Ramp C, Gosselin J-F, Lawson JW, Greene CH. 2022. Redefining North Atlantic right whale habitat-use patterns under climate change. Limnology and Oceanography https://doi.org/10.1002/lno.12242.

[3] Ganley LC, Byrnes J, Pendleton DE, Mayo CA, Friedland KD, Redfern JV, Turner JT, Brault S. 2022. Effects of changing temperature phenology on the abundance of a critically endangered baleen whale. Global Ecology Conservation 38: e02193 https://doi.org/10.1016/j.gecco.2022.e02193.

[4] Davies KTA and Brillant SW. 2019. Mass human-caused mortality spurs federal action to protect endangered North Atlantic right whales in Canada. Marine Policy 104: 157-162 https://doi.org/10.1016/j.marpol.2019.02.019.

[5] NOAA Northeast Fisheries Science Center. State of the Ecosystem 2023: New England. https://doi.org/10.25923/9sb9-nj66

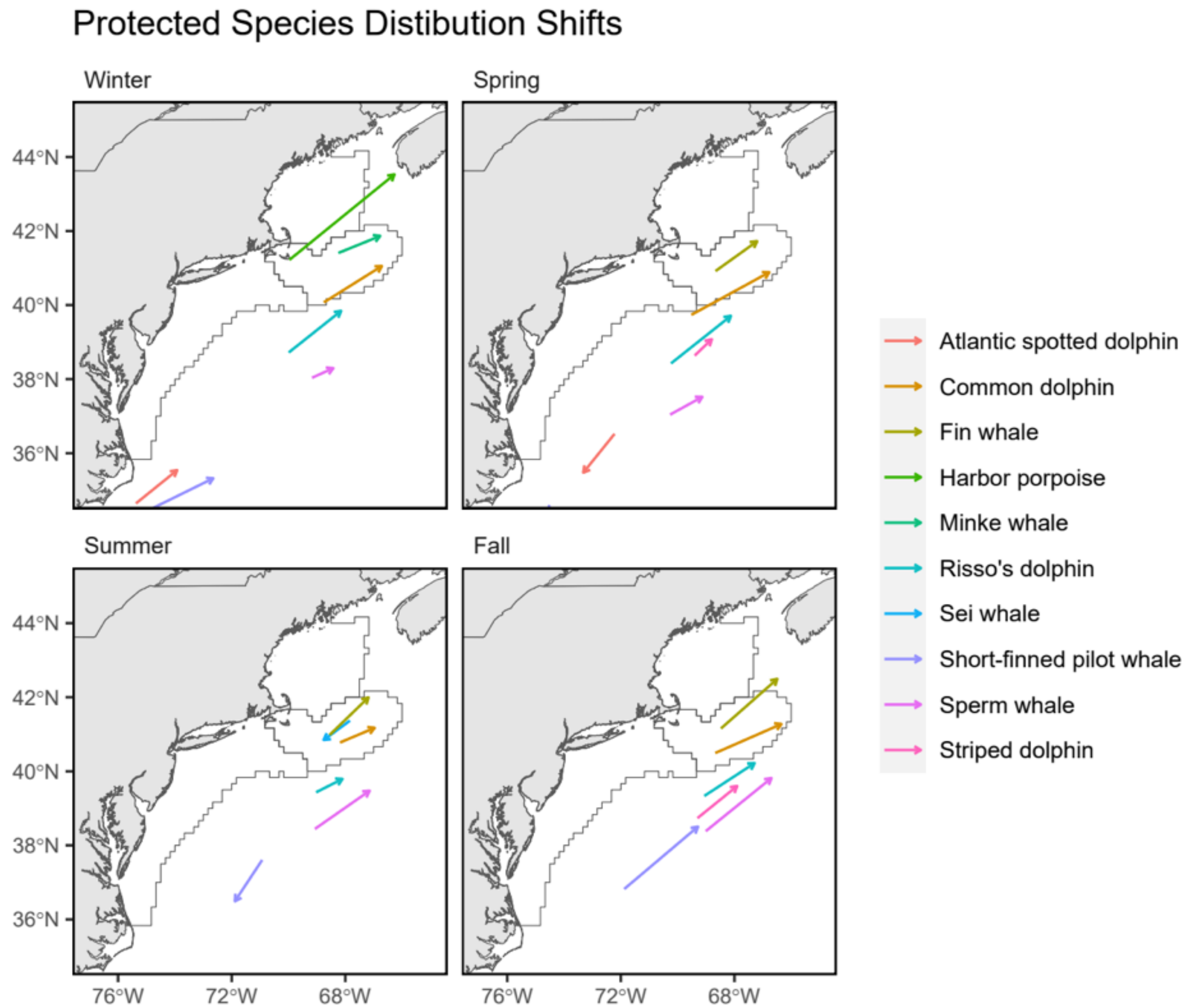

Figure 1. Direction and magnitude of core habitat shifts, represented by the length of the line of the seasonal weighted centroid for species with more than 70 km difference between 2010 and 2017 (tip of arrow).

1.1.1 North Atlantic right whale

North Atlantic right whales (NARWs) are predicted to go extinct in less than 30 years[6]. NARWs are listed as endangered under the ESA and considered depleted under the MMPA. The species is in decline (Pace III et al. 2017; Pace III et al. 2021) and experiencing an ongoing unusual mortality event, which was declared in 2017 (Daoust et al. 2018; NOAA Fisheries 2022a). The population estimate in NOAA Fisheries' most recent Stock Assessment Report (Hayes et al. 2022) is 368 individuals (95% CI: 356–378); this estimate is based on information through January 2019. The most recent population estimate is 340 individuals[7]. The potential biological removal level for the species, defined as the maximum number of animals that can be removed

[6] Meyer Gutbrod EL and Greene CH. 2018. Uncertain recovery of the North Atlantic right whale in a changing ocean. Global Change Biology 24: 455-464 https://doi.org/10.1111/gcb.13929.

[7] https://www.narwc.org/uploads/1/1/6/6/116623219/2022reportcardfinal.pdf

annually while allowing the stock to reach or maintain its optimal sustainable population level, is less than 1 (Hayes et al. 2022). In addition to vessel strikes and entanglement in fishing gear, which are the primary causes of NARW mortality and serious injury, modeling indicates that low female survival, a male-biased sex ratio, and low calving rates are contributing to the population's current decline (Pace III et al. 2017). The species has low genetic diversity, as would be expected based on its low abundance, and the species' resilience to future perturbations is expected to be very low (Hayes et al. 2018).

1.1.2 Humpback whale

In 2016, NOAA Fisheries revised the ESA listing for humpback whale and determined that the population in the North Atlantic (also known as the West Indies Distinct Population Segment) had recovered enough to not be listed as endangered or threatened[8]. The species is increasing in abundance throughout much of its range but faces threats from entanglement in fishing gear, vessel strikes, vessel-based harassment, and underwater noise[9].

Since January 2016, elevated humpback whale mortalities have occurred along the Atlantic coast from Maine through Florida. This event was declared an Unusual Mortality Event in April 2017, and includes stranded humpback whales from 2016. Partial or full necropsy examinations were conducted on approximately half of the whales. Of the whales examined, about 40 percent had evidence of human interaction, either ship strike or entanglement[10].

Besides the current UME, three previous UMEs involving humpback whales have occurred since 2000—in 2003, 2005, and 2006. The 2003 and 2006 events primarily involved humpback whales, with 16 and 48 humpback mortalities respectively. The 2005 event involved multiple cetacean species, including seven humpback whales. Causes of the three UMEs were undetermined[11].

1.2 Sources of regional-scale distribution information for marine mammals

1.2.1 Cetacean and pinniped density models

There have been several studies of cetacean distribution, abundance, and some aspects of behavior along the U.S. Atlantic coast (Roberts et al. 2016, Bailey et al. 2018, Salisbury et al. 2018), but fewer studies of the distribution and abundance of seals. The Duke Marine Geospatial Ecology Laboratory leads an ongoing collaboration of federal, state, academic, and independent research organizations who pool scientific data and expertise to develop marine

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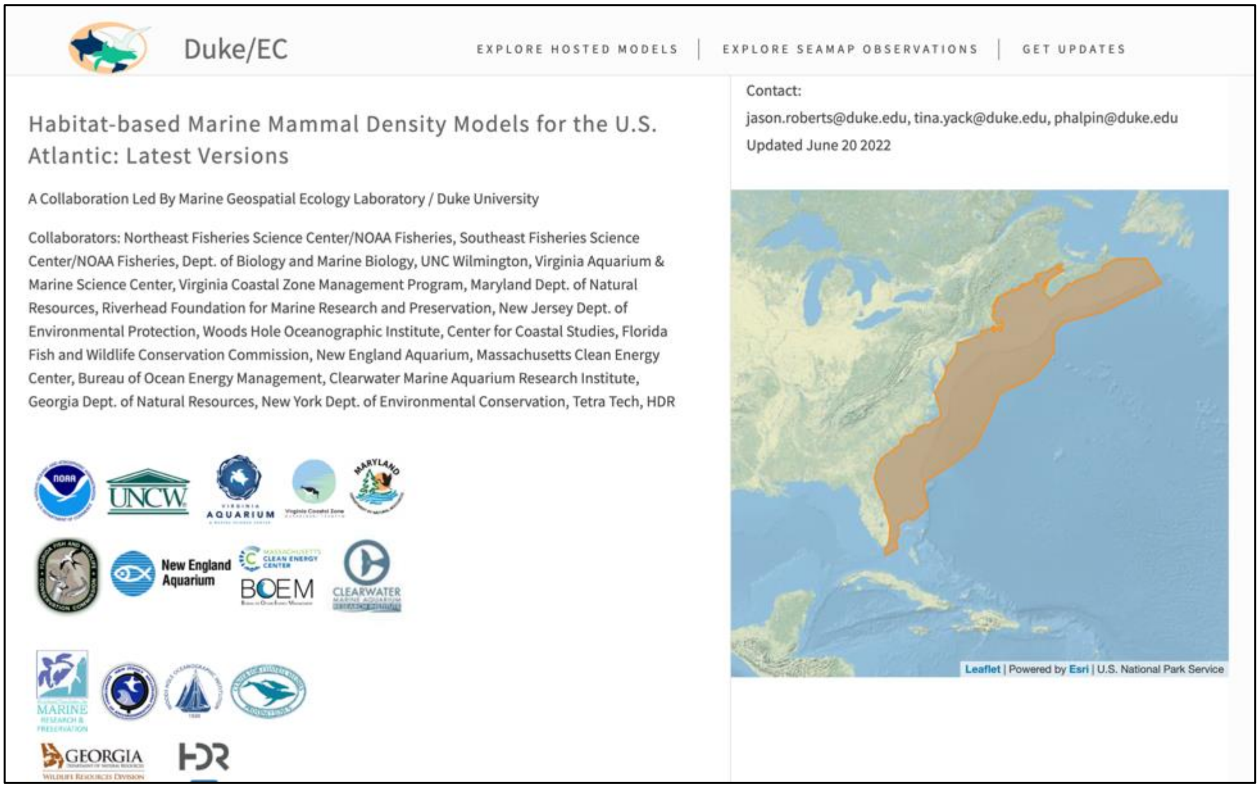
[8] https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/frequent-questions-offshore-wind-and-whales

[9] https://www.fisheries.noaa.gov/species/humpback-whale

[10] https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2023-humpback-whale-unusual-mortality-event-along-atlantic-coast

[11] https://www.fisheries.noaa.gov/national/marine-life-distress/frequent-questions-2016-2023-humpback-whale-atlantic-coast-unusual

mammal species density models spanning the U.S. east coast and southeast Canada. The models estimate absolute density, rendered as maps of the number of individual animals per 100 km^2, by statistically correlating sightings reported on shipboard and aerial surveys with oceanographic conditions. Since its initial publication in 2016, the project has expanded to utilize over 2.8 million linear kilometers of survey effort collected between 1992-2020, yielding density maps for over 30 species and multi-species guilds, including cetaceans and pinnipeds. These density maps serve as crucial pre-development estimates of marine mammal distributions.

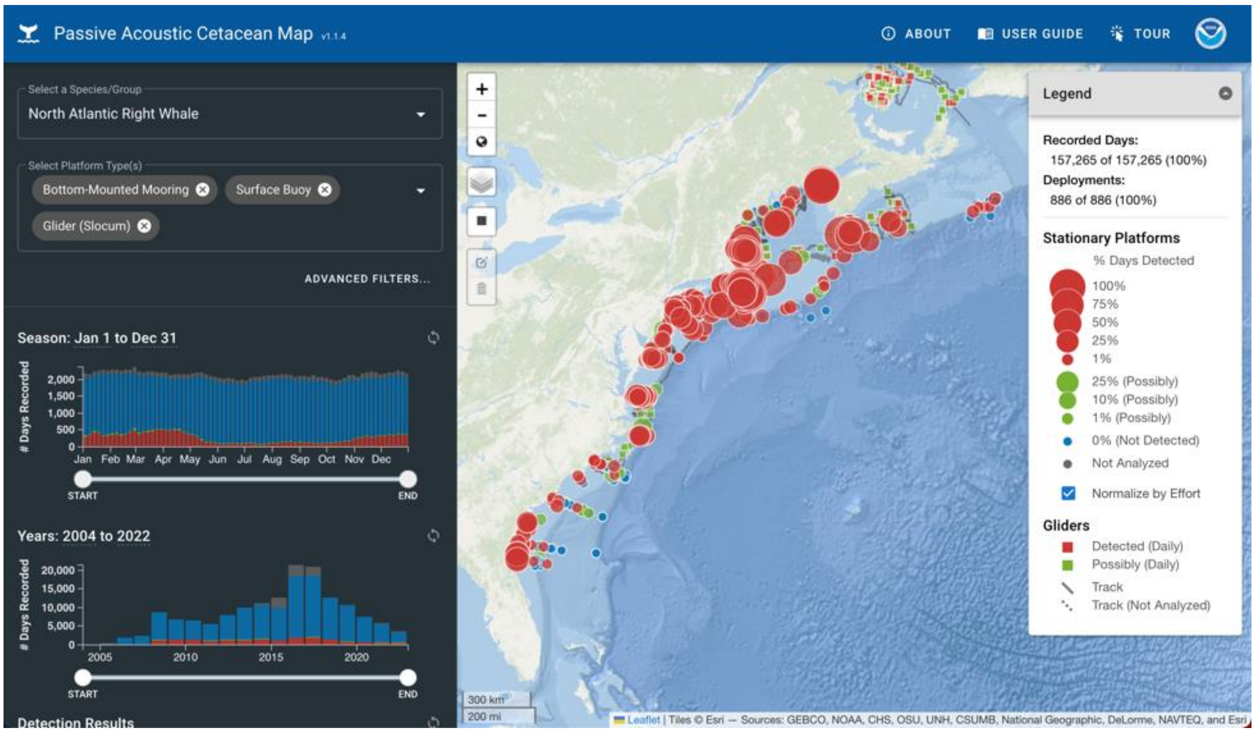


1.2.2 Passive Acoustic Cetacean Map

The Passive Acoustic Cetacean Map (PACM)[12] shows when and where specific whale, dolphin, and other cetacean species were acoustically detected in the North Atlantic Ocean based on Passive Acoustic Monitoring (PAM). The dataset was compiled by the NOAA NEFSC Passive Acoustic Research Program using detection data collected by many collaborators. Information on data ownership can be found in the metadata of each station or platform. Species that are currently represented include the North Atlantic right whale, fin whale, humpback whale, sei whale, blue whale, sperm whale, beaked whale species, and Kogia species (dwarf/pygmy sperm whales). The specific call types used for each species along with other metadata related to the recording and detection analysis can be found by hovering over or clicking on each platform.

[12] Passive Acoustic Cetacean Map. 2023. Woods Hole (MA): NOAA Northeast Fisheries Science Center v1.1.3 [02-23-2023]. https://apps-nefsc.fisheries.noaa.gov/pacm

Acoustic detections were recorded using stationary (bottom-mounted moorings, surface buoys) and mobile (autonomous gliders and towed arrays) platforms. These acoustic detections only represent times when animals are calling; they do not capture time periods when animals are present but silent. Detections are from archival acoustic recorders and do not show recorders currently in the water (this is not a real-time tool). Differences in recorder detection ranges for each species are not accounted for; they can vary based on differences in instrumentation (i.e., recording hardware), environmental conditions (i.e., weather, bottom type, ambient sound levels), and anthropogenic sound levels.



1.2.3 Real-time Marine Mammal Observations Data and Maps

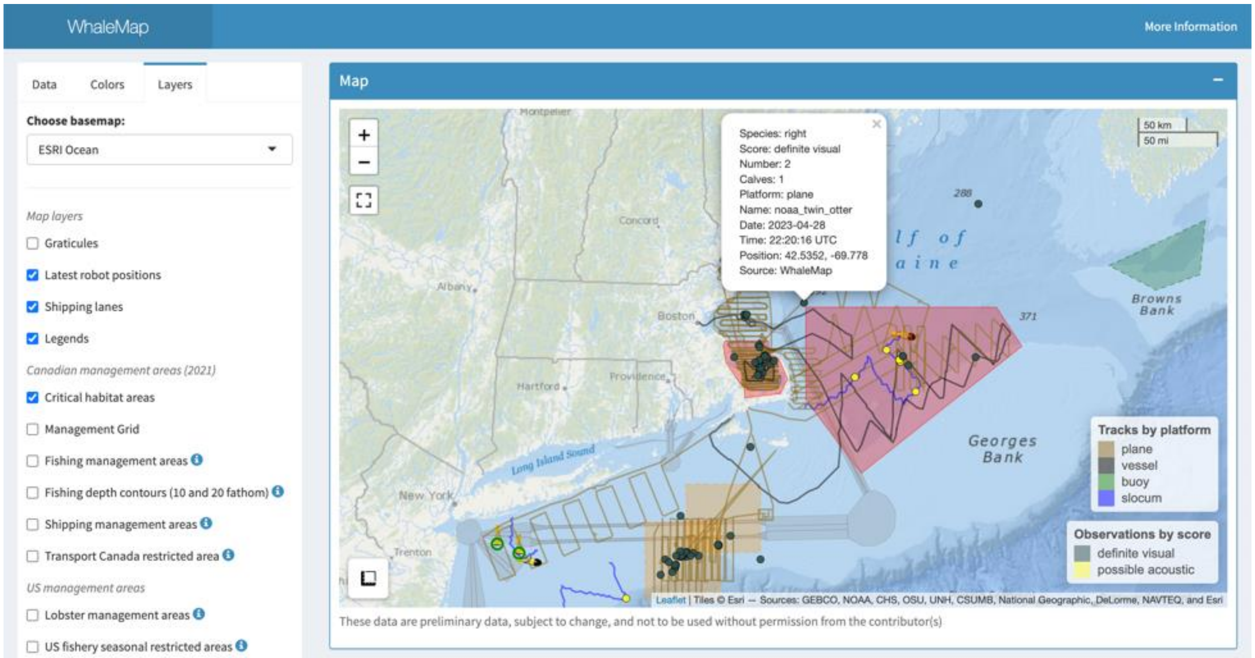
Several web-based tools provide the public with information about the real-time location of whales in the RWSC study area.

Whalemap.org

Whalemap.org was designed to communicate the latest whale survey results to scientific, regulatory, and industrial sectors to inform more effective, dynamic planning of research and conservation activities[13]. The map is synchronized with data repositories from several different survey groups such that results are reported in near-real time. The following entities contribute data to Whalemap.org: Department of Fisheries and Oceans Canada; Transport Canada; NOAA Protected Species Branch; Woods Hole Oceanographic Institution (robots4whales); New England Aquarium; Center for Coastal Studies; Canadian Whale Institute; Mingan Island

[13] Johnson H, Morrison D, Taggart C. 2021. WhaleMap: a tool to collate and display whale survey results in near real-time. Journal of Open Source Software, 6(62), 3094, https://joss.theoj.org/papers/10.21105/joss.03094.

Cetacean Study; Ocean Tracking Network; Dalhousie University; University of New Brunswick; Nick Hawkins Photography.



Whale Alert App

The [Whale Alert app]() was launched in 2012 as a citizen science tool aimed at reducing the risk of vessel strikes. The free app uses whale presence data including verified sightings, acoustic detections from buoys and gliders, and aerial surveys to display a user-friendly map based on nautical charts from country-specific government agencies.

Mariners, scientists, whale watchers, recreational boaters, and beachgoers alike can use their personal devices to easily share whale sightings with the Whale Alert team who then verify the information before posting it to the map in near-real time. Regular users of the app can become trusted observers, helping to streamline the review process.

Public whale sightings submitted via Whale Alert help establish speed zones, warnings, and other measures to reduce vessel speeds and reduce risks to whales and mariners. Contributing to Whale Alert informs more accurate, evidence-driven administration of management areas to protect both whales and the livelihoods of people on the water.

The development and maintenance of the Whale Alert app is led by the International Fund for Animal Welfare (ifaw).

Right Whale Slow Zones / Dynamic Management Areas

Right Whale Slow Zones and Dynamic Management Areas (DMAs) are voluntary programs NOAA Fisheries uses to notify vessel operators to slow down to avoid right whales[14]. Maintaining speeds of 10 knots or less can help protect right whales from vessel collisions. Under these programs, NOAA Fisheries provides maps and coordinates to vessel operators indicating areas where right whales have been detected. For a period of 15 days after a whale is detected, mariners are encouraged to avoid these areas or reduce speeds to 10 knots or less while transiting through these areas.

NOAA Fisheries establishes DMAs based on visual sightings of three or more right whales within a discrete area. Right Whale Slow Zones are based on both visual and acoustic triggers. They are identical to DMAs when triggered by right whale visual sightings.

NOAA Fisheries announces Right Whale Slow Zones and DMAs to mariners through our communication channels and lists zones below. The most recent designation is listed first. There are multiple ways to be notified or to view active Right Whale Slow Zones and DMAs:

- Sign up for email or text notifications from NOAA Fisheries
- Follow relevant NOAA Fisheries Facebook (@NOAAFisheriesNEMA) and Twitter (@NOAAFish_GARFO) accounts for announcements
- Whalemap.org online right whale sightings map
- Whale Alert app (free) which will automatically notify you when you enter one of these areas
- The Northeast Ocean Data Portal Data Explorer map includes current DMAs as a layer that can be overlaid with many other datasets depicting the footprints of ocean resources and activities, including offshore wind lease areas and vessel traffic

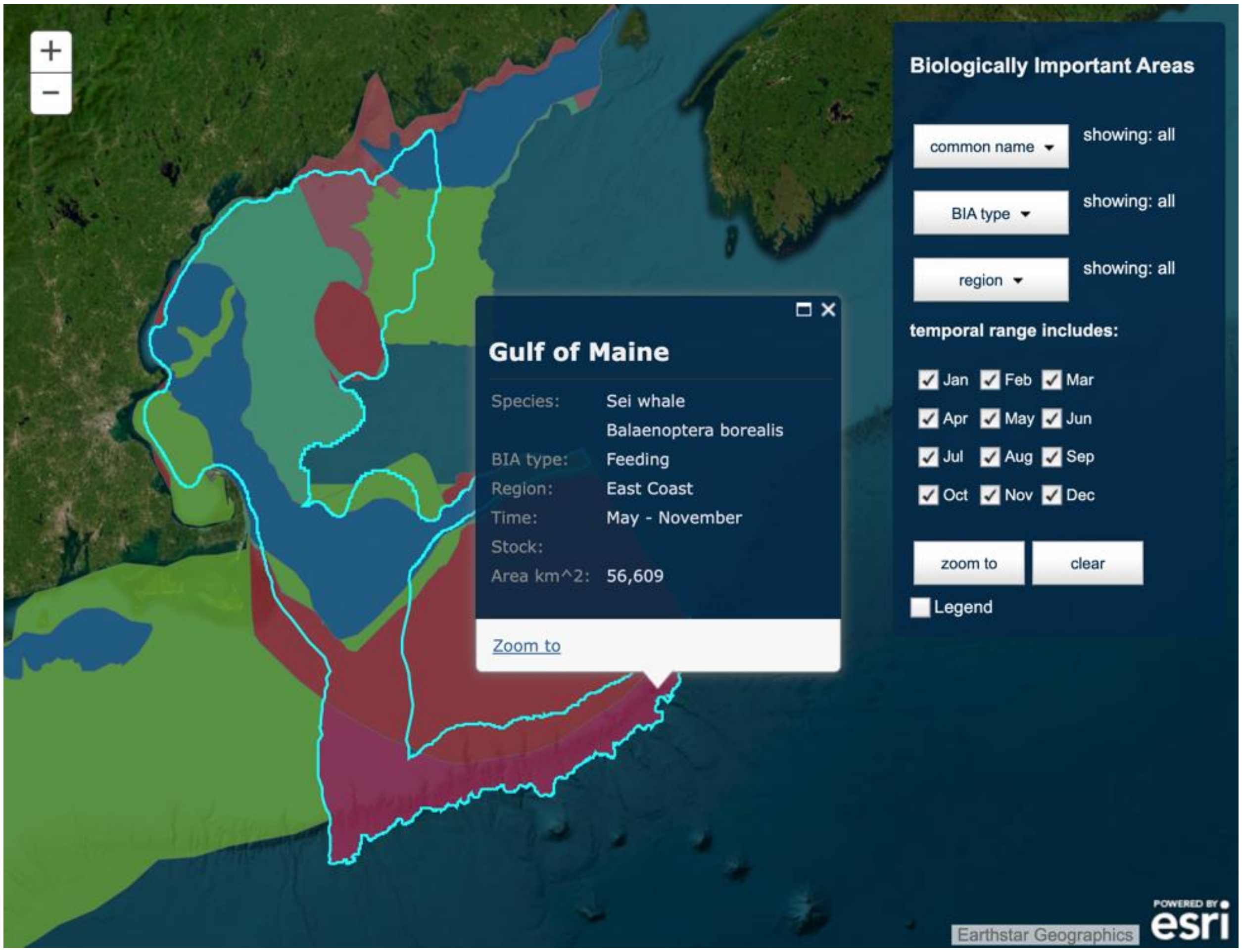
1.2.4 Biologically Important Areas for Cetaceans within U.S. Waters

Biologically Important Areas (BIAs) represent areas and times in which cetaceans (whales, dolphins, and porpoises) are known to concentrate for activities related to reproduction, feeding, and migration, as well as the known ranges of small and resident populations. BIAs can be used to better understand and predict how individual marine mammals are likely to respond to or be impacted by disturbances, and where populations may be more susceptible to certain types of impacts. BIAs may be used like any other scientific information to support analyses and decisions, as appropriate, for the purposes of environmental planning, compliance, and protection. BIAs are compilations of the best available science and have no inherent or direct regulatory power.

In the BIA II effort, NOAA, with the support of the U.S. Navy, convened a working group of regional cetacean experts who have updated and revised the BIAs identified in Van Parijs et al. (2015) using new methods and scoring protocols described in Harrison et al. (2023) that improve the utility, interpretability, and consistency of the BIAs by designating an overall Importance Score for each BIA. Seven regional manuscripts, which will be available in the Identifying and Comparing Important Areas for Marine Sustainable Use and Conservation Research Topic of Frontiers in Marine Science, include the maps and scores for the BIAs, by

[14] https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-vessel-strikes-north-atlantic-right-whales

region, and narratives describing the rationale and information upon which several representative BIAs (across types and scores) are based[15]. The descriptions and maps for U.S. East Coast BIAs are not yet available (as of May 2023) but will be incorporated by reference once they are published. Below is a map of the older version of U.S. East Coast BIAs.



1.2.5 North Atlantic right whale critical habitat

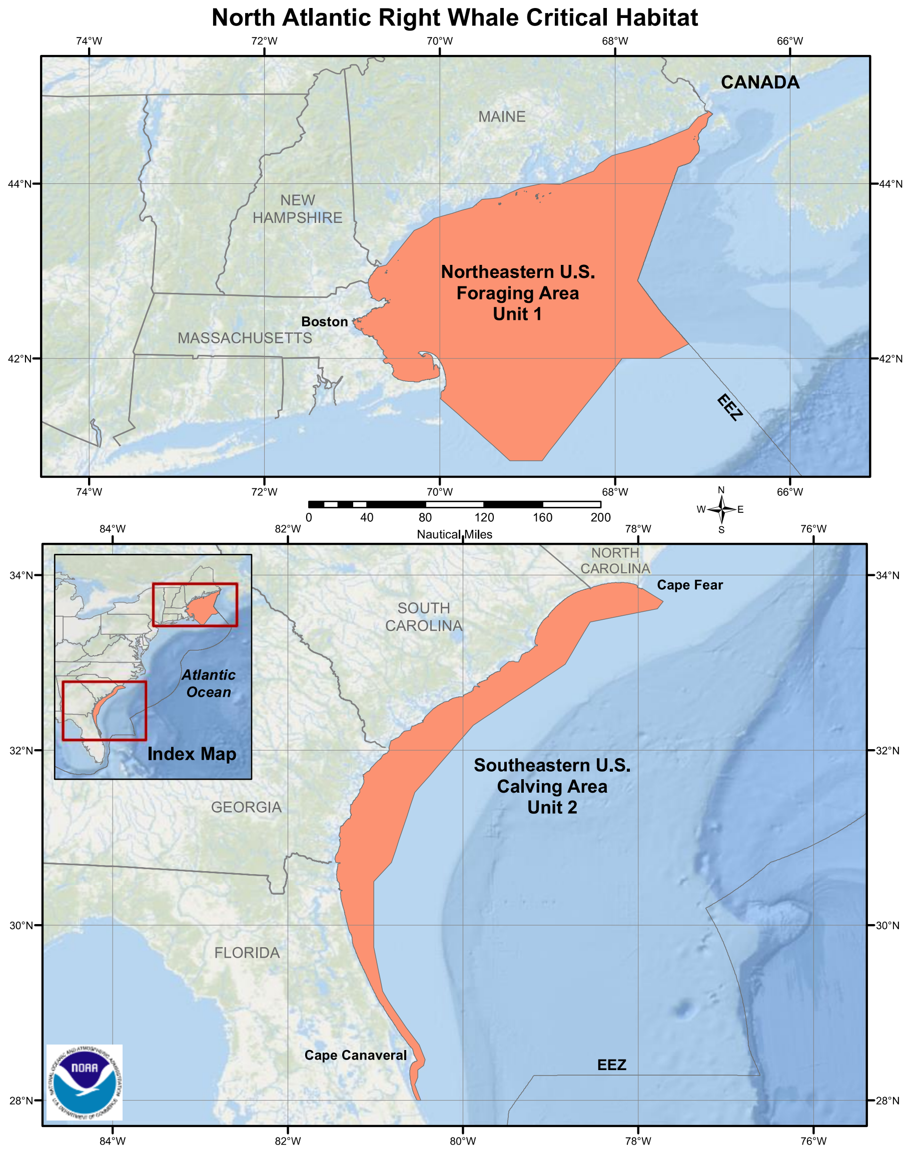
Critical habitat is defined in the Endangered Species Act as specific areas within the geographical area occupied by the species that contain physical or biological features essential to conservation of the species and that may require special management considerations or protection; and specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation.

The critical habitat designation for North Atlantic right whales was updated in 2016 and encompasses approximately 29,763 nm^2 of marine habitat in the Gulf of Maine and Georges Bank and off the Southeast U.S. coast[16]. This designation considers the physical and/or

[15] https://oceannoise.noaa.gov/biologically-important-areas

[16] https://www.federalregister.gov/documents/2016/01/27/2016-01633/endangered-and-threatened-species-critical-habitat-for-endangered-north-atlantic-right-whale

biological features of foraging and calving habitats that are essential to the conservation of the species. The NOAA Fisheries Biological Source Document[17] describes these habitat features in detail. Maps and GIS data of right whale critical habitat can be obtained on the NOAA Fisheries GIS page and are available to view in the regional data portals.



1.2.6 North Atlantic right whale Seasonal Management Areas

Seasonal Management Areas (SMAs) for North Atlantic right whales are zones and times of year when all vessels 65 feet or longer must travel at 10 knots or less to reduce the threat of vessel

[17] https://media.fisheries.noaa.gov/dam-migration/16narwchbiologicalsourcedocument122115-508.pdf

collisions[18]. Because vessels of all sizes can strike a whale, NOAA Fisheries also encourages vessels less than 65 feet in length to help protect right whales by slowing to 10 knots or less within active SMAs as well. Maps and GIS data of SMAs on the U.S. east coast can be obtained on the NOAA Fisheries GIS page and are available to view in the regional data portals.

1.2.7 Atlantic Large Whale Take Reduction Plan

NOAA Fisheries implemented the Atlantic Large Whale Take Reduction Plan (ALWTRP) to reduce injuries and deaths of large whales due to incidental entanglement in fishing gear[19]. The ALWTRP is an evolving plan that changes more is learned about why whales become entangled and how fishing practices might be modified to reduce the risk of entanglement. It has several components including restrictions on where and how gear can be set; research into whale populations and whale behavior, as well as fishing gear interactions and modifications; outreach to inform and collaborate with fishermen and other stakeholders; and a large whale disentanglement program. The ALWTRP includes requirements such as use of weak links and sinking groundline, gear marking, seasonal area closures, and a minimum number of traps per trawl. For the most recent requirements, see the outreach guide for each location and gear type on the ALWTRP webpage. The complete plan is published in the Code of Federal Regulations (§ 229.32 Atlantic large whale take reduction plan regulations).

1.3 Potential effects with respect to offshore wind

As migratory species, many marine mammals' ranges overlap the areas proposed for offshore wind development in the Atlantic Ocean. In addition, most marine mammal species are exposed to many other types of stressors in these areas. The cumulative effect of several stressors may create a biologically significant population level response[20].

Of the large whale species listed in Table 1 that are of greatest concern, baleen whales have been prioritized for attention with respect to offshore wind research[21], due to their distribution and abundance in the study area, behavior, and life history characteristics that make them susceptible to some of the specific stressors potentially associated with offshore wind.

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[18] https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-ship-strikes-north-atlantic-right-whales

[19] https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-mammal-protection/atlantic-large-whale-take-reduction-plan

[20] Kraus SD, Kenney RD, Thomas L. 2019. A framework for studying the effects of offshore wind development on marine mammals and turtles. Report prepared for the Massachusetts Clean Energy Center, Boston, MA 02110, and the Bureau of Ocean Energy Management. May 2019. https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Renewable-Energy/A-Framework-for-Studying-the-Effects.pdf

[21] Southall B, Morse L, Williams KA, Jenkins E. 2021. Marine Mammals Workgroup Report for the State of the Science Workshop on Wildlife and Offshore Wind Energy 2020: Cumulative Impacts. Report to the New York State Energy Research and Development Authority (NYSERDA). Albany, NY. 50 pp. Available at https://www.nyetwg.com/2020-workgroups.

The majority of studies describing the effects of construction and operation of windfarms on cetaceans come from Europe, where small odontocetes (dolphins and porpoise mainly) are the most common cetaceans. Avoidance and displacement effects, at ranges up to 10-26 km from the whole footprint of offshore windfarms during construction have been reported (Dähne et al. 2013, Brandt et al. 2016, Dähne et al. 2017, Brandt et al. 2018, Graham et al. 2019, Benhemma-Le Gall et al. 2021, Graham et al. Submitted). All of these studies indicate that the distance and duration of avoidance is related to received noise, which is further influenced by source level, sound propagation conditions, hearing range of the studied species, distance to the noise source, duration of exposure, level and type of mitigation and presence of other noise sources like construction vessels. There is variation among studies in the time reported for animal behaviour to return to pre-construction levels, from hours (Dähne et al. 2017) and days (Brandt et al. 2018) to years (Teilmann and Carstensen 2012), which also suggest that operation of offshore windfarms may also affect cetacean behavior.

Tagging data from Europe around wind energy sites suggest that harbor and grey seals either habituate quickly or may take advantage of the wind farm physical structures as a foraging opportunity[22].

Kraus et al. 2019 summarized the potential short-term and long-term effects of offshore wind development on marine mammals and sea turtles in Massachusetts and Rhode Island Wind Energy Areas[23]. The list of potential effects below from this report is relevant to the entire RWSC study area. Any concerns related to marine mammal species that are specific to each subregion will be further described in the following sections of this chapter.

Overall, climate change increases the uncertainty surrounding marine mammal behavior, distribution and demography, which can abruptly and unexpectedly increases the risks associated with offshore wind development if marine mammals begin to use new areas and habitats or existing habitat more frequently or during different times of year.

Potential short-term effects of offshore wind construction activities

Potential short-term effects include noise from pile driving, vessel operating noise, and the increased presence of vessels. These stressors could influence:

- Displacement of marine mammals from wind energy areas
- Disruption to critical behaviors of marine mammals such as feeding, socializing, or nursing
- Elevation of stress hormone levels in marine mammals

[22] Russell DJ, Hastie GD, Thompson D, Janik VM, Hammond LA, Scott-Hayward LA, Matthiopoulous J, Jones EL, McConnel BJ. 2016. Avoidance of wind farms by harbour seals is limited to pile driving activities. Journal of Applied Ecology 53: 1642-1652. https://doi:10.1111/1365-2664.12678.

[23] Kraus SD, Kenney RD, Thomas L. 2019. A framework for studying the effects of offshore wind development on marine mammals and turtles. Report prepared for the Massachusetts Clean Energy Center, Boston, MA 02110, and the Bureau of Ocean Energy Management. May 2019. https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Renewable-Energy/A-Framework-for-Studying-the-Effects.pdf

- Changes in vertical distribution, density, or patch structure of zooplankton and/or fish prey

Potential long-term effects of offshore wind operation

Potential long-term effects include wind turbine presence, and increased vessel activity to/from and near turbine fields. These stressors could influence:

- Marine mammal exclusion from or attraction to wind energy areas
- Increased risk of vessel strike
- Changes to feeding opportunities
- Enhancements to marine productivity due to artificial reef effect around wind turbine foundations
- Increased risk of entanglement from ghost gear attached to underwater offshore wind structures

1.4 Common data collection methods and approaches

To address questions about marine mammals and the potential concerns with respect to offshore wind development, this Science Plan describes commonly used methods and approaches for data collection and research. The following categories of methods are used throughout this chapter for consistency, but the Subcommittee recognizes that different tools, technologies, and/or procedures could be implemented with respect to each.

Type of Science Plan Action	**Science Plan Action**	**Possible Platforms**	**Method Description**
Field data collection and analysis	Aerial visual - strip transect	Aerial	Standard survey technique to count individuals/species
	Aerial high def imagery	Aerial	High-resolution/definition photography or video for quantifying animals, nests, colonies, and/or characterizing habitat
	Aerial visual - distance sampling	Aerial	Standard survey technique to quantify abundance
	Boat-based - distance sampling	Boat-based	Standard survey technique to quantify abundance
	Boat-based - strip transect	Boat-based	Standard survey technique to count individuals/species
	Opportunistic visual	Aerial, Boat-based	Non-standard and unstructured surveys to quantify individuals/species
	Stationary visual	Stationary	Visual observations made from a stationary platform (e.g., turbine) or shore
	Thermal camera	Stationary	Thermal cameras mounted to turbines or buoys for bird/bat detection
	Infrared camera	Stationary, Boat-based	Infrared cameras mounted to turbines or buoys for bird/bat detection; boat-

			based infrared for marine mammal detection
	Passive acoustic monitoring - real-time	Glider, buoy	Hydrophones deployed to record sounds produced by animals and the environment with real-time reporting. Can be stationary bottom-mounted (buoys) or mobile (gliders).
	Passive acoustic monitoring - archival	Stationary, Glider	Hydrophones deployed to record and archive sounds produced by animals and the environment; can be stationary bottom-mounted (buoys) or mobile (gliders)
	Satellite tagging	Animal telemetry	Includes deploying tags on animals
	Acoustic tagging	Animal telemetry	Includes deploying tags on animals and deploying receivers
	VHF tagging	Animal telemetry	Includes deploying tags on animals and deploying receivers
	GPS tagging	Animal telemetry	Includes deploying tags on animals and deploying receivers
	Other tagging	Animal telemetry	Includes deploying tags on animals and deploying receivers
	eDNA	Stationary, Glider	Environmental DNA collection and analysis for species detection; could be collected at stations via discrete water samples or via mobile flow-through systems?
	Diet analysis	Boat-based	Stomach content analyses; chemical analyses; stable isotope analyses
	Animal physiology	Boat-based	Physiological measurements including stress hormones from blood, blow, mucus, tissue, fecal samples, etc.
	Focal follow	Glider, ROV, AUV, Drone	
	Satellite remote sensing		Surface measurements of winds, temperature, height, ocean color (chlorophyll, dissolved organic matter, suspended particles) and other ocean and atmosphere variables collected remotely via satellite
	Water quality and oceanography	Stationary, Realtime data, Glider	In-situ measurements properties including salinity, dissolved oxygen, temperature, etc.
	Nets and tows	Boat-based	Zooplankton and small fish sampling
	Seafloor acoustics - geophysical	Boat-based, ROV, AUV	Multibeam bathymetry, backscatter, side scan sonar
	Active acoustics / echosounders	Boat-based, Stationary	Acoustic instrumentation used to characterize prey fields in the water column; can also be directed at the seafloor for bottom characterization
Non-field actions	Coordination and planning		Coordination among the four RWSC Sectors and the research community

		through the operation of the RWSC, but also other multisector coordination activities led by federal agencies and individual states; deconflicting research activities; coordination around an issue or species, such as the North Atlantic right whale.
	Standardizing data collection, analysis, and reporting	Development and maintenance of informal “best practices” as well as formal guidance from government entities on the specific protocols and methods that should be used for specific data types and/or studies to ensure alignment with advances in technologies and practices.
	Historical data collection/compilation	Adding existing data to modern databases so that historical data can be used in long-term/time-series analyses and studies.
	Study optimization	Implementation of statistical frameworks and analyses to determine optimal study designs given a set of data conditions and research goals.
	Manipulative experiments	Multiple replicate experimental units are created and an experimental manipulation (a “treatment”) is applied to a random set of these units, with the remaining units being left as controls. A measured difference in average response between the manipulated and control units can then be inferred to be due to the treatment. This involves ensuring that studies have adequate replication to have a good chance of detecting an observed change of biologically significant magnitude (see below, on power analysis), and having adequate control sites or a gradient of locations around the treatment site.
	Model development and statistical frameworks	Development and maintenance of species distribution models, habitat suitability models, risk assessment frameworks, Population Consequences of Disturbance (PCoD) models, cumulative impact assessments, etc.
	Technology advancement	Includes the development and testing of new field research tools/methods or mitigation options; can also include development of and improvements to data systems.

	Meta-analysis and literature review	Examples include compilations of research priorities, impacts literature, assessments of data availability, life history parameters to inform models.
	Outreach and platforms to provide data products and results to stakeholders	Includes the work that RWSC does to summarize and convey findings and results to stakeholders and decision-makers, including through regional data portals and other web-based platforms that display interpretive maps with exploratory tools and links to the underlying data as appropriate.

2 Research Topics: Marine mammals and offshore wind in the U.S. Atlantic Ocean

Over the last decade, several entities and expert groups have proposed research topics and questions related to marine mammals and offshore wind that should be addressed by a regional collaborative[24,25,26,27,28,29]. This Science Plan builds on those prior efforts. Importantly, the BOEM and NOAA Fisheries Draft North Atlantic Right Whale Offshore Wind Strategy identifies a number of specific research needs and actions under several goals related to mitigation, monitoring, and communication (more detail about the Draft Strategy is provided in Section 3.2). The research topics in this Science Plan will align and be coordinated with future activities guided by the Draft Strategy.

The RWSC Marine Mammal Subcommittee considered these previous bodies of work in developing the following list. In doing so, they have also highlighted the following concepts:

- Climate change: Disentangling the effects on marine mammals as a result of climate change from any potential effects from offshore wind development will be a major challenge. For example, any attempt to establish a "baseline" representative of the past several decades must acknowledge that the environment changed rapidly over that

[24] May 2018 Workshop on Marine Mammal Research Priorities convened by Massachusetts, BOEM, and New England Aquarium (https://www.masscec.com/resources/related-wildlife-analyses)

[25] NYSERDA E-TWG State of the Science Workshop on Wildlife and Offshore Wind Energy 2020: Marine Mammals Workgroup Report (https://www.nyetwg.com/_files/ugd/78f0c4_75022670bf6f4bc6b001727e7be618ef.pdf)

[26] Monitoring of Marine Life During Offshore Wind Energy Development - Guidelines and Recommendations contributed by more than 20 environmental organizations (https://www.nrdc.org/sites/default/files/ow_marine-life_monitoring_guidelines.pdf)

[27] Priorities identified by the New Jersey Offshore Wind Research and Monitoring Initiative (https://dep.nj.gov/offshorewind/rmi/)

[28] NYSERDA E-TWG Regional Synthesis Workgroup Atlantic Offshore Wind Environmental Research Recommendations (https://tethys.pnnl.gov/atlantic-offshore-wind-environmental-research-recommendations)

[29] Draft BOEM and NOAA Fisheries North Atlantic right whale and offshore wind strategy – Oct 2022 version

time and continues to change rapidly. In addition, climate change increases the uncertainty surrounding marine mammal behavior, distribution and demography, which can abruptly and unexpectedly increases the risks associated with offshore wind development if marine mammals begin to use new areas and habitats or existing habitat more frequently or during different times of year.

- A key contribution of the RWSC Science Plan is the ability to look across all the various data collection activities and identify opportunities for synthesis.
- Assigning causality to observed changes may not be possible in all studies.

For the purposes of this chapter, the Subcommittee organized research topics by RWSC Research Themes, which are used throughout this Plan by other Subcommittees. For each stated topic, there are potentially many detailed related questions, hypotheses, and potential approaches that could be used to address each.

In subsequent sections, many of the detailed questions, hypotheses, and potential approaches that correspond to these Research Topics and Themes are described for regional-scale studies and for each subregion (Gulf of Maine; Southern New England; New York/New Jersey Bight; U.S. Central Atlantic; U.S. Southeast Atlantic).

		RWSC Science Plan Actions	
RWSC Research Theme	**Research Topic**	**Field data collection methods and analysis**	**Other**
Mitigating negative impacts that are likely to occur and/or are severe in magnitude	Understand increases in vessel traffic from construction and maintenance of offshore wind projects and develop or update existing vessel & marine mammal co-occurrence models		Model development and statistical frameworks
	Advance quieting technologies		Technology advancement
	Assess entanglement risks associated with floating offshore wind; monitor entanglement with subsea structure of floating offshore wind structures; monitor secondary entanglement where derelict fishing gear/marine debris may attach to subsurface offshore wind structures	Opportunistic visual surveys, aerial visual, boat-based visual, tagging	Model development and statistical frameworks Technology advancement
	Advance Population Consequences of Disturbance (PCoD) and Population Consequences of Multiple Stressors modeling	Animal physiology, tagging, behavioral response studies during construction	Model development and statistical frameworks

		RWSC Science Plan Actions	
RWSC Research Theme	**Research Topic**	**Field data collection methods and analysis**	**Other**
	Mitigate impacts on regional scientific surveys	Aerial visual, boat-based visual, nets and tows, animal physiology	Coordination and planning Technology advancement
Detecting and quantifying changes to wildlife and habitats	Collect information on distribution, abundance, behavior, health, reproduction, and movement patterns of marine mammals and integrate new data types into species distribution models (e.g., PAM) and/or develop new models and data products	Visual and digital aerial surveys, ship-based visual surveys, passive acoustic monitoring, tagging studies, animal physiology	Standardizing data collection, analysis, and reporting Study optimization Model development and statistical frameworks
	Implement a regional long-term archival passive acoustic monitoring network in the U.S. Atlantic Ocean	Passive acoustic monitoring – archival and real-time	Coordination and planning Standardizing data collection, analysis, and reporting Study optimization
	Expand analysis and synthesis of rates of marine mammal strandings and mortality events in the U.S. Atlantic Ocean over time		Model development and statistical frameworks Coordination and planning
Understanding the environmental context around changes to wildlife and habitats	Work with the Habitat & Ecosystem Subcommittee to ensure that key oceanographic and habitat data are collected and available as data products for use in marine mammal studies		Coordination and planning Standardizing data collection, analysis, and reporting Outreach and platforms to provide data products and results to stakeholders
	Work with the Habitat & Ecosystem Subcommittee to determine whether offshore wind structures alter hydrodynamics, stratification, and mixing		Coordination and planning

		RWSC Science Plan Actions	
RWSC Research Theme	**Research Topic**	**Field data collection methods and analysis**	**Other**
	Develop a coordinated regional scale zooplankton (marine mammal prey) monitoring and mapping effort, building off existing programs and studies	Satellite remote sensing, nets and tows, echosounders	Model development and statistical frameworks
	Monitor ambient noise levels in the ocean for historic conditions, present day, and predicted future scenarios	Passive acoustic monitoring – archival and real-time	Historical data collection/compilation Model development and statistical frameworks
Determining causality for observed changes to wildlife and habitats	Conduct a synthetic baseline assessment of marine mammals over the past several decades that integrates density modeling and/or visual survey data, passive acoustic monitoring data, tagging data, oceanography/habitat data, and climate data to characterize pre-development levels of spatial and temporal variability in marine mammal distribution and abundance patterns		Historical data collection/compilation Model development and statistical frameworks Meta-analysis and literature review
	Determine whether construction activities displace or attract marine mammals	Passive acoustic monitoring – archival and real-time, visual and digital aerial surveys, boat-based surveys, tagging	Model development and statistical frameworks
	Determine whether offshore wind structures displace or attract marine mammals	Passive acoustic monitoring – archival and real-time, visual and digital aerial surveys, boat-based surveys, tagging	Model development and statistical frameworks
	Determine whether marine mammal feeding is altered due to changes to hydrodynamics or prey distribution/abundances caused by offshore wind structures	Passive acoustic monitoring – archival and real-time, visual and digital aerial surveys, boat-based surveys, tagging	Model development and statistical frameworks

		RWSC Science Plan Actions	
RWSC Research Theme	**Research Topic**	**Field data collection methods and analysis**	**Other**
	Distinguish between climate change-driven shifts in marine mammal distribution, abundance, and behavior and changes that may be driven by offshore wind construction and operation	Visual and digital aerial surveys, shipboard surveys, tagging, water quality and oceanography	Model development and statistical frameworks
	Study how species detect/receive EMF, whether they respond to EMF (from both AC and DC cables) with changes in distributions or behavior, and whether those responses vary with factors such as EMF strength, cable burial depth, and floating/fixed technology	Visual and digital aerial surveys, boat-based surveys, tagging	Manipulative experiments Model development and statistical frameworks
Enhancing data sharing and access	Create an inventory of all ongoing data collection and research projects for marine mammals and offshore wind to encourage a coordinated approach to regional-scale analysis and planning future work		Coordination and planning Standardizing data collection, analysis, and reporting Outreach and platforms to provide data products and results to stakeholders
	Coordinate data collection and synthesis of existing data efforts at a regional scale including baseline data, population monitoring, and data collected at individual OSW project sites (e.g., post-construction monitoring data) and facilitate pooling of data to obtain the statistical power to examine regional-scale effects		Coordination and planning Standardizing data collection, analysis, and reporting
	Make all data publicly available, including data collected for Environmental Impact Statements and post-construction monitoring to aid in the assessment of broad-scale questions, ecosystem-level research, and potential cumulative impacts		Coordination and planning Outreach and platforms to provide data products and results to stakeholders

3 Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for marine mammals and offshore wind

3.1 Field data collection and analysis

The following activities include marine mammal observational data acquired in the field at the regional scale (i.e., consistently across the entire Atlantic coast in all RWSC Subregions), including any observations of location, distribution, abundance, behavior, and health.

Ongoing and pending activities

Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Aerial visual – distance sampling, aerial photography	North Atlantic Right Whale Aerial Sighting Survey	NOAA Fisheries	1998-present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Aerial visual – distance sampling, boat-based – distance sampling; passive acoustic monitoring – archival, acoustic tagging, nets and tows, model development and statistical frameworks	Atlantic Marine Assessment Program for Protected Species (AMAPPS) I, II, and III	NOAA, BOEM, U.S. Fish & Wildlife Service, U.S. Navy	2010 - 2023	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring - archival	Partnership for an Offshore Wind Energy Regional Observation Network (POWERON) in the U.S. Atlantic Ocean	BOEM, NOAA, RWSC	2022 - present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around**

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
				changes to wildlife and habitats
Passive acoustic monitoring – real-time, acoustic tagging, eDNA	Addressing key information gaps in acoustic ecology of North Atlantic right whales	BOEM	2023 – 2025	**Detecting and quantifying changes to wildlife and habitats**
Nets and tows, water quality and oceanography	Ecosystem Monitoring on the Continental Shelf (EcoMon)	NOAA NEFSC, BOEM	1992-present	**Understanding the environmental context around changes to wildlife and habitats** **Enhancing data sharing and access**

Recommendations

- **Detecting and quantifying changes to wildlife and habitats - Collect information on distribution, abundance, behavior, health, reproduction, and movement patterns of marine mammals and integrate new data types into species distribution models (e.g., PAM) and/or develop new models and data products:**
    - Continue regional scale protected species data collection through AMAPPS or similar programs and supplement AMAPPS data with methods that detect smaller species and juveniles.
    - Advance and/or adopt recommendations related to the use of aerial visual and aerial digital survey techniques for certain species, life history stages, or geographies.
- **Detecting and quantifying changes to wildlife and habitats - Implement a regional long-term archival passive acoustic monitoring network in the U.S. Atlantic Ocean:** Use the results of the RWSC Marine Mammal Subcommittee's power analysis to guide future deployments of passive acoustic recorders. Continue to coordinate and communicate field deployment and retrieval of passive acoustic recorders via the RWSC Marine Mammal Subcommittee. The network may also leverage existing or add new ocean observing assets maintained by Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS), Mid-Atlantic Regional Association of Coastal Ocean Observing Systems (MARACOOS), and Southeastern Coastal Ocean Observing Regional Association (SECOORA), to the extent practicable. The RWSC Marine Mammal Subcommittee will be used as a forum for information exchange and coordination related to developing collaborative funding models for optimizing PAM deployments.

- **Understanding the environmental context around changes to wildlife and habitats - Develop a coordinated regional scale zooplankton (marine mammal prey) monitoring and mapping effort, building off of existing programs and studies:** Continue to collect regional scale data that allow analysis and synthesis of prey fields and expand upon existing prey field sampling (including EcoMon, Continuous Plankton Recorder, the Gulf of Maine MBON, and projects conducted by Stony Brook University and Rutgers University).
- **Determining causality for observed changes to wildlife and habitats – Determine whether construction activities displace or attract marine mammals; Determine whether offshore wind structures displace or attract marine mammals; Distinguish between climate change-driven shifts in marine mammal distribution, abundance, and behavior and changes that may be driven by offshore wind construction and operation: Implement a regional long-term archival passive acoustic monitoring network in the U.S. Atlantic Ocean:** Use the RWSC Marine Mammal Subcommittee's Data Management and Best Practices for Long-term Archival Passive Acoustic Monitoring Data[30] to guide consistent data collection, storage, and analysis such that regional scale questions related to marine mammal displacement can be addressed (see Appendix). The RWSC Marine Mammal Subcommittee will be used as a forum for information exchange and coordination related to developing collaborative funding models for PAM data analysis strategies.

3.2 Coordination and planning

The following activities include the active coordination and planning that occurs through RWSC via the Marine Mammal Subcommittee as well as other regional-scale efforts (e.g., led by federal agencies) around particular issues or species.

Ongoing and pending activities

RWSC Marine Mammal Subcommittee: The Marine Mammal Subcommittee will maintain situational awareness of marine mammal data collection and research in the U.S. Atlantic Ocean by coordinating with the entities and groups described in this Science Plan. The Subcommittee will meet regularly to share information and track Science Plan progress.

Maine Offshore Wind Research Consortium: In 2021, the governor and legislature in Maine established the Maine Offshore Wind Research Consortium to better understand the local and regional impacts of floating offshore wind power projects in the Gulf of Maine. The statute directs the Governor's Energy Office (GEO) to serve as the coordinating agency and outlines an Advisory Board with representation from fisheries interests, and the Department of Marine Resources (DMR) and including other state agencies and stakeholders. The Advisory Board is responsible for establishing a research strategy that at a minimum includes the following themes: Opportunities and challenges caused by the deployment of floating offshore wind projects to the existing uses of the Gulf of Maine; Methods to avoid and minimize the impact of floating offshore wind projects on ecosystems and existing uses of the Gulf of Maine; and ways

[30] https://rwscollab.github.io/pam-data-mgmt/

to realize cost efficiencies in the commercialization of floating offshore wind projects. The Maine Offshore Wind Consortium will collaborate closely with other states and regional and national science and research partners, including the National Offshore Wind Research and Development Consortium, and the Regional Wildlife Science Collaborative, of which the Governor's Energy Office is a member.

Massachusetts Habitat Working Group on Offshore Wind Energy: To augment the BOEM Intergovernmental Task Force process and engage directly with key stakeholders, the Executive Office of Energy and Environmental Affairs and the Massachusetts Clean Energy Center (CEC) convenes two working groups for marine habitat and fisheries issues. While the working groups are voluntary and informal, they provide a critically important forum for maintaining a dialogue with key stakeholders, getting their feedback and guidance, and identifying issues and concerns. Input from the working groups has directly resulted in accommodations to avoid important marine habitat, fishing grounds, and marine commerce routes in the designation of the wind energy lease areas. The working groups will continue to provide valuable advice as leaseholders proceed through the next phases of the BOEM wind energy commercial leasing process, including site assessments, environmental and technical reviews, and development of construction and operations plans. The Habitat Working Group on Offshore Wind Energy is comprised of scientists and technical experts from environmental organizations, academia, and state and federal agencies.

NYSERDA Environmental Technical Working Group: The 2018 Offshore Wind Master Plan for New York included the development of collaborative, science-focused Technical Working Groups to advise the State about offshore wind energy development. As defined in the Plan, the Environmental Technical Working Group (E-TWG) advises the State about "measures to avoid, minimize, and mitigate anticipated impacts on wildlife during offshore wind energy development activities," including: Development of wildlife best management practices; Identification of research needs and coordination; Multi-agency coordination for adaptive management; Creation of a framework for an environmental conservation fund. The E-TWG meets up to four times annually. New York State Energy Research and Development Authority (NYSERDA) and other state agencies provide the E-TWG with oversight and direction, and use group recommendations and discussions to inform decision making.

New Jersey Research & Monitoring Initiative: The Research and Monitoring Initiative (RMI) addresses the need for regional research and monitoring of marine and coastal resources during offshore wind development, construction, operation and decommissioning as recommended in the New Jersey Offshore Wind Strategic Plan. Initial funding is provided by developers through New Jersey's Offshore Wind Solicitation 2. The RMI is administered by the NJ Department of Environmental Protection in collaboration with the NJ Board of Public Utilities. The goal of the RMI is ensure that New Jersey adheres to the mandate to protect and responsibly manage its coastal and marine resources as it moves towards a clean energy economy.

NOAA Fisheries & BOEM Federal Survey Mitigation Strategy – Northeast U.S. Region: NOAA Fisheries' scientific surveys collect data used in hundreds of species stock assessments and are critical to the agency's responsibility for stewardship of the nation's living marine resources including fisheries, marine mammals, endangered and threatened species, and the habitats and ecosystems that support these species. These assessments rely on more than 50 long-term, standardized surveys, many of which have been ongoing for more than 30 years. The Federal Survey Mitigation Strategy[31] guides the development and implementation of a program to mitigate impacts of wind energy development on scientific surveys (including both vessel and aerial surveys) over the expected full duration (30+ years) of wind energy development from Maine to North Carolina.

BOEM & NOAA Fisheries North Atlantic Right Whale and Offshore Wind Strategy (Draft, October 2022): BOEM and NOAA Fisheries initiated development of a shared draft North Atlantic Right Whale (NARW) and Offshore Wind Strategy to focus and integrate past, present, and future efforts related to NARW and offshore wind development. To achieve the common vision and to meet the agencies' legislative mandates, the Draft Strategy identifies a number of actions under three categories: (1) Mitigation and Decision-Support Tools; (2) Research and Monitoring; and (3) Collaboration, Communication, and Outreach. Executing this Strategy will involve collaboration and coordination among the many Federal and non-Federal partners with shared interests, including RWSC.

Recommendations

- **Mitigating negative impacts that are likely to occur and/or are severe in magnitude – Mitigate impacts on regional scientific surveys:** NMFS Long-term protected species, fisheries, and ecosystem surveys form the backbone of the scientific monitoring system needed for the management of wildlife, fisheries, habitats, and ecosystems. In order to understand potential changes in wildlife and habitats from offshore wind energy development--it is critical that long-term standardized surveys continue to provide timely, accurate, and precise data on wildlife, habitats, and ecosystems. The need to fully implement the NMFS and BOEM Survey Mitigation Strategy is critical to putting site and regional level studies in the context of population trends and ecosystem conditions. The Strategy calls for the development of a Northeast Survey Mitigation Program. This is largely unfunded but it is highlighted as a significant priority for the region.
- **Enhancing data sharing and access - Coordinate data collection and synthesis of existing data efforts at a regional scale including baseline data, population monitoring, and data collected at individual OSW project sites (e.g., post-construction monitoring data) and facilitate pooling of data to obtain the statistical power to examine regional-scale effects**
    - Continue to lead or participate in the ongoing and pending coordination and planning activities described above, using the RWSC Marine Mammal Subcommittee as a forum for information exchange and coordination among federal agencies, states, offshore wind industry, eNGOs, and the research community.

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[31] https://repository.library.noaa.gov/view/noaa/47925

- Coordinate and initiate collaborations with additional partners to facilitate data and information sharing, including the Marine Mammal Health and Stranding Response Program, regional stranding coordinators, the National Marine Mammal Tissue Bank, and others.

3.3 Standardizing data collection, analysis, and reporting

This section identifies existing best practices and/or guidance for standardizing data collection, analysis, and reporting, and lists existing and ongoing work to address these issues. The Subcommittee identified a number of existing repositories for marine mammal data (below). Guidance for the use of those repositories, including templates for data and/or metadata submission are described where available. If those resources are missing or need to be developed, they are captured as "Recommendations" in this section.

Method(s) and data type(s)	Repository
Observational surveys; telemetry data; detections from passive acoustic monitoring; photo identification; oceanographic data products; model outputs	**OBIS-SEAMAP**[32] (Ocean Biogeographic Information System – Spatial Ecological Analysis of Megavertebrate Populations): Including mapping tools, data extraction / data download; visualization and quantification of effort data. BOEM recommends that survey data for marine mammals are shared via OBIS-SEAMAP. OBIS-SEAMAP website includes instructions for minimum required data fields, acceptable formats, a data sharing policy with multiple sharing options, and methods for submitting data to the archive.
Raw passive acoustic data; passive acoustic data products (e.g., ambient noise metrics and species detections)	**NOAA NCEI Passive Acoustic Data Archive**[33]: Archived passive acoustic datasets are made publicly available for search, discovery, and access through a web-based map viewer. The PassivePacker software tool simplifes data submission to the archive. The software packages the data into standardized structures and creates machine-parsable JavaScript Object Notation (JSON) metadata records. Data providers then send these data packages to NCEI. There is a ~$145/TB cost associated with archiving data at NCEI to support long-term data stewardship that meets the National Archives and Records Administration standards. The PassivePacker webpage includes a manual found under 'Help' for comprehensive data submission guidance specific to passive acoustic data. It is requested that data be sent to NCEI within a year of retrieval. If an embargo is needed past that time to delay public access until after publication, NCEI may be able to provide that service.
Tagging data	**Animal Telemetry Network**[34] (ATN): The Integrated Ocean Observing System (IOOS) Animal Telemetry Network Data Assembly Center (ATN DAC) is designed to serve as an access point to search, discover and access animal telemetry data, and associated oceanographic datasets, from a wide variety of species and platforms. ATN has implemented a multi-year program funded by the Office of Naval Research which will pay for the cost of Argos satellite

[32] https://seamap.env.duke.edu

[33] https://www.ncei.noaa.gov/products/passive-acoustic-data

[34]

	tracking services for marine animal telemetry researchers who agree to submit their data and metadata to ATN's DAC. The DAC provides a secure data access and analysis space for researchers, while offering public visualizations of tracks and data archiving following user-specified embargo periods. Visit https://portal.atn.ioos.us/ to access the map-based inventories. The ATN website includes instructions for how to submit data and metadata to the ATN DAC.
Passive acoustic data products (e.g., ambient noise metrics and species detections)	**NOAA Passive Acoustics Reporting System**[35]**:** All confirmed passive acoustic detections of target species/species, whether from archival or real-time data, are archived in a publicly accessible location. For the U.S. East Coast, all species detection data and ambient noise metrics should be reported to the Northeast Passive Acoustic Reporting System via nmfs.nec.pacmdata@noaa.gov. Formatted spreadsheets that follow ISO standards with required detection, measurement, and metadata information are available for submission purposes. When PAM is used for long-term monitoring, all data (detection data, metadata, GPS data, and ambient noise data) should be provided via the formatted spreadsheets and uploaded within 90 days of the retrieval of the recorder or data collection. The data will be displayed on the Passive Acoustic Cetacean Map. Recorder locations will be shared with the RWSC Marine Mammal Subcommittee, Northeast Ocean Data Portal, and Mid-Atlantic Ocean Data Portal.
Observational data; Photography	**North Atlantic Right Whale Consortium**[36] (NARWC): The Sightings Database houses North Atlantic right whale and other marine mammal sightings data (opportunistic and structured survey data) from the 1970s-present. The North Atlantic Right Whale Catalog (Identification Database) houses photographs of right whales from 1935-present. Data and metadata submission guidelines are available on the website. BOEM recommends that all right whale data are shared via NARWC databases.

Ongoing and pending activities

Click project names to view full descriptions.

Project	Lead and Partner Entities	Time period	Research Theme
RWSC Data Management and Storage Best Practices for Long-term and Archival Passive Acoustic Monitoring (PAM) Data [37]	NOAA, BOEM, RWSC	2022 - present	**Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**

[35] https://www.fisheries.noaa.gov/resource/document/passive-acoustic-reporting-system-templates

[36] https://www.narwc.org/

[37] https://rwscollab.github.io/pam-data-mgmt/

Project	Lead and Partner Entities	Time period	Research Theme
SoundCoop (Passive Acoustic Monitoring National Cyberinfrastructure Center) – honing workflows and infrastructure for passive acoustic data management, storage, and use	NOAA NCEI with multi-sector Steering Committee that includes RWSC	2021 - 2024	**Enhancing data sharing and access**
Developing best practices and applying environmental DNA (eDNA) tools in support of assessing and managing living marine species in an ecosystem-based context	BOEM, NOAA	2023	**Detecting and quantifying changes to wildlife and habitats**

Recommendations

- **Detecting and quantifying changes to wildlife and habitats - Coordinate data collection and synthesis of existing data efforts at a regional scale including baseline data, population monitoring, and data collected at individual OSW project sites (e.g., post-construction monitoring data) and facilitate pooling of data to obtain the statistical power to examine regional-scale effects**
- **Enhancing data sharing and access - Make all data publicly available, including data collected for Environmental Impact Statements and post-construction monitoring to aid in the assessment of broad-scale questions, ecosystem-level research, and potential cumulative impacts**
    - Ensure that existing data repositories for marine mammal data have resources and personnel to integrate and provide access to offshore wind and wildlife monitoring datasets as they are collected. Include a minimum budget threshold that must be allocated to data management and access in all project budgets (e.g., 20%).
    - Require that marine mammal observations (opportunistic data, structured survey data, passive acoustic detections, other detections) be submitted to OBIS-SEAMAP with any associated effort data. North Atlantic right whale observations should also be submitted to the North Atlantic Right Whale Consortium.
    - Require that raw data and deployment metadata be submitted for archiving at the NCEI Passive Acoustic Data Archive. Species detection data and ambient noise metrics data should be submitted to the NOAA Passive Acoustics Reporting System with the appropriate metadata and detector performance metrics. For more information about managing and sharing passive acoustic data, refer to the RWSC Data Management and Storage Best Practices for Long-term and Archival Passive Acoustic Monitoring Data.
    - Require that raw data and deployment metadata be submitted for storage, management, and visualization to the Animal Telemetry Network and/or its regional nodes (ACT, FACT, MATOS) according to the guidance provided by these entities.

- Continue work with BOEM and partners on the development and use of a Master Protected Species Observer (PSO) Sightings Database. With the RWSC Subcommittee, review, require, and disseminate the resulting best practices and data standards that are currently under development.
- Work with BOEM, the U.S. Fish & Wildlife Service, USGS, and others as they develop the infrastructure and guidelines around the use of a repository for aerial digital imagery.

3.4 Study optimization

This section describes work to implement statistical frameworks and analyses to determine optimal study designs given a set of data conditions and research goals.

Ongoing and pending activities

Click project names to view full descriptions.

Project	Lead and Partner Entities	Time period	Research Theme
Comparative Study of Aerial Survey Techniques	BOEM, NOAA, U.S. Fish & Wildlife Service	2022 - 2024	**Detecting and quantifying changes to wildlife and habitats**
Power analysis for optimal design of a regional passive acoustic monitoring network in the Atlantic Ocean	RWSC, BOEM, University of St. Andrews, Virginia Department of Environmental Quality	2022-2023	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats**

Recommendations

- **Detecting and quantifying changes to wildlife and habitats - Collect information on distribution, abundance, behavior, health, reproduction, and movement patterns of marine mammals and integrate new data types into species distribution models (e.g., PAM) and/or develop new models and data products:** Advance and/or adopt recommendations related to the use of aerial visual and aerial digital survey techniques for certain species, life history stages, or geographies.

- **Detecting and quantifying changes to wildlife and habitats - Implement a regional long-term archival passive acoustic monitoring network in the U.S. Atlantic Ocean:** Use the results of the RWSC Marine Mammal Subcommittee's power analysis to support initial design of a regional long-term archival passive acoustic monitoring network in the Atlantic Ocean. Repeat a power analysis/optimization analysis every 3-5 years to ensure that new monitoring assets are accounted for in the optimal design and that existing or new hypotheses and questions can be addressed by the regional network.

3.5 Model development and statistical frameworks

The following activities include the development and maintenance of species distribution models, habitat suitability models, risk assessment frameworks, Population Consequences of Disturbance (PCoD) models, cumulative impact assessments, etc.

Ongoing and pending activities

Click project names to view full descriptions.

Project	Lead and Partner Entities	Time period	Research Theme
Habitat-based marine mammal density models for the U.S. Atlantic[38]	Duke University Marine Geospatial Ecology Laboratory	2016 - present	**Detecting and quantifying changes to wildlife and habitats**
Risk Assessment to Model Encounter Rates Between Large Whales and Sea Turtles and Vessel Traffic from Offshore Wind Energy on the Atlantic OCS[39]	BOEM	2023-2024	**Mitigating negative impacts that are likely to occur and/or are severe in magnitude**
Project WOW Task 2: Development and maintenance of research/risk frameworks • Occurrence, Exposure, Response, Consequence (OERC) Framework • Risk Matrix Framework • Population Consequences of Disturbance (PCoD) models for exemplar species	Project WOW	2022 - present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats**
Assessing population effects of offshore wind development on North Atlantic right whales (*Eubalaena glacialis*)	BOEM University of St. Andrews	2021-2024	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context**

[38] https://seamap.env.duke.edu/models/Duke/EC/

[39] https://espis.boem.gov/final%20reports/BOEM_2021-034.pdf

Project	Lead and Partner Entities	Time period	Research Theme
			around changes to wildlife and habitats
Development of Computer Simulations to Assess Entanglement Risk to Whales and Leatherback Sea Turtles in Offshore Floating Wind Turbine Moorings, Cables, and Associated Derelict Fishing Gear Offshore California (includes a North Atlantic right whale model	BOEM NOAA's National Centers for Coastal Ocean Science	2019-2025	**Mitigating negative impacts that are likely to occur and/or are severe in magnitude**

Recommendations

- **Detecting and quantifying changes to wildlife and habitats - Collect information on distribution, abundance, behavior, health, reproduction, and movement patterns of marine mammals and integrate new data types into species distribution models (e.g., PAM) and/or develop new models and data products:**
    - Continue to update marine mammal density models with new observational and environmental covariate data every 2-3 years or as is practical. For North Atlantic right whale models, updates should be more frequent. Incorporate passive acoustic data and other data types as practical into future versions of cetacean density models so that model outputs reflect more types of observational effort.
    - Periodically validate and evaluate the performance of models and statistical frameworks. Use validation and evaluation results to continually inform and advance model/framework development and application.

- **Mitigating negative impacts that are likely to occur and/or are severe in magnitude - Understand increases in vessel traffic from construction and maintenance of offshore wind projects and develop or update existing vessel & marine mammal co-occurrence models:**
    - Inform models with information from the offshore wind industry regarding vessel types and numbers. Validate models with AIS and effort-corrected whale sightings data.
    - Continue the existing collaboration between Project WOW and the RWSC Marine Mammal Subcommittee to inform and be informed by the development and maintenance of research/risk frameworks as applied to marine mammals in the RWSC study area.

- **Mitigating negative impacts that are likely to occur and/or are severe in magnitude – Assess entanglement risks associated with floating offshore wind:** Build off of existing simulation modeling funded by BOEM and other efforts to better understand entanglement risk.

- **Mitigating negative impacts that are likely to occur and/or are severe in magnitude - Advance Population Consequences of Disturbance (PCoD) and Population Consequences of Multiple Stressors modeling:** Continue to advance PCoD modeling and other frameworks, through Project WOW, projects funded by BOEM and others.

3.6 Technology advancement

The following activities include the development and testing of new field research tools/methods or mitigation options; can also include development of and improvements to data systems.

Ongoing and pending activities

Click project names to view full descriptions.

Project	Lead and Partner Entities	Time period	Research Theme
Automated detection and classification of wildlife targets in digital aerial imagery – Phase II	BOEM, USGS, U.S. Fish & Wildlife Service, Vision Group at the International Computer Science Institute at the University of California Berkeley	2024	**Detecting and quantifying changes to wildlife and habitats**
Technology development priorities for scientifically robust and operationally compatible wildlife monitoring and adaptive management	Advisian, BRI, NOWRDC	2022-2023	**Mitigating negative impacts that are likely to occur and/or are severe in magnitude** **Detecting and quantifying changes to wildlife and habitats**

Recommendations

- **Mitigating negative impacts that are likely to occur and/or are severe in magnitude - Advance quieting technologies:** Develop new and advance existing technologies that can mitigate potential impacts including noise (e.g., bubble curtains).
- **Detecting and quantifying changes to wildlife and habitats - Collect information on distribution, abundance, behavior, health, reproduction, and movement patterns of marine mammals and integrate new data types into species distribution models (e.g., PAM) and/or develop new models and data products; Make all data publicly available:**

- Develop integrated monitoring and mitigation systems within wind facilities that leverage and advance new technologies. This includes “smart” mitigation methods triggered by marine mammal presence, quieting technologies, and potentially sharing real-time observations online.
- Explore and expand the use of satellite data, unmanned systems (gliders or autonomous underwater vehicles) and emerging technologies (e.g., eDNA) for marine mammal distribution and habitat use; Develop and deploy safe long duration satellite tagging telemetry technology for tracking high-resolution movements of marine mammals in and around offshore wind structures.
- Advance, evaluate, and apply new technologies to better detect marine mammals where they occur, including using infrared cameras or laser detection (on ships or other platforms).
- Improve analysis of monitoring data through artificial intelligence, automated acoustic, and image processing, and near real-time data availability.

3.7 Meta-analysis and literature review

This section describes existing projects and recommendations to compile research priorities, impacts literature, and/or life history parameters, as well as to conduct assessments of data availability to inform models.

Ongoing and pending activities

Click project names to view full descriptions.

Project	Lead and Partner Entities	Time period	Research Theme
Project WOW Task 1.1: Create an annotated catalog of existing relevant datasets and their anticipated availability	Duke University	2022-2023	**Detecting and quantifying changes to wildlife and habitats**
Project WOW Task 1.2: Summary of temporal distribution and abundance of cetaceans and seabirds for the East Coast region and Wind Energy Areas of interest	Duke University	2022-2023	**Detecting and quantifying changes to wildlife and habitats**
Project WOW Task 2: Development and maintenance of research/risk frameworks - gap analysis and framework development (synthesize existing frameworks; list existing knowledge/data portals; systematically review evidence availability)	Duke University, University of St. Andrews	2022-2023	**Detecting and quantifying changes to wildlife and habitats**
North Atlantic Right Whale Research and Management Activities	BOEM	2023	**Mitigating negative impacts that are likely to occur**

Project	Lead and Partner Entities	Time period	Research Theme
			and/or are severe in magnitude **Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**

Recommendations

- **Determining causality for observed changes to wildlife and habitats - Conduct a synthetic baseline assessment of marine mammals over the past several decades that integrates density modeling and/or visual survey data, passive acoustic monitoring data, tagging data, oceanography/habitat data, and climate data to characterize pre-development levels of spatial and temporal variability in marine mammal distribution and abundance patterns:** Use the results of this analysis to characterize pre-development levels of spatial and temporal variability in marine mammal distribution and abundance patterns, from which to measure and assess any potential changes after the onset of offshore wind construction and regional-scale operation activities.
- **Detecting and quantifying changes to wildlife and habitats - Expand analysis and synthesis of rates of marine mammal strandings and mortality events in the U.S. Atlantic Ocean over time:** Continue and expand stranding data collection and analysis, as well as strandings and mortality data time series analysis for the U.S. Atlantic Ocean.

3.8 Outreach and platforms to provide data products and results to stakeholders

This category of activities includes the work that RWSC and others do to summarize and convey findings and results to stakeholders and decision-makers, including through regional data portals and other web-based platforms that display interpretive maps with exploratory tools and links to the underlying data as appropriate.

Ongoing and pending activities

Click project names to view full descriptions.

Project	Lead and Partner Entities	Time period	Research Theme
Northeast and Mid-Atlantic Ocean Data Portals[40,41] - in collaboration with RWSC	Northeast Regional Ocean Council, Mid-Atlantic Regional Council on the Ocean	2009 – present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats** **Enhancing data sharing and access**
Support for Regional Wildlife Science Collaborative Ocean Portal Products and Services	BOEM	2023 - 2024	**Enhancing data sharing and access**
North Atlantic Right Whale Consortium Annual Report Card[42]	New England Aquarium, University of Rhode Island, Center for Coastal Studies, Marineland of Florida, Woods Hole Oceanographic Institution	1986 - present	**Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**
WhaleMap.org[43]	Dalhousie University	2021 - present	**Mitigating negative impacts that are likely to occur and/or are severe in magnitude** **Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**
Passive Acoustic Cetacean Map (PACM)[44]	NOAA NEFSC	2021 - present	**Detecting and quantifying changes**

[40] https://www.northeastoceandata.org

[41] https://portal.midatlanticocean.org

[42] https://www.narwc.org/

[43] https://whalemap.org/

[44] https://apps-nefsc.fisheries.noaa.gov/pacm/#/

Project	Lead and Partner Entities	Time period	Research Theme
			to wildlife and habitats **Enhancing data sharing and access**

Recommendations

- **Enhancing data sharing and access - Create an inventory of all ongoing data collection and research projects for marine mammals and offshore wind to encourage a coordinated approach to regional-scale analysis and planning future work:** Develop data products that reflect the results of data collection and research activities throughout the RWSC study area and encourage or require projects to include funding for data product development, hosting, and maintenance/updates in their budgets. Data could be hosted and maintained by individual providers but should be shared in formats compatible with existing platforms described above.

The following sections describe ongoing and pending data collection and research activities with respect to marine mammals in each subregion of the U.S. Atlantic Ocean. Following those summaries, a synopsis of data and research gaps, needs, and recommendations is provided.

4 Gulf of Maine ongoing, pending, and recommended research and data collection activities for marine mammals and offshore wind

4.1 Focal species and habitats of interest

The Gulf of Maine subregion extends from Canadian waters to Cape Cod. The ocean waters of the Gulf of Maine are warming faster than 99% of the global ocean average[45]. The rate and degree of ocean warming provides important context for focal marine mammal species and their uses of this subregion. The Gulf of Maine has long represented important feeding grounds for baleen whales from late fall to early spring (see BIAs maps). A resident population of Harbor porpoise is present in the coastal/nearshore areas of the Gulf of Maine from July to September (see BIAs maps). Almost all of the Gulf of Maine subregion is critical habitat (Northeastern U.S. foraging area) for North Atlantic right whales.

4.2 Potential effects of concern

All of the potential effects noted in Section 1.3 apply in the Gulf of Maine.

In addition, water depths in the Gulf of Maine are within the range (>60 m) where floating offshore wind development is likely. The mooring lines and inter-array cables associated with these developments may present physical hazards to marine life. The potential for secondary entanglement of marine life with marine debris snagged on floating offshore wind cable systems is the leading cause of concern, given that the cable systems have a large diameter and are sufficiently heavy, which likely prevents them from looping and entangling marine life[46].

4.3 Field data collection and analysis

Ongoing and pending activities

Click project names to view full descriptions.

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[45] Pershing AJ, Alexander MA, Hernandez CM, Kerr LA, Le Bris A, Mills KE, Nye JA, Record NR, Scannel HA, Scott JD, Sherwood GD, Thomas AC. 2015. Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery. Science 350 (6262): 809-812. DOI: 10.1126/science.aac9819.

[46] (SEER) U.S. Offshore Wind Synthesis of Environmental Effects Research. 2022. Risk to Marine Life from Marine Debris & Floating Offshore Wind Cable Systems. Report by National Renewable Energy Laboratory and Pacific Northwest National Laboratory for the U.S. Department of Energy, Wind Energy Technologies Office. Available at https://tethys.pnnl.gov/seer.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Water quality and oceanography, nets and tows, eDNA	Gulf of Maine Marine Biodiversity Observation Network (MBON)	U.S. IOOS, NERACOOS, BOEM, Integrated Sentinel Monitoring Network (ISMN), University of Maine	2019-present	**Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring – archival	Unnamed project	Office of Naval Research, NOPP	2023?	**Detecting and quantifying changes to wildlife and habitats**
Boat-based – distance sampling, boat-based – strip transect, aerial high def imagery	Ecological Baseline Study of the U.S. Outer Continental Shelf Off Maine	BRI, HiDef Aerial Surveys Ltd, BOEM	2022-2024	**Detecting and quantifying changes to wildlife and habitats**
Nets and tows	Zooplankton Ecology of the Gulf of Maine	University of Maine, BOEM	2019-2023	**Understanding the environmental context around changes to wildlife and habitats**
Aerial visual – strip transect, water quality and oceanography, nets and tows	North Atlantic right whale and humpback whale population and prey monitoring	Center for Coastal Studies	1999-present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Aerial visual – strip transect	Maine aerial surveys	New England Aquarium	2022 – January 2025 (September – January only)	**Detecting and quantifying changes to wildlife and habitats**
Passive acoustic monitoring – archival, passive acoustic monitoring – real-time	Maine Department of Marine Resources Passive Acoustic Monitoring Project	Maine Department of Marine Resources, NOAA NEFSC, Maine Community Foundation	2021 - present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring – archival, passive acoustic	SanctSound (Stellwagen Bank)	NOAA, Navy	1996 - present	**Detecting and quantifying changes to wildlife and habitats**

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
monitoring – real-time				**Understanding the environmental context around changes to wildlife and habitats**
Acoustic tagging	Digital acoustic tagging of sei whales	NOAA Stellwagen Bank National Marine Sanctuary, BOEM	2022	**Detecting and quantifying changes to wildlife and habitats**
Satellite tagging; collection of citizen science; aerial surveys	Mapping abundance, distribution, and foraging ecology of gray seals in the North Atlantic	BOEM, NOAA	2023-2027	**Detecting and quantifying changes to wildlife and habitats**

Recommendations

- **Understanding the environmental context around changes to wildlife and habitats - Develop a coordinated regional scale zooplankton (marine mammal prey) monitoring and mapping effort, building off of existing programs and studies:** In coordination with NERACOOS and the RWSC Habitat & Ecosystem Subcommittee, expand upon existing prey field sampling in the Gulf of Maine through the Gulf of Maine MBON, BOEM-funded Zooplankton Ecology study, Canadian AZMP, and Center for Coastal Studies. Synthesize patterns to identify trends and linkages across trophic levels.

4.4 Non-field data actions

Ongoing and pending activities

Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Coordination and planning	Maine Offshore Wind Research Consortium	Maine Governor's Energy Office	2022-present	**Mitigating negative impacts that are likely to occur and/or are severe in magnitude** **Detecting and quantifying changes to wildlife and habitats**

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
				Understanding the environmental context around changes to wildlife and habitats **Determining causality for observed changes to wildlife and habitats** **Enhancing data sharing and access**

Recommendations

(Relevant to all Research Themes) Coordinate with the Maine Offshore Wind Research Consortium on funding and implementing common research priorities as they are developed.

5 Southern New England ongoing, pending, and recommended research and data collection activities for marine mammals and offshore wind

5.1 Focal species and habitats of interest

The Southern New England subregion includes waters from Cape Cod to the mouth of Long Island Sound. Feeding and migration areas for several baleen whale species occur in Southern New England. On Nantucket Shoals, where unique hydrography aggregates enhanced prey densities, right whale foraging hot spots have recently been mapped[47].

5.2 Potential effects of concern

All of the potential effects noted in Section 1.3 apply in Southern New England. The shallow shelf waters and high prey densities drive concern about turbine presence and extraction of energy from the system that could alter local oceanography and affect whale prey availability[47].

5.3 Field data collection and analysis

Ongoing and pending activities

Click project names to view full descriptions.

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[47] NOAA Northeast Fisheries Science Center. 2023. State of the Ecosystem 2023: New England. https://doi.org/10.25923/9sb9-nj66

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Passive acoustic monitoring - archival	Passive Acoustic Monitoring in the Massachusetts and Rhode Island Wind Energy Areas in Support of the Partnership for an Offshore Wind Energy Regional Observation Network (POWERON)	BOEM, LGL	2022-2025 (with possible extension)	**Detecting and quantifying changes to wildlife and habitats**
Aerial visual – strip transect, passive acoustic monitoring – archival, water quality and oceanography	Southern New England marine mammal and sea turtle aerial surveys	New England Aquarium, MassCEC, BOEM, NOAA offshore wind developers	October 2011 – present	**Detecting and quantifying changes to wildlife and habitats**
Nets and tows, echosounders, water quality and oceanography	Investigating Persistent Super Aggregations of Right Whales and Their Prey in Lease Areas OCS-A 0521 and OCS-A 0522 in the North Atlantic	BOEM, NOAA, USFWS	2022-2024	**Understanding the environmental context around changes to wildlife and habitats**
Echosounders, boat-based surveys, prey sampling, archival research	Assessing Environmental and Biological Drivers of North Atlantic Right Whale Abundance and Distribution in New York and the Southern New England Shelf	Stony Brook University	January 15 2022 – January 14 2024	**Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring - archival	Passive Acoustic Monitoring for NARW in Nantucket Shoals	NOAA NEFSC	2020-present	**Detecting and quantifying changes to wildlife and habitats**
Passive acoustic monitoring – real-time	Real-time Passive Acoustic Monitoring:	WHOI	2021-present	**Detecting and quantifying changes to wildlife and habitats**

	Martha's Vineyard buoy			
Passive acoustic monitoring – real-time, model development and statistical frameworks	Baleen Whale Acoustic Ecology	Syracuse University	2022-2027	**Detecting and quantifying changes to wildlife and habitats**
Acoustic tagging, satellite tagging	Northwest Atlantic Harbor and Gray Seal Monitoring	AMSEAS, Mystic Aquarium	2018-2026	**Detecting and quantifying changes to wildlife and habitats**
Nets and tows, historical data collection/compilation, water quality and oceanography, echosounders	Assessing environmental and biological drivers of North Atlantic right whale abundance and distribution in New York and the Southern New England Shelf	Stony Brook University, Syracuse University, Rutgers University, New England Aquarium, Bigelow Laboratory	2022-2024	**Understanding the environmental context around changes to wildlife and habitats**
Satellite tagging; collection of citizen science; aerial surveys	Mapping abundance, distribution, and foraging ecology of gray seals in the North Atlantic	BOEM, NOAA	2023-2027	**Detecting and quantifying changes to wildlife and habitats**
Aerial visual – strip transect, aerial high-def imagery	Project WOW IRES – aerial surveys	Project WOW, DOE, BOEM	2023-2025	**Detecting and quantifying changes to wildlife and habitats**
Passive acoustic monitoring - archival	Project WOW IRES – passive acoustic monitoring	Project WOW, DOE, BOEM	2023-2025	**Detecting and quantifying changes to wildlife and habitats**
Acoustic tagging, animal physiology, passive acoustic monitoring – real-time	Project WOW IRES – Opportunistic behavioral research study	Project WOW, DOE, BOEM	2023-2025	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**

Satellite tagging	Project WOW IRES – marine mammal satellite tagging	Project WOW, DOE, BOEM	2023-2025	**Detecting and quantifying changes to wildlife and habitats**
Animal physiology	Non-invasive sampling for health monitoring in aquarium and free-ranging whales	Mystic Aquarium	2023-present	**Detecting and quantifying changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats**
eDNA	eDNA to detect marine mammals	Mystic Aquarium	2023-present	**Detecting and quantifying changes to wildlife and habitats**
Thermal camera, technology advancement	AI whale detection technology at Vineyard Wind 1	Vineyard Wind	2023-present	**Detecting and quantifying changes to wildlife and habitats**
Water quality and oceanography, nets and tows	Northeast U.S. Shelf Long-Term Ecological Research (LTER)	WHOI	2021-present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**

Recommendations

- **Detecting and quantifying changes to wildlife and habitats - Implement a regional long-term archival passive acoustic monitoring network in the U.S. Atlantic Ocean:** Incorporate elements of the ECO-PAM Project (ended 12/31/22) into the regional-scale PAM network. ECO-PAM was a marine mammal real-time automated detection and oceanographic sampling project with the goal to better understand the habitat as well as the presence, distribution and seasonality of North Atlantic right whale within Orsted lease areas. The three-year project included two hydrophones deployed by WHOI and URI along with an unmanned glider deployed by Rutgers University Center for Ocean Observing Leadership to provide both oceanographic and audio detection data.
- **Detecting and quantifying changes to wildlife and habitats - Collect information on distribution, abundance, behavior, health, reproduction, and movement patterns of**

marine mammals and integrate new data types into species distribution models (e.g., PAM) and/or develop new models and data products: In collaboration with the Massachusetts Habitat Working Group on Offshore Wind and other partners, continue supporting the development of collaborative funding plans for Southern New England marine mammal and sea turtle aerial surveys that have occurred consistently since 2011.
- **Understanding the environmental context around changes to wildlife and habitats - Develop a coordinated regional scale zooplankton (marine mammal prey) monitoring and mapping effort, building off of existing programs and studies:** Link and coordinate studies of zooplankton prey led by Rutgers University and Stony Brook University in southern New England and the NY Bight with those in the Gulf of Maine (Gulf of Maine MBON, NERACOOS, Center for Coastal Studies, Northeast U.S. Shelf LTER, AZMP) to establish a broader ecosystem observing system. Synthesize patterns to identify trends and linkages across trophic levels.

5.4 Other Science Plan Actions

Ongoing and pending activities

Click project names to view full descriptions.

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Modeling and statistical frameworks	Right Wind: Resolving Protected Species Space-Use Conflicts in Wind Energy Areas	Cornell University, New England Aquarium, Lautec US, NOWRDC	2022-2024	**Detecting and quantifying changes to wildlife and habitats**
Historical data analysis	Evaluating the utility of Protected Species Observer data to address cetacean management and conservation	New England Aquarium, NOAA, Marine Mammal Commission	2020-present	**Detecting and quantifying changes to wildlife and habitats**
Technology advancement	Thermal camera marine mammal automated detection project	Stony Brook University	2022-2023	**Detecting and quantifying changes to wildlife and habitats**
Modeling and statistical frameworks	Project WOW IRES – marine mammal analytical methods	Project WOW, DOE, BOEM	2023-2026	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around**

				changes to wildlife and habitats **Determining causality for observed changes to wildlife and habitats**
Historical data collection/compilation	Marine mammal strandings (Mystic Aquarium)	Mystic Aquarium	2023-present	**Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**
Meta-analysis and literature review, model development and statistical frameworks	Evaluation of hydrodynamic modeling and implications for offshore wind development: Nantucket Shoals	National Academy of Science	2023-present	**Understanding the environmental context around changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats**

6 New York/New Jersey Bight ongoing, pending, and recommended research and data collection activities for marine mammals and offshore wind

6.1 Focal species and habitats of interest

The NY/NJ Bight extends from Long Island to the tip of Cape Map, NJ. Whale sightings off New York and New Jersey have increased recently, including humpback, fin, minke, and North Atlantic right whales[48]. Large whales and their calves migrate and forage through this area. In recent decades, the number of juvenile humpback whales has increased in coastal waters of the New York/New Jersey Bight, likely related to an increase in their menhaden prey[49].

[48] https://whalesofnewyork.wcs.org/

[49] The East Coast Whale Die-Offs: Unraveling the Causes. Yale Environment 360. March 8, 2023. https://e360.yale.edu/features/humpback-whale-strandings-u.s.-east-coast

6.2 Potential effects of concern

All of the potential effects noted in Section 1.3 apply in the New York/New Jersey Bight. In addition, the foraging juvenile humpbacks in particular may be particularly vulnerable to vessel strike due to their behavior and the high density and speed of vessels in nearshore waters in this region (Stepanuk et al. 2021)[50].

6.3 Field data collection and analysis

Ongoing and pending activities

Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Passive acoustic monitoring - archival, boat-based – distance sampling, water quality and oceanography, nets and tows, echosounders	Development and implementation of an ocean ecosystem monitoring program for New York Bight	Stony Brook University, NYDEC	2018-2026	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring – archival, LiDAR, acoustic tagging	Hudson North & South metocean buoys	Ocean Tech Services, Normandeau, NYSERDA	2019-present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring – archival	NOAA Fisheries Northeast Fisheries Science Center Passive Acoustic Monitoring in the mid-Atlantic	NOAA NEFSC	2022-present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**

[50] Stepanuk JEF, Heywood EI, Lopez JF, DiGiovanni RA Jr, Thorne LH. 2021. Age-specific behavior and habitat use in humpback whales: implications for vessel strike. Mar Ecol Prog Ser 663:209 222. https://doi.org/10.3354/meps13638

Satellite tagging; collection of citizen science; aerial surveys	Mapping abundance, distribution, and foraging ecology of gray seals in the North Atlantic	BOEM, NOAA	2023-2027	**Detecting and quantifying changes to wildlife and habitats**
Acoustic tagging, satellite tagging	Northwest Atlantic Harbor and Gray Seal Monitoring	AMSEAS	2018-2026	**Detecting and quantifying changes to wildlife and habitats**
Nets and tows, historical data collection/compilation, water quality and oceanography, echosounders	Assessing environmental and biological drivers of North Atlantic right whale abundance and distribution in New York and the Southern New England Shelf	Stony Brook University, Syracuse University, Rutgers University, New England Aquarium, Bigelow Laboratory	2022-2024	**Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring – archival	(Request for Proposals) New Jersey Offshore Wind Research and Monitoring Initiative - Passive Acoustic Monitoring in the NY/NJ Bight	NJ Research & Monitoring Initiative	2023-?	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring – real-time	Whales of New York	Wildlife Conservation Society, WHOI, Equinor	2016-2028	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring – archival, water quality and oceanography, echosounders	Eco-gliders: An ecological and oceanographic baseline to inform offshore wind development over the continental shelf	Rutgers University, NJ Research & Monitoring Initiative	2022-present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around**

	off the coast of New Jersey			**changes to wildlife and habitats**
Passive acoustic monitoring – archival, water quality and oceanography, acoustic tagging	GLIDE: Glider based ecological and oceanographic surveys of the New York Bight	Rutgers University, Stony Brook University, WHOI, NYSERDA	2022-2024	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Boat-based – visual (opportunistic)	Gotham Whale marine mammal research	Gotham whale	2011-present	**Detecting and quantifying changes to wildlife and habitats**
eDNA, diet analysis, animal physiology	Harbor seal population monitoring and food habits in southern New Jersey	Stockton University, Orsted	2021-2024	**Detecting and quantifying changes to wildlife and habitats**
Aerial visual – strip transect, aerial high-def imagery	Project WOW IRES – aerial surveys	Project WOW, DOE, BOEM	2023-2025	**Detecting and quantifying changes to wildlife and habitats**
Passive acoustic monitoring - archival	Project WOW IRES – passive acoustic monitoring	Project WOW, DOE, BOEM	2023-2025	**Detecting and quantifying changes to wildlife and habitats**
Acoustic tagging, animal physiology, passive acoustic monitoring – real-time	Project WOW IRES – Opportunistic behavioral research study	Project WOW, DOE, BOEM	2023-2025	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Satellite tagging	Project WOW IRES – marine mammal satellite tagging	Project WOW, DOE, BOEM	2023-2025	**Detecting and quantifying changes to wildlife and habitats**

Recommendations

- **Understanding the environmental context around changes to wildlife and habitats - Develop a coordinated regional scale zooplankton (marine mammal prey) monitoring and mapping effort, building off of existing programs and studies:** Link and coordinate studies of zooplankton prey led by Rutgers University and Stony Brook University in southern New England and the New York Bight with those in the Gulf of Maine (Gulf of Maine MBON, Center for Coastal Studies) to establish a broader ecosystem observing system. Synthesize patterns to identify trends and linkages across trophic levels.

6.4 Other Science Plan Actions

Click project names to view full descriptions.

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Historical data collection/compilation	Assessing environmental and biological drivers of North Atlantic right whale abundance and distribution in New York and the Southern New England Shelf	Stony Brook University, Syracuse University, Rutgers University, New England Aquarium, Bigelow Laboratory	2022-2024	**Understanding the environmental context around changes to wildlife and habitats**
Modeling and statistical frameworks	Project WOW IRES – marine mammal analytical methods	Project WOW, DOE, BOEM	2023-2026	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats**

7 U.S. Central Atlantic ongoing, pending, and recommended research and data collection activities for marine mammals and offshore wind

7.1 Focal species and habitats of interest

The Central Atlantic subregion aligns roughly with BOEM's offshore wind planning area and extends from Cape May, NJ to Cape Hatteras, NC. This area is an important migratory route for large whales, and small resident populations of bottlenose dolphins.

7.2 Potential effects of concern

All of the potential effects noted in Section 1.3 apply in the Central Atlantic.

7.3 Field data collection and analysis

Ongoing and pending activities

Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Passive acoustic monitoring - archival, passive acoustic monitoring – real-time	Long-term sound traps offshore Delaware and Chesapeake Bay	NOAA NEFSC	2022-2024	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring – real-time	US Wind – UMCES real-time whale detection	UMCES, US Wind, Maryland DNR, Maryland EA, WHOI	2014 - 2028	**Detecting and quantifying changes to wildlife and habitats**
Passive acoustic monitoring – archival, acoustic tagging	US Wind – UMCES passive acoustic monitoring array	UMCES, US Wind, Maryland DNR, Maryland EA, Cornell University	2014 - 2028	**Detecting and quantifying changes to wildlife and habitats**
Diet analysis, animal physiology	Foraging ecology and movements of baleen whales in the US mid-Atlantic using stable isotopes	Rutgers University, AMSEAS, Virginia Aquarium and Marine Science Center, Marine Mammal Stranding Center, Mystic Aquarium	2018 - present	**Detecting and quantifying changes to wildlife and habitats**

7.4 Other Science Plan Actions

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Study optimization	Design of baseline monitoring of baleen whales in the Virginia Offshore Wind Area	RWSC Marine Mammal Subcommittee, SMRU, Virginia DEQ	2022-2023	**Understanding the environmental context around changes to wildlife and habitats**

8 U.S. Southeastern Atlantic ongoing, pending, and recommended research and data collection activities for marine mammals and offshore wind

8.1 Focal species and habitats of interest

The Southeastern U.S. subregion extends from Cape Hatteras south along the Atlantic coast of Florida. This subregion includes critical habitat (Southeastern U.S. calving area) for North Atlantic right whales. In addition to calving habitat, the Southeastern U.S. subregion is a migratory corridor for large whales and year-round habitat for resident populations of bottlenose dolphins.

8.2 Potential effects of concern

All of the potential effects noted in Section 1.3 apply in the Southeastern U.S.

8.3 Field data collection and analysis

Ongoing and pending activities

Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Passive acoustic monitoring – archival, passive acoustic monitoring – real-time	Real-time and archival acoustic detections of right whales in the Southeast US	University of South Carolina, University of Georgia	2023	**Detecting and quantifying changes to wildlife and habitats**

8.4 Other Science Plan Actions

Click project names to view full descriptions.

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Historical data collection/compilation	The Southeast US Marine Biodiversity Observation Network (MBON): Toward Operational Marine Life Data for Conservation and Sustainability	University of South Florida, SECOORA, GCOOS	2023-2027	**Understanding the environmental context around changes to wildlife and habitats**
Outreach and platforms to provide data products and results to stakeholders	The Southeast Marine Mapping Tool (Phase 2): Increasing access to regional ecological data to help inform offshore ocean use decisions: Analysis and Visualization of Ocean Resources in the Context of Offshore Wind Energy Development	The Nature Conservancy, SECOORA	2023- present	**Enhancing data sharing and access**

RWSC Marine Mammal Subcommittee

Roster

Name	Affiliation
Aaron Rice	Cornell University
Andrea Bogomolni	Northwest Atlantic Seal Research Consortium
Anita Murray	Maine Department of Marine Resources
Ann Zoidis	Tetra Tech
Brandon Southall	Southall Environmental Associates
Chandra Goetsch	Biodiversity Research Institute
Cindy Driscoll	Maryland Department of Natural Resources
Cynthia Pyć	RWE
Danielle Brown	Gotham Whale/Rutgers University
David Wiley	NOAA Stellwagen Bank National Marine Sanctuary
Erica Staaterman	Bureau of Ocean Energy Management
Erin LaBrecque	Marine Mammal Commission
Erin Meyer-Gutbrod	University of South Carolina
Genevieve Davis	NOAA Northeast Fisheries Science Center
Howard Rosenbaum	Wildlife Conservation Society
Jason Roberts	Duke University
Jeff Runge	University of Maine
Jessica Redfern	New England Aquarium
Joel Bell	US Navy (NAVFAC)
Jordan Carduner	Equinor
Kathy Vigness-Raposa	INSPIRE Environmental
Laura Morse	Invenergy
Meghan Rickard	New York Department of Environmental Conservation
Robert DiGiovanni	Atlantic Marine Conservation Society
Sharon Whitesall	Ørsted
Stormy Mayo	Center for Coastal Studies
Susan Barco	Barco Marine Consulting

Chapter 8: Birds

Executive Summary

This chapter describes ongoing data collection and research initiatives related to offshore wind and birds, funded by a variety of partners (states, federal agencies, industry) and others. For an up-to-date list of active projects, visit the RWSC Offshore Wind & Wildlife Research Database. Given this ongoing work, the Bird & Bat Subcommittee is making recommendations for additional research that is both aligned with existing efforts and that fills important gaps. These recommendations reflect information shared with RWSC in discussions held with the Subcommittee and meeting participants during public Bird and Bat Subcommittee meetings between May 2022 and June 2023, as well as in follow-up meetings held with participating stakeholders. The recommendations are described in detail throughout each section of this chapter and are summarized as part of this Executive Summary.

Context

Over 400 species of birds occur along the U.S. Atlantic Coast, representing a variety of life histories and interactions with the offshore environment, from petrels and shearwaters that spend most of their lives at sea to gulls and terns that regularly move between coasts, islands, and marine environments to migratory passerines which make long-distance movements over ocean waters seasonally en route to overwintering areas in the Caribbean and Central and South America. These species face a variety of potential negative impacts from offshore wind development, including direct collision mortality, as well as habitat loss, degradation, or reductions in connectivity via displacement, physiological effects, changes in prey or predator distributions, and other mechanisms. In addition to negative impacts, there are potential positive impacts of offshore wind development, including climate change mitigation, positive habitat-mediated effects, and off-site compensatory mitigation, which could be calibrated to provide net positive benefits to East Coast bird species.

While studies from Europe can provide some insights into anticipated effects of offshore wind development on certain taxa, much of what we learn about the impacts of offshore wind facilities on North American bird species will be occurring in real time, as pilot-scale and large-scale facilities are installed at multiple sites within the five subregions of the U.S. Atlantic Coast. This truncated timeline means that while researchers are collecting baseline data on bird distributions and movements offshore, risk assessments are being refined based on proxies for risk and the best available science, actual impacts of pilot-scale and large-scale installations are beginning to be evaluated, and the efficacy of avoidance and on-site mitigation strategies can begin to be assessed. Meanwhile, structures and workflows to facilitate collaboration, coordination, advance planning, and the ready sharing and prompt analysis of data are still being formalized. Wildlife monitoring technologies are still being perfected, and integration of this equipment with wind turbine infrastructure is an active process. Given that we will still be learning about the effects of offshore wind well after turbines have been installed, avoidance and on-site mitigation strategies may be insufficient to address negative impacts. The development and evaluation of efficient, off-site compensatory mitigation options hence also needs to be an early part of bird and offshore wind discussions.

Recommendations

Focal species

- Federally listed (endangered or threatened) species in the RWSC study area include Roseate Tern, Piping Plover, and Red Knot. Where these species are expected to be impacted by offshore wind development, they should be targeted for monitoring and research. Given the geographic range of these species, regional (and potentially international) coordination will be required.
- Other species targeted for research may also include state-listed threatened or endangered species, species otherwise of conservation concern (e.g., because of rapidly declining populations), or more common species that could act as proxies for rare species.
- Species might also be chosen as focal taxa for research because of anticipated vulnerability to a particular potential impact, a lack of knowledge about potential effects, or a wealth of baseline data from which to evaluate changes over time.

Standardization of data workflows

- This Plan reviews appropriate field protocols, data collection applications, and databases, where available, and identifies gaps that could be filled through updated guidance or refinements to existing databases.
- While standardized protocols and databases already exist or are currently under development for some research methodologies (aerial and boat-based surveys, tracking data), for others, database infrastructure needs to be further developed (e.g., colony, shorebird, and wading bird surveys).
- Formation of a Data Standardization Working Group is recommended to comprehensively review existing standards and to compile detailed Data Management Guidance for bird research related to offshore wind development
- Additional databases may need to be further developed or funded where infrastructure is lacking (e.g., centralized raw data storage for large file types, derived radar data, acoustics, seabird diet).

Historic data sets and analysis

- Historic offshore survey data were successfully compiled and synthesized through the Northwest Atlantic Seabird Catalog and subsequent analyses, but there remains a need to solicit, compile, and to the extent possible standardize additional breeding colony, shorebird, and wading bird survey data, as well as seabird diet data and tracking data from non-Motus tags.
- There is a need to synthesize and summarize multiple data types using qualitative, and where possible, quantitative, methods, to establish clear baselines for well-studied species and determine where data are lacking.
- Compilation of flight heights, flight speeds, and other data to inform Collision Risk Models is also recommended.
- Existing frameworks or new statistical models can be utilized to integrate different types of data, including synthesizing tracking and survey data for birds offshore, as well as further evaluating relationships between marine predators and their prey species.

Regional-scale field studies

- Field research planning could benefit from regularly updated guidance regarding appropriate focal species and the different types of methods used to study and characterize birds, including pros and cons, associated biases, financial costs, and types of data collected.
- Conducting coordinated aerial surveys that cover multiple lease areas could be more cost-efficient and produce better scientific outcomes.
- Centralized calibration of Motus towers for automated telemetry data collection would provide cost efficiencies. Further, centralizing the deployment of Motus stations and automated telemetry tags on marine birds and shorebirds would provide cost savings, produce better scientific outcomes, and improve conservation outcomes.

Site-specific field studies

- Data collection systems at the turbine scale are recommended, including passive acoustics to detect nocturnal migrants and cameras to record bird behavior in the rotor-swept zone.
- Radar systems can also be used at facilities to evaluate bird passage rates and measure flight heights.
- Validated collision detection technologies should be deployed in the offshore environment as soon as it is practicable to do so.
- Pilot studies that test similar detection technologies at multiple facilities should be coordinated among sites and results should be shared.

Coordination and planning

- The RWSC Bird & Bat Subcommittee should continue to serve as a forum for information exchange and coordination among federal agencies, states, offshore wind industry, eNGOs, and the research community.
- Continuing coordination and information dissemination activities of the NYSERDA E-TWG and other regional groups are also of great value to the offshore wind-bird community.
- Coordinating with offshore wind developers and manufacturers to advance the integration of wildlife monitoring equipment with offshore wind facilities and facilitate remote data access is of great importance for long-term research and monitoring.
- Facilitated discussions around compensatory mitigation are needed early in the offshore wind development process.
- Synthesizing bird-offshore wind interactions data in one place to allow for the collective consideration of all factors recommended in regional prioritization frameworks could aid in the identification of priority ecological questions.
- The Bird & Bat Subcommittee should coordinate with other RWSC Subcommittees to adopt consistent approaches for assessing and addressing cumulative impacts.

1 Introduction

1.1 Purpose

This chapter of the **draft** RWSC Science Plan addresses bird research and associated scientific needs in the context of offshore wind development. As a draft plan, this chapter will be available through the summer months of 2023 for review and comment by the Bird & Bat Subcommittee, RWSC's sector caucuses, the RWSC Steering Committee, and other stakeholders and researchers. The final plan is intended to reflect the research and data collection needs of RWSC's four Sectors with input from the science community. The plan will provide a path forward to ensure appropriate data and standards are in place to support science priorities; the document will also aid in coordination and alignment of funding to carry out priorities.

This plan benefits greatly from the contributions of RWSC Bird & Bat Subcommittee members; researchers, managers, and other practitioners who joined Subcommittee calls; and the many scientists who conducted research or developed reference materials referenced throughout this plan.

1.2 Structure

Following this introduction, the first section of the chapter discusses the geographic extent of the area considered within this chapter, the subregions defined within this area, and the species of birds which occur within this geographic range. It briefly describes aspects of their life histories as relevant to their exposure and potential vulnerability to offshore wind development. It also addresses other conservation threats facing these species. The species section is followed by a brief section summarizing primary sources of information about species' distributions.

The next section of this chapter discusses potential effects (negative or positive) of offshore wind development on bird species. This section is followed by a section summarizing common field research methods for the study of birds, with a focus on the offshore environment. The subsequent section addresses the major research topics relevant to birds in the context of offshore wind development.

The remainder of the chapter addresses recent, ongoing, pending, and recommended science actions of value to the four sectors that make up RWSC (state and federal agencies, eNGOs, and the offshore wind industry). These actions include additional field research to better understand the impacts of offshore wind development on birds and to test out new methodologies. They also include actions like coordination and planning, meta-analysis and literature review, model development, technology development, historical data collection, and, importantly, the standardization of data collection, storage, and analysis. Most science actions important for bird conservation in the context of offshore wind are relevant across the entire RWSC Study Area. However, specific subregion considerations are also noted in the final portion of the chapter.

2 Species

This chapter addresses bird (Class Aves) species which could be at risk from offshore wind development occurring in the Northwest Atlantic within U.S. waters. For the purposes of this plan, the geographic area of interest comprises the East Coast of the United States, extending from Maine's northern border with Canada south to the Florida Keys, and from coastal areas extending 200 nm east into the ocean, including state waters (3 nm from shore) and federal waters of the Outer Continental Shelf (3-200 nm). While the focus of this plan is on offshore impacts of offshore wind development, potential onshore impacts of offshore wind on bird species are also possible. For example, excavation efforts where transmission cables are coming ashore from offshore facilities could affect beach-nesting birds. Therefore, bird species which primarily or solely occur in the onshore environment along the East Coast are also included within the scope of this plan, although they are not the focus of the bulk of this chapter.

Within the geographic area of interest, some portions of the plan will be discussed within the context of five subregions, as described below:

- **Gulf of Maine**: This subregion extends from the northern border of the United States at the southern tip of Nova Scotia to a line extending southeast from Hyannis. The subregion includes the Gulf of Maine and Great South Channel.
- **Southern New England**: This subregion extends from the southern border of the Gulf of Maine subregion to a line extending directly south from the Connecticut/Rhode Island state border, running roughly through the eastern border of Montauk, New York.
- **New York/New Jersey Bight**: This subregion extends south from the southern border of the Southern New England subregion to a line running roughly east-southeast from Cape May, New Jersey. The subregion includes the Hudson Canyon.
- **U.S. Central Atlantic**: This subregion extends south from the southern border of the New York/New Jersey Bight subregion to a line running roughly southeast from Cape Hatteras, North Carolina.
- **U.S. Southeast Atlantic**: This subregion extends south from the southern border of the U.S. Central Atlantic subregion up to and including the Florida Keys.

Figure 1 (below) provides a map of the five subregions.

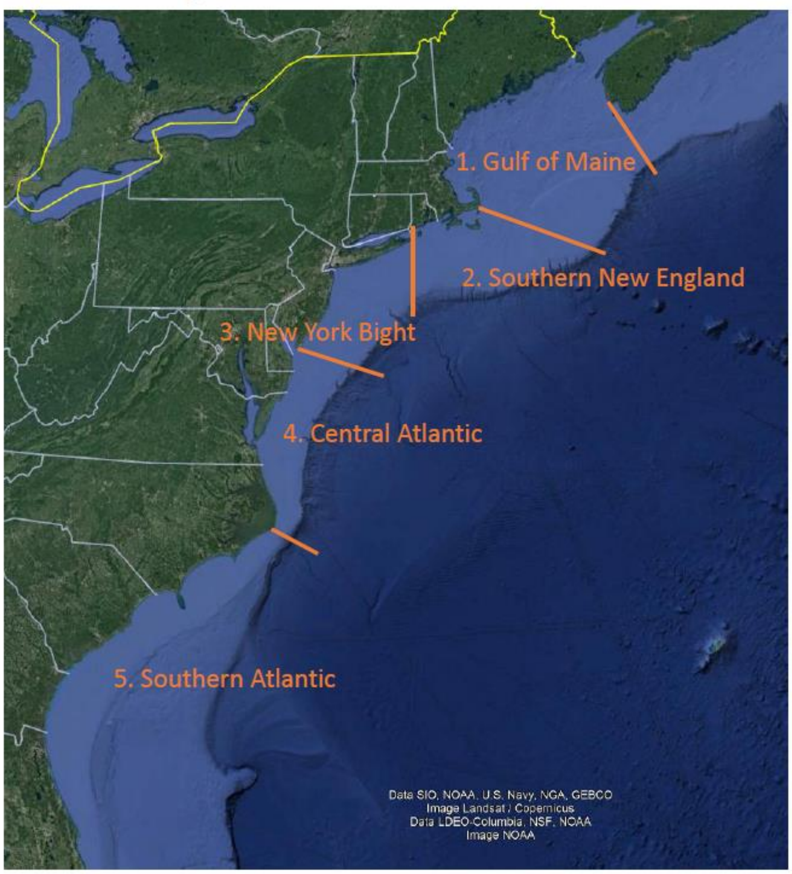

Figure 1. Geographic scope of interest for this plan, including five subregions.

2.1 Regulatory Status

A number of bird species are protected via federal regulations. Important and relevant federal laws include the following:

Endangered Species Act (ESA). Currently 16 bird species that regularly occur in the RWSC Study Area are listed as Threatened or Endangered under the federal ESA. The ESA places strict limits on the import, export, sale, possession, transportation, or “take” of listed species, with “take” defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” The ESA also allows for the designation of critical habitat for a species and prohibits the destruction of that habitat.

Migratory Bird Treaty Act (MBTA). The MBTA was enacted in 1918 to implement four international conservation treaties that the U.S. entered into with Canada, Mexico, Japan, and Russia (several of which were amended in more recent years). The MBTA covers over 1,000 bird species and is intended to ensure the sustainability of their populations. The MBTA prohibits the take (including killing, capturing, selling, trading, and transport) of protected migratory bird species without prior authorization by the USFWS.

Bald and Golden Eagle Protection Act (BGEPA). The BGEPA is more limited in scope than the two proceeding regulations. It protects Bald and Golden Eagles, prohibiting take of individuals, as well as their parts (e.g., feathers), nests, or eggs. The Act defines "take" as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb." Regulations further define "disturb" as “to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior" (50 CFR 22.6).

In addition to federal regulations, most states have a state Endangered Species List, which offers its own protections. Over 150 bird species bat species are protected by state ESAs in the 14 states of the RWSC Study Area. Individual State Wildlife Action Plans also identify Species of Greatest Conservation Need (SGCN) which serve as foci for research and conservation efforts. At least two-thirds of East Coast birds are listed as SGCN in one or more states.

2.2 Defining Focal Species

While some scientific research methods will provide information about a variety of taxa (e.g., aerial surveys), other research methods (e.g., tagging) must by nature be species-specific. Since over 400 bird species occur regularly or occasionally in the 14 states of the U.S. East Coast, it is not practicable to study all of these species using species-specific methods. With this in mind, there are in some cases a need to identify birds which should serve as focal species for the purposes of specific field research and other scientific activities.

In developing a framework to guide identification of focal species for these types of studies, the RWSC Bird & Bat Subcommittee began with criteria identified in a NYSERDA Stakeholder Workshop (2020). Through subcommittee discussions, the list of criteria was slightly expanded to read as follows. Focal species could include:

- Threatened and endangered species (federal and/or state-listed)

- Species designated as of conservation concern (such as Species of Greatest Conservation Need in State Wildlife Action Plans, state-listed "special concern" species, or ESA candidate species)
- Other federally regulated species
- Surrogates for rare species, which may be the best available proxy to study and understand rare species' movements, behaviors, or expected effects of offshore wind development. (The Subcommittee recognizes that these are not perfect surrogates for the rare species themselves, but for some rare species, using a surrogate is the best available option.)
- Species known or suspected of being sensitive to impacts from offshore wind development due to existing information and/or aspects of their life history which might render them susceptible to offshore wind. (Existing information could come from pilot studies in North America, or from longer-term studies in Europe, where more research has been conducted to date. Life history aspects that inform risk could include foraging strategy, typical flight height, or overlap between areas of high abundance for a species and Wind Energy Areas).
- Species or populations with high levels of existing baseline data, and those for which the scientific community can more easily measure population parameters such as productivity and survival.
- Species for which very little is known about potential impacts, because there has not yet been significant offshore development in their habitats. (For example, pelicans fall into this category.)

"Keystone" species were also suggested as a category of interest, although it was acknowledged that this category is not well-defined, and it might be difficult to accurately characterize certain species as "keystone" species at this time.

Species that meet this definition of focal species are highlighted in the section that follows (Section 2.3) and as appropriate throughout the rest of this Science Plan chapter, with several exceptions. As noted previously, at least two-thirds of bird species that occur in the RWSC Study Area are listed as Species of Greatest Conservation Need in one or more states. This categorization therefore is not particularly helpful in developing a limited list of species for consideration as focal species. In addition, the category of "other federally regulated species" includes species protected under the Migratory Bird Treaty Act. The regulation covers nearly all bird species in the RWSC Study Area, with the exception of some species in the Order Gruiformes and the Order Galliformes. This protection is important from a regulatory and conservation standpoint, but it is not helpful in developing a priority list of focal species, and therefore it is not further highlighted in Section 2.

2.3 Bird Species occurring in the Northwest Atlantic

Hundreds of bird species occur along the East Coast of the United States. At least 415 native species are included in eBird[1] lists for the 14 coastal states of the Eastern Seaboard, depicted with East Coast ranges in *Birds of the World*[2], or included in iPaC (Information for Planning and Consultation)[3] as birds using North Atlantic offshore areas. These species are included in RWSC's *Bird Species List*, which is still under development, but is intended to provide a complete listing of and basic information about the current (2023) regulatory and conservation status of relevant East Coast bird species. This list is also being expanded to include life history characteristics relevant to vulnerability to offshore wind impacts.

[1] https://ebird.org/home

[2] https://birdsoftheworld.org/bow/home

[3] https://ipac.ecosphere.fws.gov/

With so many species, it is infeasible to address each species individually. Instead, for the purposes of this Science Plan, bird species are grouped into categories. These categories are loosely based on taxonomy, but also incorporate considerations relevant to offshore wind. Relevant considerations used in grouping birds include differences in life histories, timing and extent of potential exposure to offshore wind development, anticipated interactions with and potential conservation concerns related to offshore wind, and relevant field study methodologies.

The following sections (2.3.1-2.3.20) provide basic information about categories of birds and their life histories as relevant to their exposure and potential vulnerability to offshore wind development. These sections also address other conservation threats facing these species, which could be of interest in investigating potential impacts of offshore wind or compensating for its effects. Species at particular risk from offshore wind development due to their life histories or conservation status are highlighted.

The information included in these bird category descriptions draws heavily upon several sources. Information about life history, including diet, habitat, and conservation status, is drawn primarily from the Cornell Lab of Ornithology *All About Birds* website[4]; this includes utilizing *All About Birds* summaries of Breeding Bird Survey[5] and Partners in Flight data[6], rather than reviewing that information directly. Where conservation status was not available from Cornell, the IUCN Red List was consulted[7]. Life history and conservation status information were also drawn from the National Audubon Society's *Guide to North American Birds*[8]. Range information is taken from the RWSC *Bird Species List*, which utilizes the sources referenced earlier in Section 2.

2.3.1 Tropicbirds

Tropicbirds include members of the family Phaethontidae. As the name suggests, tropicbirds are primarily birds of tropical regions, and are distributed widely far out to sea over tropical oceans. The White-tailed Tropicbird is considered a vagrant in most East Coast states, but utilizes habitat in Florida outside of the breeding season. Other species typically only occur south of the RWSC Study Area.

Fish are the most common food source for the White-tailed Tropicbird. The species forages by plunging into water from flight, submerging briefly, or sometimes by swooping down to water's surface. It will also take flying fish in the air. Nesting colonies in some parts of world have declined owing to human disturbance, but this species is still widespread and common in many areas. It is listed as of Least Concern on the IUCN Red List.

2.3.2 Petrels & Shearwaters

Petrels & Shearwaters include all members of the family Procellariidae found in the Northwest Atlantic, including petrels, shearwaters, and fulmars. There are eight species that regularly occur in the RWSC Study Area. All occur almost exclusively during the nonbreeding season, although there are records of the Manx Shearwater breeding on islands off of Massachusetts. During the

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[4] https://www.allaboutbirds.org

[5] https://www.pwrc.usgs.gov/bbs/

[6] https://partnersinflight.org/resources/pif-watch-list-table-2016/

[7] https://www.iucnredlist.org/

[8] https://www.audubon.org/bird-guide

nonbreeding season, Great Shearwaters, Sooty Shearwaters, and Cory's Shearwater are found along the entire U.S. Atlantic Coast, and the Northern Fulmar and Manx Shearwaters are found from Maine to North Carolina. The Black-capped Petrel is found from Massachusetts to Florida. Audubon's Shearwater and the Trinidade Petrel are found in more southern locations, from North Carolina to Florida and Virginia to South Carolina, respectively. The Bermuda Petrel is listed as occurring sporadically along the coast, in Maine, New York, New Jersey, Virginia, North Carolina, and South Carolina.

Petrels and shearwaters are long-lived, wide-ranging marine birds that spend most of their time at sea, only coming ashore to nest on remote islands. Most species are rarely seen from shore; however, the Great Shearwater, Cory's Shearwater, and Manx Shearwater tends to occur closer to shore, and can sometimes be seen from land. Some species prefer cooler ocean waters (e.g., Great Shearwaters, Sooty Shearwaters, Northern Fulmars), while others prefer relatively warm, tropical waters (Cory's Shearwaters, Audubon's Shearwaters, Trinidade Petrel). Some species range over both the Atlantic and Pacific Oeans (e.g., Audubon's Shearwaters), while others are confined to the Atlantic (e.g., Great and Manx Shearwaters).

These birds feed primarily on fish, squid, crustaceans, offal, and sometimes the bycatch from ships. Depending on the species, they may catch prey by diving from a height or plunging into the water from just above the surface; some species are component swimmers and will chase prey underwater. Capturing prey at or just below the water's surface while swimming is also common. Some species forage singly or in small groups, but Great Shearwaters, Sooty Shearwaters and Northern Fulmars will congregate in large numbers with other seabirds.

Marine pollutants, including heavy metals, pesticides, plastic particles, and oil spills, present a conservation threat. Entanglement in fishing gear is also a problem. Thousands of Sooty Shearwaters are killed every year as bycatch in gillnets. For the species that nest and forage in higher altitudes, the impacts of climate change on their habitats and food resources are also a conservation concern.

The locations of breeding habitats are a significant factor in conservation of the species.

- Great Shearwaters and Northern Fulmars are considered to be abundant species of low conservation concern by Partners in Flight; however, Great Shearwaters rely on just four known nesting sites, which make them susceptible to disturbance during the breeding season.
- Audubon's Shearwaters are currently common but decreasing, likely due to human disturbance near Caribbean nesting sites. Black-Capped Petrels were formerly abundant nesters on several islands, but numbers dropped sharply in the mid-1800s, likely due to the introduction of rats, as well as hunting by humans. They are now known to nest in mountainous areas of several Caribbean islands, and are vulnerable in these few spots.
- Numbers of Sooty Shearwater have been in decline for decades, with some colonies losing almost 40% of their numbers or disappearing between 1970 and 2000. As part of traditional cultural practices, Maori in New Zealand kill hundreds of thousands of chicks annually for food.
- The Bermuda Petrel, which nests on Bermuda, almost went extinct, but was brought back from the brink via concerted breeding efforts by conservationists. It is still one of the world's rarest seabirds, and is Endangered in the U.S..
- The Manx Shearwater and Cory's Shearwater are considered of Least Concern by the IUCN, but their population trajectories are unknown.

2.3.3 Storm Petrels

Storm-petrels include all members of the family Hydrobatidae found in the Northwest Atlantic. There are three that occur along the U.S. East Coast regularly; these are the Band-rumped Storm-petrel, Leach's Storm-Petrel, and Wilson's Storm-petrel. Wilson's Storm-petrel is found throughout the RWSC Study Area during the nonbreeding season. Leach's Storm-petrel is likewise found throughout this range during the nonbreeding season; it also breeds on islands off the coasts of Maine and Massachusetts. The Band-rumped Storm-petrel can be found off the coasts of North Carolina, South Carolina, and Georgia during the nonbreeding season.

Storm-petrels are small birds (roughly the size of robins) that are nevertheless at home over the open ocean; like petrels, they range widely over the world's oceans. They are seldom found close to land outside of the breeding season, but may concentrate over upwellings where warm and cool water currents meet. They are surface feeders, hovering over the ocean surface or occasionally dropping into the water and then resuming flight. They consume small fish, crustaceans, squid, sometimes other marine invertebrates, and carrion. They may feed at natural oil slicks on the water's surface, and will sometimes follow whales, other marine mammals, or ships.

Wilson's Storm-petrels breed in southern oceans around Antarctica and the southern tip of South America, but are possibly the most common seabird off the coast of the United States during the summer months. The species' population numbers in the millions, and it is not thought to be a species of concern, although it could be vulnerable to pollution, overfishing, and other impacts to the Atlantic Ocean.

Leach's Storm-petrels are also thought to number in the millions, but are believed to be declining. In addition to vulnerability to degradation of ocean habitats, they are also vulnerable to predators, especially introduced mammals, on nesting islands. They are considered "Vulnerable" according to the IUCN Red List, and are listed as Endangered in Massachusetts.

Band-rumped Storm-petrels occur as a number of distinct subpopulations with different breeding locations. There are no breeding locations on the East Coast. One subpopulation breeds in Hawaii, where it is threatened by non-native predators; this breeding population is federally listed as Endangered, and global populations are thought to be declining.

2.3.4 Gannets

The Northern Gannet is the sole member of the family Sulidae found in the Northwest Atlantic. In North America, Northern Gannets breed in six well-established colonies in eastern Canada, but many spend the non-breeding season along the U.S. Atlantic Coast. During this season, gannets are typically found at sea or in marine bays, foraging primarily in saltwater. They are uncommon in very deep water, remaining instead over the continental shelf.

Gannets eat almost exclusively fish, especially those that school near the surface. Gannets catch fish by diving from significant heights at high speeds. They dive as deeply as 72 feet and can maneuver and swim underwater using both wings and feet. They often feed in large flocks.

Northern Gannet populations are thought to be stable in North America. However, they have been highlighted as a species at potential risk from offshore wind, due to their high-diving foraging strategy and the high overlap between their habitats and Wind Energy Areas. Like other seabirds, they are vulnerable to accumulation of toxic contaminants in their prey species, ingestion or entanglement in trash, entanglement in fishing nets, and potential overfishing of prey species. There is concern that changes in prey distributions associated with climate change could lead to a disconnect between breeding and foraging areas.

2.3.5 Alcids

Alcids include all members of the family Alcidae found in the Northwest Atlantic. In the RWSC Study Area, there are six species, the Razorbill, Dovekie, Black Guillemot, Atlantic Puffin, and Common and Thick-billed Murres.

Alcids breed in northern climes; the RWSC Study Area is at the southern limit, or is located south of, their breeding range. Atlantic Puffins, Black Guillemots, and Razorbills breed in Maine. These and other species occur during the nonbreeding season into more southern portions of the North Atlantic, with Black Guillemot using winter habitat in New Hampshire and Massachusetts, Thick-billed Murres occurring from Maine south to New York, Atlantic Puffins occurring from New Hampshire to Maryland, Dovekies and Common Murres occurring from Maine south to Virginia, and Razorbills occurring from Maine to North Carolina.

Alcids have stout, streamlined bodies, short, narrow wings, thick, waterproof plumage, short tails, and feet set well back on the body. Outside of the nesting season, they typically remain at sea, rather than coming ashore to roost. They are swift in flight and also "fly" underwater, swimming using half-opened wings. They are capable of diving to great depths to find prey.

Each species tends to specialize on different prey and habitats.

- Dovekies dive deeply (down to 100 feet), then capture prey as they ascend toward the surface. In shallow water, they sometimes forage along the sea bottom. They eat mostly planktonic crustaceans, but also mollusks and small fishes.
- Common and Thick-billed Murres eat mostly fish, along with squid, octopus, and small crustaceans. Dives as deep at 591 and 689 feet, respectively, have been recorded, but more typically, prey is captured at 60-160 feet. They forage alone or in flocks, often with other seabird species. Thick-billed Murres tend to forage over deeper waters than Common Murres, typically over waters greater than 100 feet deep.
- Razorbills eat mostly small, schooling fish year-round, but small crustaceans and bristleworms are also important parts of their diet. Razorbills move around for foraging during the nonbreeding season, searching for prey sometimes close to shore but more often farther away over deeper waters of the continental slope. In winter, they forage mostly over water that is 130 feet deep or less, typically over sandy bottom.
- Atlantic Puffins eat small fish around 2 to 6 inches long. During the breeding season, they forage in shallow waters close to the breeding colony, generally not straying more than about 10 miles from shore. They can dive to depths of around 200 feet, but they typically feed in shallower waters.
- Black Guillemots eat mostly small fish, with smaller quantities of invertebrates such as crabs, worms, and mollusks. They capture prey near the bottom, from between rocks, in the water column, and from below sea ice.

All three alcids that breed in Maine choose rocky habitats for nesting. Razorbills select cliffs over ocean (or sometimes brackish) waters, Guillemots nest along rocky coasts and on islands, finding crevices in the rock to place their nests. Atlantic Puffins nest in burrows on rocky islands with short vegetation, as well as on sea cliffs.

A major concern for these species of northern waters is climate change, which is forecast to modify ocean temperatures and currents and affect the distribution and availability of prey species. Such changes could have significant, even catastrophic effects on murres and other seabirds. They are also vulnerable to marine pollutants, entanglement in fishing gear, overfishing of prey species, and the introduction of mammalian predators to their nesting areas. Currently, a number of alcid species are hunted, with eggs and adults taken for food.

- Atlantic populations of Common Murre appear to be increasing slightly in some areas; Razorbills appear to be stable or increasing.
- Because of the species' remote breeding habitat, it is difficult to determine whether Black Guillemot numbers are rising, stable, or falling. These species, as well as Dovekies and Thick-billed Murres, are currently all considered of low conservation concern.
- Atlantic Puffins are common at the global scale, but their numbers are declining mainly because of changes to their food supplies from warming of ocean waters. In Iceland, where many puffins breed, the warming ocean has changed the availability of sandlance, causing almost complete breeding failure. In North America, hunting around the turn of the century caused puffins to disappear from the United States. However, conservation of protected areas and relocation of young to former nesting islands has led to success of breeding populations in Maine. The species is ranked as Vulnerable on the IUCN Red List.

2.3.6 Gulls & Allies

This category includes a subset of members of the family Laridae, specifically gulls, kittiwakes and noddies. The genera *Anous*, *Chroicocephalus*, *Hydrocoloeus*, *Larus*, *Leucophaeus*, *Rissa*, and *Xema* are included in this category.

Both noddy species (Black Noddy and Brown Noddy) are generally birds of more southern climes. They are considered vagrants in most parts of the Northwest Atlantic, but regularly occur in Florida during the breeding (Brown Noddy) and non-breeding (Black Noddy) seasons respectively. The two species are considered of Least Concern according to the IUCN Red List, although populations of the Black Noddy are thought to be declining.

This group also includes eleven gulls – the Black-headed Gull, Black-legged Kittiwake, Bonaparte's Gull, Glaucous Gull, Great Black-backed Gull, Herring Gull, Iceland Gull, Laughing Gull, Lesser Black-backed Gull, Little Gull, and Ring-billed Gull. These gull species represent varying life histories and habits. Most species enter U.S. waters outside of the nesting season, although Greater Black-Backed Gulls and Herring Gulls are considered year-round residents of the northern parts of the RWSC Study Area. The Laughing Gull also breeds along the East Coast, in its case throughout the 14 East Coast states, and is considered a year-round resident of the Carolinas and points south.

In general, gull species are abundant, with large populations globally or within North America. They are not federally listed or state-listed in any of the East Coast states. Population trajectories vary. Bonaparte's Gulls, Laughing Gulls, and Ring-billed Gulls appear to be increasing. Glacous Gull populations appear to be stable. Little Gull and Icelandic Gull populations are unknown.

Four species appear to be declining:

- Black-legged Kittiwakes are considered of low conservation concern due to large global breeding populations, but long-term studies in Europe indicate rapid decline, most likely due to warming sea temperatures affecting plankton populations and higher tropic levels in the food chain.
- Herring Gull populations declined by approximately 2.7% per year between 1966 and 2019, resulting in a cumulative decline of about 76% according to the North American Breeding Bird Survey. The species is listed as Common Bird in Steep Decline.
- Great Black-backed Gulls are numerous on the East Coast, however, since 1966 populations have been declining according to the North American Breeding Bird Survey.
- According to the North American Breeding Bird Survey, Franklin's Gull populations declined throughout the species' range by almost 3% per year between 1968 and 2015, resulting in a cumulative decline of 76% over that period. In the United States (which represents only a

small portion of the species' breeding range), declines were over 6% per year during the same period, which amounts to a 95% decline. This species is included on the Partners in Flight Yellow Watch List due to steep declines.

Conservation threats for gulls include vulnerability to contaminants in the environment (e.g., heavy metals, PCBS, organochlorines, pesticides, oil spills), disturbance of nesting sites and breeding birds, and habitat loss, particularly through destruction of wetland habitats and development of beachfront properties and estuaries. Changes in prey distributions and abundance associated with climate change are a concern, as are the stronger storms and greater weather variability which global warming will bring; these changes can reduce nesting habitat and nest success. Overfishing and culling of gulls to reduce their predation of favored species are also potential threats. Deliberate reductions in food resources – for example, through closures of open landfill sites, improved storage of waste, and reductions in fishing boats dumping fish waste overboard – may also be leading to declines in populations of some species.

2.3.7 Terns & Allies

Terns & Allies include a subset of members of the family Laridae, including terns and skimmers. The genera Chlidonias, Gelochelidon, Hydroprogne, Onychoprion, Rynchops, Sterna, and Thalasseus are included in this category. Twelve terns and one skimmer (the Black Skimmer) occur in the RWSC Study Area, with varying distributions:

- The Caspian Tern, Arctic Tern, and Black Tern primarily breed north or west of the U.S. Atlantic, although breeding colonies of the Arctic and Black Tern are found in Maine. These species primarily occur along the East Coast during migration, although the Caspian Tern is known to overwinter in Florida.
- Roseate and Common Terns breed in northern and central portions of the RWSC Study Area, from Maine south to New York and South Carolina, respectively. Roseate Terns also breed in Florida. On migration, Roseate Terns are found as far south as North Carolina, while Common Terns are found throughout U.S. Atlantic waters, with some individuals overwintering in Florida.
- Foster's Terns and Black Skimmers occur from Massachusetts south to Florida. Black Skimmers breed throughout that range, and overwinter in South Carolina, Georgia, and Florida. Forster's Terns breed from New York to Maryland, and occur from Delaware south outside of the breeding season.
- Least and Gull-billed Terns breed from Massachusetts south to Florida, but Florida is the only region where either species overwinters.
- The Sandwich Tern breeds from Delaware to Georgia and occurs in the winter in Florida; it can be found on migration between these areas. The Royal Tern breeds in Delaware, Maryland, and Virginia. It can be found on migration from Massachusetts to Virginia, and occurs during the nonbreeding season in all states south of its breeding range.
- The Bridled and Sooty Terns can be found breeding in Florida only; during the nonbreeding season, Bridled Terns occur as far north as New Jersey, while the Sooty Tern occurs north to North Carolina.

Terns and skimmers feed singly, in small groups, or in large flocks, by plunge-diving or skimming prey off the water's surface. They may feed in near-shore or offshore waters. Their primary prey is small fish. They breed in treeless areas, often on offshore islands or barrier beaches, although saltmarshes also provide nesting habitat, and several species breed in interior portions of the northern U.S. and Canada.

Historically, a number of tern species were targets for the feather trade, which caused steep declines in the late nineteenth century. Egg collection was also a problem. The enactment of the Migratory Bird Treaty Act in 1918 helped with the recovery of these species. Today, a major threat for tern and skimmer colonies on beaches and islands is disturbance by humans, whether by beach-goers, dog-walkers, over-sand vehicles, or boaters near shore. Other development or disturbance that degrades these habitats is also problematic. Where non-native species have been introduced, or where other threats have already reduced numbers, both non-native and native predators can significantly reduce nest success at colonies. Rising sea levels, induced by climate change, have already led to breeding habitat loss for some species, and this trend is expected to continue. Reductions in fish stocks – or spatial changes in prey species distributions relative to breeding colonies – is also a major conservation concern. Exposure to pollutants is considered a threat to many species; the list includes oil spills, pesticides (e.g., DDT), PCBs, and heavy metals.

Population numbers and trajectories for some tern species are difficult to estimate, either because they breed in remote and often inaccessible places (Caspian and Arctic Terns), or nest sites often change from year to year (Black, Forster's, Gull-billed, and Sandwich Terns). Due to difficulties in estimation, authorities sometimes differ in their assessment of these populations.

- The North American Breeding Bird Survey indicates Caspian Tern populations are relatively stable overall, but regionally and locally, the species is listed as of conservation concern in many places. The Canadian population is classified as Vulnerable, and the species is listed as of Special Concern in New Jersey.
- The North American Waterbird Conservation Plan lists Arctic Tern as a species of high conservation concern, whereas Partners in Flight rates it as a species of low conservation concern.
- According to the North American Breeding Bird Survey, Forster's Tern populations were approximately stable between 1966 and 2015, but this species is listed as Endangered in several states.
- Black Terns, which commonly breed in the interior U.S. and Canada, have declined by an estimated 1.4% per year between 1966 and 2015, resulting in a cumulative decline of 51%. Partners in Flight includes the species its the Yellow Watch List for species with declining populations, and it is listed as Endangered in several states.
- Both Sandwich and Gull-billed Terns are thought to be relatively stable, with Sandwich Terns widespread, and Gull-billed Terns uncommon. Gull-Billed Terns are also listed as of Special Concern, Threatened, or Endangered from New Jersey through Virginia.

Royal Tern populations appear to be stable in North America. Common Terns are also considered to be stable between 1996 and 2019 by the North American Breeding Bird Survey. However, Partners in Flight lists the Common Tern as a Common Bird in Steep Decline due to longer-term declines.

The remaining three species are also in decline, and all three are on the Partners in Flight Yellow Watch List for species with declining populations.

- Black Skimmers declined 4% per year between 1966 and 2015, indicating a cumulative loss of 87% of their population over that period. The North American Waterbird Conservation Plan also lists Black Skimmers as a Species of High Concern. They are state-listed from New York through Maryland.
- Least Tern numbers have declined significantly in the last fifty years. The North American Breeding Bird Survey estimates Least Tern numbers declined 4.13% per year from 1966 to 2015—equivalent to a cumulative decline of about 87%.

- Roseate Tern populations have been in decline for more than a century. The U.S. Fish and Wildlife Service lists the species as Endangered from Maine south to North Carolina. Populations in Florida are federally listed as Threatened.

2.3.8 Jaegers & Skuas

Jaegers & Skuas include all members of the family Stercorariidae found in the Northwest Atlantic. In the RWSC Study Area, these include the Great Skua, Long-tailed Jaeger, Parasitic Jaeger, Pomarine Jaeger, and South Polar Skua

The Pomarine Jaeger, Parasitic Jaeger, and South Polar Skua occur during the nonbreeding season throughout the RWSC Study Area. The Great Skua occurs during the nonbreeding season from Maine south to North Carolina. The Long-tailed Jaeger occurs as a migrant from Maine south to North Carolina.

All three jaeger species breed in the high Arctic, where they are carnivorous, feeding on lemmings, other rodents, and birds (for the Pomarine and Parasitic Jaeger, shorebirds in particular). They spend the nonbreeding season at sea, harrying other seabirds to steal their prey. They may also feed on fish and marine invertebrates plucked (alive or dead) from the ocean surface, and may sometimes feed on discards from fishing vessels.

Because they breed in the high Arctic, their populations can be difficult to track. They are thought to have generally stable populations, and are not found on the Partners in Flight Watch List or considered of high conservation concern.

The South Polar Skua nests in the Antarctic. The Great Skua nests on treeless northern islands. Both skua species range widely over cold and warm ocean waters during the nonbreeding season, remaining far offshore. These birds feed primarily on fish, and similarly to jaegers, they commonly pirate food items from other seabirds, or catch them and shake them to cause them to regurgitate their catch. They also forage for their own fish by plunging into the ocean from flight. Both are considered of "Least Concern" according to the IUCN Red List and their populations are thought to be stable.

2.3.9 Land-based Shorebirds

Land-based Shorebirds include a subset of members of the order Charadriiformes found in the Northwest Atlantic, including members of the families Charadriidae, Haematopodidae, Recurvirostridae, and Scolopacidae, except for the genus Phalaropus. There are 37 species included in this category that frequent the RWSC Study Area, including a variety of plovers and sandpipers. These species use inland wetlands and coastal habitats of the East Coast states in different ways and at different times of year:

- Seven species, the Hudsonian Godwit, American Golden-Plover, and Pectoral, Semipalmated, Buff-breasted, White-rumped, and Solitary Sandpipers, pass through the East Coast states during migration.
- Three species occupy habitat in south or south-central portions of the RWSC Study area during the nonbreeding season. These include the Snowy Plover (Florida only), the Long-billed Curlew (North Carolina to Florida), and the Marbled Godwit (Delaware to Florida).
- Nine species migrate through many of the East Coast states and overwinter in south or south-central portions of the RWSC Study Area. These include the Greater and Lesser

Yellowlegs, the Short-billed and Long-billed Dowitchers, the Least and Stilt Sandpipers, the Semipalmated Plover, the Whimbrel, and the American Avocet.
- Six species occur along much of the East Coast during the nonbreeding season. Black-bellied Plovers, Dunlins, Red Knots, Ruddy Turnstones, and Sanderlings are all found in Maine and New Hampshire during migration, and overwinter from New Hampshire or Massachusetts south to Florida. The Purple Sandpiper is found from Maine to Georgia.
- The Western Sandpiper overwinters from New Jersey south to Florida.
- Eleven species breed in East Coast states. The American Oystercatcher, Piping Plover, and Spotted Sandpiper occur along much of the East Coast, and breed in most, but not all, East Coast states. The Upland Sandpiper, Willet, and Wilson's Snipe breed from Maine to New Jersey, and migrate through or overwinter south to Florida. The Black-necked Stilt and Wilson's Sandpiper breed from Delaware or Maryland south to Florida, and are rarely found in northern states. The Limpkin only breeds in Florida, where it is found year-round. Killdeer and American Woodcock, both inland species, breed throughout the East Coast and overwinter from Rhode Island or Connecticut south to Florida.

Most birds in this category feed along shorelines or the margins of wetlands, capturing marine or freshwater invertebrates in shallow water or probing and pulling them from the sediment. American Woodcock, Killdeer, and Upland Sandpipers frequently occur in upland habitats, where they eat insects, worms, and other invertebrates.

While some shorebirds occupy the same habitats and ranges year-round, most are medium or long-distance migrants. Some travel extremely long distances during migration between Arctic breeding grounds in the north and overwintering areas in South America.

The conservation status for these animals differs by species, and sometimes by subpopulation. The majority are still common and numerous, but many have declining populations, which is a major conservation concern.

- At least 12 species of shorebird are thought to have relatively stable populations at the global scale, although it can be difficult to estimate population trends for the many species that nest in northern climes. Relatively numerous and common species include the Greater Yellowlegs, Semipalmated Plover, Long-billed Dowitcher, Wilson's Snipe, Whimbrel, American Avocet, Black-necked Stilt, Solitary Sandpiper, and White-rumped Sandpiper. Long-billed Curlew populations are smaller, but stable.
- Upland Sandpipers and Least Sandpipers have experienced declines in some subpopulations, but their global populations appear stable at present.
- Population trends for the Western Sandpiper and Dunlin are not known, but they are generally thought to be of low conservation concern.
- Two species that occur in upland habitats, the American Woodcock and Killdeer, have experienced population declines, but are nevertheless considered of low conservation concern. Killdeer adapt well to living in proximity to people. Woodcock may have declined due to forest succession in previously open habitats. They are also susceptible to accumulation of heavy metals due to the fact that earthworms comprise a large portion of their diet.
- Eight species of shorebird are still common but are included on the Partners in Flight Yellow Watch List, due to population declines. These include the Pectoral Sandpiper, Purple Sandpiper, Semipalmated Sandpiper, Lesser Yellowlegs, Short-billed Dowitcher, Wilson's Plover, Snowy Plover, and American Golden-Plover.
- The Marbled Godwit and Hudsonian Godwit are also on the Partners in Flight Yellow Watch List, in this case due to their restricted ranges. Marbled Godwit populations are currently stable; Hudsonian Godwit population trajectories are not well known, although the eastern

subpopulation appears to have declined, likely due to overgrazing of tundra habitat by geese. The American Oystercatcher is also on the Yellow Watch List due to its restricted range and narrow habitat preferences. Oystercatcher populations fluctuate widely year to year, which can make it difficult to assess overall population trajectories.

- The Willet, while still common, is listed on the 2014 State of the Birds Watch List, also due to significant declines. Spotted Sandpipers, Sanderlings, and Ruddy Turnstones are very common but declining. The latter two are considered of High Concern by the Western Hemisphere Shorebird Reserve Network. The Ruddy Turnstone is also listed under the U.S. Shorebird Conservation Plan.
- Stilt Sandpipers are thought to be in decline, but the degree of that decline is not known.
- Little information is available about recent Limpkin population numbers or trends. This species is much less common in Florida than it was historically due to historic hunting practices and wetland habitat loss.
- Piping Plovers are rare shorebirds. In the RWSC Study Area they are federally listed as Threatened, although they are listed as Endangered under the ESA in some other portions of the country. Partners in Flight considers them a Red Watch List species. They are listed as Near Threatened on the IUCN Red List.
- There are three subspecies of Red Knot in North America, and all are in decline. The *rufa* subspecies is listed as federally Threatened in the United States. Partners in Flight includes the species on their Yellow Watch List for declining species. The IUCN Red List lists Red Knot as a Near Threatened species.

Shorebirds face numerous conservation threats, particularly long-distance migrants, which depend on a range of habitats throughout the year. Shorebird hunting was a cause of decline for many populations historically. While hunting has ceased in North America, for the most part, hunting of birds that overwinter in the Caribbean and South America continues, and is considered a major conservation threat for many species. Species that nest along beaches on the East Coast are threatened by human development and disturbance by beachgoers and dogwalkers. Other threats along the East Coast include wetland destruction and competition for food resources – some shorebirds depend on horseshoe crab eggs, which are also harvested by humans. For Arctic breeders, climate change and sea level rise are a major concern at present and looking ahead to the future. Canada Geese and Snow Geese are also known to overgraze the tundra habitats favored by some of these birds for breeding. On wintering grounds in South America, conversion of wetlands to agriculture and other development is a major cause of habitat loss. As with many aquatic and marine birds, water pollution in the form of oil spills, heavy metals, pesticides, and PCBs can also affect populations. Willet appear particularly sensitive to collisions with powerlines, which could also represent a concern with regards to wind energy development.

2.3.10 Phalaropes

Phalaropes, members of the family Scolopacidae, genus *Phalaropus*, are included in a separate category from other shorebirds given their differing life history. Both Red Phalaropes and Red-necked Phalaropes breed in the Arctic, but occur along the East Coast during nonbreeding portions of the year. The Red-necked Phalarope is considered a migrant throughout the East Coast states. The Red Phalarope is considered a migrant in the northern part of the RWSC area of interest, but a nonbreeding season occupant of habitat in South Carolina, Georgia, and Florida. Wilson's Phalarope is an occasional vagrant along the East Coast.

Phalaropes winter at sea in the open ocean, where they feed primarily on zooplankton.

Due to their remote breeding and foraging habitat, population trends for both species are hard to determine. Individual studies have indicated localized steep declines in studied populations. Due to their relative abundance, neither species is currently considered of high conservation concern, and they are not listed at the federal or state level. As surface-feeding species, oil spills and ingestion of plastic trash are considered potential conservation threats. Changes in zooplankton abundance and distribution associated with climate change are also of concern.

2.3.11 Large Wading Birds

Large Wading Birds include all members of the families Ardeidae and Threskiornithidae occurring along the Atlantic Coast of the United States, including herons, egrets, bitterns, and ibises. The Anhinga (family Anhingidae) is also included here.

- There are 20 native species in this group, although four (American Flamingo, Reddish Egret, Roseate Spoonbill, White-faced Ibis) occur only in Florida.
- Ten species breed throughout much or all of the RWSC Study Area, including the Black-crowned Night-Heron, Yellow-crowned Night-Heron, Great Blue Heron, Little Blue Heron, Tricolored Heron, Green Heron, American Bittern, Least Bittern, Glossy Ibis, and Snowy Egret. Several of these species stay year-round, while others migrate to southern portions of the RWSC Study Area (or further south) for the winter.
- The Great Egret is found throughout the East Coast, but only breeds from New Jersey south. The White Ibis inhabits North Carolina south to Florida, where it occurs year-round. Wood Storks are found from North Carolina south to Florida, and breed in the southern three coastal states (South Carolina, Georgia, Florida). The Anhinga occurs in South Carolina, Georgia, and Florida.
- Some Sandhill Cranes can be found breeding from Maine to New York. They are considered vagrants in the central portion of the East Coast, but can be seen on migration in North and South Carolina, and occur year-round in Georgia and Florida. Whooping Cranes are rare north of North Carolina, and only found breeding in Florida.

Larger herons and egrets prey largely on fish and amphibians, while some smaller wading birds prefer invertebrates, including earthworms, leeches, insects, and crustaceans. Although they sometimes forage in upland habitats, these species are largely associated with wetlands. Preferences for freshwater, brackish, or saltwater habitats vary by species and with the time of year. For example, American Bitterns tend to occur in freshwater habitats, but will use brackish water in the colder months since it does not freeze. Least Bitterns use both freshwater and brackish habitats in the summer, and winter in freshwater, brackish, or saltwater habitats. Great Blue Herons can be found foraging in both freshwater and saltwater areas throughout the year. Little Blue Herons and Reddish Egrets prefer saltwater.

Large wading birds exhibit a range of migratory behavior, from long-distance migration to year-round residency. This range of behavior is evident even within some species, with different subpopulations displaying different characteristic behavior.

The most common conservation threat is wetland loss or degradation, which affects all of these species. Historically, many species were hunting in large numbers for their feathers, but in North America at least, this practice has been halted. Some hunting or culling continues illegally or in other parts of the world, either because the species are thought to compete for fish stocks or for food. Water pollutants, including mercury, PCBs, and DDT, are a problem for these species.

- Among large wading birds, about half of the species along the East Coast are numerous or fairly common and have populations that are stable or increasing. The Great Egret, Great

Blue Heron, Snowy Egret, White Ibis, Black-crowned Night-Heron, Roseate Spoonbill, and American Flamingo are among them. Anhinga populations are also increasing. The White-faced Ibis and Glossy Ibis appear to be increasing their population sizes and possibly expanding in range.

- Least Bitterns and Yellow-crowned Night-Herons remain common, but it is hard to judge their population trajectories, and there is some evidence that the Yellow-crowned Night-Heron may be in decline.
- Tricolored Herons are common and their populations were stable from 1966 to 2015, according to the North American Breeding Bird Survey. However, the 2002 North American Waterbird Conservation Plan listed the Tricolored Heron as a species of high conservation concern. Population estimates can be difficult to accurately obtain due to the challenge in detecting a dark bird using aerial surveys. Different subpopulations may also have different trajectories. Florida breeding pairs decreased by 75% from 1996 to 2002 and 2007 to 2010, and the species is now listed as state threatened. Meanwhile, in several mid-Atlantic states populations have increased following construction of intercoastal waterways.
- American Bitterns and Green Herons remain fairly common, but both species declined between 1966 and 2019, according to the North American Breeding Bird Survey. Partners in Flight includes the Green Heron on its list of Common Birds in Steep Decline. The North American Waterbird Conservation Plan lists Little Blue Herons as a species of High Concern that are known or thought to be declining.
- The Reddish Egret is on the Partners in Flight Yellow Watch List due to its restricted range.
- Wood Storks are uncommon in the United States but their numbers have remained stable from 1966 to 2019, according to the North American Breeding Bird Survey. Because Wood Storks occur only in a small portion of the United States, the USFWS lists them as federally threatened.
- The two crane species (Whooping and Sandhill) have restricted ranges and are also federally protected, but they are not particularly common in coastal areas of the U.S. Atlantic.

2.3.12 Pelicans

The Brown Pelican is the only member of the family Pelecanidae regularly found in the Northwest Atlantic, although the American White Pelican occurs in Florida during the nonbreeding season.

Brown Pelicans live year-round in estuaries and coastal marine habitats of Virginia, the Carolinas, Georgia, and Florida, and occur during the nonbreeding season in New Jersey, Delaware, and Maryland. They usually feed within 12 miles of shore. They primarily eat small fish that school near the surface of the water. Foraging pelicans dive for fish head-first from heights of up to 65 feet.

Pelicans breed in colonies of up to several thousand pairs—usually on small islands free from terrestrial predators. They fly to and from their fishing grounds in V-formations or lines just above the water's surface.

After dramatic declines associated with pesticide contamination, Brown Pelican populations stabilized thanks to conservation efforts, and populations have slowly increased between 1966 and 2019, according to the North American Bird Breeding Survey. Since their recovery, Brown Pelicans have been removed from the federal ESA. They are not listed in any state and are generally considered of low conservation concern. Nevertheless, they remain vulnerable to oil spills, entanglement in fishing gear, and human disturbance of nesting areas, as well as hunting of adults and egg collection in Latin America and the Caribbean.

2.3.13 Diving Ducks & Seaducks

Diving Ducks & Seaducks include those members of the family Anatidae belonging to the Tribe Mergini, or the Subfamily Aythyinae, including members of the genera *Aythya, Bucephala, Clangula, Histrionicus, Lophodytes, Melanitta, Mergus, Oxyura, and Somateria*. Eiders, scoters, goldeneyes, mergansers, Buffleheads, Long-Tailed Ducks, and Harlequin Ducks are often referred to as seaducks; Canvasbacks, Redheads, Ring-necked Ducks, Ruddy Ducks, and scaups are also included in this category as diving ducks. There may be ecological reasons to differentiate between these two groups in the future, but until we have a better scientific understanding of their relative use of marine habitats, they are grouped together.

There are 19 native species of diving ducks or seaducks that occur regularly in one or more of the East Coast states. Only five of these species regularly breed within the RWSC Study Area.

Common and Red-Breasted Mergansers belong to the genus *Mergus*. The Common Merganser occurs year-round from Maine to New York, and can be found during the nonbreeding season from New Jersey south to North Carolina. The Red-Breasted Mergranser can be found during migration and the nonbreeding season throughout the East Coast. Common Mergansers spend the breeding season in northern forested habitats near large lakes and rivers. They tend to prefer freshwater wintering habitat over saltwater, but they may winter in coastal bays, estuaries, and harbors. Red-Breasted Mergansers use oceans, lakes, and rivers during the nonbreeding season. They tend to use saltwater, including estuaries and bays, more often than Common Merganser.

Both species primarily eat fish, but also include aquatic invertebrates as part of their diets. Mergansers tend to forage in shallow waters, but in winter, Common Mergansers sometimes venture into deeper waters where fish are schooling. Both species find their prey by sight, diving underwater or swimming with their eyes just below the surface. Common Mergansers often probe sediments and underwater stones with their slender bills. Mergansers spend much of their time afloat on open water, in small groups or large flocks. Red-breasted Mergansers are among the fastest flying ducks, clocking speeds of up to 81 miles per hour.

The Hooded Merganser is a member of the genus *Lophodytes*, which occurs year-round along the East Coast, except for in Florida, where it is only found during the nonbreeding season. During the summer, these species are found in inland waters. They winter in these habitats, but also on brackish bays, estuaries, and tidal creeks. During migration they may be found on a variety of freshwater habitats, but also in brackish coastal bays and tidal creeks. Hooded Mergansers have a broader diet than other mergansers, consuming small fish, but also aquatic invertebrates, amphibians, and vegetation. Like other mergansers, they locate prey by sight. They occur in pairs or small flocks.

The two eider species (genus *Somateria*) are the Common and King Eiders. Both species occur during the nonbreeding season from Maine south to Maryland. Common Eiders also can be found breeding along northern, rocky coastlines from Maine to Massachusetts. For nesting, they use low-lying coastal islands, islets, and shorelines with grasses, mosses, and sometimes low shrubs or stunted trees. Females typically select a site within walking distance of the sea.

Common Eiders typically winter in areas with rocky seafloors and strong tides. King Eiders usually winter farther from land, and over deeper water, than Common Eiders. Young birds typically remain at sea during their first summer, as they do not breed in their first year. Over the course of a year, a King Eider may cover more than 9,000 miles. Eiders at sea eat primarily marine invertebrates, especially shellfish/mollusks, crustaceans, and echinoderms. King Eiders also commonly consume vegetable matter, such as algae and eelgrass. These birds forage mostly by diving for prey, sometimes to depths of 180 feet but usually to shallower depths. They feed alone or in flocks, with large numbers of birds often diving simultaneously. They take prey from the bottom, from the underside of sea ice, and from the water column.

Ring-necked Ducks breed in Maine, but are primarily found in the RWSC Study Area during migration (New Hampshire to North Carolina) or the nonbreeding season (Connecticut to Florida). This species breeds in freshwater bogs and marshes of the northern boreal forest. During migration and winter, they use freshwater habitats but may also be found in brackish estuaries and coastal marshes. They dive for submerged plants and aquatic invertebrates. Outside of the breeding season, they may occur in flocks of several to several thousand.

The remaining species only occur in the RWSC Study Area during migration or the nonbreeding season.

Three members of the genus *Bucephala* are present, the Bufflehead, Barrow's Goldeneye, and Common Goldeneye. Barrow's Goldeneye is found in Maine, New Hampshire, and Massachusetts during nonbreeding season. Common Goldeneye are found throughout the RWSC study area during the nonbreeding season. They winter on large inland rivers and lakes or on sheltered saltwater habitats. Barrow's Goldeneyes favor shallower waters than Common Goldeneyes. The birds dive frequently in search of prey, and often synchronize dives. Both species eat mainly aquatic invertebrates, although Common Goldeneyes also consume fish, fish eggs, and some vegetation. Barrow's Goldeneyes prefer mollusks. They feed mainly along shorelines in relatively shallow water (less than 13 feet), although will sometimes forage in water more than 20 feet deep. They are strong swimmers and divers, spending much of their time on the water, often in flocks.

Buffleheads migrate through the northern portion of the Study Area and occur throughout during the winter months. During these times, they occur mainly near the coast (although they can be found in smaller numbers inland). They use shallow, sheltered areas, avoiding open coastlines. Bufflehead dive for aquatic invertebrates, crustaceans, and mollusks, foraging in open, shallow water over sparse submerged vegetation or over mudflats that would be exposed at low tide.

There are three scoters – the Black, Surf, and White-winged Scoters. All are found throughout U.S. Atlantic waters during migration and/or the non-breeding season. Black Scoters migrate across a broad front, so they may occur in inland areas during migration, but like other scoters, they ultimately end up in coastal waters, congregating in flocks (sometimes of mixed species) where the water is relatively shallow and prey species are abundant. All three species consume primarily invertebrates of the sea floor, especially small clams and mussels. They capture prey by diving to the bottom, where they pry prey from the sand or rock. Because this is more easily accomplished in shallow water, scoters tend to occur near shore, although Surf Scoters, at least, roost in flocks that at night move several miles offshore in good weather.

Ruddy Ducks occur during migration and/or the nonbreeding season along all of the East Coast. Their wintering habitat includes freshwater habitats but also brackish water and coastal marshes. Ruddy Ducks spend the vast majority of their time on the water. These ducks consume a variety of aquatic invertebrates, including insects, crustaceans, and zooplankton. They forage primarily by diving to the bottom in shallow waters, straining mouthfuls of mud through thin plates on their bills and swallowing the prey items that are left behind. Occasionally they strain food from the surface of the water.

Long-tailed Ducks occur during the migration and nonbreeding seasons from Maine south to Virginia. They spend the winter along ocean coasts and on large freshwater lakes. They can often be found far offshore, especially at night. During winter in ocean waters, they eat marine crustaceans, mussels, small fish, and zooplankton, plucked from the bottom of the water column and accessed by impressively deep dives (to 200 feet deep). They occasionally feed at night. These ducks spend most of their time on the water, except when forced to go to land to breed. They can be highly social when not breeding, and occasionally form mixed flocks with other diving duck species.

Harlequin Ducks occur during the nonbreeding season from Maine south to Maryland. They are vagrants in more southern states. In the winter, they are found almost exclusively on rocky coastal shorelines. At night they roost on open water farther from shore. These ducks are excellent swimmers and feed by diving underwater. Dives can be as deep as 70 feet and last as long as 45 seconds. On wintering grounds, they consume marine invertebrates and small fish.

Greater Scaup are found during migration from Maine to Maryland, and during the nonbreeding season from Maine south to North Carolina. Lesser Scaup have a slightly more southerly distribution, being found from Maine to Georgia during migration, and Connecticut to Florida during the nonbreeding season. Lesser Scaup are often one of the last ducks to move south after breeding and one of the last species to head back north from the wintering grounds. In the winter, scaup forage in bays and along shorelines. They tend to feed in shallow waters (less than 20 feet deep). Both species eat aquatic invertebrates such as mollusks, insects, and crustaceans as well as aquatic plants and seeds. Like other ducks, scaup sleep on the water. They are social and frequently flock with other diving ducks during the nonbreeding season.

Redheads occur during the nonbreeding or migration and nonbreeding season from Massachusetts south to Florida. During migration, large flocks can be found on inland bodies of water and bays. In winter, Redheads are often found in coastal bays, feeding in large, mixed flocks. Redheads eat submerged aquatic plants, as well as some invertebrates. Though classified as diving ducks, they can be seen “dabbling” in shallow water.

Canvasbacks occur during migration between New Hampshire and Georgia, and during the nonbreeding season from Massachusetts south to Florida. During migration and on the wintering grounds, Canvasbacks use marine and freshwater areas, including estuaries and marshes. They are social outside of the breeding season, gathering in large rafts by the thousands to tens of thousands. During migration and winter, they primarily eat rhizomes and tubers from aquatic plants.

A number of conservation threats are likely affecting these species. These include contaminants (pesticides, organochlorines, heavy metals) in runoff, oil spills, ingestion of lead shot, degradation of breeding, migratory, and overwintering habitat, overharvest of food species (mussels, algae), and entanglement in fishing gear. For species that breed in the far north, climate change and associated sea level rise are particular concerns. Many species are also hunted in North America – however, duck hunting is carefully managed by the USFWS under the MBTA. Conservation of migratory and breeding habitat in the Prairie Pothole Region is of especial importance for a number of these duck species.

- A number of seaduck and diving duck species have stable or increasing populations. These include the Ring-necked Duck, Bufflehead, Hooded Merganser, Common Merganser, Red-headed Merganser, and Ruddy Duck.
- The Redhead population appears to be stable overall, despite some subpopulation declines in the West.
- Common Eiders are generally thought to be abundant with a stable population, although Arctic subpopulations appear to be declining.
- Other species are currently common and not listed under the ESA, but declining. Populations of Lesser Scaup declined between slightly between 1966 and 2019, according to the North American Breeding Bird Survey. Meanwhile, Greater Scaup appear to be rapidly declining, and are identified as a Common Bird in Steep Decline by Partners in Flight.

- A 1993 study of eastern North America estimated a decline in all three scoter species at 1% per year between 1955 and 1992, indicating a cumulative decline of 31% over that period. Black Scoter is listed as Near Threatened by the IUCN.
- Population trends are difficult to estimate for species that breed in the far north. Common Goldeneye are numerous, and their breeding population held steady in areas covered by the North American Breeding Bird Survey, but many areas are outside of that range. Barrow's Goldeneye and Harlequin Ducks are difficult to estimate, but may be declining. Wintering populations of Harlequin Duck in eastern North America are much smaller than historical (late 1800s) numbers. Long-tailed Duck populations are declining, although the species' remote breeding grounds and offshore wintering areas complicate measurement of the rate of decline. Partners in Flight classifies it as a Common Bird in Steep Decline. King Eiders nest in very remote areas, so information about their populations and population trends is very limited, although there are some indications that western populations are declining.
- Population trends are also difficult to estimate for the Canvasback, whose populations have fluctuated widely since the 1950s. Fluctuations are thought to be tied to wetland loss and annual precipitation; legal hunting may also contribute.

2.3.14 Dabbling Ducks

Dabbling Ducks include thirteen members of the family Anatidae belonging to the Subfamily Anatinae, including the genera *Anas, Aix, Chendytes, Spatula,* and *Mareca*. This group includes mallards, black ducks, teals, pintails, wigeons, whistling-ducks, and several others. Among the thirteen species that occur in the RWSC Study Area, at least nine regularly occur in saltwater habitats.

Mallards are perhaps the most familiar of all North American ducks. They occur year-round from Maine south to Virginia, and during the nonbreeding season in more southern states. As generalist foragers, they consume vegetation and a variety of invertebrate species, as well as human hand-outs. They do not occur far out to sea, but can be found in almost any type of wetland habitat, including saltwater marshes and estuaries. They remain the most widespread and abundant duck on the continent, with steady population numbers, despite heavy hunting.

American Black Ducks have a similar geographic distribution to Mallards. They breed mostly in freshwater wetlands, but may also nest in saltmarshes. They mostly spend the winter in saltwater wetlands, although freshwater habitats are also utilized. They eat mostly plant matter (e.g., seeds, roots, tubers, stems, leaves), with insects added during the breeding season. Wintering birds eat mostly plant parts in freshwater habitats, adding mussels, zooplankton, and small fish in marine habitats. American Black Ducks are slow, heavy fliers but excellent swimmers.

The White-cheeked Pintail is a marsh bird of the Caribbean that occasionally occurs north into Florida, particularly during the winter months. The species is found primarily in coastal areas, using brackish water more than most dabbling ducks. Habitats include mangrove swamps, coastal estuaries, and saline ponds and lakes.

The Mottled Duck is found year-round in South Carolina, Georgia, and Florida. These use shallow waters in fresh and brackish wetlands for resting, feeding, and nesting and are not shy – making use of small urban and suburban wetlands. They consume a variety of plant and animal matter, which varies greatly by region and season.

American Wigeons and Gadwalls have very similar distributions, occurring as migrants in northern U.S. Atlantic waters (Maine, New Hampshire), and during migration and nonbreeding seasons along the rest of the East Coast. Outside of the breeding season, both species forage and rest in inland habitats, but also estuaries, bays, and salt marshes. Both species consume plant matter primarily, but also consume insects and other aquatic invertebrates. American Wigeons migrate mostly during the day, forming small flocks during spring migration and larger flocks during fall migration. On the wintering grounds they congregate in large, mixed groups with other ducks.

Blue-winged Teal are the second most abundant duck in North America, behind the Mallard. They breed from Maine south to Maryland, and occur during the migration and nonbreeding seasons from Virginia south to Florida. These birds nest among vegetation and forage in summer in shallow ponds or marches. They typically stopover and winter in freshwater or brackish areas rather than saltwater. Blue-winged Teal eat a variety of invertebrates, as well as vegetation and grains.

Green-winged Teal are known to breed in Maine and Massachusetts, but primarily occur in East Coast states during migration (New Hampshire to Virginia) or nonbreeding (Rhode Island to Florida) seasons. They breed in grasslands or alongside vegetated wetlands, occurring in the prairie pothole region, but they not as restricted to it as many other dabbling ducks. Migrating and overwintering birds use shallow wetlands, including coastal marshes, mudflats, and estuaries. Aquatic invertebrates and seeds are the main foods. Green-winged Teal are fast, agile, buoyant flyers. In winter, Green-winged Teal gather in roosting flocks of up to 50,000 birds.

Northern Pintails occur during migration from Maine south to South Carolina, and during the nonbreeding season from Rhode Island to Florida. During these times, their habitats include estuaries, saltmarshes, and freshwater and brackish wetlands. They eat seeds from aquatic plants and agricultural grains, as well as invertebrates. They are social birds, migrating in groups.

Northern Shovelers occur during the migration and nonbreeding seasons throughout much of the RWSC Study Area, although only occurring as migrants in Maine and New Hampshire, and during the nonbreeding season in Florida. During these times, they can be found filter-feeding for tiny crustaceans, other aquatic invertebrates, and seeds, including in saltmarshes and estuaries. They are fairly social ducks, occurring in groups with other dabbling ducks, especially during the winter.

Wood Ducks breed in Maine, and occur year-round from New Hampshire south to Florida. These ducks live in inland wetlands. They eat seeds, fruits, insects and other arthropods.

The two Whistling-Ducks, Black-bellied and Fulvous, are vagrants throughout most of the RWSC study area, but occur year-round in Florida. Both species will nest in thickets or stands of trees, although Fulvous Whistling-Ducks will also nest in flooded rice paddies where they forage. Black-bellied Whistling-Ducks eat mainly plants, including agricultural crops. They eat a smaller amount of aquatic animals. Fulvous Whistling-Ducks eat mostly invertebrates and the seeds of aquatic plants. Both species graze on vegetation, but Fulvous Whistling-Ducks are more often filter-feeders, foraging by touch and straining fine mud through the bill to extract seeds and invertebrates. Foraging habitats include mangrove wetlands, among other habitats. Newly arrived migrants in spring sometimes show up in brackish or saltwater marshes, but most occupy freshwater habitats.

Unlike many groups of birds, dabbling ducks in general have populations that are holding steady or increasing.

- Abundant species with stable or increasing populations include the Mallard, Blue-Winged Teal, Green-winged Teal, Gadwalls, Northern Shovelers, Wood Ducks, White-cheeked Pintails, and both species of Whistling-Duck.
- American Wigeons, American Black Ducks, and Northern Pintails are still common, but declining.
- Mottled Duck declined by an estimated 3.1% per year between 1966 and 2015, resulting in a cumulative decline of 78% over that period, according to the North American Breeding Bird Survey. They are on the Red Watch List, Partners in Flight's highest level of

conservation concern. Numbers fluctuate widely in response to periodic drought conditions, and wetland habitat degradation and loss is a major conservation challenge. Mottled Ducks are most imperiled by hybridization with introduced Mallards.

Conservation concerns for these species include loss or degradation of wetlands, water pollution (pesticides, DDT, organochlorines, heavy metals), and consumption of lead shot. Many species are also hunted in North America – however, duck hunting is carefully managed by the USFWS under the MBTA.

2.3.15 Geese & Swans

Geese & Swans include members of the family Anatidae belonging to the Subfamily Anserinae. This group includes geese and swans, which belong to one of three genera (*Anser*, *Branta*, and *Cygnus*).

Both Snow Geese and Ross's Geese breed in tundra habitats in the arctic and subarctic. During the winter months, Ross's Geese can be found in small portions of the Carolinas. Snow Geese occur as migrants and winter residents along much of the East Coast. They winter in coastal areas, as well as in some inland areas, frequenting open habitats. Snow Geese are vegetarians with voracious appetites for a wide variety of wild grasses, sedges, forbs, and shrubs. During migration and winter, they roost mainly at night and afloat. Warming in the Arctic has led to a steep increase in both Snow and Ross's Geese, to the point where the birds are overgrazing their tundra habitat. Hunting, carefully managed by the USFWS, accounts for the largest known impact on these populations. They are vulnerable to pesticides and ingestion of lead shot.

Brant also use the Arctic for breeding and are migrants or non-breeding residents of East Coast states from New England south to North Carolina. Most migrating and wintering Brant use coastal waters, especially lagoon systems behind barrier beaches. Brant are vegetarian, relying on eelgrass and large green algae during migration and winter. They graze on exposed tidal flats or by tipping up in shallow water like dabbling ducks. Due to their northern breeding areas, the population trajectory of the species is unknown, but their species appear to have declined since the 1970s. Partners In Flight includes them on their Yellow Watch List for species with restricted ranges. Hunting of Brant is allowed in the U.S., but monitored by the USFWS. In the Arctic, some native communities collect Brant eggs and conduct subsistence hunting of molting birds. Habitat loss – due to petroleum development in nesting habitats, as well as wetland degradation – is considered a conservation threat.

Cackling Goose occasionally occur during the winter months from New Hampshire south to Virginia. They are not considered of conservation concern. Canada Geese are year-round residents along the entire East Coast of the U.S. They live in many habitats near water, including grassy fields, lawns, and grain fields. In spring and summer, geese concentrate their feeding on grasses and sedges. During fall and winter, they rely more on berries and seeds, including agricultural grains. Geese breeding in the northernmost reaches of their range tend to migrate long distances to winter in the more southerly parts of the range, whereas geese breeding in southern Canada and the conterminous United States migrate shorter distances or not at all. Canada Geese are abundant, and their population has increased dramatically since 1966, according to the North American Breeding Bird Survey. Lawns and golf courses provide novel, year-round habitats. Several million Canada Geese are harvested by hunters yearly in North America, but this does not appear to affect the population. They are not generally considered of conservation concern, although the Atlantic Migratory subpopulation is considered a SGCN in Delaware.

Both Trumpeter Swans and Tundra Swans breed in Canada and Alaska. Trumpeter Swans occur as winter residents in isolated portions of Delaware, Maryland, Virginia and North Carolina, and are vagrants elsewhere. Tundra Swans occur more widely as migrants or winter residents from New

Jersey south to South Carolina. When not breeding Tundra Swans form large flocks that travel, forage, and roost together. Wintering flocks gather on ice-free inland water bodies, but also estuaries and bays. Both birds feed on a broad range of plants, tipping in the air like dabbling ducks. Both species eat a variety of plant matter, although Tundra also eat mollusks and arthropods.

Despite being driven nearly to extinction in the early 20th century, Trumpeter Swans have rebounded. Their numbers are increasing and are estimated to have tripled between 2000-2005. Federal management plans cover the three major populations (Interior, Rocky Mountain, Pacific), and hunting is illegal. Tundra Swans are North America's most numerous swan species. They are generally considered of low conservation concern. There is an annual hunting season for Tundra Swans in some states. Conservation threats for both species include exposure to contaminants in the environment (e.g., lead shot, fishing sinkers, and mine wastes), power lines, and habitat loss. Tundra swans may be exposed to oil and gas drilling in their breeding habitats; Trumpeter Swans are also sensitive to human disturbance at their breeding grounds. Habitat loss is also a concern for Tundra Swans at migratory stopover sites. Birds are also killed by diseases, including avian cholera.

2.3.16 Loons & Grebes

This category includes all members of the families Gaviidae and Podicipedidae present in the Northwest Atlantic. Specifically, the Common Loon, Red-throated Loon, Horned Grebe, Pied-billed Grebe, and Red-necked Grebe are found in the RWSC Study Area.

The Common Loon is a year-round resident of Maine and New Hampshire, and a migrant and winter resident as far south as Florida. These birds inhabit inland waters during the breeding season. In their winter range along ocean coasts, they occur fairly close to shore and in bays and estuaries. The Red-throated Loon breeds in tundra and taiga environments, occurring as a migrant and winter resident from Maine to South Carolina, and as a winter resident in Georgia and Florida. They likewise inhabit shallow marine waters near land, including major estuaries and sounds, rarely occurring far out to sea.

When foraging over the ocean, the Red-throated Loon is highly mobile and may dive for prey from a height, much like the Northern Gannet. Both species more typically hunt prey by diving from the water's surface, often locating prey first by dipping their head underwater. Common Loons prefer fish, but will catch invertebrates as well. Red-throated Loons eat a variety of fish and invertebrates.

Red-throated Loons occur across North America, Europe, and eastern Asia. In the late twentieth century, scientists recorded long-term population declines of about 50%, possibly due to lake acidification. However, these declines appear to have stabilized. North American Common Loon populations have been stable overall between 1966 and 2019 according to the North American Breeding Bird Survey. The species is of relatively low conservation concern, with some range contractions and declines in southern portions of their range. Common Loons require clear, unpolluted lakes, and can be harmed by pollution of their breeding habitat, including acid rain, mercury contamination, lead fishing sinkers leading to lead poisoning, as well as human disturbance. Oil spills, entanglement in fishing gear, overfishing of prey, and degradation of marine habitats are wintering ground threats faced by both species. Red-throated Loons also face hunting (in northern Canada and parts of Europe) and industrial activity in breeding areas.

Pied-billed Grebes breed throughout the states of the East Coast, and are found year-round from Massachusetts south. Throughout the year, the birds occur in fresh to slightly brackish water. They forage in open water or among aquatic plants and below mats of floating vegetation. They construct floating nests using aquatic or emergent vegetation. Pied-billed Grebes are opportunistic feeders that consume a variety of prey, primarily crustaceans and small fish, which they typically capture via underwater dives and crush with their stout bills. Pied-billed Grebes are widespread and fairly common in most of the U.S. and southern Canada, and overall, populations were stable between 1966 and 2019, according to the North American Breeding Bird Survey.

Horned Grebes are found in most East Coast states during migration and the nonbreeding seasons, occurring in Georgia and Florida only during the nonbreeding season. Migrants can appear on almost any type of body of water. Wintering Horned Grebes may be found on freshwater or saltwater, sometimes in sizable flocks. They sometimes remain all winter in the same vicinity; but at other sites they can be highly mobile, searching out schools of small fish. In migration and during winter, they primarily feed on small crustaceans and fish. Horned Grebes breed mostly north of the limit of the North American Breeding Bird Survey, so it is difficult to estimate their population trends. They are fairly numerous but appear to have had population declines over the last half-century. The species is vulnerable to entanglement in fishing nets, pollutants in water, and oil spills.

Red-necked Grebes are found from Massachusetts to North Carolina during the migration season, and Maine to North Carolina during the nonbreeding season. Migrants appear on all types of inland water bodies in spring or fall, though larger lakes are most commonly used. Wintering birds frequent mostly cold, shallow waters along ocean coastlines. Along coasts, they consume fish and crustaceans (especially shrimp). They hunt visually in relatively clear water, from the top of the water to the bottom, if they can reach it. Migration occurs both during the day and at night, sometimes in loose aggregations, as with loons. Wintering birds are usually solitary but sometimes congregate where food is plentiful or in preparation for migration.

Red-necked Grebes are fairly common. Populations were stable between 1968 and 2015 and grew by an estimated 3.7% per year in the last decade of that period, according to the North American Breeding Bird Survey. Like the Horned Grebe, the species is vulnerable to entanglement in fishing nets, pollutants in water, and oil spills. Disturbance and destruction of wetlands, especially in the southern portions of the breeding range, has reduced nesting areas available. As with Horned Grebe, there is some evidence that the breeding range of Red-necked Grebe is contracting northward in North America.

The Least Grebe occurs as a vagrant in Florida, and rarely occurs in saltwater; this species is therefore not discussed further.

2.3.17 Cormorants

Cormorants include the two species of the family Phalacrocoracidae found in the Northwest Atlantic, the Double-crested Cormorant and Great Cormorant. Great Cormorants occur in coastal areas of all 14 states of the East Coast during their nonbreeding season. Double-crested Cormorants are found year-round along the coasts of several states (Massachusetts, Rhode Island, Florida). At the northern part of their range, they are more likely to occur during the breeding and migration seasons, while in southern states, they are more common during migration and nonbreeding (although they are considered “year-round” residents of Florida).

Cormorants are colonial waterbirds that form flocks during both breeding and nonbreeding seasons. They feed almost entirely on fish, diving from the water’s surface, typically in shallow, near-shore ocean waters. Because they have less preen oil than other marine birds, they must spend much of the day perched, drying their feathers, but this adaptation is thought to make their underwater swimming more efficient.

Both species appear to have large and stable or increasing populations, except in Maine, where Great Cormorants are thought to be declining due to increased Bald Eagle predation. Entanglement in fishing gear, pesticide and oil pollution, and killing as a means of pest control to protect fisheries are all threats that negatively affect their numbers.

2.3.18 Rails & Allies

Rails & Allies include the nine native members of the family Rallidae found along the East Coast of the United States, including coots, gallinules, and rails. Several are found only in southerly portions of the RWSC Study Area – the Purple Gallinule breeds from South Carolina south and lives year-round in Florida, the Yellow Rail occurs during the nonbreeding season from North Carolina to Florida, and the Black Rail breeds from New Jersey south and lives year-round from North Carolina south to Florida. The remaining species are found through most or all of the East Coast states at some point during the year. Common Gallinules, King Rails, and Clapper Rails breed in most East Coast states and overwinter in southern portions of the RWSC Study Area. Virginia Rails breed from Maine south to Virginia and overwinter from North Carolina south to Florida. Sora can be found breeding from Maine to New Jersey and then migrate through and overwinter in Delaware south to Florida. American Coots are primarily found on the East Coast during migration and the nonbreeding seasons, although they do occur year-round in Florida.

Rails and their allies are birds of marshes and other wetlands. Depending on the species, they may show a preference for freshwater, brackish, or saltwater. American Coots, Black Rails, Purple Gallinules, Virginia Rails and Yellow Rails commonly use freshwater. King Rails, Soras, and Common Gallinules occur commonly in freshwater and some brackish wetland habitats. Black and Virginia Rails also utilize saltwater habitats, and King and Yellow Rails may be found in saltwater habitats during the winter. Clapper Rails prefer saltmarshes. This latter species is hence more likely to encounter offshore wind facility transmission infrastructure where it comes ashore.

These species are more or less omnivorous, feeding on aquatic and terrestrial plants, invertebrates (especially insects and crustaceans), and small vertebrates (e.g., tadpoles and salamanders), with some species having a preference for animal or vegetable matter, and others consuming a mixed diet. They glean food items from vegetation and the water's surface or probe sediments and pluck food from the water in shallow wetlands. American Coots also often feed while swimming and dabbling.

Rails and allies exhibit a range of migratory behaviors, even within a species. Some coots, rails (Black, Clapper, Virginia) and Purple Gallinules are residents in the same area year-round; others migrate short or medium distances to the southern U.S., Mexico, and Central America. Yellow Rails migrate from northern Canada to the southeastern U.S. Common Gallinules move from the eastern U.S. to the southeastern U.S., Mexico, and Central and South America. Soras are long-distance migrants, moving from breeding grounds in the northern U.S. and Canada to wintering ground in the southern U.S., Mexico, Central America, and South America. The members of this category migrate at night and are vulnerable to collisions with structures – which could also mean they are vulnerable to collisions with offshore turbines.

- Both American Coots and Soras are common and widespread, and appear to have stable populations.
- Clapper Rails and Virginia Rails are common and also appear to have stable populations, but because of their secretive habits, population trends can be difficult to track.
- Other rail species appear to be doing more poorly. The Yellow Rail is on the Partners in Flight Yellow Watch List for species with restricted ranges. The King Rail is also on the

Yellow Watch List, in this case for its declining population, and is considered "Near Threatened" by the IUCN. It is listed in five states of the East Coast as Endangered, Threatened, or of Special Concern. Populations of this species have declined in all areas surveyed in North America by an average 4.5% per year since 1966, indicating a cumulative decline of 90%. Black Rails are also declining. Population sizes for this secretive bird are difficult to estimate, but well-studied populations along the Atlantic coast are in steep decline, and this eastern subspecies (*jamiacensis*) is listed as Threatened under the federal ESA. It is state-listed as Endangered in a number of states. The species is also on the Partners in Flight Red Watch List.

- Purple Gallinule populations across the U.S. have overall decreased slightly or held stable from 1966–2019, although numbers in the southeastern coastal plain have declined dramatically.
- Common Gallinules, while still abundant, have declined by nearly 1.5% per year between 1966 and 2015, according to the North American Breeding Bird Survey, resulting in a cumulative decline of 52%. The species is listed as Endangered, Threatened, or of Special Concern in five East Coast states.

The largest common conservation concern for these species is wetland loss and degradation, whether due to urbanization, agricultural development, or other sources. They are sensitive to changes in water depth, whether due to sea level rise or wetland alteration by humans, as well as water pollution by pesticides, heavy metals, or other contaminants. Hunting of some species is legal in the U.S. and Canada, but it is not clear if this has a significant effect at the population level. As noted above, collisions with structures during migration is a concern. Rails also die in collisions with vehicles, and yellow rails may be killed by agricultural equipment during haying or disking.

2.3.19 Migratory Passerines & Other Small Landbirds

Migratory Passerines & Other Small Landbirds includes seven orders of landbirds occurring along the Atlantic Coast of the United States which are known to include Neotropical migrants. These include the Orders Columbiformes (pigeons and doves), Cuculiformes (cuckoos), Caprimulgiformes (nightjars), Apodiformes (swifts and hummingbirds), Coraciiformes (kingfishers), Piciformes (kingfishers), and the largest order, Passeriformes (passerines, or "songbirds"). This category includes a long and varied list of species, but they are similar in terms of their exposure and potential risk from offshore wind development. Aside from small subpopulations which might inhabit islands, this category of individuals rarely occurs offshore during breeding or nonbreeding seasons. They cannot rest on the water and rarely forage far from land. However, some species travel long distances over ocean waters, and occur far offshore, during migration. Members of this group may also inhabit coastal areas where they could interact with transmission infrastructure from offshore wind development.

Based on a report prepared for BOEM (Robinson Wilmott et al. 2013)[9], at least 22 small landbirds have detected over the Outer Continental Shelf, all of which were passerines. This list includes the American Goldfinch, American Redstart, Baltimore Oriole, Barn Swallow, Bicknell's Thrush, Blackburnian Warbler, Blackpoll Warbler, Blue-gray Gnatcatcher, Canada Warbler, Cape May Warbler, Chipping Sparrow, Common Yellowthroat, Indigo Bunting, Kirtland's Warbler, Northern Parula, Northern Waterthrush, Ovenbird, Palm Warbler, Savannah Sparrow, Song Sparrow, White-throated Sparrow, and Yellow-rumped Warbler. In addition, the Northern Flicker was detected acoustically by the Dominion CVOW project.

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[9] *https://espis.boem.gov/final%20reports/5319.pdf*

2.3.20 Raptors, Owls, & Vultures

Raptors, Owls, & Vultures includes large landbirds in the Orders Accipitriformes, Cathartiformes, Falconiformes, and Strigiformes, including hawks, falcons, eagles, osprey, vultures, and owls. Some of these species are fish-eaters and will forage over near-shore waters. In addition, individuals of some species, such as Bald Eagles and Osprey, may be found nesting on offshore islands, particularly in the Gulf of Maine, where such islands are numerous. However, these species do not rest on the water, however, and in general are not found in offshore environments during the breeding or nonbreeding seasons. However, a number of these species are Neotropical migrants and may travel long distances over marine waters during migration. Species that have been detected over the Outer Continental Shelf include the American Kestrel, Bald Eagle, Merlin, Northern Harrier, Osprey, Peregrine Falcon, and Turkey Vulture.

2.4 Regional Coastal and Offshore Distribution Information

This section addresses major regional sources of information about bird distributions in coastal and offshore environments of the RWSC Study Area.

In addition to the sources listed below, many individual studies document the distribution and/or abundance of one or more species along all of, or a portion of, the Atlantic Coast. State agencies often hold information about locations and sizes of breeding colonies and some of this information is available from the National Audubon Society in the context of Important Bird Areas. Some states, like New York, maintain a state-level Breeding Bird Atlas. Publicly available tracking data can also be drawn from Movebank for species or areas of particular interest. However, these types of data are not currently collated in one central location. A compilation of all of these individual sources is outside the scope of this Science Plan – although recommendations for historic data compilation are included in Section 6.

2.4.1 Marine Bird Distribution Maps

One of the most comprehensive analyses of marine bird distributions in the RWSC Study Area was conducted by Winship et al. (2018)[10]. Over 30 years of survey data contained in the Northwest Atlantic Seabird Catalog database, along with Eastern Canada Seabirds at Sea data from Canadian Wildlife Service, were analyzed using spatial predictive modeling to derive seasonal maps of the spatial distributions of 47 marine bird species in U.S. Atlantic Outer Continental Shelf and adjacent waters from Florida to Maine. Model predictions are presented as seasonal maps of the relative density of each study species, indicating where they are anticipated to be more or less abundant. The analysis was designed to provide relative density, and does not purport to estimate the actual number of individuals/density of a given species that would be expected in any specific location. The maps were reviewed by experts with experience and knowledge of marine birds in the study area and their comments were incorporated into the accompanying report.

Through funding from BOEM, these maps were updated by NCCOS between 2020-2023[11]. As an additional component of this project, predicted changes in oceanographic conditions were used to predict range shifts of several marine bird species in the context of climate change.

2.4.2 eBird Maps

eBird is a project of the Cornell Lab of Ornithology and collaborators which collects and analyzes information about bird sightings by expert and citizen scientists in terrestrial and marine environments. Birders enter when, where, and how they went birding, and then fill out a checklist of all the birds seen and heard. The eBird Science team uses statistical models and machine learning to analyze patterns of abundance, distribution, and migratory movements. Raw eBird data are combined with high-resolution satellite imagery from NASA, NOAA, and USGS to estimate population trends and to predict distribution and abundance of bird species for every week of the year[12].

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10 https://coastalscience.noaa.gov/data_reports/modeling-at-sea-density-of-marine-birds-to-support-atlantic-marine-renewable-energy-planning-final-report/

11 https://www.boem.gov/sites/default/files/documents/environment/Anticipating%20Shifts%20in%20Marine%20Bird%20Distributions%20for%20Planning%2C%20Leasing%2C%20and%20Assessment%20of%20Energy%20Development%20on%20the%20Outer%20Continental%20Shelf.pdf

12 https://science.ebird.org/en

Because these data are collected based on (often incidental) observations, rather than using rigorous scientific methods, the marine bird distribution maps described above are considered of greater value for the marine birds included in that analysis than eBird maps. eBird data are nevertheless valuable for species not modelled in the maps described above.

2.4.3 Identified Critical Habitat

For bird species listed as Threatened or Endangered under the federal Endangered Species Act, the USFWS is required to determine whether there are identifiable areas that meet the definition of "critical habitat." Critical habitat is defined as:

- Specific areas within the geographical area occupied by the species at the time of listing that contain physical or biological features essential to conservation of the species and that may require special management considerations or protection; and
- Specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation.

There are 16 bird species occurring along the East Coast that are identified as Threatened or Endangered across some or all of their range. Of these, most either do not have critical habitat defined, or identified habitats do not occur in coastal areas. Defined critical terrestrial habitats could be relevant to where cables come ashore to connect to grid infrastructure, but are not broadly relevant to offshore wind infrastructure development. Critical habitat for the five shorebird and marine bird species that occur along the Atlantic Coast is summarized below:

- The Atlantic Coast subpopulation of **Piping Plovers** is considered Threatened. Critical habitat has been defined for other, Endangered, breeding populations, but no critical habitat has been proposed or designated for the breeding range of the Atlantic Coast population.
- A new definition of critical habitat for the Threatened **Red Knot** was proposed in April 2023. The proposed revised definition includes coastal areas of Massachusetts, New York, New Jersey, Delaware, Virginia, North Carolina, South Carolina, Georgia, and Florida, which are described in detail here: https://www.govinfo.gov/content/pkg/FR-2023-04-13/pdf/2023-06619.pdf
- The **Roseate Tern** is considered Endangered in the northern part of its Atlantic range, and Threatened south of North Carolina. No critical habitat has been defined for this species.
- No critical habitat has been defined for the Bermuda Petrel or Band-rumped Storm-Petrel, both of which nest outside of the RWSC Study Area.

3 Potential Effects of Offshore Wind on Birds

Offshore wind development and operations could have positive, negative and/or mixed impacts on birds. These effects may directly affect individual animals, or indirectly affect them through changes to the environment, prey/predator distributions, and/or changes in human activities. Animals and populations may also be impacted by multiple, mixed impacts, some positive and some negative.

3.1 Potential Negative Effects

Birds face a number of potential negative impacts from offshore wind. The most straightforward type of impact is collisions – birds may collide with turbine blades, towers, or other facility infrastructure, leading to injuries or fatalities. These collisions could have subpopulation or population-level impacts, if they affect a significant fraction of the population, or place stress on an already vulnerable species.

Birds may also face habitat-mediated impacts, including habitat loss, habitat degradation, and reductions in habitat connectivity. These effects could occur via a broad suite of mechanisms, which are not easily divided into distinct categories. Birds could face complete loss of habitat within a wind facility if they are displaced from it entirely, displaying outright avoidance of the entire area. Birds might also avoid areas in direct proximity to turbines, which could lead to loss of part of the habitat within a wind facility. Micro-avoidance of turbine blades or the rotor-swept zone during flight could, in effect, lead to habitat loss in a manner that has negative energetic consequences for birds.

Habitat degradation could occur if birds are less comfortable foraging within a wind facility, such that fewer individuals of a species will forage in an area, foraging is less efficient due to distraction or difficulty foraging near turbine infrastructure, and/or the presence of the turbines cause stress levels to be higher, reducing the bird's condition, with negative consequences for survival or fecundity. Habitat degradation could also occur via interactions with other species. For example, if turbine infrastructure changes the distribution patterns or abundance of forage fish or other prey, this could potentially reduce the forage quality of certain habitats, bring a certain species into greater proximity to other species which compete for the same food sources, or concentrate animals in a way that increases risk of disease spread. Changes in prey distributions for marine birds and shorebirds is particularly a concern in proximity to breeding colonies, where adult birds may be limited to foraging within a certain vicinity for food for their young. Laying of transmission cables along the seafloor could also result in unknown changes to prey distributions and foraging habitat. Turbine infrastructure could change the distribution of predator species, by creating perching/roosting habitat for raptors, for example, or concentrating prey species in a way that attracts predators to them. Offshore wind development might also affect human interactions with birds – for example, if an artificial reef effect of turbine structures brought more recreational fishing into areas of high marine bird density, entanglement in fishing gear could become more common.

Development of offshore wind facilities could also reduce habitat connectivity, again due to avoidance, on a macro- or micro-scale. This potential impact is of particular concern during spring and fall migration seasons, when many migratory species make long-distance movements. Avoidance of wind facilities during these flights could result in large increases in energy expenditures, reducing survival during migration, birds' condition when they arrive at wintering or breeding grounds, and potentially fecundity. Deviations from their usual migratory routes could expose birds to inhospitable habitats to which they are not accustomed or (due to increased travel time) increase risk of exposure to adverse weather conditions. While often thought of in the context of migratory movements, habitat connectivity is also of particular concern during the breeding season if a wind facility is built between a breeding colony and foraging areas. On wintering grounds, avoidance of wind facilities could also lead to challenges for birds traveling between areas or attempting to follow prey species.

The above focuses on offshore effects of offshore wind. Of course, trenching for cables at coastal sites and construction of transmission corridors to connect offshore facilities with onshore grid infrastructure are land-based components of offshore wind development that could affect species that frequent shorelines and inland habitats. Disturbance of beach-nesting birds is a particular concern where cables come ashore. Clearing of transmission corridors and installation of transmission lines also have potential habitat consequences for wildlife, including loss, degradation, and connectivity. Because these are not novel development types in the United States, have been the subject of past research, are addressed by current environmental laws, and represent a small area of impact relative to the footprint of offshore wind facilities, they are not the focus of this section or this chapter. However, they represent a potential source of impact that certainly must be evaluated as part of the environmental review of any wind facility.

3.2 Potential Positive Effects

Impacts of offshore wind development need not be inherently negative. On a global scale, the development of offshore wind facilities is a major step towards transitioning away from fossil fuel use, reducing greenhouse gas emissions, and mitigating climate change. Over long time scales, the mitigation of climate change is an extremely important conservation action affecting many bird species, especially those that breed or forage at high latitudes. This positive effect of offshore wind development will likely not be apparent in bird populations in the U.S. Atlantic in the next several decades – or will only be apparent in the occurrence of less harm to bird populations due to climate change than might otherwise have occurred – a very difficult effect to measure on the ground; nevertheless, it is an important positive effect of offshore wind development which can be explored through modelling.

At the regional scale, offshore wind could have local, habitat-mediated benefits to avian species, if it alters habitat in a way that benefits birds. For example, the artificial reef effect might increase forage fish populations, or concentrate forage fish around turbine foundations. If this effect occurs on a broad scale, and bird species can safely and efficiently forage around turbine infrastructure, wind turbines could potentially increase carrying capacity for certain bird species or increase their foraging efficiency. Installation of turbines might also inadvertently provide beneficial perching, roosting, stopover, or even nesting habitat for some species.

In addition, offshore wind development could indirectly benefit avian species if compensatory mitigation efforts are conducted in such a way and to the extent that they provide a net benefit to the species, more than offsetting any of the potential negative impacts described above. Compensatory mitigation planning is discussed later in this chapter.

Finally, a greater scientific interest and research focus on certain species in the context of offshore wind development might lead to a better scientific understanding that elucidates unrelated conservation issues and opportunities and ultimately better serves these species.

4 Common Data Collection Methods and Approaches

A wide variety of scientific methods are used for studying birds, which are summarized below. Note that this brief review focuses on technologies or methods which can be used in the offshore environment or at coastal/island nesting sites of seabirds and shorebirds. There are many additional survey techniques and protocols used in the onshore environment. These are relevant to the study of terrestrial effects of offshore wind – such as effects of trenching for cables where they are brought ashore, or clearing of transmission corridors to connect offshore wind with onshore grid infrastructure – but for the sake of brevity and a focus on novel offshore issues, they are not addressed here.

4.1 Observational Surveys, Photography, and Video

At-sea aerial surveys for seabirds were historically conducted using airplanes flying at roughly 75-100 m over the ocean surface, with live observers recording observations within a certain distance from the line of transect. In more recent years, some at-sea surveys have transitioned over to the use of aerial photos or videos, including high-definition photos or video, which can be conducted at a higher flight altitude. High-definition aerial photography has some advantages over live observers, including reduced bird disturbance due to the higher flight altitude, less effect of observer bias, and the availability of raw data for quality control and future re-analysis. In addition, there is some evidence that aerial video can cover a larger area, provide greater spatial accuracy, lead to higher numbers of sightings, and more frequently identify birds to species (e.g. see Zydelis et al. 2019[13]). Of greatest importance to offshore wind studies is the higher flight altitude – conducting at-sea surveys at 75-100 m over the ocean surface will not be possible at offshore wind facilities once turbines are installed. In order to be able to accurately compare before/after survey results in the vicinity of offshore wind facilities, high-definition aerial photography (still photos or video) are recommended for all offshore surveys of seabirds moving forward.

Censusing birds at sea is the primary objective of this research method; however, flight height estimates can in some cases be gleaned from the data. In addition, with digital aerial photographs, or particularly video, it is sometimes possible to identify obvious behaviors, like foraging dives. However, even with video, recordings are only brief (e.g., 6-8 frames of a bird over 1 second), and therefore not particularly informative regarding behavior.

Boat-based surveys can also be used to inventory/census bird species present at sea. These types of surveys are currently commonly proposed as part of Bird Monitoring Plans at offshore wind facilities. At smaller spatial scales, they tend to be more cost-effective than aerial surveys. As lease areas become larger and locations further offshore, aerial surveys may naturally become more cost-effective and more common. While all study methods have some biases, boat-based surveys tend not to be as good as aerial surveys for detecting some taxa – particularly seaducks, alcids, and loons, which can be disturbed by boats.

Boat-based or stationary (e.g., turbine platform-based) observations using live observers can also be used to estimate flight height and collect behavioral data, such as documenting foraging behavior or responses to turbines.

In coastal areas and on islands, **population surveys** of nesting seabirds or shorebirds are common. These surveys are sometimes aerial (using aerial still photographs or video), or may be ground-based, including surveys at nesting colonies to census the entire population at a particular site. At nesting colonies, other observational studies may also be conducted, including **nest monitoring to document productivity over time, behavioral studies, and observations of adults feeding young** to document diet.

On turbine platforms, turbine nacelles, or other offshore infrastructure, **cameras** are beginning to be used to record bird presence and behavior in the vicinity of turbines, which can inform when and where animals are present in the rotor-swept zone and document bird interactions with

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[13] https://link.springer.com/article/10.1007/s10336-018-1622-4

turbines, including perching, roosting, attraction, micro-avoidance, lack of response, or collisions. Cameras differ in their mode of action, resolution, and the frequencies of electromagnetic radiation they use, from conventional cameras that operate in the visual range, to so-called "infrared" cameras that operate in the near infrared range, to so-called "thermal" cameras that operate in the far infrared range. The information provided by continuously operating cameras is unique and of great value to bird and offshore wind research. However, all of these types of systems are expensive at present and often only deployed at one or a few turbines in a study area. The field of view of a particular camera is often not sufficient to encompass the full rotor-swept zone, at least with sufficient granularity to identify birds throughout that zone. The extent to which these technologies can be counted upon to operate continuously in the harsh offshore environment is currently being evaluated.

4.2 Radar and LiDAR

Radar systems (RAdio Detection And Ranging) come in a range of types, sizes, frequencies, and modes of action, which affect the spatial scale of detection, resolution, and types of data collected. They detect birds by emitting pulses or continuous streams of radiowaves which are bounced back from any object encountered, producing an "echo" which is detected and interpreted by the radar equipment.

NEXRAD towers are large, S-band, Doppler weather radar stations deployed across the United States to provide information on a broad set of weather conditions, including precipitation and wind speed. This radar is not capable of picking up individual animals, but will detect concentrated densities of migrants leaving stopover sites for high-altitude nocturnal flights in the spring and fall. It has been used to study changes in total bird abundance (measured as biomass) over time.

X-band radars use smaller antennae and have a smaller spatial range. They operate using a shorter wavelength, and hence have a higher target resolution. Mobile X-band radar units can be deployed on coastal and island sites, boats, or offshore infrastructure to monitor for passage rates of commuting or migrating birds. They cannot identify animals to species, but can provide information about body size, which can inform classification, as well as information about flight height.

Many ships are equipped with S-band or X-band radars (or both) to aid in navigation, with S-band systems providing longer-range data and better functioning in fog, and X-band radars, as noted above, providing greater precision. These "marine" radars can also be used to track birds, with precise applications and data dependent on the type of system.

LiDAR (Light Detection and Ranging) systems work by a similar mechanism, but use a different frequency on the electromagnetic spectrum. In this technology, a laser beam is emitted, which bounces back after it encounters an object. LiDAR systems are more precise than radar, but operate over a shorter range, and are obstructed by fog or rain. The use of this technology for measuring bird flight height is beginning to be explored offshore (Cook et al. 2018[14]).

4.3 Acoustics

Acoustic surveys can be conducted using acoustic detectors to record calls of birds. Acoustic surveys are more commonly used for bats, where they may be conducted using passive (stationary) or active methods. Acoustic surveys for birds are most common for night migrants, and typically use passive, stationary detectors geared towards the audible range. Passive surveys offshore utilize stationary detectors deployed on ocean buoys, meteorological towers, offshore wind turbines, other

[14] https://data.marine.gov.scot/sites/default/files/SMFS%200914_1.pdf

offshore infrastructure (such as electrical service platforms or "ESPs"). Note that acoustic surveys are only effective when study animals are vocalizing. Ambient noise can interfere with detection of vocalizing animals and limit the distance over which calls will be recorded.

4.4 Banding, Tagging, and Tracking

Capture-mark-recapture studies can be used to assess population size, evaluate survival, and study migratory movements of long-ranging birds. **Bird banding** is a very common practice for birds of all sizes, with banding information going to a central repository, the Bird Banding Laboratory. PIT (passive integrated transponder) tags are less commonly used for birds. These tags are implanted into the animal using an injector.

There are a variety of different types of **tags** which can be attached to birds to gather information about their movements. Birds can be outfitted with **geolocator tags**, which measure daylight versus time, allowing for estimates of latitude and longitude, approximating bird positions. An advantage of these tags is that they are very lightweight, so they can be attached even to the smallest species. However, they do not provide as accurate a position as some other types of tags, and the animal must be recaptured in order to retrieve the data.

Satellite tags are also deployed on birds. These come in several types[15]. GPS dataloggers receive information from a satellite system known as the Global Positioning System, which is maintained by the U.S. government. Wherever a GPS receiver has unobstructed line-of-sight to four or more GPS satellites, it can use the information transmitted by the satellites to calculate accurate time and location. GPS dataloggers are set to record data at regular intervals (rather than continuously) to generate a dotted movement track. In order to access the data, the animal must be recaptured and the tag recovered. Alternatively, GPS receivers can be paired with a transmitter that sends the data to a particular server, which can be a satellite system (for global coverage) or cellular phone system (where cell tower coverage is expected to be available). For these types of tags, the animal does not need to be recaptured; however, the use of a transmitter requires a larger battery, which means that they cannot be deployed on smaller bird species. Platform Transmitting Terminals (PTT) tags operate similarly to GPS transmitters; these transmitters send periodic messages to a global satellite system called Argos, which is dedicated to ecological and environmental research. Argos satellites pick up and store signals, relaying them in real-time back to earth, where data are processed and delivered to researchers. As with GPS transmitters, battery size currently limits the size of bird on which these tags can be deployed.

VHF (Very High Frequency) radiotags transmit signals in the radio frequency range, which can be detected with a receiver. These types of tags are regularly deployed on both birds. Historically, tags with slightly different frequencies were deployed on animals within one research study to allow for easy identification of different individuals. The animals were then tracked, often via manual telemetry with a hand-held receiver. Manual tracking could be conducted on-foot, using a vehicle, or even via small airplane. Study animals could also be tracked via a receiver attached to a stationary tower with antennae pointed in multiple directions, which could be automated to detect signals periodically or rotated manually by a researcher to detect a signal with an associated bearing. Manual telemetry is limited by the search effort available for finding and pinpointing the radio signal, and hence faces significant challenges in tracking animals that range over long distances.

[15] https://nationalzoo.si.edu/migratory-birds/what-satellite-telemetry

In recent years, the development of the Motus Wildlife Tracking System has allowed for much more widespread use of VHF telemetry for tracking of wide-ranging and/or migrating birds. This system relies on coded radiotransmitters which all operate on one of several frequencies, but which emit slightly different patterns of code to identify different individuals. These tags are used in concert with fixed telemetry stations consisting of antennae, a receiver, a power source, memory storage, and sometimes data transmission infrastructure. Telemetry stations can be deployed on land, on coastal locations, or on offshore infrastructure, including ocean buoys and offshore wind turbine platforms. A great advantage of this system is that stations deployed by one research group can detect passage of animals by other researchers operating in the same network, allowing for development of a widespread network with more likelihood of detecting wide-ranging study animals. This system also has the distinct advantage over manual telemetry that signals can be monitored for continuously. Motus system technology has limitations, including limited range of some telemetry stations and, in most cases, an ability to determine only general proximity or bearing from the station rather than precise location.

4.5 Other Monitoring Methodologies

At onshore wind facilities, **carcass surveys** are commonly used to document mortality and estimate fatality rates for a variety of bird species, particularly raptors, that collide with wind turbines. Offshore, carcasses of individuals can be expected to fall into the ocean in most instances. Methods to reliably detect collisions are sorely needed, but are not yet commercially available. Beach carcass surveys for the bodies of birds killed at turbines have been proposed, but are only likely to be effective, if at all, in locations with very specific geographies and patterns of ocean currents. Occasionally, birds that collide with turbines may fall to the turbine platform. These carcasses can be collected, identified, and documented, providing incidental information.

There are a range of **tissue sampling** methods from live-caught birds, or their feces, which provide a variety of information about individuals' migratory status, diet, and health, as well as population-level genetic structure. These include collections of feathers, blood, skin, stomach contents, and fecal matter, to variously conduct stable isotope analysis, physiological analyses (e.g., for stress hormones), diet assays, genetic analyses, or others. In addition to direct sampling of individuals, collection of DNA from the ambient environment (**eDNA**) also has the potential to provide information about species present in an area. This is a relatively new technology and the utility of this technique to address various research questions is not yet fully understood.

Incidental observations can also provide useful information about species presence and behavior, particularly for those infrequently observed at sea. Citizen science can also be used to collect these types of data – eBird is one database that capitalizes on this type of data to generate useful information about timing and distributions of bird occurrence.

In addition to the methods described above, it should be noted that **some systems incorporate multiple methodologies simultaneously**, in order to better understand and, in some cases, verify detections. For example, systems might include various combinations of acoustic, camera, and radar systems to track bird movements and aid in species identification.

5 Research Topics: Birds and Offshore Wind in the U.S. Atlantic

Research questions about offshore wind development and wildlife are centered around two common themes. First, there is a need to measure, estimate, model, or otherwise assess the scale of impacts of offshore wind development on birds, in order to determine which impacts are significant at a subpopulation or population scale. Second, there is a need to understand how to address any impacts that may occur via effective mitigation. In the context of this chapter, "mitigation" is used broadly, as defined by the Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) regulations. Thus, mitigation in this context includes avoidance, on-site minimization and mitigation of impacts, restoration of the affected environment to rectify impacts, and off-site compensation for impacts. Some examples of the types of specific actions these categories might include are given as examples below.

- Avoidance could include siting wind facilities far from breeding colonies of rare birds or outside of areas with high abundances of particular marine bird species.
- On-site mitigation could include curtailing wind turbine operations during periods of high bird activity so as to reduce the risk of collision fatalities.
- Rehabilitating or restoring the affected environment to rectify impact could include stabilizing or revegetating areas affected where trenching occurred to allow for laying of a transmission cable.
- Compensating for the impact off-site could include supporting predator control at a nesting colony to increase populations of a breeding tern species that is affected by collision mortality.

The goal of mitigation measures is that they will negate or offset any negative impacts of offshore wind development, and ideally provide a net benefit to the species.

From the perspective of a regulator, conservationist, or offshore wind developer, the progress of research would ideally begin with development of accurate and cost-effective technologies for wildlife monitoring, as well as development of standardized systems for data collection and analysis, followed by evaluation of impacts and mitigation strategies at a pilot study-scale, followed by evaluation of impacts and mitigation measures on a large scale, moving to widespread development of offshore wind in the context of implementation of effective mitigation measures. This would allow regulators and conservationists to fully understand baseline conditions of bird populations at sea, to prioritize threats based on their impacts to species, and to determine appropriate, effective, and scientifically defensible mitigation measures. This would also allow developers to understand upfront what negative impacts of their facilities are likely to be the most significant, to implement any siting choices or on-site mitigation measures that are called for, and to understand the financial costs, upfront, of any compensatory mitigation that may be warranted.

Of course, this is not a realistic or practicable scientific timeline. Methods for studying birds are constantly improving, but are by no means perfect – nor can they be expected to be perfected in the next several years, or the next decade. For some species, we have only a limited understanding of baseline population size, distribution, abundance, survival and fecundity rates, or causes of decline. Meanwhile, the need to combat climate change is driving rapid development of offshore wind energy – the first large-scale facility is expected to begin commercial operation in 2023, with four additional large projects (over 100 turbines per project) expected in 2024. This means that short-term scientific needs include development of data standards AND advancement of wildlife monitoring technologies and study techniques, pilot studies of offshore wind impacts at existing small-scale facilities AND large-scale assessments of baseline conditions. As the first large-scale wind facilities begin operations, evaluations of the impacts of these large-scale facilities, and assessments of the efficacy of mitigation measures, must also commence.

In the meantime, regulators must necessarily rely on the best available science, scientific "best guesses" about vulnerability, research studies from Europe, and proxy metrics, both in identifying areas that should be avoided in siting of wind facilities (mitigation via avoidance) and in assessing potential risks to protected and vulnerable species. Tools must continue to be developed to help inform these efforts. While many conservationists prefer focusing on earlier steps in the mitigation hierarchy, the reality is that the impacts of offshore wind development will not be fully evaluated until many hundreds of turbines are installed. This suggests that effective on-site mitigation and off-site compensatory mitigation measures will also need to be an early focus, because once turbines are in the water, they are unlikely to be removed or fully turned off. On-site mitigation options may be employed, where feasible. However, off-site compensatory mitigation may be the only viable option, in some cases, for addressing impacts.

The timeline for offshore wind development hence necessitates moving forward on a multitude of fronts at once. Research topics of interest for birds and offshore wind include:

- **Creating a structure in which to collaboratively conduct and share scientific research and advances, through discussion, coordination, and planning.**
- **Improving data collection and distribution methods.** This includes standardization of data workflows, refinement of structures for data sharing, and technological advances.
- **Understanding baseline conditions of bird ecology offshore.** This includes addressing questions about how distribution patterns, density, and movements vary by time of year, with meteorological conditions, across seasons, by sex, age, and reproductive status, with interannual variation, and especially in the context of global climate change. Understanding distribution and abundance during the breeding season is of particular interest for colonial nesters that may be tied to only a few historic breeding areas. Movement metrics of interest include speed, distance and longevity of flights, flight height, and starting points and destinations. This also includes assessing important variables relative to population dynamics (e.g., fecundity, survival, population structure) and interactions among bird species and with prey populations.
- **Informing pre-construction risk assessments of potential impacts to birds.** This includes considering exposure of birds to offshore wind development, based on baseline distributions noted above. Collecting data to inform Collision Risk Models and developing these models are also included.
- **Assessing impacts of construction and operation of offshore wind facilities.** This includes assessing changes from baseline conditions (e.g., distribution patterns, movements, population dynamics and trajectories, ecological interactions) in the context of climate change and other environmental changes. It also includes documenting collision fatalities, where possible.
- **Evaluating on-site mitigation strategies**. This could include mitigation activities effective during construction (e.g., noise reduction measures) or operation (e.g., painting turbine blades).
- **Identifying and evaluating off-site compensatory mitigation strategies.** As noted above, due to the rapid pace of offshore wind development relative to the pace of research on impacts, off-site mitigation could represent an important aspect of offshore wind development, if significant impacts are found.

6 Regional-scale Ongoing, Pending, and Recommended Science Actions in the U.S. Atlantic for Birds and Offshore wind

This section of the Science Plan discusses on-going, pending, and recommended science actions related to gaining a better understanding of effects of offshore wind infrastructure on birds in the marine environment and to address mitigation strategies in the context of identified impacts. This section is structured by the type of action, including:

- Coordination, planning, and data sharing
- Standardization of data collection, analysis, and reporting
- Historical data compilation
- Model development and statistical frameworks
- Meta-analysis and literature review
- Optimizing research, monitoring, and mitigation
- Technology advancement
- Field data collection and analysis

Most of the actions discussed are of relevance throughout the RWSC Study Area. Specific subregion considerations are addressed in Section 7 of this plan.

6.1 Coordination, Planning, and Data Sharing

6.1.1 Entities providing Regular Coordination, Planning, and Information Sharing

Many entities conduct regional coordination or planning regarding wildlife research in the coastal and marine environments, but several conduct work specifically focused on birds and offshore wind.

Information sharing is also conducted by most organizations regarding their own work or collaborative efforts. However, the organizations discussed below are focused on sharing information at a regional level of specific relevance to offshore wind and wildlife. Of course, many databases have a public interface which also allows for information sharing, as do regional data portals. In the interest of avoiding redundancy, this category of platform for information sharing is not included here, but is instead detailed in Section 6.2 of this chapter, which deals in depth with databases.

RWSC

This Science Plan reflects one of the coordination and planning activities the RWSC[16] was founded to carry out. The mission of RWSC is: *To collaboratively and effectively conduct and coordinate relevant, credible, and efficient regional monitoring and research of wildlife and marine ecosystems that supports the advancement of environmentally responsible and cost-efficient offshore wind power development activities in U.S. Atlantic waters*.

The development of this Plan was undertaken by the RWSC in collaboration with state and federal agencies, the offshore wind industry, environmental NGOs, academic researchers, and other stakeholders in order to identify regional research needs and determine a path forward to fund and carry out these scientific activities.

Other RWSC activities include hosting monthly taxa-specific Subcommittee meetings to discuss current and upcoming research, provide feedback on proposed methods and plans, and share other relevant updates. In addition to Subcommittee meetings, RWSC hosts regular meetings of state, federal, and industry caucuses, as well as its overarching Steering Committee.

The organization has also developed the RWSC Offshore Wind and Wildlife Research Database to compile and track active and recent projects addressing offshore wind and wildlife interactions in U.S. Atlantic Waters.

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[16] https://rwsc.org/

E-TWG

The New York Environmental Technical Working Group (E-TWG)[17] was organized to advise the state government of New York regarding measures to avoid, minimize, and mitigate anticipated impacts on wildlife during offshore wind energy development. While created to support the state of New York in particular, the group's work is relevant to the wider region. The group includes membership from offshore wind development companies, NGOs, and state and federal government. Specific tasks of the E-TWG include developing wildlife best management practices, identifying research needs and coordination opportunities, and creation of a framework for an environmental conservation fund.

Every other year, the E-TWG hosts Offshore Wind & Wildlife "State of the Science" workshops, which are open to researchers and stakeholders from throughout the region (as well as nationally and internationally). These workshops offer an opportunity for researchers to present and discuss updates on the state of knowledge regarding wildlife and offshore wind energy development; they are also designed to promote collaboration and regional coordination.

Specialist Committees address issues that the E-TWG has designated as priorities. These committees may include both E-TWG and non-E-TWG members with relevant expertise. Current specialist committees include:

- The **Regional Synthesis Workgroup**[18], which was organized to inform and provide interim guidance for regional-scale research and monitoring of offshore wind energy and wildlife in the eastern United States. As part of the work of this group, a database of research needs and data gaps were compiled from existing sources (e.g., State of the Science Workgroups, federal and state agency efforts, previous E-TWG Specialist Committees, etc.). The database was designed to synthesize existing data gaps and research needs so that researchers and funders could easily access, sort, and further prioritize topics. The database specifies focal taxa, spatial scale, and other information relating to each priority research topic. The Workgroup also drafted written guidance, including definitions of common terminology to support regional communications, general suggested criteria for prioritization of regional research topics, and general recommendations on study design and data transparency for regional-scale research efforts.
- The **Avian Displacement Guidance Committee**[19] was organized to develop guidance for pre- and post-construction monitoring to detect macro-to meso-scale changes in avian distributions and habitat use in relation to offshore wind development.
  The goals of this Workgroup include identifying key displacement and attraction-related questions, highlighting appropriate methodologies to address those questions, and providing specific study design and analytical recommendations for boat-based and aerial surveys.

The E-TWG also hosts a library of public webinars (https://www.nyetwg.com/webinar-library) about environmental issues and offshore wind. The library allows for basic searches, and is updated roughly twice a year. An Annual Bulletin is also produced by the group, highlighting E-TWG, fisheries-related, and New York/regional environmental offshore wind initiatives.

E-TWG activities are funded by the New York State Energy Research and Development Authority (NYSERDA), with technical support provided by the Biodiversity Research Institute (BRI).

[17] https://www.nyetwg.com/
[18] https://www.nyetwg.com/regional-synthesis-workgroup
[19] https://www.nyetwg.com/avian-displacement-guidance

Tethys

The Tethys Knowledge Base[20] is a literature database hosted by PNNL (Pacific Northwest National Laboratory) which compiles and provides access to documents and information about the environmental effects of wind and marine renewable energy. The database is easily searchable and can be filtered via a number of fields. It is updated regularly.

6.1.2 Project-specific Coordination Efforts

Compensatory Mitigation Planning

The Atlantic Marine Bird Cooperative is an international group of resource managers, scientists, and other professionals with a specific focus and expertise in marine birds. Members include agency staff, non-governmental organizations, industry, and universities. The Marine Spatial Planning Working Group[21] within the AMBC identified a need for advance planning regarding compensatory mitigation. Specifically, the group realized that the scale and pace of deployment of offshore wind may not allow for a thorough understanding of potential negative impacts to birds prior to widespread offshore wind deployment, and that once turbines are in the water, they are unlikely to be removed. Where on-site mitigation is not sufficient, effective compensatory mitigation measures must be identified and validated. The AMBC MSP has taken several steps to move this process forward. A presentation and dialogue were held at the most recent (2022) Offshore Wind & Wildlife "State of the Science" Workshop regarding needs for compensatory mitigation. Most recently, the Working Group is developing a letter to the USFWS and BOEM, detailing recommendations to initiate compensatory mitigation planning.

Coordination with Manufacturers

One project providing important coordination in the wildlife/offshore wind arena is an effort to review types of wildlife monitoring equipment used to study birds and marine mammals offshore, and to coordinate with turbine manufacturers to ensure the compatibility of wildlife monitoring/mitigation technologies with turbine platforms and infrastructure. This effort is being conducted by BRI and Advisian through funding from the National Offshore Wind R & D Consortium. Outcomes from this work are anticipated in summer of 2023. These products will inform next steps for bird monitoring; however, it is anticipated that follow-up work will be needed.

Coordination and Centralization of Motus Field Research

In summer 2022, USFWS organized initial meetings among stakeholders to discuss the value of coordinating and possibly centralizing calibration of Motus stations, as well as deployment of both Motus stations and VHF radiotags for automated telemetry in the offshore environment. This effort, and recommended science actions, are described in more detail in Section 6.8 (Field Research).

[20] https://tethys.pnnl.gov/knowledge-base-all

[21] https://atlanticmarinebirds.org/working-groups/

6.1.3 Recommended Science Actions

Recommended science actions in this category include:

- ***Continue regularly scheduled coordination, planning, and information sharing efforts** of RWSC, the E-TWG, and Tethys.*
- ***Initiate development of a compensatory mitigation framework** to address potential impacts of offshore wind facilities on birds, as outlined in the AMBC MSP's letter to BOEM and USFWS.*
- ***Coordinate and possibly centralize calibration and deployment of Motus infrastructure and tagging efforts** (see Section 6.8).*
- ***Cross-Taxa: Collaborate to develop and share strategies to bring data to shore from offshore monitoring sites.***
  - *Hold discussions with offshore developers regarding how to securely transfer wildlife monitoring data to researchers via the same cables that carry wind facility operational data, without compromising proprietary information.*
  - *Develop relationships and lines of communication with turbine manufacturers to understand how to integrate with wind turbine platforms and cable infrastructure.*
  - *Convene a workshop to share strategies to bring data to shore from offshore sites.*
  - *Disseminate findings from the workshop in guidance document format.*
  - *Create a platform to allow for continued discussion/development of new or improved methods to bring data to shore from offshore monitoring sites.*
- ***Cross-Taxa: Coordinate with turbine manufacturers to ensure compatibility of bird monitoring/mitigation technologies with turbine platform infrastructure.***
  - *Review published outcomes from the BRI/Advisian project (see above).*
  - *Convene a cross-taxa working group to discuss findings as relevant to included (birds, marine mammals) and excluded taxa (bats, sea turtles).*
  - *Develop recommendations and design specifications for a generic platform that could support current and anticipated future wildlife monitoring equipment needs.*
  - *Develop relationships and lines of communication with turbine manufacturers to ensure compatibility of wildlife monitoring equipment.*
- ***Cross-Taxa:*** *Convene a working group to address implementation of the* NOAA Fisheries and BOEM Federal Survey Mitigation Strategy *and associated activities in order to ensure that regular wildlife and fisheries surveys carried out by NOAA, other federal agencies, and other organizations are able to continue in the context of offshore wind development.*

6.2 Standardizing Data Collection, Analysis, and Reporting

6.2.1 Introduction

This section addresses data collection, processing, and housing for the types of data collected as part of studies to inform potential impacts of offshore wind development on bat species in the Northwest Atlantic.

Benefits of Standardization

Standardizing data workflows provides value to all stakeholders working in the field of offshore wind and wildlife, promotes species conservation, and supports the informed deployment and operation of offshore wind energy facilities. Some of the specific benefits and goals of data standardization include:

- **Ensuring a standard product for funders of research**

- **Reducing the time investment for funders of research**, who can refer to standard practices rather than spending valuable time detailing a scope of work, or updating study requirements as science and research technologies advance
- **Reducing the time investment for data collectors**, who can refer to standard practices rather than developing new protocols, and avoid collecting unnecessary or incompatible data
- **Improving data consistency**
- **Improving data accessibility** through making data available and searchable in publicly available databases and data repositories as soon as possible after data collection.
- **Leading to better science and management decision-making** due to improved data consistency and prompt accessibility, streamlining reviews and analyses
- **Reducing duplicative research**, since all stakeholders have broad access to the range of studies conducted

Structure of this Section

Appropriate data collection tools, protocols, databases, and repositories are available for many types of wildlife data. General guiding principles and best practices for data standardization are described in Section 6.2.2. Specific recommended databases, where available, are detailed in Subsection 6.2.3. These best practices are applicable both to wildlife data and associated study data necessary for analysis and interpretation, such as, for example, meteorological covariates, effort data, or the specifics of methodology, equipment, and technology used.

Importantly, there are some types of studies or data for which detailed guidance on best practices or infrastructure for housing data are not available. Where further guidance is needed in the context of existing databases, recommended actions are noted throughout Section 6.2.3. Subsection 6.2.4 addresses gaps in database infrastructure. These sections of the Science Plan identify next steps which can be taken to improve on currently available options as well as next steps that may require dedicated funding as part of a larger effort to develop necessary data collection tools, protocols, and databases.

Acknowledgements

In addition to the hard work of RWSC Bird and Bat Subcommittee members and other meeting participants, this section of the Science Plan relies heavily on the 2021 report ***Wildlife Data Sharing and Standardization***; partner initiatives, including a USFWS-led effort to develop offshore Motus deployment guidance; and other collaborating institutions and researchers. This section also benefits enormously from the work of many database managers and funders, who have contributed thought, time, effort, and funds towards database design, data entry, and making available standard protocols, how-to guides, and data products.

6.2.2 General Best Practices

Identifying Appropriate Databases

Where standard databases have not been identified for disposition of data, the following criteria should be evaluated in identifying appropriate databases to store data. These criteria are also helpful to consider in the development of new databases. It is not expected that existing databases will meet all of these criteria, but these can also be considered as aspirational goals for wildlife monitoring databases.

- Publicly available databases, ideally with a long-term or steady source of funding
- Robust relational databases, so data are easily searchable
- Databases are compatible with freely available platforms or data sheets for data collection

- Databases provide a specific data entry protocol or tag for data collected according to specific offshore wind protocols
- Databases included a straightforward public interface for both those looking to upload data and/or download data for analysis
- Outside meteorological data/covariates can be easily incorporated, where relevant
- Databases can accommodate relevant associated data (e.g., effort, local meteorological data) as well as wildlife data
- Databases are regularly updated so managers/researchers can analyze all current and applicable data
- Database managers conduct effective Quality Assurance/Quality Control practices as part of routine data maintenance
- Basic data products/visualizations are provided, so that those without an in-depth statistical background can understand basic outcomes of summarized data

Best Practices for Data Management

In general, the following best practices for data management are recommended, where specific workflows are not specified:

- Use standardized protocols, where available
- Keep data entry as close as possible to data collection efforts and the data collector to reduce possibility of error
- Limit and define fields to encourage consistent collection of data
- Make data available publicly to the greatest extent possible and on the shortest appropriate timeline.
- Make detailed data available to federal regulators at the finest resolution possible, including survey protocols, effort data, and all covariates and other metadata collected.
- If research studies include any wildlife-related data deemed "confidential" or "proprietary", but relevant to science and management decisions, these data should be housed so as to provide maximum opportunity for analysis and interpretation; such practices can include, for example, consistent data sharing agreements, with standard protocols for dispersal to researchers via non-disclosure agreements or data aggregation, making aggregated products and analyses publicly available, and rendering data non-confidential as soon as possible in any cases where it is no longer proprietary.

6.2.3 Recommended Databases

The following databases and guidelines should be used for storage of bird data collected in the offshore environment:

Data Types	**Database**	**Data Guidance**
Observational Survey (onshore)	eBird	**No specific guidance available*
Observational Survey (offshore)	Northwest Atlantic Seabird Catalog	-Utilize SeaScribe for data collection -Utilize forthcoming E-TWG Avian Displacement Guidance Committee guidelines for aerial and boat-based surveys
Tracking (automated radio telemetry)	Motus Wildlife Tracking System	-Follow Atlantic Offshore Wind Motus Group guidance for deployment and data collection

Tracking (except for automated radiotelemetry)	Movebank	-Follow interim USFWS guidance for all deployment and data collection (see Appendix A) **Development of more in-depth guidance is recommended as an action*

The following pages provide a brief summary of each database, particularly with regards to the aspirational criteria for databases noted in Section 6.2.2. Based on the extent to which these databases meet the various goals, additional science actions are recommended.

Database: eBird

For use with:

- **Data Type(s):** Observational survey data, onshore only

Database Basics:

- **Website:** https://ebird.org/home
- **Ownership/Funding Status:** eBird is a project of the Cornell Lab of Ornithology; it is currently supported by grants, sponsors, and donations.
- **Database Updates:** The eBird Basic Dataset is updated monthly on the 15th of each month.
- **QA/QC Procedures:** All eBird observations are run through automated filters which flag unusual species or numbers of birds. Volunteer reviewers then work with observers to determine the authenticity of and verify or remove flagged records.

Data Collection & Data Entry:

Public Interface to Upload Data: Yes, including eBird mobile app **.**

Standard Protocols, Data Collection Platform, and/or Data Entry Forms: The eBird mobile app provides a standard format for collecting data; however, the information collected through this platform is limited. Additional data fields would be required to fully standardize data collection and interpret results, including details regarding bird locations, survey conditions (e.g., meteorological data), and survey effort, for most types of onshore surveys.

Data Permissions: eBird data are by default public; however, users have the option to make certain checklists "not public."

Entry Options for Survey Conditions (e.g., Meteorological Data): Not available, (only in comments section, not quantifiable).

Entry Options for Effort Data: Limited effort data is collected; (it is not sufficient to fully interpret some survey types).

Data Use & Interpretation:

Public Access to Data: Yes. Public access to most eBird data is automatic. eBird checklists are public by default; eBird users have the ability to "hide" checklists, although this practice is not encouraged. For sensitive (at-risk species), data is automatically restricted to reduce the risk of capture, targeted killing, or significant targeted disturbance by humans.

Public Interface to Download Data: The eBird basic dataset is the core dataset for accessing all raw eBird observations and associated metadata. This data is available for direct download through eBird to any logged-in user after completing a data request form. Requests are typically approved within seven days.

Search Functions: Subsets of the eBird basic dataset can be filtered or searched in Excel or similar spreadsheet applications; R packages are available to aid in searching and summarizing larger datasets.

Outside Meteorological Data Incorporated: Staff are exploring the possibility; this option is not currently publicly available.

Data Products/Visualizations: eBird Status and Trends Data Products include estimates of species ranges, abundances, and environmental associations; associated maps and charts are also available online.

Recommended Science Actions:

[Note that because eBird is only recommended for use in the terrestrial environment, these recommended steps are not of high priority for offshore bird research.]

- *Develop detailed protocols for different types of onshore avian observational surveys associated with transmission ROW clearing and cable permitting processes.*
- *Update eBird mobile app to allow for more detailed recording and retention of quantifiable survey conditions and survey effort in eBird.*
- *Update eBird platform to support incorporation of outside meteorological data into downloadable data or data products.*

Database: *Northwest Atlantic Seabird Catalog*

For use with:

- **Data Type(s):** Observational survey data, offshore only

Database Basics:

- **Website:** n/a
- **Ownership/Funding Status:** The Catalog has no formal long-term funding, but has received regular funding by BOEM. The National Centers for Coastal Ocean Science (NCCOS) is currently contracted to oversee and maintain the Catalog.
- **Database Updates:** The Catalog is updated by an NCCOS contractor as new data is submitted.
- **QA/QC Procedures:** An NCCOS contractor provides automated and manual review of newly submitted data.

Data Collection & Data Entry:

Public Interface to Upload Data: No, via e-mail only.

Standard Protocols, Data Collection Platform, and/or Data Entry Forms: Recommended protocols for at-sea aerial and boat-based surveys are currently being developed by the E-TWG Avian Displacement Guidance Committee. SeaScribe is an appropriate data entry platform.

Data Permissions: Data submissions to the Catalog are included in analyses and may be made available to other researchers by request to the NCCOs contractor.

Entry Options for Survey Conditions (e.g., Meteorological Data): Yes, available. Several survey condition categories could be updated to provide a more consistent, quantifiable metric across observers.

Entry Options for Effort Data: Yes, available.

Data Use & Interpretation:

Public Access to Data: Yes, by request to NCCOS contractor.

Public Interface to Download Data: None

Search Functions: The Catalog is a relational database and searchable using spreadsheet or R tools.

Outside Meteorological Data Incorporated: These are not incorporated into the Catalog but are utilized as part of analyses performed using data from the Catalog.

Data Products/Visualizations: Derived spatial distributions of marine birds are made available through NCCOS as GIS data files or printable maps.

Recommended Science Actions:

- *Review and adopt E-TWG Avian Displacement Committee protocols for aerial and boat-based surveys.*
- *Review definitions in SeaScribe to ensure consistency across observers.*
- *Develop recommendations for a public interface to upload/download data.*
- *Encourage the provision of stable, long-term funding for the Catalog, as well as funding for regular updated analyses of data into derived spatial distributions.*

Database: Motus Wildlife Tracking

For use with:

- **Data Type(s):** Automated telemetry data

Database Basics:

- **Website:** https://motus.org/
- **Ownership/Funding Status:** Motus is a project of Bird Studies Canada; the database is funded through user fees and grants, contributions, contracts,and unrestricted sources available to Bird Studies Canada.
- **Database Updates:** The database is updated regularly as data are received.
- **QA/QC Procedures:** Full entry of basic metadata is required in order to access data results, encouraging prompt entry of these data. Automated QA/QC procedures are in place and run regularly to promote accurate detection data.

Data Collection and Data Entry:

Public Interface to Upload Data: Yes, collaborators can register to set up a project and submit data.

Standard Protocols, Data Collection Platform, and/or Data Entry Forms: Standard data entry forms, protocols, and methodologies for the deployment of Motus telemetry stations offshore are now available through the Motus website at this link: https://motus.org/groups/atlantic-offshore-wind/. These protocols should be followed during station and tag deployment. Basic Motus tag deployment metadata must be supplied to the Motus database (e.g., species, date of deployment).

Data Permissions and Access: *Summary Data* available through Motus consists of basic information about a project, limited deployment metadata for tags and stations, as well as daily summaries of tag detections and track maps. Summary Data for all projects can be viewed by anyone visiting Motus.org and can be downloaded in csv format by anyone with a Motus account. Summary data may also be presented on other collaborating platforms and products. *Complete Data* consists of detailed tag detection data including properties such as signal strength, direction from the station, precise date and time stamps, and expanded tag metadata fields. Complete Data is only available through the Motus R Package, but by default is open to all registered Motus collaborators. Access can be restricted at any time to only members of a particular project, which will remain in effect for 5 years after tag deployment, after which time Complete Data will become open to all Motus collaborators (unless otherwise exempt; request to reduce temporal or spatial resolution can be made). If access is restricted to project members, federal regulators should be added as project members so that they can view detailed project results.

Entry Options for Survey Conditions (e.g., Meteorological Data): Not available. Meteorological conditions during detections (and non-detections) are more relevant than conditions at time of capture/tag deployment. There is not currently a function available to link local meteorological data with specific Motus receiver stations or detections within the Motus database, but this could relatively easily be done in R.

Entry Options for Effort Data: "Effort" measured as telemetry station locations, numbers, and status (functioning, # of antennae, antenna bearings) are more relevant than effort to deploy tags. Some work is being done to make this information more accessible through the Motus site. The number of tags deployed on a specific species is available for all public data.

Data Use and Interpretation:

Public Access to Data: Yes. Public access to all Summary Data is available via the website. Complete Data are available by default to all registered Motus users, but if blocked, become accessible after 5 years.

Public Interface to Download Data: Yes. Public access to all data not restricted is available for download by Motus users.

Search Functions: R packages are available to aid in searching and summarizing larger datasets.

Outside Meteorological Data Incorporated: Outside meteorological data is not automatically incorporated. However, R code is available through the Motus R package to facilitate linkages to meteorological data collected by third parties.

Data Products/Visualizations: Estimated movement tracks by species, project, or dates are publicly available.

Recommended Science Actions:

Recommended Science Actions:

- *Incorporate Atlantic Offshore Wind Motus Group guidance into a complete* Recommended Data Practices *guide for offshore bird research.*
- *Develop guidance regarding deployment, metadata, and data storage of local meteorological data associated with telemetry receiver stations (whether from turbine weather stations or stand-alone meteorological stations) to inform timing of bird movements and behavior relative to weather conditions.*

Database: Movebank

For use with:

- **Data Type(s):** Tracking data, except automated telemetry data (e.g., geolocators, GPS dataloggers, satellite tags)

Database Basics:

- **Website:** https://www.movebank.org
- **Ownership/Funding Status:** Movebank has stable, long-term funding through the Max Planck Society and the University of Konstanz.
- **Database Updates:** The database is updated regularly as data are added.
- **QA/QC Procedures:** There are no QA/QC procedures. Users are responsible for vetting their own data prior to entry.

Data Collection & Data Entry:

Public Interface to Upload Data: Yes, collaborators can register to set up a project and submit data.

Standard Protocols, Data Collection Platform, and/or Data Entry Forms: Federal agencies have been working internally to develop guidance regarding basic data fields to include during deployment of satellite tags, but no public guidance is available.

Data Permissions: Data permissions in Movebank affect the visibility of the project study summary, visibility of tagged animals on the tracking data map, and data downloads. All offshore wind studies of bird movements should be included as "Research Studies" so that project summaries are visible in Movebank. Movement tracks should also be made visible to the public in the Tracking Data Map. Exact location coordinates and timestamps cannot be extracted from the map. Data downloads should be allowed, at minimum, for collaborators, who should include federal regulators. Allowing data download by the public for noncommercial use is encouraged. A rolling embargo (blocking access to the most recent data) or a static embargo (blocking access for a period of months) can also be imposed.

Entry Options for Survey Conditions (e.g., Meteorological Data): This option is not explicitly included, but this data could be added as a supplementary file. This may not be relevant to data interpretation.

Entry Options for Effort Data: Not explicitly, but this data could be added as a supplementary file. May not be relevant to data interpretation.

Data Use & Interpretation:

Public Access to Data: Yes. Public access to all data labeled public is available via the website.

Public Interface to Download Data: Yes. Data download may be restricted by the data uploader, but can be downloaded for further analysis if allowable.

Search Functions: Available data can be searched by permissions level, species, and tag type.

Outside Meteorological Data Incorporated: Yes, via ENV-Data, a variety of regional environmental data and metrics can be incorporated.

Data Products/Visualizations: Estimated movement tracks by species, project, or dates for all public data.

Recommended Science Action:

- *Review USFWS guidance regarding metadata standards (Appendix A) and take-aways from the Avian Tracking Workshop[22], expand upon these materials as needed, and publish guidance on data standards for deployment of satellite, GPS datalogger, and geolocator tags on birds offshore.*

Regional Data Portals

In addition to the data type-specific databases described above, three regional data portals, the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS), Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS), and Southeast Coastal Ocean Observing Regional Association (SECOORA) collate and allow for simple mapping of multiple data products. Transfer processes from the databases described above and new databases (described above) to the regional data portals should be streamlined for both new and existing databases.

Recommended Science Action:

[22] https://www.boem.gov/sites/default/files/documents//BOEM_Avian_Tracking_Workshop_2023_001.pdf

- *Ensure processes are in place to facilitate transfer of data products from wildlife databases to appropriate regional data portals.*

6.2.4 Gaps in Database Infrastructure

There are a number of identified gaps in infrastructure to support standard data collection and workflows. The major gaps identified for birds are as follows:

Raw File Data Repository

In addition to databases, there is a need for a data repository to store raw data with large file types – e.g., radar data, thermal video, digital aerial survey photos and videos, and acoustic files. Derived data from these types of files should be made available in relational databases as relevant; however, the raw data should also be retained in a central location for quality control, re-analysis, and future re-evaluations with better tools. For example, future machine learning advances may allow for faster and more effective automated identification of bird species.

Recommended Science Action

- ***Cross-taxa*** *-Develop a data repository for raw data with large file types, including identifying significant and stable funding to retain these files. This is of value for multiple taxa.*

Tissue Sample Repository

There is an identified need for a tissue repository to store tissue samples, including carcasses of birds recovered from offshore wind facilities. These remnants are much less likely to be found at offshore facilities than at terrestrial facilities, since carcasses are most likely to fall into the ocean and not be recoverable and regular carcass searches are not likely to be proscribed. However, carcasses of birds may occasionally be recovered on offshore turbine platforms incidentally. In addition, tissue samples may be collected from both birds in offshore or coastal areas for various research purposes, including genetic, physiological, stable isotope, or disease dynamics studies. If not destructively sampled for analysis as part of the initial study, these samples could be stored for later use and to benefit future analyses.

At present, there is no defined repository for the many bat and bird carcasses recovered at terrestrial wind facilities, whether collected incidentally or as part of regular fatality monitoring. In addition, there is no centralized site for the storage of tissue samples, such as bones, feathers, or wing punches. Todd Katzner (USGS) has established a successful system for collecting and tracking bird samples from wind facilities, including sample storage and an Access database. However, this small-scale repository could easily be overwhelmed if all bird carcasses and tissue samples currently stored by state agencies, federal agencies, wind developers, and environmental consultants were to suddenly begun to be shipped to these locations.

USGS researchers, working with colleagues, have mapped out a hierarchical structure for a database which could allow for the tracking of carcasses and tissue subsamples throughout the country. There has also been discussion of logistical needs – for example, the establishment of regional collection centers to reduce transportation/shipping challenges for frozen samples.

Recommended Science Action

- ***Cross-taxa: Finalize, fund, and implement a USGS tissue sample repository plan*** *to 1) purchase tissue storage infrastructure, 2) identify regional storage locations, and 3) establish and maintain a database of tissue samples. [This is a lower priority for offshore than for* *onshore, where the need is greatest. It could be jointly funded, but terrestrial specimens will make up bulk of samples collected.]*

Bird Acoustic Database

Acoustic monitoring of birds is typically conducted for nocturnal migrants. It can be valuable in the offshore environment, where we have little information about smaller bird species, particularly those moving at night. This methodology is of interest as a cost-efficient strategy to assess bird activities offshore (Robinson Willmott & Forcey 2014[23]), and it is included as a part of some Bird Monitoring Plans, but there is currently no centralized database to house such data.

Recommended Science Actions

- *Identify an existing entity that could build upon its current data infrastructure to house bird acoustic data collected offshore (e.g., Cornell Lab of Ornithology or Avian Knowledge Network).*
- *Develop best practices for deployment of bird acoustics, based on current knowledge.*

Colony & Shorebird Database

Year to year monitoring of colonial seabirds and shorebirds occurring along the Atlantic Coast is relevant to offshore wind development for a number of reasons. These types of data provide important metrics, including year-to-year survivorship for birds loyal to a colony, fecundity, and population health. These data are useful in evaluating how offshore wind may be affecting populations. For example, lower juvenile survival could be associated with reduced foraging near wind facilities. These data are also needed to understand other longer-term trends or factors affecting populations, which may have nothing to do with wind development, but can help isolate the impacts of offshore wind through comparing regional to local data and recent to historic trends.

Historically, many states individually compiled colony data and stored it locally. Occasional (roughly decadal) surveys of colonial seabirds and long-legged wading birds have also been coordinated and conducted by multiple states simultaneously. However, there was no central repository. Some states' data were eventually collated into a database managed by USGS Patuxent. This database was updated by collaborators from USGS, USFWS, and UMaine, who inventoried the data and created an ArcGIS Shiny App as an inventory for exploring what data was in database (an inventory). The Maine Seabird Atlas and other colony data were also incorporated into the database at that time. The database is now held by the Avian Knowledge Network, but QA/QC has been challenging, and the data are not ready for analysis. These are old data, not always complete, and not necessarily collected in a consistent fashion.

Recommended Science Actions

- *Identify an existing entity that is willing to collect and house colony and shorebird data long-term (e.g., Avian Knowledge Network or the Atlantic Seabirds organization) and determine a stable source of funding.*
- *Develop recommendations on a structure for the database moving forward, as well as consistent guidance on data to include in future colony and shorebird surveys. An example of a*

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[23] https://espis.boem.gov/final%20reports/5349.pdf

similar format/database is available from the Southeast (https://www.atlanticseabirds.org/atlas).

Seabird Diet Database

Seabird diet data also provide important information associated with adult and fledgling survival, health, and forage fish availability. One potential impact of offshore wind could be to change foraging patterns as well as forage fish abundance, distribution, and species composition – potentially having important ramifications for feeding marine birds and shorebirds. With this in mind, collecting these types of data in a centralized location is also important for an understanding of impacts.

Recommended Science Actions

- *Request that the entity identified to collect colony and shorebird data also collect seabird diet data.*
- *Develop recommendations on a structure for a database to collect data from seabird diet studies.*

Radar Data Results

There is currently no central location or format for collecting radar data results. As discussed in Section 4, radar can provide information about bird passage rates and flight heights.

Recommended Science Actions

- *Identify goals for radar and LiDAR studies offshore, develop protocols for offshore radar studies, identify necessary data fields, and suggest a structure for a database.*
- *Determine anticipated needs (data storage costs, database complexity) for a radar results database, and identify appropriate entities to approach regarding housing of the data.*

Collision Fatality Database

As discussed in Section 4, some incidental collision fatalities may be identified during visits to offshore turbine platforms. However, currently, there is no standard, cost-effective way to rigorously monitor for collisions offshore. Thermal and infrared cameras can detect collisions (e.g., see Happ et al. 2021[24]), but they are expensive to deploy widely, unable to detect collisions during periods of low visibility, and not necessarily reliable in harsh conditions occurring offshore. Efforts are currently underway at terrestrial wind facilities to develop and improve collision monitoring technologies for birds at these sites. Once these systems have been shown to be effective in onshore environments (where it is easier to access and maintain these systems, as well as validate reliability, as by comparing results to carcass searches), it is anticipated that these technologies can be further tested in and adapted for the offshore environment.

There is some sensitivity regarding reporting of fatality and collision information, because reporting and results are related to regulatory requirements under federal law, because collision/fatality reporting may result in negative publicity, and because important covariates to use in analysis include wind speed and the operational status of the turbine. Some wind companies

[24] https://doi.org/10.3390/jimaging7120272

consider these last items to be proprietary, although once facilities are fully operational, some developers report that wind speed and turbine status need not be kept confidential.

Where fatalities are only documented in an incidental fashion, fatality data may be of limited value, but are nevertheless important, given our limited scientific understanding of potential offshore impacts. In the future, as technologies allow for collection of these data in a more scientific and rigorous fashion, collision fatality data will be critical for evaluating impacts of offshore wind and (if needed) identifying effective mitigation strategies. The need for a designated database and availability of detailed data for scientific analysis will hence become crucial.

At onshore facilities, hesitancy to reveal post-construction fatality monitoring results has been addressed, in part, through the American Wind Wildlife Information Center (AWWIC), a database of post-construction fatality monitoring, conceived of and managed by the Renewable Energy Wildlife Institute (REWI). Database managers work with wind industry collaborators to compile both publicly available and privately contributed fatality data, including important covariates (e.g., effort, methodology, meteorological conditions), and to allow for the analysis of this data by REWI staff, as well as other researchers, through careful limitations on data sharing and requirements for sharing aggregated data so that no data from private sources could lead to identification of individual wind facilities.

The AWWIC database could serve as a model for a fatality/collision database for offshore wind, with important caveats. The existing database includes tailored non-disclosure agreements (NDAs) negotiated with each wind facility operator individually, and new data analyses and studies must often be negotiated with data contributors. An offshore collision fatality database for bats should include standard protocols for how data is collected, entered, and reported to the database, including which covariates are necessary for interpretation. There must be no barrier for federal regulators in accessing the data. The database should also include standard data sharing agreements detailing how the data could and could not be used and how results would be shared publicly. This could allow for simplified sharing of data with outside researchers for analysis and synthesis, while addressing developer concerns regarding confidentiality and any needs for data aggregation.

This database could also potentially house data collected from turbine-mounted cameras, which might also include potentially sensitive information about turbine operational status and bird interactions with turbines, including collisions.

Recommended Science Action

- *Suggest a structure for a collision fatality database and develop a draft generic NDA. Identify entities that could potentially house this database and determine required funding.*

6.2.5 Recommended Science Actions Summary

Recommended science actions are scattered throughout Section 6.2, so that they can be discussed in context. For the sake of easy reference, they are also collected in summary form here.

- ***Use recommended databases and protocols as detailed in Section 6.2.3 for all bird studies conducted along the U.S. Atlantic Coast.***
- ***Convene a* Bird Data Standards Working Group *to review, modify (as needed), and adopt existing data guidelines, suggest structures for new or inchoate databases, and publish comprehensive Data Standards Guidance for offshore bird research.*** *Specific activities of the working group could include:*

- *Review and adopt E-TWG Avian Displacement Committee protocols for aerial and boat-based surveys.*
- *Review definitions in SeaScribe to ensure consistency across observers.*
- *Develop recommendations for a public interface to upload/download data to the Northwest Atlantic Seabird Catalog.*
- *Incorporate Atlantic Offshore Wind Motus Group guidance into a complete Data Standards Guidance for offshore bird research.*
- *Develop guidance regarding deployment, metadata, and data storage of local meteorological data associated with telemetry receiver stations (whether from turbine weather stations or stand-alone meteorological stations) to inform timing of bird movements and behavior relative to weather conditions.*
- *Review USFWS guidance regarding metadata standards (Appendix A) and take-aways from the 2021 Avian Tracking Workshop, expand upon these materials as needed, and publish guidance on data standards for deployment of satellite, GPS datalogger, and geolocator tags on birds offshore.*
- *Identify an existing entity that could build upon its current data infrastructure to house bird acoustic data collected offshore (e.g., Cornell Lab of Ornithology or Avian Knowledge Network).*
- *Develop best practices for deployment of bird acoustics, based on current knowledge.*
- *Identify an existing entity that is willing to collect and house colony and shorebird data long-term (e.g., Avian Knowledge Network or the Atlantic Seabirds organization) and determine a stable source of funding. Develop recommendations on a structure for the database moving forward, as well as consistent guidance on data to include in future colony and shorebird surveys.*
- *Request that the entity identified to collect colony and shorebird data also collect seabird diet data. Develop recommendations on a structure for a database to collect data from seabird diet studies.*
- *Develop detailed protocols for different types of onshore avian observational surveys associated with transmission ROW clearing and cable permitting processes.*
- *Update eBird mobile app to allow for more detailed recording and retention of quantifiable survey conditions and survey effort in eBird.*
- *Update eBird platform to support incorporation of outside meteorological data into downloadable data or data products.*

- ***Encourage the provision of stable, long-term funding for the Northwest Atlantic Seabird Catalog, as well as funding for regular updated analyses of data into derived spatial distributions.***
- ***Cross-taxa -Convene a Cross-Taxa Database Working Group** to address shared needs for data repositories. Tasks of this working group could include:*
    - *Develop a data repository for raw data with large file types, including identifying significant and stable funding to retain these files. This is of value for multiple taxa.*
    - *Finalize, fund, and implement a USGS tissue sample repository plan to 1) purchase tissue storage infrastructure, 2) identify regional storage locations, and 3) establish and maintain a database of tissue samples. [This is a lower priority for offshore than for onshore, where the need is greatest. It could be jointly funded, but terrestrial specimens will make up bulk of samples collected.]*
    - *Identify goals for radar and LiDAR studies offshore, develop protocols for offshore radar studies, identify necessary data fields, and suggest a structure for a database.*
    - *Determine anticipated needs (data storage costs, database complexity) for a radar results database, and identify appropriate entities to approach regarding housing of the data.*

- *Ensure processes are in place to facilitate transfer of data products from wildlife databases to appropriate regional data portals.*
- *Suggest a structure for a collision fatality database and develop a draft generic NDA. Identify entities that could potentially house this database and determine required funding.*

6.3 Historical data collection/compilation

In addition to encouraging newly collected field data to be added to a standard repository, it is highly advantageous to ensure historical data are also saved in the same location. Storing these data in the same database or data repository can ensure they are easily accessible to researchers conducting long-term studies or meta-analyses - or regulators or developers simply looking for information about species likely to occur in a particular subregion or site. Historic data are highly important for understanding long-term trends in species populations and can help to tease out causes of change over time relative to offshore wind energy development, other anthropogenic impacts (e.g., climate change, fisheries management), and natural interannual variation. Through modeling, these data can also help predict future species distributions or occurrences.

One challenge with organizing and storing historical data is that these data may not always be collected in a consistent manner – from year to year, site to site, organization to organization - or consistent with current practices and technologies. It is important that any differences in data collection methodology are captured in data repositories and included (to the greatest extent possible, through estimates of uncertainty, etc.) in any analyses that incorporate these data. It is also important to recognize that efforts to store and organize historical data may require additional time and effort to ensure data are stored using standard values and terminology consistent with present practices. In addition to storing raw historical data, some studies may warrant providing "corrected" data or correction factors based on updated analysis methods to allow for comparison with current data.

This section describes current and recommended historical data compilation efforts using the same organizational scheme of data categories and databases discussed previously in Section 6.2. Please see that section for a more detailed discussion of any databases referred to in this section.

6.3.1 Current and Recent Efforts

Observational Offshore Surveys for Birds (Northwest Atlantic Seabird Catalog)

Historical offshore survey data in the Northwest Atlantic was compiled as part of the establishment of the Northwest Atlantic Seabird Catalog, completed in 2018. This effort represented a collaboration of BOEM, NOAA, and NCCOS, with many researchers and organizations contributing data. This enormous effort included development of the catalog in a format that allowed for flexibility to include and categorize different historic survey methodologies and practices. The catalog is open to collecting new or historical data sources as they become available, but a concerted effort to collect additional historical data in this category is no longer necessary at this time.

Recommended Science Actions

- *Due to recent data compilation efforts, the Subcommittee did not identify a need to compile additional historical data in the Northwest Atlantic Seabird Catalog. However, as currently planned, the Catalog should continue to ingest new data.*

Tracking via Automated Telemetry (Motus)

Automated telemetry data collected via the Motus Wildlife Tracking Network is automatically stored in the Motus system. Hence, historical data for birds are naturally stored alongside data collected from current and recent projects. Birds Canada staff have also made efforts in recent years to solicit tag metadata associated with tag deployment from past projects where not previously recorded in the Motus system.

Recommended Science Actions

- ***Improve access to historical offshore bird Motus data*** *through a systematic effort to 1) identify past projects with the potential to provide information related to offshore bird movements, 2) reach out to researchers to request that a new "offshore" tag be applied to these projects, and 3) request of these same researchers that access permissions be set to allow public access to these data, if not available already.*

Tracking via other Tagging Systems (Movebank)

Use of geolocators, satellite tags, and VHF tags on birds in coastal and offshore environments is a common historic practice. While some efforts have been made to organize tracking data in a central location, these efforts are by no means exhaustive.

Recommended Science Actions

- ***Systematically solicit and compile historical tracking data for seabirds, shorebirds, waterfowl, migratory passerines and raptors in coastal and offshore environments into Movebank.***
    - *Notably, these should include data from the Seaduck Joint Venture, but the call for data needs to be distributed widely.*
    - *These data should be entered into Movebank using best practices consistent with those identified by a working group, as described in Section 6.2.3.*

Breeding Colony Data

Data related to breeding colonies of shorebirds and seabirds are relevant to offshore wind development in several ways. First, these data can provide important information about what species occur in the vicinity of proposed wind facilities and which colonies could be vulnerable to adjacent development. Second, colony data can provide important metrics of colony health, which may be relevant to wind energy impacts, including colony size, demographics, survival, fecundity, nest success, days to fledging, etc. As noted above, historical data can help to tease out changes over time due to wind energy development as compared to other anthropogenic or natural causes, and to recognize unusual changes.

Colony data have historically been collected and stored by many state agencies and other organizations in a relatively disparate and varied manner. For some time, the USGS office in Patuxent established and maintained a database of colony information. When this office was unable to continue maintaining the database, the existing database was transferred to collaborators based in Maine (Cindy Lofton, USGS, Zack Loman, UMaine, and USFWS). These scientists inventoried the data and created an ArcGIS Shiny App for exploring what data was in database (an inventory). Colony data from the Maine Seabird Atlas and some additional colony data were also incorporated. This database is now held by the Avian Knowledge Network and the data are electronically preserved. However, the database is not easily accessible for general use.

Recommended Science Actions

- ***Review existing colony data held by the Avian Knowledge Database****, carry out quality assurance/quality control procedures to the extent possible, and develop standard methods to note inconsistencies or other problems in the data where not correctable.*
- ***Solicit additional colony data*** *stored by individual states and organizations, with outreach efforts through existing organizations and working groups to encourage data contributions.*

Wading Bird Survey Data

Wading bird surveys have also been conducted by multiple states. Similar to colony data, these surveys can provide important information about population demographics and survival, which can provide indirect information about population health and impacts of offshore wind development. As with colony data, these survey data are not necessarily collected in a consistent manner from state to state or stored in a central location.

Recommended Science Actions

- ***Conduct a similar solicitation and QA/QC process to colony data*** *for wading bird survey data.*

Seabird Diet Data

Seabird diet data is valuable for understanding how wind energy development may be indirectly affecting bird populations via displacement or changes in the distribution of forage fish. Seabird diet data (terns and alcids) collected by NAS and USFWS in Maine are all in an ACCESS database, but this has not been publicly shared and does not currently include data from other states or other projects (e.g., there is a regional project examining fecal DNA from common terns).

Collection of this historic data in a centralized database is a need that has been identified by other avian working groups; the data are relevant for many uses, and not an understanding of offshore wind impacts alone.

Recommended Science Actions

- ***Review NAS/USFWS seabird diet data****, carry out quality assurance/quality control procedures to the extent possible, and develop standard methods to note inconsistencies or other problems in the data where not correctable.*
- ***Solicit additional diet data stored by individual states and organizations****, with outreach efforts through existing organizations, working groups, and via literature review to encourage data contributions.*

6.3.2 Recommended Science Actions Summary

Recommended science actions are scattered throughout Section 6.3, so that they can be discussed in context. For the sake of easy reference, they are also collected in summary form here.

- ***Improve access to historical offshore bird Motus data*** *through a systematic effort to identify and gain access to past projects.*
- ***Systematically solicit and compile historical tracking data of coastal and offshore bird movements into Movebank.***

- ***Systematically solicit and compile historical colony data, wading bird survey data, and seabird diet data into a new database.*** *Include data current held by the Avian Knowledge Network as well as NAS/USFWS seabird diet data.*

6.4 Meta-analysis and literature review

Meta-analyses and literature reviews are, of course, of great importance for summarizing the current "state of the science," synthesizing common findings, and identifying data gaps. As noted previously, literature related to offshore wind and wildlife is tracked in the Tethys database, which can facilitate these types of analyses, whether qualitative or quantitative.

6.4.1 Current and Recent Efforts

Several analyses of this nature are currently ongoing or recently completed. These include:

Literature Review: Summary of Research Priorities. As noted in Section 6.1, the E-TWG Regional Synthesis Workgroup[25], with technical support from BRI, has compiled a summary database of research priorities related to wildlife and offshore wind development.

Data Gaps Analysis. Project WOW[26], a Wildlife and Offshore Wind study led by Duke University, with collaborators, is performing a data gaps analysis to understand where sufficient data exist to generate meaningful estimates of likely impacts, and where they do not. This analysis will be based on a quantitative scoring of literature, based on species names and taxa.

Review: Collision Risk for North Atlantic Seabirds. Normandeau prepared a report for BOEM on the vulnerability and sensitivity to collision risk for seabirds of the Atlantic OCS (Robinson Wilmott et al. 2013)[27]. Subsequent studies have been prepared by other groups. These studies have focused on other geographic areas and different suites of species, but the higher-level findings of these studies may also be relevant to offshore wind development in U.S. Atlantic waters.

Literature Review: Displacement, Avoidance, and Attraction. A separate E-TWG Working Group, the Avian Displacement Guidance Committee[28], is currently conducting a literature review of studies related to bird displacement, avoidance, and/or attraction to offshore wind facilities, with technical assistance provided by BRI. The review is including papers from Europe (where most of the existing literature comes from) as well as the U.S. Information gleaned from papers will include survey methods, degree of attraction/displacement, the type of analysis, and other factors. The literature review will be used to inform a guidance document which outlines how to conduct pre- and post-construction surveys so as to have sufficient power and scope to identify displacement or attraction effects if they occur. For example, buffer zone recommendations will be included. This document is anticipated to be completed and issued in 2023.

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[25] https://www.nyetwg.com/regional-synthesis-workgroup
[26] https://offshorewind.env.duke.edu/

[27] https://espis.boem.gov/final%20reports/5319.pdf

[28] https://www.nyetwg.com/avian-displacement-guidance

Review: Mitigation Options for Seabirds. Aspen Ellis recently completed a review of mitigation options for seabirds at offshore facilities[29].

Meta-analysis: Forage Fish and Marine Predators. Through NYSERDA funding, BRI is using movement and survey data, spatial modelling, and forage fish modelling to examine ecological relationships between forage fish and their marine predators, including birds. The project utilized data collected by BRI, Normandeau, NOAA, and others to examine the extent to which abiotic environmental factors shape forage fish communities, what local conditions promote visible surface aggregations of forage fish, and associations between forage fish aggregations and abundance of marine predators along portions of the NW Atlantic seaboard. A brief summary of these efforts were provided in Meeting 10 of the RWSC Bird & Bat Subcommittee. Presentation slides and a recording of the presentation (as part of the full Subcommittee meeting) are available in the Subcommittee folder. Peer-reviewed scientific publications are expected to be forthcoming.

Regional Analysis. Environment Canada is beginning regional assessments off of Nova Scotia and Newfoundland, looking towards future offshore wind development. These assessments will consider which marine birds are likely to be most sensitive to offshore wind development, based in part on models developed in Europe. The agency will be considering whether European models need to be refined/adapted to the North American context, which species are of greatest risk of impacts, and what are the riskiest areas for development.

6.4.2 Recommended Science Actions

Recommended science actions in this category include:

- ***Conduct a meta-analysis of offshore bird tracking data****. As described in Section 6.2.3, analyses of at-sea survey data have been used to compile maps of abundance and distribution information for nearly 50 marine bird species. However, an equivalent compilation and meta-analysis of offshore bird tracking data has not been conducted. This should be conducted, following solicitation of historic data and disposition in Movebank. Objectives and study questions will need to be more closely defined by the Bird & Bat Subcommittee or an identified working group, but a partial goal would be to characterize seabird movements on the Northeast OCS and address how movement data relate to broadscale ecosystem changes.*
- ***Summarize available seabird diet, colony data, and wading bird surveys.*** *Following collection of historic data on seabird diets, colony metrics, and wading bird surveys, these data should be summarized in qualitative and/or quantitative format to provide an analysis of the current state of knowledge regarding different species and highlighting necessary next steps.*
- ***Summarize available data to inform collision risk models for birds.*** *Given the relative infrequency of bird collisions with wind energy infrastructure and the current lack of sophisticated and reliable systems to track collisions, collision risk models are often used as a proxy for actual collision detections. For species considered at potentially high risk of collision, an assessment is needed to identify key parameters for collision-risk data and systematically collect species-specific data, including movement metrics, distribution and abundance, flight height, flight speed, and other factors, from the literature.*
- ***Continue development of RWSC Bird Species List****, expanding the spreadsheet to include life history characteristics relevant to vulnerability to offshore wind impacts.*

[29] https://tethys.pnnl.gov/events/compensating-impacts-offshore-wind-energy-birds

- ***Develop a user-friendly guidance document on different bird research methods****, summarizing the costs and benefits of each in terms of types and quality of data collected, effort required, financial costs, and options available.*
- ***Summarize the state of knowledge of anticipated interactions with wind facilities by bird category, highlighting focal species.*** *Research topics, as described in Section 5, are broadly characterized, particularly the big questions around bird ecology and offshore wind. While it is possible to specifically identify needed technological advances, improvements to data workflows, etc., it is more difficult to narrow large ecological questions – what are the baseline conditions of bird ecology offshore? what are the impacts of construction and operation of wind facilities? – down to the most necessary and specific research questions that should be tackled. A number of projects have provided or are developing frameworks or criteria by which to identify and prioritize more specific research questions. These include the Research Prioritization guidance provided through a 2020 stakeholder workshop addressing effects of offshore wind energy development on birds and bats in the Eastern United States (Gulka and Williams 2020[30]), as well as the framework provided in the draft Regional Synthesis Workgroup guidance document[31]. However, carrying out these prioritization processes requires summarizing data to address all of the considerations raised in these guidance documents. This process of identifying the critical conservation questions could benefit from a systematic review to summarize the state of knowledge of potential or anticipated interactions with wind facilities, specific research questions identified in the Atlantic Offshore Wind Research Recommendations, and current research individually for each category of birds (as defined in this plan), calling out specific risks and identified focal species.*
- ***Review cumulative effects frameworks relevant to bird species occurring in the offshore environment.*** *Concerns about cumulative effects are widespread, but these concerns are not always clearly defined. Reviewing available cumulative effects frameworks and adopting clear guidelines for assessing cumulative effects is an important step towards addressing these effects (see also Section 6.5).*

6.5 Model development and statistical frameworks

This section addresses model development and novel or advanced statistical frameworks to further the scientific evaluation and prediction of offshore wind effects on birds. This section could include, for example, Population Viability Analyses, models of synthesizing data, evaluations of sensitive parameters that drive differences in model outcomes, collision risk models, or cumulative impacts assessments.

6.5.1 Current and Recent Efforts

A number of projects are underway or recently concluded that address development of new models or statistical frameworks. These include:

BAG Modelling. Project WOW will include advanced Before-After Gradient displacement modelling. In later stages of Project WOW, BRI will be utilizing Bayesian spatial modelling framework to integrate before and after survey data to understand displacement effects.

Position Estimation with Motus. In an upcoming project, BRI and the University of Rhode Island (URI) will be working on Motus position estimation modelling, with the goal of developing a more

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[30] https://www.nyetwg.com/bird-bat-research-framework

[31] https://www.nyetwg.com/regional-synthesis-workgroup

accurate and effective method for estimating positions of tagged birds, based on signal strength and series of detections at one or more Motus towers/antennae.

Collision Risk Modelling. USFWS, BRI, and URI recently completed development of a user-friendly Collision Risk Model that can inform risk assessments of offshore wind development to listed and rare shorebird species. The model is known as "SCRAM" and made available as an R Shiny web application.[32] USFWS, URI and BRI are also now collaborating on a collision risk model for endangered species in the United States. Normandeau recently finished a report on bird activity in the rotor-swept zone at two CVOW turbines which may inform/improve collision risk models. Three seasonal surveys were conducted, looking at micro-avoidance. The draft report will be available in a few months, after BOEM and the client have reviewed its contents.

Cumulative Effects Framework. Croll et al. (2022)[33] recently published a proposed framework for assessing and mitigating impacts of offshore wind development on marine birds.

6.5.2 Recommended Science Actions

- ***Synthesize tracking and survey data on a regional scale****.* *Survey data for marine birds has been analyzed independently, but not in conjunction with tracking/movement data. Innovative models and statistical frameworks will be required to integrate these two types of data. Following compilation of historic tracking data and analysis of that data alone, it would be valuable to conduct a combined analysis. Ideally, this analysis should include both an analysis of present conditions, sensitivity analysis, and predictions of future distribution and abundance patterns, incorporating offshore wind development, climate change, and other relevant conservation threats (e.g., oil and gas infrastructure, lighting, bycatch, changes to prey populations).*
- ***Develop community models that connect prey species to predator species****.* *Some initial work in this area has been completed, but additional analysis could provide more information about links between bird abundance, density, and movement patterns and patterns of forage fish and other prey distributions.*
- ***Adopt a framework to address regional and cumulative impacts of offshore wind in the context of other stressors*** *(see also Section 6.4).*
    - *Consider available frameworks for addressing regional and/or cumulative impacts of offshore wind. Assess whether additional components or context need to be added.*
    - *Modify (as needed) and adopt framework.*
    - *Based on identification of appropriate framework, consider needs for data collection, literature review, meta-analysis, or statistical models to provide quantitative depth to the framework.*

6.6 Optimizing Research, Monitoring, & Mitigation

This section includes activities related to optimizing research, monitoring, and mitigation efforts within a given study, at a regional scale, and across different types of science and conservation activities. Different types of research and monitoring methods have varying costs and types of data

[32] https://www.boem.gov/sites/default/files/documents/environment/environmental-studies/Transparent%20modeling%20of%20collision%20risk%20for%20three%20federally-listed%20bird%20species%20to%20offshore%20wind%20development_0.pdf

[33] https://doi.org/10.1016/j.biocon.2022.109795

they provide; some expensive research methods may be worth the cost if they provide valuable data, while others may not be worth the extra expense. As discussed in the Technology portion of the RWSC Science Plan, there is a need to identify metrics to track efficacy and efficiency of different monitoring methods.

As noted in Section 5, the timeline for offshore wind development means that mitigation for potential impacts of offshore wind development will need to occur at the same time that monitoring to assess impacts is taking place. In some circumstances, making the assumption that impacts are occurring and mitigating for those impacts could be more cost-efficient than determining exact impacts in a detailed and precise manner.

6.6.1 Current and Recent Efforts

Recent work on optimization of Motus infrastructure included analysis and modelling of Motus tower layout and bird sampling strategies conducted by Juliet Lamb of The Nature Conservancy. This analysis resulted in recommendations regarding appropriate tower layout and sampling of breeding shorebirds and colony-nesting seabirds to maximize Motus detections[34]. USFWS, BRI, and other collaborators also developed a Motus decision support tool known as "Informing the Design and Implementation of Offshore Motus Systems" or IDIOMS[35], a free on-line tool that allows users to optimize site-specific Motus study designs at offshore wind energy facilities. This includes identification of the number and locations of receiving stations necessary to cover a given offshore wind energy project area, relative to factors such as the project size and configuration, key species, question of interest, and specific Motus technology used. Results from the tool are summarized in automated reports that contain key information on study design that offshore Motus monitoring studies should include as standardized elements in post-construction monitoring plans.

6.6.2 Recommended Science Actions

Recommended science actions in this category include:

- ***Develop a guidance document on different bird research methods,*** *summarizing the costs and benefits of each in terms of types and quality of data collected, effort required, and financial costs. (see also Section 6.4).*
- *Once further work has been done to evaluate compensatory mitigation options,* ***conduct an analysis of the various costs and benefits of different compensatory mitigation options for birds.***

6.7 Technology advancement

6.7.1 Current and Recent Efforts

Collision Detection Technologies

Some collisions between birds and wind turbine towers or blades are inevitable. Effective collision detection technologies would be of great value in understanding the frequency of collisions and affected species, as well as timing, meteorological conditions, and turbine operational status associated with collisions. If monitoring efforts determine that collisions are occurring with frequency sufficient to affect species at the subpopulation or population level, or are occurring for

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[34] https://www.nyetwg.com/2022-workshop

[35] https://motus.org/groups/atlantic-offshore-wind/

protected species, collision mitigation efforts may be necessary. Effective collision detection technologies would also aid in assessing the efficacy of any implemented mitigation measures.

In terrestrial systems, collisions have primarily been monitored through carcass surveys for injured or killed birds under and around wind turbines. More recently, alternative collision detection systems, utilizing thermal and visual cameras, acoustic detectors for species ID, and sensors to monitor for small impacts to turbine blades have begun to be developed and tested at land-based facilities (e.g., see Hu et al. 2017[36]). These systems are not yet widely commercially available, but development of commercial technologies is a near-term goal. Collision detection systems have also begun to be designed and evaluated for their potential use in the offshore environment (Dirksen 2017[37], Good and Schmitt 2020[38], Albertani et al. 2022[39]).

In the offshore environment, it is currently challenging to estimate fatalities or validate collision detection systems. The standard land-based practice of carrying out carcass surveys is, of course, not effective in the offshore environment, where carcasses would quickly sink into ocean waters. Collision detection technologies would therefore be of great value in assessing and addressing impacts of offshore wind development, and of interest and concern to the RWSC Subcommittee. However, it currently is most appropriate to develop and test these technologies in terrestrial environments, because validation and data/equipment access are both more feasible at land-based facilities.

Field and analysis efforts to inform Collision Risk Models are detailed in the field research section (6.8) and elsewhere.

Recommended Science Actions

- ***Coordinate with land-based wind groups to ensure support and funding for land-based testing of collision detection technologies.***
- ***Coordinate with developers of collision detection systems to continue discussions of how they could be adapted for offshore use****. Review how these systems may need to be altered in terms of weatherproofing, data access, relevant species, etc.*
- ***Test collision detection technologies in the offshore environment as soon as it is practicable to do so.***
- ***Continue work on proxy metrics to inform Collision Risk Models*** *(see other sections of this plan).*

Artificial Intelligence for Species Identification

Use of artificial intelligence to identify visual or acoustic detections of birds can significantly speed up processing time, reduce costs, and potentially increase accuracy.

USFWS and USGS are working on development of AI software for use in identifying species detected in aerial surveys, including seabirds and waterfowl[40]. Initial machine learning algorithm

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[36] https://www.osti.gov/servlets/purl/1766443

[37] https://tethys.pnnl.gov/sites/default/files/publications/Dirksen-2017.pdf

[38] https://tethys.pnnl.gov/sites/default/files/events/2-WEST.pdf

[39] https://www.osti.gov/servlets/purl/1963218

[40] https://eros.usgs.gov/doi-remote-sensing-activities/2021/usgs/automated-detection-wildlife-targets-aerial-imagery

development has achieved the extraction of targets (individual birds and other wildlife) from imagery; current algorithm development is focused on classifying detected targets to the species level. This project has involved the development of an online feature annotation tool (based on the open-source annotation tool Computer Vision Annotation Tool - CVAT) for easy, streamlined labeling of training data by biologists and to serve as an imagery and annotation database for online data archiving and sharing.

Recommended Science Actions

- *Continue work on automated identification of bird species in aerial survey data.*

Integration of Wildlife Monitoring/Mitigation Equipment with Wind Turbines

As discussed in Section 6.1, through funding from the National Offshore Wind R & D Consortium, BRI and Advisian are reviewing wildlife monitoring technology and needs for incorporating equipment into turbines. Successful integration of this equipment with offshore platforms will require further coordination with turbine manufacturers and, ideally, development of a standard platform for wildlife monitoring equipment.

Recommended Science Actions

- *See recommendations at the end of Section 6.1.*

Improving Remote Data Access Options

As also discussed in Section 6.1, there is a need to improve upon current methods to convey data collected at remote, offshore locations to researchers. For systems deployed on offshore turbines, these data should be transferred via the same fiber-optic cables that carry wind facility operational data. This can be accomplished without compromising proprietary information, but simple, standardized systems need to be developed for conveying and processing these data and transferring them to researchers. Allowing for remote data transfer from offshore facilities is much more time- and cost-efficient than physically accessing hardware, allows for close to real-time processing and detection of any faults in equipment, and also reduces safety risks, by reducing the time that personnel need to visit the facility.

For monitoring equipment deployed at remote locations offshore that are not part of an offshore wind facility or close to a fiber-optic connection, further discussion is also needed to highlight the most viable options for deployment.

Recommended Science Actions

- *See recommendations at the end of Section 6.1.*

Improvements in Tag Technology

Satellite, GPS datalogger, and VHF tags are constantly improving, becoming smaller and lighter, and with greater longevity. However, many types of tags are still too heavy to be deployed on certain species or deployed for long periods of time. Development of lighter tags and/or tags with longer range, longevity, and reliability could aid in more efficient and effective data collection. In addition, alternatively powered tags, using accelerometers, for example, could be explored, as an alternative to the slow process of making batteries smaller.

Developing better implantable tags for diving species (with higher accuracy/precision) is also of interest.

Recommended Science Actions

- *Begin a dialogue with tag manufacturers to understand expected near-term improvements in technology and current technical/funding challenges for development of advanced tags.*
- *Based on these dialogues, consider whether pilot testing of certain tag technologies would be valuable in the field.*

Other Technological Advancements

Other technology advancements that the Subcommittee noted would be valuable, but which were not associated with particular action items, include:

- Development of tags that detect additional parameters
- Development of advanced tag attachment techniques (e.g., for lower risk to wildlife, better likelihood of staying on the animal longer)
- Improvements in camera technology, including better quality/higher definition images and video, improvements in thermal imagery, and more cost-effective options
- Weatherization to improve technology's reliability in harsh offshore environment
- Improvements or testing of bird call species ID auto-classification
- Automated tracking of flight paths in videos
- Automated tracking of flight paths in radar

6.7.2 Recommended Science Actions Summary

- ***Coordinate with land-based wind groups to ensure support and funding for land-based validation of collision detection technologies.***
- ***Coordinate with developers of collision detection systems to continue discussions of how they could be adapted for offshore use.*** *Review how these systems may need to be altered in terms of weatherproofing, data access, relevant species, etc.*
- ***Test collision detection technologies in the offshore environment*** *as soon as it is practicable to do so.*
- ***Continue work on efforts to inform Collision Risk Models*** *(see other portions of this plan).*
- ***Begin a dialogue with tag manufacturers to understand expected near-term improvements*** *in technology and current technical/funding challenges for development of advanced tags.*
- ***See recommendations at the end of Section 6.1*** *regarding coordination to integrate wildlife monitoring equipment with offshore turbines and facilitate remote data access.*

6.8 Field data collection and analysis

6.8.1 Current and Pending Efforts

Surveys at Sea (Aerial & Boat-Based)

Observational surveys at sea for birds are currently being carried out at various spatial scales by a number of different entities.

AMAPPS[41] is a joint effort of NOAA, BOEM, USFWS and the U.S. Navy to carry out large-scale, regional aerial surveys covering the full Atlantic Coast. These surveys extend 200 nm to the edge of the U.S. Exclusive Economic Zone. These surveys allow for modelling of territorial waters, providing a context for more localized surveys (which tend to be more granular). These surveys are helpful for understanding baseline distributions but are not designed to detect effects at lease area scale. These surveys are conducted roughly quarterly, but are episodic, since the funding agency varies. Each survey uses the same tracklines, and bird surveys are run concurrently with surveys for marine mammals. The most recent completed AMAPPS survey ran from January-April 2023. AMAPPS also carries out some boat-based surveys.

Sea duck surveys were conducted by the USFWS along the Atlantic Coast, although the most recent surveys were from 2008-2011.[42]

Regional Ecological Baseline Assessments have been conducted by various entities in the different subregions of the RWSC Study Area:

- **Gulf of Maine** –BRI is leading a current BOEM-funded effort to conduct high-definition aerial surveys (2022-2023).
- **New York/New Jersey Bight** – Normandeau and APEM conducted aerial digital surveys of the New York Bight for NYSERDA.[43] The New Jersey DEP also conducted baseline surveys off the coast of New Jersey in the 2008-2009 window.
- **U.S. Central Atlantic** – The U.S. DOE funded baseline regional scale boat-based and digital aerial surveys off of Maryland, Delaware, and Virginia from 2012-2014; BRI conducted these surveys with Dick Veit at CUNY and HiDef Aerial Surveying.
- **U.S. Southeast Atlantic** – Normandeau and APEM conducted high-altitude aerial digital surveys in February 2018 and quarterly in 2019/2020 over the ocean off the coast of North and South Carolina out to the -30-m contour line. The approximate size of the area covered was 11,000 square nautical miles. Transect surveys covered a minimum of 5% of the area. In addition, 10% of the total area within the Kitty Hawk, Wilmington East, and Wilmington West Wind Energy Areas –as well as the South Carolina–Grand Strand Call Area were surveyed.[44]

Lease Area+ - Observational surveys, largely boat-based, but also some aerial, have been conducted over and in a buffer around identified lease areas. These efforts include:

- **Block Island** - Boat-based, pre-construction surveys were conducted from 2010-2011; post-construction surveys were conducted in 2017 and 2019/2020.
- **CVOW** - Boat-based surveys were conducted in 2018, and again in 2021.
- **Atlantic Shores South**– Boat-based surveys were conducted in over the south lease area of the NY Bight.

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[41] https://www.fisheries.noaa.gov/new-england-mid-atlantic/population-assessments/atlantic-marine-assessment-program-protected

[42] https://migbirdapps.fws.gov/mbdc/databases/afsos/aboutafsos.html; https://www.researchgate.net/publication/277677292_Wintering_Sea_Duck_Distribution_Along_the_Atlantic_Coast_of_the_United_States

[43] https://remote.normandeau.com/nys_aer_overview.php

[44] https://espis.boem.gov/final%20reports/BOEM_2021-079.pdf

- **Mayflower Wind** - Boat-based avian surveys were conducted during 2019. Digital high-resolution aerial surveys were conducted monthly from November 2019 – October 2020 across the Lease Area.
- **Empire Wind** – Aerial surveys were conducted over this lease area in the New York Bight.
- **Vineyard Wind 1** – Monthly pre-construction boat-based avian and bat surveys were conducted over this lease area; boat-based avian and bat surveys will again be conducted post-construction on a monthly basis.
- **OCS-A 0490 (off Maryland)** – Two years of aerial digital surveys were conducted by Normandeau over this area to assess the impacts of vessel traffic

Motus Network Build-out

Many Motus telemetry stations are already deployed as part of the Motus network – originally along the Eastern Seaboard, and now globally. However, long-term funding for deployment and maintenance of East Coast Motus stations remains a challenge. Land-based systems are currently being upgraded with recent funding, but maintenance and data fees to keep stations running are annual needs that are not always being met with current funding.

Some additional stations have been upgraded or added as part of offshore wind development projects. In 2020, Deepwater Wind installed a wildlife tracking station on the easternmost foundation platform at the Block Island Wind Farm off of Rhode Island. Motus stations were also deployed on the two Dominion CVOW turbine platforms off of Virginia. The Vineyard Wind 1 COP requires installation of Motus receivers on wind turbines within the lease area, as well as upgrades or maintenance of two onshore Motus receivers (see section 5.2 in VW1 COP and Project Easement Approval Letter (OCS-A 0501)**.** Permitting for the South Fork wind project requires installation of Motus receivers at up to four locations within the wind farm and refurbishment of up to two onshore Motus receiver stations near SFWF (e.g., Block Island, Buzzards Bay (see section 5.2 in Conditions of Construction and Operations Plan Approval Lease Number OCS-A 0517. The state of New Jersey has also proactively begun planning for build-out of coastal and offshore stations, including potentially adding nine new or upgraded land-based stations at priority locations, as well as deploying ten ocean buoy-based stations in an east-west line off the coast, extending out to a current buoy station at the corner of the Atlantic Shores Wind lease area. Empire Wind is also planning two to four new Motus stations. Boat-based and aerial calibration trials are planned in conjunction with at least some of these deployments.

These efforts represent important contributions to expansion and maintenance of the Motus network. However, the system could benefit from a more coordinated and less piecemeal approach towards deployment of Motus stations, in an arrangement that maximizes detection probabilities for focal species of birds and bats. In addition, centralized calibration and maintenance efforts, to ensure stations are functioning and to measure detection ranges systematically, would also be of benefit for scientific rigor and cost savings. In summer 2022, USFWS organized initial meetings among stakeholders to discuss the value of coordinating and possibly centralizing calibration of Motus stations, as well as deployment of both Motus stations and VHF radiotags for automated telemetry in the offshore environment. Phase 1 of the project would include efforts by RWSC to develop a plan for coordination and centralization, incorporating the *Offshore Motus Framework*[45], highlighting subregions/sites and species of interest, proposing a design or framework for optimal

[45] https://motus.org/groups/atlantic-offshore-wind/

or strategic tag deployment, listing key participants (tag project funders, species and land managers, etc.), and describing data standardization practices.

Tag Deployments

Many studies have utilized Motus tags to track migrating songbirds and shorebirds along the East Coast over the last decade, including projects funded by eNGOs, academic researchers, and state and federal agencies. These projects can be found via the Motus website. Offshore wind developers are starting to plan for the funding of additional Motus tag deployments along the East Coast. The COP for Vineyard Wind states that up to 150 Motus tags will be deployed per year for up to three years to track Roseate Terns, Common Terns, and/or nocturnal passerine migrants. South Fork Wind will provide funding for up to 50 Motus tags per year to researchers working with Roseate Terns for up to three consecutive years. Empire Wind is planning for deployment of 300 transmitters over the course of multiple years. Meanwhile, Dominion is currently funding deployment of nanotags on piping plovers in the vicinity of the CVOW project.

State agencies and eNGOs continue to also deploy nanotags and other transmitters. New Jersey Audubon is carrying out deployment of hybrid or solar-powered radiotransmitters on Veery, Northern Waterthrush, and Red-eyed Vireo. Thirty nanotags provided as cost share by the Atlantic Flyway as part of Project WOW will be used to double-tag along with GPS transmitters on gannets and large gulls, in a project led by Stonybrook and BRI.

Passive Acoustics

Passive acoustics are being deployed at a number of wind energy sites along the East Coast. In the Hudson North and South Wind Energy Areas off of New York, buoy-based passive acoustics have been deployed since 2019 by Normandeau, with funding from NYSERDA. Preliminary bird acoustic work was conducted at Block Island, but it was not particularly successful, and the company is currently reviewing the data. The ATOM system on the Dominion CVOW project includes bird acoustic detectors, which collected a lot of noise files, but also collected novel data, documenting passerines and Northern Flicker at the site. Looking ahead, Vineyard Wind's COP requires installation of acoustic monitoring devices on electrical service platforms (ESPs). Per the South Fork COP, acoustic monitoring devices for bats must also be installed on offshore substations (OSS).

Turbine-Mounted Cameras

Turbine-mounted cameras are relatively new technologies, but both operating wind facilities in the RWSC Study Area have deployed them. The Block Island wind farm is using cameras to assess nocturnal flight and collision risk in years one, three, and five of operation. This project is focused on assessing bird risks. The Dominion CVOW project's upgraded ATOM system includes two thermographic cameras operating in stereo to permit flight height calculations and document bird activity in the rotor-swept zone.

Other On-Going Field Research

Coastal shorebird and seaduck surveys are planned to be conducted by multiple states from 2023-2024. Colony data are collected annually in many coastal states.

Avian radar monitoring was conducted in years one, three, and five post-construction of the Block Island Wind Facility. Radar was also utilized as part of New Jersey DEP surveys offshore from 2008-2009.

6.8.2 Recommended Science Actions

- ***Develop a plan to coordinate and possibly centralize calibration of Motus stations, deployment of Motus telemetry stations, and Motus tagging efforts.***
- ***Encourage stable funding of AMAPPS*** *to allow for quarterly surveys each year*
- ***Conduct coordinated high-definition digital aerial surveys that cover multiple lease areas****, incorporating proposed wind facility footprints and buffer areas as defined by the Avian Displacement Guidance Committee.*
    - *At-sea surveys conducted as part of bird monitoring at offshore facilities are often carried out at the scale of individual lease areas, and often use boat-based methods.*
    - *However, as lease areas become larger, high-definition aerial surveys may become more practicable. In addition, recent work suggests surveys may need to include large buffer areas to accurately assess avian displacement. In many cases, this may mean surveying into neighboring lease areas.*
    - *Conducting coordinated aerial surveys that cover multiple lease areas could be more cost-efficient and produce better scientific outcomes, through the assurance of standardized survey methods, adequate coverage, and the greater value of aerial surveys over boat-based methods.*
- ***Coordinate state surveys of colonies, shorebirds, and wading birds****, so that consistent data are collected throughout the region.*
- ***Develop a list of recommended focal species for species-specific studies*** *(e.g., tagging, diet studies) within each subregion, based on focal species guidance, identification of areas with sufficient sample size, and expert input*
- ***Annually review focal species, tag recommendations, and any plans for centralized deployment based on conservation and science needs and new technology***
- ***Pilot test different deployment methods for bird passive acoustics.***
- ***Deploy passive acoustic monitors for birds on offshore infrastructure*** *to assess nocturnal migrants.*
- ***Deploy turbine-mounted thermal/infrared cameras*** *pointed towards the rotor-swept zone to assess bird behavior in the vicinity of turbines and monitor for potential collisions.*
- ***Cross-taxa: Develop a multi-pronged approach to study potential impacts of transmission cables on the sea floor*** *on foraging predators (particularly terns) and their prey species.*

7 Subregion considerations regarding birds and offshore wind

RWSC's work covers U.S. Atlantic waters, within the context of five subregions (as outlined in detail in Section 2). Many of the current research activities within the RWSC Study Area are occurring across multiple subregions. In addition, most of the relevant research questions and future science needs relevant to birds are applicable across most or all of the RWSC Study Area. With that said, there are subregional differences which are highlighted here.

There are notable geographic differences in the Gulf of Maine subregion, where the water depth is significantly deeper than elsewhere along the U.S. Atlantic Coast. The topography of the Maine coast is also notable – its many islands, peninsulas, and inlets lead to changes in movement and migration patterns that may be distinct from those elsewhere in the RWSC Study Area. Species that might be considered as occurring primarily close to land sometimes nest, roost, or forage in the vicinity of islands which can be, at times, far from shore. This can mean species that would not be likely to frequently encounter offshore wind facilities located in federal waters in other subregions may be in closer proximity to these facilities in the Gulf of Maine.

The Gulf of Maine subregion also sits at the northern edge of the RWSC Study Area, and hence includes a suite of species adapted to colder waters and more northern climes, which either do not occur or do not breed in the other subregions. Several alcid species, for example, breed along the Maine coast, but are not found breeding in other states. Colonies of breeding Arctic Terns and Black Terns, likewise, are only found in Maine. At the opposite end of the Study Area, birds of more tropical regions, like Whistling-Ducks, Limpkins, and Flamingos, are only found in Florida.

Species distributions, abundance, and seasons of occurrence of course also vary broadly across the five subregions, with species variously breeding or occurring only in one or several subregions. The state listing status of a species and associated level of conservation concern may also vary by state. Recognizing that over 400 species of birds occur across the RWSC Study Area, these differences are important to consider when identifying which set of species to focus on when conducting species-specific studies within a given subregion. If breeding colonies of a particular seabird or shorebird, for example, only occur within one or two subregions, these areas will, of course, naturally have to be the focus for breeding season studies. In addition, where certain focal species have been identified, it may be important to focus studies in certain subregions where the species are most common and abundant, so as to obtain sufficient sample sizes. The listing status of a species in a particular state is also important to consider from a regulatory and logistical perspective.

Also of great relevance is the timeline of offshore wind development across the five subregions. To date, small projects (of five and two turbines) have been installed and are operating in the Southern New England and US Central Atlantic subregions respectively. These are the first sites where bird monitoring equipment can be deployed on turbines, where this equipment can be tested for reliability, and where preliminary data can begin to be collected. Three large-scale offshore wind facilities of 130-800 MW are planned to begin commercial operation in the New England subregion in 2023 and 2024, with four additional projects scheduled for 2025. In the Central Atlantic, the first large-scale project (250 MW) is expected for 2024, with three projects (combined capacity of 1770 MW) to follow in 2026. The first large-scale projects in the New York Bight are projected to begin commercial operation in 2025 (1,100 MW) and 2026 (800 MW). In the Gulf of Maine subregion, meanwhile, only one pilot-scale project has been identified, which should begin operation in 2024. In the US Southeastern Atlantic, commercial operation dates have not yet been estimated. Given this pattern of roll-out, studies on the impacts of large-scale offshore development on birds will inevitably begin in the middle three subregions of the study area. In the other two subregions, there will be more time to coordinate field research plans and collect baseline data.

Appendix A – USFWS Guidance for Coordination of Data from Avian Tracking Studies

Main objective: Develop guidance for standardized data delivery and archiving practices to ensure the timely and consistent availability of data and metadata from avian tracking studies.

Standardized data delivery and archiving practices:

Studies that use electronic tags (including satellite and radio transmitters) to track animals provide invaluable data to benefit species conservation but also may subject individual animals to risk of injury, behavioral abnormalities, or mortality due to risks associated with capture and tagging activities. Therefore, the conservation value of data from tagging studies must be maximized by ensuring that all tracking data and metadata are complete, consistent, and available for use in resource assessments, conservation management decisions, and for other purposes. To help meet these information needs, the following guidance should be applied to any data collected using technology that involves attaching electronic tracking devices to animals.

Technologies and associated tracking devices associated with the guidance include:

1. Satellite telemetry technologies that use satellite systems to estimate locations and transmit data remotely
    a. Platform Transmitting Terminals (PTTs): operating on the Argos system (https://www.argos-system.org/)

2. Global Positioning System (GPS) technologies that use GPS satellites to estimate locations. Data is either stored on the tracking device (loggers) or transmitted remotely.
    a. GPS data loggers: data are stored on board and need to be recovered manually
    b. GPS-radio transmitters: data are transmitted to radio (VHF or UHF) base stations and downloaded manually
    c. GPS-satellite transmitters: data are transmitted remotely to a satellite system (e.g. Argos, Iridium)
    d. GPS-GSM transmitters: data are transmitted remotely to cellular networks

3. Automated radio telemetry technologies use radio transmitters and a network of automated receiving stations to track animals
    a. Motus Wildlife Tracking System (Motus): radio transmitters operating on coordinated frequencies (currently 166.380 MHz or 434 MHz in North America)

Workflows for satellite telemetry and GPS data:

Location data and metadata from animals tracked using satellite telemetry or GPS technologies should be stored in Movebank (www.movebank.org) using the workflow and minimum data standards described below. Movebank is a free, global database that is used by agencies and non-governmental organizations to manage, share, analyze and archive animal-borne sensor data. Movebank has long-term (>20 years) funding through the Max Planck Society and the University of Konstanz and has been developed with support from various funders including NASA, the US National Science Foundation, and the United Nations Convention on the Conservation of Migratory Species of Wild Animals (Convention on Migratory Species).

Create a study
Prior to deployment of satellite or GPS transmitters, the Cooperator will create a study in Movebank (https://www.movebank.org/cms/movebank-content/create-a-study) to manage data following best practices for study archival in Movebank: https://www.movebank.org/cms/movebank-content/archiving-best-practices. At this time, the Cooperator will add designated agency contacts listed above from Department of Interior to the Movebank study as 'Collaborators' with full access to view and download data.

Add location data and sensor data
For tag technologies that transmit data via satellite systems (e.g. Argos, Iridium) or cellular networks (e.g. GSM) the Cooperator will enable automated live data feeds (https://www.movebank.org/cms/movebank-content/live-data-feeds) for all transmitters in the study. For tag technologies with manual data downloads (e.g. GPS loggers, GPS-radio transmitters), the Cooperator will upload all location data and other sensor data to Movebank following the instructions found here: https://www.movebank.org/cms/movebank-content/create-study-overview. The Cooperator will add all location data and other sensor data to Movebank within 30 days following each data download. At this time, the Cooperator will quality control the data following instructions from Movebank, found here: https://www.movebank.org/cms/movebank-content/upload-qc.

Add reference data

Within 30 days following transmitter deployment, the Cooperator will enter reference data (information describing animals, tags, and deployments) for each tagged animal into Movebank (https://www.movebank.org/cms/movebank-content/upload-qc#add_deployments). A complete list of terms, definitions, and formatting requirements can be found in the Movebank Attribute Dictionary (https://www.movebank.org/cms/movebank-content/movebank-attribute-dictionary).

Reference data should include, but is not limited to, the following attributes:

1. 'Animal' information:
    a. Taxon: Genus and species (as defined by the Integrated Taxonomic Information System (www.itis.gov), e.g. *Calidris canutus*)
    b. Taxon detail: Use if appendix to scientific name (e.g. *rufa*)
    c. Sex (if known; allowed values: m=male, f=female, u=unknown)
    d. Animal ID: Unique identifier of animal (e.g. flag or aux band code)
    e. Animal comments: include information on auxiliary markers (e.g. leg flags)
    f. Ring ID: BBL band #

2. 'Tag' information:
    a. Tag ID: Unique identifier for the tag
    b. Tag manufacturer name (e.g. Lotek)
    c. Tag model (e.g. Sunbird Avian Argos PTT)
    d. Tag mass (in grams)
    e. Tag comments: other relevant info (e.g. auxiliary devices such as Motus tag or barometer)

2. 'Deployment' information:
    a. Start of tag deployment (deploy on timestamp): yyyy-MM-dd HH:mm:ss in UTC
    b. Deployment ID (uniquely identified to animal and tag combination, e.g. 'animal id'-'tag ID')
    c. Deployment comments: additional information about the deployment that is not described by other reference data terms (e.g. body length, animal condition at time of capture, etc.)
    d. Animal Life Stage: enter age code (e.g. HY, SY, ASY, AHY)
    e. Attachment type: see controlled list in the Movebank Attribute Dictionary (e.g. glue, leg-loop-harness, etc.)

f. Deploy-on latitude and deploy-on longitude: latitude and longitude of deployment site (note: need to select "More fields" for this to appear)
g. Duty cycle: transmission frequency (e.g. locations every 15-min during daylight hours / Nautical Twilight)

3. Following deployment, if tags are subsequently removed, dropped, or the tagged animal dies, the following information should be added:
    a. Deploy-off latitude and deploy-off longitude (latitude and longitude of known or approximate deployment end site)
    b. Deploy-off timestamp (yyyy-MM-dd HH:mm:ss in UTC)
    c. Deployment end type: see controlled list in the Movebank Attribute Dictionary (e.g. dead, fall-off, removal, unknown, etc.)

<u>Workflows for automated radio telemetry data (Motus):</u>

Motus Wildlife Tracking System (Motus) is an international collaborative automated radio telemetry network. Motus includes radio transmitters that currently operate on two frequencies in North America: 166.380 MHz and 434 MHz.

Prior to ordering Motus transmitters, the Cooperator will designate a new or existing project in Motus to add tags to. At this time, the Cooperator will add designated agency contacts from Department of Interior to the Motus project as 'Collaborators' with full access to view and download data. When ordering transmitters, provide the manufacturer (Lotek or CTT) the Motus project name and number so that the transmitters are registered to the project (https://motus.org/tag-deployment/).

During the time of tag registration, the Cooperator should record the following minimum information on tag properties in Motus:
1. Tag #
2. Burst interval (in seconds)
3. Manufacturer
4. Model
5. Codeset
6. Type

Tag registration information is recorded in Motus by the tag manufacturers and should be checked by the Cooperator for accuracy and completeness. Any errors or missing information on tag properties should be corrected in Motus prior to tag deployment.

Within 30 days following transmitter deployment, the Cooperator will record metadata for each tagged bird into Motus including:

1. Deployment Start Date/Time in UTC
2. Deployment location (Latitude and Longitude)
3. Species name
4. Band number: BBL band
5. Marker number: alphanumeric code of auxiliary marker code, if applicable
6. Marker type: type of auxiliary marker, if applicable
7. Sex: if known
8. Age: if known

Following deployment, if tags are subsequently removed, dropped, or the tagged animal dies, the Cooperator will update the following tag deployment information in Motus:

1. Deployment End Date/Time (UTC)
2. Tag deployment notes (record reason, if known dead, fall off, removed, unknown)

Chapter 9: Bats and Offshore Wind Development

Executive Summary

This chapter describes recent and ongoing data collection and research initiatives related to offshore wind and bats, funded by RWSC partners (states, federal agencies, industry, eNGOs) and others. For an up-to-date list of active projects, visit the [RWSC Offshore Wind and Wildlife Research Database](). Given these current scientific efforts, the Bird and Bat Subcommittee is making recommendations for additional research that is both aligned with existing efforts and that fills important gaps. These recommendations reflect information shared with RWSC in discussions held with the Subcommittee and meeting participants during public Bird and Bat Subcommittee meetings between May 2022 and June 2023, as well as in follow-up meetings held with participating stakeholders. The recommendations are described in detail throughout each section of this chapter and are listed at the end of this Executive Summary.

Our scientific understanding of bat activity and behavior in the offshore environment is relatively limited at present. Overall, bat activity is thought to be lower than onshore, but bats active in the offshore environment could be more attracted to wind turbines than they are onshore, as these are novel, tall structures in an otherwise flat seascape. At least six species of bat are known to occur offshore, including the long-distance migratory tree bats (Hoary Bat, Silver-haired Bat, Eastern Red Bat), as well as *Myotis* species of conservation concern due to the impacts of White-Nose Syndrome on their populations. These species are most often detected in the offshore environment during the fall migration season.

Collisions with operating wind turbines are thought to be the main potential impact of offshore wind development on bats. While the scale of collision fatalities in the offshore environment is currently unknown, at terrestrial facilities, these fatalities have been modeled to represent a population-level and potentially existential threat to some species. Siting to avoid areas of high bat activity and compensatory mitigation for collision fatalities are unlikely to be effective mitigation strategies for migratory tree bats, which are expected to be the species most affected by offshore wind development; however, curtailment during periods of high bat activity has proven effective at terrestrial wind facilities.

Research needs include gaining a better understanding of onshore-to-offshore gradients of bat activity, which could be accomplished via boat-based mobile acoustic surveys on vessels which already make regular trips through offshore waters, or through deployment of stationary detectors on offshore weather buoys and other infrastructure. In addition, as turbines are installed, deployment of acoustic detectors on turbines at nacelle height is of great interest, initially for providing information about the amount and timing of bat activity in the rotor-swept zone of offshore turbines, but ultimately for informing operational curtailment, if this mitigation strategy is deemed necessary. Appropriate protocols and deployment methods for bat acoustics offshore have not been defined. This plan recommends convening an offshore bat working group to adapt existing land-based protocols for bat acoustics to the marine environment, as well as to develop pilot study parameters to test and compare acoustic equipment and deployment methods at a variety of offshore facilities.

Because it is not known if bats consistently echolocate during migratory flights over water, acoustic methods may not be sufficient to capture the range of bat activity offshore. Deployment of automated telemetry tags on tree bats and *Myotis* captured at coastal and island locations is also recommended in order to document fall migratory movements of bats migrating to southern wintering areas or swarming sites and hibernacula, as well as to potentially capture movements near turbines. Collaborative calibration of the Motus automated telemetry stations that detect these tags, as well as collective planning and potentially centralization of tagging and station deployment efforts, could allow for more efficient collection of movement data.

Collision detection technologies are currently being tested in the onshore environment, where validation via carcass surveys is possible. As soon as practicable, these devices should begin to be tested at offshore facilities as well, although validation could prove difficult. In the meantime, thermal and infrared cameras can be used to document bat behavior in the rotor-swept zone of offshore turbines.

Development of a greater understanding of bat interactions with offshore wind facilities, evaluation of potential negative impacts, and assessment of effective curtailment options can be facilitated by continued collaborations among researchers and stakeholders through established entities, use of publicly accessible relational databases, minor modifications to existing databases to facilitate incorporation of offshore bat data, and development of new data repositories to address gaps (e.g., raw data file storage, tissue repository, offshore collision/fatality database). In addition, advances in technology and communication with OEMs and wind developers could allow for remote data access and better integration of bat monitoring technologies with wind turbine platforms.

Recommended Science Actions

Research Theme: Developing structures and methods to effectively and collaboratively conduct and share scientific research.

- *Continue regularly scheduled coordination, planning, and information sharing efforts of RWSC, the E-TWG, and Tethys.*
- *Convene an Offshore Bat Working Group to develop guidance documents for bat acoustics, Motus tagging, and weather data collection in coastal and offshore areas.*
- *Develop a guidance document on different bat research methods, summarizing the costs and benefits of each in terms of types and quality of data collected, effort required, and financial costs.*
- *Convene a workshop to share methodologies for monitoring and mitigation of bat fatalities onshore and discussion of how to transfer these strategies to the offshore environment.*
- *Add capabilities to the NABat database to allow for more informative incorporation of offshore data.*
- *Solicit additional acoustic and sighting data for the NABat database.*
- *Improve access to historical offshore bat Motus data.*
- *Evaluate the need for an updated offshore bat occurrence summary following historic data collection.*
- *Fund development of USGS software to allow for improved auto-classification of bat species in acoustic data.*
- *Begin a dialogue with tag manufacturers to understand expected near-term improvements in technology.*
- *Review existing frameworks and adopt a common framework to evaluate population-scale risks of wind collision mortality to bats in terrestrial and offshore environments.*
- ***Cross-Taxa:*** *Collaborate to develop and share strategies to bring data to shore from offshore monitoring sites. Coordinate with turbine manufacturers to ensure compatibility of bat monitoring/mitigation technologies with turbine platform infrastructure.*

Research Themes: Understanding baseline and post-construction patterns of bat occurrence, activity, and movements offshore.

- *Develop a plan to coordinate and possibly centralize calibration of Motus stations, deployment of Motus telemetry stations, and Motus tagging efforts.*
- *Identify feasible capture locations for focal bat species by soliciting feedback from Bat Working Groups along the coast.*
- *Deploy Motus tags on migratory tree bats to evaluate patterns of movement during the late summer-fall migration season.*
- *Deploy Motus tags on Little Brown Bats and Northern Long-eared Bats in coastal areas and on islands in late summer to evaluate dispersal from maternity colonies to swarming or overwintering sites.*
- *Work with states and Bat Working Groups to deploy passive acoustics on islands and at coastal sites.*
- *Deploy passive acoustic systems on offshore infrastructure.*
- *Coordinate with vessels already active in areas of interest to conduct mobile acoustic surveys documenting coastal to offshore gradient of bat activity.*

Research Themes: Assessing collision risk at offshore facilities; designing and evaluating on-site mitigation strategies.

- *Conduct pilot studies at installed turbines to test and evaluate appropriate deployment methods for bat acoustics offshore.*
- *Conduct year-round acoustic monitoring of bat activity at turbine nacelles.*
- *Deploy turbine-mounted thermal/infrared cameras to assess bat behavior in the vicinity of turbines and monitor for potential collisions.*
- *Deploy Motus stations in conjunction with local meteorological stations to assess weather conditions under which bats are active near wind facilities.*
- *Coordinate with land-based wind groups to ensure support and funding for land-based validation of collision detection technologies.*
- *Coordinate with developers of "smart" curtailment technologies and collision detection systems to continue discussions of how they could be adapted for offshore use.*
- *Test collision detection technologies in the offshore environment as soon as it is practicable to do so.*

Table of Contents

1 Introduction

1.1 Purpose

This chapter of the **draft** RWSC Science Plan addresses bat research and associated scientific needs in the context of offshore wind development. As a draft plan, this chapter will be available through the summer months of 2023 for review and comment by the RWSC Bird and Bat Subcommittee, RWSC's sector caucuses, the RWSC Steering Committee, and other stakeholders and researchers. The final plan is intended to reflect the research and data collection needs of RWSC's four Sectors with input from the science community. The plan will provide a path forward to ensure appropriate data and standards are in place to support scientific research; the document will also provide a plan to coordinate and align funding to carry out necessary scientific activities.

This plan benefits greatly from the contributions of RWSC Bird and Bat Subcommittee members; researchers, managers, and other practitioners who joined Subcommittee calls; and the many scientists who conducted research or developed reference materials cited throughout this plan.

1.2 Structure

Following this introduction, the first section of the chapter discusses the geographic extent of the area considered within this chapter, the subregions defined within this area, and the species of bats which occur within this geographic range. It briefly describes aspects of their life histories as relevant to their exposure and potential vulnerability to offshore wind development. It also addresses other conservation threats facing these species. The species section is followed by a brief section summarizing primary sources of information about species' distributions.

The next section of this chapter discusses potential effects of offshore wind development on bat species. This section is followed by a section summarizing common field research methods for the study of bats, with a focus on the offshore environment. The subsequent section addresses the major research topics and questions relevant to bats in the context of offshore wind development.

The remainder of the chapter addresses recent, ongoing, pending, and recommended science actions of value to the four sectors that make up RWSC (state and federal agencies, eNGOs, and the offshore wind industry). These actions include additional field research to better understand the impacts of offshore wind development on bats and to test out new methodologies. They also include actions like coordination and planning, meta-analysis and literature review, model development, technology development, historical data collection, and, importantly, the standardization of data collection, storage, and analysis. Most science actions important for bat conservation in the context of offshore wind are relevant across the entire RWSC Study Area. However, specific subregion considerations are also noted in the final portion of the chapter.

2 Species

This chapter addresses bat (Class Mammalia, Order Chiroptera) species which could be at risk from offshore wind development occurring in the Northwest Atlantic within U.S. waters. For the purposes of this plan, the geographic area of interest comprises the East Coast of the United States, extending from Maine's northern border with Canada south to the Florida Keys, and from coastal areas extending 200 nm east into the ocean, including state waters (3 nm from shore) and federal waters of the Outer Continental Shelf (3-200 nm). While the focus of this plan is on offshore impacts of offshore wind development, potential onshore impacts of offshore wind on bat species are also possible. For example, clearing of transmission line corridors could remove trees used by summer maternity colonies. Therefore, bat species which primarily or solely occur in the onshore environment along the East Coast are nevertheless included within the scope of this plan, although they are not the focus of the bulk of this chapter.

Within the geographic area of interest, some portions of the plan will be discussed within the context of five subregions, as described below:

- **Gulf of Maine**: This subregion extends from the northern border of the United States at the southern tip of Nova Scotia to a line extending southeast from Hyannis. The subregion includes the Gulf of Maine and Great South Channel.
- **Southern New England**: This subregion extends from the southern border of the Gulf of Maine subregion to a line extending directly south from the Connecticut/Rhode Island state border, running roughly through the eastern border of Montauk, New York.
- **New York/New Jersey Bight**: This subregion extends south from the southern border of the Southern New England subregion to a line running roughly east-southeast from Cape May, New Jersey. The subregion includes the Hudson Canyon.
- **U.S. Central Atlantic**: This subregion extends south from the southern border of the New York/New Jersey Bight subregion to a line running roughly southeast from Cape Hatteras, North Carolina.
- **U.S. Southeast Atlantic**: This subregion extends south from the southern border of the U.S. Central Atlantic subregion up to and including the Florida Keys.

Figure 1 (below) provides a map of the five subregions.

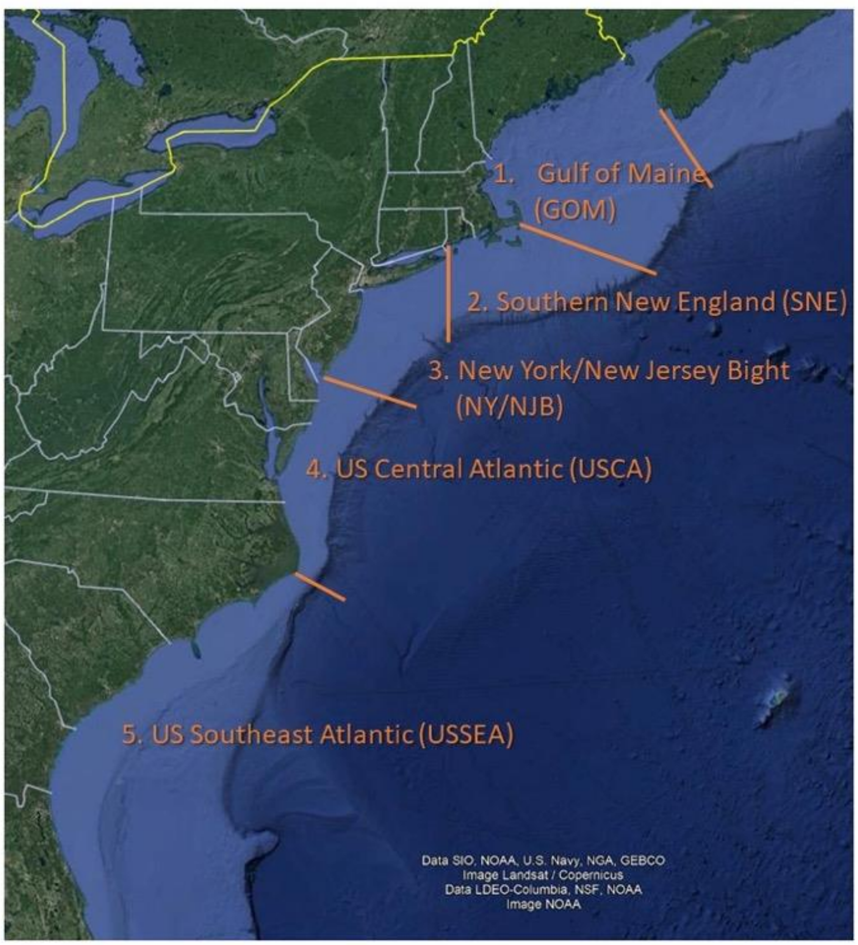

Figure 1. Geographic scope of interest for this plan, including five subregions.

2.1 Bat Species occurring in the Northwest Atlantic

There are 20 species of bat which commonly or occasionally occur in the 14 coastal states of the eastern United States. They are all insectivorous species that belong to the family Vespertilionidae. Seventeen of these species are included in **Table 1** (below). The remaining three species are tangential to the scope of this plan:

- The Velvety Free-Tailed Bat (*Molossus molossus*), a bat of Central and South America, occurs north as far as the Florida Keys, but its range does not overlap with most of the region covered by this plan.
- There are infrequent, incidental records of the Big Free-Tailed Bat (*Nyctinomops macrotis*), a bat of the Southwest U.S. and points south, in South Carolina.
- The Virginia Big-Eared Bat (*Corynorhinus townsendii virginianus*) has extremely limited distribution in western Virginia and North Carolina, and is not likely to interact with coastal or offshore activities related to offshore wind development.

Scientific Name	Common Name	Federal ESA Status	IUCN Red List Status	State ESA	SGCN
Corynorhinus rafinesquii macrotis	Rafinesque's eastern big-eared bat		Least Concern	3	5
Eptesicus fuscus	Big Brown Bat		Least Concern	0	10
Eumops floridanus	Florida Bonneted Bat	Endangered	Vulnerable	1	1
Lasionycteris noctivagans	Silver-Haired Bat		Least Concern	1	12
Lasiurus borealis	Eastern Red Bat		Least Concern	1	12
Lasiurus cinereus	Hoary Bat		Least Concern	1	12
Lasiurus intermedius	Northern Yellow Bat		Least Concern	2	4
Lasiurus seminolus	Seminole Bat		Least Concern	0	3
Myotis austroriparius	Southeastern Myotis		Least Concern	2	6
Myotis grisescens	Gray Bat	Endangered	Vulnerable	3	4
Myotis leibii	Eastern Small-Footed Bat		Endangered	8	13
Myotis lucifugus	Little Brown Bat	Under Review	Endangered	6	13
Myotis septentrionalis	Northern Long-Eared Bat	Endangered	Near Threatened	10	13
Myotis sodalis	Indiana Bat	Endangered	Near Threatened	7	7
Nycticeius humeralis	Evening Bat		Least Concern	0	3
Perimyotis subflavus	Tri-Colored Bat	proposed Endangered (Sept 2022)	Vulnerable	4	14
Tadarida brasiliensis	Brazilian Free-Tailed Bat		Least Concern	0	1

Table 1. Bats regularly occurring in the 14 states of the RWSC Study Area. The state ESA column indicates the number of East Coast states in which the species is listed as state endangered, threatened, or of special concern. The SGCN column indicates the number of East Coast states in which the species is listed as SGCN.

2.1.1 Regulatory Status

Currently four bat species that regularly occur in the RWSC Study Area are listed as Endangered under the federal Endangered Species Act (ESA) and one has been proposed for listing. The ESA places strict limits on the import, export, sale, possession, transportation, or “take” of listed species, with “take” defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." The ESA also allows for the designation of critical habitat for a species and prohibits the destruction of that habitat.

In addition to federal regulations, most states have a state Endangered Species List, which offers its own protections. Fourteen bat species are protected by state ESAs in the 14 states of the RWSC Study Area. Individual State Wildlife Action Plans also identify Species of Greatest Conservation Need (SGCN) which serve as foci for research and conservation efforts; all of the bat species that regularly occur along the Atlantic Coast are listed as SGCN in one or more states.

2.1.2 Species Descriptions

Lasiurus and Lasionycteris Species

The species displayed in Table 1 include five species belonging to the genus *Lasiurus* or genus *Lasionycteris*. These species typically do not inhabit caves or hibernate, instead remaining active throughout the winter months and entering temporary torpor under cold conditions. The Hoary Bat, Eastern Red Bat, and Silver-Haired Bat have wide geographic distributions and make long-distance migratory movements between summer territories in the northern U.S. and Canada and wintering grounds in (depending on the species) the southeastern U.S., Central America, or South America. The Seminole Bat is primarily a bat of the southeastern U.S., which makes short, seasonal migratory movements, occurring more commonly in northern portions of its range in the summer and in southern portions of its range in the winter. The Northern Yellow Bat is a non-migratory species of coastal portions of the Gulf States and Mexico.

As shown in Table 1, none of these species is federally listed under the Endangered Species Act. None are listed as Endangered at the state level, although several are considered of Special Concern. All five species are listed as Species of Greatest Conservation Need in one or more of the 14 East Coast states. For the three long-distance migrants (Hoary Bat, Eastern Red Bat, Silver-Haired Bat), conservation concerns are primarily focused on fatalities at land-based wind facilities. Because these species never congregate in large numbers, it is difficult to impossible to estimate population sizes or population trajectories. Nevertheless, estimates based on population modelling and expert solicitation suggest that collisions with land-based wind turbines could lead to significant species' declines and possible extinction for one or more of these three species (Frick et al. 2017[1], Friedenberg and Frick 2021[2]). The Northern Yellow Bat and Seminole Bat are not well-studied, but could be at risk from the collection of Spanish moss (a common roosting substrate) and pesticide use.

Myotis and Perimyotis Species

Six *Myotis* species and one *Perimyotis* species are shown in Table 1. These small-to-medium-sized bats all hibernate during the winter in northern parts of their range, although the Southeastern Myotis is active for much of the winter in southern portions of its range. Most species congregate for hibernation in large numbers in caves or mineshafts, although the Eastern Small-Footed Bat is more commonly found in small numbers in talus slopes and other rocky crevices. Unheated basements, old miliary bunkers, and other human infrastructure may also serve as hibernacula. Female *Myotis* and *Perimyotis* form small or large maternity colonies in the summer months; a number of species occupy tree cavities as summer roosts, although human structures, such as old barns, attics, and house trimboards, are also common. Eastern Small-Footed Bats frequently

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[1] https://doi.org/10.1016/j.biocon.2017.02.023
[2] https://doi.org/10.1016/j.biocon.2021.109309

occupy talus slopes and rock crevices during the summer; Southeastern Myotis regularly inhabit caves in the summer months, typically forming large colonies in relatively warm caves with large, high-domed ceilings. Aside from the Southeastern Myotis and Eastern Small-Footed Bat, which may be non-migratory, *Perimyotis* and *Myotis* species are often characterized as short to medium-distance migrants, typically traveling from dozens up to several hundred kilometers between summer habitat and winter hibernacula.

The Indiana Bat was listed as federally endangered in 1966, and the Gray Myotis was listed as federally endangered in 1976, with declines in both species associated with human disturbance of the cave environments they inhabit. More recently, the Tricolored Bat and three *Myotis* species (Little Brown Bat, Northern Long-Eared Bat, and Indiana Bat) have experienced declines of at least 75-98% due to White Nose Syndrome (*Pseudogymnoascus destructans*), a fungal pathogen first detected in a cave in New York in 2006. The pathogen infects the bats during hibernation, leading to more frequent arousals and fatally burning fat stores needed by the bats to survive through the winter. The Northern Long-Eared Bat was added to the federal Endangered Species List in 2015 and upgraded from Threatened to Endangered status in 2022. The Tricolored Bat was proposed for inclusion on the federal ESA in 2022 and is listed as Endangered in four states. The Little Brown Bat is under review for inclusion on the federal ESA and is listed as Endangered in six of 14 East Coast states. The remaining species have no federal status, but are listed as Endangered or of Special Concern in several states. All seven species are considered Species of Greatest Conservation Need in one or more of the 14 East Coast states.

Other Species

The Big Brown Bat is widely distributed across North America. It is often considered a resident or short-distance migrant. Individuals occupy roosts in trees or human dwellings during the summer and move short distances to attics, caves, or mines for overwintering. The species has experienced some declines with WNS but remains common. It is a SGCN in ten East Coast states.

The Evening Bat is a medium-sized bat of the Southeast and mid-Atlantic states. Males are thought to stay in the southern portion of the species' range, while females migrate to maternity colonies in the northern portions of their range. They roost in colonies of several dozen individuals in tree cavities or buildings. They do not appear to use caves frequently. This species is considered a SGCN in three states. It is not known to be infected by WNS.

The Florida Bonneted Bat has an extremely limited range in southern Florida. It is federally endangered due to its limited range and small population size, which leave it vulnerable to habitat loss and natural disasters. These bats forage and roost in a variety of habitats, including natural and developed environments and tree cavities and bat boxes. Their small colonies often consist of a male and several females.

Rafinesque's Eastern Big-eared Bats are bats of the Southeast and southern Midwest. They inhabit a variety of roost habitats during the warmer months, including dead or decaying trees, human structures, mine shafts, and occasionally caves. They hibernate in caves and mines throughout their range, and in human structures and snags in more southerly portions. They are typically considered residents or short-distance migrants. While thought to be sensitive to habitat loss and disturbance of maternity sites and hibernacula, they are not listed federally, although they are listed as Endangered, Threatened, and of Special Concern, respectively, in three southeastern states. They are considered SGCN in five East Coast states.

Brazilian Free-Tailed Bats occur across the southern United States from the West Coast to the East Coast. In the winter, many bats migrate south into Mexico, Central America, and South America, but some subpopulations are non-migratory. In the U.S., these bats congregate in large colonies (sometimes over one million individuals), roosting in caves, under bridges, and where possible, in buildings. Though widespread and common, they can be vulnerable to impacts to local subpopulations, especially habitat loss, since they gather in such large numbers.

2.1.3 Focal Species

At least six bat species have been detected visually or acoustically over the waters of the Northwest Atlantic (Solick and Newman 2021[3]). The vast majority of detections identified to species were one of the three long-distance migratory tree bats (Eastern Red Bat, Hoary Bat, Silver-haired Bat). Tricolored Bats, Big Brown Bats, and *Myotis* species have also been detected, albeit rarely. Acoustic detections of *Myotis* can be difficult to differentiate to species, although the Little Brown Bat is thought to be among those recorded. Challenges in differentiating amongst species acoustically means that it can be difficult to positively determine which *Myotis* spp. are detected offshore – the Little Brown Bat has certainly been detected, but there may be others.

While some scientific research methods will provide information about a variety of taxa (e.g., acoustic surveys), other research methods (e.g., tagging) must by nature be species-specific. In the offshore environment, the three long-distance migrants are the focal species of greatest interest for tagging efforts, especially Eastern Red Bats, which are detected most frequently, and Hoary Bats, which are thought to be at greatest risk from land-based wind development. Coastal and island populations of Little Brown Bats and Northern Long-eared Bats are also of interest, particularly during the late summer and early fall, when they may make longer-distance movements to hibernation sites, which could involve over-ocean travel. If other *Myotis* or *Perimyotis* species are captured at coastal or island sites, they could also be considered potential focal species, but at present, there are not identified sites where they could be captured in numbers large enough to represent a meaningful sample size.

Other species could be affected if near-shore facilities are built in the future, or by tree clearing and construction where transmission cables come ashore. In these circumstances, federally listed species would be of greatest concern during the development process.

2.2 Regional Coastal/Offshore Distribution Information

Patterns of bat distribution and abundance in the offshore environment are poorly understood. Limited tagging/tracking efforts and mobile and stationary acoustic surveys have been conducted, in addition to documentation of incidental visual observations during surveys for birds. These studies have all been summarized in a recent literature review by Solick and Newman (2021), which provides a thorough compilation as well as links to the various studies included in the review. This review is referenced in Section 2.1.3.

Critical habitat for ESA-listed bat species, where designated, typically can be expected to focus on important hibernation sites or large summer maternity colonies. Offshore habitats are highly unlikely to be included in critical habitat, although defined critical habitat could in limited circumstances be relevant to onshore locations of transmission infrastructure for interconnection between offshore facilities and the electricity grid.

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[3] https://doi.org/10.1002/ece3.8175

The North American Bat Monitoring Program (NABat) provides seasonal occupancy and abundance maps for a number of bat species across the U.S.[4], modelled based on data collected by a host of federal researchers and other collaborators. Because the data are sparse, these maps do not yet include the offshore environment. However, the NABat grid system has been extended offshore, and is prepared to collect coastal and offshore detections of bat species, which can be incorporated into future analyses and mapping of species distributions.[5]

3 Potential Effects of Offshore Wind on Bats

The major potential effect of offshore wind development that is of concern for bats is collision with rotating wind turbine blades. In the terrestrial environment, bat mortality at wind facilities is a common occurrence (e.g., see Allision et al. 2020[6]), and these fatalities are estimated to represent a population-level, and even existential, threat to some bat species (Frick et al. 2017[7], Friedenberg and Frick 2021[8]). In the offshore environment, it is generally expected that bat occurrences are likely to be fewer, but the collision rate (relative to local bat activity) could be higher. In the onshore environment, for reasons as yet unclear, bats appear to be attracted to wind turbines (e.g., see Cryan et al. 2014[9]). Some theories hold that this is due to their height, and evidence exists that they may also occur frequently at communication towers and other tall structures (Jameson and Willis 2014[10]). In the offshore environment, turbines represent a novel and tall feature, which due to the flat seascape is expected to be visible from a longer distance away. Historic records indicate that bats sometimes flocked around sailing ships (Pelletier et al. 2014[11]), and more recent studies have documented bats roosting and foraging around offshore turbines in Europe (Ahlen et al. 2009[12]). There are concerns that attraction to turbines may be stronger and occur over greater distances in the offshore environment than onshore (although, as noted above, the overall numbers of bats present in marine environments are expected to be lower).

Among bat species, three migratory tree bats – the Hoary Bat, Eastern Red Bat, and Silver-Haired Bat – have been found to be the most vulnerable to collisions in the onshore environment, and these are the species for which the risk of population-level impacts is most clear. These species are presumed to be at the greatest risk in the offshore environment as well. The Eastern Red Bat, in particular, appears to be the species most commonly recorded over ocean waters. In addition to these species, rare *Myotis* species may be of second-greatest concern. There is widespread documentation of members of this genus occurring on islands and over the ocean, and analyses of onshore rates of fatality at land-based wind facilities has suggested that wind-associated mortality could compound population-level impacts to bat populations already affected by WNS (Erickson et al. 2016[13]).

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4 https://sciencebase.usgs.gov/nabat/#/results
5 https://www.usgs.gov/data/north-american-grid-based-offshore-sampling-frames
6 https://rewi.org/resources/awwic-bat-technical-report/
7 https://doi.org/10.1016/j.biocon.2017.02.023
8 https://doi.org/10.1016/j.biocon.2021.109309
9 https://doi.org/10.1073/pnas.140667211
10 https://doi.org/10.1016/j.anbehav.2014.09.003
11 https://tethys.pnnl.gov/sites/default/files/publications/BOEM_Bat_Wind_2013.pdf
12 https://doi.org/10.1644/09-MAMM-S-223R.1
13 https://peerj.com/articles/2830/

Habitat-mediated impacts are not likely to be a significant component of offshore wind effects on bats. Bats are believed to use marine habitats primarily as travel corridors during the fall, and to a lesser extent, spring, migration seasons. They are not thought to utilize offshore habitats as important foraging areas, although incidental foraging along the migratory route is expected, and bats have been observed foraging over ocean waters in multiple instances. Given these facts, the development of offshore wind is not likely to lead to an important loss of foraging habitat for bats. If bats avoided offshore wind facilities or turbines, offshore development could lead to loss of migratory connectivity; however, as noted above, bats appear to be attracted to rather than displaced from the vicinity of wind turbines. Offshore wind turbines in fact probably offer potential roost and stopover habitat for migrating bats, but due to collision risk, any energetic advantage conveyed by this increase in roosting habitat is likely more than offset by the potential negative impact of fatalities. One negative habitat-mediated impact that could occur is the attraction of bats to offshore wind turbines from long distances away, leading to deviation from migratory pathways. This could have negative energetic consequences for migrating bats, as well as longer exposure to harsh conditions offshore. The distance over which attraction may occur for bats is not currently known in either the onshore or offshore context.

Positive effects of offshore wind development on bats may be few and far between. As wide-ranging, highly mobile species that survive in a range of habitats and (in some cases) utilize temperature-stable caves during winter conditions, the bats of the U.S. Atlantic Coast are broadly speaking not particularly vulnerable to climate change. Therefore, they are not likely to particularly benefit from the climate change mitigation effects of offshore wind development. This statement is in no way intended to denigrate the high value of this climate mitigation for many species, including other bat species (and humans!).

There are not clear and effective methods for off-site compensatory mitigation to offset, or more than compensate for, potential fatalities of bats at offshore wind facilities. The main conservation threats faced by migratory tree bats and cave-hibernating *Myotis* or *Perimyotis* species detected offshore are, respectively, land-based wind fatalities and WNS. However, compensatory mitigation is discussed further in Section 5.

One benefit of offshore wind development to these species could be the greater scientific interest and research focus on these under-studied organisms in the context of offshore wind development; this might lead to a better scientific understanding that ultimately better serves these species.

4 Common data collection methods and approaches

A number of scientific methods are used for studying bats in the offshore environment, which are summarized below. Note that this brief review focuses on technologies or methods relevant to marine environments. There are additional survey techniques and protocols used in the onshore environment. Those are relevant to the study of terrestrial effects of offshore wind – such as effects of clearing transmission corridors to connect offshore wind with onshore grid infrastructure – but for the sake of brevity and a focus on novel offshore issues, they are not addressed here.

Acoustic Surveys

Acoustic surveys can be conducted using acoustic detectors to record calls of bats. Surveys may be conducted using passive (stationary) methods or active methods. Active surveys onshore are typically conducted using a vehicle; at sea, they are often boat-based, although drones could be considered in the future. Passive surveys offshore utilize stationary detectors deployed on ocean buoys, meteorological towers, offshore wind turbines, other offshore infrastructure (such as electrical service platforms or "ESPs"); use of coastal and island sites are also common for understanding timing and locations of bat movements in the coastal and marine environments. Acoustic surveys for bats are quite common, and utilize detectors which operate in the ultrasonic range in which most echolocation calls fall. Note that acoustic surveys are only effective when study animals are vocalizing. Ambient noise can interfere with detection of vocalizing animals and limit the distance over which calls will be recorded. Differentiating among species can also be difficult for some species.

Tagging and Tracking

Tagging and tracking can be a useful way to understand bat movements and activity. **VHF (Very High Frequency) radiotags** transmit signals in the radio frequency range, which can be detected with a receiver. These types of tags are regularly deployed on bats. Historically, tags with slightly different frequencies were deployed on animals within one research study to allow for easy identification of different individuals. The animals were then tracked, often via manual telemetry with a hand-held receiver. Manual tracking could be conducted on-foot, using a vehicle, or even via small airplane. Study animals could also be tracked via a receiver attached to a stationary tower with antennae pointed in multiple directions, which could be automated to detect signals periodically or rotated manually by a researcher to detect a signal with an associated bearing. Manual telemetry is limited by the search effort available for finding and pinpointing the radio signal, and hence faces significant challenges in tracking animals that range over long distances.

In recent years, the development of the Motus Wildlife Tracking System has allowed for much more widespread use of VHF telemetry for tracking of wide-ranging and/or migrating bats, birds, and other wildlife. This system relies on coded radiotransmitters which all operate on one of several frequencies, but which emit slightly different patterns of code to identify different individuals. These tags are used in concert with fixed telemetry stations consisting of antennae, a receiver, a power source, memory storage, and sometimes data transmission infrastructure. Telemetry stations can be deployed on land, on coastal locations, or on offshore infrastructure, including ocean buoys and offshore wind turbine platforms. A great advantage of this system is that stations deployed by one research group can detect passage of animals by other researchers operating in the same network, allowing for development of a widespread network with more likelihood of detecting wide-ranging study animals. This system also has the distinct advantage over manual telemetry that signals can be monitored for continuously. Motus system technology has limitations, including limited range of some telemetry stations and, in most cases, an ability to determine only general proximity or bearing from the station rather than precise location.

At present, other types of tags, including geolocators, GPS dataloggers, and satellite tags are not regularly deployed on bats in the RWSC Study Area. Satellite tags are currently too heavy to be placed on the bat species that occur along the East Coast of the United States. GPS dataloggers are only practicable for species that regularly return to the same roost, where the animal can be recaptured. They have been used in studies of the Florida Bonneted Bat (Webb 2018[14]), one of the largest bats on the East Coast, but other species are not as large or not as predictable. Geolocators require exposure to daylight to function, which is not necessarily available in bat roost locations.

[14] https://original-ufdc.uflib.ufl.edu/UFE0054081/00001

Cameras

On turbine platforms, turbine nacelles, or other offshore infrastructure, **cameras** are beginning to be used to record bat presence and behavior in the vicinity of turbines, which can inform when and where animals are present in the rotor-swept zone and document bat interactions with turbines, including perching, roosting, attraction, micro-avoidance, lack of response, or collisions. Cameras differ in their mode of action, resolution, and the frequencies of electromagnetic radiation they use, from conventional cameras that operate in the visual range, to so-called "infrared" cameras that operate in the near infrared range, to so-called "thermal" cameras that operate in the far infrared range. The information provided by continuously operating cameras is unique and of great value to bat and offshore wind research. However, all of these types of systems are expensive at present and often only deployed at one or a few turbines in a study area. The field of view of a particular camera is often not sufficient to encompass the full rotor-swept zone, at least with sufficient granularity to identify bats throughout that zone. The extent to which these technologies can be counted upon to operate continuously in the harsh offshore environment is currently being evaluated.

Banding and PIT Tags

Capture-mark-recapture studies can be used to assess longevity and survival of bats. While bird banding is a very common practice for birds of all sizes, bat banding is less common. Banding of bats (on the forearm, rather than the leg) is carried out by some researchers, but there are concerns that this practice could result in injuries to the animal. The USFWS has convened a working group to study this issue in bats and come up with recommendations. PIT (passive integrated transponder) tags are also used on bats in some instances. These tags are implanted into the animal using an injector. These types of identification systems are most useful in situations where an animal is expected to return to a given site where it may be easily captured. These are most likely useful in cases such as coastal and island maternity colonies or hibernacula.

Collision and Fatality Monitoring

At onshore wind facilities, **carcass surveys** are commonly used to document mortality and estimate fatality rates for bats that collide with wind turbines. Offshore, carcasses of individuals can be expected to fall into the ocean in most instances. Methods to reliably detect collisions are sorely needed, but are not yet commercially available. Occasionally, bats that collide with turbines may fall to the turbine platform. These carcasses can be collected, identified, and documented, providing incidental information.

Tissue Sampling

There are a range of **tissue sampling** methods from live-caught bats, or their feces, which provide a variety of information about individuals' migratory status, diet, and health, as well as population-level genetic structure. These include collections of blood, hair, wing membrane, and fecal matter, to variously conduct stable isotope analysis, physiological analyses, diet assays, detection of *Pseudogymnoascus destructans* (the fungus responsible for White-Nose Syndrome), genetic analyses, or others. In addition to direct sampling of individuals, collection of DNA from the ambient environment (**eDNA**) also has the potential to provide information about species present in an area. This is a relatively new technology and the utility of this technique to address various research questions is not yet fully understood.

Incidental Observations

Incidental observations can also provide useful information about species presence and behavior, particularly for bats, which are infrequently observed at sea. These observations have in some cases been collected via literature review (e.g., Pelletier et al. 2014[15]). **At-sea aerial and boat-based surveys for seabirds** have in some cases recorded bat activity offshore on an incidental basis.

Multiple Methodologies

In addition to the methods described above, it should be noted that **some systems incorporate multiple methodologies simultaneously**, in order to better understand and, in some cases, verify detections. For example, systems might include various combinations of acoustic, camera, and radar systems, or, in the future, incorporate these with collision detection technologies that record impacts to the turbine blade.

5 Research Themes: Bats and offshore wind in the U.S. Atlantic

Research questions about offshore wind development and wildlife are centered around two common themes. First, there is a need to measure, estimate, model, or otherwise assess the scale of impacts of offshore wind development on bats, in order to determine whether impacts are significant at a subpopulation or population scale. Second, there is a need to understand how to address any impacts that may occur via effective mitigation. In the context of this chapter, "mitigation" is used broadly, as defined by the Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) regulations. Thus, mitigation in this context includes avoidance, on-site minimization and mitigation of impacts, restoration of the affected environment to rectify impacts, and off-site compensation for impacts. Some examples of the types of specific actions these categories might include are given as examples below:

- Avoidance could include siting wind facilities in areas expected to have low bat activity.
- On-site mitigation could include curtailing wind turbine operations during periods of high bat activity so as to reduce the risk of collision fatalities.
- Rehabilitating or restoring the affected environment to rectify impact could include placing artificial roosting habitats or creating snags in areas where maternity roost trees were cut to make way for a transmission corridor.
- Compensating for the impact off-site could include developing artificial hibernacula to support successful overwintering of WNS-affected bat species.

The goal of mitigation measures is that they will negate or offset any negative impacts of offshore wind development, and ideally provide a net benefit to the species.

In the case of offshore wind development, the timeline for collection of baseline data and pre-construction assessment of risk is quite short. The first large-scale offshore wind facility is expected to begin commercial operation in 2023, with four additional large projects (over 100 turbines per project) expected in 2024; many additional projects are planned for subsequent years. This means that in most parts of the RWSC Study Area, researchers do not have the luxury of collecting comprehensive pre-construction data to identify areas of high bat activity and potentially inform siting. Instead, efforts must be made to collect baseline data while also moving forward with other activities to inform risk assessments and evaluate mitigation options. These activities include conducting studies to assess collision risk at small-scale and large-scale wind facilities, evaluating whether on-site mitigation may be necessary, and determining parameters for efficient curtailment regimes. Basic efforts needed to facilitate these activities include developing appropriate data

[15] https://tethys.pnnl.gov/sites/default/files/publications/BOEM_Bat_Wind_2013.pdf

standards and workflows for the collection of offshore data, and testing successful methods for sampling bats in the offshore environment.

Given this context, important science and research topics related to bats and offshore wind development include the following:

- **Developing structures and methods to effectively and collaboratively conduct and share scientific research**. This includes coordination, planning, collaboration, the standardization of data workflows, and development of improved data collection and dissemination methods.
- **Understanding baseline conditions of bat occurrence, activity, and movements offshore.** This includes assessing species occurrence and relative activity of bats over different areas of the ocean, with particular attention towards whether relative bat activity declines over a gradient from coastal to offshore areas. This also includes documenting characteristics of offshore flights, including timing (time of year, time of night), relationships to meteorological conditions, flight speed, and differences across species, sexes, or ages. These types of data have the potential to inform siting decisions to avoid impacts to bats. However, because of the rapid pace of wind development compared to the pace of data collection, and because it is possible that attraction will lead bats to visit offshore lease areas more frequently once turbines are installed, near-term siting decisions are unlikely to be made based on collection of baseline data.
- **Determining if patterns of bat occurrence, activity, and movements change after construction of offshore wind facilities.** This includes continuing surveys of bat occurrence and activity post-construction to understand if patterns change. This also includes continuing to document characteristics of offshore flights. Post-construction studies of this kind may help elucidate whether, and to what degree, attraction to turbines is occurring, and whether siting could be an effective mitigation strategy for future wind projects.
- **Assessing collision risk at offshore facilities.** Until such time as validated and effective collision detection methods are available, proxies are necessarily used to assess collision risk. For bats, acoustic activity, particularly recorded at nacelle height in conjunction with information regarding turbine operational status, may be the best indicator of potential collision risk (e.g., see Peterson et al. 2021[16]). Assessing bat activity at turbine nacelle height relative to timing, meteorological conditions, turbine characteristics, turbine operational status, and species is an important research goal. (Tracking data may also provide information about movements of non-echolocating bats.) Turbine-mounted cameras – and future collision detection technologies – may be able to provide actual measures of collision risk and fatalities. These data can help in understanding the relative risks to bat populations posed by collisions offshore as compared to fatalities at land-based wind facilities and other threats.
- **Designing and evaluating on-site mitigation strategies.** Assessments of the conditions associated with heightened collision risk (previous bullet) can inform design of efficient, "smart" curtailment strategies for bats, if these methods are deemed necessary to avoid population-level impacts to bats.
- **Evaluating off-site compensatory mitigation strategies.** If on-site mitigation measures are deemed insufficient or are cost-prohibitive, off-site mitigation measures could be considered. However, these measures would need to be evaluated carefully to determine if they are realistic and adequate to address negative impacts. While forest habitat conservation has been touted as a potential bat compensatory mitigation strategy for some types of

[16] https://wildlife.onlinelibrary.wiley.com/doi/full/10.1002/wsb.1236?af=R

development, the major known sources of fatalities for bat species considered at risk from offshore wind development are land-based wind development and WNS, for migratory tree bats and *Myotis/Perimyotis* species respectively. For WNS-affected species, the conservation need most lacking at present is WNS-free overwintering habitats. The development of effective, WNS-free artificial bat hibernacula could be one way to compensate for potential collision mortality. Among migratory bats, collisions at onshore wind facilities remains the most pressing conservation threat and hence, ironically, the most effective compensatory mitigation effort would be for offshore wind facilities to pay for curtailment at onshore wind facilities. Offshore facilities might instead prefer to curtail their own turbines during the limited, low-wind conditions when bats are likely to be present.

6 Regional-scale ongoing, pending, and recommended science actions in the U.S. Atlantic for bats and offshore wind

This section of the Science Plan discusses current, pending, on-going, and recommended science actions related to gaining a better understanding of effects of offshore wind infrastructure on bats in the marine environment, as well as to address mitigation strategies in the context of identified impacts. This section is structured by the type of action, including:

- Coordination, planning, and data sharing
- Standardization of data collection, analysis, and reporting
- Historical data compilation
- Model development and statistical frameworks
- Meta-analysis and literature review
- Optimizing research, monitoring, and mitigation
- Technology advancement
- Field data collection

Most of the actions discussed are of relevance throughout the RWSC Study Area. Specific subregion considerations are addressed in Section 7 of this plan.

6.1 Coordination, planning, and information sharing

6.1.1 Entities providing regular coordination, planning, and information sharing

Many entities conduct regional coordination or planning regarding wildlife research in the coastal and marine environments, but several conduct work specifically focused on wildlife and offshore wind.

Information sharing is also conducted by most organizations regarding their own work or collaborative efforts. However, the organizations discussed below are sharing information at a regional level of specific relevance to offshore wind and wildlife. Of course, many databases have a public interface which also allows for information sharing, as do regional data portals. In the interest of avoiding redundancy, this category of platform for information sharing is not included here, but is instead detailed in Section 6.2, which deals in depth with databases.

RWSC

This Science Plan reflects one of the coordination and planning activities the RWSC was founded to carry out. The mission of RWSC is: *To collaboratively and effectively conduct and coordinate* *relevant, credible, and efficient regional monitoring and research of wildlife and marine ecosystems that supports the advancement of environmentally responsible and cost-efficient offshore wind power development activities in U.S. Atlantic waters*.

The development of this Plan was undertaken by the RWSC in collaboration with state and federal agencies, the offshore wind industry, environmental NGOs, academic researchers, and other stakeholders in order to identify regional research needs and determine a path forward to fund and carry out these scientific activities.

Other RWSC activities include hosting monthly taxa-specific Subcommittee meetings to discuss current and upcoming research, provide feedback on proposed methods and plans, and share other relevant updates. In addition to Subcommittee meetings, RWSC hosts regular meetings of state, federal, and industry caucuses, as well as its overarching Steering Committee.

The organization has also developed the RWSC Offshore Wind and Wildlife Research Database to compile and track active and recent projects addressing offshore wind and wildlife interactions in U.S. Atlantic Waters.

E-TWG

The New York Environmental Technical Working Group (E-TWG) was organized to advise the state government of New York regarding measures to avoid, minimize, and mitigate anticipated impacts on wildlife during offshore wind energy development. While created to support the state of New York in particular, the group's work is relevant to the wider region. The group includes membership from offshore wind development companies, NGOs, and state and federal governments. Specific tasks of the E-TWG include developing wildlife best management practices, identifying research needs and coordination opportunities, and creation of a framework for an environmental conservation fund.

Every other year, the E-TWG hosts Offshore Wind and Wildlife "State of the Science" workshops, which are open to researchers and stakeholders from throughout the region (as well as nationally and internationally). These workshops offer an opportunity for researchers to present and discuss updates on the state of knowledge regarding wildlife and offshore wind energy development; they are also designed to promote collaboration and regional coordination.

Specialist Committees address issues that the E-TWG has designated as priorities. These committees may include both E-TWG and non-E-TWG members with relevant expertise. A current committee of relevance to bats and offshore wind is the **Regional Synthesis Workgroup**, which was organized to inform and provide interim guidance for regional-scale research and monitoring of offshore wind energy and wildlife in the eastern United States. As part of the work of this group, a database of research needs and data gaps was compiled from existing sources. The database was designed to synthesize existing data gaps and research needs so that researchers and funders could easily access, sort, and further prioritize topics. The database specifies focal taxa, spatial scale, and other information relating to each priority research topic. The Workgroup also drafted written guidance, including definitions of common terminology to support regional communications, general suggested criteria for prioritization of regional research topics, and general recommendations on study design and data transparency for regional-scale research efforts. Draft products from the Workgroup are available at https://www.nyetwg.com/regional-synthesis-workgroup.

The E-TWG also hosts a library of public webinars (https://www.nyetwg.com/webinar-library) about environmental issues and offshore wind. The library allows for basic searches, and is updated roughly twice a year. An Annual Bulletin is also produced by the group, highlighting E-TWG, fisheries-related, and New York/regional environmental offshore wind initiatives.

E-TWG activities are funded by the New York State Energy Research and Development Authority (NYSERDA), with technical support provided by the Biodiversity Research Institute (BRI).

Tethys

The Tethys Knowledge Base is a literature database hosted by PNNL (Pacific Northwest National Laboratory) which compiles and provides access to documents and information about the environmental effects of wind and marine renewable energy. The database is easily searchable and can be filtered via a number of fields. It is updated regularly. The database is available at https://tethys.pnnl.gov/knowledge-base-all.

6.1.2 Project-specific coordination efforts

Coordination with turbine manufacturers

One project providing important coordination in the wildlife/offshore wind arena is an effort to review types of wildlife monitoring equipment used to study birds and marine mammals offshore, and to coordinate with turbine manufacturers to ensure the compatibility of wildlife monitoring/mitigation technologies with turbine platforms and infrastructure. This effort is being conducted by BRI and Advisian through funding from the National Offshore Wind R and D Consortium. Outcomes from this work are anticipated in summer of 2023. These products will inform next steps for bird monitoring, but also other taxa, including bats. It is anticipated that follow-up work will be needed.

Coordination and centralization of Motus field research

In summer 2022, USFWS organized initial meetings among stakeholders to discuss the value of coordinating and possibly centralizing calibration of Motus stations, as well as deployment of both Motus stations and VHF radiotags for automated telemetry in the offshore environment. This effort, and recommended science actions, are described in more detail in Section 6.8 (Field Research).

6.1.3 Recommended Science Actions

Recommended science actions in this category include:

- ***Continue regularly scheduled coordination, planning, and information sharing efforts*** *of RWSC, the E-TWG, and Tethys.*
- ***Convene a workshop to share methodologies for monitoring and mitigation of bat fatalities onshore and discussion of how to transfer these strategies to the offshore environment.***
- ***Coordinate coastal and offshore acoustic surveys*** *with ocean-going vessels and bat working groups (see Section 6.8).*
- ***Coordinate and possibly centralize calibration and deployment of Motus infrastructure and tagging efforts*** *(see Section 6.8).*
- ***Cross-Taxa: Collaborate to develop and share strategies to bring data to shore from offshore monitoring sites.***
    - *Hold discussions with offshore developers regarding how to securely transfer wildlife monitoring data to researchers via the same cables that carry wind facility operational data, without compromising proprietary information.*
    - *Develop relationships and lines of communication with turbine manufacturers to understand how to integrate with wind turbine platforms and cable infrastructure.*
    - *Convene a workshop to share strategies to bring data to shore from offshore sites.*

- *Disseminate findings from the workshop in guidance document format.*
- *Create a platform to allow for continued discussion/development of new or improved methods to bring data to shore from offshore monitoring sites.*

➢ ***Cross-Taxa: Coordinate with turbine manufacturers to ensure compatibility of bat monitoring/mitigation technologies with turbine platform infrastructure.***
- *Review published outcomes from the BRI/Advisian project (see above).*
- *Convene a cross-taxa working group to discuss findings as relevant to included (birds, marine mammals) and excluded taxa (bats, sea turtles).*
- *Develop recommendations and design specifications for a generic platform that could support current and anticipated future wildlife monitoring equipment needs.*
- *Develop relationships and lines of communication with turbine manufacturers to ensure compatibility of wildlife monitoring equipment.*

➢ ***Cross-Taxa:*** *Convene a working group to address implementation of the* NOAA Fisheries and BOEM Federal Survey Mitigation Strategy *and associated activities in order to ensure that regular wildlife and fisheries surveys carried out by NOAA, other federal agencies, and other organizations are able to continue in the context of offshore wind development.*

6.2 Standardizing data collection, analysis, and reporting

6.2.1 Introduction

This section addresses data collection, processing, and housing for the types of data collected as part of studies to inform potential impacts of offshore wind development on bat species in the Northwest Atlantic.

Benefits of Standardization

Standardizing data workflows provides value to all stakeholders working in the field of offshore wind and wildlife, promotes species conservation, and supports the informed deployment and operation of offshore wind energy facilities. Some of the specific benefits and goals of data standardization include:

- **Ensuring a standard product for funders of research**
- **Reducing the time investment for funders of research**, who can refer to standard practices rather than spending valuable time detailing a scope of work, or updating study requirements as science and research technologies advance
- **Reducing the time investment for data collectors**, who can refer to standard practices rather than developing new protocols, and avoid collecting unnecessary or incompatible data
- **Improving data consistency**
- **Improving data accessibility** through making data available and searchable in publicly available databases and data repositories as soon as possible after data collection.
- **Leading to better science and management decision-making** due to improved data consistency and prompt accessibility, streamlining reviews and analyses
- **Reducing duplicative research**, since all stakeholders have broad access to the range of studies conducted

Structure of this Section

Appropriate data collection tools, protocols, databases, and repositories are available for many types of wildlife data. General guiding principles and best practices for data standardization are described in Section 6.2.2. Specific recommended databases, where available, are detailed in

Subsection 6.2.3. These best practices are applicable both to wildlife data and associated study data necessary for analysis and interpretation, such as, for example, meteorological covariates, effort data, or the specifics of methodology, equipment, and technology used.

Importantly, there are some types of studies or data for which detailed guidance on best practices or infrastructure for housing data are not available. Where further guidance is needed in the context of existing databases, recommended actions are noted throughout Section 6.2.3. Subsection 6.2.4 addresses gaps in database infrastructure. These sections of the Science Plan identify next steps which can be taken to improve on currently available options as well as next steps that may require dedicated funding as part of a larger effort to develop necessary data collection tools, protocols, and databases.

Acknowledgements

In addition to the hard work of RWSC Bird and Bat Subcommittee members and other meeting participants, this section of the Science Plan relies heavily on the 2021 report ***Wildlife Data Sharing and Standardization***; partner initiatives, including a USFWS-led effort to develop offshore Motus deployment guidance; and other collaborating institutions and researchers. This section also benefits enormously from the work of many database managers and funders, who have contributed thought, time, effort, and funds towards database design, data entry, and making available standard protocols, how-to guides, and data products.

6.2.2 General Best Practices

Identifying Appropriate Databases

Where standard databases have not been identified for disposition of data, the following criteria should be evaluated in identifying appropriate databases to store data. These criteria are also helpful to consider in the development of new databases. It is not expected that existing databases will meet all of these criteria, but these can also be considered as aspirational goals for wildlife monitoring databases.

- Publicly available databases, ideally with a long-term or steady source of funding
- Robust relational databases, so data are easily searchable
- Databases are compatible with freely available platforms or data sheets for data collection
- Databases provide a specific data entry protocol or tag for data collected according to specific offshore wind protocols
- Databases included a straightforward public interface for both those looking to upload data and/or download data for analysis
- Outside meteorological data/covariates can be easily incorporated, where relevant
- Databases can accommodate relevant associated data (e.g., effort, local meteorological data) as well as wildlife data
- Databases are regularly updated so managers/researchers can analyze all current and applicable data
- Database managers conduct effective Quality Assurance/Quality Control practices as part of routine data maintenance
- Basic data products/visualizations are provided, so that those without an in-depth statistical background can understand basic outcomes of summarized data

Best Practices for Data Management

In general, the following best practices for data management are recommended, where specific workflows are not specified:

- Use standardized protocols, where available

- Keep data entry as close as possible to data collection efforts and the data collector to reduce possibility of error
- Limit and define fields to encourage consistent collection of data
- Make data available publicly to the greatest extent possible and on the shortest appropriate timeline.
- Make detailed data available to federal regulators at the finest resolution possible, including survey protocols, effort data, and all covariates and other metadata collected.
- If research studies include any wildlife-related data deemed "confidential" or "proprietary", but relevant to science and management decisions, these data should be housed so as to provide maximum opportunity for analysis and interpretation; such practices can include, for example, consistent data sharing agreements, with standard protocols for dispersal to researchers via non-disclosure agreements or data aggregation, making aggregated products and analyses publicly available, and rendering data non-confidential as soon as possible in any cases where it is no longer proprietary.

6.2.3 Recommended Databases

NABat and Motus should be used for storage of bat data collected in the offshore environment. The following pages provide a brief summary of the two databases, particularly with regards to the aspirational criteria for databases noted in Section 6.2.2. Based on the extent to which these databases meet the various goals, additional science actions are recommended.

Database: NABat

For use with:

Data Type(s):

- Passive and active acoustic survey data
- Raw acoustic files from bat detectors (although see Section 6.2.4)
- Any observational data collected on bats, including live or dead capture, roost surveys relative to coastal/island landing sites, or incidental observations

Database Basics:

- **Website:** https://sciencebase.usgs.gov/nabat/
- **Ownership/Funding Status:** NABat is a multi-national, multi-agency project with stable funding, and staffing provided primarily through USGS.
- **Database Updates:** The database is updated as data are incorporated, with derived products updated at least annually.
- **QA/QC Procedures:** Although users are ultimately responsible for some aspects of QA/QC, the database uses automated QA/QC to provide warnings and identify potentially incomplete or erroneous data. See https://www.nabatmonitoring.org/data-qaqc

Data Collection and Data Entry:

Public Interface to Upload Data: Yes, researchers can request permission to register to set up a project and submit data.

Standard Protocols, Data Collection Platform, and/or Data Entry Forms: A detailed, standardized protocol for mobile and passive acoustic surveys is available for onshore but not for offshore. There are standard options for incorporating land-based observations, such as roost surveys.

Data Permissions: Data stored in NABat are used as part of published and unpublished annual analyses and reports, although they are in all cases anonymized to the grid cell level. **Public data sharing** should be selected when entering data into NABat. This does not provide public access to data, but adds the project to an inventory of current projects. Federal regulators should be granted access to view detailed data within the NABat Partner Portal. Registered users wishing to access data from projects for which they are not members can submit a data request through the NABat Partner Portal, which includes information about how the data would be used. Auto-approval of third-party requests is encouraged, but at minimum, data contributors should be open to considering approving of third-party use. Limitations on the degree of discrete spatial data available to third parties can also be set via data sharing limits. See:

- https://www.nabatmonitoring.org/_files/ugd/3b3b76_1dcc304d3b34406fb3ee925766bcee33.docx?dn=NABat%20Data%20Use%20and%20Sharing_2022_01_14.docx
- https://sciencebase.usgs.gov/nabat/assets/NABat%20General%20Terms%20and%20Conditions.pdf

Entry Options for Survey Conditions (e.g., Meteorological Data): Start and end survey conditions are entered, but this may not be relevant to long-term deployment of detectors. Through minor updates to the database, continuously collected meterological data (e.g., on a 10-minute time scale) could be added as a supplementary file.

Entry Options for Effort Data: Effort data is derived from metadata about the survey. Effort associated with passive acoustic surveys is currently measured as detector nights, based on the start and end dates of deployment. This method of calculating does not account for potential issues with detectors failing for part of a survey night in the midst of a survey, or other similar challenges.

Data Use and Interpretation:

Public Access to Data: Yes. Summarized information by grid cell and basic information about each project are available via the NABat website.

Public Interface to Download Data: Yes. Data download may be restricted by the data uploader, but can be downloaded for further analysis, it allowed, through a third-party request process.

Search Functions: Available data can be searched by spatial area, temporal range, survey type, and species.

Outside Meteorological Data Incorporated: Outside meteorological data are incorporated into NABat data products and visualizations, but not automatically provided to individual researchers/users.

Data Products/Visualizations: Data products and visualizations include seasonal occupancy maps as well as a variety of analyses on status and trends.

Recommended Science Actions:

- ***Add capabilities to the NABat database to allow for more informative incorporation of offshore data.*** *These include:*
  - *Creating an offshore Atlantic polygon so that users can filter for offshore data only.*
  - *Creating a template to allow for entering meteorological data for negative hits on a short time-scale (10 min interval). This is not currently part of the database, but would be important for collecting data that could inform curtailment regimes (if deemed necessary offshore).*
  - *Allowing users to enter effort data in cases where detector-nights mask faulty detections during portions of a long deployment period*

- *[Note that the database manager confirms these could relatively easily be incorporated into the existing database framework.]*

- ***Convene an Offshore Bat Working Group*** *to develop several guidance documents:*
  - *A protocol for acoustic deployment offshore based on current knowledge and the existing NABat protocol for onshore surveys, including guidance on necessary sample size and incorporation of the NABat grid*
  - *Example data collection forms*
  - *Guidelines for a pilot study to test different deployment methods/equipment for bat acoustic detectors*
- ***Communicate with the Northwest Atlantic Seabird Catalog regarding incidental sightings of bats****, to determine whether these sightings could be coded for easy transfer to the NABat system.*

Database: *Motus Wildlife Tracking*

For use with:

- **Data Type(s):** Automated telemetry data

Database Basics:

- **Website:** https://motus.org/
- **Ownership/Funding Status:** Motus is a project of Bird Studies Canada; the database is funded through user fees and grants, contributions, contracts,and unrestricted sources available to Bird Studies Canada.
- **Database Updates:** The database is updated regularly as data are received.
- **QA/QC Procedures:** Full entry of basic metadata is required in order to access data results, encouraging prompt entry of these data. Automated QA/QC procedures are in place and run regularly to promote accurate detection data.

Data Collection and Data Entry:

Public Interface to Upload Data: Yes, collaborators can register to set up a project and submit data.

Standard Protocols, Data Collection Platform, and/or Data Entry Forms: Standard data entry forms, protocols, and methodologies for the deployment of Motus telemetry stations offshore are now available through the Motus website at this link: https://motus.org/groups/atlantic-offshore-wind/. These protocols should be followed during station and tag deployment. Basic Motus tag deployment metadata must be supplied to the Motus database (e.g., species, date of deployment).

Data Permissions and Access: *Summary Data* available through Motus consists of basic information about a project, limited deployment metadata for tags and stations, as well as daily summaries of tag detections and track maps. Summary Data for all projects can be viewed by anyone visiting Motus.org and can be downloaded in csv format by anyone with a Motus account. Summary data may also be presented on other collaborating platforms and products. *Complete Data* consists of detailed tag detection data including properties such as signal strength, direction from the station, precise date and time stamps, and expanded tag metadata fields. Complete Data is only available through the Motus R Package, but by default is open to all registered Motus collaborators. Access can be restricted at any time to only members of a particular project, which will remain in effect for 5 years after tag deployment, after which time Complete Data will become open to all Motus collaborators (unless otherwise exempt; request to reduce temporal or spatial resolution can be made). If access is restricted to project members, federal regulators should be added as project members so that they can view detailed project results.

Entry Options for Survey Conditions (e.g., Meteorological Data): Not available. Meteorological conditions during detections (and non-detections) are more relevant than conditions at time of capture/tag deployment. There is not currently a function available to link local meteorological data with specific Motus receiver stations or detections within the Motus database, but this could relatively easily be done in R.

Entry Options for Effort Data: "Effort" measured as telemetry station locations, numbers, and status (functioning, # of antennae, antenna bearings) are more relevant than effort to deploy tags. Some work is being done to make this information more accessible through the Motus site. The number of tags deployed on a specific species is available for all public data.

Data Use and Interpretation:

Public Access to Data: Yes. Public access to all Summary Data is available via the website. Complete Data are available by default to all registered Motus users, but if blocked, become accessible after 5 years.

Public Interface to Download Data: Yes. Public access to all data not restricted is available for download by Motus users.

Search Functions: R packages are available to aid in searching and summarizing larger datasets.

Outside Meteorological Data Incorporated: Outside meteorological data is not automatically incorporated. However, R code is available through the Motus R package to facilitate linkages to meteorological data collected by third parties.

Data Products/Visualizations: Estimated movement tracks by species, project, or dates are publicly available.

Recommended Science Actions:

- *Develop guidance regarding recording and storage of local meteorological data associated with telemetry receiver stations (whether from turbine weather stations or stand-alone systems) to inform timing of bat movements and behavior.*
- *Develop recommended metadata lists, field protocols, or field data forms for Motus tags deployed on bats in the coastal and offshore environments.*

6.2.4 Gaps in Database Infrastructure

There are a number of identified gaps in infrastructure to support standard data collection and workflows. The major gaps identified for bats are as follows:

Raw File Data Repository

In addition to databases, there is a need for data repositories for raw data with large file types – e.g., radar data, thermal video, digital aerial survey data, and acoustic files. Derived data from these types of files should be made available in relational databases as relevant; however, the raw data should also be retained in a central location for future re-analysis, quality control, and future re-evaluations with better tools. For example, future machine learning advances may allow for faster and more effective automated identification of bird species. The NABat database currently accepts raw acoustic files, but if this platform were to accept large volumes of acoustic files, it would quickly be overwhelmed.

Recommended Science Action

- ***Cross-taxa*** *-Develop a data repository for raw data with large file types, including identifying significant and stable funding to retain these files. This is important for multiple taxa.*

Tissue Sample Repository

There is an identified need for a tissue repository to store tissue samples, including carcasses of bats recovered from offshore wind facilities. These remnants are much less likely to be found at offshore facilities than at terrestrial facilities, since carcasses are most likely to fall into the ocean and not be recoverable and thus regular carcass searches are not proscribed. However, carcasses of bats may occasionally be recovered on offshore turbine platforms incidentally. In addition, tissue samples may be collected from both bats in offshore or coastal areas for various research purposes, including genetic, physiological, stable isotope, or disease dynamics studies. If not destructively sampled for analysis as part of the initial study, these samples could be stored for later use and to benefit future analyses.

At present, there is no defined repository for the many bat carcasses recovered at terrestrial wind facilities, whether collected incidentally or as part of regular fatality monitoring. In addition, there is no centralized site for the storage of tissue samples, such as bones, feathers, or wing punches. Mark Davis at the Illinois Natural Heritage Program, a program of the University of Illinois, is currently accepting tissue and bat carcasses from around the country and is committed to making these samples available for research. However, this small-scale repository could easily be overwhelmed if all bat carcasses currently stored by state agencies, federal agencies, wind developers, and environmental consultants were to suddenly begun to be shipped to this location.

USGS researchers, working with colleagues, have mapped out a hierarchical structure for a database which could allow for the tracking of carcasses and tissue subsamples throughout the country. There has also been discussion of logistical needs – for example, the establishment of regional collection centers to reduce transportation/shipping challenges for frozen samples.

Recommended Science Action

- ***Finalize, fund, and implement a USGS tissue sample repository plan*** *to 1) purchase tissue storage infrastructure, 2) identify regional storage locations, and 3) establish and maintain a database of tissue samples. [This is a lower priority for offshore than for onshore, where the need is greatest. It could be jointly funded, but terrestrial specimens will make up bulk of samples collected.]*

Collision Fatality Database

As discussed in Section 4, some incidental collision fatalities may be identified during visits to offshore turbine platforms. However, currently, there is no standard, cost-effective way to rigorously monitor for collisions offshore. Thermal and infrared cameras can detect collisions (e.g., see Happ et al. 2021[17]), but they are expensive to deploy widely, unable to detect collisions during periods of low visibility, and not necessarily reliable in harsh conditions occurring offshore. Efforts are currently underway at terrestrial wind facilities to develop and improve collision monitoring technologies for bats at these sites. Once these systems have been shown to be effective in onshore environments (where it is easier to access and maintain these systems, as well as validate

[17] https://doi.org/10.3390/jimaging7120272

reliability, as by comparing results to carcass searches), it is anticipated that these technologies can be further tested in and adapted for the offshore environment.

There is some sensitivity regarding reporting of fatality and collision information, because reporting and results are related to regulatory requirements under federal law, because collision/fatality reporting may result in negative publicity, and because important covariates to use in analysis include wind speed and the operational status of the turbine. Some wind companies consider these last items to be proprietary, although once facilities are fully operational, some developers report that wind speed and turbine status need not be kept confidential.

Where fatalities are only documented in an incidental fashion, fatality data may be of limited value, but are nevertheless important, given our limited scientific understanding of potential offshore impacts. In the future, as technologies allow for collection of these data in a more scientific and rigorous fashion, collision fatality data will be critical for evaluating impacts of offshore wind and (if needed) identifying effective mitigation strategies. The need for a designated database and availability of detailed data for scientific analysis will hence become crucial.

At onshore facilities, hesitancy to reveal post-construction fatality monitoring results has been addressed, in part, through the American Wind Wildlife Information Center (AWWIC), a database of post-construction fatality monitoring, conceived of and managed by the Renewable Energy Wildlife Institute (REWI). Database managers work with wind industry collaborators to compile both publicly available and privately contributed fatality data, including important covariates (e.g., effort, methodology, meteorological conditions), and to allow for the analysis of this data by REWI staff, as well as other researchers, through careful limitations on data sharing and requirements for sharing aggregated data so that no data from private sources could lead to identification of individual wind facilities.

The AWWIC database could serve as a model for a fatality/collision database for offshore wind, with important caveats. The existing database includes tailored non-disclosure agreements (NDAs) negotiated with each wind facility operator individually, and new data analyses and studies must often be negotiated with data contributors. An offshore collision fatality database for bats should include standard protocols for how data is collected, entered, and reported to the database, including which covariates are necessary for interpretation. There must be no barrier for federal regulators in accessing the data. The database should also include standard data sharing agreements detailing how the data could and could not be used and how results would be shared publicly. This could allow for simplified sharing of data with outside researchers for analysis and synthesis, while addressing developer concerns regarding confidentiality and any needs for data aggregation.

Recommended Science Action

- *Convene a working group to suggest a structure for a collision fatality database and to develop a draft generic NDA. Identify entities that could potentially house this database and determine required funding.*

6.2.5 Recommended Science Actions – Summary

Because recommended science actions are scattered throughout Section 6.2, they are also summarized here:

- *Add capabilities to the NABat database to allow for more informative incorporation of offshore data.*
- *Convene an Offshore Bat Working Group to develop guidance documents for bat acoustics and Motus tagging in coastal and offshore areas.*

- *Communicate with the Northwest Atlantic Seabird Catalog regarding incidental sightings of bats, to determine whether these sightings could be coded for easy transfer to the NABat system.*
- *Develop guidance regarding recording and storage of local meteorological data associated with telemetry receiver stations (whether from turbine weather stations or stand-alone systems) to inform timing of bat movements and behavior.*

6.3 Historical data collection/compilation

In addition to encouraging newly collected field data to be added to a standard repository, it is highly advantageous to ensure historical data are also saved in the same location. Storing these data in the same database or data repository can ensure they are easily accessible to researchers conducting long-term studies or meta-analyses - or regulators or developers simply looking for information about species likely to occur in a particular subregion or site. Historic data are highly important for understanding long-term trends in species populations and can help to tease out causes of change over time relative to offshore wind energy development, other anthropogenic impacts (e.g., climate change, fisheries management), and natural interannual variation. Through modeling, these data can also help predict future species distributions or occurrences.

One challenge with organizing and storing historical data is that these data may not always be collected in a consistent manner – from year to year, site to site, organization to organization - or consistent with current practices and technologies. It is important that any differences in data collection methodology are captured in data repositories and included (to the greatest extent possible, through estimates of uncertainty, etc.) in any analyses that incorporate these data. It is also important to recognize that efforts to store and organize historical data may require additional time and effort to ensure data are stored using standard values and terminology consistent with present practices. In addition to storing raw historical data, some studies may warrant providing "corrected" data or correction factors based on updated analysis methods to allow for comparison with current data.

This section describes current and recommended historical data compilation efforts using the same organizational scheme of data categories and databases discussed previously in Section 6.2. Please see that section for a more detailed discussion of any databases referred to in this section.

Current and Recent Efforts

Motus. Automated telemetry data collected via the Motus Wildlife Tracking Network is automatically stored in the Motus system. Hence, historical data for both bats are naturally stored alongside data collected from current and recent projects. Birds Canada staff have also made efforts in recent years to solicit tag metadata associated with tag deployment from past projects where not previously recorded in the Motus system.

NABat. As noted above (Section 6.2.3), the NABat database can accept presence/absence bat acoustic data on collected from offshore wind turbines, associated infrastructure, meteorological towers, and other offshore, island, or coastal locations (e.g., offshore weather buoys, lighthouses, tree-mounted units on islands). The NABat database also allows for inclusion of bat acoustic data collected as part of boat-based surveys.

Recommended Science Actions

- ***Improve access to historical offshore bat Motus data*** *through a systematic effort to 1) identify past projects with the potential to provide information related to offshore bat movements, 2) reach out to researchers to request that a new "offshore" tag be applied to these projects, and 3) request of these same researchers that access permissions be set to allow public access to these data, if not available already.*
- ***Solicit additional acoustic data for the NABat database.*** *Researchers with historical acoustic data not in the database should be identified via a literature review and solicited to provide data to the NABat database, using the standardized formats developed in Section 6.2.3 above. This should include any associated meteorological data collected as part of the study.*

6.4 Meta-analysis and literature review

Meta-analyses and literature reviews are, of course, of great importance for summarizing the current "state of the science," synthesizing common findings, and identifying data gaps. As noted previously, literature related to offshore wind and wildlife is tracked in the Tethys database, which can facilitate these types of analyses, whether qualitative or quantitative.

Several analyses of this nature related to bats are currently ongoing or recently completed. These include:

6.4.1 Current and Recent Efforts

Data Gaps Analysis. Project WOW, a Wildlife and Offshore Wind study conducted by Duke University and collaborators, is performing a data gaps analysis to understand where sufficient data exist to generate meaningful estimates of likely impacts, and where they do not. This analysis will be based on a quantitative scoring of literature, based on species names and taxa.

Offshore Bat Activity. As referenced in Section 2.2, Donald Solick and Christian Newman at EPRI recently completed a literature review paper regarding the current state of knowledge regarding bat occurrences offshore, with respect to offshore wind development.

Curtailment Efficacy. In the terrestrial environment, several recent meta-analyses have considered the efficacy of curtailment in reducing bat fatalities at terrestrial facilities

- Adams et al. (2021): https://doi.org/10.1371/journal.pone.0256382
- Whitby et al. (2021): https://tethys.pnnl.gov/sites/default/files/publications/Whitby-et-al-2021.pdf

Bat Attraction to Turbines. Theories about causes of bat attraction to wind turbines have also been addressed:

- WEST recently completed a literature review regarding whether insect feeding is a risk factor for bat fatalities at turbines.
- Guest et al. (2022) provided an updated review of hypotheses regarding bat attraction to wind turbines: https://doi.org/10.3390/ani12030343.

6.4.2 Recommended Science Actions

- ***Evaluate need for updated offshore bat occurrence summary following historic data collection.*** *The recent publication by Solick and Newman represents a thorough review of recent literature. Following collection of additional historic data into the NABat, the need for* *an updated review should be evaluated based on how much additional information was collected.*

6.5 Model development and statistical frameworks

This section is intended to address model development and novel or advanced statistical frameworks to further the scientific evaluation, prediction, and mitigation of offshore wind effects on bats. This section could include, for example, Population Viability Analyses, models for synthesizing data, evaluations of sensitive parameters that drive differences in model outcomes, or cumulative impacts assessments.

6.5.1 Current and Recent Efforts

Several projects are underway or recently concluded that address development of new models or statistical frameworks relevant to bats. These include:

Motus Position Estimation. In an upcoming project, the Biodiversity Research Institute and University of Rhode Island (URI) will be working on Motus position estimation modelling, with the goal of developing a more accurate and effective method for estimating positions of tagged animals, based on signal strength and series of detections at one or more Motus towers/antennae. While this effort is focused on tagged birds, this should also be informative for tagged bat species.

Efficient Curtailment Regimes. "Smart" curtailment systems incorporate algorithms that allow for cost-efficient operational curtailment regimes, which can reduce risk of bat collisions while also minimizing energy production losses due to curtailment. These algorithms and technologies are currently being developed in terrestrial environments, but could be adapted for offshore use if need be. One summary presentation of the various projects supported through recent U.S. Department of Energy funding is available from Tethys (https://tethys.pnnl.gov/events/new-research-smart-curtailment-bats-wind-energy-facilities-supported-us-department-energy), but more recent individual updates are also available.

Estimating Population-Level Impacts. Determining whether collision fatalities are likely to have population-level impacts on bat species can be difficult due to lack of knowledge about their current population sizes, as well as survival and fecundity metrics. Several recent analyses have provided statistical frameworks to evaluate potential impacts of land-based wind fatalities on Hoary Bat populations (Frick et al. 2017[18], Friedenberg and Frick 2021[19]). It would be valuable to agree upon a common framework for risk assessments to bat populations in the onshore and offshore environment, including thresholds for implementing mitigation.

6.5.2 Recommended Science Actions

- ***Review existing frameworks and adopt a common framework to evaluate population-scale risks of wind collision mortality to bats in terrestrial and offshore environment.*** *Concerns about cumulative effects of wind development are widespread, but these concerns are not always clearly defined. Defining a clear framework for assessing and addressing these effects and identifying thresholds for intervention would be beneficial.*

[18] https://doi.org/10.1016/j.biocon.2017.02.023
[19] https://doi.org/10.1016/j.biocon.2021.109309

6.6 Optimizing research, monitoring, and mitigation

This section includes activities related to optimizing research, monitoring, and mitigation efforts within a given study, at a regional scale, and/or across different types of science and conservation activities. Different types of research and monitoring methods have varying costs and types of data they provide; some expensive research methods may be worth the cost if they provide valuable data, while others may not be worth the extra expense. As discussed in the Technology portion of the RWSC Science Plan, there is a need to identify metrics to track efficacy and efficiency of different monitoring methods.

As discussed in Section 5, the timeline for offshore wind development means that mitigation for potential impacts of offshore wind development will need to occur at the same time that monitoring to assess impacts is taking place. In some circumstances, making the assumption that impacts are occurring and mitigating for those impacts may be more cost-efficient than determining exact impacts in a detailed and precise manner.

Some optimization efforts are currently underway. One example of a recent optimization effort is the new "IDIOMS" tool, which helps to optimize site-specific Motus study designs at offshore wind energy facilities. This tool was designed with birds in mind, but this general approach could also be considered in developing tower layout and sampling regimes relevant to bats.

Recommended Science Actions

Recommended science actions in this category include:

- ***Develop a guidance document on different bat research methods****, summarizing the costs and benefits of each in terms of types and quality of data collected, effort required, and financial costs.*
- ***Conduct a cost-benefit analysis to determine the value of monitoring for bat collisions*** *as compared to assuming collisions will occur based on acoustic activity and implementing mitigation in the form of curtailment.*
- ***Evaluate the relative costs and benefits of conducting more centralized deployment of Motus infrastructure and automated telemetry tags*** *(see Section 6.8).*

6.7 Technology advancement

6.7.1 Current and Recent Efforts

Collision Detection Systems

Some collisions between bats and wind turbine blades are inevitable. Effective collision detection technologies would be of great value in understanding the frequency of collisions and affected species, as well as timing, meteorological conditions, and turbine operational status associated with collisions. If monitoring efforts determine that collisions are occurring with frequency sufficient to affect species at the subpopulation or population level, or are occurring for protected species, collision mitigation efforts may be necessary. Effective collision detection technologies would also aid in assessing the efficacy of any implemented mitigation measures.

In terrestrial systems, collisions have primarily been monitored through carcass surveys for injured or killed bats under and around wind turbines. More recently, alternative collision detection systems, utilizing thermal and visual cameras, acoustic detectors for species ID, and sensors to monitor for small impacts to turbine blades have begun to be developed and tested at land-based facilities (e.g., see Hu et al. 2017[20]). These systems are not yet widely commercially available, but development of commercial technologies is a near-term goal. Collision detection systems have also begun to be designed and evaluated for their potential use in the offshore environment (Dirksen 2017[21], Good and Schmitt 2020[22], Albertani et al. 2022[23]).

In the offshore environment, it is currently challenging to estimate fatalities or validate collision detection systems. The standard land-based practice of carrying out carcass surveys is, of course, not effective in the offshore environment, where carcasses would quickly sink into ocean waters. Collision detection technologies would therefore be of great value in assessing and addressing impacts of offshore wind development, and of interest and concern to the RWSC Subcommittee. However, it currently is most appropriate to develop and test these technologies in terrestrial environments, because validation and data/equipment access are both more feasible at land-based facilities.

Field and analysis efforts to inform proxies for collisions are detailed in the field research section (6.8) and elsewhere.

Artificial Intelligence for Species Identification

Use of artificial intelligence to identify acoustic detections of bats can significantly speed up processing time, reduce costs, and potentially increase accuracy. A number of auto-classifiers for bat acoustic data exist (BCID, Kaleidoscope Pro, Sonobat, Echoclass), but these could be improved upon (see Khaligifar et al. 2022[24]). Manual identification of calls is still common – a practice that is not easily scalable.

Integration of Wildlife Monitoring/Mitigation Equipment with Wind Turbines

As discussed in Section 6.1, through funding from the National Offshore Wind R and D Consortium, BRI and Advisian are reviewing wildlife monitoring technology and needs for incorporating equipment into turbines. Successful integration of this equipment with offshore platforms will require further coordination with turbine manufacturers and, ideally, development of a standard platform for wildlife monitoring equipment.

Improving Remote Data Access Options

As also discussed in Section 6.1, there is a need to improve upon current methods to convey data collected at remote, offshore locations to researchers. For systems deployed on offshore turbines, these data should be transferred via the same fiber-optic cables that carry wind facility operational data. This can be accomplished without compromising proprietary information, but simple, standardized systems need to be developed for conveying and processing these data, and

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[20] https://www.osti.gov/servlets/purl/1766443

[21] https://tethys.pnnl.gov/sites/default/files/publications/Dirksen-2017.pdf

[22] https://tethys.pnnl.gov/sites/default/files/events/2-WEST.pdf

[23] https://www.osti.gov/servlets/purl/1963218

[24] https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.14280

transferring them to researchers. Allowing for remote data transfer from offshore facilities is much more time- and cost-efficient than physically accessing hardware, allows for close to real-time processing and detection of any faults in equipment, and also reduces safety risks, by reducing the time that personnel need to visit the facility.

For monitoring equipment deployed at remote locations offshore that are not part of an offshore wind facility or close to a fiber-optic connection, further work is also needed to identify the most viable options for deployment.

Improvements in Tag Technology

Satellite, GPS datalogger, and VHF tags are constantly improving, becoming smaller and lighter, and with greater longevity. However, many tags are still too heavy to be deployed on bats or deployed for long periods of time. Development of lighter tags and/or tags with longer range, longevity, and reliability could aid in more efficient and effective data collection. In addition, alternatively powered tags, using accelerometers, for example, could be explored, as an alternative to the slow process of making batteries smaller.

Other

Other technology advancements that the Subcommittee noted would be valuable, but which were not associated with particular action items, include:

- Development of tags that detect additional parameters
- Development of advanced tag attachment techniques (e.g., for lower risk to wildlife, better likelihood of staying on the animal longer)
- Improvements in camera technology, including better quality/higher definition images and video, improvements in thermal imagery, and more cost-effective options
- Weatherization to improve technology's reliability in harsh offshore environments
- Automated tracking of flight paths in videos
- Automated tracking of flight paths in radar

6.7.2 Recommended Science Actions

- ***Coordinate with land-based wind groups to ensure support and funding for land-based validation of collision detection technologies.***
- ***Coordinate with developers of "smart" curtailment technologies and collision detection systems to continue discussions of how they could be adapted for offshore use.*** *(See also Section 6.1 regarding an onshore/offshore bat workshop.) Review how these systems may need to be altered in terms of weatherproofing, data access, relevant species, etc.*
- ***Test collision detection technologies in the offshore environment*** *as soon as it is practicable to do so.*
- ***Continue work on proxy metrics for collision to inform collision risk and curtailment regimes*** *(see other sections of this plan).*
- ***Fund development of USGS software to allow for improved auto-classification of bat species in acoustic data.*** (see Khaligifar et al. 2022[25])

[25] https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.14280

- ➢ ***Begin a dialogue with tag manufacturers to understand expected near-term improvements*** *in technology and current technical/funding challenges for development of advanced tags. Based on these dialogues, consider whether funding of specific tag developments or pilot testing of certain tag technologies would be valuable in the field.*
- ***See recommendations at the end of Section 6.1*** *regarding coordination to integrate wildlife monitoring equipment with offshore turbines and facilitate remote data access.*

6.8 Field data collection

6.8.1 Recent, Current, and Pending Efforts

Motus Network Build-out

Many Motus telemetry stations are already deployed as part of the Motus network – originally along the Eastern Seaboard, and now globally. However, long-term funding for deployment and maintenance of East Coast Motus stations remains a challenge. Land-based systems are currently being upgraded with recent funding, but maintenance and data fees to keep stations running are annual needs that are not always being met with current funding.

Some additional stations have been upgraded or added as part of offshore wind development projects. In 2020, Deepwater Wind installed a wildlife tracking station on the easternmost foundation platform at the Block Island Wind Farm off of Rhode Island. Motus stations were also deployed on the two Dominion CVOW turbine platforms off of Virginia. The Vineyard Wind 1 COP requires installation of Motus receivers on wind turbines within the lease area, as well as upgrades or maintenance of two onshore Motus receivers (see section 5.2 in VW1 COP and Project Easement Approval Letter (OCS-A 0501)**.** Permitting for the South Fork wind project requires installation of Motus receivers at up to four locations within the wind farm and refurbishment of up to two onshore Motus receiver stations near SFWF (e.g., Block Island, Buzzards Bay (see section 5.2 in Conditions of Construction and Operations Plan Approval Lease Number OCS-A 0517. The state of New Jersey has also proactively begun planning for build-out of coastal and offshore stations, including potentially adding nine new or upgraded land-based stations at priority locations, as well as deploying ten ocean buoy-based stations in an east-west line off the coast, extending out to a current buoy station at the corner of the Atlantic Shores Wind lease area. Boat-based and aerial calibration trials are planned in conjunction with at least some of these deployments.

These efforts represent important contributions to expansion and maintenance of the Motus network. However, the system could benefit from a more coordinated and less piecemeal approach towards deployment of Motus stations, in an arrangement that maximizes detection probabilities for focal species of bats and birds. In addition, centralized calibration and maintenance efforts, to ensure stations are functioning and to measure detection ranges systematically, would also be of benefit for scientific rigor and cost savings. In summer 2022, USFWS organized initial meetings among stakeholders to discuss the value of coordinating and possibly centralizing calibration of Motus stations, as well as deployment of both Motus stations and VHF radiotags for automated telemetry in the offshore environment. Phase 1 of the project would include efforts by RWSC to develop a plan for coordination and centralization, incorporating the *Offshore Motus Framework*[26], highlighting subregions/sites and species of interest, proposing a design or framework for optimal or strategic tag deployment, listing key participants (tag project funders, species and land managers, etc.), and describing data standardization practices.

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[26] https://motus.org/groups/atlantic-offshore-wind/

Motus Tag Deployments

Several past studies used Motus tags to evaluate bat movements in coastal areas and offshore along the U.S. Atlantic Coast (see Dowling 2018[27], True et al. 2023, also T. Peterson, personal communication). While Motus tagging studies are being funded, or planned for funding, by developers of Dominion CVOW, Vineyard Wind, and the South Fork Wind project, these projects are currently focused on birds, and do not include any funding dedicated to deployment of Motus tags on bat species.

Passive and Active Acoustics

Past use of acoustics along the Atlantic Coast is summarized in Solick and Newman 2021 (see Section 2.1.3). More recently, boat-based and turbine-mounted acoustic monitoring for bats have occurred at the Block Island Wind Farm, although no results are yet available. In addition, the Dominion CVOW Acoustic and Thermographic Offshore Monitoring system (ATOM) includes acoustic monitoring devices for bats. In the Vineyard Wind COP, the installation of acoustic monitoring devices for bats is required on electrical service platforms (ESPs), although not on turbines. Per the South Fork COP, acoustic monitoring devices for bats must also be installed, in this case, on offshore substations (OSS).

Deployment of acoustic detectors for bats on offshore turbine nacelles would be of great value to address collision risk and potential curtailment parameters, as highlighted in Section 5, but these must be deployed in proximity to local weather stations to maximize the value of collected data. Pilot studies are needed to understand how best to deploy detectors in the offshore environment. In addition, a greater understanding of baseline conditions and onshore-to-offshore gradients of bat activity could be accomplished through additional mobile transects using vessels.

Turbine-Mounted Cameras

Turbine-mounted cameras are relatively new technologies, but both operating wind facilities in the RWSC Study Area have deployed them. The Block Island wind farm is using cameras to assess nocturnal flight and collision risk in years one, three, and five of operation. This project is focused on assessing bird risks, but could also provide data relevant to bats. The Dominion CVOW project's upgraded ATOM system includes two thermographic cameras operating in stereo to permit flight height calculations and document bat and bird activity in the rotor-swept zone.

6.8.2 Recommended Science Actions

- ***Develop a plan to coordinate and possibly centralize calibration of Motus stations, deployment of Motus telemetry stations, and Motus tagging efforts.***
- ***Deploy Motus stations in conjunction with local meteorological stations*** *to assess weather conditions (e.g., wind speed, precipitation, pressure) under which bats are active near wind facilities). Wind facility weather stations should be sufficient if present, otherwise, stand-alone stations are needed.*

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[27] https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=2439&context=dissertations_2

- ***Identify feasible capture locations for focal bat species** by soliciting feedback from Bat Working Groups along the coast.*
- ***Deploy Motus tags on migratory tree bats** (Hoary Bats, Silver-haired Bats, Eastern Red Bats) to evaluate patterns of movement during the late summer-fall migration season.*
- ***Deploy Motus tags on Little Brown Bats and Northern Long-eared Bats** in coastal areas and on islands in late summer to evaluate dispersal from maternity colonies to swarming or overwintering sites.*
- ***Coordinate with vessels already active in areas of interest to conduct mobile acoustic surveys** documenting coastal to offshore gradient of bat activity. Conduct a review of relevant vessels (e.g., NOAA, Coast Guard, state, offshore wind vessels) to understand patterns of activity and identify appropriate vessels for mobile survey deployment.*
- ***Work with states and Bat Working Groups to deploy passive acoustics on islands and at coastal sites** to understand patterns of coastal bat activity.*
- ***Deploy passive acoustic systems on offshore infrastructure**, including buoys, meteorological towers, and other infrastructure, as available.*
- ***Conduct pilot studies at installed turbines to test and evaluate appropriate deployment methods for bat acoustics offshore**. Develop guidance based on these field tests.*
- ***Conduct year-round acoustic monitoring of bat activity at turbine nacelles** once installed. These data must be collected with contemporaneous meteorological and turbine status data (to inform potential curtailment). Local meteorological data could be collected from offshore wind facility weather stations (if available) or stand-alone stations may need to be installed.*
- ***Deploy turbine-mounted thermal/infrared cameras** pointed towards the rotor-swept zone to assess bat behavior in the vicinity of turbines and monitor for potential collisions.*

7 Subregion considerations regarding bats and offshore wind

RWSC's work covers U.S. Atlantic waters, within the context of five subregions (as outlined in detail in Section 2). Many of the current research activities within the RWSC Study Area are occurring across multiple subregions. In addition, most of the relevant research questions and future science needs relevant to bats are applicable across most or all of the RWSC Study Area. With that said, there are subregional differences which are highlighted here.

There are notable geographic differences in the topography of the Maine coast– its many islands, peninsulas, and inlets lead to changes in movement and migration patterns that may be distinct from those elsewhere in the RWSC Study Area. Bat species that might be considered as occurring primarily close to land sometimes roost on and forage in the vicinity of islands, which can be located far from shore. This can mean species that would not be likely to frequently encounter offshore wind facilities located in federal waters in other subregions may be in closer proximity to these facilities in the Gulf of Maine.

Species distributions, abundance, and seasons of occurrence of course also vary broadly across the five subregions, with species variously occurring, breeding, or overwintering only in one or several subregions. Given the anticipated heightened risk to migratory bats during their fall migration season, it may make sense to focus tagging efforts in northern subregions of the RWSC Study Area, so that as much of southward migratory movements can be captured as is possible. In addition, because bat capture rates can be low, opportunistically sampling and tagging bats at known successful capture sites is likely preferable to sampling in a more random, statistically sound framework. The state listing status of a species and associated level of conservation concern may also vary by state; this status is important to consider from a regulatory and logistical perspective.

Perhaps of greatest relevance is the timeline of offshore wind development across the five subregions. To date, small projects (of five and two turbines respectively) have been installed and are operating in the Southern New England and U.S. Central Atlantic subregions. These are the first sites where bat monitoring equipment can be deployed on turbines, where this equipment can be tested for reliability, and where preliminary data can begin to be collected. Three large-scale offshore wind facilities of 130-800 MW are planned to begin commercial operation in the Southern New England subregion in 2023 and 2024, with four additional projects scheduled for 2025. In the U.S. Central Atlantic, the first large-scale project (250 MW) is expected for 2024, with three projects (combined capacity of 1770 MW) to follow in 2026. The first large-scale projects in the New York/New Jersey Bight are projected to begin commercial operation in 2025 (1,100 MW) and 2026 (800 MW). In the Gulf of Maine subregion, meanwhile, only one pilot-scale project has been identified, which should begin operation in 2024. In the U.S. Southeastern Atlantic, commercial operation dates have not yet been estimated. Given this pattern of roll-out, studies on the impacts of large-scale offshore development on bats will inevitably begin in the middle three subregions of the study area. In the other two subregions, there will be more time to coordinate field research plans and collect baseline data.

Chapter 10: Sea Turtles

Note: Scientific and ecological terminology and agency/organization acronyms are used throughout this chapter. An Appendix of Definitions and Acronyms is included at the end of the chapter.

1 Executive Summary

This chapter describes individual ongoing and pending (funded but not yet contracted/awarded/started) data collection and research initiatives related to offshore wind and sea turtles. The projects are funded by a variety of partners (states, federal agencies, industry, eNGOs). For an always up-to-date list of active projects, visit the RWSC Offshore Wind & Wildlife Research Database. Given this ongoing work, the Sea Turtle Subcommittee is making recommendations for additional research and coordination that is both aligned with existing efforts and that fills important gaps. Three significant concerns of the Sea Turtle subcommittee regarding existing and pending research on sea turtles and offshore wind were:

1) Sea turtles are the only protected species group where there are almost no impact data available from existing wind installations. They may also represent the most abundant ESA listed species that will be affected by OSW off the US Atlantic, especially in the US Central Atlantic. As such, the Subcommittee believes that sea turtle-specific studies should be prioritized as soon as possible to better understand the potential impacts of offshore wind construction and operation. Research designs for these studies should be tailored to detect and understand potential effects on sea turtles specifically, with other wildlife data to be collected ancillary to the target species.
2) Some of the ongoing/pending projects that list sea turtles as a species group of interest are not specifically designed to collect sea turtle data. Numerous field studies may detect turtles but the target species are marine mammals, fishes, or birds (e.g. high altitude aerial surveys for whales, acoustic receiver deployments without additional tags deployments on sea turtles, high definition imagery for birds in areas/seasons when sea turtles may be observed, etc.) and it is unclear how/whether sea turtle data will be analyzed for these projects. Some technological development projects list sea turtles as a target taxon group and may assist with advancement of turtle studies, but the project description focuses on other species (e.g. AI to applied to high definition aerial imagery for birds, eDNA analyses for baleen whales). Thus, a number of the projects listed as sea turtle projects may not provide much needed data, protocols or models useful in advancing sea turtle science. Studies where the Subcommittee is unsure of the overall contribution to sea turtle science are marked with an * in the tables throughout the Chapter.
3) It appears that there is little voluntary sea turtle monitoring and data collection associated with the imminent offshore wind projects in the U.S. Central Atlantic region (CVOW and Kitty Hawk North). Yet, these areas are likely to have 1) higher turtle densities of most species, 2) longer seasonal sea turtle occurrence and 3) active breeding and nesting adults compared with projects to the north. In addition,

restrictions on turbine construction activities designed to avoid times when critically endangered right whales will mean that construction will occur when densities for sea turtle species in this area are highest. Thus, the subcommittee recommends that there is a need to fund sea turtle impact studies around specific projects south of the NY/NJ Bight subregion such as the CVOW and Kitty Hawk North development areas and areas adjacent to these projects including vessel corridors.

Additional concerns identified by the subcommittee include:

- The lack of baseline knowledge of sea turtle species, which have a very different life history, compared to other species groups, plays into sea turtle risk assessments and adds potential for more unexpected results, compared to other wildlife impacted by OSW. Without risk assessment specific to sea turtles, unidentified impacts cannot be assessed or mitigated with enhanced monitoring and adaptive management
- For several reasons, most aerial surveys used for marine species abundance estimation do not detect smaller turtles (<40cm carapace length), and there is an overall lack of understanding of availability and perception bias for sea turtle detections. Providing funding and effort to better understand which turtles are being detected under what conditions, developing small turtle abundance estimates for green and Kemp's ridley turtles, and developing robust surface time estimates for all sea turtle species, in all subregions and seasons is critical for developing baseline abundance of sea turtle species. Without this basic knowledge, assessing and mitigating effects of OSW on sea turtles will be extremely difficult
- Some effects of OSW development on sea turtles, both individually and at population levels, are likely to be indirect, cumulative, synergetic, and difficult assign to a single cause. Disentangling the effects on sea turtles of climate change from any potential effects of OSW will be a challenge

The research topics and recommendations below consider the status and trends of sea turtle populations in the U.S. Atlantic Ocean, the available regional scale distribution information, and potential impacts related to offshore wind development. For the purposes of this section, the topics are organized by RWSC Research Themes, which are used throughout this Plan. For the research topics listed below, there are potentially many detailed, related questions, hypotheses, and approaches that could be used to address each. Recommendations are described in detail throughout each section of this chapter and are summarized in the table below.

RWSC Research Theme	Research Topic	Sea Turtle specific Recommendations
Mitigating negative impacts that are likely to occur and/or are	Understand increases in vessel traffic from construction and maintenance of offshore wind projects and develop vessel & sea turtle co-occurrence models to	Inform models with information from the offshore wind industry regarding vessel types and numbers. Validate models with AIS and effort-corrected sea turtle sightings data from a variety of sources

RWSC Research Theme	Research Topic	Sea Turtle specific Recommendations
severe in magnitude	determine risk and vulnerability to lethal and non-lethal vessel strike	Investigate sea turtle carcass drift to understand the likelihood of detecting sea turtle mortality that occurs in the vicinity of OSW vessel paths & development by coastal stranding networks Investigate other means of investigating sea turtle vessel strikes drift such as tag deployment on reported carcasses
	Assess surface and subsurface entanglement risks associated with static and floating offshore wind	With additional data collection in the RWSC study area, build off existing simulation modeling funded by BOEM and other efforts for NARW and leatherbacks to incorporate all sea turtle species to better understand entanglement risk Assess the effects of floating turbines in Sargassum habitat and the potential effects on post-hatchling dispersal stage turtles Explore the possibility of entrainment in subsurface rotors that may be used on floating turbines for sea turtles of various sizes and life stages (post-hatchling - small juvenile) Assess risk of sea turtle ingestion of and entanglement in debris and gear associated with subsea turbine structure
	Advance Population Consequences of Disturbance (PCoD) and Population Consequences of Multiple/cumulative Stressors modeling	Incorporate sea turtle–specific modeling to include thermal (and other) stressors related to climate change
	Mitigate impacts on regional scientific surveys	NMFS Long-term protected species, fisheries, and ecosystem surveys form the backbone of the scientific monitoring system needed for the management of wildlife, fisheries, habitats, and ecosystems. In order to understand potential changes in wildlife and habitats from offshore wind energy development--it is critical that long-term standardized surveys continue to provide timely, accurate, and precise data on wildlife, habitats, and ecosystems. The need to fully implement the NMFS and BOEM Survey Mitigation Strategy and review the strategy to more directly affect sea turtle survey needs is critical to putting site and regional level studies in the context of population trends and ecosystem conditions. The Strategy calls

RWSC Research Theme	Research Topic	Sea Turtle specific Recommendations
		for the development of a Northeast Survey Mitigation Program. This largely unfunded strategy should be fully funded and be a significant priority for the region as well as for the Atlantic waters of the Southeast region.
Detecting and quantifying changes to wildlife and habitats	Develop biologically important areas for sea turtles in the Atlantic by species, life stage and season	Enhance and expand abundance estimation, surface density estimates and habitat modeling and known threats (mortality and serious injury) using all appropriate forms of turtle occurrence data, including, but not limited to, verified sightings, strandings, bycatch data and prey distribution to determine biologically important areas for each sea turtle species
	Collect additional information on distribution, abundance, behavior, health, foraging, vertical water column use, surface time, and movement patterns of sea turtles than can be used to develop and refine species density models with new observational data (through AAPPS and other efforts)	Increase level of regional-scale sea turtle species data collection including both surveys and at sea tagging through AMAPPS and US Navy projects
	Improve information on distribution, abundance, behavior, health, foraging, vertical water column use, surface time, and movement patterns of sea turtles than can be used to develop and refine species density models with new observational data (through AAPPS and other efforts)	Develop, test, and ground truth aerial survey detection parameters, methods, and protocols for all sea turtle species, size ranges in varying conditions (sea state, turbidity, etc.) Continue to develop and test safe, long-term (5 years or more), external attachment and/or internal insertion methods for acoustic sea turtle tags in field and rehab settings Develop a better understanding of surface time especially for small turtles and determine both the best use of existing technology and needs for technology development for surface time estimates Work with permitting agencies (NMFS & USFWS) to acquire region-wide permits in support of OSW wind research, testing new tags/tagging techniques for both stranded/rehabilitated and wild turtles
	Above topic continued	Employ recommendations by NMFS to enhance AMAPPS sea turtle abundance estimates listed in Schroeder et al. 2020, especially detection studies of

RWSC Research Theme	Research Topic	Sea Turtle specific Recommendations
		all sea turtle species and sizes in a variety of conditions. Conduct a synthetic baseline assessment of sea turtle abundance/availability data over the past decade and projected into the future that determines and prioritizes what additional data are needed and integrates density modeling and/or visual survey data, tagging data, oceanography/habitat data, and climate data to characterize pre-development levels of spatial and temporal variability to determine best wind installation location(s) and experimental design(s) to assess impacts Create research design for development of abundance models similar to (or equivalent with) Winton et al. 2018 and availability analyses similar to Hatch et al. 2020 for other species. Include review of existing sat tag data, including historic data, for species other than loggerhead turtles for possible inclusion in future analyses Conduct power analysis and experimental design development focusing on using multiple methods to detect changes to abundance, distribution, and behavior on one or more sea turtle species in each subregion
	Understand the impacts of warm water effluent from proposed sub-surface sub-stations and develop recommendations for future placement and mitigation	Model and/or test the effect of warm water effluent from proposed HVDC substations on the habitat where sea turtles may co-occur
	Develop a better understanding of post hatchling dispersal stage habitat use in the NW Atlantic for all sea turtle species	Deploy tags on post-hatchling dispersal stage turtles in the NW Atlantic with drifters co-deployed Model effects of floating turbines on Sargassum and post-hatchling dispersal where they may co-occur
Understanding the environmental context around changes to wildlife and habitats	Work with the Habitat & Ecosystem Subcommittee to ensure that key oceanographic and habitat data are collected and available as data products for use in sea turtle studies	
	Monitor and map the distribution and abundance of sea turtle prey species including benthic invertebrate, pelagic and neritic gelatinous species, incorporating	Incorporate historic prey distribution/abundance into analyses to assist with understanding and separating the role of climate change from OSW impacts

RWSC Research Theme	Research Topic	Sea Turtle specific Recommendations
	past and future forecasting with environmental correlates.	
Determining causality for observed changes to wildlife and habitats	Determine the best experimental design and methodology for assessing whether construction activities displace or attract sea turtles	Conduct a study optimization analysis of effort required (tag and survey) to assess impacts to turtle species for each wind energy area to determine where impact assessment efforts will most likely be successful for each species
	Determine whether offshore wind structures displace or attract sea turtles (reef effects) for future impact assessment	Conduct a study optimization of the best species, areas, and seasons to assess changes in turtle distribution where reef effects are simultaneously monitored Conduct research to examine behavioral responses to OSW construction, operation, and removal using results of optimization study (e.g., controlled exposure study, visual monitoring of distribution before, during, and after construction, etc.)
	Understand effects of EMF on in-water and nesting/hatching sea turtles	Study how sea turtle species and their prey detect/receive EMF, whether they respond to EMF (from both AC and DC cables) with changes in distributions or behavior, and whether those responses vary with factors such as EMF strength, cable burial depth, location (land, shallow, deep water) and floating/fixed technology
	Improve our understanding of sea turtle hearing and physiological responses (e.g., hearing loss, stress) to OSW noises by species and life stage including impact of noise created by OSW construction and operation	Continue and expand research to determine the impacts of OSW on hearing and physiological responses.
	Conduct impact studies designed for sea turtle species in the vicinity of wind projects currently being developed.	Design, plan, fund and conduct, long-term, small-scale studies specifically designed to determine effects on sea turtle species using multiple methodologies in the vicinity of wind projects currently under development in the SNE, NY/NJB and CA regions. Tailor studies to take advantage of each subregion’s development timeline and unique sea turtle occurrence. Build on knowledge from each study to optimize results for future studies
Enhancing data sharing and access	Coordinate data collection and synthesis of existing data efforts at a regional scale including baseline	Synthesize sea turtle nesting data (minimally number of nests & crawls), by species for Atlantic coast nesting

RWSC Research Theme	Research Topic	Sea Turtle specific Recommendations
	data, population monitoring, data collected at individual OSW project sites (e.g., post-construction monitoring data), and long-term monitoring efforts (e.g. stranding and nesting data). Coordination also includes linking efforts across groups (e.g., researchers, developers, state and federal agencies) and pooling data to have the statistical power to examine regional-scale effects.	beaches in a combined searchable format for future analyses Coordinate and initiate collaborations with additional partners to facilitate data and information sharing, including the Sea Turtle Stranding and Salvage Network, organizations conducting sea turtle nest monitoring, sea turtle rescue organizations operating under USFWS permits and authorization as well as satellite, acoustic and other tag data Collaborate with the Protected Fish Species Subcommittee and other fish scientists and other acoustic telemetry users to implement a long-term archival acoustic detection network in the NW Atlantic Ocean, following sea turtle optimization analysis to guide future detector and tag deployments Work with the sea turtle research and rescue community to determine whether development of a cache of tags suitable for sea turtles (acoustic and satellite) would assist organizations that have needs for a small/unpredictable number of tags for deployment Work with the sea turtle research and rescue community to determine whether the use of a data portal (similar to a combination of seaturtle.org & movebank) would facilitate collaborative tagging studies, especially for determining surface time Work with USFWS & the stranding networks to apply for regionwide rehab turtle tagging permit in support of offshore wind research Work with NMFS & USFWS to encourage acceptance of internal acoustic tagging with SOP
	Create an accessible inventory of all historic and ongoing tracking projects for sea turtles to encourage a coordinated approach to making research results compatible, available, and applicable in Marine Spatial Planning, particularly concerning OSW energy development.	Determine the best method of developing an inventory of and access to satellite/GPS tags historically deployed on sea turtles for future collaborative studies. Include tag type, deploy location, species, size, turtle source (wild/rehab/bycaught), days at large and general location and determine appropriate time frame for inventory Compile historic sea turtle acoustic tag IDs from NW Atlantic for detection database searches with emphasis on attachment type and minimum tag retention time

RWSC Research Theme	Research Topic	Sea Turtle specific Recommendations
		Convene a working group for sea turtle tag data compilation. Make use of professional assistance, managers and programmers of existing portals with data agreements, portal development/renovation and incentives for researchers to participate
	Develop a centralized publicly accessible data repository for OSW-related data including baseline surveys, acoustic telemetry data, and benthic monitoring data to promote transparency, prevent duplication of effort, and aid in the development of collaborations. This data can be used to inform all aspects of the decision-making process.	
	Improve acoustic telemetry use for sea turtles	Work with USFWS & the stranding networks to apply for regionwide rehab turtle (satellite & acoustic) tagging permit in support of offshore wind research Work with NMFS & USFWS to encourage acceptance of internal acoustic tagging with SOP Develop or adjust existing BMPs for acoustic tag and receiver deployment, detection studies, and data archiving and analysis for sea turtle research Conduct outreach with sea turtle rehab and research use on use acoustic tags and portal options Coordinate receiver location coast-wide with other stakeholders to optimize sea turtle data collection
	Develop eDNA SOPs and BMPs for sea turtle detection and indices	Develop and test eDNA assays/surveys/sampling regimes for use developing indices of occurrence/abundance, including testing the effect of carcasses in the environment on eDNA detection

1 Sea turtle species in the RWSC study area

All sea turtles in the U.S. are federally protected by the Endangered Species Act (ESA) and most states adopt the federal status for management purposes. In the U.S., sea turtles in water (foraging, migrating, oceanic dispersal, mating, disentanglement and stranding response) are managed federally by NOAA Fisheries[1] and on land (nesting, rehabilitation and captive display) by the U.S. Fish and Wildlife Service[2].

Sea turtles have a unique life history. They are generally long lived and, besides eggs and hatchlings, only adult females spend a brief period on beaches while nesting. For all six species found in U.S. waters combined, sea turtles can be found in the northwest Atlantic from shallow coastal waters, including brackish and inshore bays, sounds and river mouths to offshore pelagic waters. Collectively sea turtles may be the ESA listed species most commonly affected by offshore wind. They range in size from <10cm Kemp's ridley hatchlings to >2m adult leatherbacks. In the oceanic dispersal stage they feed in surface waters often associated with floating algae such as sargassum, as larger juveniles-adults, diets range from herbivorous adult green turtles to leatherbacks feeding primarily on gelatinous prey to Kemp's ridley and loggerhead turtles that feed primarily on benthic crustaceans and mollusks.

In the U.S. Atlantic, sea turtles are migratory in temperate and northern sub-tropical areas and may live in relatively static or seasonally shifting home ranges in sub-tropical and tropical waters depending on the species and habitat.

On the U.S. Atlantic coast, loggerhead and green turtles regularly nest from Florida to North Carolina. Loggerheads nesting in the U.S. belong to the NW Atlantic DPS, and greens belong to the N Atlantic DPS. Small numbers of loggerheads annually nest in southeastern Virginia and occasional nests of both species have been reported north of Virginia. In the same region, leatherback turtles in the NW Atlantic DPS nest primarily in Florida and numbers have fluctuated at index beaches but have generally increased since the late 1980s[3]. Occasional Kemps ridley and hawksbill turtles nest on the U.S. Atlantic coast, hawksbills in Florida and Kemp's ridleys from FL to VA. Extralimital nesting outside of known nesting areas have been documented for all turtle species.

There is no parental investment after a nest is laid and hatchlings emerge from nests, make their way to the water and swim frenetically until they reach offshore habitat where they spend several years to over a decade in an oceanic dispersal stage. For northwest Atlantic green and loggerhead turtles, we believe this life stage is spent primarily in the Gulf Stream and Sargasso Sea. Little is known about NW Atlantic leatherbacks in the oceanic dispersal stage. Most Kemp's ridleys nest in the Gulf of Mexico and some of these turtles exit the Gulf and are dispersed into the northwest Atlantic most likely via the Gulf Stream.

Healthy juvenile through adult life stage sea turtles are considered 'surfacers' instead of 'divers' meaning that most of their time is spent below the surface, and, with a couple of exceptions, they only come to the surface briefly to breathe (Kooyman 2012)[4]. One exception to this mostly subsurface lifestyle is basking behavior which has been exhibited by loggerhead turtles on the outer continental shelf, mostly in the spring months as they are migrating north to summer

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[1] https://www.fisheries.noaa.gov/sea-turtles#overview
[2] https://usfws.medium.com/protecting-sea-turtles-coast-to-coast-e443518576f1
[3] https://myfwc.com/research/wildlife/sea-turtles/nesting/nesting-atlas/
[4] https://link.springer.com/book/10.1007/978-3-642-83602-2

foraging areas (Hochscheid *et al.* 2010)[5]. Post-hatchling turtles in the dispersal phase (Phillips 2022)[6] also appear to spend most of their time in the top several meters of the water column.

Movement from the oceanic dispersal life stage to the juvenile-adult neritic life stages occurs at different age and size for loggerhead, green, and Kemp's ridley turtles. Little is known about leatherback distribution from hatchling to sub-adult life stages.

Because their behavior and distribution varies among life stages, the Science Plan will address research priorities by species, life stage and subregion (Table 1). Thus, for the remainder of this document, sea turtle life stages will be defined as:

Egg/hatchling – for the conservation purposes of the RWSC, we are combining incubating egg in nests with hatchling emergence and swimming frenzy; beach phase including incubation, emergence & swim frenzy that results in arrival in offshore pelagic habitat.

Juvenile dispersal – 'lost years' life stage, post-hatching dispersal where turtles are near the surface, in open water. Off the U.S. Atlantic coast these small turtles are thought to be distributed primarily in the Gulf Stream and Sargasso Sea. Little is known about the dispersal life stage for leatherback turtles, and this life stage primarily occurs in the Gulf of Mexico for Kemp ridley turtles (Phillips 2022).

Juvenile-subadult (post dispersal)– foraging phase of sexually immature turtles (neritic habitat for Kemp's ridley, green and loggerhead turtles in the NW Atlantic; pelagic and neritic for NW Atlantic leatherbacks), characterized in some species and subregions by north/south and/or inshore offshore seasonal migrations or seasonally shifting home ranges.

Adult – sexually mature; loggerheads nest in the Central Atlantic and Southern Atlantic subregions, green and leatherback turtles almost exclusively in the Southern Atlantic, occasional nests of all species are found outside normal nesting areas. Females of most populations have an inter-nesting period of >1 year. Non-breeding and post-breeding/nesting adults may behave seasonally much like juveniles and sub-adults. Tracking data suggest foraging occurs outside of nesting areas in post-nesting females.

[5] https://journals.biologists.com/jeb/article/213/8/1328/10182/When-surfacers-do-not-dive-multiple-significance
[6] https://stars.library.ucf.edu/etd2020/1428/

Table 1: Sea turtle species and life stage covered by this plan by subregion (UN=unknown, NA=not applicable, Winter=Jan-Mar, Spring=Apr-Jun, Summer=Jul-Sep, Fall=Oct-Dec).

Gulf of Maine

Species	ESA Status	Life stage(s)					Annual occurrence	Habitat use	Seasonal timing
		egg/ hatchling	oceanic dispersal	juvenile-subadult	adult	nesting females			
leatherback	endangered	NA	UN	✓	✓	NA	common	neritic & pelagic foraging	spring-fall
loggerhead	threatened	NA	NA	✓	✓	NA	common	neritic foraging	spring-fall
Kemp's ridley	endangered	NA	NA	✓	NA	NA	UN	neritic foraging	summer-fall
green	threatened	NA	NA	✓	NA	NA	rare	neritic foraging	summer-fall

Southern New England

Species	ESA Status	Life stage(s)					Annual occurrence	Habitat use	Seasonal timing*
		egg/ hatchling	oceanic dispersal	juvenile-subadult	adult	nesting females			
leatherback	endangered	NA	UN	✓	✓	NA	common	neritic & pelagic foraging	spring-fall
loggerhead	threatened	NA	NA	✓	✓	NA	common	neritic foraging	spring-fall
Kemp's ridley	endangered	NA	NA	✓	NA	NA	UN	neritic foraging	summer-fall
green	threatened	NA	NA	✓	NA	NA	UN	neritic foraging	summer-fall

New York Bight

Species	ESA Status	Life stage(s): egg/ hatchling	oceanic dispersal	juvenile-subadult	adult	nesting females	Annual occurrence	Habitat use	Seasonal timing
leatherback	endangered	NA	UN	✓	✓	NA	common	neritic & pelagic foraging	spring-fall
loggerhead	threatened	NA	NA	✓	✓	NA	common	neritic foraging	spring-fall
Kemp's ridley	endangered	NA	NA	✓	NA	NA	common	neritic foraging	summer-fall
green	threatened	NA	NA	✓	NA	NA	UN	neritic foraging	summer-fall

Central Atlantic

Species	ESA Status	Life stage(s): egg/ hatchling	oceanic dispersal	juvenile-subadult	adult	nesting females	Annual occurrence	Habitat use	Seasonal timing
leatherback	endangered	NA	UN	✓	✓	NA	common seasonally	neritic & pelagic foraging, migration	spring-fall
loggerhead	threatened	UN	UN	✓	✓	NA	common seasonally	neritic (& pelagic?) foraging, migration, nesting	spring-fall
Kemp's ridley	endangered	NA	NA	✓	NA	NA	common seasonally	neritic foraging, migration	spring-fall
green	threatened	NA	NA	✓	UN	NA	common seasonally	neritic foraging, migration, nesting	summer-fall

Southern Atlantic

Species	ESA Status	Life stage(s): egg/ hatchling	oceanic dispersal	juvenile-subadult	adult	nesting females	Annual occurrence	Habitat use	Seasonal timing
leatherback	endangered	✓	✓	✓	✓	✓	common	neritic & pelagic foraging, migration, nesting	year round
loggerhead	threatened	✓	✓	✓	✓	✓	common	neritic (& pelagic?) foraging, migration, nesting	year round
Kemp's ridley	endangered	NA	UN	✓	UN	NA	common	neritic foraging, migration	year round
green	threatened	✓	UN	✓	✓	✓	common	neritic foraging, migration, nesting	year round

Table 2: Sea turtle occurrence by species and life stage with relevant inshore and offshore boundaries of the RWSC Science plan for sea turtles (Dc=leatherback, Cc=loggerhead, Lk=Kemp's ridley, Cm=green, Ei=hawksbill, Y=yes, N=no, UN=unknown, NA=not applicable). Descriptions of life stages are in the XX section [ADD LINK].

RWSC Subregion	Species & Life stage(s)					Activity/behavior			Boundaries	
	Dc	Cc	Lk	Cm	Ei	Foraging & migrating	Oceanic dispersal	Mating & nesting	Inshore	Offshore
Gulf of Maine	juvenile-adult	juvenile-adult	juvenile-sub-adult	juvenile-sub-adult	NA	Y	N	N	Including Cape Cod Bay and Bay of Fundy, both likely to have increased vessel traffic from offshore wind	400m isobath
Southern New England	juvenile-adult	juvenile-adult	juvenile-sub-adult	juvenile-sub-adult	NA	Y	N	N	ports with turtle presence likely to have increased vessel traffic from offshore wind (New Bedford, MA, others?)	100m isobath
New York Bight	juvenile-adult	juvenile-adult	juvenile-sub-adult	juvenile-sub-adult	NA	Y	N	N	Long Island sound and NY harbor	100m isobath
Central Atlantic	juvenile-adult	hatchling-adult	juvenile-adult	juvenile-adult	NA	Y	Y	Y	Including Delaware Bay and Chesapeake Bay as well as nesting beaches near cables	2,600m isobath
Southern Atlantic	hatchling-adult	hatchling-adult	juvenile-adult	hatchling-adult	NA	Y	Y	Y	Including ports of Wilmington & Beaufort NC, Charleston SC, Brunswick, GA, Cape Canaveral FL); nesting beaches near onshore cables	50m isobath

1.1 Focal species and notable recent trends

Because there are only five sea turtle species that can be found off the United States Atlantic coast: 1) loggerhead[7] (*Caretta caretta*), 2) green[8] (*Chelonia mydas*), 3) leatherback[9] (*Dermochelys coriacea*), 4) Kemp's ridley[10] (*Lepidochelys kempii*), and 5) hawksbill[11] (*Eretmochelys imbricata*), the first four species, which occur consistently in the RWSC study area, are considered focal species for this chapter. The first three species regularly nest on U.S. Atlantic coast beaches, and the other two occasionally nest on U.S. Atlantic beaches. Table 1 indicates that the sea turtle species, occurrence, and life stages in the RWSC study that will be considered in this plan by sub-region. Of the five species that occur in the NW Atlantic, the plan will cover four of them, all but hawksbill. Sea turtles occur from inshore bays and river mouths to pelagic waters and use habitats in different ways during their life stages. Table 2 indicates the life stage and behavioral states of the species considered under the plan as well as the estimated inshore and offshore boundaries of the plan.

1.2 RWSC Sub-regions and regional scale sea turtle distribution

RWSC is organized by subregion along the U.S. Atlantic coast, roughly aligned with current offshore wind development planning areas. RWSC subregions and map are described on page 2 of Chapter 2: Science Plan Organization.

In this document, region wide ongoing, pending and recommended field research is briefly described, discussed and organized into one of several research themes described on pages 2-4 of Chapter 2: Science Plan Organization. Details of ongoing and pending research and long-term monitoring efforts informative to the questions regarding OSW are available in the searchable RWSC Offshore Wind and Wildlife Research Database, and links to queries for each research project are included in the tables describing projects in the chapter. Following regionwide field research, is discussion of field research specific to each subregion. Following subregion field data collection discussion, are on-going, pending and recommended non-field efforts by research theme and action. Non-field data collection actions include: 1) outreach and platforms to provide data products/results to stakeholders; 2) coordination and planning; 3) standardizing data collection, analysis, and reporting; 4) study optimization; 5) historic data collection/compilation; 6) model development and statistical frameworks; 7) technology advancement; 8) manipulative experiments, and 9) meta-analysis and literature review and are further described in Chapter 3: Science Plan Actions.

[7] https://www.fisheries.noaa.gov/species/loggerhead-turtle#seafood
[8] https://www.fisheries.noaa.gov/species/green-turtle
[9] https://www.fisheries.noaa.gov/species/leatherback-turtle
[10] https://www.fisheries.noaa.gov/species/kemps-ridley-turtle
[11] https://www.fisheries.noaa.gov/species/hawksbill-turtle

1.2.1 Regional-scale distribution information

Consistent data to capture spatial and temporal distribution is provided via survey effort. In addition, tag, sighting, stranding and bycatch data contribute to distribution information, especially in areas and times where survey effort is limited and under conditions where turtles are not likely to be detected. While there has been a substantial amount of survey effort conducted to detect large sea turtles in the NW Atlantic, turtle distribution and behavior is variable both within and between seasons and is likely affected directly and indirectly by a combination of environmental factors. As such, abundance estimates should be based on multiple years and seasons of data (Schroeder et al. 2020[12]). Currently, a thorough understanding of surface availability and abundance is lacking for all species in much of the NW Atlantic. For some species and subregions, especially sub-adult loggerheads in shelf waters of CA through SNE subregions, availability estimates are based on relatively large data sets, but still contain some data gaps (Hatch et al. 2022[13]). Importantly, most recent distance sampling aerial surveys (AMAPPS) have been conducted using parameters appropriate for detecting a variety of species. The speed and altitude at which most of these surveys were conducted prevent detection of smaller turtles (<40cm carapace length; Schroeder et al. 2020[14], Palka et al. 2021[15]), and all turtle detections decrease in sub-optimal conditions, especially with increasing sea state. Regardless of the survey effort level, substantial data gaps on sea turtle distribution and abundance exist for all species, seasons and subregions.

Efforts to develop an index of abundance and distribution using satellite tag data for loggerhead turtles by month were conducted by Winton et al. (2018)[16]. Loggerheads used nearly all shelf waters from Long Island, NY south to near the tip of peninsular FL. In winter months, loggerhead turtles were largely south of the Virginia-North Carolina border. This analysis was possible due to a large tag dataset with similarly programmed tags for animals captured and tagged with broad temporal and spatial variation. Similar efforts may yield better results for other species if undertaken as a coordinated effort.

The U.S. Navy recently completed a sea turtle surface density modeling project along the U.S. Atlantic coast from shore to the EEZ which produced estimates for across the NW Atlantic for juvenile-adult stage turtles large enough to be detected from a variety of platforms (DiMatteo and Sparks 2022[17]), but as of early 2023 results of those surveys are not yet available in a public format. Similarly, estimates for sea turtle abundance are not yet available from AMAPPS

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[12] https://www.fisheries.noaa.gov/resource/document/developing-and-evaluating-methods-determine-abundance-and-trends-northwest

[13] https://doi.org/10.1002/jwmg.22208

[14] https://www.fisheries.noaa.gov/resource/document/developing-and-evaluating-methods-determine-abundance-and-trends-northwest

[15] https://repository.library.noaa.gov/view/noaa/47287

[16] https://doi.org/10.3354/meps12396

[17] DiMatteo A, Sparks L. Draft Models of Sea Turtle Distribution and Abundance on the East Coast of the United States. Technical Report in prep by Naval Undersea Warfare Center Division Newport. Draft models provided 12 Dec 2022.

surveys. Tagging results of loggerhead and leatherback turtles from AMAPPS surveys are available in AMAPPS reports (Palka et al. 2021[18]).

1.2.2 Biologically Important Areas for sea turtles within U.S. Waters

Biologically important areas in the United States for NW Atlantic sea turtle species/populations have not been determined. State space modeling applied to telemetry studies suggest that inshore and coastal continental shelf habitat are important foraging areas for loggerhead (Evans et al. 2019[19], McNeil et al. 2020[20]) and Kemp's ridley (Bean and Logan 2019[21]) turtles in the Central Atlantic and New York Bight subregions. Work is underway through AMAPPS research to establish similar areas of importance for leatherback turtles (C. Sasso *pers comm*). Although all established Kemp's ridley nesting areas are in the Gulf of Mexico, the coastal and inshore waters of the NW Atlantic appear to be important foraging areas for juvenile and subadult Kemp's ridley turtles although the contribution of this region to the population remained unclear in the 2015 status review for the species[22]. A new critical habitat designation for N Atlantic green turtles is currently being prepared and is expected to be released in late 2023 or early 2024. It is expected that findings will discuss the northward expansion of the species as well as increases in nesting on Southern Atlantic beaches since the previous review in 2015[23].

Better understanding of biologically important sea turtle habitat is needed for all species U.S. Atlantic waters.

1.3 Potential effects of offshore wind on sea turtles

The subcommittee recognizes that there may be positive, negative and/or mixed impacts of offshore wind development and operation on sea turtles. These effects may directly affect individual animals or indirectly affect them through changes to the environment, prey/predator distribution and/or changes in human activities. Animals and populations may be impacted by multiple, cumulative, effects, some positive and some negative.

As ectothermic, mostly migratory populations in U.S. waters, some sea turtle population's foraging, breeding, nesting, and migratory ranges overlap the areas proposed for offshore wind development in the Atlantic Ocean. In addition, sea turtle species are exposed to multiple and cumulative stressors throughout their life cycles, including climate and non-climate threats (Fuentes et al. 2013[24], Fuentes et al. 2020[25]). The cumulative effect of these and other stressors are likely to create biologically significant population level responses.

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[18] https://repository.library.noaa.gov/view/noaa/47287
[19] https://doi.org/10.1007/s00227-019-3583-4
[20] https://doi.org/10.3354/meps13296
[21] https://doi.org/10.1007/s00227-019-3516-2
[22] https://repository.library.noaa.gov/view/noaa/17048/noaa_17048_DS1.pdf
[23] https://repository.library.noaa.gov/view/noaa/4922
[24] https://doi.org/10.1111/gcb.12138
[25] https://doi.org/10.1007/s10113-020-01689-4

There have been no studies describing the effects of construction and operation of windfarms on sea turtles, largely because most research has come from European and U.K. waters, where sea turtles do not commonly occur. Discussion of potential impacts of offshore wind on each sea turtle species are, therefore, based on data from other species groups. The subcommittee is concerned that this lack of knowledge for sea turtle species, which have a very different life history, compared to other species groups, plays into sea turtle risk assessments and adds potential for more unexpected results, compared to other wildlife impacted by OSW. Without risk assessment specific to sea turtles, unidentified impacts cannot be assessed or mitigated with enhanced monitoring and adaptive management.

OSW, like other human activities in the marine environment, will have effects on sea turtles. Positive effects will most likely be related to reef effects of physical structures supporting turbines. Structures are expected to attract invertebrate fouling organisms and reef/wreck fishes, which will likely attract small schooling fishes (Glarou et al. 2020[26]). Sea turtles have been documented around underwater structures and are likely attracted to them (Broadbent et al. 2020[27], Reimer et al. 2023[28]) These structures will also attract anglers and some commercial fishers such as pot/trap fishers which may increase the likelihood of interactions with active and discarded gear. The most probable direct negative effects of offshore wind construction and operation are serious injury and mortality from increased vessel interaction and increase in fishery interaction because of attraction to turbines due to reef effects. It is likely that there will be direct, indirect and/or temporary negative effects related to noise, EMF, as well as changes in prey distribution, oceanographic parameters, fishing and shipping distribution. Other oceanographic and substrate impacts are not well understood and impacts are yet to be determined.

Since little is known about effects of OSW on sea turtles, the subcommittee must look to studies on large marine vertebrates for comparison. In European waters, researchers have documented avoidance and displacement effects, primarily of harbor porpoises (*Phocoena phocoena*). These effects occurred at ranges of 10-26 km from the whole footprint of offshore windfarms during construction (Dähne et al. 2013[29], Brandt et al. 2016[30], Brandt et al. 2018[31],Graham et al. 2019[32], Benhemma-Le Gall et al. 2021[33], Graham et al. 2023[34]). All of these studies indicate that the distance and duration of avoidance is related to received noise, which is further influenced by source level, sound propagation conditions (environmental parameters, substrate type, etc.), hearing range of the studied species, distance to the noise source,

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[26] https://doi.org/10.3390/jmse8050332
[27] https://doi.org/10.3354/ab00722
[28] https://doi.org/10.3354/esr01232
[29] https://doi:10.1088/1748-9326/8/2/025002
[30] https://www.offshore-stiftung.de/sites/offshorelink.de/files/documents/Study_Effects%20of%20offshore%20pile%20driving%20on%20harbour%20porpoise%20abundance%20in%20the%20German%20Bight _0.pdf
[31] https://doi.org/10.3354/meps12560
[32] https://doi.org/10.3389/fmars.2021.664724
[33] https://doi.org/10.1098/rsbl.2022.0101
[34] https://doi.org/10.1098/rsbl.2022.0101

duration of exposure, level and type of mitigation, and presence of other noise sources like construction vessels.

For harbor and grey seals, tagging data around wind energy sites in Europe showed behavior consistent with foraging after construction was completed (Russel et al. 2014[35], 2016[36]). Pinnipeds appeared to either habituate quickly or to take advantage of wind farm physical structures as a foraging opportunity, whereas small dolphins and porpoises showed high variability in displacement and recovery response to wind farm construction and operations. Although considerable research is still needed to understand sea turtle hearing sensitivity and behavioral responses to noise, effects of noise associated with OSW construction and operation may be more similar to pinnipeds than cetaceans, which, as a species group, are more highly auditory and vocal in nature than sea turtles, but we do not fully understand the ranges of sea turtle hearing or their physiological and behavioral response to underwater noise such as pile driving associated with turbine construction

Kraus et al. (2019[37]) summarized the potential short-term and long-term effects of offshore wind development on marine mammals and sea turtles in Massachusetts and Rhode Island Wind Energy Areas. The list below is also relevant to the entire Atlantic coast. Any specific concerns related to sea turtle species in each subregion will be further described in the following sections of this chapter.

Potential short-term effects of offshore wind construction activities (Kraus et al. 2019)

Potential short-term effects include reaction to noise from pile driving, vessel operating noise, and impacts of an increased presence of vessels. These stressors could influence:

- Displacement from wind energy areas
- Disruption to critical behaviors such as feeding, socializing, or nesting
- Elevation of stress hormone levels
- Changes in vertical distribution, density, or patch structure of prey

Potential long-term effects of offshore wind operation (Kraus et al. 2019)

Potential long-term effects include wind turbine presence, and increased vessel activity to/from and near turbine fields. These stressors could influence:

- Exclusion from or attraction to wind energy areas
- Changes to feeding opportunities
- Enhancements to marine productivity due to artificial reef effect around wind turbine foundations

The Sea Turtle Subcommittee also discussed potential impacts to sea turtles across the entire RWSC region. The Kraus et al. (2019) report addressed MA and Rhode Island, and thus only listed potential impacts in the GOM and SNE subregions which are limited to seasonal foraging

[35] https://doi.org/10.1016/j.cub2014.06.033
[36] https://doi.org/.1111/1365-2664.12678

[37] https://tethys.pnnl.gov/sites/default/files/publications/Kraus-et-al-2019.pdf

habitat for neritic hard-shelled and leatherback turtles. Loggerhead turtles have mating and nesting habitat from MD to FL. Although not currently designated as critical reproductive habitat, green and leatherback turtles nest and mate in FL waters.

Below is an additional list of potential effects of concern identified by the subcommittee

- Increased vessel interactions, lethal and non-lethal
- Acoustic disturbance
- EMF effects from underwater cables linking turbines and distributing electricity to shore
    - Prey distribution – Some evidence of attraction to EMF (Albert et al. 2020[38])
    - Navigation disturbance in foraging and migratory areas
    - Nesting disturbance (south of Chesapeake Bay)
    - Hatchling dispersal disturbance (south of Chesapeake Bay)
- Other
    - Changes in habitat from structure effects on water column stratification, frontal field, current velocity/direction, thermocline, halocline
    - Reef effects
    - Temporal and/or spatial changes in turtle and/or prey distribution due to warm water effluent from underwater DC substations
    - Changes in entanglement/ingestion risk because of changes in distribution of fishing gear and aquaculture structures (especially increased fixed gear in lease areas)
    - Interaction with floating/surface components and/or rotor intakes that could trap sargassum in off shelf planning areas

1.4 Methods and approaches

To address questions about sea turtles and the potential concerns with respect to offshore wind development, the Science Plan describes commonly used methods and approaches for data collection and research in Chapter 3: Science Plan Actions. The following categories of methods are used throughout this chapter, but the Subcommittee recognizes that different tools, technologies, and/or procedures could be implemented with respect to each.

- Aerial and vessel-based line transect observational surveys

  Large scale abundance data for sea turtles is generally collected using distance sampling surveys conducted from aerial, shipboard, and, in future, unmanned platforms such as drones.

  In order to accurately estimate turtle abundance and/or density, aerial and vessel surface turtle counts are corrected for bias including perception bias and availability bias. Perception bias is the likelihood that observers will detect a turtle at the surface. Unlike small cetaceans such as dolphins and porpoises, turtles do not travel in groups and are relatively cryptic at the surface with no visible blow (exhalation) to cue observers. Thus, it is likely that a proportion of turtles that are at the surface are missed by observers and the proportion that are missed

[38] https://doi.org/10.1016/j.marenvres.2020.104958

is correlated with increasing sea state, turbidity and glare. Availability bias incorporates the likelihood that an animal will be at the surface and *available* to be detected compared with the likelihood it will be subsurface and unable to be detected (*unavailable*). It is imperative to understand the relationship between number of turtles detected at the surface, those that are available to be detected, and the proportion of the population that is below the surface and unavailable to be detected. Again, compared to cetaceans which often travel in groups, detection of one individual in a group cues the observer to focus on a particular area increasing the likelihood of detection. A single diving turtle may only be perceived as a surface disturbance and not be identified to the species level.

Unlike cetaceans, sea turtles surface time highly variable by species, season, habitat, behavioral state, and other co-variates such as depth and water temperature. Because they are ectothermic, surface time is variable for sea turtles and complicates abundance estimation for these marine vertebrates over other species (Hatch et al. 2022[39]). Surface time is estimated using tagged individuals, and, for sea turtles, should ideally be assessed at the time and location that surveys are being conducted. Minimally, tag data used to determine availability should include multiple years and individuals of all species being detected and include a range of animal sizes in all survey strata and seasons. Poor understanding of both perception and availability bias increases uncertainty in abundance estimates.

Because sea turtle abundance may be low and CV high for some species in some seasons of the RWSC study area, ability to detect changes in abundance and assigning causality to detected changes may be difficult. In a tech memo summarizing a workshop on estimating loggerhead turtle abundance in the NW Atlantic, NOAA estimated that ten years of survey data may be needed to develop robust loggerhead turtle abundance estimates in the NW Atlantic and that current protocols are unable to detect turtles less than 40cm carapace length (Schroeder et al. 2020).

On page 15 of NOAA Tech Memo NMFS-OPR-67, authors list several next steps that are important elements in developing robust estimates for NW Atlantic loggerheads (Schroeder et al. 2020[40]):

- Define management needs relative to the ability of aerial surveys to detect changes in abundance across appropriate timeline(s). Define desired level of confidence in those abundance estimates.
- Establish the optimal survey altitude for sea turtles by conducting additional experiments at altitudes between 500–1,000ft to examine/understand the size of turtles that can be seen and turtle behavior relative to the survey platform.
- Conduct additional field testing to determine detectability of a range of turtle sizes under varying water clarity and sea state conditions.

[39] https://doi.org/10.1002/jwmg.22208
[40] https://www.fisheries.noaa.gov/resource/document/developing-and-evaluating-methods-determine-abundance-and-trends-northwest

- Explore the pros and cons of high resolution aerial photogrammetry and use of automatic pattern recognition, considering likely improvements in the next 5-10 years. Establish whether calibration or ground-truthing is needed for aerial photogrammetry using side-by-side flights with both photogrammetry and observers.
- Ensure relevant aspects of sea turtle life history (e.g., seasonal migrations, behavioral state) are considered appropriately in the development of the survey design.
- Design and conduct an experiment to assess variability of abundance estimates through repeat aerial surveys.
- Explore whether existing satellite telemetry data are sufficient to assess the effects of sea state on surfacing behavior.
- Refine measures of surface availability
  - o Take stock of satellite telemetry data and identify data gaps relative to location, life stage, and behavioral state (foraging, migrating, internesting).
  - o Design appropriate satellite telemetry experiment(s) to fill identified data gaps. o Assess the value of repeated counts to inform surface availability; compare to satellite telemetry approach; integrate methods to improve surface availability estimation.
- Mine data from all relevant existing aerial surveys to inform a new survey design, including block identification if appropriate. Develop simulations to refine survey design.
- Coordinate survey design and implementation with other ongoing efforts to maximize efficiency and reduce duplication/overlap.
- Develop funding estimates and consider potential funding sources, including leveraging existing funding. Develop a plan for and approach to seek funds.

[Note that loggerheads are the most abundant sea turtle species in the NW Atlantic, perhaps by an order of magnitude over other species, making the complexity of developing robust abundance estimates for other species greater than for loggerheads.]

The subcommittee believes that few of the suggestions made at the workshop in 2016 have been fully accomplished and believes that most are needed for loggerheads as well as other turtle species. Providing funding and effort to better understand which turtles are being detected under what conditions, small turtle occurrence for green and Kemp's ridley turtles estimates, and developing robust surface time estimates for all sea turtle species, in all subregions and seasons is critical for developing baseline abundance of sea turtle species. Without this basic knowledge, assessing and mitigating impacts to sea turtles from a variety of sources, including offshore wind, will be extremely difficult.

- Tagging

For the purposes of this document, tagging refers to active tagging where tags transmit or archive data related to the tagged animal's location, physiology and/or behavior. This is in contrast to passive tags such as flipper (Inconel) and subdermal (PIT) tags which are applied to an animal and must later be detected on that animal during subsequent observations. Tagging individual sea turtles includes the use of satellite and acoustic telemetry and may be paired with animal born and/or autonomous underwater cameras. The size of some turtles restricts the use of larger and heavier tags which limits battery life and additional instrumentation such as time depth recorders (TDRs) and GPS chips

- eDNA

  Environmental DNA (eDNA) is DNA released from an organism into the environment via feces, mucus, shed skin, hair, etc. It is detected in air, water, and substrate samples and requires assays from the organisms to be detected. eDNA is useful for determining presence of a species, population, or individual, but its utility as an index of abundance is unclear. Several organizations are developing eDNA assays for sea turtles and are ground truthing use of this technology in providing an index of abundance. Pilot studies at several sites are pending.

- Long-term monitoring - Stranding response, nest surveys, sightings databases, and observed takes (dredge & fishery)

  Sea turtles only come ashore to nest, at the time of hatching, and when stranded (sick, injured, or dead). Nesting sea turtles in the U.S. are monitored annually on many beaches from Virginia through the U.S. Gulf coast, and several index beaches are established to provide long term indices of nesting turtle presence which are correlated with abundance. Nesting trends from index beaches which have been consistently monitored over decades are the primary data available for long-term population trend analysis for sea turtles in the U.S. Atlantic. An index of abundance has been established from long term nest monitoring data at specific sites in the Southern Atlantic subregion and in areas where turtles are resident or have relatively small seasonally shifting home ranges through capture/recapture studies.

  Although many caveats exist with use of stranding data, the U.S. Sea Turtle Stranding and Salvage Network may be another source of distribution and phenological trend information.

  In addition, where survey data have few detections, citizen science sightings databases can add information on sea turtle presence. There is at least one curated long-term sightings database curated by Mass Audubon that can provide information about individual sightings of species that are small and are not easily detected with most survey methodologies.

  Finally, dredge and fishery observers record takes associated with permitted and authorized activities in many regions. Observers follow established protocols and receive substantial training. Though relatively rare, observed takes may also provide information on turtle presence in areas where abundance data are low. This is particularly true of offshore areas where distribution data may be poor for some species.

  Analyses of long-term data sets may provide the basis for future hypotheses regarding baseline population and distribution trends for sea turtle species, but these data sets have not always been consistently collected or reviewed and experience of data collectors for some monitoring data sets varies widely.

2 Sea turtle research topics

The RWSC Sea Turtle Subcommittee recognizes that impacts to sea turtles associated with OSW have not been studied since much of the previous work has been done in European waters where sea turtles are not commonly observed. The subcommittee also recognizes that impacts to sea turtles individually and at population levels are likely to be indirect, cumulative, synergetic and difficult assign to a single cause. Disentangling the effects on sea turtles of climate change from any potential effects from offshore wind development will be a major challenge.

RWSC has established several Research Themes for the study of impacts to wildlife by OSW that build on work conducted by previous groups, on other wildlife species. In subsequent sections, many of the detailed questions, hypotheses, and potential approaches that correspond to these Research Themes are described for regional-scale studies and for each subregion (Gulf of Maine-GOM; Southern New England-SNE; New York/New Jersey Bight-NYB; Central Atlantic-CA; Southern Atlantic-SA).

2.1 Regional Field data collection and analysis

*Ongoing and pending (*indicates projects where the subcommittee believes data on sea turtles may be minimal)*

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Aerial visual-distance sampling; Boat-based-distance sampling; PAM; satellite tagging; model development & statistical frameworks; nets & tows *(marine mammals, sea turtles, birds & bats, fishes, habitat & ecosystem)*	Atlantic Marine Assessment Program for Protected Species (AMAPPS)	NOAA, BOEM, USFWS, US Navy	Jan 2010 - ongoing	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Aerial high definition imagery; technology advancement *(birds & bats, sea turtles, marine mammals)*	*Automated detection and classification of wildlife targets in digital aerial imagery – Phase II	BOEM, USGS, USFWS, Vision Group at the International Computer Science Institute at the University of California Berkeley	Jan 2021 – Dec 2024	**Detecting and quantifying changes to wildlife and habitats**

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Water quality & oceanography; nets & tows *(marine mammals, sea turtles, birds & bats, habitat & ecosystems)*	*Ecosystem Monitoring on the Continental Shelf (EcoMon)	NOAA NEFSC	Jan 1977-ongoing	**Understanding the environmental context around changes to wildlife and habitats** **Enhancing data sharing & access**

Recommended

- NMFS Long-term protected species, fisheries, and ecosystem surveys form the backbone of the scientific monitoring system needed for the management of wildlife, fisheries, habitats, and ecosystems. In order to understand potential changes in wildlife and habitats from offshore wind energy development--it is critical that long-term standardized surveys continue to provide timely, accurate, and precise data on wildlife, habitats, and ecosystems. The need to fully implement the NMFS and BOEM Survey Mitigation Strategy and review the strategy to directly affect sea turtle survey needs is critical to putting site and regional level studies in the context of population trends and ecosystem conditions. The Strategy calls for the development of a Northeast Survey Mitigation Program. This largely unfunded strategy should be fully funded and be a significant priority for the region as well as for the Atlantic waters of the Southeast region.
- Increase level of regional-scale sea turtle species data collection including both surveys and at sea tagging through AMAPPS and US Navy projects
- Employ recommendations by NMFS to enhance AMAPPS sea turtle abundance estimates listed in Schroeder et al. 2020, especially detection studies of all sea turtle species and sizes in a variety of conditions
- Enhance and expand abundance estimation, surface density estimates and habitat modeling using all appropriate forms of turtle occurrence data, including, but not limited to, verified sightings, strandings, bycatch data and prey distribution to determine biologically important areas for each sea turtle species

2.2 Regional Non-field research by type of action

2.2.1 Coordination and planning

Ongoing and pending

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme

There are no current sea turtle Coordination and Planning Projects listed in the RWSC database.

Recommended

- Specifically request that emphasis on sea turtles be included in the Federal Survey Mitigation Strategy as they are all ESA species likely to be impacted by offshore wind development
- Coordinate and initiate collaborations with additional partners to facilitate data and information sharing, including the Sea Turtle Stranding and Salvage Network, organizations conducting sea turtle nest monitoring, sea turtle rescue organizations operating under U.S. FWS permits and authorization as well as satellite, acoustic and other tag data
- Develop collaborations with fish scientists and other acoustic telemetry users to implement a long-term archival acoustic detection network in the NW Atlantic Ocean, following sea turtle optimization analysis to guide future detector and tag deployments
- Work with the sea turtle research and rescue community to determine whether development of a cache of tags suitable for sea turtles (acoustic and satellite; thru RWSC?) would assist organizations that have needs for a small/unpredictable number of tags for deployment
- Work with the sea turtle research and rescue community to determine whether the use of a data portal (similar to a combination of seaturtle.org & Movebank) would facilitate collaborative tagging studies, especially for determining surface time
- Work with USFWS & the GARS stranding network to apply for regionwide rehab turtle tagging permit in support of offshore wind research
- Work with NMFS & USFWS to encourage acceptance of internal acoustic tagging with SOP

2.2.2 Historical data collection/compilation

Ongoing and pending

Method(s)	**Project**	**Lead and Partner Entities**	**Time period**	**Research Theme**
Satellite tagging; historical data collection *(sea turtles)*	Comparing satellite telemetry data between wild caught and rehabilitated sea turtles	USGS, multiple partners contributing data	Jan 2022 - ongoing	**Understanding the environmental context around changes to wildlife and habitats**

Recommended

- Compile inventory of satellite/GPS tags deployed on sea turtles since 2010(?) for future collaborative studies. Include tag type, deploy location, species, size, turtle source (wild/rehab/bycaught), days at large and general location
- Compile historic sea turtle acoustic tag IDs from NW Atlantic for detection database searches and collaborative MS

- Compile historic sea turtle nesting data by species, date, subregion and lat/lon for data portals

2.2.3 Standardizing data collection, analysis, and reporting

Ongoing and pending

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Auditory evoked potentials *(sea turtles, hard shelled only)*	Hearing in juvenile sea turtles	NC State, Duke University, NOAA, BOEM	Jan 2021-current	**Understanding the environmental context around changes to wildlife and habitats**
Aerial visual-distance sampling; aerial high definition imagery *(marine mammals, sea turtles, birds & bats)*	Comparative Study of Aerial Survey Techniques	BOEM, NOAA, USFWS	Jan 2022 – Dec 2024	**Detecting and quantifying changes to wildlife and habitats**
eDNA *(marine mammals, sea turtles, birds & bats)* *Also relevant under Technology advancement & Outreach & platforms to provide data products actions*	Developing Best Practices and Applying Environmental DNA (eDNA) Tools and in Support of Assessing and Managing Living Marine Species in an Ecosystem-based Context	BOEM, NOAA NEFSC, Smithsonian Institution, AMAPPS	Jan 2021 – Dec 2023	**Detecting and quantifying changes to wildlife and habitats**
Standardizing animal handling *(sea turtles)*	Update of Sea turtle Research Standards Tech Memo	NOAA		**Enhancing Data sharing and access**
eDNA; water sampling *(sea turtles)* *Also relevant under Technology advancement*	Developing and testing sea turtle specific eDNA assays	Coonamessett Farm Foundation, MET	Jan 2022-Jan 2023	**Detecting and quantifying changes to wildlife and habitats**

Recommended

- Compile and disseminate acoustic tag/receiver deployment, detection study SOP, data archiving and analysis, data portal use for sea turtle research and rehab organizations

- Sat tag data programming/processing for availability calculations (target audience – stranding networks)
- Develop, test, and ground truth aerial survey detection parameters, methods, and protocols for all sea turtle species, size ranges in varying conditions (sea state, turbidity, etc.)
- Develop and test eDNA assays/surveys/sampling regimes for use developing indices of occurrence/abundance, including testing the effect of carcasses in the environment on eDNA detection

2.2.4 Study optimization

Ongoing and pending

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Model development & Statistical frameworks (whales & leatherback turtles) [NOTE: Project is for west coast but model may be applicable to east coast]	Development of Computer Simulations to Assess Entanglement Risk to Whales and Leatherback Sea Turtles in Offshore Floating Wind Turbine Moorings, Cables, and Associated Derelict Fishing Gear Offshore California	BOEM, NOAA NCCOS	Jan 2019-Dec 2025	**Mitigating impacts that are likely to occur and/or are severe in magnitude**

Recommended

- Review AMAPPS sea turtle survey effort (especially spring and fall) to determine effort gaps where turtles were unlikely to be detected/present due to conditions (sea state) and/or temperature
- Conduct power analysis and experimental design development focusing on using multiple methods to detect changes to abundance, distribution, and behavior on one or more sea turtle species in each subregion
- Develop an experimental design to obtain a better understanding of post hatchling dispersal stage habitat use in the NW Atlantic for all RWSC sea turtle species
- Develop an understanding of sea turtle hearing and reaction to OSW noises by species and life stage including behavioral and physiological impact of noise created by OSW construction and operation
  Determine the best methodology for assessing whether construction activities displace or attract sea turtles

Create research design for development of abundance models similar to (or equivalent with) Winton et al. 2018 and availability analyses similar to Hatch et al. 2020 for other species. Include review of existing sat tag data, including historic data, for species other than loggerhead turtles for possible inclusion in future analyses

2.2.5 Model development and statistical frameworks

Ongoing and pending

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Model development and statistical frameworks (sea turtles)	Sea turtle Distribution & Abundance on the East Coast of the United States	U.S. Fleet Forces Command	Jan 2020-Jan 2022	**Detecting and quantifying changes to wildlife and habitats**

Recommended

- Use existing and newly acquired sea turtle behavioral data to describe sea turtle surfacing behavior in time-area strata with sufficient data and identify other time-area strata for further data collection
- Investigate sea turtle carcass drift coastwide to understand the likelihood of detecting sea turtle mortality that occurs in offshore waters
- Incorporate better understanding of uncertainty in abundance & distribution estimates similar to MM density model work (e.g. detectability in higher sea states, depth of detection, effect of size on detectability, error associated with poor understanding of availability)
- Develop or update existing vessel and sea turtle/marine mammal co-occurrence models with vessels of various type and size associated with turbine construction and operation

2.2.6 Technology advancement

Ongoing and pending

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
eDNA (multiple species) *Also relevant under Standardizing data collection, analysis & reporting & Outreach & platforms to provide data products actions*	Developing Best Practices and Applying Environmental DNA (eDNA) Tools and in Support of Assessing and Managing Living Marine Species in an Ecosystem-based Context	BOEM, NOAA NEFSC, Smithsonian Institution, AMAPPS	Jan 2021 – Dec 2023	**Detecting and quantifying changes to wildlife and habitats**
eDNA; water sampling (*sea turtles*) *Also relevant under Standardizing data collection, analysis & reporting*	Developing and testing sea turtle specific eDNA assays	Coonamessett Farm Foundation, MET	Jan 2022-Jan 2023	**Detecting and quantifying changes to wildlife and habitats**
eDNA; water sampling (*sea turtles, marine mamals*)	Contribution to validate environmental DNA (eDNA) to identify the presence of certain marine species	Mystic Aquarium Research Department	Jan 2023	**Detecting and quantifying changes to wildlife and habitats**

Recommended

- Develop and test safe long term external attachment and/or internal insertion methods for acoustic tags on sea turtles
- Develop and test smaller tags with depth sensors capable of surface time calculations for availability bias calculations in small juvenile turtles
- Develop and test longer term (non-archival) tags and/or tag attachment techniques with low drag for capture/release in difficult (offshore) environments
- Develop and test remote tag attachment techniques for in water work, especially for hard-shelled turtles

2.2.7 Meta-analysis and literature review

Ongoing and pending

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
(marine mammals, birds & bats, sea turtles, habitat & ecosystem)	Project WOW Task 1.1: Create an annotated catalog of existing relevant datasets and their anticipated availability	Project WOW	Jan 2022-Dec 2032	**Detecting and quantifying changes to wildlife and habitats**
Historical data collection/compilation	Characterizing vessel-related mortality of sea turtles in the Southeast and Mid-Atlantic	FSU	Jan 2023-	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**

Recommended

- Synthesize current and historic sea turtle nesting data, by species for Atlantic coast nesting beaches for trends analyses, permit applications, and mitigation. Make nesting data available to developers and researchers and store in a combined searchable format for future use. Provide assistance to states, municipalities, and NGOs who collect these data with upload/conversion to collective database.

2.2.8 Outreach and platforms to provide data products and results to stakeholders

Ongoing and pending

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
eDNA *Also relevant under Standardizing data collection, analysis & reporting & Outreach & platforms to provide data products actions*	Developing Best Practices and Applying Environmental DNA (eDNA) Tools and in Support of Assessing and Managing Living Marine Species in an Ecosystem-based Context	BOEM, NOAA NEFSC, Smithsonian Institution, AMAPPS	Jan 2021 – Dec 2023	**Detecting and quantifying changes to wildlife and habitats**
Data sharing (all species groups)	Northeast and Mid-Atlantic Ocean Data Portals	NROC, MARCO	ongoing	**Enhancing data sharing & access**
Data sharing (all species groups)	Support for Regional Wildlife Science Collaborative Ocean Portal Products and Services	BOEM, RWSC	Jan 2023 – Jan 2026	**Enhancing data sharing & access**

Recommended

- Synthesize sea turtle nesting data, by species for Atlantic coast nesting beaches for trends and store in a combined searchable format for future analyses [also listed under meta-analysis]
- Facilitate collaborative tag analysis with stranding networks and field researchers

The following sections describes ongoing and pending data collection and research activities with respect to marine mammals in each subregion of the U.S. Atlantic Ocean. Following those summaries, a synopsis of data and research gaps and needs is provided.

2.3 Gulf of Maine (GOM) ongoing, pending, and recommended research and data collection activities for sea turtles

2.3.1 Focal species and habitats of interest in the GOM

The Gulf of Maine subregion is seasonal foraging habitat for all sea turtle species covered by the Plan but, with the exception Cape Cod Bay, might be considered marginal habitat for

Kemp's ridley and green turtles. Wild caught loggerhead and leatherback turtles have been tracked in and out of the Gulf of Maine, including, but not exclusive of Cape Cod Bay (Dodge et al. 2014[41], Palka et al. 2021[42]), and individuals of both species have been bycaught in the Atlantic Canadian longline fishery, suggesting seasonal distribution in the region (Paul et al. 2010[43], James et al. 2006[44], James et al. 2007[45]). Suitable leatherback turtle habitat off Nova Scotia has been identified using both leatherback and Mola sightings along with environmental correlates in modeling analyses (Mosnier et al. 2019[46]). Jellyfish distribution has also been used to predict leatherback distribution. (Nordstrom et al. 2020[47]).

Most individuals are juveniles (Kemp's ridley, green, loggerhead) and subadults (loggerhead), but adult leatherbacks can also be found in the subregion (Dodge et al. 2014[48]).

Better understanding of the importance of Cape Cod Bay for juvenile Kemp's ridley and green turtles is needed as it appears to be the primary area of the subregion in which these two species occur. For smaller individuals, primarily Kemp's ridley and green turtles, there is a paucity of sightings in historic aerial and shipboard abundance surveys (DiMatteo and Sparks 2022[49], Palka et al. 2021[50]) and relatively few opportunistic citizen science sightings (Sea Turtle Sighting Hotline for New England Boaters[51]). A query of historic strandings of hard shelled turtles (loggerhead, Kemp's ridey, green) from Cape Cod Bay north through Maine from April-early November (outside of cold stun season) resulted in a total of 50 strandings from 2013-2022, an average of five per year. All strandings occurred in MA, and 25 were loggerhead, 23 Kemp's ridley, one green turtle and one possible hybrid. Low sightings combined with relatively few green turtles in the stranding record outside of the late fall cold stun season (STSSN unpublished data[52]) raise questions about the role of the GOM subregion in the ecology of this species. Paucity of detections from survey, sighting and stranding data is not sufficient to hypothesize that the GOM subregion is not important habitat for Kemp's ridley turtles because these small juvenile turtles are difficult to detect from planes and vessels. Though stranding numbers were low overall, the similarity of loggerhead and Kemp's ridley strandings in addition to very high numbers of cold stunned Kemp's ridleys in late fall call into question whether Kemp's ridleys are present in Cape Cod Bay in similar numbers as loggerheads.

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[41] https://doi.org/10.1371/journal.pone.0091726

[42] https://repository.library.noaa.gov/view/noaa/47287

[43] Paul SD, Hanke A, Smith SC, Neilson JD. 2010. An Examination of Loggerhead Sea Turtle (*Caretta caretta*) Encounters in the Canadian Swordfish and Tuna Longline Fishery. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/088: vi + 32 p.

[44] https://doi.org/10.1016/j.biocon2006.06.012

[45] https://doi.org/10.3354/meps337245

[46] https://doi.org/10.1139/cjz-2018-0167

[47] https://doi.org/10.1371/journal.pone.0232628

[48] https://doi.org/10.1371/journal.pone.0091726

[49] DiMatteo A, Sparks L. 2022. Draft Models of Sea Turtle Distribution and Abundance on the East Coast of the United States. Technical Report in prep by Naval Undersea Warfare Center Division Newport. Draft models provided 12 Dec 2022.

[50] https://repository.library.noaa.gov/view/noaa/47287

[51] www.seaturtlesightings.org

[52] MA, NH, ME Sea Turtle Stranding Network data provided by NOAA Fisheries

Assuming that cold stunned sea turtle numbers in Cape Cod Bay are representative of cheloniid habitat-use, this region could constitute important seasonal habitat for Kemp's ridleys, followed by loggerheads, with less importance for green sea turtles. There is concern, however, what type of ecological impact the area may have on the Kemp's ridley population given the high numbers of cold stunned turtles that are reported each year. Few if any of the hundreds of turtles would survive cold stunning without human intervention. Global climate change is likely to result in increasing numbers of hard-shelled turtles in this region, thus regular reassessment of turtle occurrence in the GOM will be necessary.

Because baseline data for sea turtles in the GOM is relatively sparse and most turtle species, with the exception of leatherbacks, are not present in high enough densities to detect changes in abundance with any confidence, determining and studying impacts on a subregion-wide and/or population level are unlikely to be successful and studies small focused studies on individual animal movement and behavior that are site specific may be most effective strategies for assessing impacts in the GOM.

2.3.2 Potential effects of concern in the GOM

In addition to the potential regionwide effects discussed in section 1.3 of this chapter, there may be different effects due to turbine designs needed for the deeper waters in this subregion. Because of depth in the federal portion of GOM, turbines used to develop wind energy areas in this subregion will be floating units (Musial et al 2016[53]). It is currently unclear whether this technology will have different impacts from turbines attached to the bottom. Use of this technology may provide opportunities for comparison studies with nearby installations in the Southern New England subregion. Rafts of debris and algae associated with a different surface footprint and floating turbine movement may impact turtles and their non-benthic prey in different ways than static, bottom anchored turbines. If floating designs incorporate subsurface rotors to maintain stability and position, small turtles and near surface (gelatinous) prey may be impacted in ways that they will not be impacted by static turbines.

2.3.3 Field data collection and analysis in the GOM

Ongoing and pending

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Tagging (multiple types); focal follows; ROV, AUV (sea turtles)	Sea turtle survivorship models and behavior	New England Aquarium	Jan 2007 - ongoing	Detecting and quantifying changes to wildlife and habitats

[53] http://www.nrel.gov/docs/fy16osti/66599.pdf

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Boat-based – distance sampling; boat-based strip transect; aerial high def imagery (marine mammals, sea turtles, sea birds)	*Ecological Baseline Study of the U.S. Outer Continental Shelf Off Maine	Biodiversity Research Institute, HiDef Aerial Surveying Ltd.	Aug 2022-Sep 2024	**Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing & access**

Recommended

- Continue regional-scale protected species data collection through AMAPPS survey and tagging studies or similar programs – emphasize GOM? Especially tagging
- Supplement AMAPPS data with methods that detect smaller species and juveniles, especially in Cape Cod Bay
- Determine ecological role of Cape Cod Bay for juvenile Kemp's ridley turtles through additional tagging and modeling that incorporated sighting and stranding data
- Explore potential impacts to sea turtles and gelatinous prey when they co-occur with floating turbines

2.4 Southern New England (SNE) ongoing, pending, and recommended research and data collection activities for sea turtles

2.4.1 Focal species and habitats of interest in the SNE subregion

The Southern New England subregion is seasonal foraging habitat for all sea turtle species covered by the Plan. Leatherback and loggerhead turtles have been detected on distance sampling surveys conducted as part of the regional AMAPPS program as well as on smaller scale survey efforts used in addition to AMAPPS survey by a Navy abundance estimation effort (Palka et al. 2021[54], DiMatteo and Sparks 2022[55]). Capture, tag, release (loggerhead and leatherback), remote tagging (leatherback), and disentanglement (leatherback) have been conducted in the SNE subregion (Dodge et al. 2014[56], Dodge et al. 2022[57], Palka et al. 2021[58], Hatch et al. 2022[59]). Few Kemp's ridley and green turtles were detected in the SNE subregion on AMAPPS surveys, but there were some unidentified hard-shelled turtles detected that may have been these

[54] https://repository.library.noaa.gov/view/noaa/47287
[55] DiMatteo A, Sparks L. 2022. Draft Models of Sea Turtle Distribution and Abundance on the East Coast of the United States. Technical Report in prep by Naval Undersea Warfare Center Division Newport. Draft models provided 12 Dec 2022.
[56] https://doi.org/10.1371/journal.pone.0091726
[57] https://doi.org/10.3354/esr01173
[58] https://repository.library.noaa.gov/view/noaa/47287
[59] https://doi.org/10.1002/jwmg.22208

species (Palka et al. 2021[60]). Opportunistic sightings of Kemp's ridley turtles are rare but consistently occur each year in summer and early fall in the Mass Sea Turtle Sightings Database but sightings of green turtles are less consistent, and the subcommittee believes this subregion may also currently be a marginal habitat for green turtles (Sea Turtle Sighting Hotline for New England Boaters[61]).

2.4.2 Potential effects of concern in the SNE subregion

The potential effects of offshore wind development are similar in this subregion as are discussed in section 1.3 of this chapter. The imminent development of the Vineyard and Southfork Wind projects makes the SNE subregion of particular interest to the subcommittee, since we do not have data or published research from other wind developments in sea turtle habitat. Both projects had estimated foundation construction start dates in late spring 2023. Development in the SNE will pose the first opportunity to study sea turtle behavior during construction and operation of NW Atlantic wind turbines. It is unclear whether baseline abundance data for loggerhead and leatherback turtles in the SNE subregion will be sufficient to detect changes in abundance and/or distribution at the regional level using distance sampling techniques. Thus, smaller scale studies with a phase gradient experimental approach, focused on the development area and areas increasingly distant from the development (Ellis & Schneider 1997[62]), as well as vessel corridors could be the focus of study in this subregion. Sea turtles should be included as a significant part of vessel co-occurrence and reef development studies. Turbine construction activities are designed to avoid times when critically endangered right whales were historically in the area (Jan-April), but these limitations will not avoid the times of highest sea turtle occurrence.

2.4.3 Field data collection and analysis in the SNE subregion

*Ongoing and pending (*indicates projects where the subcommittee believes data on sea turtles may be minimal)*

Method(s)	**Project**	**Lead and Partner Entities**	**Time period**	**Research Theme**
Tagging, other; other-play back (sea turtle)	Behavioral Response of Sea Turtles from Controlled Exposures to a Mobile Impulsive Sound Source	Coonamessett Farm Foundation, BOEM, NOAA, NESFC	Jan 2022 – Jan 2024	**Understanding the environmental context around changes to wildlife and habitats**

[60] https://repository.library.noaa.gov/view/noaa/47287
[61] www.seaturtlesightings.org
[62] https://doi.org/10.1023/A:1005752603707

Boat-based surveys (sea turtles, birds & bats)	*Post-Construction Wildlife Surveys Outside of the MA WEA	BOEM	Jan 2023 – Jan 2026	**Detecting and quantifying changes to wildlife and habitats**
Aerial visual-strip transect; aerial high def imagery (marine mammals, sea turtles, fish, birds & bats)	*Project WOW IRES - aerial surveys	Project WOW	Jun 2023-Dec 2025	**Detecting and quantifying changes to wildlife and habitats**
High-resolution aerial surveys (all taxa)	*ReMOTe for Equinor's Lease Area OCS-A 0520	Equinor, Normandeau, Apem Inc.	Dec 2019 – Nov 2020	**Detecting and quantifying changes to wildlife and habitats**
Tagging, satellite (sea turtles)	Sea turtle post rehabilitation movements and survivorship	AMSEAS, sea turtle rehab centers	Jan 2017 - ongoing	**Detecting and quantifying changes to wildlife and habitats**
Tagging (multiple types); focal follows; ROV, AUV (sea turtles)	Sea turtle survivorship models and behavior	New England Aquarium	Jan 2007 - ongoing	**Detecting and quantifying changes to wildlife and habitats**
Aerial survey with high resolution camera (sea turtles, marine mammals)	*Southern New England marine mammal and sea turtle aerial surveys	New England Aquarium, MASS CEC, BOEM, Offshore Wind Developers	Oct-2011	**Detecting and quantifying changes to wildlife and habitats**
Fecal sampling, animal physiology (sea turtles, marine mammals)	Effects of offshore wind power systems on the physiology of harbor seals, gray seals, and sea turtles	Mystic Aquarium research Department	Jan 2023	**Detecting and quantifying changes to wildlife and habitats**
Satellite tagging, animal physiology (marine mammals, sea turtles)	Tracking and behavior of seals and sea turtles in relation to offshore wind	Mystic Aquarium research Department	Jan 2023	**Detecting and quantifying changes to wildlife and habitats**

Recommended

- Design, plan, fund and conduct, long-term, small-scale studies specifically designed to determine effects on sea turtle species using multiple methodologies in the vicinity of wind projects currently under development in the SNE, NY/NJB and CA regions. Tailor studies to take advantage of each subregion’s development timeline and unique sea turtle occurrence. Build on knowledge from each study to optimize results for future studies

2.5 New York/New Jersey Bight ongoing, pending, and recommended research and data collection activities for sea turtles

2.5.1 Focal species and habitats of interest in the NY/NJB subregion

The NY/NJ Bight subregion is seasonal foraging habitat for all sea turtle species covered by the Plan. Leatherback and loggerhead turtles have been detected on distance sampling surveys conducted as part of the regional AMAPPS program as well as on smaller scale survey efforts used in addition to AMAPPS survey by a Navy abundance estimation effort (Palka et al. 2021[63], DiMatteo and Sparks 2022[64]). Kemp's ridley and green turtles have been sighted and regularly strand in Long Island Sound (Montello et al. 2022[65]). Capture, tag, and release (loggerhead) has been conducted in the subregion (Winton et al. 2018[66], Hatch et al. 2022[67]) and numerous rehabilitated turtles have been released with tags, both acoustic and satellite (Robinson et al. 2020[68]). Few Kemp's ridley and green turtles were detected in the NY/NJB subregion on AMAPPS and other surveys, but there were some unidentified hard-shelled turtles detected that may have been these species (DiMatteo and Sparks 2022[69]; Palka et al. 2021[70]).

2.5.2 Potential effects of concern in the NY/NJB subregion

The potential effects of offshore wind development are similar in this subregion as are discussed in section 1.3 of this chapter. The imminent future development of the Empire Wind New York waters and Ocean Wind in New Jersey waters makes the NY/NJB subregion of interest to the subcommittee, since the timeline for these projects may allow for both pre- and post-construction assessment of the area. Permit applications have been submitted and permits are expected to be issued in 2023. Development in the NY/NJB will pose some of the first opportunities to study sea turtle behavior prior to approved construction. It is unclear whether baseline abundance data for loggerhead and leatherback turtles in the NY/NJB subregion will be sufficient to detect changes in abundance and/or distribution at the regional level using distance sampling techniques. Thus, the subcommittee recommends smaller scale

[63] https://repository.library.noaa.gov/view/noaa/47287

[64] DiMatteo A, Sparks L. 2022. Draft Models of Sea Turtle Distribution and Abundance on the East Coast of the United States. Technical Report in prep by Naval Undersea Warfare Center Division Newport. Draft models provided 12 Dec 2022.

[65] https://doi.org/10.2744/CCB-1506.1

[66] https://doi.org/10.3354/mps12396

[67] https://doi.org/10.1002/jwmg.22208

[68] https://doi.org/10.3354/esr01065

[69] DiMatteo A, Sparks L. 2022. Draft Models of Sea Turtle Distribution and Abundance on the East Coast of the United States. Technical Report in prep by Naval Undersea Warfare Center Division Newport. Draft models provided 12 Dec 2022.

[70] https://repository.library.noaa.gov/view/noaa/47287

studies focused on the development areas and areas adjacent to developments, as well as vessel corridors could be the focus of sea turtle studies in this subregion. Sea turtles should also be included as a significant part of vessel co-occurrence and reef development studies. Turbine construction activities will be designed to avoid times when critically endangered right whales were historically in the area, but these limitations are not likely to avoid the times of highest sea turtle occurrence.

2.5.3 Field data collection and analysis in the NY/NJB subregion

*Ongoing and pending (*indicates projects where the subcommittee believes data on sea turtles may be minimal)*

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Boat-based surveys, sampling; glider surveys with PAM (sea turtles, birds & bats, marine mammals, fish, habitat & ecosystem)	*Development and implementation of an ocean ecosystem monitoring program for New York Bight	Stony Brook University, NYDEC	Jan 2018 – Jan 2026	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Satellite tagging; Animals physiology (sea turtles)	Loggerhead ecology in the Mid-Atlantic Bights	Coonamessett Farm Foundation, NESFC	June 1, 2009	**Detecting and quantifying changes to wildlife and habitats**
Aerial visual -strip transect; boat-based-strip transect; PAM (marine mammals, sea turtles, birds & bats, fish, habitat & ecosystem)	New Jersey Department of Environmental Protection Baseline Studies	NJ DEP, Geo-Marine	Jan 2008-Dec 2009	**Detecting and quantifying changes to wildlife and habitats**
Tagging, detection, acoustic tag deployment (sea turtles)	Seasonal Residency and Movement of Highly Migratory Sea Turtles in the New York Bight Wind Energy Areas	BOEM, RWSC, Animal Telemetry Network	Pending Jan 2023 – Jan 2025	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**

Recommended

- Design, plan, fund and conduct, long-term, small-scale studies specifically designed to determine effects on sea turtle species using multiple methodologies in the vicinity of wind projects currently under development in the SNE, NY/NJB and CA regions. Tailor studies to take advantage of each subregion's development timeline and unique sea turtle occurrence. Build on knowledge from each study to optimize results for future studies

- Compile and analyze historic satellite and acoustic sea turtle tag data in the subregion. Analysis should focus on seasonal migratory timing, environmental correlated with animal movement, offshore distribution, and contribute to analyses on tag effort needed to develop robust surface time estimates for all species in all appropriate seasons.

2.6 US Central Atlantic (USCA) ongoing, pending, and recommended research and data collection activities for sea turtles

2.6.1 Focal species and habitats of interest in the USCA subregion

The CA subregion is seasonal foraging habitat for all sea turtle species covered by the Plan. In addition, this subregion represents the northern limits of consistent loggerhead nesting for the NW Atlantic DPS, and offshore waters including the Gulf Stream are likely to be habitat for post-hatchling dispersal stage (lost years) loggerhead and green turtles (Mansfield et al. 2014[71], 2021[72]). All species covered by the plan have been detected on distance sampling surveys conducted as part of the regional AMAPPS program as well as on smaller scale survey efforts used in addition to AMAPPS survey by a Navy abundance estimation effort (Barco et al. 2015[73], Barco et al. 2018[74], DiMatteo and Sparks 2022[75], Palka et al. 2021[76]). Coastal ocean waters, Chesapeake Bay and North Carolina sounds act as important seasonal inshore foraging areas for loggerhead, Kemp's ridley and green turtles (Braun-McNeill et al. 2008[77], DiMatteo et al. 2022[78], Mansfield et al. 2009[79], McClellan and Read 2007[80], 2009[81]) and their spring and fall movement appears to be highly correlated with water temperature. It is likely that Delaware Bay is a similarly important foraging habitat. Capture, tag, and release (loggerhead) has been conducted in the subregion (Hatch et al. 2022[82]) and numerous rehabilitated turtles have been released with tags, both acoustic and satellite (Barco et al. 2015, Robinson et al. 2020[83]). Fewer Kemp's ridley and green turtles were detected in the CA subregion than loggerheads and

[71] http://dx.doi.org/10.1098/rspb.2013.3039
[72] https://doi.org/10.1098/rspb.2021.0057
[73] https://energy.maryland.gov/Documents/Marine%20Mammal%20and%20Sea%20Turtle%20Sightings%20in%20the%20Vicinity%20of%20the%20Maryland%20Wind%20Energy%20Area.pdf
[74] https://doi.org/10.3354/esr00917
[75] DiMatteo A, Sparks L. 2022. Draft Models of Sea Turtle Distribution and Abundance on the East Coast of the United States. Technical Report in prep by Naval Undersea Warfare Center Division Newport. Draft models provided 12 Dec 2022.
[76] https://repository.library.noaa.gov/view/noaa/47287
[77] https://doi.org/10.3354/esr00145
[78] DiMatteo A, Sparks L. 2022. Draft Models of Sea Turtle Distribution and Abundance on the East Coast of the United States. Technical Report in prep by Naval Undersea Warfare Center Division Newport. Draft models provided 12 Dec 2022.
[79] https://doi.org/10.1007/s00227-009-1279
[80] https://doi.org/10.1098/rsbl.2007.0355
[81] https://doi.org/10.3354/esr00199
[82] https://doi.org/10.1002/jwmg.22208
[83] https://doi.org/10.3354/esr01065

leatherbacks on AMAPPS surveys, but there were some unidentified hard-shelled turtles detected that may have been these species (DiMatteo and Sparks 2022[84]; Palka et al. 2021[85]).

2.6.2 Potential effects of concern in the CA subregion

The potential effects of offshore wind development are similar in this subregion as are discussed in section 1.3 of this chapter. The imminent future development of the CVOW project in VA waters makes the CA subregion of interest to the subcommittee, since the timeline for these projects may allow for both pre- and post-construction assessment of the area. Additional projects off Maryland (US Wind) and northern North Carolina (Kitty Hawk Wind N) are farther away from construction than CVOW. Unlike states to the north in the CA region such as Maryland and southern New Jersey and states in subregions to the north of CA, neither Virginia nor North Carolina are funded through powersharing agreements or other means to implement environmental monitoring projects independent of federal resources. For this reason, both the CVOW and Kitty Hawk N projects are unlikely to be the subject of meaningful monitoring or research outside of required mitigation without funding from federal sources. These two areas are likely have: 1) higher turtle densities of most species, 2) longer exposure seasonally and 3) active breeding and nesting adults than projects to the north and, for the reasons above, should be the focus of sea turtle oriented research on impacts of OSW on sea turtle species. In addition, restrictions on turbine construction activities designed to avoid times when critically endangered right whales will mean that construction will occur when densities for sea turtle species in this area are highest. Thus, the subcommittee recommends that federal funding for sea turtle impact studies around specific projects be focused on the CVOW and Kitty Hawk N development areas and areas adjacent to development including vessel corridors.

2.6.3 Field data collection and analysis in the CA subregion

*Ongoing and pending (*indicates projects where the subcommittee believes data on sea turtles may be minimal)*

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Sampling; eDNA assays (sea turtles)	Developing sea turtle specific eDNA assays	Coonamessett Farm Foundation, MET	Jan 2022-Jan 2023	**Enhancing data sharing & access**
Satellite tagging; Animals physiology (sea turtles)	Loggerhead ecology in the Mid-Atlantic Bights	Coonamessett Farm Foundation, NESFC	June 1, 2009	**Detecting and quantifying changes to wildlife and habitats**

[84] DiMatteo A, Sparks L. 2022. Draft Models of Sea Turtle Distribution and Abundance on the East Coast of the United States. Technical Report in prep by Naval Undersea Warfare Center Division Newport. Draft models provided 12 Dec 2022.

[85] https://repository.library.noaa.gov/view/noaa/47287

Tagging, satellite; health assessment (sea turtles)	Sea turtle monitoring and health assessment program	Atlantic Marine Conservation Society (AMSEAS)	Jan 2017 - ongoing	**Detecting and quantifying changes to wildlife and habitats**
Tagging, satellite (sea turtles)	Marine Turtle Habitat Use Patterns Within the Outer Banks Ecosystem at Cape Hatteras and Cape Lookout National Seashores, 2021-2022	USGS, USFWS	Jan 2021 – Jan 2022	**Detecting and quantifying changes to wildlife and habitats**
Tagging, acoustic detection & data archiving (sea turtles, fishes)	*Mid-Atlantic Acoustic Telemetry Observation System (MATOS)	MARACOOS, IOOS, NOAA, Animal Telemetry Network, Atlantic states Marine Fisheries Commission, Smithsonian Environmental System	Jan 2012 - ongoing	**Enhancing data sharing & access**
Tagging, acoustic detection; PAM (marine mammals, fish, sea turtles)	*US Wind - UMCES passive acoustic monitoring array	University of Maryland CES, Maryland Energy Administration, Maryland DNR, Cornell University	Jan 2014 – Dec 2028	**Detecting and quantifying changes to wildlife and habitats**

Recommended

- Design, plan, fund and conduct, long-term, small-scale studies specifically designed to determine effects on sea turtle species using multiple methodologies in the vicinity of wind projects currently under development in the SNE, NY/NJB and CA regions. Tailor studies to take advantage of each subregion's development timeline and unique sea turtle occurrence. Build on knowledge from each study to optimize results for future studies

2.7 US Southeast Atlantic (USSEA) ongoing, pending, and recommended research and data collection activities for sea turtles

2.7.1 Focal species and habitats of interest in the USSEA subregion

The SA subregion provides foraging, nesting and breeding habitat for all sea turtle species covered by the Plan. This subregion includes the majority of nesting on US Atlantic shorelines for loggerhead, green and leatherback turtles. Kemps ridley nesting effort on SA beaches is sporadic. Nesting and breeding in the SA region is significant for loggerhead and green turtle populations. In addition, offshore waters including the Gulf Stream is habitat for post-hatchling dispersal stage (lost years) loggerhead and green turtles (Mansfield et al. 2014[86], 2021[87]) and may be habitat for leatherbacks as well. Sea turtles have a year-round presence in the waters of the SA subregion. Some loggerhead turtles overwinter south of Vape Hatteras in the northern portion of the sub-region (Mansfield et al 2009[88]). All species covered by the plan have been detected on distance sampling surveys conducted as part of the regional AMAPPS program as well as on other survey efforts used in addition to AMAPPS survey by a Navy abundance estimation effort (DiMatteo and Sparks 2022[89], Palka et al. 2021[90]).

2.7.2 Potential effects of concern in the SA subregion

The potential effects of offshore wind development are similar in this subregion as are discussed in section 1.3 of this chapter with the addition of nesting, breeding and hatching behavior to be considered. There are, however, no projects in this subregion currently under review by BOEM, and only two leases have been awarded off southern North Carolina. Development in this subregion is significantly lower and farther from completion than subregions to the north. This extended timeline to development will allow for projects in the subregion to benefit from research conducted in the more northern subregions, which will be important as this subregion has a higher turtle density, significant nesting and breeding habitat, and greater year-round occurrence of sea turtles that other subregions. Although different from OSW development, efforts to study impacts of oil and gas operation and decommissioning in the Gulf of Mexico in the wake of the Deep Water Horizon Spill in 2010 is adding to the body of knowledge about turtle presence and behavior in sub-tropical climates. As in Virginia and North Carolina, states are unlikely to have significant funds from powersharing and other agreements that states to the north are able to receive. As such, most research in this subregion will likely need to be fully federally funded.

2.7.3 Field data collection and analysis in the SA subregion

Ongoing and pending

Method(s)	**Project**	**Lead and Partner Entities**	**Time period**	**Research Theme**

There are no current sea turtle Field Data Collection and Analysis Projects listed in the RWSC database for the SA subregion.

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[86] http://dx.doi.org/10.1098/rspb.2013.3039
[87] https://doi.org/10.1098/rspb.2021.0057
[88] https://doi.org/10.1007/s00227-009-1279
[89] DiMatteo A, Sparks L. 2022. Draft Models of Sea Turtle Distribution and Abundance on the East Coast of the United States. Technical Report in prep by Naval Undersea Warfare Center Division Newport. Draft models provided 12 Dec 2022.
[90] https://repository.library.noaa.gov/view/noaa/47287

Recommended

There are no Field Data Collection and Analysis recommendations specifically for the SA sub-region. Region-wide recommendations that include the SA region are included in section 2.1 of this chapter.

2.7.4 Non-field research by type of action

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Outreach and platforms to provide data products and results to stakeholders (sea turtles, fish, habitat & ecosystem)	Southeast Area Monitoring and Assessment Program (SEAMAP)	ASMFC, NMFS SEFSC, USFWS SAFCO, FL FWC, GA DNR, NC DENR, SC DNR, South Atlantic Fishery Management Council	Jan 1981-ongoing	**Detecting and quantifying changes to wildlife and habitats**
Outreach and platforms to provide data products and results to stakeholders (all species groups)	*The Southeast Marine Mapping Tool (Phase 2): Increasing access to regional ecological data to help inform offshore ocean use decisions: Analysis and Visualization of Ocean Resources in the Context of Offshore Wind Energy Development	SECOORA, The Nature Conservancy	Jan 2023 -	**Enhancing data sharing & access**
Historical data collection/compilation (all species groups)	*The Southeast US Marine Biodiversity Observation Network (MBON): Toward Operational Marine Life Data for Conservation and Sustainability	USF, SECOORA, GCOOS, NOAA AOML, U Miami, FWRI, NOAA NMS, FL Keys NMS, U of Porto, Portugal U, UNESCO, OSU	Jan 2023-Dec 2027	**Understanding the environmental context around changes to wildlife and habitats**

Recommended

There are no Non-Field Data Collection and Analysis recommendations specifically for the SA sub-region. Region-wide recommendations that include the SA region are included in section 2.1 of this chapter.

Appendix: Definitions and Acronyms

AMAPPS – Atlantic Marine Assessment Program for Protected Species; a joint project funded by BOEM, NOAA Fisheries, US Navy, and US Fish and Wildlife Service to provide seasonal abundance estimates that incorporate environmental habitat characteristics for marine mammals, turtles, and seabirds in the western North Atlantic Ocean

AMSEAS – Atlantic Marine Conservation Society, Hampton Bays, NY

ARGOS - a global satellite-based location and data collection system dedicated to studying and protecting our planet's environment. The polar-orbiting satellites making up Argos fly at an orbit of 850 km above the earth. They pick up the signals, store them on-board, and relay them in real-time back to earth. Receiving stations then relay data from satellites to processing centers. These processing centers collect all incoming data, process them and distribute them to users.

benthic – adjective describing species, habitat, etc. associated with the ocean bottom

BOEM – Bureau of Ocean Energy Management, the federal agency regulating OSW planning areas, auctions and leases

CA – Central Atlantic subregion, see Figure 1

CFF – Coonamessett Farm Foundation, East Falmouth, MA

CV – coefficient of variation; a measure of confidence in statistical calculations such as density and abundance. A low CV suggests higher confidence that the true value is close to the estimated value

DPS – distinct population segment, in the US some turtle species are managed in distinct population segments usually defined by distribution of nesting females

ectothermic – 'cold-blooded;' refers to animals such as fish, amphibians, and reptiles whose core body temperature is correlated with the environment, some ectothermic species such as leatherback turtles are able to maintain body temperatures up to 10 °C above ambient environmental temperatures but their body temperature is still correlated with ambient temperature

endothermic – 'warm blooded;' refers to animals whose core body temperature is maintained within a narrow range regardless of ambient environmental temperatures. Birds and mammals are endothermc.

EMF – electromagnetic field; a classical (*i.e*. non-quantum) field produced by accelerating electric charges. The field can be viewed as the combination of an electric field and a magnetic field. The electric field is produced by stationary charges, and the magnetic field by moving charges (currents); these two are often described as the sources of the field.

ESA – U.S. Endangered Species Act

Gelatinous zooplankton – group of macroscopic zooplankton including jelly fishes, comb jellies, salps and other similar species that are prey for some sea turtles, especially leatherback turtles.

GOM – Gulf of Maine the northernmost subregion described in the RWSC Science Plan; see Figure 1

GPS – global positioning system

MARCO – Mid-Atlantic Regional Council on the Ocean

NEAq – New England Aquarium, Boston, MA

Neritic – adjective describing ocean habitat over the continental shelf. Following their oceanic dispersal stage, most sea turtle species enter a juvenile neritic foraging stage that may continue for 3 to more than 20 years.

NEFSC – Northeast Fisheries Science Center for NOAA Fisheries, Woods Hole, MA

NMFS – see NOAA Fisheries

NOAA Fisheries – formerly called National Marine Fisheries Service (NMFS), federal agency tasked with managing protected marine species in their in-water marine habitats. Jurisdiction of species that spend time in freshwater and/or terrestrial habitat is shard with the U.S. Fish and Wildlife Service (USFWS). For sea turtles, NOAA Fisheries manages all behavior and life stages except for nesting and nest protection which falls under USFWS.

NROC – Northeast Regional Ocean Council

NYB – New York Bight subregion of the RWSC; see Figure 1

NYSERDA – New York State Energy Research and Development Authority

pelagic – adjective describing ocean habitat over the deep ocean. In the NW Atlantic the oceanic dispersal stage of a sea turtle's life is spent in the pelagic environment, most notably in the Sargasso Sea

(the) Plan – RWSC Science Plan

Project WOW – Wildlife and Offshore Wind: A multi-organization research project with the goal of creating a system for the comprehensive evaluation of potential effects of offshore wind energy development on marine wildlife. Project WOW is led by the Duke University Marine Geospatial Lab (https://offshorewind.env.duke.edu/)

PTT – Platform Transmitting terminal, the part of a satellite tag that sends user-defined periodic messages to satellites.

SA – Southern Atlantic subregion of the RWSC Science Plan; see Figure 1

SNE – Southern New England subregion of the RWSC Science Plan; see Figure 1

telemetry – measurement of wireless transmission of data from remote sources, in this context animal borne tags such as satellite and acoustic tags

USFWS – U.S. Fish and Wildlife Service

Chapter 11: Habitat & Ecosystem-Oceanography

Executive Summary

This science plan chapter describes around 75 individual ongoing data collection and research initiatives related to offshore wind (OSW) and oceanographic/pelagic habitats and ecosystems funded by a variety of partners (states, federal agencies, industry). Each initiative is a near-term investment for either field or non-field activities related to understanding and mitigating the potential regional and subregional oceanographic effects of OSW energy development. The main types of potential oceanographic effects that are discussed include considerations related to the physical effects of structures, noise propagation, water quality, and biological linkages. For an always up-to-date list of active projects, visit the RWSC Offshore Wind & Wildlife Research Database. Given this ongoing work, the Habitat & Ecosystem Subcommittee is making recommendations for additional research that is both aligned with existing efforts and that fills important gaps. Those recommendations are described in detail throughout each section of this chapter. The recommendations are also summarized below:

RWSC Research Theme	Research Topic	Recommendations
Mitigating negative impacts that are likely to occur	Identify sensitive pelagic habitats and inform wind farm design characteristics, siting, and marine spatial planning	• Define significant oceanographic features and areas of biological productivity. • Develop daily, monthly, and seasonal climatologies of oceanography, pelagic habitat, and biological productivity to inform marine spatial planning and offshore wind project design.
	Evaluate approaches to mitigate impacts to oceanography, pelagic habitat, and biological productivity	• Evaluate effects of noise mitigation and abatement technologies on oceanography, pelagic habitat, and biological productivity. • Monitor and model effects of using different mitigation measures to minimize sound propagation during construction to understand best approaches for minimizing environmental effects.
	Adapt layout of wind farms to minimize the wake effects	• Utilize wake modeling and mesoscale modeling of wind farms to understand how different wind farm layouts affect atmospheric, oceanographic, and biogeochemical processes and how effects can potentially be minimized.
Detecting and quantifying changes to wildlife and habitats	Characterize sound propagation and changes to the ocean soundscape	• Coordinate with the Marine Mammal Subcommittee on soundscape characterization and sound propagation data collection and modeling. • Assess baseline soundscape and ecosystem conditions in support of predictive environmental modeling and trend analyses.

		• Improve sound measuring technologies and sound propagation models to include very low frequencies (below 10 Hz).
	Baseline hydrodynamic and oceanographic processes (e.g., ocean stratification; seasonally dependent effects on the cold pool)	• Ensure that hydrodynamic and oceanographic processes (e.g., ocean stratification, seasonally dependent effects on the cold pool) are consistently measured across the RWSC study area by: o More extensively using observing system simulation experiments (OSSEs) to determine optimal location of oceanographic observing at the region-wide scale. o Coordinating with the Regional IOOS Associations and other taxa-based subcommittees that may be deploying instrumentation via buoys to strategically co-locate sensors for metocean and habitat data. o Investing in region wide data collection with AUVs and remote sensing, including gliders, to supplement buoy data and collect more seamless broad scale coverage of physical oceanographic and biogeochemical data, and to record ambient noise. • Collect in a consistent way hydrographic, oceanographic, and productivity data from the fine- to regional scales that inform coupled hydrodynamic, biogeochemical, and biological productivity models and produce a collection of standardized data products for priority species modeling covariates. • Develop a fine-scale region-wide hydrodynamic model of offshore wind effects, encompassing all the lease areas throughout the region. The current modeling should be extended to the Gulf of Maine and south of Cape Hatteras. • Establish a region-wide strategy to ensure that reliable reference/control sites for collecting background baseline data are selected in areas outside of future OSW leasing.
	Biomass, composition, and distribution of phytoplankton and associated primary production (including broad-scale primary productivity and distance, overlap of productivity from offshore wind projects, and food availability for filter feeders)	• Synthesize primary productivity data across existing programs (e.g., EcoMON, U.S. LTER, MBON, Continuous Plankton Recorder) and across methods (e.g., satellites, fixed and mobile sensors, and ship-based sampling) to characterize changes at fine to regional scales. • Conduct coupled physical-biological and ecosystem modeling to understand drivers of observed changes. • Coordinate with the Habitat & Ecosystem - Seafloor Subcommittee to ensure that data is available (or collected) to understand food availability for filter feeders. This involves finer

		scale vertical monitoring at turbines from seafloor to surface.
	Understand zooplankton biomass, composition, and distribution, and shifts over time	• In collaboration with the Marine Mammal Subcommittee, synthesize zooplankton data across existing programs and across methods to characterize changes at fine to regional scales. • Conduct coupled physical-biological and ecosystem modeling to understand drivers of observed changes. • Coordinate with the Habitat & Ecosystem - Seafloor Subcommittee to ensure that data is available (or collected) to understand zooplankton characteristics around turbines. This involves finer scale vertical monitoring of turbines from seafloor to surface.
Understanding the environmental context around changes to wildlife and habitats	Atmospheric effects associated with energy removal by wind turbines (i.e., effects on wind and waves to better understand wake effects)	• Conduct studies of atmospheric response to wind farms using both simulations and field experiments, incorporating learnings from ongoing work in the MA-RI lease areas. • Test and validate the results of model-based studies related to offshore wind farms and atmospheric effects using real-world observations. Field observations are needed that can discern the physical effect of offshore wind farms in contrast to what are solely naturally-caused processes that may have been impacted by other factors. • Coordinate with the Bird & Bat Subcommittee to understand the implication of any observed atmospheric effects on bird and bat movement/migrations.
	Physical oceanographic conditions (e.g., Mid Atlantic Cold Pool) formation and dynamic overlap with OSW energy development, with focus on stratification changes	• Conduct simulations and field experiments to further develop models of wind farm-induced flow and atmospheric response to both momentum and heat fluxes. • Collect measurements of the local turbulence production and induced mixing of different offshore wind foundation structures to develop more accurate mixing parameterizations.
	Ambient soundscape assessments before OSW development and throughout the lifecycle of OSW activities	• Coordinate with the taxa-based subcommittees to collect measurements of ambient soundscape using fixed and mobile platforms that provide information on historic, present, and future ambient noise levels, including underwater sound source identification, to validate and improve soundscape models.
	Changes in water quality and light penetration (e.g., chemical contamination associated with increased vessel traffic and presence	• Collect spatiotemporal water quality and bio-optical data using satellites, fixed and mobile sensors, and ship-based sampling to understand

	of OSW structures; effects on suspended particulate matter and turbidity)	potential effects from a single turbine to multiple wind farms at the regional scale. • Conduct physical-biogeochemical modeling to understand drivers of observed changes.
Determining causality for observed changes to wildlife and habitats	Understand natural variability and anthropogenic climate change as a contributor to observed changes in wildlife and habitat	• Coordinate with existing programs that document changes in oceanography, habitat, and productivity due to a variety of stressors, including climate change. • Improve ecosystem models that incorporate the complex interactions of natural and anthropogenically-mediated oceanographic processes influencing the abundance, community composition, spatial distribution, and productivity of phytoplankton and zooplankton and the implications for higher trophic levels.
	Effects of changes in hydrodynamics, water stratification and turbidity on marine communities and regional ecosystems across different spatiotemporal scales (particularly phytoplankton and zooplankton community structure, biomass and larval settlement success and recruitment)	• Build on the National Academy of Sciences project “Evaluation of Hydrodynamic Modeling and Implications for Offshore Wind Development: Nantucket Shoals” to design experiments and conduct field studies elsewhere in the RWSC study area to characterize effects of offshore wind turbines on hydrodynamics. • Design experiments (field, models) to examine relationships between offshore wind structure presence, temperature, stratification, and plankton distribution and biomass. • Conduct multivariate regional scale analyses of oceanographic, phytoplankton, and zooplankton observational data (e.g., community structure, biomass) at regular intervals (every 5 years, 10 years) after offshore wind development begins to characterize any changes. • In collaboration with the Habitat & Ecosystem Subcommittee – Seafloor experts and Responsible Offshore Science Alliance, conduct experiments to determine if changes in oceanographic systems due to the presence of offshore wind infrastructure affect benthic organism and/or fish larval settlement success. • Coordinate with taxa-based Subcommittees to ensure that oceanographic processes are measured concurrent with wildlife observations to maximize the chances of determining causality for any observed changes in distribution, abundance, behavior, and health.
	Integrated modeling of the combined effects of wind field modification and in situ structure friction and fish responses to related hydrodynamic predictors relevant to their key habitats and lifecycle stages	• In coordination with the Protected Fish Species Subcommittee, simultaneously collect oceanographic and fish data to assess effects of wind energy development, including through development of predictive models.

	Explore how shifts in plankton and forage fish populations affect higher trophic levels	• Coordinate with the taxa-based subcommittees to conduct data collection and ecosystem modeling to assess effects on higher trophic levels.
Enhancing data sharing and access	Maintain the inventory of ongoing data collection and research projects for oceanography and OSW to encourage regional coordination	• For each known project, identify and catalogue repositories where data are being stored. • Collaboratively develop oceanographic data products that could be used to assess change over time or as inputs to species distribution models. • Encourage or require future projects to include funding for data product development, hosting, and maintenance/updates in their budgets. • Require that oceanographic data are shared in formats compatible with existing platforms such as the IOOS regional and functional Data Assembly Centers.
	Coordinate data collection and synthesis of existing data efforts at a regional scale, including baseline data and data collected at individual OSW project sites (e.g., post-construction monitoring data)	• Facilitate pooling of data to obtain the statistical power to examine regional scale effects. • Continue to lead or participate in the ongoing and pending coordination and planning activities, using the RWSC Habitat and Ecosystem (Oceanography) Subcommittee as a forum for information exchange and coordination among federal agencies, states, offshore wind industry, eNGOs, and the research community.
	Make all data publicly available to aid in the assessment of broad-scale questions, ecosystem-level research, and potential cumulative impacts	• Ensure that existing data repositories for oceanographic data have resources and personnel to integrate and provide access to offshore wind and environmental monitoring datasets as they are collected. Include a minimum budget threshold that must be allocated to data management and access in all project budgets. • In collaboration with the IOOS RAs, support the integration of oceanographic datasets associated with research projects and offshore wind developers' monitoring into the IOOS data management system. • Require that raw data and deployment metadata be submitted for archiving at NCEI.

1 Background

A wealth of scientific information has been collected on the oceanography of U.S. Atlantic waters, setting the stage with a historical baseline for helping to understand future changes. At a high level, physical oceanographic processes are largely shaped by the Gulf Stream flowing north along the coast and the Labrador Current flowing south, with an abrupt transition occurring at Cape Hatteras where the Gulf Stream comes to within 30 km of shore (Townsend et al. 2006; Figures 1-2). The Labrador Current transports cold water southward where it meets the shelf waters of the North Atlantic Ocean and the Gulf Stream at Cape Hatteras (Blair et al. 2022). The Gulf Stream flowing from the south contributes to heat redistribution in the North Atlantic and also influences the shelf ecosystem, particularly through the formation of meanders and eddies. Beyond these two major current systems, shelf water and slope water are distinct water masses that also influence the region. Shelf water has origins on the continental shelf and includes inputs from the multiple river systems along the coast. Thus, shelf water is less dense than slope waters which consist of a deep, nutrient rich water mass that lies between the shelf and the major offshore currents.

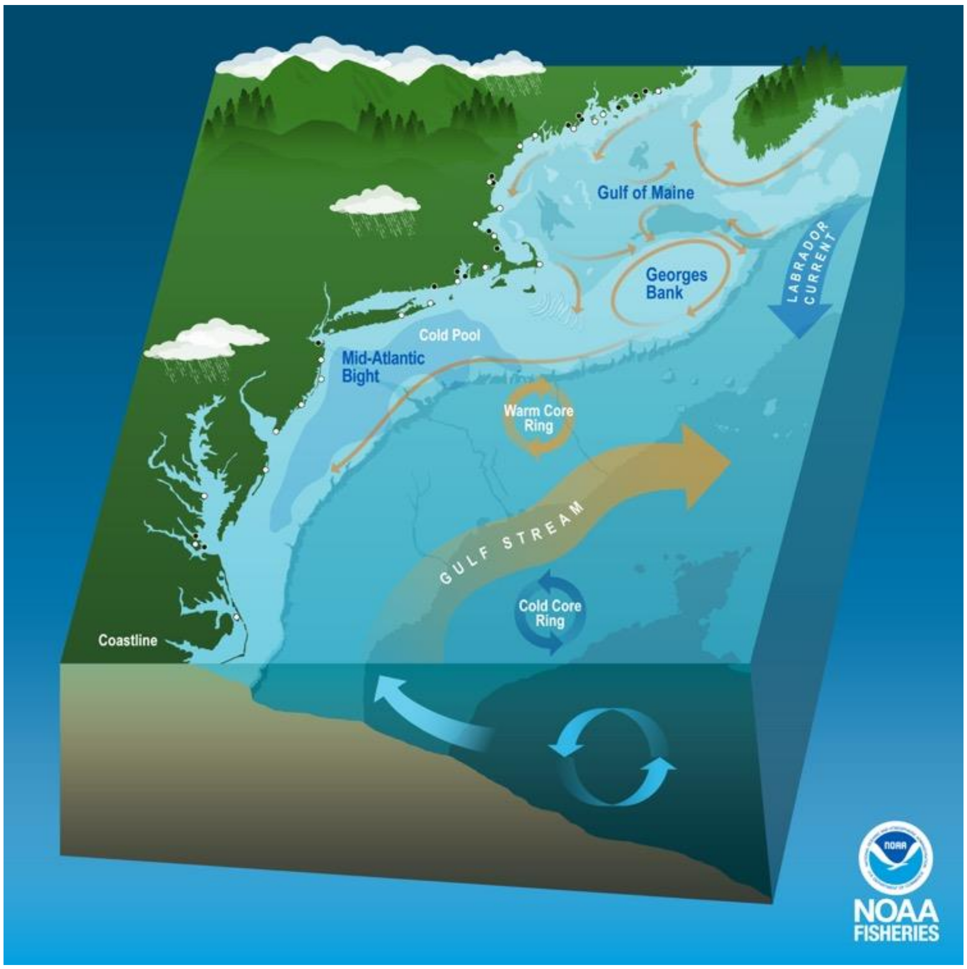

Figure 1. The Northeast U.S. Continental Shelf ecosystem showing the dominant currents and oceanographic features.

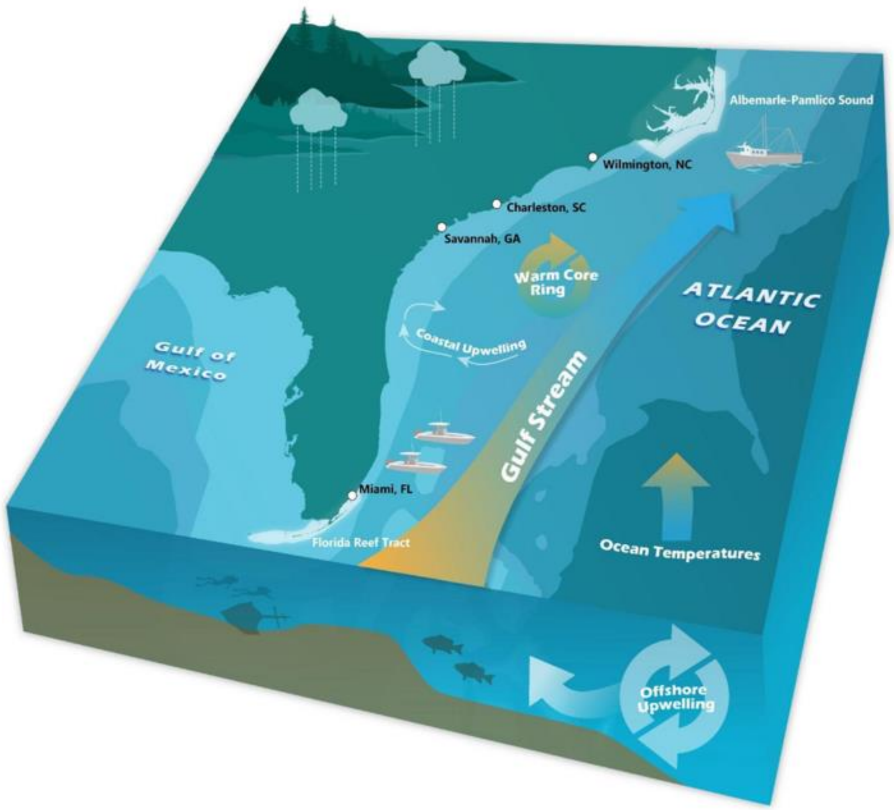

Figure 2. The U.S. South Atlantic marine ecosystem. Credit: [NOAA/Seann Regan](#).

Variability in regional atmospheric conditions impact sea surface properties (e.g., winds and temperature) and cause both short- and long-term changes in oceanographic processes along the Atlantic coast. Annual average wind speeds increase from the south and peak in New England and Gulf of Maine waters (e.g., Musial et al. 2016; Bodini et al. 2020). Winds fluctuate over multiple time scales including seasonally (with mid-latitudes generally higher in the summer), weekly (e.g., during synoptic-scale storms), daily (with higher winds at night), and hourly/sub-hourly (e.g., due to fluctuations in turbulence and gusts) (Archer et al. 2017). At longer time scales, the North Atlantic Oscillation (NAO) impacts the region and can be described in terms of an index value (NAOI) related to differences in sea level pressure, with patterns persisting across decades. The NAOI has been predominantly positive during the last several decades (NMFS 2021), associated with an increase in westerly winds, an increase in precipitation, and warmer water temperatures for the eastern United States. By contrast, a negative NAOI is associated with a decrease in westerly winds, decreased storminess, drier conditions, and cooler water temperatures in the region.

Primary productivity in the region is determined by a physically dynamic ecosystem with complex interactions among environmental factors that influence the abundance, community composition, spatial distribution, and productivity of the phytoplanktonic communities. These environmental factors include the sunlight, nutrients, water temperature, physical processes (i.e., vertical mixing, upwelling, currents, and tides), and the feeding activity of zooplankton and shellfish (Blair et al. 2022). Water mass characteristics and oceanographic features (e.g., circulation patterns and frontal zone positions) are particularly important factors influencing phytoplankton patterns (Lipsky 2020; NMFS 2021). Seasonality greatly influences the dynamic ecosystem of the region, given that phytoplankton growth rates strongly correlate to temperature, light availability, and phytoplankton community size-structure (e.g., Marrec et al. 2021). Zooplankton graze on phytoplankton and are then prey for fish, crabs, whales, and other large organisms; biovolume (total volume of material caught in zooplankton nets) measurements have shown seasonal and interannual trends in the region (Blair et al. 2022).

1.1 Oceanographic processes in the Atlantic region

1.1.1 Historical processes

From north to south, each of the five regions described in this Science Plan have distinct oceanographic conditions and features. Based on differences in latitude and the influences of the two major currents (Gulf Stream and Labrador), some of the most obvious features are that wind speeds and sea surface temperatures (SST) generally decrease from north to south with highest wind speeds and coldest SSTs in the Gulf of Maine and lowest wind speeds and warmest SSTs in the U.S. southeastern Atlantic (e.g., Bodini et al. 2020; NOAA SST contour charts). An overview of the oceanography and key features in each region is provided in the following paragraphs.

The **Gulf of Maine** is a continental shelf sea with deep basins (e.g., Georges and Jordan Basins) that also includes the shallow offshore areas of Nantucket Shoals, Georges and Browns Banks, and the Scotian Shelf (Townsend et al. 2015). The Gulf reaches a maximum depth of over 1,200 feet in the Georges Basin. Inside the basins of the Gulf, tidal mixing as well as the seasonal warming and cooling of slope water and Scotian Shelf water create a seasonal intermediate layer, resulting in a three-layered water column structure. Buoyancy-driven flow propels surface circulation in the Gulf and results in a counterclockwise direction due to freshwater riverine inputs and higher density offshore waters. Notably, the Gulf has among the greatest tidal ranges in the world and associated swift tidal currents. This tidal mixing strongly influences nutrient delivery to the euphotic zone and overall biological productivity. With its shallow and well-mixed waters, Georges Bank is unique for its high primary productivity and high concentrations of chlorophyll a, supporting an extensive food web including high levels of fish production (Northeast Integrated Ecosystem Assessment).

Southern New England waters extend from Cape Cod to Montauk Point, New York and include features such as Nantucket Shoals, Martha's Vineyard, Block Island, and Long Island Sound, and submarine canyons in deeper waters (Blair et al. 2022). In the northern part of the region, the Great South Channel acts as a passage that connects the Gulf of Maine and the southern New England shelf. Nantucket Shoals are a well-mixed, shallow region and are biologically productive due to the cold, nutrient rich water arriving from the Gulf of Maine (Townsend et al. 2004). South of Martha's Vineyard is an expanse of continental shelf with a gradual slope and cross-shelf currents leading to the edge of the shelf, where several submarine canyons cut into the shelf. To the south, Rhode Island Sound demonstrates seasonality of thermal stratification in the spring and summer. By contrast, Block Island Sound is an area with strong tidal currents and density stratification year-round. The greater-shelf region experiences warm core rings that break off from the Gulf Stream. The northern portion of the Mid Atlantic Cold pool extends into southern New England waters.

The **Mid-Atlantic Bight** encompasses the entire Mid-Atlantic region, including the two RWSC subregions of the NY/NJ Bight (at its northern end) and the U.S. central Atlantic (at its southern end). The Mid-Atlantic region is influenced by both cool waters of the Labrador Current from the north and warm waters of the Gulf Stream from the south, with shelf water generally flowing south toward Cape Hatteras, North Carolina (Townsend et al. 2004). The New York Bight is a triangular feature that runs from Montauk at the eastern point of Long Island, New York to Cape May, New Jersey. Within the New York Bight, circulation is highly sensitive to changes in wind (Blumberg and Galperin 1990) and biological productivity is affected by riverine nutrient outputs and cross-shelf interactions (Townsend et al. 2004). More broadly across the Mid-Atlantic Bight, the mixing of slope and shelf waters, along with upwelling, increases nutrient availability and promotes productivity (Townsend et al. 2004). The Mid-Atlantic Bight Cold Pool is a characteristic of the region, where strong seasonal stratification promotes productivity among all levels of the food chain; it is a dynamic feature that provides crucial habitat in the northeast shelf, particularly as a thermal refuge for benthic species (Blair et al. 2022).

The **U.S. southeastern Atlantic** is connected by the Loop Current-Florida Current-Gulf Stream continuum and influenced by the tropical and sub-tropical oceanic, atmospheric, and ecosystem domains. The confluence of the tropical and sub-tropical domains influences a range of sub-to super-regional physical and biogeochemical phenomena (SECOORA 2019). In this region, the shelf is relatively wide and shallow; the physical dynamics are dominated by interactions with the Gulf Stream and the overlying atmosphere. Water movement is dominated by tidal and synoptic scale atmospheric events, and Gulf Stream frontal waves. Within Long Bay, situated in NC and SC, and other coastal bays, buoyancy also plays an important role in inner shelf oceanographic dynamics. In these areas, river plumes deliver sediment, nutrients, and pollutants to coastal waters, as well as also providing chemical cues that affect recruitment of estuarine-dependent fishery species. River plumes may also influence rates of coastal acidification in nearshore waters.

1.1.2 Ongoing and future alterations due to climate change

Human-induced climate change is causing an increase in sea surface temperatures, sea level rise, and ocean acidification, and is changing circulation patterns (Blair et al. 2022). Over the last two decades, ocean temperatures in the northeast Atlantic Ocean have warmed faster than the global ocean on average, with the Gulf of Maine warming faster than 99% of the global ocean (NMFS 2021b). During this period, the Gulf Stream has moved northward, driving warmer, saltier water onto the northeast shelf, with a decrease in colder Labrador slope water entering the Gulf of Maine (Mid-Atlantic Fishery Management Council and New England Fishery Management Council 2022). Additionally, the size and position of the Mid-Atlantic Bight Cold Pool varies annually and is significantly smaller and less sustained during warmer years (Mid-

Atlantic Fishery Management Council and New England Fishery Management Council 2022). Annual mean chlorophyll concentration trends across the northeast shelf and all subareas were steady from 1998 until 2012, at which point a downward trend persisted across the shelf through 2019 (Friedland et al. 2020). In the southeast region, the mean sea surface temperature between 2016 and 2021 was higher than 86% of the temperatures between 1985 and 2021; the average concentration levels of chlorophyll a between 2016 and 2021 were slightly lower than the long-term median of levels between 1998 and 2021 (NOAA undated).

1.2 Potential effects with respect to offshore wind

The main types of potential oceanographic effects due to offshore wind energy development are summarized in this section. They include considerations related to the physical effects of structures, noise propagation, water quality, and biological linkages.

Wind energy structures can have potential physical effects both above and below the water surface. The two primary components of these physical effects include: (1) structures above the water extracting energy, with associated wake effects (ocean-atmospheric interactions), and (2) structures in the water affecting turbulence and vertical mixing (hydrodynamic interactions). The extraction of energy has the potential to affect air-sea exchange processes, and associated changes in wind speeds, wave energy, turbulence, and eddy formation (Blair et al. 2022). For example, wake lengths of more than tens of kilometers under stable atmospheric conditions have been observed, with maximum wind speed deficits of 40%, and enhanced turbulence (Platis et al. 2018). In the water, the presence of turbine foundations can create localized friction, block ocean hydrodynamics, change wave amplitudes, and increase turbulent kinetic energy (e.g., van Berkel et al. 2020). Effects on hydrodynamics can cause lateral and vertical changes in the temperature and salinity profiles within the water column. These potential effects on water column mixing have implications for ocean stratification and the residence time of waters in a region. Consideration also needs to be given to the potential for energy extraction to affect upwelling, downwelling, and frontal zones, since these regions can aggregate prey and attract higher trophic level organisms.

Noise and vibration are generated by offshore wind turbines and associated operations, with variation in the amount and quality of noise generated throughout the lifecycle of a wind farm (SEER 2022a). For example, the installation of turbine foundations using monopiles is considered one of the noisiest aspects of wind farm construction due to pile driving activities, and opportunities exist to reduce the amount of noise and vibration produced during future offshore wind farm development (Green et al. 2023). Other wind farm related activities can also generate noise and vibration, including wind farm operations and support vessels for site assessment, as well as constructing, building and maintaining the wind turbines. The three main environmental factors that will affect undersea acoustic propagation include variability in pressure, temperature, and salinity, which produce changes in sound speed and consequently affect the characteristics of acoustic propagation (e.g., Lin et al. 2019). The effects of noise on marine mammals and sea turtles are discussed in separate chapters of this Science Plan. In addition to marine mammals and sea turtles, fish and invertebrate species can also be impacted by noise, including by particle motion (back-and-forth motion of the medium), sound pressure, and substrate vibration. The propagation or emission rates for these stressors are intrinsically dependent on the marine environmental conditions (Hogan et al. 2023).

The placement of wind turbine structures and associated effects on hydrodynamics can in turn affect biogeochemical and water quality characteristics of the water column. In terms of turbidity, the turbulence created around a turbine foundation can result in increased sediment erosion and suspended sediment concentrations in the water column (van Berkel et al. 2020). As observed in satellite imagery, offshore turbine structures can increase near-surface suspended sediment concentrations in the form of turbid wakes (Vanhellemont and Ruddick 2014). Suspended sediment concentrations can also affect light conditions with implications for phytoplankton growth in the water column. As well, any impacts of wind farms on hydrodynamics and mixing could also affect the vertical profiles of nutrient, oxygen, and chlorophyll concentrations within the water column, with implications for primary productivity and higher trophic levels (Blair et al. 2022).

In terms of linkages to biological effects, the introduction of new structures during offshore wind farm construction can alter the habitat and modify food webs as the turbines are colonized. Habitat can be temporarily or permanently altered directly beneath and in the vicinity of turbine foundations, depending on the foundation type, materials used, and sediment type (SEER 2022b). Emplacement of structures, such as foundations, can alter habitat by introducing new hard surfaces into an environment of soft sediment, which are then rapidly colonized by epifaunal organisms. Through colonization, the structures can introduce a different community of organisms, which can cause changes in local primary production, alter the food web, change predator/prey relationships, and alter carbon flow to the benthos (e.g., Degraer et al. 2020). Depending on the changes, the shifts have been considered both an enhancement of the environment (e.g., supporting local biodiversity) and a detriment (e.g., altering the local ecological system). Offshore wind farms have been observed to attract certain fish and invertebrate species to the turbine structures; these potential "artificial reef" effects refer to the ability of the structures to mimic characteristics of a natural reef (e.g., Carey et al. 2020). Additionally, changes in flow patterns around wind farm foundations have been modeled to potentially affect larval transport pathways and settlement (e.g., Johnson et al. 2021).

1.3 Platforms, environmental variables, models, and species model covariates

The metocean and oceanographic methods and approaches that are relevant to this Science Plan are described below.

The Subcommittee discussed the importance of meteorological and oceanographic data as input to/drivers of species models (e.g., distribution, density, movement models). A key recommendation of the Subcommittee is to ensure that sufficient oceanographic data are collected to support species models and that those data are made available in the form of standardized data products that could be used by existing and future species modeling efforts. Some of the data products are simple spatial interpolations; others are more complex models that may be covered in the subsection below the table. Covariates included in this list have also been informed by Roberts et al. (2016), MDAT (2019), and Hogan et al. (2023).

The descriptions below are organized by variable, with notations related to potential platform(s), and whether or not the variable has been identified by the Subcommittee as an important species model covariate. This list is not exhaustive and will likely change as technologies and model development advances.

Many of the data streams from these platforms, sensors, and models are served on the websites of the regional IOOS organizations: NERACOOS, MARACOOS, and SECOORA.

Covariates	Potential platform(s)	Priority taxa
AIR		
Cloud cover	Satellites and aircraft	Birds & bats
Surface wind speed and direction	Satellites and aircraft Ship-based sampling	Birds & bats, Cetaceans
Wind speed profiles	Buoys and bottom-mounted sensors	
Wind wake	Satellites and aircraft	
Atmospheric pressure	Ship-based sampling Buoys and bottom-mounted sensors	Birds & bats
Humidity	Buoys and bottom-mounted sensors	
Irradiance, solar radiation	Buoys and bottom-mounted sensors	
Mass fluxes	Buoys and bottom-mounted sensors	
Precipitation	Buoys and bottom-mounted sensors	Birds & bats
WATER		
Sea surface temperature	Satellites and aircraft Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	Birds & bats, Cetaceans, Sea turtles, Protected fish
Sea surface height	Satellites and aircraft	Birds & bats, Cetaceans, Sea turtles
Surface waves	Hi-frequency radar	
Wave height	Buoys and bottom-mounted sensors	
Surface currents	Hi-frequency radar Ship-based sampling Buoys and bottom-mounted sensors	Birds & bats, Cetaceans, Sea turtles, Protected fish
Ocean color (chlorophyll, dissolved organic matter, suspended particles)	Satellites and aircraft	Birds & bats, Cetaceans, Sea turtles, Protected fish
Chlorophyll concentration	Ship-based sampling Buoys and bottom-mounted sensors	Birds & bats, Cetaceans, Sea turtles, Protected fish

	Autonomous surface and underwater vehicles	
Turbidity	Ship-based sampling Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	Birds & bats, Protected fish
Dissolved organic matter	Ship-based sampling Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	
Suspended particles	Ship-based sampling Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	
Light (PAR, in-situ illumination)	Ship-based sampling Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	
Nutrients (e.g., ammonium, nitrate, phosphate)	Ship-based sampling Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	
Conductivity/temperature/depth profiles	Ship-based sampling Autonomous surface and underwater vehicles	Cetaceans, Sea turtles, Protected fish
Bottom temperature	Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	Cetaceans, Sea turtles, Protected fish
Salinity, density	Ship-based sampling Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	Cetaceans, Sea turtles, Protected fish
Alkalinity, pH	Ship-based sampling Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	Protected fish
Dissolved oxygen	Ship-based sampling Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	Protected fish
Phytoplankton biomass	Ship-based sampling	Protected fish
Zooplankton biomass	Ship-based sampling	Cetaceans, Sea turtles, Protected fish
Primary productivity	Ship-based sampling	Cetaceans, Sea turtles, Protected fish

Acoustics (e.g., backscatter for prey density estimation, passive acoustic monitoring)	Ship-based sampling Buoys and bottom-mounted sensors Autonomous surface and underwater vehicles	Protected fish
Upwelling	Satellites and aircraft	Birds & bats, Protected fish
Meso-scale fronts and eddies	Satellites and aircraft	Birds & bats, Cetaceans, Sea turtles, Protected fish

The descriptions below are organized by variable, with notations related to potential platform(s), and whether or not the variable has been identified by the Subcommittee as an important species model covariate. This list is not exhaustive and will likely change as technologies and model development advances.

- **Wind and wake modeling**: Marine atmospheric boundary layer (mesoscale, e.g., weather research and forecasting (WRF); microscale, e.g., large eddy simulations), wind resource, wake effects from turbines (including wake loss that affects the wind resource), turbulence dissipation rates, mesoscale modeling of wind farms (including wind farm layout effects).

- **Hydrodynamic and coupled modeling**: Wave direction/height/period, gridded-ocean circulation (3D current fields, temperate, salinity, pressure), upwelling, downwelling, frontal zones, localized turbulence effects (via computational fluid dynamics modeling), coupled hydrodynamic-biogeochemical models (e.g., nutrients, phytoplankton).

- **Ecosystem modeling**: Whole ecological system and food webs, from primary producers to higher trophic levels (e.g., zooplankton), and often including human components.

- **Biological productivity:** Net primary production (mg C m^{-2} day^{-1}) such as derived from SeaWiFS and Aqua using the Vertically Generalized Production Model (VPGM); Zooplankton production (PkPP; g m^{-2} day^{-1}) and biomass (PkPB; g m^{-2}) and Epipelagic micronekton production (EpiMnkPP; g m^{-2} day^{-1}) and biomass (EpiMnkPB; g m^{-2}) such as derived from the SEAPODYM ocean model.

- **Particle tracking and agent-based modeling**: Larval dispersal, sediment transport.

- **Soundscape and Sound propagation modeling**: Soundscape prediction, sound source field, underwater soundscape (interaction with underwater variables), propagation loss.

2 Research topics: Oceanography and offshore wind in the U.S. Atlantic Ocean

The following topics were pulled from the Atlantic Offshore Wind Environmental Research Recommendations Database that was filtered on habitat, oceanographic, phytoplankton, and zooplankton considerations. Additional recommendations were identified from Hogan et al.

(2023). These research topics were then aligned with RWSC research themes and science plan actions were identified, with associated field data collection methods and analysis, as well as other non-field activities (next Table).

		RWSC Science Plan Actions	
RWSC Research Theme	**Research Topic**	**Field data collection methods and analysis**	**Other**
Mitigating negative impacts that are likely to occur	Identify sensitive pelagic habitats and inform wind farm design characteristics, siting, and marine spatial planning		Planning
	Evaluate approaches to mitigate impacts to oceanography, pelagic habitat, and biological productivity		Planning
	Adapt layout of wind farms to minimize the wake effects		Wake modeling; Planning
Detecting and quantifying changes to wildlife and habitats	Characterize sound propagation and changes to the ocean soundscape	Acoustics measurements from fixed and mobile platforms	Sound propagation modeling
	Baseline hydrodynamic and oceanographic processes (e.g., ocean stratification; seasonally dependent effects on the cold pool)	Satellites, HF radar, moored buoys, autonomous vehicles with physical sensors	Hydrodynamic modeling
	Biomass, composition, and distribution of phytoplankton and associated primary production (including broad-scale primary productivity and distance, overlap of productivity from offshore wind projects, and food availability for filter feeders)	Satellites, aircraft, ship based, moored buoys, autonomous vehicles with biogeochemical sensors and primary productivity sampling	Coupled hydrodynamic-biogeochemical models; Biological productivity models
	Understand zooplankton biomass, composition, distribution, and shifts over time	Ship based, moored buoy, autonomous vehicles with zooplankton sensors/sampling	Coupled hydrodynamic-biogeochemical models; Biological productivity models; Ecosystem modeling
Understanding the environmental context around changes to wildlife and habitats	Atmospheric effects associated with energy removal by wind turbines (i.e., effects on wind and waves to better understand wake effects)	Air-sea interaction towers with doppler lidars, doppler radars, and passive infrared and microwave spectrometers, lidar buoys, surface flux buoys, rawinsonde launches, ship-based transects, satellite-based remote sensing, HF radar-based wind observations	Coupled atmosphere-ocean modeling

	Physical oceanographic conditions (e.g., Mid Atlantic Cold Pool) formation and dynamic overlap with OSW energy development, with focus on stratification changes	Satellites, moored buoys, autonomous vehicles with physical sensors	Wind and wake modeling; Hydrodynamic modeling
	Ambient soundscape assessments before OSW development and throughout the lifecycle of OSW activities	Ship based, moored buoys, bottom-mounted sensors, autonomous vehicles with acoustics sensors	Soundscape and sound propagation modeling
	Changes in water quality and light penetration (e.g., chemical contamination associated with increased vessel traffic and presence of OSW structures; effects on suspended particulate matter and turbidity)	Satellites, ship based, moored buoys, autonomous vehicles with chemical sensors	Coupled hydrodynamic-biogeochemical models
Determining causality for observed changes to wildlife and habitats	Understand natural and anthropogenic climate change as a contributor to observed changes in wildlife and habitat	Satellite, aircraft, ship-based, moored buoys, and autonomous vehicle ecosystem and biological sensors	Ecosystem modeling
	Effects of changes in hydrodynamics, water stratification and turbidity on marine communities and regional ecosystems across different spatiotemporal scales (particularly phytoplankton and zooplankton community structure, biomass and larval settlement success and recruitment)	Satellite, aircraft, ship-based, moored buoys, autonomous vehicle ecosystem and biological sensors	Coupled hydrodynamic-biogeochemical models; Biological productivity models; Ecosystem modeling
	Integrated modeling of the combined effects of wind field modification and in situ structure friction and fish responses to related hydrodynamic predictors relevant to their key habitats and lifecycle stages		Ecosystem modeling
	Explore how shifts in plankton and forage fish populations affect higher trophic levels	Ship based, moored buoy, autonomous vehicles with zooplankton sensors/sampling	Coupled hydrodynamic-biogeochemical models; Biological productivity models; Ecosystem modeling
Enhancing data sharing and access	Maintain the inventory of ongoing data collection and research projects for oceanography and OSW to encourage regional coordination		Coordination and planning
	Coordinate data collection and synthesis of existing data efforts at a		Coordination and planning

	regional scale, including baseline data and data collected at individual OSW project sites (e.g., post-construction monitoring data)		
	Make all data publicly available to aid in the assessment of broad-scale questions, ecosystem-level research, and potential cumulative impacts		Coordination and planning

3 Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for oceanography and offshore wind

3.1 Field data collection and analysis

The following activities include atmospheric and oceanographic observational data acquired in the field at the regional scale (i.e., consistently across the entire Atlantic coast in all RWSC Subregions).

Ongoing and pending activities

Click project names below to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Ship-based and aerial surveys, ship towed and bottom PAM, telemetry, CTD, video plankton recorder, various nets and trawls, imaging sonar	Atlantic Marine Assessment Program for Protected Species (AMAPPS) I, II, and III	NOAA, BOEM, US Navy, USFWS	2010-ongoing	Detecting and quantifying changes to wildlife and habitats Understanding the environmental context around changes to wildlife and habitats
Surface buoys (winds, temperature)	Coastal Data Information Program (CDIP)	Scripps Institution of Oceanography, USACE, NOAA	1975-ongoing	Understanding the environmental context around changes to wildlife and habitats Enhancing data sharing and access

Recommendations

Ensure continued support for broad region-scale habitat monitoring surveys, and expand collection of priority covariates as part of these surveys. Maintain monitoring programs that document changes in oceanography, habitat, and productivity due to a variety of stressors, including climate change. For example, AMAPPS is currently funded by federal agencies to collect wildlife and habitat data through 2023 but future programming after that is still unclear. The oceanographic and habitat covariates to inform the species density distribution modeling are a priority for data collection. It is recommended that these oceanographic/habitat covariates continue to be an important focus of regional scale wildlife surveys and that the data be made publicly available in the appropriate repositories.

Improve ecosystem models that incorporate the complex interactions of oceanographic factors influencing the abundance, community composition, spatial distribution, and productivity of phytoplankton and zooplankton. These models will help provide understanding of change due to OSW farms versus other driving factors, including climate change. Collect oceanographic and productivity data from the fine- to regional scale that informs coupled hydrodynamic, biogeochemical, and biological productivity models. Use field data and model output to assess effects of oceanographic changes on local communities and regional ecosystems.

Expand a regional buoy network that optimally collects metocean and habitat data temporally and spatially across subregional boundaries to understand potential effects of OSW farms along the coast at full buildout. Coastwide, there are fewer buoys in deeper waters (Figure 3). The network could be augmented with buoys in strategic locations that collect data associated with fixed and floating wind farms in deeper waters than most buoys are currently located. These buoys can include above water (e.g., Lidar), water surface, and below water measurements. Collaborate with other subcommittees to optimize locations and technology.

Invest in region-wide data collection with AUVs and remote sensing, including gliders, to collect more seamless broad-scale coverage of physical oceanographic and biogeochemical data, and to record ambient noise. Current glider missions are largely performed in more focused areas within subregions, and a larger regional perspective is needed to understand the effects of OSW buildout across subregions. Regional glider and other AUV missions can be used to run a standardized sampling pattern and to provide event-driven data when needed. These missions can provide an understanding of oceanographic processes and productivity across subregions, including documenting any changes in processes over time and identifying the causes of such change.

Use environmental data (real-time and historical) to inform mitigation of OSW development effects on oceanographic processes. At the regional scale, environmental data should be compiled and analyzed to understand potential effects of OSW development throughout its lifecycle to adaptively manage wind farms based on any observed effects on oceanographic processes that cross sub-regional boundaries (e.g., cold pool, frontal zones, upwelling, etc.).

Using real-world observations, there is a need to test and validate model-based studies that have shown OSW farms will have some discernible atmospheric and/or hydrodynamic impact on surrounding oceanography. Field observations are needed that can discern the physical effect of OSW farms in contrast to what are solely naturally-caused processes that may have been impacted by other factors. In terms of atmospheric response to wind farms, simulations and field experiments need to be carried out to further develop models of wind farm-induced flow and atmospheric response to both momentum and heat fluxes. While studies have suggested there is the potential for OSW structures to alter oceanographic processes, measurements are needed of the local turbulence production and induced mixing of different OSW foundation structures to develop more accurate mixing parameterizations.

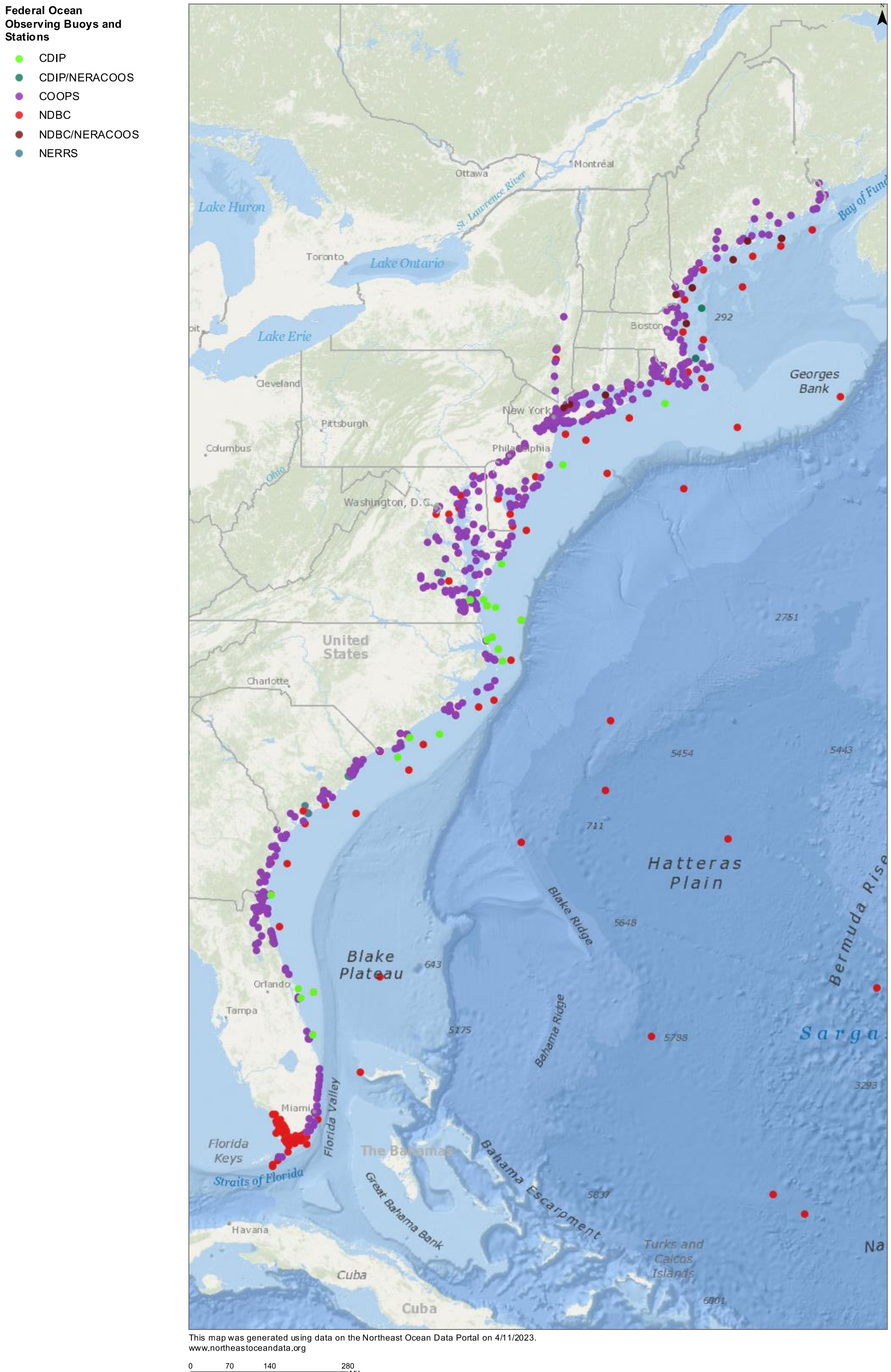

Figure 3. Federal ocean observing buoys and stations in the whole eastern Atlantic region. (Source: Northeast Ocean Data Portal)

3.2 Coordination and planning

The following activities include the active coordination and planning that occurs through RWSC via the Habitat and Ecosystem Subcommittee as well as other regional-scale efforts (e.g., led by federal agencies) around particular issues or species.

Ongoing and pending activities

RWSC Habitat and Ecosystem Subcommittee: The Habitat and Ecosystem Subcommittee will maintain situational awareness of Habitat and Ecosystem data collection and research in the U.S. Atlantic Ocean by coordinating with the entities and groups described in this Science Plan. The Subcommittee will meet regularly to share information and track Science Plan progress.

BOEM's Environmental Studies Program: 2022-2024 Offshore Wind Impacts on Oceanographic Processes: North Carolina to New York. Lead entity DHI Water & Environment, Inc.

Regional Synthesis Workgroup: Developing "Responsible Practices for Regional Wildlife Monitoring and Research in Relation to Offshore Wind Development" (NYSERDA-funded; BRI)

Click project name below to view full description.

Project	Lead and Partner Entities	Time period	Research Theme
Support for Regional Wildlife Science Collaborative Ocean Portal Products and Services	BOEM, RWSC	2023-2026	Enhancing data sharing and access

Recommendations

Ensure coordination between RWSC and the three IOOS RAs covering the region to spearhead data collection, archival, and sharing according to industry standards.

3.3 Standardizing data collection, analysis, and reporting

This section identifies existing best practices and/or guidance for standardizing data collection, analysis, and reporting and lists existing and ongoing work to address these issues. The Subcommittee identified a number of existing repositories for Habitat and Ecosystem data.

Ongoing and pending activities

Click project names below to view full descriptions.

Project	Lead and Partner Entities	Time period	Research Theme
High Frequency Radar Data Assembly Center (HFR DAC)	IOOS, GCOOS, SCCOOS, NANOOS, CeNCOOS, AOOS, PACIOOS, GLOS, MARACOOS, NERACOOS, SECOORA, CARICOOS, NOAA AOML, ONR, NSF, EPA	2005-ongoing	Enhancing data sharing and access
National Glider Data Assembly Center (DAC)	IOOS, GCOOS, SCCOOS, NANOOS,	2014-ongoing	Enhancing data sharing and access

	CeNCOOS, GLOS, MARACOOS, AOOS, CARICOOS, NERACOOS, PACIOOS, SECOORA, AOML, NOAA, ONR, NSF, EPA		
National Data Buoy Center	NOAA	ongoing	Enhancing data sharing and access
Standardizing Integrated Ecosystem-Based Assessment Nationally (NT-21-x15)	Blue World Research Institute, Inc., BOEM	2022-2025	Enhancing data sharing and access
NCEI	NOAA	Ongoing	Enhancing data sharing and access

Recommendations

See the Data Standardization and Management chapter of this Science Plan.

3.4 Historical data collection/compilation

The following activities encompass the need to add existing data to modern databases so that historical data can be used in long-term/time-series analyses and studies.

Ongoing and pending activities

Click project names below to view full descriptions.

Project	**Lead and Partner Entities**	**Time period**	**Research Theme**
Coastal Data Information Program (CDIP)	Scripps Institution of Oceanography, USACE, NOAA, CA-DPR	1975-ongoing	Understanding the environmental context around changes to wildlife and habitats Enhancing data sharing and access

Recommendations

Identify and populate a unique place for archiving all oceanographic and atmospheric data related to offshore wind, similar to DOE's A2e (Atmosphere to electron) but for any source of funding.

Require that raw data and deployment metadata be submitted for archiving at NCEI.

3.5 Study optimization

This section describes work to implement statistical frameworks and analyses to determine optimal study designs given a set of data conditions and research goals.

Ongoing and pending activities

No region-wide ongoing or pending activity has been identified in this field.

Recommendations

More extensively use observation system simulation experiments (OSSEs) to determine optimal location of oceanographic observing at the region-wide scale.

Consider how wind farms are sited in relationship to significant oceanographic features and biological productivity, and incorporate long-term understanding of oceanography, habitat, and biological productivity into marine spatial planning to inform OSW development.

Review existing mitigation technologies and methods as new data is gathered related to effectiveness, such as related to noise mitigation and abatement during construction. In addition, monitor and model effects of using different mitigation measures to minimize sound propagation during construction to understand best approaches for minimizing environmental effects.

Investigate pros and cons related to habitat implications of decommissioning and develop best practices and guidance for options related to decommissioning.

3.6 Model development and statistical frameworks

This section describes existing projects and recommendations related to the development and maintenance of atmospheric and oceanographic models.

Ongoing and pending activities

Click project names below to view full descriptions.

Project	**Lead and Partner Entities**	**Time period**	**Research Theme**
Coupled Northwest Atlantic Prediction System (CNAPS) model	North Carolina State University, SECOORA, NASA, NOAA, USGS, ONR, Sea Grant North Carolina, BOEM, DOE, Gulf of Mexico Research Initiative, UNC Coastal Studies Institute	2016-ongoing	Understanding the environmental context around changes to wildlife and habitats
Global climate modelling	The Nature Conservancy	2023-ongoing	

Recommendations

Develop a fine-scale region-wide hydrodynamic model of offshore wind effects, encompassing all the lease areas throughout the region. The current modeling should be extended to the Gulf of Maine and south of Cape Hatteras.

Identify data gaps and technological challenges that hinder the development of a fine-scale region-wide hydrodynamic model that connects all subregions and has the ability to assess cumulatively wind farm development up and down the coast.

Utilize wake modeling and mesoscale modeling of wind farms to understand how different wind farm layouts affect atmospheric and oceanographic processes and how effects can potentially be minimized.

3.7 Meta-analysis and literature review

This section describes existing projects and recommendations to compile research priorities, impacts literature, and/or life history parameters, as well as to conduct assessments of data availability to inform models.

Ongoing and pending activities

Click project names below to view full descriptions.

Project	Lead and Partner Entities	Time period	Research Theme
Project WOW Task 1.1: Create an annotated catalog of existing relevant datasets and their anticipated availability	Project WOW	2022-2023	Detecting and quantifying changes to wildlife and habitats
Project WOW Task 2: Gap analysis and framework development (synthesize existing frameworks; list existing knowledge/data portals; systematically review evidence availability)	Project WOW	2022-2023	Detecting and quantifying changes to wildlife and habitats
Metadata Library for the Northeast Fisheries Science Center (NEFSC) of NOAA Fisheries	NOAA	2006-ongoing	Enhancing data sharing and access
Atlantic Offshore Wind Environmental Research Recommendations Database	BRI, PNNL, NREL, NYSERDA, DOE	2021-ongoing	Detecting and quantifying changes to wildlife and habitats Enhancing data sharing and access

Recommendations

Continue to update meta-analysis and literature reviews at a region-wide scale as new information becomes available.

3.8 Outreach and platforms to provide data products and results to stakeholders

This section describes the work that RWSC does to summarize and convey findings and results to stakeholders and decision-makers, including through regional data portals and other web-based platforms that display interpretive maps with exploratory tools and links to the underlying data as appropriate.

Ongoing and pending activities

Click project names below to view full descriptions.

Project	Lead and Partner Entities	Time period	Research Theme
Support for Regional Wildlife Science Collaborative Ocean Portal Products and Services	BOEM, RWSC	2023-2026	Enhancing data sharing and access

Recommendations

Develop data products that reflect the results of data collection and research activities throughout the RWSC study area and encourage or require projects to include funding for data product development, hosting, and maintenance/updates in their budgets. Data could be hosted and maintained by individual providers but should be shared in formats compatible with existing platforms.

Continue to lead or participate in the ongoing and pending coordination and planning activities, using the RWSC Habitat and Ecosystem (Oceanography) Subcommittee as a forum for information exchange and coordination among federal agencies, states, offshore wind industry, eNGOs, and the research community.

Facilitate pooling of data to obtain the statistical power to examine regional scale effects.

Ensure that existing data repositories for oceanographic data have resources and personnel to integrate and provide access to offshore wind and environmental monitoring datasets as they are collected. Include a minimum budget threshold that must be allocated to data management and access in all project budgets.

4 Gulf of Maine ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for oceanography and offshore wind

4.1 Focal habitats and processes of interest

The following provides a brief summary of Gulf of Maine focal habitats and processes of interest. See Section 1.1 for a more complete description.

- Continental shelf sea with deep basins (e.g., Georges and Jordan Basins) that experience tidal mixing as well as the seasonal warming and cooling
- The Gulf has among the greatest tidal ranges in the world and associated swift tidal currents, influencing nutrient delivery and overall biological productivity
- Shallow offshore areas: Nantucket Shoals, Georges and Browns Banks, and the Scotian Shelf
- Georges Bank is unique for its high primary productivity and fish production (Northeast Integrated Ecosystem Assessment).

4.2 Potential effects

All of the potential effects noted in Section 1.2 apply in the Gulf of Maine. In addition, water depths in the Gulf of Maine are within the range (> 60 m) where floating offshore wind development is likely. Oceanographic effects of floating turbines may differ from those of bottom-mounted turbines because of differences in structures spanning the whole water column (mooring lines vs. foundations).

4.3 Field data collection and analysis

Ongoing and pending activities

Click project names below to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Ocean modeling, telemetry, glider observations, buoys, water sampling	[Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)]	U.S. IOOS, UMaine, Bedford Institute of Oceanography, USGS, Gulf of Maine Research Institute, UNH, Charybdis Group LLC, Woods Hole Group, WHOI, UMass-Dartmouth, UConn, URI, MCCF, Passamaquoddy Pleasant Point	Ongoing	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats Enhancing data sharing and access
Conduct aerial surveys using high-resolution cameras and/or boat-based wildlife surveys on OCS off Maine in the North Atlantic Plan Area.	[Ecological Baseline Study of the U.S. Outer Continental Shelf Off Maine]	NOAA, FWS	2022 - 2024	Detecting and quantifying changes to wildlife and habitats Enhancing data sharing and access
Vessel-based surveys with plankton nets and water samples	[Ecosystem Monitoring on the Continental Shelf (EcoMon)]	NOAA NEFSC	1977 - ongoing	Understanding the environmental context around changes to wildlife and habitats Enhancing data sharing and access
Bottom temperature, surface current using GPS drifters, real-time bottom temperature sensors, bottom-current meter	[Environmental Monitors on Lobster Traps and Large Trawlers (eMOLT)]	NOAA NEFSC	2001-ongoing	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Monthly CPR tows on ships of opportunity - first route runs across the Scotian Shelf off Nova Scotia to Cape May, New Jersey. The second, runs across the North Atlantic from Iceland to Newfoundland.	[Gulf of Maine Continuous Plankton Recorder Survey]	NOAA NEFSC	1961-2024	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Water sampling to measure plankton biodiversity at 2 time-series stations. Been collecting samples since 2004. Developing	[Gulf of Maine Marine Biodiversity]	MBON, BOEM, NERACOOS, NROC, U.S. IOOS	2020-?	Understanding the environmental context around changes to wildlife and habitats

time series of Calanus finmarchicus (primary prey of NARW).	Observation Network (MBON)			
Suite of carbon-specific standing stocks and rate measurements (e.g., POC, PIC [calcite], DOC, primary productivity, and calcification) plus hydrographic, chemical, and optical measurements. Ship and satellite measurements.	Gulf of Maine North Atlantic Time Series (GNATS)	Bigelow Laboratory for Ocean Sciences, NASA	2001-2020	Understanding the environmental context around changes to wildlife and habitats
Real-time measurements of surface currents and waves, plus forecasts through Short-Term Prediction System	Gulf of Maine high frequency radar network	NERACOOS, U.S. IOOS, MARACOOS, WHOI, Rutgers University, UConn, UMaine, Maine Department of Marine Resources	Ongoing	Understanding the environmental context around changes to wildlife and habitats
Vessel-based surveys of biomass, length and age structures, and diet compositions of finfishes and select invertebrates, water quality, weather conditions	NorthEast Area Monitoring and Assessment Program (NEAMAP)	Atlantic States Marine Fisheries Commission	2006-Ongoing	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Outreach and platforms to provide data products and results to stakeholders	Northeast and Mid-Atlantic Ocean Data Portals – e.g., Oceanography theme data	NROC, MARCO	ongoing	Enhancing data sharing and access
CTD rosette, net tows, gliders - physical samples include water samples (temperature, conductivity, nutrients, chlorophyll), filters, plankton net samples, and fish specimens	Northeast U.S. Shelf (NES) Long-Term Ecological Research (LTER)	WHOI, UMD, URI, Wellesley College, NOAA NFSC, NSF	2017 - ongoing	Understanding the environmental context around changes to wildlife and habitats
Vessel-based surveys - Air temperature, depth, cloud cover, barometric pressure, wind direction and speed, wave height and direction, surface temp & salinity, bottom temp & salinity	Northern Shrimp Survey	NOAA NEFSC	1983 - ongoing	Understanding the environmental context around changes to wildlife and habitats
Underwater gliders - seasonal deployments of underwater	Optimizing Ocean Acidification	Rutgers University, NOAA OAP, Stony	2019 – 2022	Understanding the environmental context

gliders equipped with sensors, including newly developed pH sensors, to understand how the ocean chemistry in this region varies on seasonal timescales relevant to organism ecologies and life histories.	Observations for Model Parameterization in the Coupled Slope Water System of the U.S. Northeast Large Marine Ecosystem	Brook University, University of New Hampshire, University of Maine, MARACOOS, NERACOOS		around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Aerial surveys, plankton tows, and CTDs in Cape Cod Bay - 20 years of aerial surveys and prey time series data (NARW and humpbacks). Developing a probability of occurrence index at varying zooplankton densities. Oceanographic information (depth, salinity, ambient light and temperature)	North Atlantic right whale and humpback whale population and prey monitoring	Center for Coastal Studies, NARWC	1999-?	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Glider deployments with PAM. U.S. Sanctuary-wide project collecting PAM across U.S. Sanctuaries to monitor soundscapes. Bottom mounted recorders are deployed at 3-4 sites in each sanctuary collecting continuous recordings. A real-time slocum glider, operated by WHOI is routinely deployed in SBNMS.	Sanctsound	NOAA NEFSC; NOAA SBNMS; U.S. Navy; NOAA Sanctuaries; WHOI	2018 - 2022	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Vessel-based surveys in the Gulf of Maine collecting time series plankton data.	Zooplankton Ecology of the Gulf of Maine	University of Maine, BOEM	2019 - ongoing	Detecting and quantifying changes to wildlife and habitats

Recommendations

Gaps in assessing the potential impacts of hydrodynamic and atmospheric alterations on physical and biological resources in the northeast have been identified and apply to the Gulf of Maine region (Blair et al. 2022). Determining oceanographic baselines and competing phenomena, such as the impacts of climate change, in addition to effects of offshore wind development is a research need. Characterizing hydrodynamic and atmospheric alterations due to offshore wind development is another broad research need related to future offshore wind development in the Gulf of Maine. Detecting the influence of scale and collecting information on cumulative impacts has emerged as a priority research topic in recent years. Monitoring of offshore wind projects sites in the Gulf of Maine will need to be conducted to increase understanding of marine ecology and oceanographic impacts. There are currently very few federal ocean observing buoys collecting data in the Gulf of Maine planning area, and the numbers of buoys in the planning area should be increased to understand baselines and effects from offshore wind development (Figure 4).

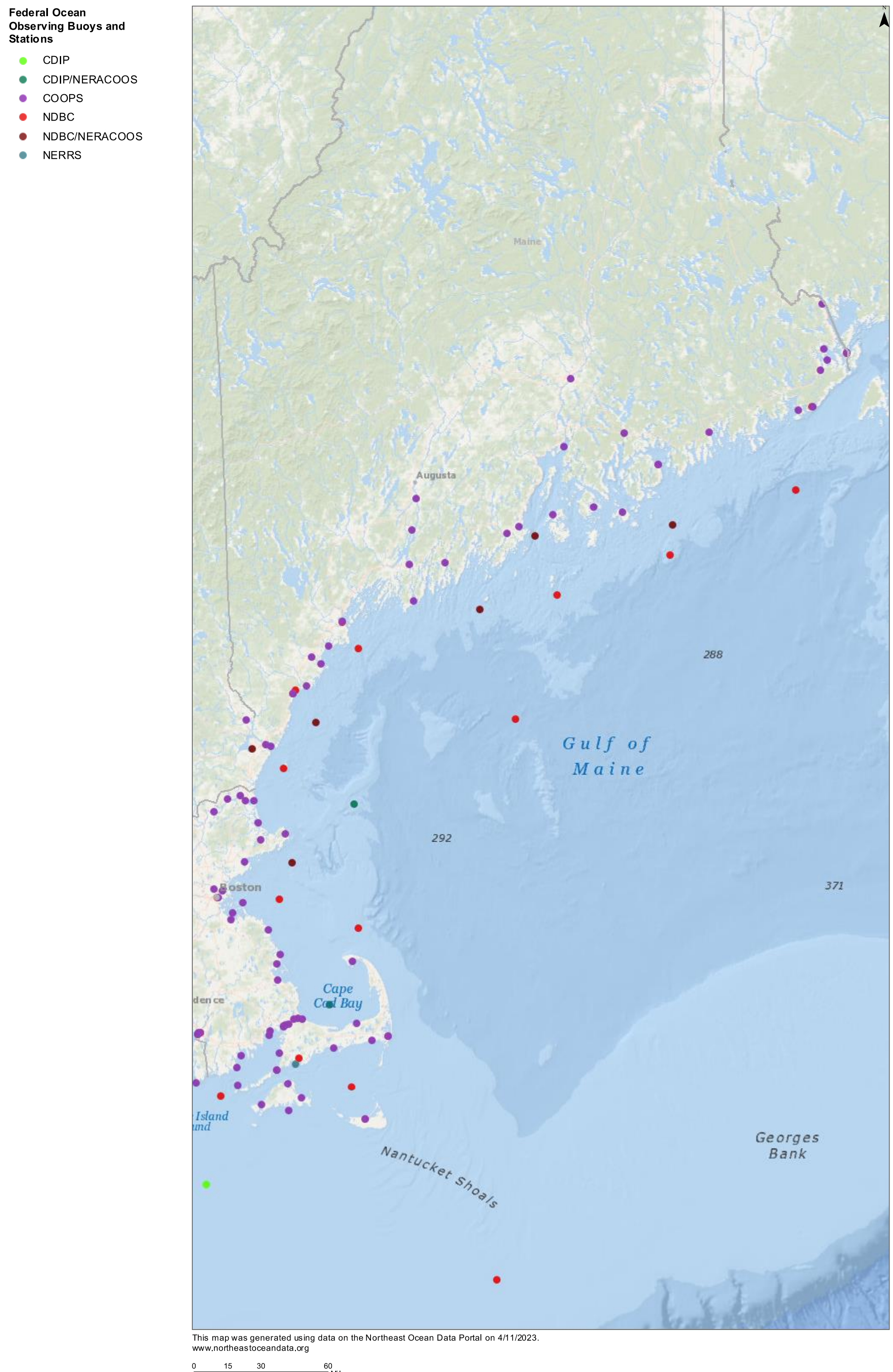

Figure 4. Federal ocean observing buoys and stations in the Gulf of Maine subregion. (Source: Northeast Ocean Data Portal)

Following are some examples of more specific research that needs to be conducted to assess the potential oceanographic effects of future offshore wind buildout in the Gulf of Maine.

- Measure the atmospheric effects associated with energy removal by future wind turbines in the region. This could be performed using instrumentation and modeling similar to the Wind Forecasting Improvement Project 3 (WFIP-3) which is being conducted in the MA/RI lease areas.
- Establish a Lidar buoy program in the Gulf of Maine similar to programs in other areas along the U.S. Atlantic (e.g., MA, NJ, VA). The buoy(s) would measure wind profile, speed and direction; solar radiation; air temperature and relative humidity; barometric pressure; water velocity, salinity and temperature; wave spectrum.
- Conduct glider-based ecological and oceanographic surveys along optimized transects in the Gulf of Maine. These surveys would be similar to what is currently being conducted in the New York Bight and could be an extension of glider surveys previously conducted in the Gulf of Maine as part of the project "Optimizing Ocean Acidification Observations for Model Parameterization in the Coupled Slope Water System of the U.S. Northeast Large Marine Ecosystem". The glider surveys would capture the seasonal variability with simultaneous oceanographic and ecological sampling. The sensor suite on each glider would characterize the ecosystem's physical structure (Temperature, Salinity, Density; CTD), tagged fish presence (Vemco receiver), and marine mammal presence (passive acoustics; DMON).
- Expand monitoring of soundscapes in the Gulf of Maine to collect background data and to measure noise from potential offshore wind development in the region. There is a gap in sound data collection in the northern part and deeper waters of the Gulf of Maine (see https://www.ncei.noaa.gov/maps/passive-acoustic-data/).
- Similar to the way RODEO has been performed in other regions, acquire real-time observations of the construction and initial operation of wind facilities to aid the evaluation of environmental effects of future facilities. Measurements should be made of: pile driving sound & operational sound (PAM), particle motion, cable layer, scour monitoring, seafloor disturbance and recovery, benthic habitat changed, epifouling, and fish.
- Before any turbines are installed then after construction, collect field measurements to understand how the placement of wind turbine structures and associated effects on hydrodynamics can in turn affect biogeochemical and water quality characteristics of the water column.

4.4 Other Science Plan Actions

Ongoing and pending activities

Click project names below to view full descriptions.

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Model development and statistical frameworks	Northeast Coastal Ocean Forecast System (NECOFS)	UMass-SMAST, NERACOOS, U.S. IOOS	2007-ongoing	Understanding the environmental context

				around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats Enhancing data sharing and access
Outreach and platforms to provide data products and results to stakeholders	Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)	UMaine, Bedford Institute of Oceanography, USGS, Gulf of Maine Research Institute, UNH, Charybdis Group LLC, Woods Hole Group, WHOI, UMass-Dartmouth, UConn, URI, IOOS		Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats Enhancing data sharing and access

Recommendations

Improve and expand the forecasting capabilities of the Northeast Coastal Ocean Forecast System (NECOFS) with relevance to understanding the potential effects of offshore wind development on oceanographic processes in the Gulf of Maine.

Work together with NERACOOS to expand engagement with key end users in the offshore wind development and oceanographic communities to clearly identify how data and information can best be provided to suit their needs, refine the technical approach, and verify that user needs are met.

5 Southern New England ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for oceanography and offshore wind

5.1 Focal habitats and processes of interest

The following provides a brief summary of Southern New England focal habitats and processes of interest. See Section 1.1 for a more complete description.

- In the north, the Great South Channel acts as a passage that connects the Gulf of Maine and the southern New England shelf.
- Nantucket Shoals are a well-mixed, shallow region and are biologically productive due to the cold, nutrient rich water arriving from the Gulf of Maine.

- South of Martha's Vineyard is an expanse of continental shelf with a gradual slope and cross-shelf currents leading to the edge of the shelf, where several submarine canyons cut into the shelf.
- To the south, Rhode Island Sound demonstrates seasonality of thermal stratification in the spring and summer. By contrast, Block Island Sound is an area with strong tidal currents and density stratification year-round.
- The greater-shelf region experiences warm core rings that break off from the Gulf Stream.
- The northern portion of the Mid Atlantic Cold pool extends into southern New England waters.

5.2 Potential effects

All of the potential effects noted in Section 1.2 apply in Southern New England. In addition, the shallow shelf waters drive concern about turbine presence and extraction of energy from the system that could alter local oceanography.

5.3 Field data collection and analysis

Ongoing and pending activities

Click project names below to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Vessel-based surveys - Fisheries acoustics surveys, vertical ring net tows, CTD profiles	Assessing environmental and biological drivers of North Atlantic right whale abundance and distribution in New York and the Southern New England shelf	Stony Brook University, Orsted	2022 - 2024	Detecting and quantifying changes to wildlife and habitats
Characterize the relevant acoustic pile driving signals in pressure and particle motion (in the water column and on the benthos) at varying distances during offshore construction	Behavioral Effects of Sound Sources from Offshore Renewable Energy Construction on the Black Sea Bass and Longfin Inshore Squid: A Field Study	WHOI, BOEM	2020 - Ongoing	Detecting and quantifying changes to wildlife and habitats
Pre-construction survey in 2021; Post-construction survey years 1 and 3	Cape Poge Eelgrass study	Vineyard Wind	2021	Understanding the environmental context around changes to wildlife and habitats
Instrumented moorings, gliders, AUVs	Coastal Pioneer Array	Ocean Observatory Initiative, NOAA, WHOI	2016-2022	Understanding the environmental context around changes to wildlife and habitats
Targeted coastal sensors for water level and water quality	NERACOOS Coastal Sensor Network	U.S. IOOS, MCCF, Passamaquoddy at	Ongoing	Understanding the environmental

monitoring at piers, research stations, and other locations		Pleasant Point, UMaine, UNH, USGS, Charybdis Group, URI		context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats Enhancing data sharing and access
Vessel-based surveys with plankton nets and water samples	Ecosystem Monitoring on the Continental Shelf (EcoMon)	NOAA NEFSC	1977 - ongoing	Understanding the environmental context around changes to wildlife and habitats Enhancing data sharing and access
Bottom temperature, surface current using GPS drifters, real-time bottom temperature sensors, bottom-current meter	Environmental Monitors on Lobster Traps and Large Trawlers (eMOLT)	NOAA NEFSC	2001-ongoing	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Real-time measurements of surface currents and waves, plus forecasts through Short-Term Prediction System	High-frequency radar network	NERACOOS & MARACOOS	2001-Ongoing	Detecting and quantifying changes to wildlife and habitats
Shipboard sampling of plankton and oceanography; combination of nets, active acoustics, underwater video; sampling paired w/ NOAA aerial survey effort, AMAPPS aerial imagery surveys, satellite imagery of whales, and right whale individual identification	Investigating Persistent Super Aggregations of Right Whales and Their Prey in Lease Areas OCS-A 0521 and OCS-A 0522 in the North Atlantic	BOEM, NOAA, FWS	2022 - 2024	Understanding the environmental context around changes to wildlife and habitats
Wind profile, speed and direction; solar radiation; air temperature and relative humidity; barometric pressure; water velocity, salinity and temperature; wave spectrum	LiDAR Buoy Program - SNE	US DOE/PNNL, BOEM	2019 - 2020	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes

				to wildlife and habitats
Temperature, salinity and water depth are recorded at each site	[Long Island Sound Trawl Survey]()	CT DEEP	2010-ongoing	Detecting and quantifying changes to wildlife and habitats
Slocum G3 glider, acoustic and tag detections	[Mapping the distribution and habitat use of soniferous fish, with a focus on Atlantic cod spawning aggregations on Cox Ledge (using acoustic telemetry, PAM)]()	NOAA NEFSC, BOEM funded, WHOI, MassDMF, TNC, UMass, NOAA-GARFO, Rutgers University	2019 - ongoing	Detecting and quantifying changes to wildlife and habitats
PAM - presence, distribution and seasonality of the endangered North Atlantic right whale	[ECO-PAM: Marine Mammal Real Time Automated Detection and Oceanographic Sampling Project]()	Rutgers University, Orsted, WHOI, University of Rhode Island, Axiom	2010 - 2022	Detecting and quantifying changes to wildlife and habitats
Ocean modeling, telemetry, glider observations, buoys, water sampling	[Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS)]()	Rutgers University, VIMS, Stony Brook, Smithsonian Environmental Research Center, IOOS	2007-ongoing	Detecting and quantifying changes to wildlife and habitats
Ocean modeling, telemetry, glider observations, buoys, water sampling	[Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)]()	UMaine, Bedford Institute of Oceanography, USGS, Gulf of Maine Research Institute, UNH, Charybdis Group LLC, Woods Hole Group, WHOI, UMass-Dartmouth, UConn, URI, IOOS		Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats Enhancing data sharing and access
A Slocum G3 glider was deployed near Cox Ledge just south of Massachusetts and Rhode Island to conduct surveys for tagged fish and baleen whales, including the seriously endangered North Atlantic right whale. Also collected fluorescence, turbidity, temp., salinity.	[Movement Patterns of Fish in Southern New England]()	NOAA NEFSC, BOEM funded; WHOI, MassDMF, TNC, UMass, NOAA-GARFO, Rutgers University	2019 - ongoing	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Vessel-based surveys of biomass, length and age structures, and diet compositions of finfishes and select invertebrates, water quality, weather conditions	[NorthEast Area Monitoring and Assessment Program (NEAMAP)]()	Atlantic States Marine Fisheries Commission	2006-Ongoing	Understanding the environmental context around

				changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Hydrodynamic modeling - Forecasts and hindcasts of ocean currents, waves, and other variables; based on FVCOM model and regional observing assets	Northeast Coastal Ocean Forecast System (NECOFS)	UMass-SMAST, NERACOOS, U.S. IOOS	2007-ongoing	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats Enhancing data sharing and access
Metocean buoys - Measurements vary by station, but include a variety of physical and chemical surface and subsurface measurements available in real-time and as downloadable time series via ERDDAP server	Northeast metocean buoy network	NERACOOS, U.S. IOOS, MassDEP, UMaine, UNH, UConn, Woods Hole Group	2000 +/- (varies by station) - ongoing	Detecting and quantifying changes to wildlife and habitats
Outreach and platforms to provide data products and results to stakeholders	Northeast and Mid-Atlantic Ocean Data Portals – e.g., Oceanography theme data	NROC, MARCO	ongoing	Enhancing data sharing and access
CTD rosette, net tows, gliders - physical samples include water samples (temperature, conductivity, nutrients, chlorophyll), filters, plankton net samples, and fish specimens	Northeast U.S. Shelf (NES) Long-Term Ecological Research (LTER)	WHOI, UMD, URI, Wellesley College, NOAA NFSC, NSF	2017 - ongoing	Understanding the environmental context around changes to wildlife and habitats
Underwater gliders - seasonal deployments of underwater gliders equipped with sensors, including newly developed pH sensors, to understand how the ocean chemistry in this region varies on seasonal timescales relevant to organism ecologies and life histories.	Optimizing Ocean Acidification Observations for Model Parameterization in the Coupled Slope Water System of the U.S. Northeast Large Marine Ecosystem	Rutgers University, NOAA OAP, Stony Brook University, University of New Hampshire, University of Maine, MARACOOS, NERACOOS	2019 – 2022	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats

Towed net surveys for larval lobster and fish in the neustonic layer (small fish organisms); Environmental loggers	Pilot Studies for Regional Fisheries Monitoring in Relation to Massachusetts and Rhode Island Offshore Wind Areas	BOEM, UMass-SMAST; INSPIRE Environmental; URI	2020 - 2023	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Pile driving sound & operational sound (PAM), particle motion, cable layer, scour monitoring, seafloor disturbance and recovery, benthic habitat changed, epifouling, fish	RODEO (Real time Opportunity for Development Environmental Observations) at Block Island Wind Farm	BOEM and partners	2016 - 2020	Detecting and quantifying changes to wildlife and habitats
Study changes in oceanographic conditions, particularly temperature	Shelf Research Fleet	Commercial Fisheries Research Foundation, WHOI	2014-2022	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Sample and monitor the fisheries in and around the SFW lease area. These surveys include ventless traps, fish pots, trawls, CTD casts, acoustic telemetry, and fish tagging.	South Fork fisheries monitoring	South Fork Wind, CFRF, INSPIRE, CCE, Stonybrook, New England Aquarium	2020 - 2026	Detecting and quantifying changes to wildlife and habitats
Bottom water temperature	Supporting Management of the Emerging Jonah Crab Fishery and the Iconic Lobster Fishery in the Northeast USA	Commercial Fisheries Research Foundation	2013-2023	Detecting and quantifying changes to wildlife and habitats
Marine atmospheric boundary layer: detailed measurements of momentum, heat, and mass fluxes at multiple levels; air-sea interaction; mesoscale flows; SST, ocean surface winds	Wind Forecasting Improvement Project 3 (WFIP-3)	WHOI, NOAA, PNNL, UC Boulder, NCAR, UT Dallas, Tufts, DNV-GL, NREL, Lawrence Livermore NL, Argone NL, Duke, BRI	2021 - 2025	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats

Recommendations

Following are some examples of more specific research that needs to be conducted to assess the potential oceanographic effects of future offshore wind buildout in the Southern New England subregion.

- Determine oceanographic baselines and competing phenomena, such as the impacts of climate change, in addition to effects of offshore wind development. With adjoining lease areas in the MA/RI area, it will be important to understand the oceanographic effects of multiple wind farms and their cumulative impacts. There are currently very few federal ocean observing buoys collecting data in the MA/RI lease areas, and the numbers of buoys in these areas should be increased to understand baselines and effects from offshore wind development (Figure 5).
- The PIONEER array collected data from the inshore and shelf area to examine exchanges between the shelf and slope and the shelf ecosystem, as well as to provide broader insight into air-sea gas exchange, including carbon dioxide absorption. The array's first deployment was off the coast of New England at the Continental Shelf/Slope interface, where it collected data from 2016 until it was recovered in September 2022; the array is now being moved to the southern Mid-Atlantic Bight (or RWSC Central Atlantic subregion). Given the time series of oceanographic data collected by the PIONEER array in New England waters, a new sampling program should be initiated to continue this time series and to expand measurements to those needed most for understanding potential effects of offshore wind development in New England waters.
- During 2023-2026, post-construction wildlife surveys will be performed by BOEM outside of the MA WEA adjacent to Vineyard Wind 1. These surveys should include collection of oceanographic and habitat covariates to understand potential effects of windfarm development on above and below water processes.
- Similar to how RODEO was performed at Block Island wind farm, perform similar types of monitoring during construction of other wind farms in the region to understand potential effects on oceanography, habitat, and colonization of foundations. Consideration should be given to monitoring of effects using different mitigation measures (such as for sound propagation) during construction to understand best approaches for minimizing environmental effects.
- Collect field measurements to understand how the placement of wind turbine structures and associated effects on hydrodynamics can in turn affect biogeochemical and water quality characteristics of the water column.

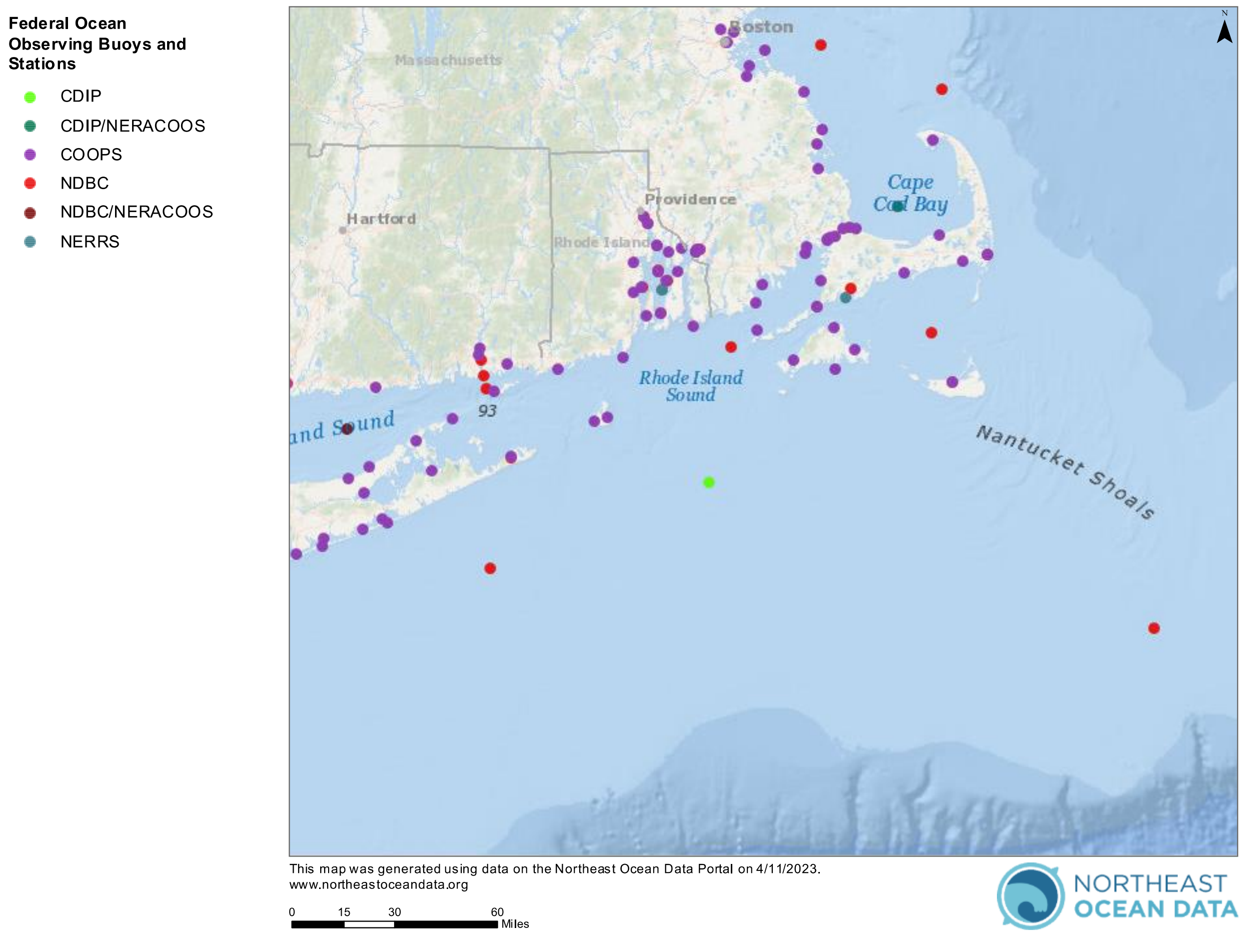

Figure 5. Federal ocean observing buoys and stations in the Southern New England subregion. (Source: Northeast Ocean Data Portal)

5.4 Other Science Plan Actions

Ongoing and pending activities

Click project name below to view full description.

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Model development and statistical frameworks Meta-analysis and literature review	Evaluation of Hydrodynamic Modeling and Implications for Offshore Wind Development: Nantucket Shoals	National Academy of Sciences, BOEM, NOAA	2023	Understanding the environmental context around changes to wildlife and habitats Determining causality for observed changes to wildlife and habitats

Recommendations

Based on methodology for WFIP-3, develop a guidance document for how similar types of field programs could be implemented in other regions. The program is unique in terms of implementing a comprehensive observational and modeling study of the coupled atmospheric and oceanic boundary layers in and around offshore wind farms and would be applicable to other subregions where wind farms are being developed.

6 New York/New Jersey Bight ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for oceanography and offshore wind

6.1 Focal habitats and processes of interest

The following provides a brief summary of New York/New Jersey Bight focal habitats and processes of interest. See Section 1.1 for a more complete description.

- The Mid-Atlantic Bight encompasses the entire Mid-Atlantic region and includes the smaller New York Bight at its northern end.
- The Mid-Atlantic region is influenced by both cool waters of the Labrador Current from the north and warm waters of the Gulf Stream from the south, with shelf water generally flowing south toward Cape Hatteras, North Carolina.
- The New York Bight is a triangular feature that runs from Montauk at the eastern point of Long Island, New York to Cape May, New Jersey. Within the New York Bight, circulation is highly sensitive to changes in wind and biological productivity is affected by riverine nutrient outputs and cross-shelf interactions.
- More broadly across the Mid-Atlantic Bight, the mixing of slope and shelf waters, along with upwelling, increases nutrient availability and promotes productivity.
- The Mid-Atlantic Bight Cold Pool is a characteristic of the region, where strong seasonal stratification promotes productivity among all levels of the food chain; it is a dynamic feature that provides crucial habitat in the northeast shelf, particularly as a thermal refuge for benthic species.

6.2 Potential effects

All of the potential effects noted in Section 1.3 apply in the New York/New Jersey Bight.

6.3 Field data collection and analysis

Ongoing and pending activities

Click project names below to view full descriptions.

Method(s)	**Project**	**Lead and Partner Entities**	**Time period**	**Research Theme**
Vessel-based surveys with CTD casts, carbonate chemistry, fisheries acoustics, zooplankton tows, midwater trawls; gliders	Development and implementation of an ocean ecosystem monitoring program for New York Bight	Stony Brook University, NYDEC	2018-2026	Detecting and quantifying changes to wildlife and habitats Understanding the environmental context around

				changes to wildlife and habitats
Vessel-based surveys; gliders	Eco-gliders: An ecological and oceanographic baseline to inform offshore wind development over the continental shelf off the coast of New Jersey	Rutgers University, New Jersey Research and Monitoring Initiative, WHOI	2022-ongoing	Detecting and quantifying changes to wildlife and habitats Understanding the environmental context around changes to wildlife and habitats
Vessel-based surveys with plankton nets and water samples	Ecosystem Monitoring on the Continental Shelf (EcoMon)	NOAA NEFSC	1977-ongoing	Understanding the environmental context around changes to wildlife and habitats Enhancing data sharing and access
Water column profilers	Environmental Monitors on Lobster Traps and Large Trawlers (eMOLT)	NOAA NEFSC, local fishers, Gulf of Maine Lobster Foundation, Nova Scotia Fishermen Scientists Research Society, Commercial Fisheries Research Foundation	2001-ongoing	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Gliders with CTD	GLIDE: Glider based ecological and oceanographic surveys of the New York Bight	Rutgers University, Stony Brook University, WHOI	2022-ongoing	Detecting and quantifying changes to wildlife and habitats Understanding the environmental context around changes to wildlife and habitats
Water samples	Impacts of Ocean Sewage Treatment Plant Outfalls	Stony Brook University, NYDEC	2018-2020	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats

				Enhancing data sharing and access
Metocean buyo	LiDAR Buoy Program - NYB	US DOE/PNNL, BOEM	2015-2017	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Ocean modeling, telemetry, glider observations, buoys, water sampling	Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS)	Rutgers University, VIMS, Stony Brook, Smithsonian Environmental Research Center, IOOS	2007-Ongoing	Detecting and quantifying changes to wildlife and habitats
Vessel-based surveys	Nearshore Ocean Trawl Survey	NYSDEC, Stony Brook University, SoMAS	2017-2027	Detecting and quantifying changes to wildlife and habitats
Vessel-based surveys	New Jersey Department of Environmental Protection Baseline Studies	NJ DEP, Geo-Marine	2008-2009	Detecting and quantifying changes to wildlife and habitats
Vessel-based surveys of biomass, length and age structures, and diet compositions of finfishes and select invertebrates, water quality, weather conditions	NorthEast Area Monitoring and Assessment Program (NEAMAP)	Atlantic States Marine Fisheries Commission	2006-Ongoing	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Water samples	Northeast U.S. Shelf (NES) Long-Term Ecological Research (LTER)	WHOI, Wellesley College, NSF, University of Maryland, University of Rhode Island	2017-ongoing	Understanding the environmental context around changes to wildlife and habitats
Water samples, gliders with CTD, optics puck, optode, AZFP	Ocean Wind 1 Fisheries Monitoring Plan	Rutgers University, Orsted, Monmouth University, Delaware State University	2021-2027	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying

				changes to wildlife and habitats
Underwater gliders - seasonal deployments of underwater gliders equipped with sensors, including newly developed pH sensors, to understand how the ocean chemistry in this region varies on seasonal timescales relevant to organism ecologies and life histories.	Optimizing Ocean Acidification Observations for Model Parameterization in the Coupled Slope Water System of the U.S. Northeast Large Marine Ecosystem	Rutgers University, NOAA OAP, Stony Brook University, University of New Hampshire, University of Maine, MARACOOS, NERACOOS	2019 – 2022	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
CTD	Shelf Research Fleet	Commercial Fisheries Research Foundation, WHOI	2014-2022	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Temperature sensor inside ventless trap	Supporting Management of the Emerging Jonah Crab Fishery and the Iconic Lobster Fishery in the Northeast USA	Commercial Fisheries Research Foundation	2013-2023	Detecting and quantifying changes to wildlife and habitats
Gliders	WOW - Integrated Regional Ecosystem Studies	Duke University, WHOI, Rutgers University, BRI, Cornell, Scientific Innovations Inc., Syracuse University, University of St. Andrews, New England Aquarium, Wildlife Conservation Society, Southall Environmental Associates Inc., Stony Brook University, University of Pennsylvania	2023-2026	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats Enhancing data sharing and access

Recommendations

Following are some examples of more specific research that needs to be conducted to assess the potential oceanographic effects of future offshore wind buildout in the New York/New Jersey Bight subregion.

- Determine oceanographic baselines and competing phenomena, such as the impacts of climate change, in addition to effects of offshore wind development. With adjoining lease areas, especially off the New Jersey coast, it will be important to understand the oceanographic effects of multiple wind farms and their cumulative impacts. There are currently very few federal ocean observing buoys collecting data in the New York/New Jersey Bight lease areas, and the numbers of buoys in these areas should be increased to understand baselines and effects from offshore wind development (Figure 6).

- Similar to how RODEO was performed at Block Island wind farm, perform similar types of monitoring during construction of other wind farms in the region to understand potential effects on oceanography, habitat, and colonization of foundations. Consideration should be given to monitoring of effects using different mitigation measures (such as for sound propagation) during construction to understand best approaches for minimizing environmental effects.
- Collect field measurements to understand how the placement of wind turbine structures and associated effects on hydrodynamics can in turn affect biogeochemical and water quality characteristics of the water column.

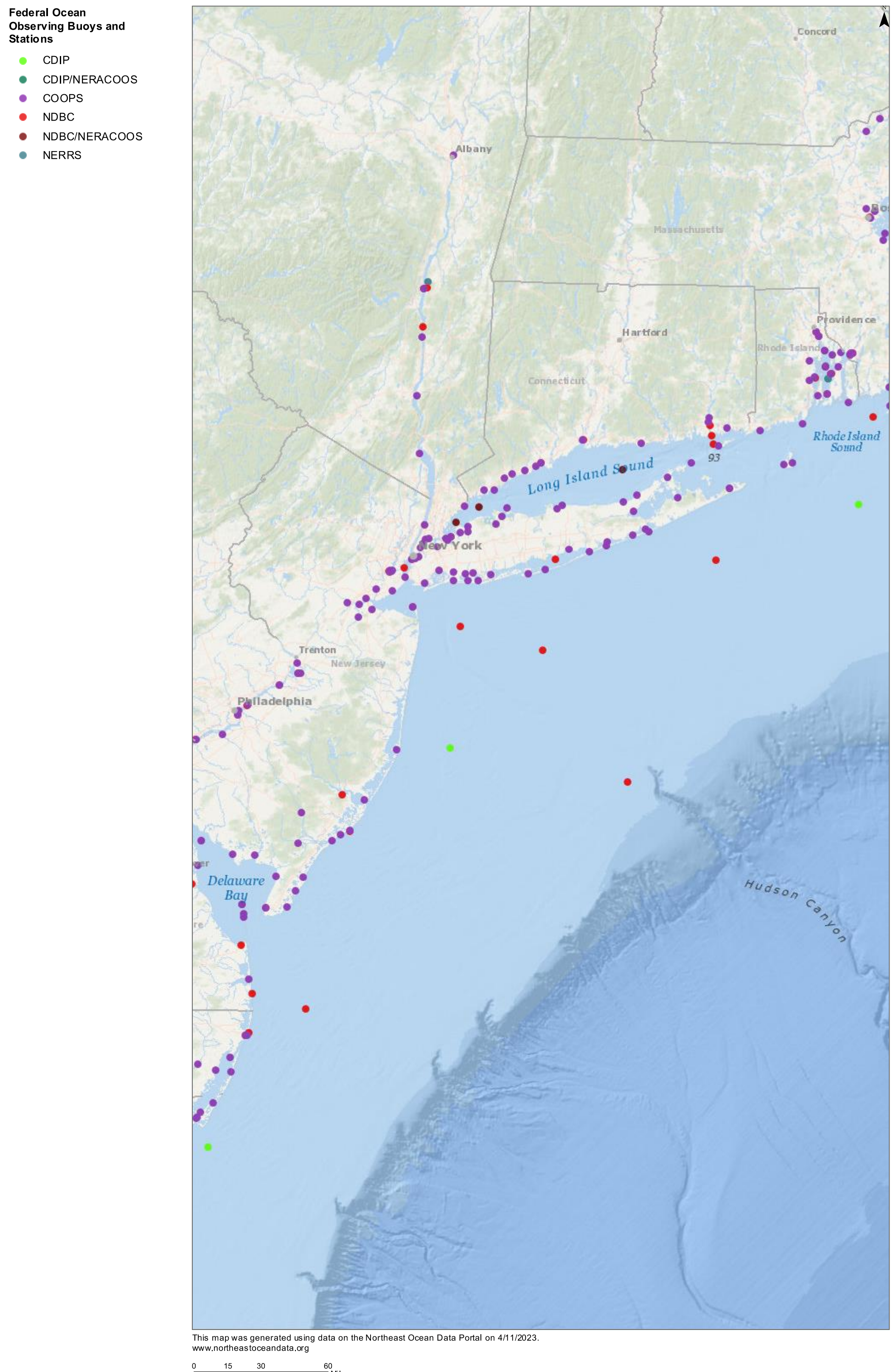

Figure 6. Federal ocean observing buoys and stations in the New York/New Jersey Bight subregion. (Source: Northeast Ocean Data Portal)

6.4 Other Science Plan Actions

Ongoing and pending activities

Click project names below to view full descriptions.

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Model development and statistical frameworks	The Impacts of Offshore Wind Farms on Local Physical Oceanography and Summer Flounder Distribution	Rutgers University, AKRF, NJ Sea Grant	2022-2024	Detecting and quantifying changes to wildlife and habitats Understanding the environmental context around changes to wildlife and habitats
Model development and statistical frameworks Outreach and platforms to provide data products and results to stakeholders	Northeast Coastal Ocean Forecast System (NECOFS)	UMass-SMAST, NERACOOS, IOOS, University of New Hampshire, WHOI, Gulf of Maine Research Institute	2007-ongoing	Detecting and quantifying changes to wildlife and habitats Understanding the environmental context around changes to wildlife and habitats Enhancing data sharing and access
Model development and statistical frameworks	Offshore Wind Impacts on Oceanographic Processes: North Carolina to New York (AT-22-01A)	DHI Water & Environment, Inc., BOEM	2022-2024	Detecting and quantifying changes to wildlife and habitats Determining causality for observed changes to wildlife and habitats
Model development and statistical frameworks	Offshore Wind Impacts on Oceanographic Processes: North Carolina to New York (AT-22-01B)	RPS Group, PNNL, BOEM	2022-2024	Detecting and quantifying changes to wildlife and habitats Determining causality for observed changes to wildlife and habitats
Outreach and platforms to provide data products and results to stakeholders	Northeast and Mid-Atlantic Ocean Data Portals – e.g., Oceanography theme data	NROC, MARCO	ongoing	Enhancing data sharing and access

Recommendations

Ensure coordination between RWSC and MARACOOS (which includes the NY/NJ Bight subregion) to spearhead data collection, archival, and sharing according to industry standards.

Work together with MARACOOS to expand engagement with key end users in the offshore wind development and oceanographic communities to clearly identify how data and information can best be provided to suit their needs, refine the technical approach, and verify that user needs are met.

7 U.S. Central Atlantic ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for oceanography and offshore wind

7.1 Focal habitats and processes of interest

The following provides a brief summary of U.S. Central Atlantic focal habitats and processes of interest. See Section 1.1 for a more complete description.

- The U.S. Central Atlantic includes waters off North Carolina, Virginia, Maryland and Delaware.
- The subregion is influenced by both cool waters of the Labrador Current from the north and warm waters of the Gulf Stream from the south, with shelf water generally flowing south toward Cape Hatteras, North Carolina.
- In this subregion, the mixing of slope and shelf waters, along with upwelling, increases nutrient availability and promotes productivity.
- The Mid-Atlantic Bight Cold Pool is a characteristic of the region, where strong seasonal stratification promotes productivity among all levels of the food chain; it is a dynamic feature that provides crucial habitat in the northeast shelf, particularly as a thermal refuge for benthic species.

7.2 Potential effects

All of the potential effects noted in Section 1.2 apply in the U.S. Central Atlantic.

7.3 Field data collection and analysis

Ongoing and pending activities

Click project names below to view full descriptions.

Method(s)	**Project**	**Lead and Partner Entities**	**Time period**	**Research Theme**
Seven benthic bottom landers, which include instrumentation for passive acoustic monitoring, active Acoustic Zooplankton Fish Profilers, and oceanographic properties.	Atlantic Deepwater Ecosystem Observatory Network (ADEON) – An Integrated System for Long-Term Monitoring of Ecological and Human Factors on the OCS	University of New Hampshire, NOAA Southwest Fisheries Science Center, BOEM, ONR, NOAA	2016-2021	Detecting and quantifying changes to wildlife and habitats Understanding the environmental context around changes to

				wildlife and habitats
Instrumented moorings, gliders, AUVs	Coastal Pioneer Array	Ocean Observatory Initiative, NOAA, WHOI	2016-2022	Understanding the environmental context around changes to wildlife and habitats
Integrated observing-modeling prediction and assessment system	Comprehensive Ocean Current, Wave, and Wind Energy Resource Assessment Using an Integrated Observing and Modeling Approach	North Carolina State University, UNC Coastal Studies Institute, UNC Chapel Hill	2021-2022	Understanding the environmental context around changes to wildlife and habitats
Vessel-based surveys with plankton nets and water samples	Ecosystem Monitoring on the Continental Shelf (EcoMon)	NOAA NEFSC	1977 - ongoing	Understanding the environmental context around changes to wildlife and habitats Enhancing data sharing and access
Depth, current speed and direction, water temperature and salinity (conductivity), wind speed and direction, air temperature, barometric pressure	Empire Wind metocean data	Equinor, BP, NYSERDA, MARACOOS	2018-2022	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Metocean buoys	LiDAR Buoy Program - VA	US DOE / PNNL, BOEM	2014-2016	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to

				wildlife and habitats
Depth, current speed and direction, water temperature and salinity (conductivity), wind speed and direction, air temperature, barometric pressure	[Metocean Survey for Beacon Wind Energy Area]()	Equinor, MARACOOS, RPS Group	2021-2023	Understanding the environmental context around changes to wildlife and habitats
High-frequency radar	[Mid-Atlantic high-frequency radar network]()	MARACOOS, NERACOOS, U.S. IOOS, WHOI, Rutgers, UConn, UMaine, ME DMR	?-ongoing	Understanding the environmental context around changes to wildlife and habitats
Ocean modeling, telemetry, glider observations, buoys, water sampling	[Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS)]()	VIMS, Stony Brook, Smithsonian Environmental Research Center, Old Dominion University, RPS Group, Rutgers University, University of Connecticut, University of Delaware, University of Maryland-CES, UMass, University of Rhode Island, WHOI	2007-ongoing	Enhancing data sharing and access
Vessel-based surveys of biomass, length and age structures, and diet compositions of finfishes and select invertebrates, water quality, weather conditions	[NorthEast Area Monitoring and Assessment Program (NEAMAP)]()	Atlantic States Marine Fisheries Commission, Maine Department of Marine Resources, Massachusetts Division of Marine Fisheries, Virginia Institute of Marine Science, the National Marine Fisheries Service Northeast Fisheries Science Center, the New England and Mid-Atlantic Fishery Management Councils, the U.S. Fish and Wildlife Service, the Potomac River Fisheries Commission, and the District of Columbia	2006-ongoing	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Hydrodynamic modeling - Forecasts and hindcasts of ocean currents, waves, and other variables; based on FVCOM model and regional observing assets	[Northeast Coastal Ocean Forecast System (NECOFS)]()	UMass-SMAST, NERACOOS, IOOS, University of New Hampshire, WHOI, Gulf of Maine Research Institute	2007-ongoing	Detecting and quantifying changes to wildlife and habitats Understanding the environmental context around changes to

				wildlife and habitats Enhancing data sharing and access
Underwater gliders - seasonal deployments of underwater gliders equipped with sensors, including newly developed pH sensors, to understand how the ocean chemistry in this region varies on seasonal timescales relevant to organism ecologies and life histories.	Optimizing Ocean Acidification Observations for Model Parameterization in the Coupled Slope Water System of the U.S. Northeast Large Marine Ecosystem	Rutgers University, NOAA OAP, Stony Brook University, University of New Hampshire, University of Maine, MARACOOS, NERACOOS	2019 – 2022	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats
Vessel-based surveys	Sandbridge Highly Migratory Species: Fish Distribution on a Dredged Shoal	University of Delaware, BOEM	2021-2025	Understanding the environmental context around changes to wildlife and habitats Detecting and quantifying changes to wildlife and habitats

Recommendations

Following are some examples of more specific research that needs to be conducted to assess the potential oceanographic effects of future offshore wind buildout in the U.S. Central Atlantic subregion.

- Determine oceanographic baselines and competing phenomena, such as the impacts of climate change, in addition to effects of offshore wind development. With multiple draft WEAs in the U.S. Central Atlantic, on both the shelf and in deeper waters, it will be important to understand the oceanographic effects of multiple wind farms and their cumulative impacts. There are currently very few federal ocean observing buoys collecting data in deeper waters of this subregion; the numbers of buoys should be increased to understand baselines and effects from offshore wind development (Figure 7).
- Measure the atmospheric effects associated with energy removal by future wind turbines in the region. This could be performed using instrumentation and modeling

similar to the Wind Forecasting Improvement Project 3 (WFIP-3) that is being conducted in the MA/RI lease areas.

- Similar to the way RODEO has been performed, acquire real-time observations of the construction and initial operation of wind facilities to aid the evaluation of environmental effects of future facilities. Measurements should be made of: pile driving sound & operational sound (PAM), particle motion, cable layer, scour monitoring, seafloor disturbance and recovery, benthic habitat changed, epifouling, and fish.
- Before any turbines are installed and after construction, collect field measurements to understand how the placement of wind turbine structures and associated effects on hydrodynamics can in turn affect biogeochemical and water quality characteristics of the water column. Biogeochemical and biological sensors could be added to existing and future moorings and buoys.

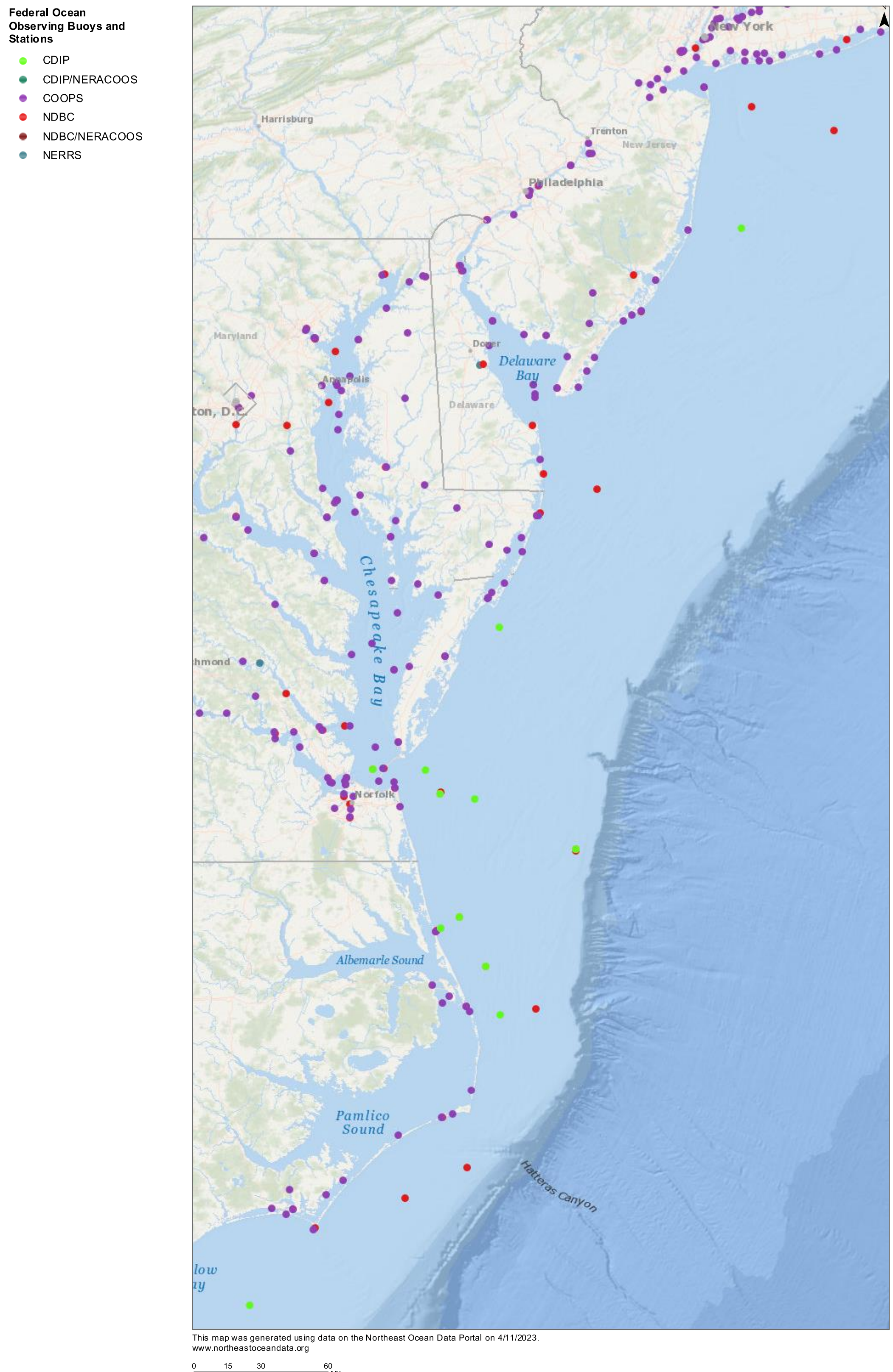

Figure 7. Federal ocean observing buoys and stations in the U.S. Central Atlantic subregion. (Source: Northeast Ocean Data Portal)

7.4 Other Science Plan Actions

Ongoing and pending activities

Click project names below to view full descriptions.

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Model development and statistical frameworks	Offshore Wind Impacts on Oceanographic Processes: North Carolina to New York (AT-22-01A)	DHI Water & Environment, Inc., BOEM	2022-2024	Detecting and quantifying changes to wildlife and habitats Determining causality for observed changes to wildlife and habitats
Model development and statistical frameworks	Offshore Wind Impacts on Oceanographic Processes: North Carolina to New York (AT-22-01B)	RPS Group, PNNL, BOEM	2022-2024	Detecting and quantifying changes to wildlife and habitats Determining causality for observed changes to wildlife and habitats
Outreach and platforms to provide data products and results to stakeholders	Northeast and Mid-Atlantic Ocean Data Portals – e.g., Oceanography theme data	NROC, MARCO	ongoing	Enhancing data sharing and access

Recommendations

Ensure coordination between RWSC and MARACOOS (which includes the U.S. Central Atlantic subregion) to spearhead data collection, archival, and sharing according to industry standards.

Work together with MARACOOS to expand engagement with key end users in the offshore wind development and oceanographic communities to clearly identify how data and information can best be provided to suit their needs, refine the technical approach, and verify that user needs are met.

8 U.S. Southeast Atlantic ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for oceanography and offshore wind

8.1 Focal habitats and processes of interest

The following provides a brief summary of U.S. Southeast Atlantic focal habitats and processes of interest. See Section 1.1 for a more complete description.

- The subregion is connected by the Loop Current-Florida Current-Gulf Stream continuum and influenced by the tropical and sub-tropical oceanic, atmospheric, and ecosystem domains.

- The confluence of the tropical and sub-tropical domains influences a range of sub-to super-regional physical and biogeochemical phenomena.
- The shelf is relatively wide and shallow; the physical dynamics are dominated by interactions with the Gulf Stream and the overlying atmosphere.
- Water movement is dominated by tidal and synoptic scale atmospheric events, and Gulf Stream frontal waves.
- Within coastal bays, buoyancy also plays an important role in inner shelf oceanographic dynamics. In these areas, river plumes deliver sediment, nutrients, and pollutants to coastal waters, as well as also providing chemical cues that affect recruitment of estuarine-dependent fishery species.

8.2 Potential effects

All of the potential effects noted in Section 1.2 apply in the U.S. Southeast Atlantic subregion. In addition, coral reefs are vulnerable habitats not found in the other subregions and special considerations should be given to oceanographic effects related to offshore wind development that could potentially impact these habitats. Similarly, the U.S. Southeast Atlantic subregion is more prone to hurricanes than the other subregions and it will be important to be able to tease out the effects of hurricanes from those of offshore wind development on ocean conditions.

8.3 Field data collection and analysis

Ongoing and pending activities

Click project names below to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Satellite; vessel-based surveys with ADCP, CTD, echosounders; bottom landers with passive acoustic monitoring, active Acoustic Zooplankton Fish Profilers, CT-DO	Atlantic Deepwater Ecosystem Observatory Network (ADEON) – An Integrated System for Long-Term Monitoring of Ecological and Human Factors on the OCS	University of New Hampshire (Contractual portion of study); NOAA Southwest Fisheries Science Center (IA portion of study); NOPP Project - sponsoring agencies include BOEM, ONR, NOAA	2016-2021	Detecting and quantifying changes to wildlife ad habitats Understanding the environmental context around changes to wildlife and habitats
Real-time mooring, non real-time moorings, research cruises	Coastal Ocean Research Monitoring Program (CORMP)	University of North Carolina Wilmington, SECOORA, NOAA, NC Sea Grant, USACE, CDIP	2000-ongoing	Detecting and quantifying changes to wildlife ad habitats Understanding the environmental context around changes to wildlife and habitats

				Enhancing data sharing and access
Vessel-based surveys, CTD, water quality	Integrated Biscayne Bay Ecological Assessment and Monitoring Project (IBBEAM)	NOAA Southeast Fisheries Science Center, SECOORA	2007-ongoing	Detecting and quantifying changes to wildlife ad habitats Understanding the environmental context around changes to wildlife and habitats
Glider deployments with PAM. U.S. Sanctuary-wide project collecting PAM across U.S. Sanctuaries to monitor soundscapes. Bottom mounted recorders are deployed at 3-4 sites in each sanctuary collecting continuous recordings. A real-time slocum glider, operated by WHOI is routinely deployed in SBNMS	Sanctsound	NOAA NEFSC, NOAA SBNMS, U.S. Navy, NOAA Sanctuaries, WHOI	2018 - 2022	Detecting and quantifying changes to wildlife ad habitats Understanding the environmental context around changes to wildlife and habitats
Vessel-based surveys, CTD profiler	Southeast Area Monitoring and Assessment Program (SEAMAP)	Atlantic States Marine Fisheries Commission, NMFS SFSC, USFWS SAFCO, Florida Fish & Wildlife Conservation Commission, Georgia Dept of Natural Resources, NC Dept of Environment & Natural Resources, SC Dept of Natural Resources, South Atlantic Fishery Management Council	1981-ongoing	Detecting and quantifying changes to wildlife ad habitats Understanding the environmental context around changes to wildlife and habitats
Profiling gliders	Southeast autonomous vehicle observatory	SECOORA, University of Southern Florida, University of North Carolina-Wilmington, North Carolina State University, Georgia Institute of Technology, Skidaway Institute of Oceanography	2016-ongoing	Understanding the environmental context around changes to wildlife and habitats
Sensors at coastal stations	Southeast coastal stations and moorings	SECOORA, University of North Carolina-Wilmington, University of Southern Florida, University of Georgia, RDSEA International Inc., NOAA	2004-ongoing	Understanding the environmental context around changes to wildlife and habitats
High-frequency radars	Southeast high-frequency radar network	SECOORA, University of North Carolina-Chapel Hill, University of South Carolina, University of Georgia, University of Miami, University of Southern Florida,	2009-ongoing	Understanding the environmental context around changes to wildlife and habitats

		East Carolina University, Florida Institute of Technology		
Vessel-based water quality monitoring	Water Quality Protection Program of the Florida Keys National Marine Sanctuary	Florida International University, NOAA, US EPA, SFWMD	1995-ongoing	Understanding the environmental context around changes to wildlife and habitats

Recommendations

Following are some examples of more specific research that needs to be conducted to assess the potential oceanographic effects of future offshore wind buildout in the U.S. Southeast Atlantic subregion.

- Determine oceanographic baselines and competing phenomena, such as the impacts of climate change, in addition to effects of offshore wind development. With currently only two, but adjoining, lease areas proposed in the northern area of the subregion, it will be important to understand the oceanographic effects of multiple wind farms and their cumulative impacts. There are currently very few federal ocean observing buoys collecting data in these lease areas, and the numbers of buoys in the whole U.S. Southeast Atlantic subregion should be increased to understand baselines and effects from offshore wind development (Figure 8). Especially, buoys and coastal stations are needed on the east coast of FL, within the 10-50 meter isobaths.
- Measure the atmospheric effects associated with energy removal by future wind turbines in the region. This could be performed using instrumentation and modeling similar to the Wind Forecasting Improvement Project 3 (WFIP-3) that is being conducted in the MA/RI lease areas.
- Add high frequency radar stations to fill coverage gaps identified in the subregion.
- Establish a Lidar buoy program in the U.S. southeastern Atlantic similar to programs in other areas along the U.S. Atlantic (e.g., MA, NJ, VA). The buoy(s) would measure wind profile, speed and direction; solar radiation; air temperature and relative humidity; barometric pressure; water velocity, salinity and temperature; wave spectrum.
- Expand monitoring of soundscapes in the U.S. Southeast Atlantic to collect background data and to measure noise from potential offshore wind development in the region. There is a gap in sound data collection in the shallower waters of the subregion (see https://www.ncei.noaa.gov/maps/passive-acoustic-data/). In addition, fishery independent research programs in the subregion (MARMAP and SEAMAP) could be leveraged to deploy hydrophones in areas where surveys occur.
- Similar to the way RODEO has been performed in other regions, acquire real-time observations of the construction and initial operation of wind facilities to aid the evaluation of environmental effects of future facilities. Measurements should be made of: pile driving sound & operational sound (PAM), particle motion, cable layer, scour monitoring, seafloor disturbance and recovery, benthic habitat changed, epifouling, and fish.
- Before any turbines are installed then after construction, collect field measurements to understand how the placement of wind turbine structures and associated effects on hydrodynamics can in turn affect biogeochemical and water quality characteristics of the

water column. Biogeochemical and biological sensors could be added to existing and future moorings and buoys.

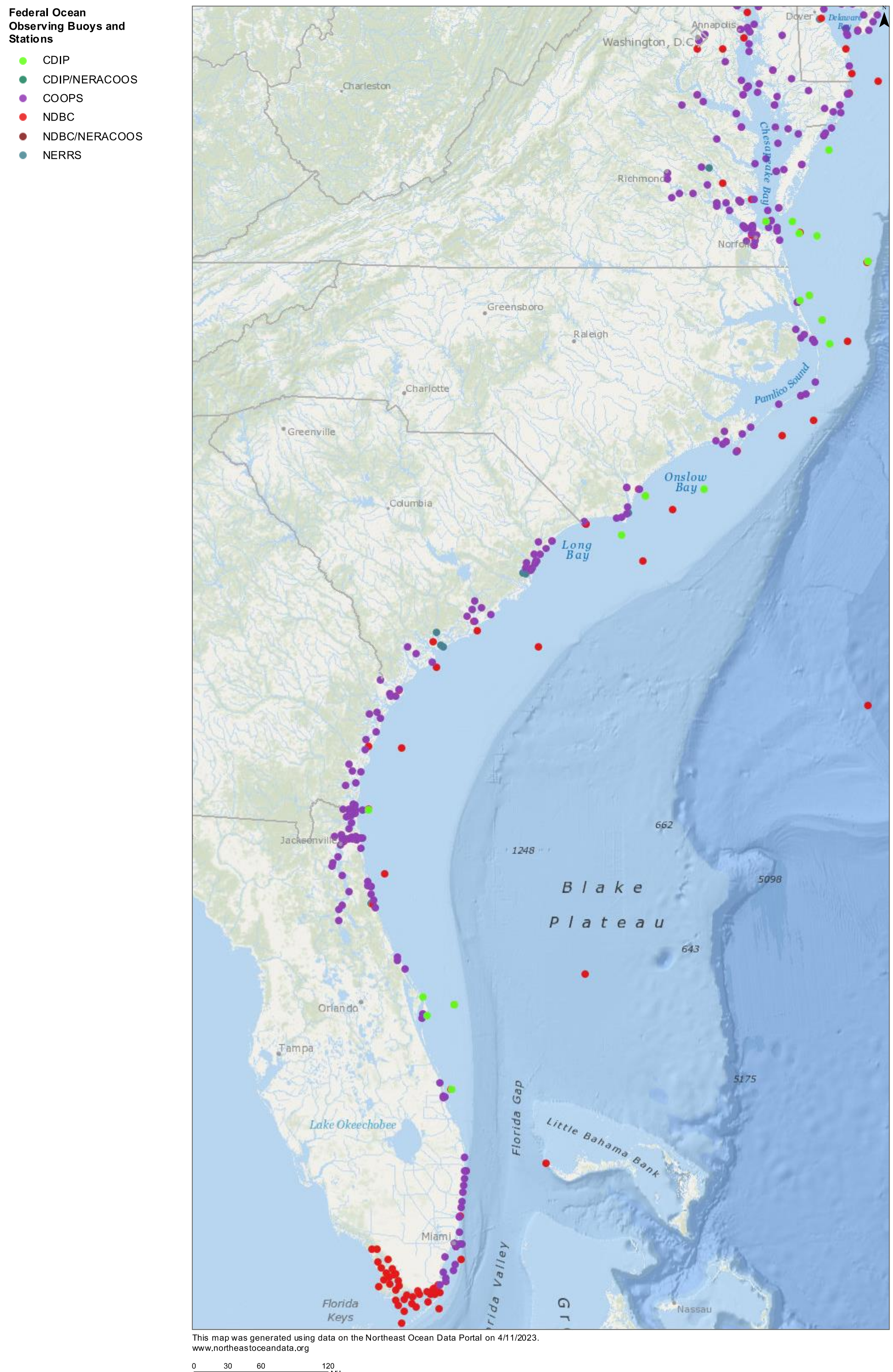

Figure 8. Federal ocean observing buoys and stations in the U.S. Southeast Atlantic subregion. (Source: Northeast Ocean Data Portal)

8.4 Other Science Plan Actions

Ongoing and pending activities

Click project names below to view full descriptions.

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Coordination and planning	The Southeast US Marine Biodiversity Observation Network (MBON): Toward Operational Marine Life Data for Conservation and Sustainability	USF, Oregon State University, GCOOS, SECOORA, NOAA AOML, Rosenstiel School of Marine & Atmospheric Science (RSMAS), University of Miami, FWRI, EcoQuants, Mitchell Roffer, NOAA NMS, FL Keys NMS, CINMS, USGS OBIS, Univ. of Porto, Portugal University, UNESCO–Intergovernmental Oceanographic Commission	2022-2027	Understanding the environmental context around changes to wildlife and habitats
Coordination and planning	Southeast Coastal Ocean Observing Regional Association	SECOORA, University of South Florida College of Marine Science, Miami-Dade County, UGA Skidaway Institute of Oceanography, South Carolina Sea Grant Consortium, Ocean Tracking Network	2003-ongoing	Enhancing data sharing and access
Model development and statistical frameworks	Delivering actionable coastal and ocean information from high-quality science and observations for the Southeast	NCSU, SECOORA, Fathom Science LLC, NOAA	2021-2026	Understanding the environmental context around changes to wildlife and habitats
Model development and statistical frameworks	Comprehensive Ocean Current, Wave, and Wind Energy Resource Assessment Using an Integrated Observing and Modeling Approach	NCSU, UNC Coastal Studies Institute, UNC Chapel Hill	2021-2022	Detecting and quantifying changes to wildlife ad habitats Understanding the environmental context around changes to wildlife and habitats
Outreach and platforms to provide data products and results to stakeholders	The Southeast Marine Mapping Tool (Phase 2): Increasing access to regional ecological data to help inform offshore ocean use decisions: Analysis and Visualization of Ocean Resources in the Context of Offshore Wind Energy Development	SECOORA, The Nature Conservancy	2022-2027	Enhancing data sharing and access

Recommendations

Ensure coordination between RWSC and to spearhead data collection, archival, and sharing according to industry standards.

Work together with SECOORA to expand engagement with key end users in the offshore wind development and oceanographic communities to clearly identify how data and information can best be provided to suit their needs, refine the technical approach, and verify that user needs are met.

Following are some examples of more specific actions that need to be conducted to assess the potential oceanographic effects of future offshore wind buildout in the U.S. Southeast Atlantic subregion.

- Identify historical data in the U.S. Southeast Atlantic subregion that needs to be preserved, as well as a pathway to collect, compile, and preserve historical data.
- Develop high-resolution coupled physical-biogeochemical models incorporating as many marine environmental variables as relevant to offshore wind development and the various U.S. Southeast Atlantic ecosystems (e.g., coral reefs).
- Leverage SECOORA's education and outreach efforts to develop public engagement campaigns related to ocean observation technologies and offshore wind effects.

9 Conclusion

This science plan chapter identifies near-term investments for both field and non-field activities related to understanding and mitigating the potential regional and subregional oceanographic effects of offshore wind energy development. The main types of potential oceanographic effects that are discussed include considerations related to the physical effects of structures, noise propagation, water quality, and biological linkages. In terms of physical effects of wind energy structures, the potential physical effects both above and below the water surface are considered, including related to structures above the water extracting energy and structures in the water affecting turbulence and vertical mixing. In coordination with the taxa-based RWSC subcommittees' recommendations, this chapter considered the noise and vibration that is generated by offshore wind turbines and associated operations, and developed recommendations specifically related to sound propagation and modeling. With respect to water quality, recommendations were developed to address the placement of wind turbine structures and associated effects on hydrodynamics that can in turn affect biogeochemical and water quality characteristics of the water column. Finally, in terms of linkages to biological effects, consideration was given to the introduction of new structures during offshore wind farm construction that can alter the habitat and modify food webs, including as the turbines are colonized.

This chapter develops a total of ~40 research recommendations that cover the five RWSC research themes. The recommendations are based on the ~75 individual ongoing data collection and research initiatives related to offshore wind and oceanographic/pelagic habitats and ecosystems funded by a variety of partners (states, federal agencies, industry). The recommendations were also informed by relevant research topics previously identified from the literature in the Atlantic Offshore Wind Environmental Research Recommendations Database that was filtered on habitat, oceanographic, phytoplankton, and zooplankton considerations.

The Subcommittee discussed the importance of meteorological and oceanographic data as input to/drivers of species models (e.g., distribution, density, movement models). A key recommendation of the Subcommittee is to ensure that sufficient oceanographic data are collected to support species models and that those data are made available in the form of standardized data products that could be used by existing and future species modeling efforts.

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Chapter 12: Habitat & Ecosystem- Seafloor

Executive Summary

This chapter describes roughly 35 individual ongoing data collection and research initiatives related to offshore wind and seafloor/benthic habitats and ecosystems funded by a variety of partners (i.e., federal agencies, states, industry). For an always up-to-date list of active projects, visit the RWSC Offshore Wind & Wildlife Research Database.

Given this ongoing work, the Habitat & Ecosystem Subcommittee is making recommendations for additional research that is both aligned with existing efforts and that fills important gaps. Those recommendations are described in detail throughout each section of this chapter. The recommendations are also summarized below:

RWSC Research Theme	Research Topic	Recommendations
Mitigating negative impacts that are likely to occur and/or are severe in magnitude	Environmental sensitivity analysis to identify sensitive habitats and inform offshore wind siting, permitting, and future assessments.	Use experts within the RWSC Habitat & Ecosystem Subcommittee to guide the development of maps and analyses of sensitive seafloor habitats, specifically: • Identify lists of key benthic habitats and taxa receptors within the RWSC study area. • Continue to use the RWSC's Offshore Wind & Wildlife Research Database to track active research projects and data collection activities to identify data availability and gaps and inform analyses. • Recommend timelines and methods for publicly sharing data from completed projects to fill baseline data gaps. • Coordinate with the RWSC Habitat & Ecosystem – Seafloor Subcommittee to identify data collection to fill baseline data gaps for seafloor habitat.
	Construction techniques and technologies to limit detrimental effects to benthos during offshore wind construction.	Coordinate with members of industry to identify and review current technologies and techniques and determine standard metrics of disturbance for existing technologies (e.g., pile driving, jet plow) across different seafloor substrates. Conduct comparative field studies with the research community and members of industry

RWSC Research Theme	Research Topic	Recommendations
		to evaluate new technologies that limit detrimental effects to benthos.
	Strategies to reduce the introduction and dispersal of non-native species from offshore wind development construction and operation activities.	Develop new and advance existing technologies and designs for offshore wind infrastructure (e.g., scour protection, cable protection) and activities (e.g., ballast water, biofouling) that deter the proliferation of non-native species, specifically: • Conduct comparative experiments and/or *in-situ* assessments of various engineering designs, including nature-based designs. • Gather initial knowledge from research leases and existing programs, as well as examples from other countries. • Develop standard hypotheses and assessment techniques that can be employed across locations.
Detecting and quantifying changes to wildlife and habitats	Coordination among federal and state agencies, eNGOs, the research community, and members of industry to standardize methods and prioritize seafloor characterization activities in the U.S. Atlantic Ocean.	Coordinate with the U.S. Interagency Working Group on Ocean and Coastal Mapping, National Ocean Mapping, Exploration, and Characterization (NOMEC) Council, the NROC Habitat Classification and Ocean Mapping Subcommittee, and others to understand ongoing and pending seafloor/habitat mapping activities at the state and regional level and facilitate collaborative opportunities. Work with Habitat & Ecosystem Subcommittee – Seafloor Group to determine what types of changes to the seafloor habitat are ecologically meaningful and develop standard to assess these changes. Use the Subcommittee as a forum to: • Periodically re-evaluate and standardize data collection and field methods to ensure collected data are suitable for regional needs. • Develop best practices for optimizing study designs and to inform data collection efforts to ensure compatibility with regional statistical analyses and research questions.
	Standardized and long-term seafloor data collection across various oceanographic contexts and in the presence of offshore wind structures.	Establish a collaborative and comprehensive monitoring framework to detect changes to seafloor habitat over time, specifically: • Determine adequate timelines for repeated sampling and, if necessary,

RWSC Research Theme	Research Topic	Recommendations
		adaptive sampling for more acute stressors (e.g., major storms on sediment and scour protection). • Identify necessary spatial coverage within and outside offshore wind areas to detect change and preemptively assess other areas of potential interest. • Evaluate the viability of opportunistic data collection activities where construction and operation vessels collect geophysical data during scheduled routines to identify precursors or anomalies. • Coordinate with the Habitat & Ecosystem Subcommittee – Oceanography Group to monitor benthic community function and other relevant metrics over a vertical gradient from water column to seafloor habitats, including on monopiles and other structures. Require that federal and state agencies, eNGOs, researchers, and offshore wind developers collect seafloor habitat data following standard data collection and field methods established by Subcommittee to ensure consistent data types for use in large-scale geospatial analyses and reviews. Additional site-specific data collection and methods may be necessary for specific lease areas. Advance, evaluate, and apply new technologies and techniques to better map the seafloor and collect ground-truth data (i.e., sediment grabs and images) for habitat mapping analyses. Coordinate with the Responsible Offshore Science Alliance (ROSA) to assess whether offshore wind infrastructure provides recruitment, spawning, and/or nursery habitat for fish species to guide data collection efforts and advancements.
	Consistent seafloor habitat maps that are reproducible at the regional scale and/or development of new habitat models and data products.	Obtain input from species modeling experts on the habitat variables needed for use in marine mammal, seabird, sea turtle, and fish distribution/abundance/density models. Apply standardized classification frameworks (i.e., the Coastal and Marine Ecological Classification Standard [CMECS]) to

RWSC Research Theme	Research Topic	Recommendations
		consistently characterize benthic habitats in terms of geoform, substrate, and biotic assemblage for use in regional-scale analyses. Evaluate and recommend crosswalk methods to apply to existing non-CMECES data to increase comparability and create synthesis data sets. Apply more advanced modeling techniques to predict CMECS substrate occurrence i.e., NROC/INSPIRE regional seafloor modeling, NCCOS’ Enhancing Habitat Mapping Accuracy and Efficiency Using Artificial Intelligence. Continue to update habitat modeling products with new geophysical and ground-truth data every 3-5 years or as is practical. Periodically validate and evaluate the performance of models and statistical frameworks. Use validation and evaluation results to inform and advance model/framework development and application. Document considerations for consistent and comparable seafloor data collection across space and time to improve model development and inform working groups.
Understanding the environmental context around changes to wildlife and habitats	Consistent and long-term oceanographic habitat data collection for use in benthic habitat studies.	Coordinate with the NERACOOS, MARACOOS, SECOORA, and RWSC Habitat & Ecosystem Subcommittee – Oceanography Group to understand recent field monitoring activities. Work with the RWSC Habitat & Ecosystem Subcommittee – Oceanography Group to identify expected oceanographic (water column and nearby benthic habitats) co-variates that may influence the response of benthic habitats to offshore wind development. View relevant research topics and recommendations in the Habitat & Ecosystem – Oceanography chapter.
	Alteration of hydrodynamics, stratification, and mixing that influence benthic habitats and larval settlement due to offshore wind structures.	Coordinate with the NERACOOS, MARACOOS, SECOORA, and Habitat & Ecosystem Subcommittee – Oceanography Group to understand recent field activities and inform modeling such that outputs are relevant to benthic species assessments.

RWSC Research Theme	Research Topic	Recommendations
		View relevant research topics and recommendations in the Habitat & Ecosystem – Oceanography chapter.
	Ambient noise level monitoring in the ocean for historic conditions, present day, and predicted future scenarios.	Coordinate with the Marine Mammals Subcommittee and Habitat & Ecosystem Subcommittee – Oceanography Group to understand recent sound monitoring activities (e.g., tagging, PAM) and inform modeling such that outputs are relevant to benthic species assessments. View relevant research topics and recommendations in the Marine Mammals chapter.
Determining causality for observed changes to wildlife and habitats	Physical and ecological effects to seafloor habitat and benthic communities related to construction activities.	Compile existing knowledge and generate hypotheses to further assess the effects of noise and vibration from construction activities on benthic organisms, specifically: • Understand impacts of noise and vibration to the growth, behavior, and survival of benthic species under controlled laboratory conditions. • Evaluate sound conditions and effects on particle motion to understand potential on sensitive marine life. • Measure sound and vibration levels during and after construction activities and resulting benthic community function and other metrics. Compile existing knowledge and generate hypotheses to further assess the effects of cable laying activities (e.g., sediment suspension and deposition related to jet plowing) across various habitats and subregions with offshore wind development activity. Compile existing knowledge and generate hypotheses to further assess the effects of seafloor preparation activities (e.g., jack-up barges, boulder relocation) across various habitats and subregions with offshore wind development activity. Obtain input from ecosystem modeling groups on what variables and methods are suitable for incorporating findings into predictive models related to primary productivity and trophic dynamics.

RWSC Research Theme	Research Topic	Recommendations
	Physical and ecological effects to seafloor habitat and benthic communities related to operation and maintenance.	Compile existing knowledge and generate hypotheses to further assess the effects of EMF and heat from cables as well as noise and vibration on benthic organisms, specifically: • Understand how benthic species detect and respond to these factors in terms of growth, behavior, and survival under controlled laboratory conditions. • Understand the range of ambient EMF levels temperatures from cables and acoustic and vibration levels from turbines during normal operation and various contexts (e.g., substrates, burial depth, floating vs. fixed technology) and how the alter habitat conditions. • Evaluate benthic community function and other relevant metrics both before and after the introduction of stressors. Coordinate with the research community on necessary experimental designs, variables, and sample size to identify relationships between observed stressors and benthic communities. Obtain input from ecosystem modeling groups on what variables and methods are suitable for incorporating findings into predictive models related to primary productivity and trophic dynamics.
	Introduction of new structures and conversion of habitat over short and longer time scales.	Characterize and compare the footprints of benthic disturbance between fixed and floating offshore wind developments. Examine how seabed alterations and hard structures affect habitat conditions, including chemical and biological composition, and ecological processes. Assess the net effects of habitat conversion on benthic community function and relevant metrics. Assess the effects of increased organic matter deposition (from offshore wind infrastructure fouling) on benthic functions and coordinate with the other RWSC Subcommittees to assess effects on higher trophic levels.
	Recovery and shifts following temporary and permanent disturbances related to offshore wind development.	Establish standard definitions of recovery and methods for detection. Establish thresholds of acceptable change, with measurable metrics.

RWSC Research Theme	Research Topic	Recommendations
		Characterize seabed physical and biotic recovery from various offshore wind disturbances (construction, regular cable maintenance), and determine what factors influence recovery (e.g., seabed properties, local hydrodynamics, type of disturbance).
Enhancing data sharing and access	Creation of an inventory of all ongoing data collection and research projects for seafloor habitat and offshore wind to encourage a coordinated approach to regional-scale analysis and planning future work.	Develop seafloor/habitat data products that reflect the results of data collection and research activities throughout the RWSC study area and encourage or require projects to include funding for data product development, hosting, and maintenance/updates in their budgets. Data could be hosted and maintained by individual providers but should be shared in formats compatible with existing platforms described above. Share data products with the NOMEC Council, NROC Habitat Classification and Ocean Mapping Subcommittee, and other groups to facilitate the review and prioritization of seafloor characterization activities.
	Coordination of data collection and synthesis of existing data at regional scale including baseline data, regular benthic monitoring data, and data collected at individual offshore wind project sites (e.g., pre- and post-construction).	Continue to lead or participate in the coordination and planning of ongoing and pending activities, using the RWSC Habitat & Ecosystem Subcommittee as a forum for information exchange and coordination among federal and state agencies, eNGOs, the research community, and members of industry. Coordinate and initiate collaborations with additional partners to facilitate data and information sharing. Facilitate pooling of data to obtain statistical power and spatial extent to examine regional-scale effects.
	Public availability of data, including those collected from Environmental Impact Assessments and post-construction monitoring, to aid in the assessment of broad-scale questions, ecosystem-level research, and potential cumulative impacts of offshore wind activities.	Collaboratively develop realistic timelines around geophysical and sediment data sharing that consider needed protections around confidential business information and potential benefits to industry and other stakeholders from improving regional seafloor/habitat data products. Require that federal and state agencies, eNGOs, researchers, and offshore wind developers abide by established data collection and reporting standards to ensure

RWSC Research Theme	Research Topic	Recommendations
		consistent geophysical and sediment data collection for incorporation into data portals as well as regional-scale analyses and reviews. Ensure that existing data repositories for seafloor habitat data have resources and personnel to integrate and provide access to offshore wind and wildlife monitoring datasets as they are collected. Include a minimum budget threshold that must be allocated to data management and access in all project budgets (e.g., 20%). Coordinate with the USGS and the University of Colorado's usSEABED database on establishing an online portal for submitting ground-truth sediment data (from sediment grabs and imagery) from opportunistic and structured surveys. Require that these data from federal and state agencies, eNGOs, researchers, and industry members be submitted to the usSEABED with any associated effort data and required metadata (develop metadata requirements if not established). Coordinate with the NOAA National Centers for Environmental Information (NCEI), BOEM, USGS, and others on expanding current data portals or establishing a new online platform for submitting high-resolution seafloor mapping (i.e., MBES bathymetry and backscatter, side-scan sonar) data as well as associated effort and metadata related to offshore wind. The platform would permit an online space for federal, state, eNGOs, and industry to share preliminary geophysical and effort data quickly and efficiently for review prior to more time intensive quality assurance/quality control protocols. Work with NOAA, BOEM, USGS, and others as they develop the infrastructure and guidelines around the use of existing or new repositories for hosting and sharing high-resolution geophysical data from seafloor habitat mapping surveys. Advance the recommendations for seafloor data formatting and sharing developed via the NROC/INSPIRE regional seafloor modeling project, specifically:

RWSC Research Theme	Research Topic	Recommendations
		• Establish standard geospatial formats for vector and raster data for facilitating data transfer protocols. • Identify and review cloud computing environments capable of hosting and sharing large amounts of geospatial data. • Develop exploratory tools and interactive capabilities to enhancing sharing and interpretation.

1 Seafloor habitat in the Atlantic region

Bordering the most densely populated portion of the country, the U.S. Atlantic continental margin has been studied for well over a century and provides a general framework of knowledge for informing past and future studies (Emery, 1966; Uchupi, 1968). In brief, the U.S. Atlantic continental margin, which includes the continental shelf, slope, and rise, encompasses about 2,500 km of coastline between Maine and Florida and an area of nearly 700,000 km^2 (Emery, 1966) (Figure 1). The geologically passive nature of the Atlantic margin has allowed broad beds of thick sediment to accumulate along the U.S Atlantic coast, resulting in a relatively shallow and wide shelf that extends more than 200 km offshore in some areas. The shelf is deeply incised by submarine canyons, especially in the northern portion of the Atlantic region, most likely a consequence of the powerful runoff from melting continental ice sheets at the end of glacial periods (BOEM, 2023).

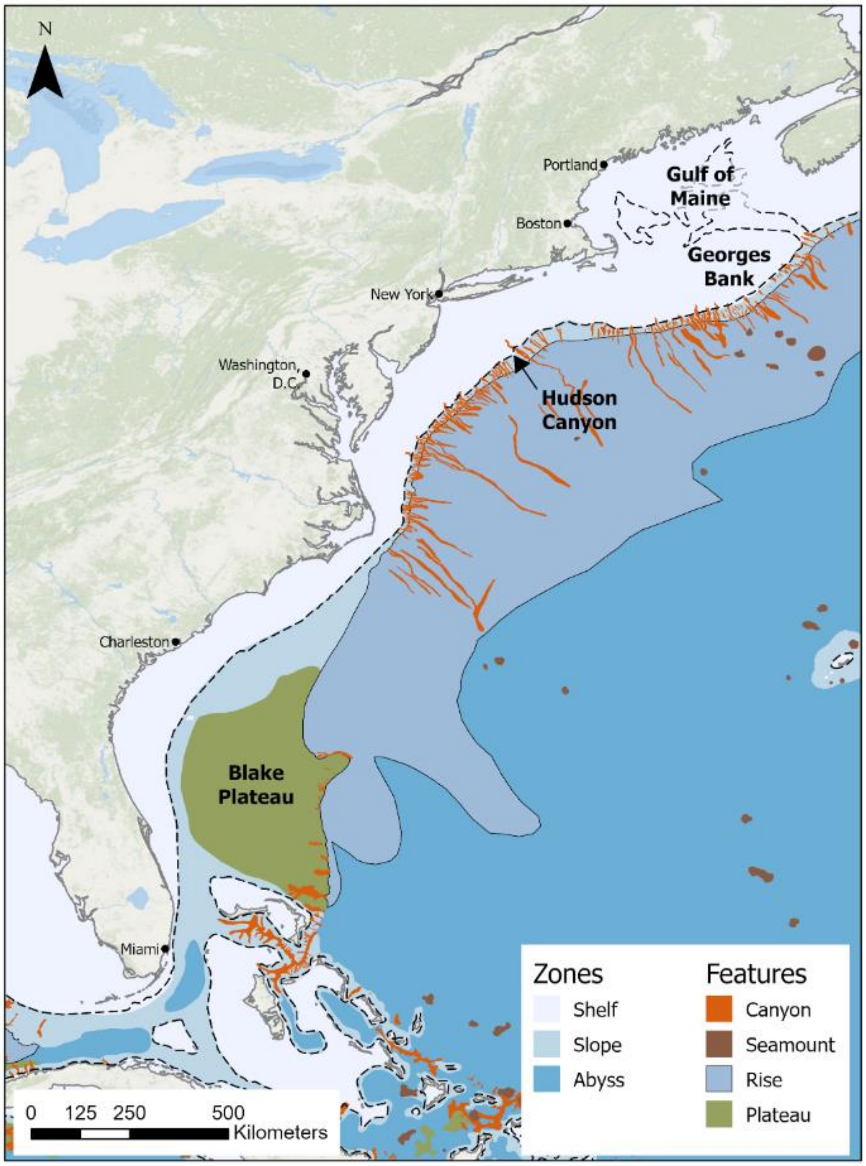

Figure 1. A geomorphological overview of the U.S. Atlantic coast, including base coastal zones (i.e., shelf, slope, and abyss) and specific seafloor features (i.e., canyons, seamounts, rises, and plateaus). The black dotted line overlapping the continental shelf border represents a 200 m bathymetric contour. Data provided by Harris et al. (2014) and downloaded from www.bluehabitats.org/.

Based on surface morphology alone, the U.S. Atlantic continental margin can be divided into three distinct zones (adapted from Uchupi (1968) that broadly align with the five subregions identified in the RWSC Science Plan (Figure 2). These three distinct zones include the (1) **Northern Zone** from Nova Scotia to Nantucket Island, (2) **Central Zone** from Nantucket Island to Cape Hatteras, NC, and (3) **Southern Zone** from Cape Hatteras, NC to the Florida Keys. An overview of the seafloor topography, surficial sediments, and habitat types for each zone is provided in the following paragraphs.

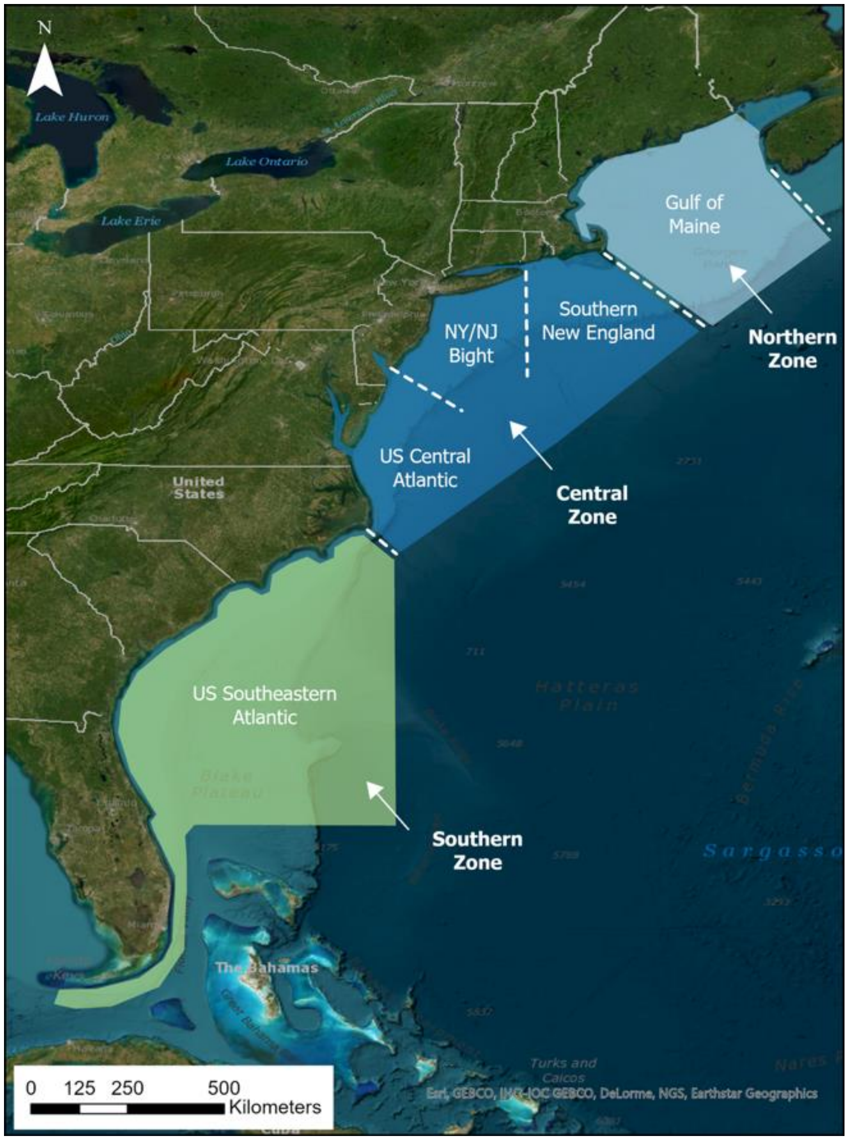

Figure 2. High-level delineation of the RWSC Science Plan subregions and distinct zones adapted from Uchupi et al. (1968). From north to south, the five RWSC Science plan subregions include the Gulf of Maine, Southern New England, New York/New Jersey (NY/NJ) Bight, U.S. Central Atlantic, and US Southeastern Atlantic (separated by dotted white lines). The three zones that are differentiated based on surface morphology include the Northern Zone (light blue), Central Zone (dark blue), and Southern Zone (light green). Note, the displayed delineations are general and designed to organize knowledge and recommendations into more manageable units along the U.S. Atlantic margin.

The **Northern Zone** ranges from Nova Scotia to Nantucket Island, MA and includes both the Gulf of Maine and Georges Bank. Despite their immediate proximity to one another, these two glacially derived topographic features are often described separately given their differing structure and sediments (Figure 3). The Gulf of Maine, for instance, is a semi-enclosed continental shelf sea (9-350 m depth) that is characterized by a system of deep basins, moraines, and rocky protrusions (Stevenson et al., 2004). In contrast, Georges Bank, a shallow (3-150 m depth) and elongated (161 km wide by 322 km long) submarine plateau that gradually slopes from north to south with steep submarine canyons on its southern edge. The Gulf of Maine's unique physiographic structure lends to a variety of surficial sediments (e.g., bedrock, silty sand, mud), whereas Georges Bank is predominantly sandy with local interruptions of glacially deposited gravel and fine sediment (Stevenson et al., 2004; NOAA, 2023b). Complex topography and unique oceanographic conditions in the Gulf of Maine and Georges Bank result in a high diversity of physical (e.g., rocky, sandy, muddy) and biogenic (e.g., seagrass, shellfish, and kelp beds, cold-water coral) habitat types across the two areas. A more thorough review of these habitat types is detailed in Tyrell (2005).

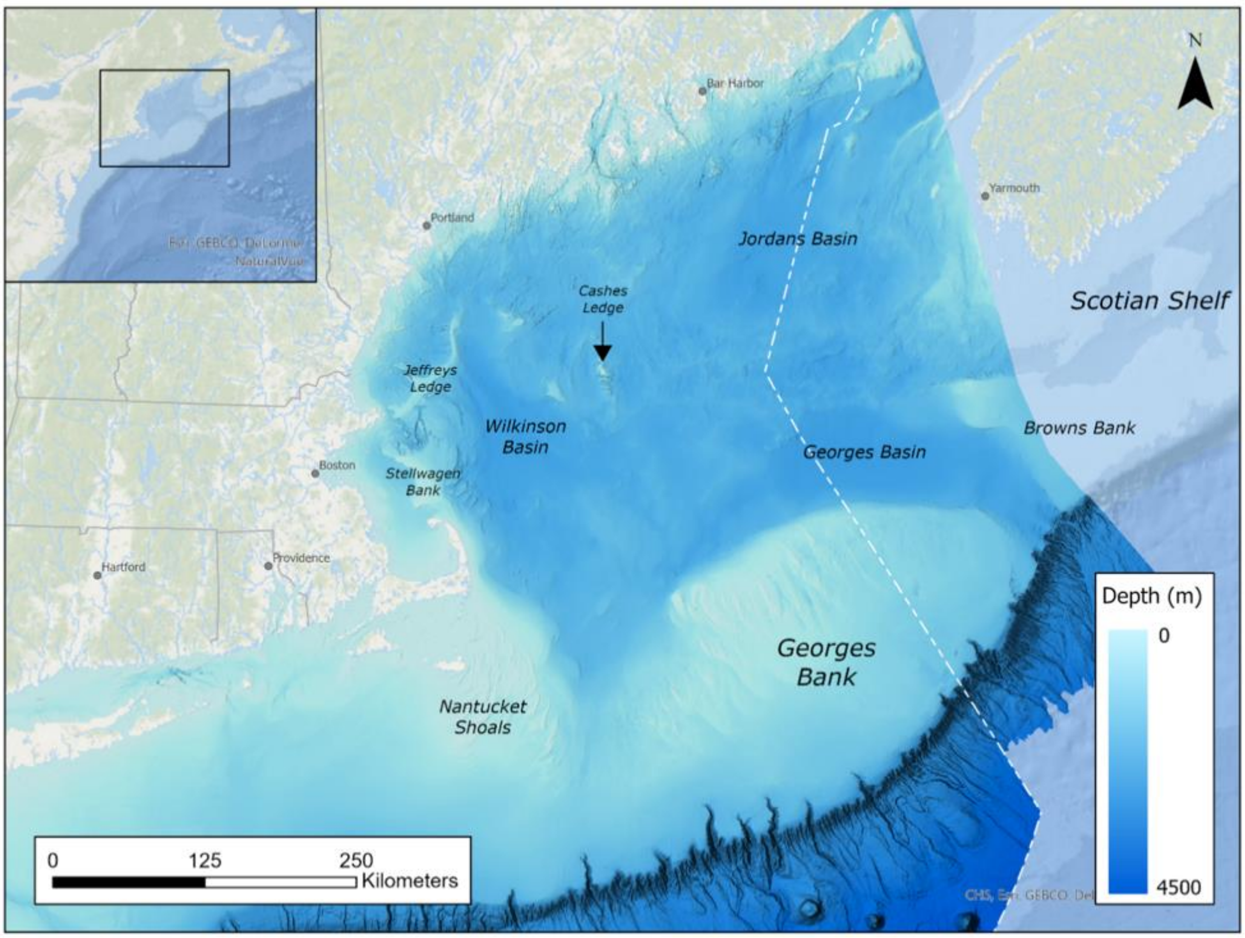

Figure 3. Topographic overview of the U.S. Atlantic continental margin within the identified Northern Zone, which includes the Gulf of Maine, Georges Bank, and other submarine features. The dotted white line represents the U.S. Exclusive Economic Zone (EEZ; 200 nautical mile limit). Vertical exaggeration of colored relief is approximately 5x. Data provided by The Nature Conservancy's Northwest Atlantic Marine Ecoregional Assessment (Greene et al., 2010).

The **Central Zone** includes the continental shelf and slope waters between Nantucket Island, MA and Cape Hatteras, NC (Figure 4), encompassing features such as the Nantucket Shoals, Long Island Sound, Hudson Shelf Valley, and a series of canyons in deeper waters. This region is characterized by a uniform and broad expanse of gently sloping continental shelf that extends up to 150 km offshore (100-200 m depth) where it transitions to the slope at the shelf break. Similar to Georges Bank, numerous canyons incise the slope, some of which cut up onto the shelf itself, as it descends rapidly to 3,000 m (Stevenson et al., 2004). Sand is the predominant surficial sediment type on the shelf with small, localized areas of sand-shell and sand-gravel. Fine sediments are also common on the shelf valleys leading to the submarine canyons as well as in areas off Southern New England, specifically the Mud Patch, where tidal currents slow significantly and allow silts and clays to settle out and mix with sand. Although rocky substrate is rare in areas south of Long Island, man-made structures like shipwrecks and artificial reefs are frequent and provide important habitat to the southern Mid-Atlantic Bight ecosystem (Steimle and Zetlin, 2000; Stevenson et al. 2004).

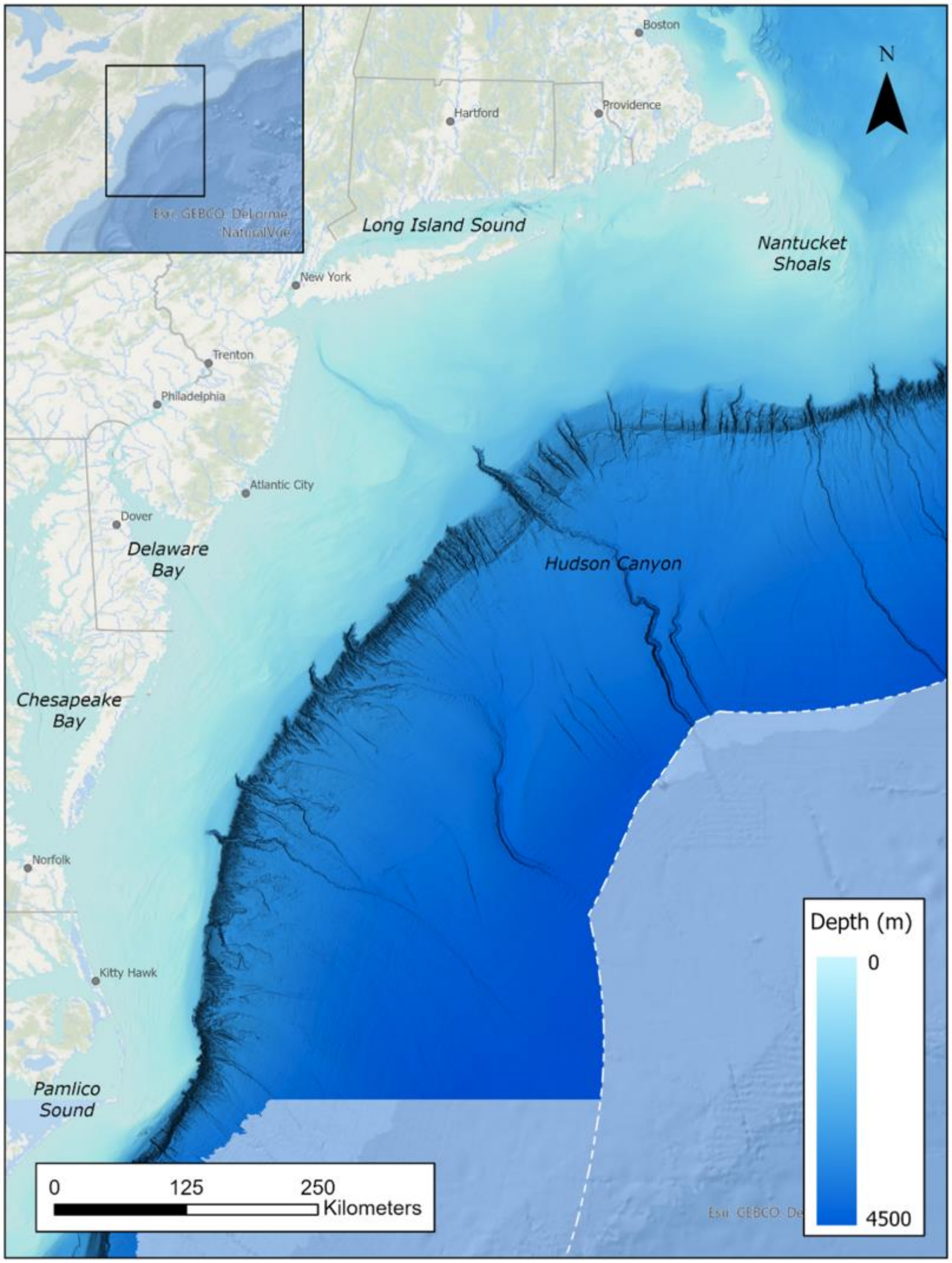

Figure 4. Topographic overview of the U.S. Atlantic continental margin within the identified Central Zone. The dotted white line represents the U.S. Exclusive Economic Zone (EEZ; 200 nautical mile limit). Vertical exaggeration of colored relief is approximately 5x. Data provided by The Nature Conservancy's Northwest Atlantic Marine Ecoregional Assessment (Greene et al., 2010).

Finally, the **Southern Zone** extends southward from Cape Hatteras, NC to the Florida Keys (Figure 5). The continental margin in the southeastern U.S. is unique in its overall dimensions and submarine features when compared to more northern regions. The shallow continental shelf in this region, for instance, is relatively wide to the north (100 km width) but contracts significantly as it approaches the Straits of Florida (11 km width) (Conley et al., 2017). In contrast to steep continental slopes, the slope in the southeastern U.S. is unusually wide and dominated by the Blake Plateau, a broad marginal plateau (184,000 km^2 area; 400-1,250 m depth), which is flanked by the Florida-Hatteras Slope on its western margin and the Blake Escarpment on its southeastern margin (descending to about 4,800 m). Sand-shell sediments dominate the southwestern end of the continental shelf, whereas foraminiferal sands or silts characterize the top of Blake Plateau (Emery, 1966). Although no major canyons cut across the slope in this area, the Gulf Stream is and has been a dominant force shaping the seafloor, scouring steep channel along most of the southeast region and often exposing hard substrates that create rugged topography (Ross and Nizinski, 2007). Sandy habitats on the shelf sustain important fish species while rocky outcrops on the seafloor provide substrate for sponges, corals, and algae (Conley et al., 2017).

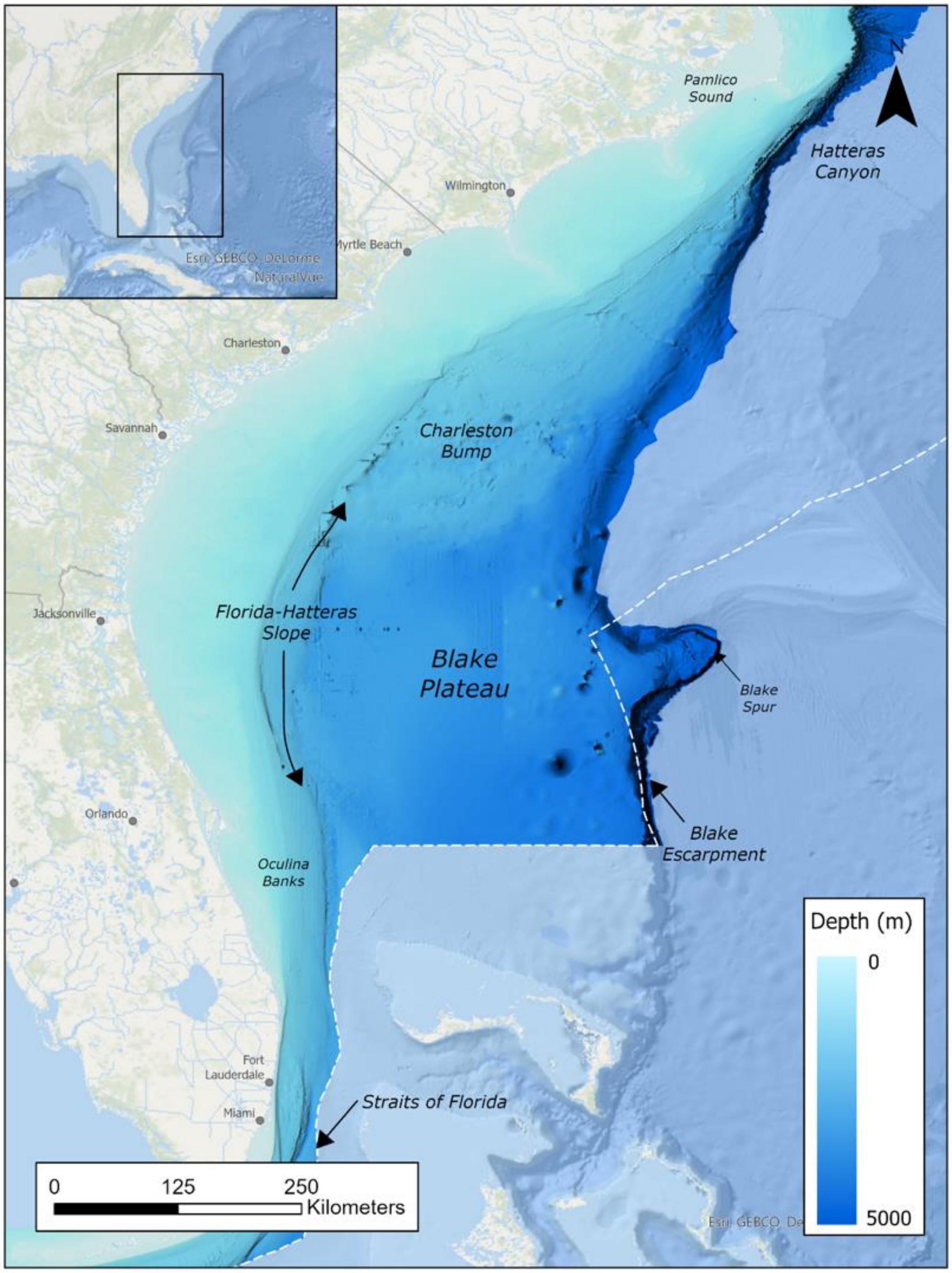

Figure 5. Topographic overview of the U.S. Atlantic continental margin within the identified Southern Zone. The dotted white line represents the U.S. Exclusive Economic Zone (EEZ; 200 nautical mile limit). Vertical exaggeration of colored relief is approximately 5x. Data provided by The Nature Conservancy's South Atlantic Bight Marine Assessment (Conley et al., 2017).

1.1 Sensitive and critical habitats

Hard, immobile substrates provide a distinct and important habitat for numerous biota across a span of life stages. Besides providing stable attachment sites for sessile organisms, complex physical habitat is depended upon by many fish[1] species to survive and reproduce, especially those that constitute economically valuable fisheries[2]. Although traditional management has historically relied on statutes that dictate acceptable levels of fishing effort, a lack of essential habitat for these fishery species can negatively influence the health of marine ecosystems and the societies that depend on them.

Therefore, to maintain productive fisheries and rebuild depleted fish stocks[3] in the United States, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (i.e., NOAA Fisheries) requires the identification and protection of fish habitat that may be adversely impacted by coastal development and other human activities. This insertion of essential fish habitat (EFH), or those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity (NOAA, 2002), under the Magnuson Stevens Fishery Conservation and Management Act (Magnuson-Steven Act), allows regional fishery management councils to pinpoint and protect EFH by limiting certain activities, including fishing gear restrictions, changing catch allowances, or a combination of measures.

To increase scrutiny, study, or mitigation planning compared to other areas, EFH can be categorized into more distinct designations. Habitat Areas of Particular Concern (HAPC), for instance, are subsets of EFH that require higher priority in terms of conservation effort and can exhibit one or more of the following traits: rare, under stress from development, sensitive to decline, or support major ecological functions (NOAA, 2023c). Once a species is listed under the Endangered Species Act, NOAA Fisheries evaluates and identifies whether any areas meet the definition of Critical Habitat, i.e., specific areas that may require special management considerations or protection for the conservation of an endangered species (NOAA, 2023a). To date, NOAA has described EFH for approximately 1,000 managed species, and identified over 100 HAPCs throughout the U.S. Atlantic coast (Figure 6).

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[1] Definition of "fish": A collective term to include finfish, skates, sharks, mollusks, crustaceans, and any other aquatic animal which is harvested (NOAA, 2006).

[2] Definition of "fishery": The combination of fish and fishers in a region, the later fishing for similar or the same species with similar or the same gear types (NOAA, 2006).

[3] Definition of "stock": A part of a fish population with a particular migrating pattern, specific spawning grounds, and is subject to a distinct fishery (NOAA, 2006).

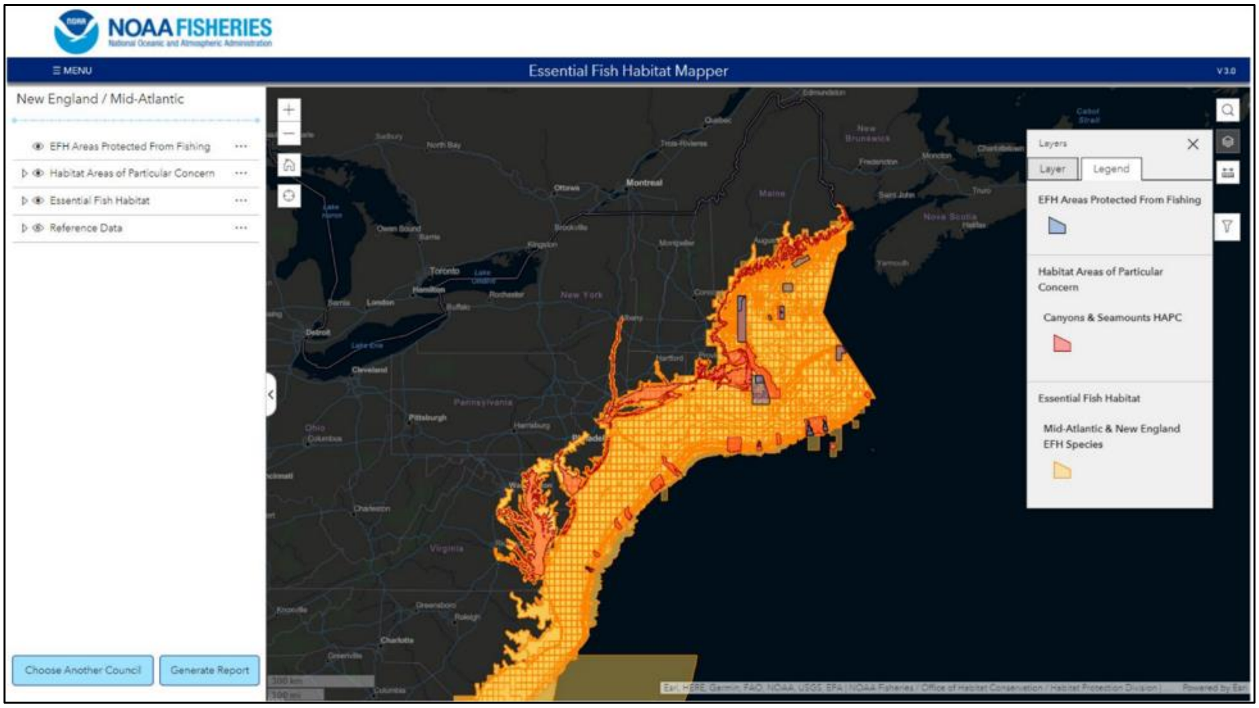

Figure 6. A screenshot of NOAA Fisheries' Essential Fish Habitat Mapper displaying Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) for federally managed species off the U.S. Atlantic coast. The online and interactive mapping tool can be found at the following hyperlink: https://www.fisheries.noaa.gov/resource/map/essential-fish-habitat-mapper .

A considerable amount of physical and biological information is necessary when accurately mapping essential and sensitive habitat types, especially to meet requirements under the Magnuson-Stevens Act (NOAA Habitat, 2020). Benthic substrates and features, for instance, should be mapped using information collected from acoustic surveys and *in-situ* seafloor sampling (e.g., sediment grain size analysis, imagery). Although it is important to delineate and characterize all habitat types in an area that may be adversely impacted by activities, structurally complex habitats are particularly important due to their numerous benefits to taxa (reviewed by Stevenson et al., 2004; Kutti et al., 2015). NOAA Fisheries defines complex habitats as (1) hard bottom substrates (e.g., gravels, gravel mixes, gravelly, and shell; Figure 7), (2) hard bottom substrates with epifauna or macroalgae cover, and (3) vegetated habitats (e.g., submerged aquatic vegetation). Complex habitats can also include heterogeneous environments (e.g., mixes of soft and complex habitats) and man-made marine structures as they can provide equally valuable habitat and functionality for some managed species.

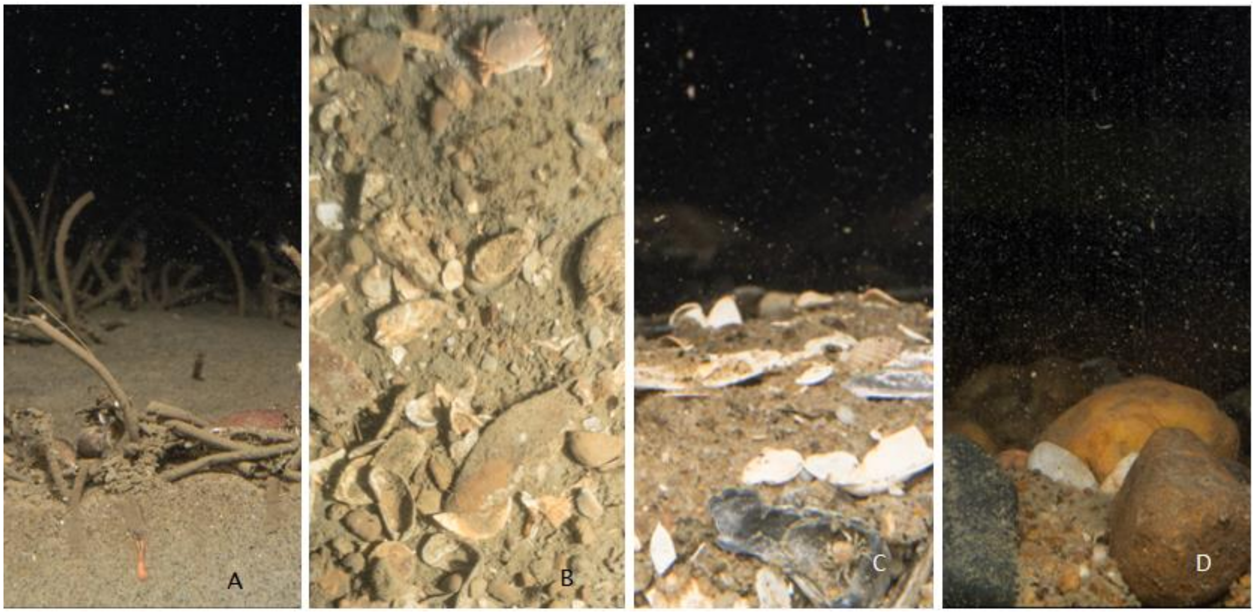

Figure 7. Examples of complex sediment types collected from sediment profile (A, C, D) and plan view (B) imaging. (A) displays infaunal, tube-building worms and an epifaunal echinoderm (i.e., sand dollar); (B) shows shell habitat with slipper shells, shell fragments and crab; (C) displays shell fragments and small crab utilizing substrate for cover; (D) displays gravel substrate with microalgal growth.

In addition to physical attributes, understanding benthic community composition is necessary for habitat classification purposes as infauna and epifauna can provide unique environmental and physical structure for other organisms (Tyrrell, 2005; NOAA Habitat, 2020). Infauna, for example, support sediment health and stability and epifauna create hard bottom and other structurally complex habitat. Submerged aquatic vegetation, along with sequestering carbon and improving water quality, provides important habitat for numerous fish in terms of shelter from predators and food availability.

1.2 Potential effects with respect to offshore wind

All offshore wind development will have some interaction with the seafloor and potentially influence benthic habitats and associated biological communities. Although accustomed to naturally occurring environmental fluctuations and disturbances, the ecological function of seafloor habitats and benthic communities can be temporarily or permanently altered with the addition of offshore wind components.

Given the contribution of benthic environments to ecosystem services globally (reviewed by Dannheim et al., 2019), it is important to understand the effects of offshore wind development. The U.S. Offshore Wind Synthesis of Environmental Effects Research group has therefore provided an overview of stressors to benthic habitats and associated biological communities during pre-construction, construction, operations and maintenance, and decommission project phases (SEER, 2022). This overview is by no means an exhaustive review but to simply illustrate the primary and secondary effects of offshore wind energy development to benthic environments to guide future research and mitigation efforts.

Primary effects:

- **Loss of habitat:** The installation of offshore wind components results in the loss of habitat, resulting in the mortality of sessile and relocation of more mobile organisms to new locations.
- **Conversion of habitat, introduction of new hard substrate:** Wind turbine foundations, anchors, and scour protection can create new hard substrate. Despite altering the native benthic ecology of the area, these components create new hard substrate that is rapidly populated by benthic communities after installation.
- **Introduction of non-native species:** The introduction of hard substrate can serve as stepping stones for non-native species to expand their range into new areas and outcompete native species.
- **Seabed disturbance and recovery:** The extent and overall impact of seabed disturbances from installing foundations and cables vary depending on local conditions, construction activity, and overall recovery.
- **Water quality, sediment, and turbidity:** Offshore wind component installation can suspend sediment into the surround water column and affect marine life (e.g., smother or burial of benthic sessile organisms, impair filtering for filtering animals, decrease visibility).

Other considerations

- **Contaminant release from sediment and offshore components:** The release of contaminants from re-suspended sediments during installation or anodes to prevent corrosion can be introduced into the food chain without proper siting.
- **Noise and vibration:** Although sensitive to noise and/or vibration during installation activities, benthic organisms are generally more likely to be impacted by the seabed disturbance caused by the physical installation activity itself. Persistent noise during wind farm operation, however, could deter benthic organisms and alter benthic ecological functions.
- **Emissions from cable:** Power flowing through inter-array and export cables generate heat (SEER, 2022a) and produce electromagnetic waves (SEER, 2022b), which may deter organism sensitive to those characteristics. Temperature increases and electromagnetic waves are naturally present in the benthic environment and occupy a limited spatial extent when originating from cables but could cause organisms to relocate or impair essential life functions.

1.3 Common data collection methods and approaches

To investigate questions about seafloor habitat, especially with respect to the potential concern of offshore wind development, this Science Plan describes commonly applied methodologies for data collection and research. The following categories of methods are used throughout this chapter for consistency, but the Subcommittee recognizes that different tools, technologies, and/or procedures could be implemented with respect to each specific chapter.

Methods for data collection can be broadly grouped into (a) field and (b) non-field activities. Field activities include real-time observations via photo or video, sensor deployment, and extractive surveys. Synthesis and modeling are the most common types of non-field activities in this science plan. Below is a high-level overview of field and non-field activities used for mapping the seafloor and characterizing associated habitat, specifically a brief description of the general technique, data type, and instruments.

Field activities include:

- **Seafloor acoustics:** Rapid and non-invasive sonar techniques used to detect and map seafloor environments via the transmission and reception of acoustic pulses. Includes multi-beam echosounders (MBES) and side-scan sonar systems deployed from vessels, either mounted to the vessel itself or via a remote-operated vehicle (ROV), or using more sophisticated autonomous underwater vehicles (AUV).
- **Seafloor grabs:** Collection technique that physically samples the seafloor and associated biota to ground-truth sediment types, sensitive habitats, and benthic community composition. Includes vessel- or diver-based grab samplers (i.e., Van Veen, Harmon, Smith McIntyre) that may influence the composition of the sample.
- **Seafloor imagery:** Optical technique for photographing or recording benthic geology and biology (e.g., seafloor surface, upper sediment column). Includes sediment profile imaging (SPI), plan view imaging (PV), drop cameras, and stationary or towed video.
- **Water quality and oceanography**: In-situ water property measurements, including measures of conductivity/temperature/depth profiles, nutrients, dissolved organic matter, suspended particles, and ocean currents.

Non-field activities include:

- **Coordination and planning**: Coordination among the four RWSC sectors and the research community through the operation of the RWSC, but also other multisector coordination activities led by federal agencies and individual states; deconflicting research activities; coordination around an issue or species, such as the North Atlantic right whale.
- **Standardizing data collection, analysis, and reporting**: Development and maintenance of informal "best practices" as well as formal guidance from government entities on the specific protocols and methods that should be used for specific data types and/or studies to ensure alignment with advances in technologies and practices.
- **Historical data collection/compilation:** Adding existing data to modern databases so that historical data can be used in long-term/time-series analyses and studies.
- **Study optimization**: Implementation of statistical frameworks and analyses to determine optimal study designs given a set of data conditions and research goals.

- **Model development and statistical framework:** Development and maintenance of sediment models, habitat suitability models; predictive modeling of rare or critical habitat or presence of species of concern.
- **Technology advancement**: Includes the development and testing of new field research tools/methods or mitigation options; can also include development of and improvements to data systems.
- **Meta-analysis and literature review:** Compilations of research priorities, impacts literature, assessments of data availability, and life history parameters to inform models.
- **Outreach and platforms to provide data products and results to stakeholders**: Includes the work that RWSC does to summarize and convey findings and results to stakeholders and decision makers, including through regional portals and other web-based platforms that display interpretive maps with exploratory tools and links to the underlying data as appropriate.

1.4 Online repositories of seafloor habitat information

Several web-based tools provide the public with information about the seafloor habitat and associated benthic communities in the RWSC study area.

1.4.1 Marine Cadastre National Viewer

With over 300 data layers from numerous sources, MarineCadastre.gov is one of the premier sources for authoritative ocean data and tools. A cooperative effort between the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration (NOAA), MarineCadastre.gov works closely with national, regional, and state partners to develop and provide direct access to the best-available data and tools to meet the growing needs of the blue economy. The MarineCadastre.gov web-based viewer, the National Viewer, provides the baseline information needed for ocean planning efforts, particularly those that involve finding the best location for renewable energy projects (Figure 8). The viewer is also a helpful tool for the permit review process. View jurisdictional boundaries, restricted areas, applicable laws, critical habitat locations, and other important features within a selected ocean area. Use these data to identify potential conflicts early in the planning process.

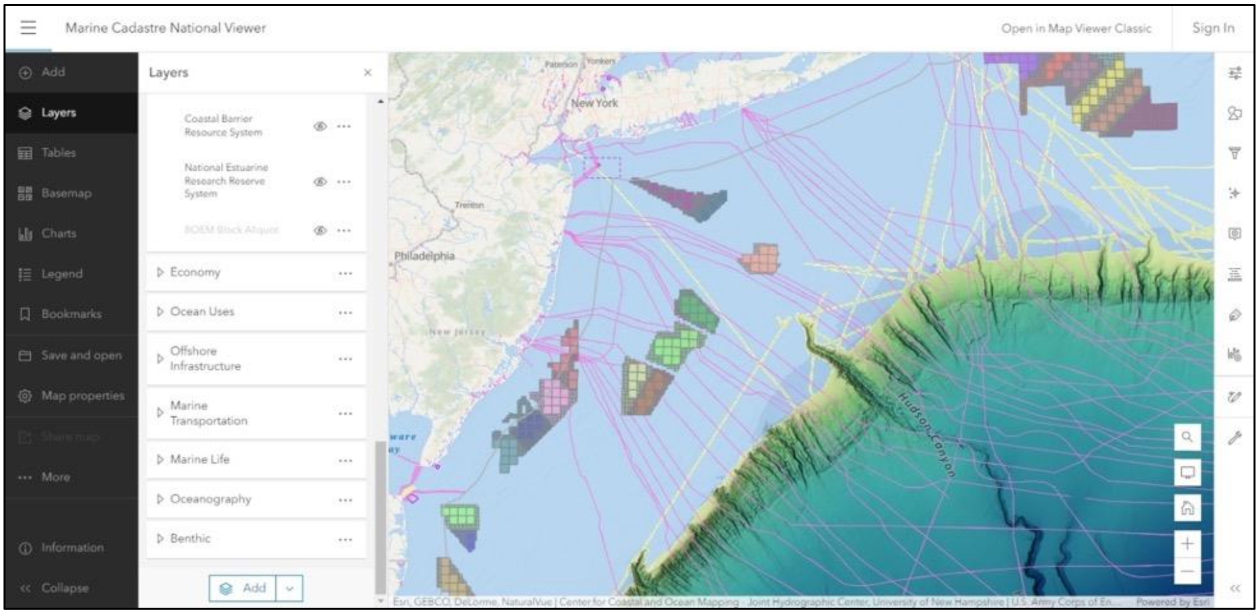

Figure 8. A screenshot of the Marine Cadastre National Viewer displaying active renewable energy leases and planning areas designated by the Bureau of Ocean Energy Management and bathymetry for the Atlantic Continental Margin.

1.4.2 Northeast Ocean Data Portal

Established in 2009, the Northeast Ocean Data Portal provides free, user-friendly access to expert-reviewed interactive maps and data on the ocean ecosystem, economy, and culture of the northeastern United States (Figure 9). The Portal's maps show the richness and diversity of the ecosystem and illustrate the many ways that humans and environmental resources interact. Portal users can view maps and data by theme, by creating custom maps in the Data Explorer, and by downloading data for use in other applications.

The Portal was developed and is maintained by the Northeast Regional Ocean Council (NROC), but many organizations contribute. Data providers include state and federal agencies, scientists, ocean industries, non-government organizations, and other entities. All of these groups, plus a variety of stakeholders, review Portal data and advise on data presentation and visualization. A core team, the Northeast Ocean Data Working Group, maintains and updates the Portal's databases, maps, and website. The Northeast Ocean Data Working Group includes the Northeast Regional Ocean Council, NOAA Office for Coastal Management, Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS), RPS, The Nature Conservancy, and Waterview Consulting.

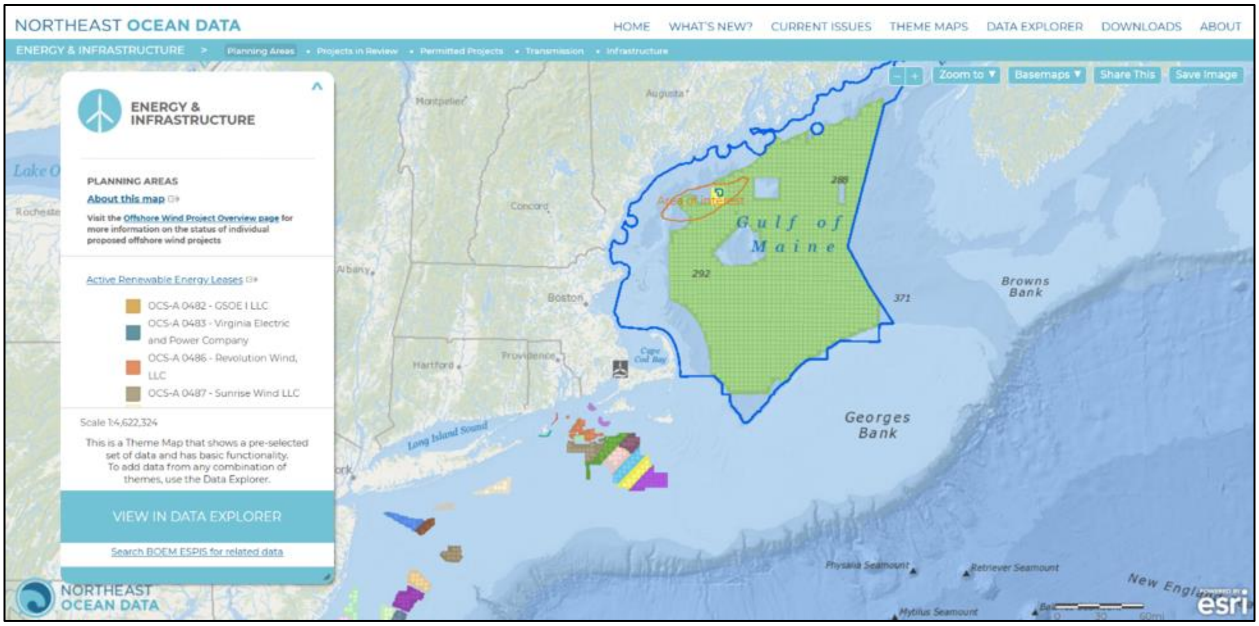

Figure 9. A screenshot of the Northeast Ocean Data Portal displaying active renewable energy leases and planning areas designated by the Bureau of Ocean Energy Management.

1.4.3 Mid-Atlantic Ocean Data Portal

With competing demands on our oceans at an all-time high, finding ways to engage all stakeholders in coastal and marine planning has never been more important. The Mid-Atlantic Regional Council on the Ocean (MARCO) recognizes that a robust ocean data and information management system that includes a wide range of human use, environmental, socioeconomic and regulatory data will provide the building blocks for multi-use, regional-scale ocean planning.

The Mid-Atlantic Ocean Data Portal is an online toolkit and resource center that consolidates available data and enables state, federal and local users to visualize and analyze ocean resources and human use information such as fishing grounds, recreational areas, shipping lanes, habitat areas, and energy sites, among others (Figure 10). The Portal serves as a platform to engage all stakeholders in ocean planning from the five-state Mid-Atlantic region—putting essential data and state-of-the-art mapping and visualization technology into the hands of the agencies, industry, and community leaders. The Portal is maintained by a team consisting of the Monmouth University Urban Coast Institute, Ecotrust, The Nature Conservancy and Rutgers University's Center for Remote Sensing and Spatial Analysis under the guidance of MARCO. It was developed with grant support from the Gordon and Betty Moore Foundation and the National Oceanic and Atmospheric Administration (NOAA).

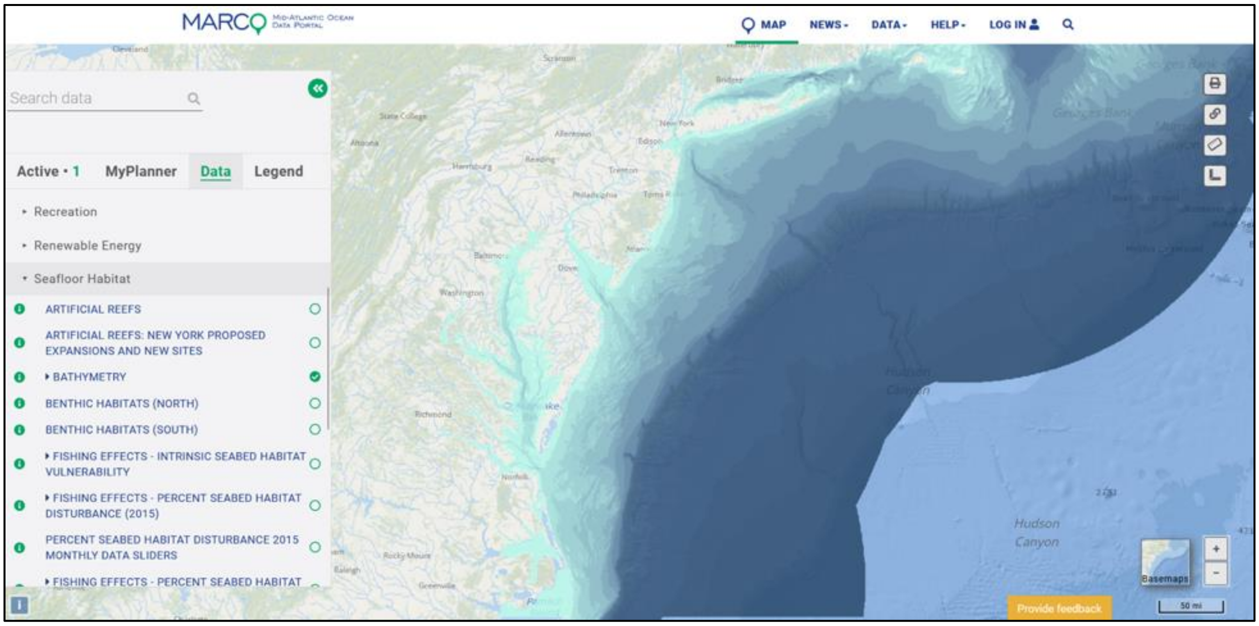

Figure 10. A screenshot of the Mid-Atlantic Ocean Data Portal displaying a regional bathymetric mosaic from The Nature Conservancy's Northwest Atlantic Marine Ecoregional Assessment (Greene et al., 2010).

1.4.4 Regional Association of Coastal Ocean Observing Systems

The Integrated Ocean Observing System (IOOS) is a national-regional partnership that provides decision tools to improve safety and strengthen the economy. IOOS is composed of a network of regional associations that enables tailored approaches and solutions to regional problems and enhances national-level programs and tools. Of the eleven regional associations, three associations are situated within the RWSC study area, including the Northeast Atlantic, Mid-Atlantic, and Southeast Atlantic regions. In addition to providing data on ERDDAP and THREDDS, each regional association provides historical and recent data products through various data portals and catalogs.

The Northeastern Regional Association of Coastal Ocean Observing

The Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS) is first IOOS regional association in the RWSC study area, and a certified Regional Information Coordination Entity (RICE) encompassing coastal waters from the Canadian Maritime Provinces to the New York Bight. NERACOOS' mission is to produce, integrate, and communicate high quality information that helps ensure safety, economic and environmental resilience, and sustainable use of the coastal ocean. Since their founding in 2009, NERACOOS has worked with a wide range of partners to build an observing system for a community of users who depend on the ocean for their livelihoods and culture. For instance, NERACOOS provides weather and ocean data to fishers and commercial shippers determining if conditions are safe for passage and to emergency managers issuing storm warnings. NERACOOS is also advancing efforts to improve water quality monitoring, harmful algal bloom predictions and warnings, and coastal flooding and erosion forecasting systems.

The Mid-Atlantic Regional Association Coastal Ocean Observing System
The Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS) is the second IOOS regional association in the RWSC study area that spans from Cape Cod, MA to Cape Hatteras, NC. MARACOOS collects unique coastal and ocean data that is transformed into information products that support jobs, the economy, safety, and well-being for the more than 78 million people living, visiting, and working in the Mid-Atlantic region. Such data include real-time observing and forecasting assets, including high-frequency radar, underwater gliders, weather stations, satellite ground stations, and an ensemble of statistical and dynamical ocean forecast models. These data are publicly disseminated through numerous data portals such as the MARACOOS OceansMap, (Figure 11), the MARCO Portal, and NOAA's Center for Operational Oceanographic Products and Services.

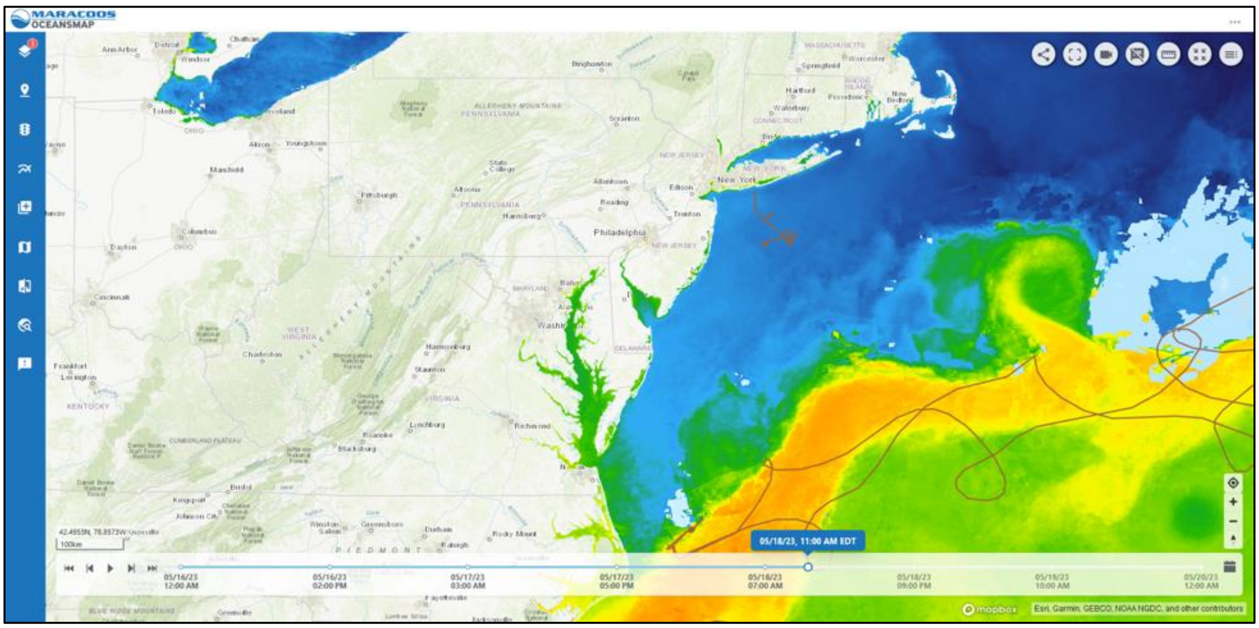

Figure 11. A screenshot of the Mid-Atlantic Regional Association Coastal Ocean Observing System's OceanMap data portal.

The Southeast Coastal Ocean Observing Regional Association
SECOORA, the Southeast Coastal Ocean Observing Regional Association, is the third IOOS regional association within the RWSC study area. SECOORA's footprint covers both the eastern Gulf of Mexico and the South Atlantic Bight, which are connected by the Loop Current-Florida Current-Gulf Stream continuum. SECOORA's observing system consists of buoys, biological sensors, water level stations, cameras, high-frequency radars, a glider observatory, models and other products. The data collected and provided by SECOORA is vital for weather forecasts, hurricane warnings, safe boating, marine life assessment, understanding climate variability, and more. Visitors can access, view, and download a suite of regional data products using SECOORA's Data Portal (Figure 12).

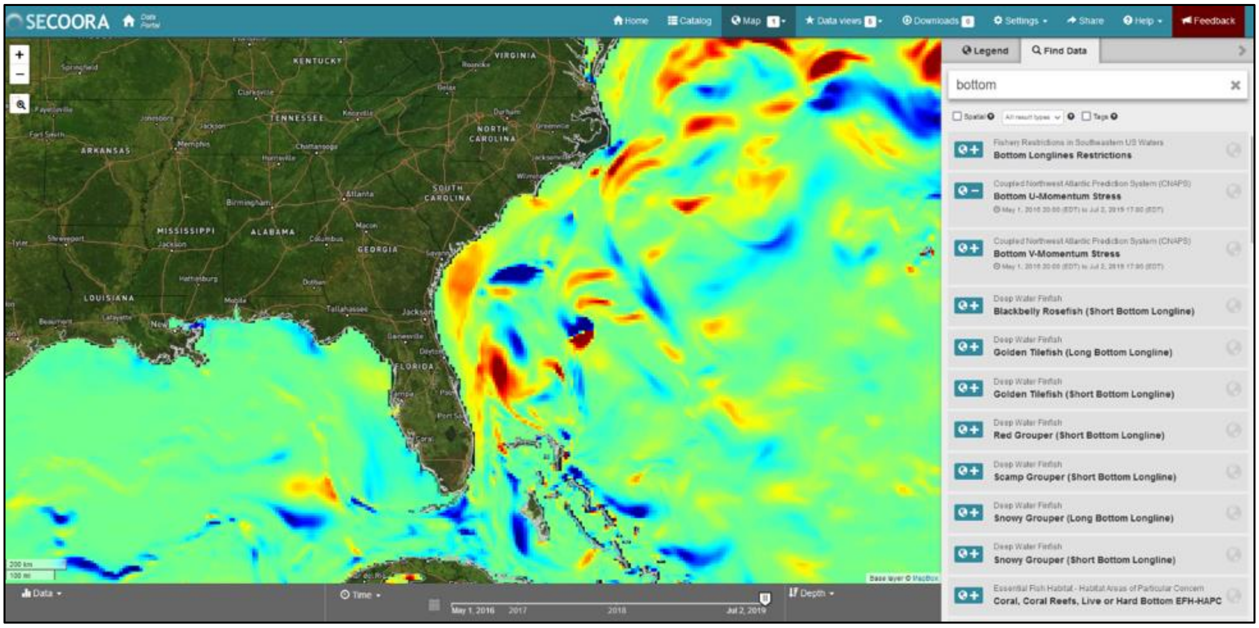

Figure 12. A screenshot of the Southeast Coastal Ocean Observing Regional Association's Data Portal.

1.4.5 NCEI Bathymetric Data Viewer

NOAA's National Centers for Environmental Information (NCEI) and the IHO Data Center for Digital Bathymetry (DCDB) archive and share depth data acquired by hydrographic, oceanographic, and industry vessels and platforms during surveys or while on passage. These data, which are used in several national and international mapping bathymetry projects, are free to the public with no restrictions via the NCEI Bathymetric Data Viewer (Figure 13). This interactive viewer allows for the identification of NOAA bathymetric data for both visualization and download. The viewer contains single-beam tracklines, multibeam surveys and mosaics for data visualization, the NOS hydrographic surveys, BAG footprints and shaded imagery, digital elevation models (DEMs), and coastal LiDAR datasets available. Despite the vast amount of publicly available seafloor mapping data, it should be noted that the NOAA-NCEI has strict submission guidelines which can potentially impact delivery of datasets online.

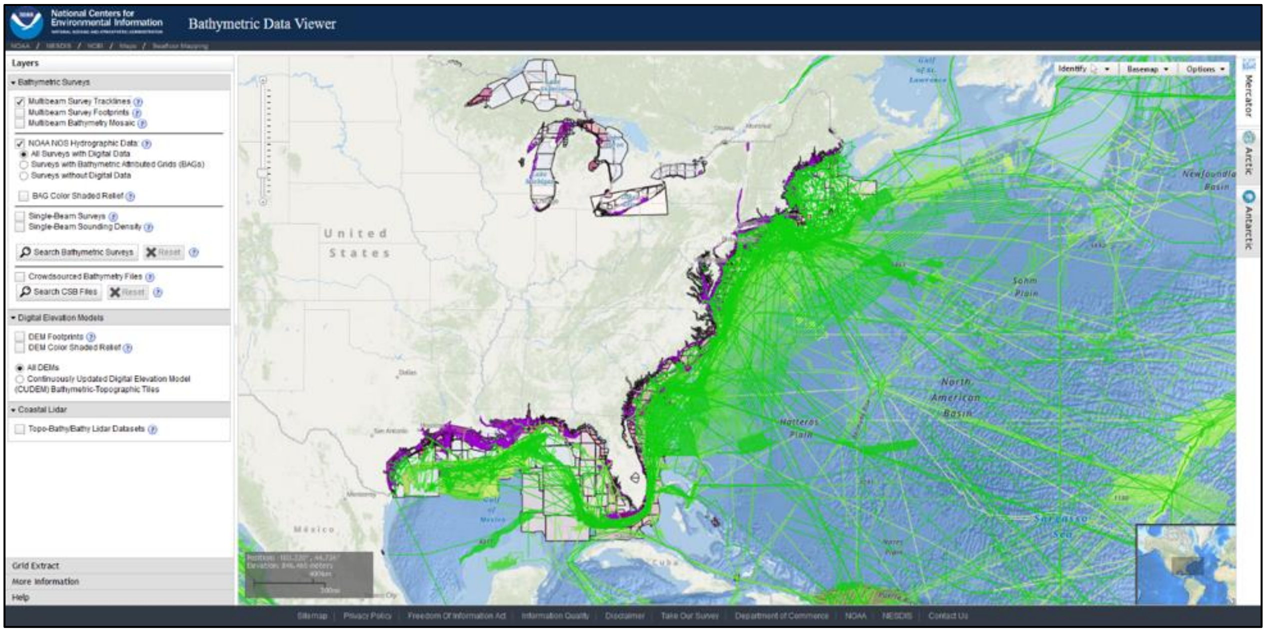

Figure 13. A screenshot of the Bathymetric Data Viewer, an online data portal and repository for bathymetric surveys hosted by NOAA's National Centers for Environmental Information (NCEI).

2 Research topics: Seafloor habitat and offshore wind in the U.S. Atlantic Ocean

For the purposes of this chapter, the Subcommittee organized research topics by RWSC Research Themes, which are used throughout this Plan by other Subcommittees. For each stated topic, there are potentially many detailed related questions, hypotheses, and potential approaches that could be used to address each. Presented research topics were synthesized from a regional literature and data search as well as the Atlantic Offshore Wind Environmental Research Recommendations, an online database created by the Regional Synthesis Workgroup that identifies data gaps and research needs from existing sources relevant to offshore wind energy development on the U.S. Atlantic coast. Given the potential number of studies to evaluate over the RWSC study area, the data search was restricted to seafloor-related studies and monitoring programs that were conducted in wind energy areas since 2010.

In subsequent sections, many of the detailed questions, hypotheses, and potential approaches that correspond to these Research Topics and Themes are described for regional-scale studies and for each subregion (Gulf of Maine; Southern New England; New York/New Jersey Bight; U.S. Central Atlantic; U.S. Southeastern Atlantic).

		RWSC Science Plan Actions	
RWSC Research Theme	**Research Topic**	**Field data collection methods and analysis**	**Other**
Mitigating negative impacts that are likely to occur and/or are severe in magnitude	Environmental sensitivity analysis to identify sensitive habitats and inform offshore wind siting, permitting, and future assessments.		Coordination and planning Historical data collection/compilation Meta-analysis and literature review Model development and statistical frameworks
	Construction techniques and technologies to limit detrimental effects to benthos during offshore wind construction.		Technology advancement
	Strategies to reduce the introduction and dispersal of non-native species from offshore wind development construction and operation activities.	Sediment grabs, seafloor imagery, tagging studies, water quality and oceanographic monitoring	Coordination and planning Technology advancement Model development and statistical frameworks
Detecting and quantifying changes to wildlife and habitats	Coordination among federal and state agencies, eNGOs, the research community, and members of industry to standardize methods and prioritize seafloor characterization activities in the U.S. Atlantic Ocean.		Coordination and planning Standardizing data collection, analysis, and reporting
	Standardized and long-term seafloor data collection across various oceanographic contexts and in the presence of offshore wind structures.	Seafloor geophysical - acoustic surveys, sediment grabs, seafloor imagery (I.e., SPI/PV sampling, video transects and imagery)	Coordination and planning Standardizing data collection, analysis, and reporting Technology advancement
	Consistent seafloor habitat maps that are reproducible at the regional scale and/or development of new habitat models and data products.		Coordination and planning Standardizing data collection, analysis, and reporting

		RWSC Science Plan Actions	
RWSC Research Theme	**Research Topic**	**Field data collection methods and analysis**	**Other**
			Model development and statistical framework Technology advancement
Understanding the environmental context around changes to wildlife and habitats	Consistent and long-term oceanographic habitat data collection for use in benthic habitat studies.	Water quality and oceanographic monitoring	Coordination and planning Standardizing data collection, analysis, and reporting Outreach and platforms to provide data products and results to stakeholders
	Alteration of hydrodynamics, stratification, and mixing that influence benthic habitats and larval settlement due to offshore wind structures.	Water quality and oceanographic monitoring	Coordination and planning
	Ambient noise level monitoring in the ocean for historic conditions, present day, and predicted future scenarios.	Passive acoustic monitoring	Coordination and planning Historical data collection/compilation
Determining causality for observed changes to wildlife and habitats	Physical and ecological effects to seafloor habitat and benthic communities related to construction activities.	**Lab-based:** Assess development and growth, behavior, survival. **Field-based:** Seafloor imagery, sediment grabs, enclosure and tagging studies, passive acoustic monitoring, water quality and oceanographic monitoring	Coordination and planning Meta-analysis and literature review Model development and statistical frameworks
	Physical and ecological effects to seafloor habitat and benthic communities related to operation and maintenance.	**Lab-based:** Assess development and growth, behavior, survival. **Field-based:** Seafloor imagery, sediment grabs, enclosure and tagging studies, passive acoustic monitoring, water quality	Coordination and planning Meta-analysis and literature review Model development and statistical frameworks

		RWSC Science Plan Actions	
RWSC Research Theme	**Research Topic**	**Field data collection methods and analysis**	**Other**
		and oceanographic monitoring	
	Introduction of new structures and conversion of habitat over short and longer time scales.	Seafloor geophysical – acoustic surveys, seafloor imagery, sediment grabs, water quality monitoring, tagging studies.	Coordination and planning Meta-analysis and literature review Model development and statistical frameworks
	Recovery and shifts following temporary and permanent disturbances related to offshore wind development.	Seafloor geophysical – acoustic surveys, sediment grabs, seafloor imagery, water quality and oceanographic monitoring	Coordination and planning Standardizing data collection, analysis, and reporting Meta-analysis and literature review Model development and statistical frameworks
Enhancing data sharing and access	Creation of an inventory of all ongoing data collection and research projects for seafloor habitat and offshore wind to encourage a coordinated approach to regional-scale analysis and planning future work.		Coordination and planning Standardizing data collection, analysis, and reporting Outreach and platforms to provide data products and results to stakeholders
	Coordination of data collection and synthesis of existing data at regional scale including baseline data, regular benthic monitoring data, and data collected at individual offshore wind project sites (e.g., pre- and post-construction).		Coordination and planning Standardizing data collection, analysis, and reporting
	Public availability of data, including those collected from Environmental Impact Assessments and post-construction monitoring, to aid in the assessment of broad-scale questions, ecosystem-level research, and potential cumulative impacts of offshore wind activities.		Coordination and planning Outreach and platforms to provide data products and results to stakeholders

3 Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind

3.1 Field data collection and analysis

The following activities include seafloor habitat observational data acquired in the field at the regional scale (i.e., consistently across the entire Atlantic coast in all RWSC Subregions), including any observations of location.

Note: Listed Science Plan activities below can cover numerous Research Themes when considered against all taxa-based topics. Given the focus of this chapter, Research Themes are therefore only included for seafloor habitat activities.

Recent, ongoing, and pending activities

Methods/Overview	Project	Lead and Partner Entities	Time period	Research Theme
A full, vessel-based environmental analysis, including estimates of air emissions, sound produced by the activities, sea floor disturbance by cabling, and potential discharges from vessels, etc.	Real-time Opportunity for Development Environmental Observations (RODEO) II	BOEM, HDR, CSA Ocean Sciences	2020 – 2024	**Detecting and quantifying changes to wildlife and habitats**

Recommendations

- Establish a collaborative and comprehensive monitoring framework to detect changes to seafloor habitat over time and in the presence of offshore wind infrastructure, specifically:
    - Determine adequate timelines for repeated sampling and, if necessary, adaptive sampling for more acute stressors (e.g., major storms on sediment and scour protection).
    - Identify necessary spatial coverage within and outside offshore wind areas to detect change and preemptively assess other areas of potential interest.
    - Evaluate the viability of opportunistic data collection activities where construction and operation vessels collect geophysical data during scheduled routines to identify precursors or anomalies.
    - Coordinate with the Habitat & Ecosystem Subcommittee – Oceanography Group to monitor benthic community function and other relevant metrics over a

vertical gradient from water column to seafloor habitats, including on monopiles and other structures.

- Require that federal and state agencies, eNGOs, researchers, and offshore wind developers collect seafloor habitat data following standard data collection and field methods established by Subcommittee to ensure consistent data types for use in large-scale geospatial analyses and reviews.

3.2 Coordination and planning

The following activities include the active coordination and planning that occurs through RWSC via the Habitat & Ecosystem Subcommittee as well as other regional-scale efforts (e.g., led by federal agencies) around seafloor habitat.

Although not consistently occurring across the RWSC study area, coordination and planning activities at the state subregion level can be applied at larger regional scales.

Recent, ongoing, and pending activities

RWSC Habitat & Ecosystem Subcommittee: The Habitat & Ecosystem Subcommittee will maintain situational awareness of seafloor habitat data collection and research in the U.S. Atlantic Ocean by coordinating with the entities and groups described in this Science Plan. The Subcommittee will meet regularly to share information and track Science Plan progress.

The National Ocean Mapping, Exploration, and Characterization Council (NOMEC): The National Ocean Mapping, Exploration, and Characterization Council was formed in June 2020 to coordinate agency policy and actions needed to advance ocean mapping, exploration, and characterization, and to support collaboration with non-governmental partners and stakeholders as well as government-to-government collaborations with Tribal Nations. The Council works to develop and implement multi-disciplinary, collaborative, and coordinated approaches to mapping, exploring, and characterizing the United States EEZ. The Council reports to the Ocean Science and Technology Subcommittee, which provides support and guidance for the Council's work as appropriate. The Ocean Policy Committee also provides strategic direction and facilitates interagency resolution of policy issues as appropriate.

The NOMEC Council includes eleven federal agencies and departments and oversees activities of two interagency working groups (IWG), specifically:

- **IWG Ocean and Costal Mapping (IWG-OCM)** - The IWG-OCM was established in 2006 to facilitate the coordination of ocean and coastal mapping activities and avoid duplicating mapping activities across the Federal sector as well as with State, private sector, academic, and non-governmental mapping interests. (SeaSketch: https://legacy.seasketch.org/#projecthomepage/5272840f6ec5f42d210016e4/about)
- **IWG Ocean Exploration and Characterization (IWG-OEC)** - The IWG-OEC was created in 2020 and, with oversight from the NOMEC Council, will recommend and facilitate exploration and characterization efforts that provide needed information and insights about deep-water (>40 m) environments, including the seafloor, sub-bottom, and water

column, from exploratory initial assessments to comprehensive characterization in direct support of specific research, resource management/stewardship, policymaking, or other mission objectives

BOEM's Environmental Studies Program: BOEM's Environmental Studies Program (ESP) develops, funds, and manages rigorous scientific research specifically to inform policy decisions on the development of energy and mineral resources on the Outer Continental Shelf (OCS). Mandated by Section 20 of the Outer Continental Shelf Lands Act, the ESP is an indispensable requirement informing how BOEM manages offshore oil and gas, offshore renewable energy, and the marine minerals program for coastal restoration. The ESP has provided over $1 billion for research since its inception in 1973. Research covers physical oceanography, atmospheric sciences, biology, protected species, social sciences and economics, submerged cultural resources, environmental fates and effects, oil spills, and more.

Atlantic Seafloor Partnership for Integrated Research and Exploration (ASPIRE): The Atlantic Seafloor Partnership for Integrated Research and Exploration, or ASPIRE, is a major multi-year, multi-national collaborative ocean exploration field program focused on raising collective knowledge and understanding of the North Atlantic Ocean. The campaign will provide data to inform and support research planning and management decisions in the region. NOAA's ASPIRE campaign will broaden both the geographic focus to include more of the U.S. Atlantic and the high seas and the scope of partnerships to include federal agencies, such as the Bureau of Ocean Energy Management and the U.S. Geological Survey, as well as international partners from the European Union and Canada. Initial ASPIRE fieldwork was conducted in 2016 and 2017, and NOAA Ship *Okeanos Explorer* will join partners in operating in the region again from 2018 to 2022.

The Northeast Regional Ocean Council: Formed in 2005, the Northeast Regional Ocean Council (NROC) is a state and federal partnership that facilitates the New England states, federal agencies, regional organizations, and other interested regional groups in addressing ocean and coastal issues that benefit from a regional response. NROC facilitates the development of coordinated and collaborative responses to coastal and ocean management issues that benefit from regional solutions. NROC conducts most of its work through three Committees focused on advancing regional priorities, including:

- **The Ocean Planning Committee:** The Ocean Planning Committee (OPC) was established to inform and recommend to the Council how best to approach regional issues and coordinate activities related to ocean planning in New England. The OPC works on regional efforts to improve the coordinated management of commercial and recreational uses of the ocean. The Committee's activities focus on engaging stakeholders and the user community, providing data and tools for ocean planning, and identifying approaches for developing and implementing a regional ocean plan.
- **The Ocean and Costal Ecosystem Health Committee:** The Ocean and Coastal Ecosystem Health Committee (OCEH) was established to help identify and coordinate regional activities to preserve and restore ecosystem health in New England. The OCEH is working to ensure that the importance of ocean and coastal ecosystem health is recognized as critical to the long-term sustainability of our region and that all levels of

government have access to and utilize comprehensive information to manage ocean and coastal resources.

The Mid-Atlantic Regional Council on the Ocean: In 2008 the Coastal Zone Management Programs of New York, New Jersey, Delaware, Maryland and Virginia began discussing the need for a regional approach to managing the Mid-Atlantic's ocean resources and uses. After developing a white paper and crafting an agreement to work together, in June 2009, the governors of these five states signed a *Mid-Atlantic Regional Ocean Conservation Agreement* and created the Mid-Atlantic Regional Council on the Ocean (MARCO). MARCO and MACO collaborate with governmental agencies, tribal nations and many other interested stakeholders through a series of specially focused work groups.

North Atlantic Regional Team (NART): NOAA's North Atlantic Regional Collaboration Team currently focuses on two topical areas: Climate & Watersheds and Coastal & Ocean Uses. This includes NOAA collaboration on habitat restoration, working waterfronts, offshore wind, and aquaculture, as well as climate and ecosystem monitoring and community resilience. Engagement and a functional focus on diversity, equity and inclusion round out our current priorities. The NART works towards a singular goal: that North Atlantic communities are healthier and more resilient to a changing environment as a result of our work. The team shares local and regional knowledge; solicits/gathers stakeholder needs; provides support for place-based efforts (e.g. NOAA Habitat Focus Areas); matches partners with NOAA funding sources/grant opportunities and NOAA technical assistance; and ensures NOAA tools are available, integrated and consistent.

Southeast and Caribbean Regional Team (SEACART): To improve NOAA's responsiveness to challenges and priorities of this region, the NOAA Southeast and Caribbean Regional Team (SECART) fosters stronger collaborative ties internally and with partners and constituents; works with constituents to evaluate and improve NOAA products and services; and promotes awareness and understanding of NOAA's regional capabilities, services, and priorities. SECART is one of eight teams in NOAA's Regional Collaboration Network. Team members reflect the capabilities of NOAA within the Southeast and U.S. Caribbean and include NOAA employees and NOAA partners.

Maine Offshore Wind Research Consortium: In 2021, the governor and legislature in Maine established the Maine Offshore Wind Research Consortium to better understand the local and regional impacts of floating offshore wind power projects in the Gulf of Maine. The statute directs the Governor's Energy Office (GEO) to serve as the coordinating agency and outlines an Advisory Board with representation from fisheries interests, and the Department of Marine Resources (DMR) and including other state agencies and stakeholders. The Advisory Board is responsible for establishing a research strategy that at a minimum includes the following themes: Opportunities and challenges caused by the deployment of floating offshore wind projects to the existing uses of the Gulf of Maine; Methods to avoid and minimize the impact of floating offshore wind projects on ecosystems and existing uses of the Gulf of Maine; and ways to realize cost efficiencies in the commercialization of floating offshore wind projects. The Maine Offshore Wind Consortium will collaborate closely with other states and regional and national science and research partners, including the National Offshore Wind Research and

Development Consortium, and the Regional Wildlife Science Collaborative, of which the Governor's Energy Office is a member.

Massachusetts Habitat Working Group on Offshore Wind Energy: To augment the BOEM Intergovernmental Task Force process and engage directly with key stakeholders, the Executive Office of Energy and Environmental Affairs and the Massachusetts Clean Energy Center (CEC) convenes two working groups for marine habitat and fisheries issues. While the working groups are voluntary and informal, they provide a critically important forum for maintaining a dialogue with key stakeholders, getting their feedback and guidance, and identifying issues and concerns. Input from the working groups has directly resulted in accommodations to avoid important marine habitat, fishing grounds, and marine commerce routes in the designation of the wind energy lease areas. The working groups will continue to provide valuable advice as leaseholders proceed through the next phases of the BOEM wind energy commercial leasing process, including site assessments, environmental and technical reviews, and development of construction and operations plans. The Habitat Working Group on Offshore Wind Energy is comprised of scientists and technical experts from environmental organizations, academia, and state and federal agencies.

The Massachusetts Office of Coastal Zone Management's Seafloor and Habitat Mapping Program: CZM collects data and develops maps showing the distribution and diversity of seafloor habitats. Among other applications, this information is used by resource managers and project proponents to help avoid or minimize impacts when siting projects in Massachusetts ocean waters. Major components of CZM's Seafloor and Habitat Mapping Program include sediment mapping, geoform mapping, biological mapping, and water column mapping. In 2003, CZM also initiated a Seafloor Mapping Cooperative with the USGS Woods Hole Science Center to jointly address the need for data and information characterizing seafloor resources. The goal of the cooperative is to comprehensively map the bathymetry (water depth) and geology of the seafloor inside the 3-nautical-mile limit of Massachusetts waters and in adjacent federal waters. As of 2012, the cooperative has mapped 2,200 square kilometers of Massachusetts marine waters and has published or is preparing to release these data as USGS Open-File Reports and Data Releases.

The Long Island Sound Habitat Mapping Initiative: The Long Island Sound Habitat Mapping Initiative is a federal, state and academic partnership that is applying some of the most advanced technologies available today to develop data and map products to guide decisions to better manage the Sound. Funded by the Long Island Sound Cable Fund and administered by the Long Island Sound Study the initiative is in the second of three phases focusing on areas selected by managers and scientists as high priority areas for habitat mapping. This web site provides information on the background and motivation for the mapping initiative, updates on the field activities conducted to date, interpretive story maps describing some of the results to date and multimedia links to images and video of the beauty and complexity of Sound.

NYSERDA Environmental Technical Working Group: The 2018 Offshore Wind Master Plan for New York included the development of collaborative, science-focused Technical Working Groups to advise the State about offshore wind energy development. As defined in the Plan, the Environmental Technical Working Group (E-TWG) advises the State about "measures to avoid, minimize, and mitigate anticipated impacts on wildlife during offshore wind energy development activities," including: Development of wildlife best management practices; Identification of research needs and coordination; Multi-agency coordination for adaptive management; Creation of a framework for an environmental conservation fund. The E-TWG meets up to four times annually. New York State Energy Research and Development Authority (NYSERDA) and other state agencies provide the E-TWG with oversight and direction, and use group recommendations and discussions to inform decision making.

New Jersey Research & Monitoring Initiative: The Research and Monitoring Initiative (RMI) addresses the need for regional research and monitoring of marine and coastal resources during offshore wind development, construction, operation and decommissioning as recommended in the New Jersey Offshore Wind Strategic Plan. Initial funding is provided by developers through New Jersey's Offshore Wind Solicitation 2. The RMI is administered by the NJ Department of Environmental Protection in collaboration with the NJ Board of Public Utilities. The goal of the RMI is ensure that New Jersey adheres to the mandate to protect and responsibly manage its coastal and marine resources as it moves towards a clean energy economy.

Recommendations

- Coordinate with the U.S. Interagency Working Group on Ocean and Coastal Mapping, National Ocean Mapping, Exploration, and Characterization (NOMEC) Council, the NROC Habitat Classification and Ocean Mapping Subcommittee, and others to understand ongoing and pending seafloor/habitat mapping activities at the state and regional level and facilitate collaborative opportunities.
- Work with Habitat & Ecosystem Subcommittee – Seafloor Group to determine what types of changes to the seafloor habitat are ecologically meaningful and develop standard to assess these changes.
- Use the Subcommittee as a forum to:
    - Periodically re-evaluate and standardize metrics and field methods to ensure collected data are suitable for regional needs.
    - Develop best practices for optimizing study designs and to inform data collection efforts to ensure compatibility with regional statistical analyses and research questions.
- Promote public availability of seafloor mapping and benthic habitat data from state, subregion, and regional efforts on data portals to assist the NOMEC Council with prioritizing seafloor characterization activities in the U.S. Atlantic Ocean.
- Coordinate with the Responsible Offshore Science Alliance (ROSA) to assess whether offshore wind infrastructure provides recruitment, spawning, and/or nursery habitat for fish species to guide data collection efforts and advancements.

3.3 Standardizing data collection, analysis, and reporting

This section identifies existing best practices and/or guidance for standardizing data collection, analysis, and reporting, and lists existing and ongoing work to address these issues.

Recent, ongoing, and pending activities

Project	Lead and Partner Entities	Time period	Research Theme
IWG-OCM Standard Ocean Mapping Protocol	NOAA, USGS	2023	**Enhancing data sharing and access**
Coastal & Marine Ecological Classification Standard (CMECS)	FGDC, NOAA, NatureServe, EPA, USGS	2012 – ongoing	**Enhancing data sharing and access**
Essential Fish Habitat Assessment and Consultation	NOAA		**Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**
Standard Approaches to Synthesizing, Visualizing, and Disseminating High-Resolution Geophysical Data to Advance Benthic Habitat Mapping in the Wind Energy Areas of the Northeast	INSPIRE Environmental, NROC	2020 – 2022	**Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**

Recommendations

- Work with Habitat & Ecosystem Subcommittee – Seafloor Group to determine what types of changes to the seafloor habitat are ecologically meaningful and develop standard to assess these changes.
- Use the Subcommittee as a forum to:
    - Periodically re-evaluate and standardize metrics and field methods to ensure collected data are suitable for regional needs.
    - Develop best practices for optimizing study designs and to inform data collection efforts to ensure compatibility with regional statistical analyses and research questions.
- When possible, apply standardized classification frameworks like the Coastal and Marine Ecological Classification Standard when describing and categorizing marine seafloor habitats based on geoform, substrate, and biotic components to maximize the use of datasets on larger scales.
- Require that seafloor habitat data, including geophysical and ground-truth sediment data, are shared to regulatory agencies and end users via standardized methods and data formats to maximize use in coordination and planning activities as well as regional-scale analyses. For more information and guidance on standard formats, refer to INSPIRE Environmental and the Northeast Regional Ocean Council's project entitled "Standard Approaches to Synthesizing, Visualizing, and Disseminating High-Resolution

Geophysical Data to Advance Benthic Habitat Mapping in the Wind Energy Areas of the Northeast".
- Obtain input from members of the research community on what variables and methods are suitable for incorporating field data into predictive models, such as species distribution models, primary productivity, trophic dynamics, etc.

3.4 Historical data collection/compilation

The following activities encompass the need to add existing data to modern databases so that historical data can be used in long-term/time-series analyses and studies.

Recent, ongoing, and pending activities

Project	Lead and Partner Entities	Time period	Research Theme
usSEABED	USGS, University of Colorado		**Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**
NGDC Seafloor Sediment Grain Size Database	NOAA NCEI	1976 – 2000	**Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**

Recommendations

- Work with the USGS-University of Colorado usSEABED and NOAA NCEI Seafloor Sediment Grain Size Databases to facilitate opportunities for increasing the frequency at which data are incorporated for use by other end users.
- Coordinate with the USGS-University of Colorado usSEABED project to develop additional functionality for receiving, hosting, and sharing information on seafloor characteristics, including industry members, for use in regional-scale benthic habitat modeling.
- Compile existing knowledge for generating hypotheses to further assess the effects of offshore wind construction and operation and maintenance activities, specifically noise and vibration, EMF, heat generation, etc., on seafloor habitat and benthic community function.

3.5 Study optimization

This section describes work to implement statistical frameworks and analyses to determine optimal study designs given a set of data conditions and research goals.

Recent, ongoing, and pending activities

No recent, ongoing, or pending study optimization activities were identified along the RWSC study area in the U.S. Atlantic Ocean.

Recommendations

- Use the Subcommittee as a forum to:
    - Periodically re-evaluate and standardize metrics and field methods to ensure collected data are suitable for regional needs.
    - Develop best practices for optimizing study designs and to inform data collection efforts to ensure compatibility with regional statistical analyses and research questions.
- Coordinate with the research community on necessary experimental designs, variables, and sample size to identify relationships between observed stressors and benthic communities.

3.6 Model development and statistical frameworks

The following activities include the development and maintenance of species distribution models, habitat suitability models, risk assessment frameworks, Population Consequences of Disturbance (PCoD) models, cumulative impact assessments, etc.

Recent, ongoing, and pending activities

No recent, ongoing, or pending model development and statistical framework activities were identified along the RWSC study area in the U.S. Atlantic Ocean.

Recommendations

- Use experts within the RWSC Habitat & Ecosystem Subcommittee to guide the development of desktop-based environmental sensitivity analyses, specifically maps and analyses that identify sensitive seafloor habitats to inform offshore wind siting, permitting, and future assessments.
- Generate a region-wide habitat model for use by other taxa-based Subcommittees and research questions.
    - Apply more advanced modeling techniques to predict CMECS substrate occurrence i.e., NROC/INSPIRE regional seafloor modeling, NCCOS' Enhancing Habitat Mapping Accuracy and Efficiency Using Artificial Intelligence.
    - Continue to update habitat modeling products with new geophysical and ground-truth data every 3-5 years or as is practical.
- Periodically validate and evaluate the performance of models and statistical frameworks. Use validation and evaluation results to inform and advance model/framework development and application.

3.7 Technology advancement

The following activities include the development and testing of new field research tools/methods or mitigation options; can also include development of and improvements to data systems.

Recent, ongoing, and pending activities

Project	Lead and Partner Entities	Time period	Research Theme
Sediments and the Sea Floor of the Continental Shelves and Coastal Waters of the United States—About the usSEABED Integrated Sea-Floor-Characterization Database, Built With the dbSEABED Processing System	USGS, University of Colorado Boulder	2005 – 2020	**Detecting and quantifying changes to wildlife and habitats**

Recommendations

- Coordinate with the research community and offshore wind developers to develop new and advance existing technologies and designs that limit detrimental effects to the benthos and prevent the introduction and dispersal of non-native species.
- Reduce and provide estimates of uncertainty associated with dbSEABED software parser for end users.
- Advance, evaluate, and apply new technologies and techniques to better map the seafloor and collect ground-truth data (i.e., sediment grabs and images) for habitat mapping analyses, i.e., NCCOS' Enhancing Habitat Mapping Accuracy and Efficiency Using Artificial Intelligence.
- Advance, evaluate, and apply new technologies and techniques to better map the seafloor and collect ground-truth data (i.e., sediment grabs and images) for habitat mapping analyses, i.e., review recent advances from University of New Hampshire's Center for Coastal and Ocean Mapping Joint Hydrographic Center

3.8 Meta-analyses and literature review

This section describes existing projects and recommendations to compile research priorities, impacts literature, and/or life history parameters, as well as to conduct assessments of data availability to inform models.

Recent, ongoing, and pending activities

Project	Lead and Partner Entities	Time period	Research Theme
Atlantic Offshore Wind Environmental Research Recommendations Database	NYSERDA, BRI, PNNL, NREL, DOE	2021–ongoing	**Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**
Benthos Workgroup Report - State of the Science Workshop on Wildlife and Offshore Wind Energy 2020: Cumulative Impacts	NYSERDA, SAMS, University of St. Andrews, BRI, The Nature Conservancy	2020 – 2021	**Detecting and quantifying changes to wildlife and habitats** **Enhancing data sharing and access**

Recommendations

- Continue to update meta-analysis and literature reviews at a region-wide scale as new information becomes available.

3.9 Outreach and platforms to provide data products and results to stakeholders

This category of activities includes the work that RWSC and others do to summarize and convey findings and results to stakeholders and decision-makers, including through regional data portals and other web-based platforms that display interpretive maps with exploratory tools and links to the underlying data as appropriate.

Recent, ongoing, and pending activities

Project	Lead and Partner Entities	Time period	Research Theme
Regional Ocean Data Portals – e.g., Seafloor theme data • Northeast Ocean Data Portal • Mid-Atlantic Ocean Data Portal	Northeast Regional Ocean Council (NROC), Mid-Atlantic Regional Council on the Ocean (MARCO)	2009 – ongoing	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats** **Enhancing data sharing and access**
IOOS Regional Association Portals: • NERACOOS • MARACOOS (OceansMap) • SECOORA	The U.S. Integrated Ocean Observing System (IOOS)		**Enhancing data sharing and access**
NCEI Bathymetry Data Viewer in collaboration with the IHO Data Centre for Digital Bathymetry)	NOAA, IHO	2023	**Enhancing data sharing and access**
Environmental Studies Program Hub	BOEM		**Enhancing data sharing and access**
usSEABED	USGS		**Enhancing data sharing and access**
Marine Cadastre National Viewer	NOAA, BOEM		**Enhancing data sharing and access**
Support for Regional Wildlife Science Collaborative Ocean Portal Products and Services	BOEM	2023 - 2024	**Enhancing data sharing and access**

Recommendations

- Develop seafloor/habitat data products that reflect the results of data collection and research activities throughout the RWSC study area and encourage or require projects to include funding for data product development, hosting, and maintenance/updates in their budgets. Data could be hosted and maintained by individual providers but should be shared in formats compatible with existing platforms described above.

- Continue to lead or participate in the coordination and planning of ongoing and pending activities, using the RWSC Habitat & Ecosystem Subcommittee as a forum for information exchange and coordination among federal and state agencies, eNGOs, the research community, and members of industry.
- Facilitate pooling of data to obtain statistical power and spatial extent to examine regional-scale effects.
- Ensure that existing data repositories for seafloor habitat data have resources and personnel to integrate and provide access to offshore wind and wildlife monitoring datasets as they are collected. Include a minimum budget threshold that must be allocated to data management and access in all project budgets (e.g., 20%).
- Require that federal and state agencies, eNGOs, researchers, and offshore wind developers abide by established data collection and reporting standards established by Subcommittee to ensure consistent geophysical and sediment data collection to facilitate data sharing and for incorporation into data portals as well as regional-scale analyses and reviews.

4 Gulf of Maine ongoing, pending, and recommended research and data collection activities for seafloor habitat and offshore wind

4.1 Field data collection and analysis

Recent, ongoing, and pending activities

Methods/Overview	Project	Lead and Partner Entities	Time period	Research Theme
Vessel-based surveys including seafloor acoustics (i.e., MBES), seafloor imagery, and seafloor grabs to support management decisions and informed ocean planning	Maine Coastal Program's Mapping Initiative	Maine DMR	Ongoing	**Detecting and quantifying changes to wildlife and habitats** **Mitigating negative impacts that are likely to occur and/or are severe in magnitude**
Vessel-based surveys including seafloor geophysical – acoustics (MBES bathymetry and backscatter, SSS), seafloor imagery, and seafloor grabs in Massachusetts waters (3-nm)	Massachusetts Office of Coastal Zone Management Seafloor and Habitat Mapping Program	Massachusetts CZM	Ongoing	**Detecting and quantifying changes to wildlife and habitats** **Mitigating negative impacts that are likely to occur and/or are severe in magnitude**
Vessel-based surveys to include seafloor acoustics – geophysical, seafloor imagery (e.g., video, still images, SPI/PV), and potentially seafloor grabs	Gulf of Maine Fish and Invertebrate Benthic Habitat Baseline Data Collection	BOEM	2023 – 2026	**Detecting and quantifying changes to wildlife and habitats**
Oceanographic sensors on mobile and fixed fishing gear; primary focus of collecting bottom temperatures for ocean models and stock assessments. Have conducted trials with tide gauges, acoustic listening devices, cameras, GPS drifters, current meters, and salinity monitors.	Environmental Monitors on Lobster Traps and Large Trawlers (eMOLT)	Local fishers, Gulf of Maine Lobster Foundation, Nova Scotia Fishermen Scientists Research Society, Commercial Fisheries Research Foundation	2001 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based survey including nets and tows as well as water quality and oceanography techniques.	Northern Shrimp Survey	NOAA NEFSC	1983 – ongoing	**Understanding the environmental context around**

				changes to wildlife and habitats
Vessel-based surveys including net tows; biomass, length and age structures, and diet compositions of finfishes and select invertebrates, water quality, weather condition	Northeast Area Monitoring and Assessment Program (NEAMAP)	Atlantic States Marine Fisheries Commission, Maine Department of Marine Resources, Massachusetts Division of Marine Fisheries, Virginia Institute of Marine Science, the U.S. Fish and Wildlife Service, NOAA NEFSC, NE Fishery Management Council, Mid-Atlantic Fishery Management Council, FWS, Potomac River Fisheries Commission	2006 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys with nets and tows, data loggers; Bottom trawl samples fish and selected invertebrate species at random stations to delineate various life history characteristics and geographic distribution. Associated oceanographic and meteorological data include salinity, conductivity, temperature at all stations.	Fall Bottom Trawl Survey	NOAA NEFSC	1963 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys including seafloor acoustics, ROV/AUV deploys for seafloor imagery and grabs will delineate substrate types and document the distribution of hard bottom areas.	Deep SEARCH: Deep Sea Exploration and Research of Coral/Canyon/Seep Habitats	BOEM, USGS, NOAA OER, Temple University	2017 – 2022	**Detecting and quantifying changes to wildlife and habitats**
Vessel-based surveys including CTD rosette, net tows, gliders; physical samples include water samples (temperature,	Northeast U.S. Shelf (NES) Long-Term Ecological	Wellesley College, NSF, University of Maryland,	2017 – ongoing	**Understanding the environmental context around**

conductivity, nutrients, chlorophyll), filters, plankton net samples, and fish specimens	Monitoring Research (LTER)	University of Rhode Island		**changes to wildlife and habitats**
Ocean modeling, telemetry, glider observations, buoys, water sampling	Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)	U.S. IOOS, UMaine, Bedford Institute of Oceanography, USGS, Gulf of Maine Research Institute, UNH, Charybdis Group LLC, Woods Hole Group, WHOI, UMass-Dartmouth, UConn, URI, MCCF, Passamaquoddy Pleasant Point	Ongoing	**Understanding the environmental context around changes to wildlife and habitats**

Recommendations

See Section 3 - Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind for recommendations related to field data collection activities.

4.2 Other Science Plan Actions

Recent, ongoing, and pending activities

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Model development and statistical frameworks	Northeastern U.S. Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England and Long Island.	UNH CCOM/JHC	2016 – 2021	**Detecting and quantifying changes to wildlife and habitats**
Model development and statistical frameworks	Northwest Atlantic Marine Ecoregional Assessment (NAM ERA)	The Nature Conservancy	2009 – 2021	**Detecting and quantifying changes to wildlife and habitats**
Outreach and platforms to provide data products and results to stakeholders	Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)	U.S. IOOS, UMaine, Bedford Institute of Oceanography, USGS, Gulf of Maine Research Institute,		**Understanding the environmental context around**

		UNH, Charybdis Group LLC, Woods Hole Group, WHOI, UMass-Dartmouth, UConn, URI, MCCF, Passamaquoddy Pleasant Point		**changes to wildlife and habitats** **Enhancing data sharing and access**
Outreach and platforms to provide data products and results to stakeholders	Northeast Ocean Data Portal	Northeast Regional Ocean Council, NOAA, RPS, The Nature Conservancy, Waterview Consulting		**Enhancing data sharing and access**

Recommendations

- Conduct an environmental sensitivity analysis with existing geophysical and benthic habitat information to identify sensitive habitats in areas where renewable wind energy areas are being planned.
- Promote interagency coordination and planning activities to consistently map seafloor habitats over time and in areas where offshore wind infrastructure is anticipated.
- Coordinate with the University of New Hampshire Center for Coastal and Ocean Mapping Joint Hydrographic Center to test and evaluate new field technologies and mapping techniques for generating consistent benthic habitat mapping data products.

See Section 3 - Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind for additional recommendations related to non-field activities.

5 Southern New England ongoing, pending, and recommended research and data collection activities for seafloor habitat and offshore wind

5.1 Field data collection and analysis

Recent, ongoing, and pending activities

See below for a list of directed research and long-term monitoring programs:

Methods/Overview	Project	Lead and Partner Entities	Time period	Research Theme
Vessel-based surveys including seafloor geophysical – acoustics (MBES bathymetry and backscatter, SSS), seafloor imagery, and seafloor grabs in Massachusetts waters (3-nm)	Massachusetts Office of Coastal Zone Management Seafloor and Habitat Mapping Program	Massachusetts CZM	Ongoing	**Detecting and quantifying changes to wildlife and habitats** **Mitigating negative impacts that are likely to occur and/or are severe in magnitude**
Oceanographic sensors on mobile and fixed fishing gear; primary focus of collecting bottom temperatures for ocean models and stock assessments. Have conducted trials with tide gauges, acoustic listening devices, cameras, GPS drifters, current meters, and salinity monitors.	Environmental Monitors on Lobster Traps and Large Trawlers (eMOLT)	Local fishers, Gulf of Maine Lobster Foundation, Nova Scotia Fishermen Scientists Research Society, Commercial Fisheries Research Foundation	2001 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Slocum G3 glider; monitoring baleen whale presence, including North Atlantic right whale, and fish tagged with acoustic transmitters. Collected fluorescence, turbidity, temperature, salinity, pressure data.	Movement Patterns of Fish in Southern New England	NOAA NEFSC, BOEM funded; WHOI, MassDMF, TNC, UMass, NOAA-GARFO, Rutgers University	2019 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Profile moorings, surface moorings, profiling gliders, coastal gliders, AUVs to monitor oceanographic conditions and examine exchanges between shelf and slope ecosystems	Coastal Pioneer Array (New England)	OOI, NOAA, WHOI	2016 – 2022	**Understanding the environmental context around changes to wildlife and habitats**

Vessel-based surveys with CTD; Assess changes in oceanographic conditions, particularly temperature, in order to better understand how these changes may impact the distribution and abundance of key fisheries resources.	Shelf Research Fleet	Commercial Fisheries Research Foundation, WHOI	2014 – 2022	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys with temperature data logger; At-sea data collection is focused on 1) Retained and discarded lobsters, 2) Retained and discarded Jonah crabs, and 3) Bottom water temperature. All data is collected, stored, and viewed on Samsung Tab A tablets.	Supporting Management of the Emerging Jonah Crab Fishery and the Iconic Lobster Fishery in the Northeast USA	Commercial Fisheries Research Foundation	2013 – 2023	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys including net tows; biomass, length and age structures, and diet compositions of finfishes and select invertebrates, water quality, weather condition	Northeast Area Monitoring and Assessment Program (NEAMAP)	Atlantic States Marine Fisheries Commission, Maine Department of Marine Resources, Massachusetts Division of Marine Fisheries, Virginia Institute of Marine Science, the U.S. Fish and Wildlife Service, NOAA NEFSC, NE Fishery Management Council, Mid-Atlantic Fishery Management Council, FWS, Potomac River Fisheries Commission	2006 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys including net tows; Bottom trawl samples fish and selected invertebrate species at random stations to delineate various life history characteristics and geographic distribution.	Fall Bottom Trawl Survey	NOAA NEFSC	1963 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**

Associated oceanographic and meteorological data include salinity, conductivity, and temperature at all stations.				
Vessel-based surveys including seafloor acoustics, seafloor imagery, and seafloor grabs; characterizes the abiotic components, biotic components, and abiotic-biotic relations (between habitat and fauna) that will support ecosystem-level assessments and cumulative impact analyses for eight WEAs	Habitat Mapping and Assessment of Northeast Wind Energy Areas	BOEM, NOAA NEFSC, University of Massachusetts Dartmouth, WHOI,	2013 – 2017	**Detecting and quantifying changes to wildlife and habitats**
Vessel and diver-based surveys including seafloor acoustics, seafloor imagery, and seafloor grabs/scrapes; real-time measurements of the nature, intensity, and duration of stressors during OSW construction and operation. Resulting data can be used as inputs to analyses or models to predict future OSW effects.	Real-time Opportunity for Development Environmental Observations (RODEO)	HDR, Fugro, Subacoustech, University of Rhode Island, Marine Acoustics, Inc., WHOI	2016 – 2023	**Detecting and quantifying changes to wildlife and habitats**
Vessel-based surveys including CTD rosette, net tows, gliders; physical samples include water samples (temperature, conductivity, nutrients, chlorophyll), filters, plankton net samples, and fish specimens	Northeast U.S. Shelf (NES) Long-Term Ecological Monitoring Research (LTER)	Wellesley College, NSF, University of Maryland, University of Rhode Island	2017 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Ocean modeling, telemetry, glider observations, buoys, water sampling	Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)	U.S. IOOS, UMaine, Bedford Institute of Oceanography, USGS, Gulf of Maine Research Institute, UNH, Charybdis Group LLC, Woods Hole Group, WHOI, UMass-Dartmouth,	Ongoing	**Understanding the environmental context around changes to wildlife and habitats**

		UConn, URI, MCCF, Passamaquoddy Pleasant Point		

See below for a list of Benthic Habitat Characterization and Site Investigations available from Construction and Operating Plan for federal renewable energy development on the Outer Continental Shelf (OCS). Figure 14 presents an overview of BOEM Renewable Energy Lease Areas in the Southern New England subregion.

Project	Overview
Revolution Wind	Revolution Wind, LLC is an 880 MW commercial wind energy facility located in Renewable Energy Lease Number OCS-A 0486 (83,798 acres; 18 statute miles southeast of Point Judith, Rhode Island and 15 statue miles east of Block Island, Rhode Island). A COP was initially submitted on March 13, 2022. An updated COP was submitted on April 29, 2021 and then on July 21, 2021.
SouthCoast Wind	SouthCoast Wind, formerly Mayflower Wind Energy, LLC, proposes to develop the entire Renewable Energy Lease Area Number OCS-0521 as an offshore renewable energy project. The Lease Area encompasses 127,388 acres and located in federal waters off the southern coast of Massachusetts. The initial COP was submitted to BOEM during December 2022.
Vineyard Wind	Vineyard Wind, LLC proposed an 800 MW wind energy project in the northern portion of Lease Area OCS-A 0501 (approximately 166,686 acres) in federal waters off the coast of Massachusetts. Vineyard Wind initially submitted its COP in December 2017. BOEM approved the construction and operation of the Vineyard Wind 1 Offshore Wind Energy Project in May 2021.
New England Wind	Park City Wind, LLC is proposing to develop offshore renewable wind energy facilities in BOEM Renewable Energy Lease Area OCS-A 0534 and potentially a portion of Lease Area OCS-A 0501. The area is approximately 20 statue miles south of Martha's Vineyard and 24 statue miles southwest of Nantucket. A phased development COP was submitted to BOEM on July 2, 2020 and updates to the COP were provided during Fall 2021 and Spring 2022.
South Fork Wind	South Fork Wind, LLC, formerly Deepwater Wind, proposed a wind energy project in BOEM Renewable Energy Lease Area OCS-A 0517, approximately 19 miles southeast of Block Island, Rhode Island, and 35 miles east of Montauk Point, New York in federal waters. South Fork Wind, LLC initially submitted its COP on June 29, 2018 and provided updated COPs on May 24, 2019, February 13, 2020, July 22, 2023, and May 7, 2021. BOEM approved the COP for the South Fork Wind Farm and South Fork Export Cable Project on January 18, 2022.
Sunrise Wind	Sunrise Wind, LLC is proposing to construct, own, and operate an offshore wind farm in Renewable Energy Lease Area OCS-A 0487, which is located 18.9 statute miles south of Martha's Vineyard, Massachusetts,

	30.5 miles east of Montauk, New York (NY), and 16.7 mi (14.5 nm, 26.8 km) from Block Island, Rhode Island. Sunrise Wind, LLC submitted a COP on September 1, 2020 and provided an updated COP on August 18, 2022.
[Deepwater Wind Block Island]()	Deepwater Wind New England, LLC and Orsted North America proposed and developed a five-turbine wind farm off Block Island, Rhode Island in 2016 that delivers 30 MW to residents. Although the lease area is maintained by the state of Rhode Island, transmission cables occupy Renewable Energy Lease Area OCS-A 0506.

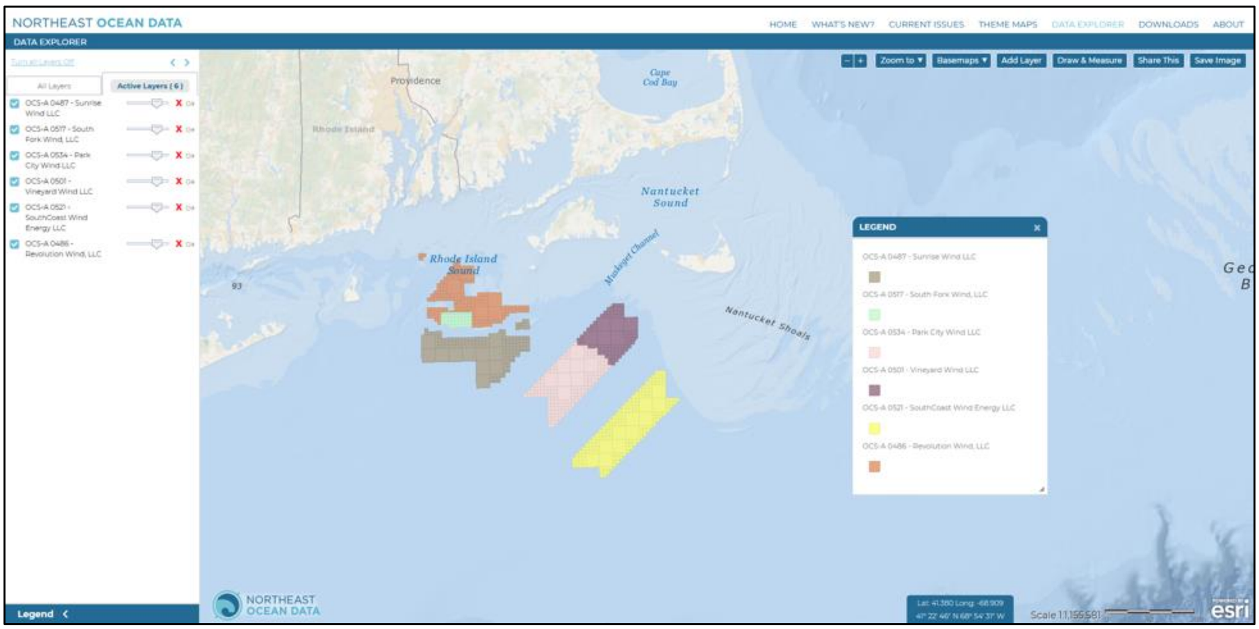

Figure 14. Location of six (of seven) BOEM Renewable Energy Lease Areas in the Southern New England subregion with publicly available COP information at the time of RWSC's data query. Deepwater Wind Block Island turbine locations and export cable are not displayed on the current map.

Recommendations

In brief, many of the field collection activities in the Southern New England region provide contextual information around seafloor habitat, specifically benthic-related oceanographic/water quality conditions such as temperature and salinity and basic depth information. *In-situ* seafloor mapping and benthic characterization activities are limited in comparison, primarily occurring up to a state's seaward limit (of 3 nautical miles) and areas either within or extending from active renewable energy lease areas. Unless stated otherwise, Massachusetts is the only state in the Southern New England region that has a dedicated state program to collect seafloor and benthic habitat information for wide dissemination. Other field activities related to collecting benthic information are primarily influenced by offshore wind energy development and therefore rarely extend beyond established wind lease area boundaries.

With respect to seafloor-related activities conducted by commercial wind energy developers, field collection activities are largely unknown and not consistent in terms of spatial coverage, applied methods, and sampled parameters. For instance, despite recent leasing activity of nearly a dozen areas off Southern New England, only six lease areas have publicly released Construction and Operation (COP) documents at the time of this chapter's development that detail seafloor mapping and habitat characterization activities. For wind leases areas with publicly available COP information, seafloor acoustic, imagery, and grab methods are not consistently applied, e.g., backscatter information were not collected/processed from multi-beam echosounder; sediment profile imaging (SPI) and plan view (PV) imaging were not used to ground-truth geophysical data in all wind areas. Additionally, available COP information indicated that benthic data were collected at varying scales to satisfy BOEM environmental regulations for offshore wind energy development. For example, although commercial developers collected data within the wind lease area and along proposed export cable paths to land, available COPs indicated geophysical surveys ranged in coverage from only areas with proposed wind turbine generator locations to the entire lease area and, in some cases, areas beyond the lease area's boundaries.

Despite its size and installation in state waters, it should be noted that a five-turbine wind farm was established in 2016 off the coast of Block Island, Rhode Island. In addition to providing roughly 30 MW of energy to island residents, it is the first wind farm in North America and serves as a valuable experimental site for understanding the effects of offshore wind energy development on seafloor habitats and benthic community function.

Recommendations include:

- Establish a collaborative and comprehensive monitoring framework to detect changes to seafloor habitat over time, including adequate timelines for repeated sampling, spatial coverage, and opportunistic sampling events from regularly occurring operations and maintenance trips.
- Require that federal and state agencies, eNGOs, researchers, and offshore wind developers collect seafloor habitat data following standard data collection and field methods established by Subcommittee to ensure consistent data types for use in large-scale geospatial analyses and reviews.
- Conduct comparative field studies with the research community and members of industry to evaluate new technologies that limit detrimental effects to benthos.
- Develop new and advance existing technologies and designs for offshore wind infrastructure that deter the proliferation of non-native species and enhance seafloor habitat data collection.
- Compile existing knowledge and generate hypotheses to further assess the effects of current construction and operation and maintenance activities (i.e., Deepwater Wind Block Island), including noise and vibration, EMF, and heat, on habitat conditions and benthic community function.

See Section 3 - Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind for additional recommendations related to field data collection activities.

5.2 Other Science Action Plans

Recent, ongoing, and pending activities

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Model development and statistical frameworks	Northeastern U.S. Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England and Long Island.	UNH CCOM/JHC	2016 – 2021	**Detecting and quantifying changes to wildlife and habitats**
Model development and statistical framework	Standard Approaches to Synthesizing, Visualizing, and Disseminating High-Resolution Geophysical Data to Advance Benthic Habitat Mapping in the Wind Energy Areas of the Northeast	NROC, INSPIRE Environmental	2020 – 2022	**Detecting and quantifying changes to wildlife and habitats**
Model development and statistical framework	Sediment-borne Wave Disturbances and Propagation and Potential Effects on Benthic Fauna	BOEM, University of Rhode Island	2022 – 2024	**Detecting and quantifying changes to wildlife and habitats**
Model development and statistical framework	Northwest Atlantic Marine Ecoregional Assessment (NAMERA)	The Nature Conservancy	2010 – ongoing	**Detecting and quantifying changes to wildlife and habitats**
Meta-analyses and literature review	New York Bight Fish, Fisheries, and Sand Features: Data Review	Rutgers University, BOEM	2020 – 2021	**Detecting and quantifying changes to wildlife and habitats**
Outreach and platforms to provide data products and results to stakeholders	Massachusetts Ocean Resource Information System (MORIS)	Massachusetts CZM	2022 – ongoing	**Enhancing data sharing and access**
Outreach and platforms to provide data products and results to stakeholders	Northeast Ocean Data Portal	Northeast Regional Ocean Council, NOAA, RPS, The Nature Conservancy, Waterview Consulting		**Enhancing data sharing and access**
Outreach and platforms to provide	Northeastern Regional Association of Coastal	University of Maine, Bedford Institute of		**Understanding the**

data products and results to stakeholders	[Ocean Observing Systems (NERACOOS)]	Oceanography, USGS, Gulf of Maine Research Institute, UNH, Charybdis Group LLC, Woods Hole Group, WHOI, UMass-Dartmouth, UConn, URI, IOOS		**environmental context around changes to wildlife and habitats** **Enhancing data sharing and access**

Recommendations

- Coordinate with the U.S. Interagency Working Group on Ocean and Coastal Mapping, National Ocean Mapping, Exploration, and Characterization (NOMEC) Council, the NROC Habitat Classification and Ocean Mapping Subcommittee, and others to understand ongoing and pending seafloor/habitat mapping activities at the state and regional level and facilitate collaborative opportunities.
- Work with Habitat & Ecosystem Subcommittee – Seafloor Group to determine what types of changes to the seafloor habitat are ecologically meaningful and develop standard to assess these changes.
- Use the Subcommittee as a forum to:
    - Periodically re-evaluate and standardize metrics and field methods to ensure collected data are suitable for regional needs.
    - Develop best practices for optimizing study designs and to inform data collection efforts to ensure compatibility with regional statistical analyses and research questions.
- Use experts within the RWSC Habitat & Ecosystem Subcommittee to guide the development of desktop-based environmental sensitivity analyses, specifically maps and analyses that identify sensitive seafloor habitats to inform offshore wind siting, permitting, and future assessments.
- Advance, evaluate, and apply new technologies and techniques to better map the seafloor and collect ground-truth data (i.e., sediment grabs and images) for habitat mapping analyses, i.e., NCCOS' Enhancing Habitat Mapping Accuracy and Efficiency Using Artificial Intelligence.
- Generate a region-wide habitat model for use by other taxa-based Subcommittees and research questions.
    - Apply more advanced modeling techniques to predict CMECS substrate occurrence i.e., NROC/INSPIRE regional seafloor modeling, NCCOS' Enhancing Habitat Mapping Accuracy and Efficiency Using Artificial Intelligence.
    - Continue to update habitat modeling products with new geophysical and ground-truth data every 3-5 years or as is practical.
- Develop seafloor/habitat data products that reflect the results of data collection and research activities throughout the RWSC study area and encourage or require projects to include funding for data product development, hosting, and maintenance/updates in

their budgets. Data could be hosted and maintained by individual providers but should be shared in formats compatible with existing platforms described above.

- Require that federal and state agencies, eNGOs, researchers, and offshore wind developers follow data collection and reporting standards established by Subcommittee to ensure consistent geophysical and sediment data collection to facilitate data sharing and for incorporation into data portals as well as regional-scale analyses and reviews.

See Section 3 - Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind for additional recommendations related to non-field activities.

6 New York/New Jersey Bight ongoing, pending, and recommended research and data collection activities for seafloor habitat and offshore wind

6.1 Field data collection and analysis

Recent, ongoing, and pending activities

See below for a list of directed research and long-term monitoring programs:

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Oceanographic sensors on mobile and fixed fishing gear; primary focus of collecting bottom temperatures for ocean models and stock assessments. Have conducted trials with tide gauges, acoustic listening devices, cameras, GPS drifters, current meters, and salinity monitors.	Environmental Monitors on Lobster Traps and Large Trawlers (eMOLT)	Local fishers, Gulf of Maine Lobster Foundation, Nova Scotia Fishermen Scientists Research Society, Commercial Fisheries Research Foundation	2001 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Profile moorings, surface moorings, profiling gliders, coastal gliders, AUVs to monitor oceanographic conditions and examine exchanges between shelf and slope ecosystems	Coastal Pioneer Array (New England)	OOI, NOAA, WHOI	2016 – 2022	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys with CTD; Assess changes in oceanographic conditions, particularly temperature, in order to better understand how these changes may impact the distribution and abundance of key fisheries resources.	Shelf Research Fleet	Commercial Fisheries Research Foundation, WHOI	2014 – 2022	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys with temperature data logger; At-sea data collection is focused on	Supporting Management of the Emerging Jonah Crab Fishery and the	Commercial Fisheries Research Foundation	2013 – 2023	**Understanding the environmental context around**

1) Retained and discarded lobsters, 2) Retained and discarded Jonah crabs, and 3) Bottom water temperature. All data is collected, stored, and viewed on Samsung Tab A tablets.	Iconic Lobster Fishery in the Northeast USA			**changes to wildlife and habitats**
Vessel-based surveys including net tows; biomass, length and age structures, and diet compositions of finfishes and select invertebrates, water quality, weather condition	Northeast Area Monitoring and Assessment Program (NEAMAP)	Atlantic States Marine Fisheries Commission, Maine Department of Marine Resources, Massachusetts Division of Marine Fisheries, Virginia Institute of Marine Science, the U.S. Fish and Wildlife Service, NOAA NEFSC, NE Fishery Management Council, Mid-Atlantic Fishery Management Council, FWS, Potomac River Fisheries Commission	2006 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys including net tows; Bottom trawl samples fish and selected invertebrate species at random stations to delineate various life history characteristics and geographic distribution. Associated oceanographic and meteorological data include salinity, conductivity, and temperature at all stations.	Fall Bottom Trawl Survey	NOAA NEFSC	1963 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Seafloor acoustics; seafloor grabs; seafloor imagery	Comprehensive Seafloor Substrate Mapping and Model Validation in the Atlantic	BOEM, NOAA NCCOS	2016 – 2019	**Detecting and quantifying changes to wildlife and habitats**
Vessel-based surveys including seafloor	Habitat Mapping and Assessment of	BOEM, NOAA NEFSC, University of	2013 – 2017	**Detecting and quantifying changes**

acoustics, seafloor imagery, and seafloor grabs; characterizes the abiotic components, biotic components, and abiotic-biotic relations (between habitat and fauna) that will support ecosystem-level assessments and cumulative impact analyses for eight WEAs	Northeast Wind Energy Areas	Massachusetts Dartmouth, WHOI,		**to wildlife and habitats**
Vessel-based surveys including CTD rosette, net tows, gliders; physical samples include water samples (temperature, conductivity, nutrients, chlorophyll), filters, plankton net samples, and fish specimens	Northeast U.S. Shelf (NES) Long-Term Ecological Monitoring Research (LTER)	Wellesley College, NSF, University of Maryland, University of Rhode Island	2017 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Ocean modeling, telemetry, glider observations, buoys, water sampling	Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)	U.S. IOOS, UMaine, Bedford Institute of Oceanography, USGS, Gulf of Maine Research Institute, UNH, Charybdis Group LLC, Woods Hole Group, WHOI, UMass-Dartmouth, UConn, URI, MCCF, Passamaquoddy Pleasant Point	Ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys including seafloor acoustics (MBES), seafloor imagery (SPI/PV)	New York State Offshore Wind Master Plan Analysis of Mulitbeam Echo Sounder and Benthic Survey Data	INSPIRE Environmental, NYSERDA	2017 – 2017	**Detecting and quantifying changes to wildlife and habitats**

See below for a list of Benthic Habitat Characterization and Site Investigations available from Construction and Operating Plan for federal renewable energy development on the Outer Continental Shelf (OCS). Figure 15 presents an overview of BOEM Renewable Energy Lease Areas in the New York/New Jersey subregion.

Project	Overview
Empire Offshore Wind	Empire Offshore Wind LLC proposes to construct and operate an offshore wind farm in Renewable Energy Lease Area OCS-A 0512. The area encompasses roughly 70,350 acres and is located approximately 14 statute miles south of Long Island, New York and 19.5 statute miles east of Long Branch, New Jersey.

	Empire Wind submitted its COP on January 10, 2020. An update COP was submitted on April 14, 2021.
[Atlantic Shores South]()	Atlantic Shores is proposing the construction and operation of two distinct offshore wind energy projects within the southern portion of Renewable Energy Lease Area OCS-A 0499. The project area encompasses roughly 102,124 acres and would be located approximately 8.7 statute miles from the New Jersey shoreline at its closest point. Atlantic Shores submitted a COP to BOEM for the southern portion of OCS-A 0499 on March 26, 2021. An updated COP was resubmitted to BOEM on May 3, 2023.
[Ocean Wind 1]()	Ocean Wind LLC is proposing to build the 1,100-megawatt Ocean Wind 1 Offshore Wind Farm Project in Renewable Energy Lease Area OCS-A 0498, located approximately 15 statute miles offshore Atlantic City, New Jersey. Ocean Wind 1's COP was submitted to BOEM on August 15, 2019, with updated versions submitted on March 13, 2020, September 24, 2020, and March 24, 2021.

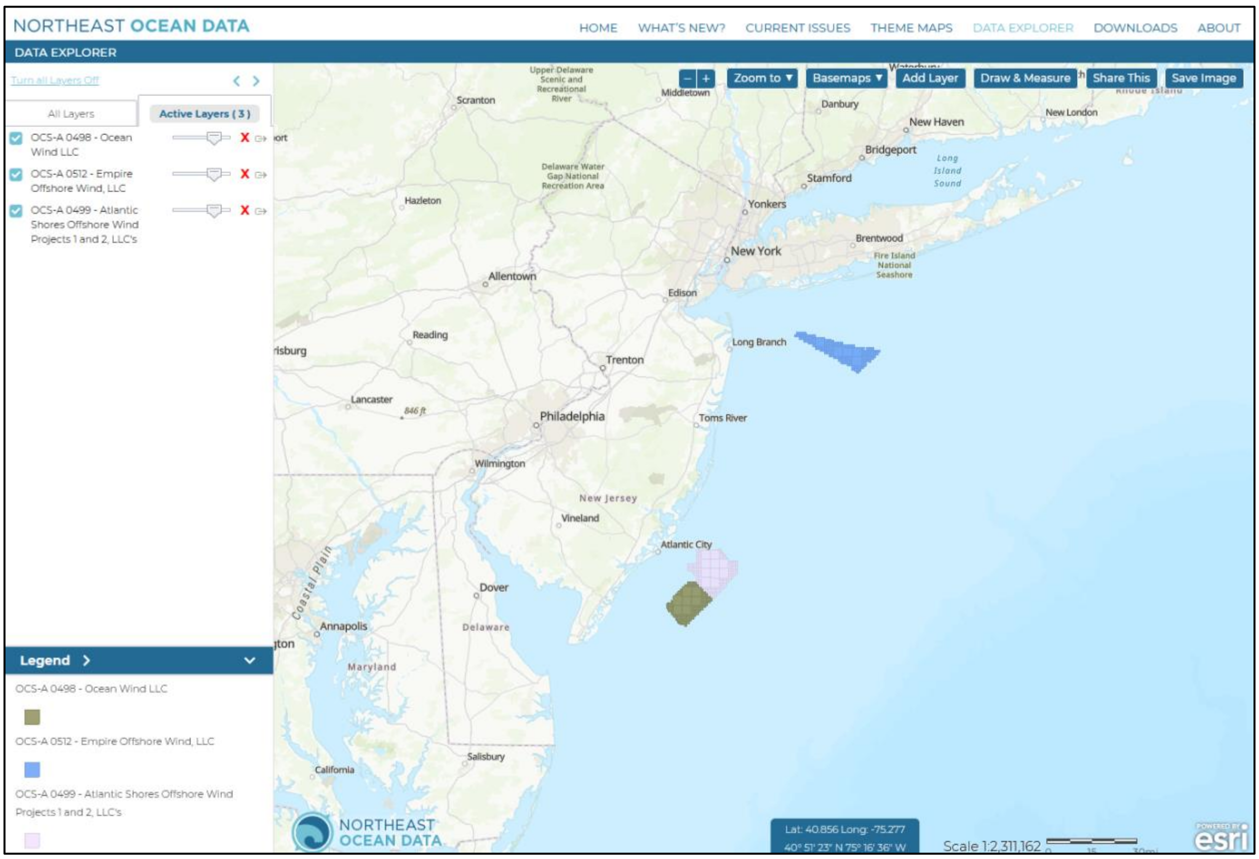

Figure 15. Location of three BOEM Renewable Energy Lease Areas in the NY/NJ Bight subregion with publicly available COP information at the time of RWSC's data query.

Recommendations

Similar to the Southern New England subregion, the New York/New Jersey Bight area is mainly characterized by water quality and oceanography monitoring activities and a small quantity of directed seafloor-related activities (e.g., seafloor geophysical – acoustics, seafloor grabs, seafloor imagery) for characterizing seafloor habitat. Publicly-available Construction and Operation Plans (COPs) are only available for three Renewable Energy Lease Areas and vary in the types of geophysical and sediment data collected for benthic habitat mapping purposes as well as spatial coverage of sampling surveys.

See Section 3 - Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind for recommendations related to field data collection activities.

6.2 Other Science Plan Actions

Recent, ongoing, and pending activities

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Model development and statistical frameworks	Northeastern U.S. Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England and Long Island.	UNH CCOM/JHC	2016 – 2021	**Detecting and quantifying changes to wildlife and habitats**
Model development and statistical frameworks	Comprehensive Seafloor Substrate Mapping and Model Validation in the Atlantic	BOEM, NOAA NCCOS	2016 – 2019	**Detecting and quantifying changes to wildlife and habitats**
Model development and statistical framework	Northwest Atlantic Marine Ecoregional Assessment (NAMERA)	The Nature Conservancy	2010 – ongoing	**Detecting and quantifying changes to wildlife and habitats**
Model development and statistical framework	New York State Offshore Wind Master Plan Environmental Sensitivity Analysis	Ecology and Environment Engineering, P.C., NYSERDA	2017 – 2017	**Mitigating negative impacts that are likely to occur and/or are severe in magnitude**
Meta-analyses and literature review	New York Bight Fish, Fisheries, and Sand Features: Data Review	Rutgers University, BOEM	2020 – 2021	
Meta-analyses and literature review	New York State Offshore Wind Master Plan Sand and Gravel Resources Study	Ecology and Environment Engineering, P.C., NYSERDA	2017 – 2017	
Outreach and platforms to provide data products and	Mid-Atlantic Ocean Data Portal	Mid-Atlantic Regional Council on the Ocean		**Enhancing data sharing and access**

results to stakeholders				
Outreach and platforms to provide data products and results to stakeholders	MARACOOS OceansMap	Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS)		**Enhancing data sharing and access**

Recommendations

Aside from one directed study that collected geophysical and sediment data, non-field activities in the New York/New Jersey subregion are dominated by model development and statistical frameworks and meta-analyses and literature reviews for pre-emptively evaluating seafloor habitat for offshore wind siting.

See Section 3 - Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind for recommendations related to non-field activities.

7 U.S. Central Atlantic ongoing, pending, and recommended research and data collection activities for seafloor habitat and offshore wind

7.1 Field data collection and analysis

Recent, ongoing, and pending activities

See below for a list of directed research and long-term monitoring programs:

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Vessel-based surveys including seafloor acoustics, ROV/AUV deploys for seafloor imagery and grabs will delineate substrate types and document the distribution of hard bottom areas.	Deep SEARCH: Deep Sea Exploration and Research of Coral/Canyon/Seep Habitats	BOEM, USGS, NOAA OER, Temple University	2017 – 2022	**Detecting and quantifying changes to wildlife and habitats**
Vessel-based surveys including water quality and oceanography and nets and tows to characterize spatial ecology of highly-migratory species and environmental conditions	Sandbridge Highly Migratory Species: Fish Distribution on a Dredged Shoal	University of Delaware, BOEM	2021-2025	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys including net tows; biomass, length and age structures, and diet compositions of finfishes and select invertebrates, water quality, weather condition	Northeast Area Monitoring and Assessment Program (NEAMAP)	Atlantic States Marine Fisheries Commission, Maine Department of Marine Resources, Massachusetts Division of Marine Fisheries, Virginia Institute of Marine Science, the U.S. Fish and Wildlife Service, NOAA NEFSC, NE Fishery Management Council, Mid-Atlantic Fishery Management Council, FWS, Potomac River Fisheries Commission	2006 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys including net tows; Bottom trawl samples fish and	Fall Bottom Trawl Survey	NOAA NEFSC	1963 – ongoing	**Understanding the environmental context around**

selected invertebrate species at random stations to delineate various life history characteristics and geographic distribution. Associated oceanographic and meteorological data include salinity, conductivity, and temperature at all stations.				**changes to wildlife and habitats**
Determine the seasonal presence/absence of endangered Atlantic sturgeon in and around the project areas in the mid-Atlantic. Characterize the habitat use (including habitat type including biological and physical characteristics) and feeding grounds of Atlantic sturgeon to the extent practicable with available data.	Endangered Atlantic Sturgeon Habitat Use in Mid-Atlantic Wind Energy Area - Virginia	U.S. Department of the Navy, Naval Facilities Engineering Command (Atlantic), Chesapeake Scientific, BOEM	2015 – 2024	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys including seafloor acoustics, seafloor imagery, and seafloor grabs; characterizes the abiotic components, biotic components, and abiotic-biotic relations (between habitat and fauna) that will support ecosystem-level assessments and cumulative impact analyses for eight WEAs	Habitat Mapping and Assessment of Northeast Wind Energy Areas	BOEM, NOAA NEFSC, University of Massachusetts Dartmouth, WHOI,	2013 – 2017	**Detecting and quantifying changes to wildlife and habitats**

See below for a list of Benthic Habitat Characterization and Site Investigations available from Construction and Operating Plan for federal renewable energy development on the Outer Continental Shelf (OCS). Figure 15 presents an overview of BOEM Renewable Energy Lease Areas in the U.S. Central Atlantic subregion.

Project	Overview
Maryland Offshore Wind	US Wind, Inc is proposing to develop the 2GW Maryland Offshore Wind Project in Renewable Energy Lease Area OCS-A 0490. The Lease Area is approximately 80,000 acres and located off the coast of Maryland. US Wind submitted its COP to BOEM on August 11, 2020, providing updates on November 23, 2021, March 3, 2022, and May 27, 2022.

[Kitty Hawk North Wind](#)	Kitty Hawk Wind, LLC, a subsidiary of Avangrid Renewables, is proposing to build, own, and operate the Kitty Hawk North Wind Project in Renewable Energy Lease Area OCS-A 0508. The Lease Area covers roughly 122,406 acres and is located approximately 27 statute miles offshore of Corolla, North Carolina. Kitty Hawk Wind, LLC submitted its COP to BOEM on December 11, 2020.
[Coastal Virginia Offshore Wind](#)	The Virginia Electric and Power Company, doing business as Dominion Energy Virginia, is proposing to build the Coastal Virginia Offshore Wind Commercial Project in Renewable Energy Lease Area OCS-A 0483. The Lease Area covers approximately 112,799 acres and is approximately 27 statute miles off the Virginia Beach coastline. A pilot project was established in 2020 and has been operational since Fall 2020 ([Coastal Virginia Offshore Wind Project – Research Lease](#)). Dominion Energy submitted its COP on December 17, 2020. Updated COP versions were submitted on June 17, 2021, October 30, 2021, December 3, 2022, and May 6, 2022.

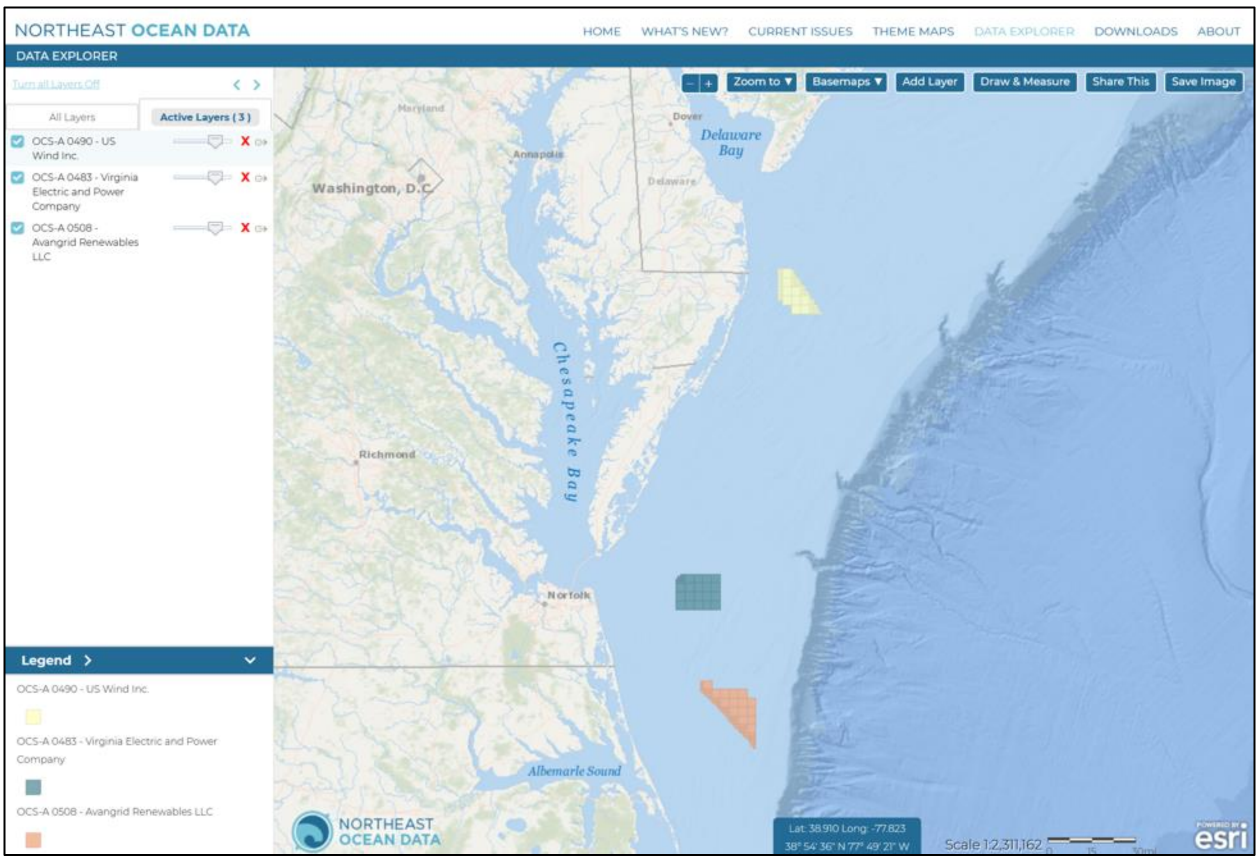

Figure 16. Location of three BOEM Renewable Energy Lease Areas in the Central Atlantic subregion with publicly available COP information at the time of RWSC's data query.

Recommendations

The U.S. Central Atlantic subregion is like the previous subregions in that it is composed mainly of water quality and oceanographic monitoring projects that can aid in understanding environmental context around changes to seafloor habitat. Projects that collect geophysical and sediment data for the purpose of detecting and quantifying changes to seafloor habitat are primarily focused in Renewable Energy Lease Areas. Publicly available Construction and Operation Plans (COPs) are only available for three projects and display a similar pattern in collected data types, methods, and spatial coverage to meet environmental guidelines. However, similar to the Southern New England subregion, a two-turbine project was installed by the Coastal Virginia Offshore Wind project and has been fully operational since 2020. The data obtained and lessons learned from this project will be made publicly available and inform the future production of renewable energy within the adjacent commercial lease area.

See Section 3 - Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind for recommendations related to field data collection activities.

7.2 Other Science Plan Actions

Recent, ongoing, and pending activities

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Historical data collection/compilation	Data Synthesis and Advanced Predictive Modeling of Deep Coral and Hardbottom Habitats in the Southeast Atlantic: Guiding Efficient Discovery and Protection of Sensitive Benthic Areas	BOEM, The National Oceanographic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Centers for Coastal Ocean Science (NCCOS)	2016 – 2018	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Model development and statistical frameworks	Data Synthesis and Advanced Predictive Modeling of Deep Coral and Hardbottom Habitats in the Southeast Atlantic: Guiding Efficient Discovery and Protection of Sensitive Benthic Areas	BOEM, The National Oceanographic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Centers for Coastal Ocean Science (NCCOS)	2016 – 2018	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to**

				wildlife and habitats
Model development and statistical framework	Northwest Atlantic Marine Ecoregional Assessment (NAMERA)	The Nature Conservancy	2010 – ongoing	**Detecting and quantifying changes to wildlife and habitats**
Model development and statistical framework	Sediment-borne Wave Disturbances and Propagation and Potential Effects on Benthic Fauna	BOEM, University of Rhode Island	2022 – 2024	**Detecting and quantifying changes to wildlife and habitats**
Meta-analyses and literature review	New York Bight Fish, Fisheries, and Sand Features: Data Review	Rutgers University, BOEM	2020 – 2021	**Detecting and quantifying changes to wildlife and habitats**
Outreach and platforms to provide data products and results to stakeholders	Mid-Atlantic Ocean Data Portal	Mid-Atlantic Regional Council on the Ocean		**Enhancing data sharing and access**
Outreach and platforms to provide data products and results to stakeholders	MARACOOS OceansMap	Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS)		**Enhancing data sharing and access**

Recommendations

See Section 3 - Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind for recommendations related to non-field activities.

8 U.S. Southeast Atlantic ongoing, pending, and recommended research and data collection activities for seafloor habitat and offshore wind

8.1 Field data collection and analysis

Recent, ongoing, and pending activities

See below for a list of directed research and long-term monitoring programs:

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Vessel-based including ship transects, water quality and oceanography (CTD), and nets and tows	Southeast Area Monitoring and Assessment Program (SEAMAP)	Atlantic States Marine Fisheries Commission, NMFS SFSC, USFWS SAFCO, Florida Fish & Wildlife Conservation Commission, Georgia Dept of Natural Resources, NC Dept of Environment & Natural Resources, SC Dept of Natural Resources, South Atlantic Fishery Management Council	1981 – ongoing	**Understanding the environmental context around changes to wildlife and habitats**
Vessel-based surveys including seafloor acoustics, ROV/AUV deploys for seafloor imagery and grabs will delineate substrate types and document the distribution of hard bottom areas.	Deep SEARCH: Deep Sea Exploration and Research of Coral/Canyon/Seep Habitats	USGS, NOAA OER, Temple University	2017 – 2022	**Detecting and quantifying changes to wildlife and habitats**
Vessel-based seafloor acoustic surveys (SSS, MBES; depth, backscatter; split-beam echosounder); Diver-based assessments via line point intercepts and benthic quadrats	Benthic Habitat Mapping and Assessment in the Wilmington-East Wind Energy Call Area	NOAA NCCOS	2016 – 2016	**Detecting and quantifying changes to wildlife and habitats**

Recommendations

There are limited field data collection activities occurring in this subregion and no publicly available Construction and Operation Plans for offshore wind development projects.

See Section 3 - Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind for recommendations related to field data collection activities.

8.2 Other Science Plan Actions

Recent, ongoing, and pending activities

Science Plan Action	Project	Lead and Partner Entities	Time period	Research Theme
Coordination and planning	Southeast and Caribbean Regional Collaboration Team (SECART)	NOAA, federal and stage agencies, academia	2014 – ongoing	
Historical data collection/compilation	Data Synthesis and Advanced Predictive Modeling of Deep Coral and Hardbottom Habitats in the Southeast Atlantic: Guiding Efficient Discovery and Protection of Sensitive Benthic Areas	BOEM, The National Oceanographic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Centers for Coastal Ocean Science (NCCOS)	2016 – 2018	**Detecting and quantifying changes to wildlife and habitats**
Model development and statistical frameworks	Data Synthesis and Advanced Predictive Modeling of Deep Coral and Hardbottom Habitats in the Southeast Atlantic: Guiding Efficient Discovery and Protection of Sensitive Benthic Areas	BOEM, The National Oceanographic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Centers for Coastal Ocean Science (NCCOS)	2016 – 2018	**Detecting and quantifying changes to wildlife and habitats**
Outreach and platforms to provide data products and results to stakeholders	The Blueways Conservation Decision Support Tool	The Nature Conservancy		**Enhancing data sharing and access**
Outreach and platforms to provide data products and results to stakeholders	SECOORA Data Portal	The Southeast Coastal Ocean Observing Regional Association (SECOORA)	Ongoing	**Enhancing data sharing and access**
Outreach and platforms to provide data products and results to stakeholders	The Southeast Marine Mapping Tool (Phase 2): Increasing access to regional ecological data to help inform offshore ocean use decisions:	SECOORA, The Nature Conservancy	2023 – ongoing	**Enhancing data sharing and access**

	Analysis and Visualization of Ocean Resources in the Context of Offshore Wind Energy Development			

Recommendations

See Section 3 - Regional-scale ongoing, pending, and recommended research and data collection activities in the U.S. Atlantic Ocean for seafloor habitat and offshore wind for recommendations related to non-field activities.

9 Conclusions

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Chapter 13: Protected Fish

Note: A list of acronyms is included at the end of the chapter.

Executive Summary

This chapter describes individual ongoing data collection and research initiatives related to offshore wind and protected fish species funded by a variety of partners (states, federal agencies, industry). For an always up-to-date list of active projects, visit the RWSC Offshore Wind & Wildlife Research Database.

There are many ongoing projects targeting protected fish species in the US Atlantic, all of which will help inform on their potential interactions with offshore wind farm development. Of the methods currently utilized, there is an overwhelming majority of projects employing acoustic tags and monitoring acoustic arrays. The Subcommittee would like to prioritize advancing this existing technology by adding more receivers throughout the region, tagging more protected fish, and fully utilizing all collected data. Entities are already working collaboratively to further acoustic telemetry, but opportunity remains for additional coordination among researchers throughout the region.

Given this ongoing work, the Protected Fish Species Subcommittee is making recommendations for additional research that is both aligned with existing efforts and fills important gaps. Those recommendations are described in detail throughout each section of this chapter. The recommendations are also summarized in Table 1 below. It is important to note that some projects in the database that tag protected fish as a taxon of interest are not specifically designed to study fish, but may collect information on them opportunistically. There are also projects that focus on fish species outside the scope of this chapter that are covered by other organizations. These projects are not included in this chapter.

A major concern of the Subcommittee remains the lack of baseline knowledge on most protected fish species and their life stages. Without a thorough comprehension of each protected fish species, distinguishing between natural variation, effects of offshore wind and effects of climate change is not possible. The first step must be to improve our understanding about protected fish. The current uncertainty adds the potential for unexpected effects on protected fish from offshore wind development as well as skewed expectations on the level of known impacts. More species and life stage information are required for protected fish in order to properly assess, monitor, and mitigate any impacts from offshore wind.

The Subcommittee also stressed the importance of relying on local experts within a region (subregional), as the ecosystems differ greatly throughout the region, as does protected fish use of each wind energy area.

Table 1. RWSC Research Themes, Topics, and Recommendations. This table summarizes all of the research recommendations at the regional and subregional scale. These are each discussed in more detail throughout the chapter.

RWSC Research Theme	Research Topic	Recommendations
Mitigating negative impacts that are likely to occur and/or are severe in magnitude	Evaluate mitigation techniques to limit exposure of protected fish to sedimentation.	• Use models that predict patterns of sedimentation/resuspension to estimate potential impacts to protected species.
	Understand the increase in vessel traffic (both number of vessels and increased time of vessels in a given area) in offshore wind farm project areas with emphasis on the shallower waters close to ports and estuaries. Pair this with the amount and type of light and noise produced by each vessel.	• Develop analyses of vessel and protected fish species co-occurrence that model nearshore vessel traffic and changes to ambient light conditions that could alter fish behavior. • Develop tools to better understand if/when vessel strikes occur as well as a standardized reporting platform for vessel strikes of protected fish. • Increase understanding of coastal transfer and test mitigation measures to prevent vessel strikes. Areas of focus would be for vessels traveling close to shore, near the estuarine environment, in known migration corridors and other areas of spatiotemporal overlap. • Increase knowledge on vessel type and activity that leave all protected fish, with emphasis on sturgeon, most susceptible to vessel strike. • Model the impacts of vessels on protected fish, primarily sturgeon.
	Better understand the effects of intake and entrainment from HVDC cooling systems on protected fish at all life stages, knowing that some adult species will not be subject to intake or entrainment.	• Compile existing data from the hydropower industry to see how all life stages of fish are impacted with particular emphasis on impingement and entrainment of the early life stages. • Model potential impacts of intake and entrainment from HVDC cooling systems to protected fish species.
	Assess both primary and secondary entanglement risk to all protected fish species associated with offshore wind.	• Build off of existing simulation modeling funded by BOEM and other

	There is the potential for increased recreational fishing near wind turbines which would lead to primary entanglement, as well as an increased possibility of secondary entanglement due to ghost gear and debris attaching to structures in the water. Risk should be assessed for structures associated with both standard and floating offshore wind technologies.	efforts by developers and researchers in the Gulf of Maine. • Test methods to make lines in the water more visible to megafauna and more regid to mitigate entanglements. • Continue to support and fund research and testing of ropeless gear to limit the amount of gear in the water.
	Ensure that protected fish species are included in risk modeling that is similarly being applied to other species, e.g., Project WOW	• Population Viability Analyses • Population Consequences of Disturbance (PCOD) • Population Consequences of Multiple Stressors (PCOMS)
	Support the recommendations in the NOAA Fisheries & BOEM Federal Survey Mitigation Strategy	• In collaboration with NOAA Fisheries and BOEM, ensure that the recommendations related to protected fish species surveys in the NOAA Fisheries & BOEM Federal Survey Mitigation Strategy are implemented.
Detecting and quantifying changes to wildlife and habitats	Collect information on distribution, abundance, behavior, health, reproduction, and other vital population rates of protected fish at all life stages. This includes estuarine and freshwater habitat if the distribution expands into those environments.	∉ With ROSA, MATOS, ACT, FACT Network, the research community, and others, convene an Offshore Wind & Acoustic Telemetry Data Collaborative with goals to coordinate on the deployment of acoustic telemetry receivers and acoustic and satellite tags to protected fish species (especially Atlantic sturgeon), and other species of focus within ROSA (e.g., highly migratory species, Atlantic cod) and RWSC (e.g., sea turtles) in the context of offshore wind development. The Data Collaborative would ensure that data are collected and stored consistently such that data can be pooled to develop a set of standardized data products that represent metrics such as distribution, abundance, occupancy, and/or movement. ∉ Continue collecting data on protected fish species using current acoustic and satellite telemetry tags and arrays. This will help the cotinued identification of protected fish populations and their critical shelf habitats.

		∉ Deploy fine-scale acoustic and satellite telemetry arrays in every leased and proposed Wind Energy Area. This should be paired with acoustic and satellite tagging of protected fish to get a better understanding of habitat use within each wind energy area. Conventional tagging, eDNA, and other methods should also be utilized. This will also allow for the ability to identify any changes in residency or usage of the area. ∉ Fully document the migration patterns of all protected fish species. ∉ Fully understand the differences in habitat use between, and resulting threats to, the two species of manta ray to aid in their conservation.
	Utilize historical data collection from multiple sources to generate a baseline of distribution and abundance of protected fish species.	• Identify repositories and existing datasets that relate to protected fish species and assess their utility. • Depending on the temporal range and density of data available, there is the potential to evaluate how the baseline has changed over time.
	Coordinate with the Marine Mammal Subcommittee to co-locate acoustic telemetry receivers within a regional long-term archival Passive Acoustic Monitoring network in the US Atlantic Ocean	• RWSC staff will coordinate across Marine Mammal and Protected Fish Species Subcommittees to ensure that funders and researchers are aware of opportunities to collaborate on co-deployment of sensors.
	Utilize existing projects and gear primarily used for other purposes to increase knowledge on protected fish.	• Expanding projects like Buoys of Opportunity to other regions outside of the Gulf of Maine. This involves adding acoustic recievers to structures already in the water to expand knowledge on migration patterns and distribution.
Understanding the environmental context around changes to wildlife and habitats	Identify protected fish species habitats and assess the connectivity (movement of individuals) between these habitats.	∉ Deploy fine-scale acoustic and satellite telemetry arrays in estuaries and along the coast to identify habitats and assess the connectivity (movement of individuals) between these habitats. Modeling can be paired with this deployment.

	Work with the Habitat & Ecosystem Subcommittee to ensure that key oceanographic and habitat data are collected and available to use in coordination with studies on protected fish.	• Identify oceanographic and habitat variables of interest with respect to mapping and modeling protected fish species distribution, movement, etc.
	Work with other Subcommittees to gain a more thorough understanding of whether or not/to what degree turbines and wind farms alter the hydrodynamics, benthic habitat distribution, food resources, stratification and mixing both at the local level directly behind the wind farm and at the cumulative regional level.	• View relevant research topics and recommendations in the Habitat & Ecosystem Chapter.
	Determine any changes in protected fish species behavior related to construction. This includes attraction/avoidance, residency, feeding, use of area.	∉ Design acoustic telemetry studies to optimally detect changes in protected fish species behavior during construction and operation of offshore wind projects. ∉ Conduct studies in each WEA as well as cable landings/approaches that are most appropriate to the potential alterations to each ecosystem in which they are proposed ∉ Provide increased funding for salvage operations and stranding programs, particularly for Atlantic sturgeon.
	Examine all protected fish species life stages to see if there are any major changes brought on by wind farms. Noted that this is only possible if we have a more thorough baseline understanding of protected fish species and their life stages.	• Prioritize the collection of baseline data for all life stages of all protected fish species. • For early life stages: use of dispersal models and plankton cameras
	Examine the effects of EMF on all protected fish species, especially chondrichthyes and sturgeon to see if migration patterns or feeding has been altered in any way.	∉ Conduct directed studies (both in situ and in laboratory if possible) of effects of EMF from transmission cables on protected fish species occurrence, movement, behavior, and feeding patterns. Research methods should be standardized so that similar studies at each wind farm can effectively inform

		the assessment of potential impacts at the regional scale.
	Distinguish (to the best extent possible) between shifts caused by other factors such as climate change and fisheries.	• Prioritize the collection of baseline data for all life stages of all protected fish species.
Enhancing data sharing and access	Create an inventory of all ongoing data collection and research projects for protected fish species and offshore wind to encourage a coordinated approach to regional-scale analysis and planning future work.	• Hold a series of special meetings of the Projected Fish Species Subcommittee and ROSA to share details around ongoing funded research and data collection activities related to acoustic telemetry studies of fish species (protected and other) and to identify opportunities for collaboration (on topics including study design, data management, use of results and data product development). • Informed by the meetings detailed above, convene an Offshore Wind & Acoustic Telemetry Data Collaborative with MATOS, additional members of the research community, and others,with goals to coordinate on the deployment of acoustic telemetry receivers and acoustic and satellite tags to protected fish species (especially Atlantic Sturgeon), and other species of focus within ROSA (e.g., highly migratory species, cod) and RWSC (e.g., sea turtles) in the context of offshore wind development. The Data Collaborative would ensure that data are collected and stored consistently such that data can be pooled to develop a set of standardized data products that represent metrics such as distribution, abundance, occupancy, and/or movement. • Ensure that funding is available for meetings and coordination.
	Coordinate data collection with projects focused on other taxa (e.g. highly migratory species, sea turtles).	• In collaboration with the Marine Mammal Subcommittee, maintain a shareable database and/or map of the coordinates of acoustic telemetry receivers that may be co-located with

		bottom-mounted PAM hydrophones, and in collaborating with ROSA, do the same for other acoustic telemetry receivers. • Use Sea Turtle Subcommittee meetings and meetings with ROSA as forums to collaborate on data collection strategies. • Coordinate with national laboratories and other organizations to develop a database.
	Coordinate data collection and synthesis of existing data efforts at a regional scale including baseline data, population monitoring, and data collected at individual OSW project sites (e.g., post-construction monitoring data) and facilitate pooling of data to obtain the statistical power to examine regional-scale effects.	• Provide for means to incorporate future acoustic telemetry and make these data publicly available.
	Make locations of acoustic arrays and receivers public and create shared maps for research planning.	• Require that all new tags/groups submit their data to the Animal Telemetry Network and/or appropriate regional nodes in an agreed upon time frame to allow for publishing.

1 Background

Marine fish are very diverse. They occupy a wide variety of habitats, have different anatomical features, and unique life histories. In the United States, marine fish are managed at both the federal and state levels, depending on where the species most commonly occurs. Species that predominantly occur in ocean waters beyond the state jurisdictional limit (3 nautical miles) are federally managed by the regional fishery management councils and NOAA Fisheries. The four regional fishery management councils responsible for managing federal fisheries in the US waters of the Atlantic Ocean include the New England Fishery Management Council (NEFMC), the Mid-Atlantic Fishery Management Council (MAFMC), the South Atlantic Fishery Management Council (SAFMC), and the Caribbean Fishery Management Council (CFMC). These regional fishery management councils are responsible for developing federal fishery management plans, regulations, and designating Essential Fish Habitat (EFH), while NOAA Fisheries is responsible for approving and implementing those plans, regulations, or EFH designations. Marine species that predominately occur in nearshore or estuarine waters are typically managed by the individual states, or the Atlantic States Marine Fisheries Commission in the case where the species occurs over a larger range. All federal and state agencies responsible for fishery management work in coordination with, and collect input from, other federal partners, state partners, tribal governments, academia, and non-governmental organizations.

The Bureau of Ocean Energy Management (BOEM) is responsible for managing the development of energy on the outer continental shelf. BOEM produces Environmental Impact Statements (EISs) or Environmental Assessments (EAs) under the National Environmental Policy Act (NEPA) for each offshore wind project. These documents are intended to thoroughly assess the potential impacts on protected fish, both from the individual project and cumulatively (to include potential impacts from offshore wind development and all other potentially impactful activities). BOEM is also required to complete an EFH Consultation under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) for all activities that may affect areas of designated habitat where federally managed fish spawn, breed, feed, or grow to maturity.

As a whole, fish are sensitive to any changes to the environment and thus are subject to the impacts of changing ocean conditions such as temperature, salinity, and acidity. Climate change, among other anthropogenic stressors, has altered the distribution of many fish species, and is projected to continue to affect fish distribution (Hare et al. 2016; NOAA 2022)[1,2]. NOAA Fisheries conducted a climate vulnerability assessment on 82 fish and invertebrate species in the US Northeast, and determined that of the fish studied, diadromous species exhibit the highest level of vulnerability to climate change induced environmental changes (Hare et al.

[1] Hare, Jon & Morrison, Wendy & Nelson, Mark & Stachura, Megan & Teeters, Eric & Griffis, Roger & Alexander, Michael & Scott, James & Alade, Larry & Bell, Richard & Chute, Antonie & Curti, Kiersten & Curtis, Tobey & Kircheis, Daniel & Kocik, John & Lucey, Sean & McCandless, Camilla & Milke, Lisa & Richardson, David & Griswold, Carolyn. (2016). A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast US Continental Shelf. PloS one. 11. e0146756. 10.1371/journal.pone.0146756.

[2] NOAA (National Oceanic and Atmospheric Administration). 2022. DisMAP data records. Accessed June 2023. https://apps-st.fisheries.noaa.gov/dismap/DisMAP.html

2016)[3]. Atlantic sturgeon, shortnose sturgeon, and Atlantic salmon are all diadromous protected fish species located in the RWSC focal area.

Fish distribution in a marine environment is influenced by a variety of factors and is known to vary seasonally and over time. Spatiotemporal distributions and migration corridors do not just vary by species, but also by contingent/population within a given species. Water temperature, salinity, dissolved oxygen levels, food availability, habitat structure/substrate type, and harvest all play major roles in where species are found. Anthropogenic activity such as commercial and recreational fishing, coastal development, pollution, and climate change each contribute to changing fish distributions. Offshore wind farm development will spark additional changes to many aspects of the ecosystem, and is likely to hasten certain biological changes including to fish distributions.

Fish species listed under the ESA are already in a vulnerable state, so are at an even greater risk with respect to anthropogenic impacts and changes in the environment. Therefore, these protected fish species may also be more susceptible to effects from offshore wind. While using wind development may benefit species by reducing the amount of carbon dioxide released into the envrionment, many of the listed protected fish species do not rely on large structured habitat when offshore. So, the population level effects of offshore wind farm construction and operation through structured habitat provision are unlikely to be beneficial.

1.1 Focal species and notable recent trends

Fish can be considered protected through multiple avenues, but for the purposes of this chapter, protected fish species will include all ESA endangered, threatened, petitioned, candidate, and proposed fish species. As part of the ESA, some species are broken up into Distinct Population Segments (DPS). A DPS is defined under the ESA as a vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species. A list of protected species in the RWSC Study area is found in Table 1 below. Under the ESA, it is prohibited to take each of these species, and NOAA Fisheries is responsible for the protection and conservation of all listed species and their habitats.

Table 2. Protected Fish species in the RWSC study area. This table includes Endangered Species Act (ESA) status including Distinct Population Segment (DPS), if applicable. Source: NOAA Fisheries Species Directory, https://www.fisheries.noaa.gov/species-directory/threatened-endangered

Species	ESA Status and DPS	NOAA Fisheries Region
Atlantic Salmon (*Salmo salar*)	Endangered (Gulf of Maine DPS)	New England/Mid-Atlantic
Atlantic Sturgeon (*Acipenser oxyrinchus*)	Endangered (New York Bight DPS, Chesapeake Bay DPS, Carolina DPS,	New England/Mid-Atlantic, Southeast

[3] are, Jon & Morrison, Wendy & Nelson, Mark & Stachura, Megan & Teeters, Eric & Griffis, Roger & Alexander, Michael & Scott, James & Alade, Larry & Bell, Richard & Chute, Antonie & Curti, Kiersten & Curtis, Tobey & Kircheis, Daniel & Kocik, John & Lucey, Sean & McCandless, Camilla & Milke, Lisa & Richardson, David & Griswold, Carolyn. (2016). A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast US Continental Shelf. PloS one. 11. e0146756. 10.1371/journal.pone.0146756.

	South Atlantic DPS) ESA Threatened (Gulf of Maine DPS)	
Shortnose Sturgeon (*Acipenser brevirostrum*)	Endangered	New England/Mid-Atlantic, Southeast
Giant Manta Ray (*Manta birostris*)	Threatened	New England/Mid-Atlantic, Southeast
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	Threatened	New England/Mid-Atlantic, Southeast
Nassau Grouper (*Epinephelus striatus*)	Threatened	Southeast
Scalloped Hammerhead Shark (*Sphyrna lewini*)	Threatened (Central & Southwest Atlantic DPS)	Southeast
Smalltooth Sawfish (*Pristis pectinata*)	Endangered	Southeast
Whitespotted Eagle Ray *(Aetobatus narinar*)	90 Day Petitioned (04/06/23)	Mid Atlantic, Southeast

In considering species for inclusion in this chapter, the Subcommittee explored other protected fish listings and other organizations involved in offshore wind and fisheries research where our efforts might overlap. The Responsible Offshore Science Alliance (ROSA) is an organization analogous to RWSC that advances research and monitoring on the potential effects of offshore wind on fisheries in the RWSC study area. The RWSC Protected Fish Species Subcommittee includes members from ROSA leadership to ensure that each organization's activities are coordinated and to reduce duplication among efforts. The RWSC and ROSA have, and will continue to, work closely together to support research and monitoring of fish and offshore wind.

In addition to the federally-administered ESA, each state/district compiles a species of concern list. Species of concern for each state may also be federally listed. The following table includes state or district Marine Fish Species of Concern. All species that are listed under the ESA and shown in the above table are not repeated/shown in Table 3 below.

Table 3. State/District species of concern in the RWSC study area. Species that are also listed under the ESA and shown in Table 2 are not repeated/shown in this table. Source: All official state fish and wildlife department websites.

Species of Concern	**State(s)/District Listed**	**Addressed by ROSA**
Blueback Herring (*Alosa aestivalis*)	New Hampshire, Connecticut, Washington D.C., Virginia	No
Alewife (*Alosa pseudoharengus*)	New Hampshire, Washington D.C., Virginia	No
American Shad (*Alosa sapidissima*)	New Hampshire, Washington D.C., Virginia	No

American Eel (*Anguilla rostrata*)	New Hampshire, Washington D.C., Virginia	No
Rainbow Smelt (*Osmerus mordax*)	New Hampshire, Connecticut	No
Sea Lamprey (*Petromyzon marinus*)	New Hampshire	No
Threespine Stickleback (*Gasterosteus aculeatus*)	Massachusetts	No
Sand Tiger Shark (*Carcharias taurus*)	Connecticut	No
Atlantic Seasnail (*Liparis atlanticus*)	Connecticut	No
Radiated Shanny (*Ulvaria subbifurcata*)	Connecticut	No
Spotfin Killifish (*Fundulus luciae*)	Maryland	No
Hickory Shad (*Alosa mediocris*)	Washington D.C.	No
Striped Bass (*Morone saxatilis*)	Washington D.C., South Carolina	Yes

Internationally, the IUCN Redlist[4] is a resource that lists the global conservation status for all species, including fish. Each species is sorted into one of nine groups: Not Evaluated, Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild or Extinct.

The Subcommittee also discussed additional species that do not appear on any lists of protected species but may be impacted by the development of offshore wind farms. One group is the highly migratory species (HMS)[5], including all tuna, swordfish, billfishes, and sharks. There are prohibited fish in various fisheries. While not explicitly protected, it can be illegal to target and harvest some fish species.

A few additional species that were brought forth by the Subcommittee for their potential to be impacted by offshore wind are the Warsaw grouper (*Epinephelus nigritus*) and the speckled hind (*Epinephelus drummondhayi*), as well as all previously petitioned and listed species. Cusk (*Brosme brosme*) was very recently removed from the candidate listing, so does not appear in *Table 1*. Despite its removal under the ESA, this species may be impacted by offshore wind development, especially in the Gulf of Maine, as its habitat is limited. These species were not included in the scope of this chapter as they are not currently listed under the ESA. This list of Protected Fish Species in the RWSC Study area may be updated periodically as more research is conducted and more information becomes available.

1.1.1 Atlantic Sturgeon

[4] https://www.iucnredlist.org/search?searchType=species
[5] https://www.ecfr.gov/current/title-50/chapter-VI/part-635#Appendix-A-to-Part-635

Atlantic sturgeon are anadromous, meaning they hatch in freshwater, migrate to saltwater as sub adults, and return to freshwater as adults to spawn. According to Stein et al. (2004)[6] Atlantic sturgeon bycatch occurs closest to the coasts, particularly bay mouths and inlets, and are bracketed by 50m isobaths in the Northeastern US and 25m isobaths in the Southeastern US. It is noted that their distribution extends up into Canada. Based on reported observer catch data, the sturgeon were most caught, and thus likelly preferred, shallower water wtih sandy bottom (Stein et al. 2004)[7]. Studies conducted in more recent years, such as in Ingram et al. (2019)[8] suggest that their habitat and distribution is likely more expansive, and that additional targeted research is needed to fully and accurately assess Atlantic sturgeon habitat. An additional example is that while it was previously accepted that Atlantic sturgeon spawn only in the spring, Balazik and Musick (2015)[9] found that a separate group spawns in the fall, adding to the known species level variation. Hager (2019)[10] expressed a similar sentiment, and indicated the need to expand understnading of the environmental variables that impact sturgeon distribution in order to effectively manage the species.

There are 5 DPSs of Atlantic sturgeon. The Gulf of Maine DPS was listed as threatened under the ESA in 2012, and the other four DPSs (Carolina, Chesapeake Bay, New York Bight, and South Atlantic) were all listed as Endangered. Hare et al. (2016)[11] conducted a climate change vulnerability assessment for species on the Northeast US Continental Shelf, and the Atlantic Sturgeon recieved an Overall Vulnerability Rank of Very High with 99% certainty. This study focused on fish from the three DPSs in the northeast, and while not studied, the southeast believes that the impacts identified will also likely affect the southern DPSs. It is also possible that fish in the Carolina and South Atlantic DPSs have adaptaions that make them less

[6] Stein, Andrew & Friedland, Kevin & Sutherland, Michael. (2004). Atlantic Sturgeon Marine Distribution and Habitat Use along the Northeastern Coast of the United States. Transactions of the American Fisheries Society. 133. 527-537. 10.1577/T02-151.1.

[7] Stein, Andrew & Friedland, Kevin & Sutherland, Michael. (2004). Atlantic Sturgeon Marine Distribution and Habitat Use along the Northeastern Coast of the United States. Transactions of the American Fisheries Society. 133. 527-537. 10.1577/T02-151.1.

[8] Ingram, E.C., Cerrato, R.M., Dunton, K.J. *et al.* Endangered Atlantic Sturgeon in the New York Wind Energy Area: implications of future development in an offshore wind energy site. *Sci Rep* 9, 12432 (2019). https://doi.org/10.1038/s41598-019-48818-6

[9] Balazik MT, Musick JA (2015) Dual Annual Spawning Races in Atlantic Sturgeon. PLoS ONE 10(5): e0128234. https://doi.org/10.1371/journal.pone.0128234

[10] Hager, C. 2019. Operation of the Navy's Telemetry Array in the Lower Chesapeake Bay: Final Report for 2013 - 2018. Cumulative Report. Prepared for US Fleet Forces Command and Commander, Navy Region Mid-Atlantic. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470-10-3011, Task Order 53, issued to HDR Inc., Virginia Beach, Virginia. July 2019.

[11] Hare, Jon & Morrison, Wendy & Nelson, Mark & Stachura, Megan & Teeters, Eric & Griffis, Roger & Alexander, Michael & Scott, James & Alade, Larry & Bell, Richard & Chute, Antonie & Curti, Kiersten & Curtis, Tobey & Kircheis, Daniel & Kocik, John & Lucey, Sean & McCandless, Camilla & Milke, Lisa & Richardson, David & Griswold, Carolyn. (2016). A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast US Continental Shelf. PloS one. 11. e0146756. 10.1371/journal.pone.0146756.

vulnerable to increasing temperatures becasue they already live in warmer climates, but this is uncertain.

The Atlantic States Marine Fisheries Council also conducts stock assessments on Atlantic Sturgeon. The last assessment was completed in 2017, and they are currently preparing for the next one. Population numbers have declined from high historical levels due to overfishing (Stein et al. 2004)[12]. Entanglement in fishing gear continues to be a problem even though Atlantic sturgeon are no longer legal to target. The large mesh sink gillnet fishery is a major source of bycatch, and as a result of findings and requirements put forth in a Biological Opinion, The Atlantic Sturgeon Bycatch Working Group developed an Action Plan to reduce sturgeon entanglement in the federal fishery by 2024 (NOAA 2022)[13]. Some area closures in existence for other species also benefit Atlantic sturgeon in areas of overlap. Two examples are the Gulf of Maine Cod Protection Closures and the Large-Mesh Gillnet Mid Atlantic Seasonal closures, both of which likely provide protection for sturgeon moving to and from their marine habitat into freshwater.

Vessel strike, EMFs, water quality, noise, and change in marine habitat may also negatively effect sturgeon. There is growing concern about sturgeon vessel strikes especially within the Chesapeake and New York Bight DPSs. A study conducted by Fox et al. (2020)[14] that is not currently published but was accepted by NOAA, found that the overall reporting rate of Atlantic sturgeon carcasses was >5%. This suggests that rate of vessel strike are likely higher than previously thought, as most incidents of vessel strikes are not seen or reported. These impacts tend to be more severe in estuarine and freshwater habitats. Rivers all along the East Coast have been defined as critical habitat for Atlantic sturgeon and are shown below in *Figure 1*.

Figure 1. Map of Atlantic Sturgeon Critical Habitat. Source: NOAA Fisheries[15]

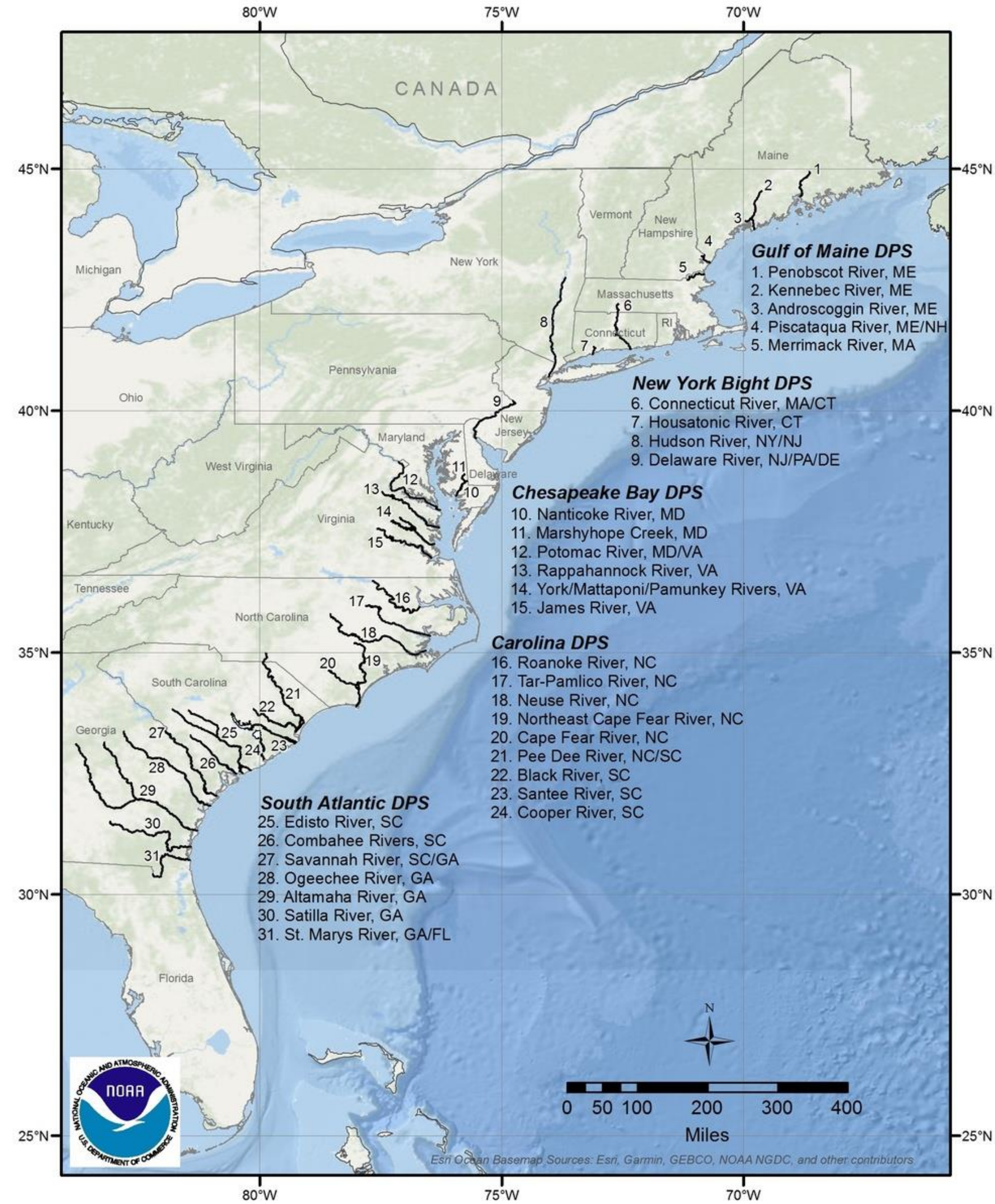
[12] Stein, Andrew & Friedland, Kevin & Sutherland, Michael. (2004). Atlantic Sturgeon Marine Distribution and Habitat Use along the Northeastern Coast of the United States. Transactions of the American Fisheries Society. 133. 527-537. 10.1577/T02-151.1.

[13] NOAA National Marine Fisheries Service Greater Atlantic Regional Fisheries Office. (2022). *Action Plan to Reduce Atlantic Sturgeon Bycatch in Federal Large Mesh Gillnet Fisheries.* https://media.fisheries.noaa.gov/2022-05/Draft-Action-Plan-to-Reduce-Atlantic-Sturgeon-Bycatch.pdf

[14] Fox, Dewayne A, Hale, Edward A, Sweka, John A. Examination of Atlantic Sturgeon Vessel Strikes in the Delaware River Estuary. (2020). Final Report. NA16NMF4720357

[15] https://www.fisheries.noaa.gov/resource/map/atlantic-sturgeon-critical-habitat-map-and-gis-data

Atlantic Sturgeon Critical Habitat



Atlantic sturgeon habitat use overlaps with many wind farm lease, planning, and cable areas (Ingram et al. 2019; Rothermel et al. 2020; Haulsee et al. 2020)[16,17,18], and so are subject to all

1.1.2 Atlantic Salmon

Atlantic salmon are anadromous fish, beginning their life in rivers, migrating to saltwater, and returning to freshwater for spawning (Fay et al. 2006)[19]. Atlantic salmon research has been conducted in Maine by NOAA Fisheries staff since the 1990s, covering all life stages, but with particular emphasis on the smolt lifestage when these fish go through a physiological transformation to prepare for migration from rivers to the ocean. Baseline telemetry studies in Maine outlined migration dynamics (Kocik et al. 2009; Renkawitz et al. 2012; Hawkes et al. 2017)[20,21,22], with other investigations including targeted management actions (Double Crested Cormorant harassment; Hawkes et al. 2013)[23] to improve smolt survival.   Additionally,

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[16] Ingram, E.C., Cerrato, R.M., Dunton, K.J. and Frisk, M.G., 2019. Endangered Atlantic Sturgeon in the New York Wind Energy Area: implications of future development in an offshore wind energy site. *Scientific reports*, *9*(1), pp.1-13.

[17] Rothermel, E.R., Balazik, M.T., Best, J.E., Breece, M.W., Fox, D.A., Gahagan, B.I., Haulsee, D.E., Higgs, A.L., O'Brien, M.H., Oliver, M.J. and Park, I.A., 2020. Comparative migration ecology of striped bass and Atlantic sturgeon in the US Southern mid-Atlantic bight flyway. *PloS one*, *15*(6), p.e0234442.

[18] Haulsee, D.E., Fox, D.A. and Oliver, M.J., 2020. Occurrence of Commercially Important and Endangered Fishes in Delaware Wind Energy Areas Using Acoustic Telemetry. *Lewes (DE): US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM*, *20*, p.80.

[19] Fay, Clem et al. (2006). Status review for anadromous atlantic salmon (Salmo salar) in the United States.

[20] Kocik, J. F., J. P. Hawkes, T. F. Sheehan, P. A. Music, and K. F. Beland. 2009. Assessing estuarine and coastal migration and survival of wild Atlantic Salmon smolts from the Narraguagus River, Maine, using ultrasonic telemetry. Pages 293–310 in A. J. Haro, K. L. Smith, R. A. Rulifson, C. M. Moffitt, R. J. Klauda, M. J. Dadswell, R. A. Cunjak, J. E. Cooper, K. L. Beal, and T. S. Avery, editors. Challenges for diadromous fishes in a dynamic global environment. American Fisheries Society, Symposium 69, Bethesda, Maryland.

[21] Renkawitz, M. D., T. F. Sheehan, and G. S. Goulette. 2012. Swimming depth, behavior, and survival of Atlantic Salmon postsmolts in Penobscot Bay, Maine. Transactions of the American Fisheries Society 141:1219–1229.

[22] Hawkes, J. P., T. F. Sheehan, and D. S. Stich. 2017. Assessment of early migration dynamics of river-specific hatchery Atlantic Salmon smolts. Transactions of the American Fisheries Society 146:1279–1290.

[23] Hawkes, James & Saunders, Rory & Vashon, Adam & Cooperman, Michael. (2013). Assessing Efficacy of Non-Lethal Harassment of Double-Crested Cormorants to Improve Atlantic Salmon Smolt Survival. Northeastern Naturalist. 20. 1-18. 10.1656/045.020.0101.

investigations by the USGS Co-op at the University of Maine have focused on quantifying threats, including impacts of dams on survival (Holbrook et al. 2011; Stich et al. 2015)[24,25] .

Beyond telemetry monitoring within the natal rivers of tagged salmon, the NOAA Fisheries staff expanded coverage by partnering with the University of Maine School of Marine Science beginning in 2005, to utilize existing marine infrastructure. This platforms of opportunity initiative incorporated deployments on oceanographic buoys, lobster traps and drifters. Data collected continued the data stream for salmon, but also benefited other tagged animals (Goulette et al. 2014; Goulette et al. 2021)[26,27]. In addition to these data collections, the salmon migration data would expand further with the deployment of the Ocean Tracking Network Halifax, Nova Scotia array in 2008.The only remaining wild Atlantic salmon in the United States belong to the Gulf of Maine DPS, and are found in a few of Maine's rivers. It is illegal to fish for Atlantic salmon, both commercially and recreationally. The range of Atlantic salmon is mostly in the northern Gulf of Maine which currently does not overlap with any lease areas. However, BOEM has published the Gulf of Maine Call for Information and Nominations (Call) in the deeper waters of the Gulf for floating offshore wind. This Call is an early step in the regulatory process for commercial leasing of offshore wind. Atlantic salmon critical habitat has been defined in rivers all along the coast of Maine and is shown below in *Figure 2*.

Figure 2. Atlantic Salmon Critical Habitat. Source: NOAA Fisheries[28]

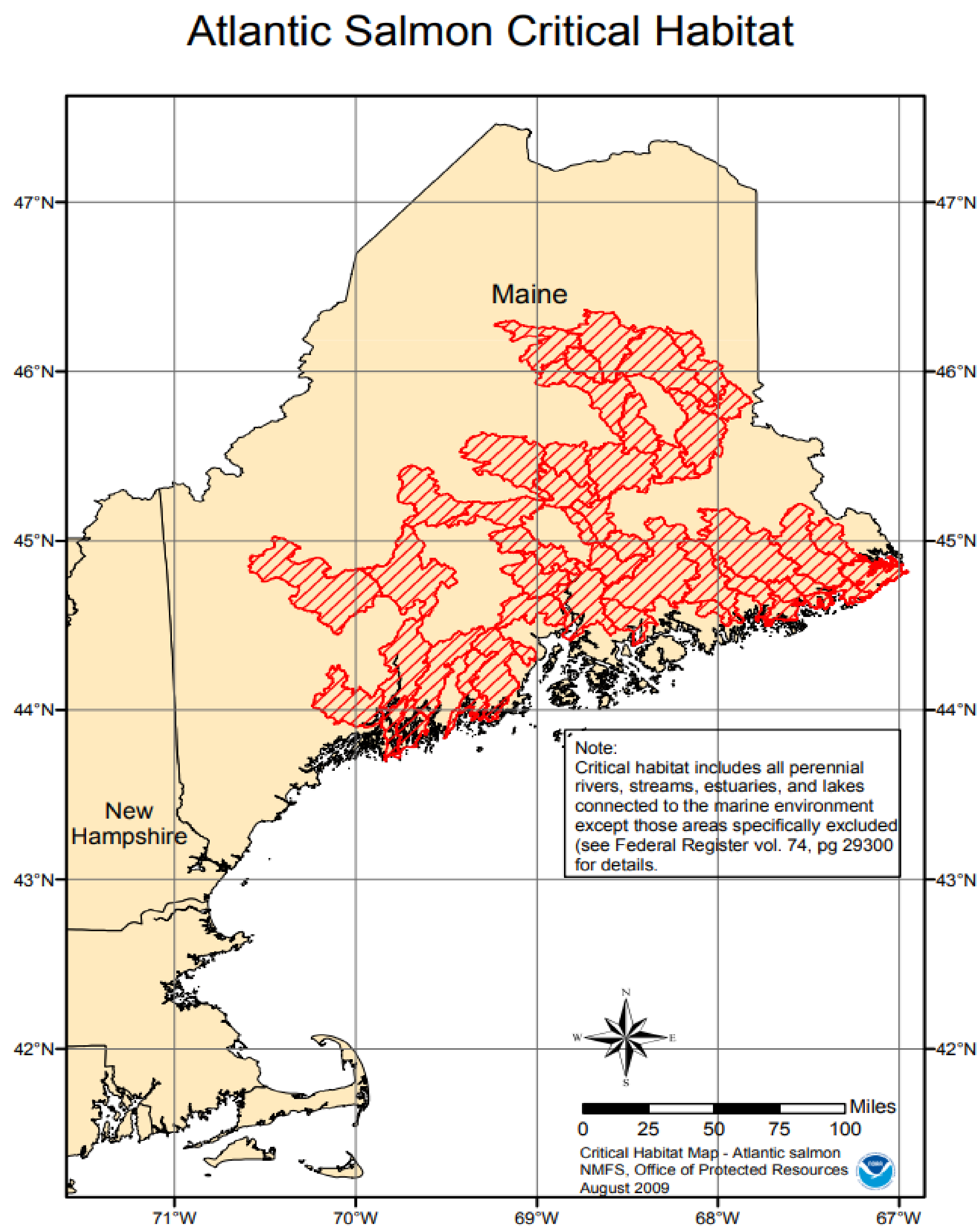
[24] Holbrook, C. M., M. T. Kinnison, and J. Zydlewski. 2011. Survival of migrating Atlantic Salmon smolts through the Penobscot River, Maine: a prerestoration assessment. Transactions of the American Fisheries Society 140:1255–1268.

[25] Stich, D. S., J. F. Kocik, G. B. Zydlewski, and J. D. Zydlewski. 2015. Linking behavior, physiology, and survival of Atlantic Salmon smolts during estuary migration. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science [online serial] 7:68–86.

[26] Goulette GS, Hawkes JP, Kocik JF, Manning JP, Music PA, Wallanga JP , Zydlewski GB. 2014. Opportunistic acoustic telemetry platforms: Benefits of collaboration in the Gulf of Maine. Fisheries 39:441–450

[27] Goulette GS, Hawkes JP, Kocik JF, Manning JP, Matzen E, Van Parijs S, Neil Pettigrew N, Wallinga J, Zydlewski GB, Ames C. 2021 Opportunistic Acoustic Telemetry Platforms: An Update on the Northeast Fisheries Science Center's Collaborative Monitoring Program in the Gulf of Maine, 2005-2018. NOAA Technical Memorandum NMFS-NE-265. 28 pp.

[28] https://www.fisheries.noaa.gov/resource/map/atlantic-salmon-gulf-maine-dps-critical-habitat-map-and-gis-data



Atlantic salmon will likely overlap with all stages of offshore wind farm development in the Gulf of Maine, so are subject to all to all potential effects with respect to offshore wind discussed in section 1.2.

1.1.2 Shortnose Sturgeon

The shortnose sturgeon is distributed all along the US Atlantic Coast, and extends up into Canada. They spend a majority of their time in estuarine environments, and move farther inland to spawn. What little time they spend in the ocean is spent very close to shore (Kynard 1997)[29]. The shortnose sturgeon is listed as endangered throughout its range under the ESA. They were subject to high levels of fishing historically, and though they are no longer targeted, bycatch is still a concern. Other anthropogenic activity involving their freshwater habitat such as power plants, pollution, and dams also remain as threats (NMFS 2010)[30].

Critical Habitat has not been designated for shortnose sturgeon because their listing under the ESA pre-dates the amendment that requires critical habitat to be designated for newly listed species. It is currently not a requirement for NOAA Fisheries to designate critical habitat for the shortnose sturgeon.

Shortnose sturgeon overlap with many wind farm lease, planning, and cable areas, and so are subject to all potential effects with respect to offshore wind discussed in section 1.2.

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1.1.3 Giant Manta Ray

The giant manta ray is a cartilaginous fish, and it is the largest ray in the world. Not much is known about its current population size. Internationally, manta rays are captured for their gill rakers (NMFS 2017)[31]. In the US, mantas are subject to bycatch in recreational fisheries and can become entangled on mooring wires and drown. Vessel strikes also remain a major issue as mantas spend much of their time at the surface. According to unpublished data from the Marine Megafauna Foundation (MMF), 8% of the south Florida juvenile population have been hit by a boat. This is likely an underestimate, as only individuals that survived can be documented. They are also attracted to light sources, which can pose additional threats.

Critical habitat has not been identified for the giant manta ray, as NOAA Fisheries has determined that no region within the United States fits the description and so it is not prudent to determine critical habitat at this time (NOAA 2017)[32]. However, manta rays are widely distributed along the East Coast of the United States (Farmer et al. 2022)[33], and potential nursery habitat (Pate & Marhsall, 2020)[34] and reproductive/foraging areas have been identified

[29] Kynard, B. Life history, latitudinal patterns, and status of the shortnose sturgeon, Acipenser brevirostrum. Environmental Biology of Fishes 48, 319–334 (1997). https://doi.org/10.1023/A:1007372913578
[30] The National Marine Fisheries Service. (2010). *Biological assessment of shortnose sturgeon Acipenser brevirostrum. https://repository.library.noaa.gov/view/noaa/17811*
[31] The National Marine Fisheries Service (2017). *Endangered Species Act Status Review Report : Giant Manta Ray (Manta biostris), Reef Manta Ray (Manta alfredi)*. https://repository.library.noaa.gov/view/noaa/17811
[32] National Oceanic and Atmospheric Administration. (2019*). Endangered and Threatened Species; Determination on the Designation of Critical Habitat for Giant Manta Ray.*
https://www.federalregister.gov/documents/2019/12/05/2019-26265/endangered-and-threatened-species-determination-on-the-designation-of-critical-habitat-for-giant
[33] Farmer, N.A., Garrison, L.P., Horn, C. et al. The distribution of manta rays in the western North Atlantic Ocean off the eastern United States. Sci Rep 12, 6544 (2022). https://doi.org/10.1038/s41598-022-10482-8
[34] Pate, J.H. & Marshall, A.D. (2020). Urban Manta Rays: Juvenile Manta Ray Habitat along a Highly-Developed Florida Coastline. Endangered Species Research, 43, 51–64. https://doi.org/10.3354/esr01054

off Florida’s east coast (MMF, unpubl. Data). In the Gulf of Mexico, manta rays are known to be associated with offshore oil and gas platforms in some areas (Childs 2001)[35] so similar associations with OSW structures could be expected. The reason behind the association is unknown, and ultimately could be coincidental. Working theories are that mantas are attracted to the lights of the oil rigs, or to their prey that concentrate around the lights and the mantas are following their prey. They could also just be curious as to the various activities occurring near the rigs such as diving. Due to the similarities between oil and gas rigs and structures associated with offshore wind, it is possible that there may be a similar pattern of association.

Researchers are hoping to learn more about the current population and their distribution in the US Atlantic. Due to their overlap with offshore wind activity, giant manta rays are subject to all potential effets with respect to offshore wind discussed in section 1.2. Impacts of most concern for giant manta rays are vessel strike, noise, EMFs, water quality, changes in marine habitat, offshore lighting, and entanglement from gear utilization or anything that snags on the structures or wires in the water column. In addition, manta rays are planktivorous, so the upwelling and concentration of prey due to changes in hydrography could act as an additional attractant.

1.1.4 Oceanic Whitetip Shark

Little is known about the current population size of the oceanic whitetip shark, especially in the US Atlantic. There was a large decline across the Pacific and the Gulf of Mexico, so it is estimated that the US Atlantic population also declined. They typically occur from the surface to 152m in depth (Bonfil et al. 2009)[36]. Critical habitat has not been identified for the oceanic whitetip shark as NOAA Fisheries has determined that no region within the United States fits the description, and so it is not prudent to determine critical habitat at this time (NOAA 2020).[37] The oceanic whitetip shark is subject to all to all potential effects with respect to offshore wind discussed in section 1.2.

1.1.5 Scalloped Hammerhead shark

The Central and Southwest Atlantic DPS of the scalloped hammerhead shark is found in the RWSC study area, which is listed as threatened under the ESA. Today, it’s main threats are interactions with commercial and recreational fisheries (as bycatch, and also as a target in the shark fin trade), and habitat degradation. Individuals have also been found to accumulate

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[35] Childs, Jeffrey Nathaniel (2001). The occurrence, habitat use, and behavior of sharks and rays associating with topographic highs in the northwestern Gulf of Mexico. Master's thesis, Texas A&M University. Available electronically from https ://hdl.handle.net/1969.1/ETD-TAMU-2001-THESIS-C45.
[36] Bonfil, Ramón & Shelley, Clarke & Nakano, Hideki. (2009). The Biology and Ecology of the Oceanic Whitetip Shark, Carcharhinus Longimanus. 10.1002/9781444302516.ch11.
[37] National Oceanic and Atmospheric Administration. (2020). *Endangered and Threatened Species; Determination on the Designation of Critical Habitat for Oceanic Whitetip Shark*. https://www.federalregister.gov/documents/2020/03/05/2020-04481/endangered-and-threatened-species-determination-on-the-designation-of-critical-habitat-for-oceanic

pollutants (Miller et al. 2014)[38]. They are found in warm temperate and tropical seas but critical habitat has not been identified for the scalloped hammerhead sharks. NOAA Fisheries has determined that no region within the United States fits the description of critical habitat (NOAA 2015)[39]. The oceanic whitetip shark is subject to all to all potential effects with respect to offshore wind discussed in section 1.2.

1.1.6 Nassau Grouper

The Nassau grouper is a reef fish generally found close to shore as larvae, but move into deeper reef areas as they grow. Historical information on its population is limited as fishing records for grouper were not separated by species, though they were known to be very common (NMFS 2013)[40]. This species produces sound that is thought to be associated with distress, and this call can be picked up on many acoustic monitors.

In the RWSC study area, the Nassau gouper is only found in Florida. Critical habitat has been proposed off the coasts of southeastern Florida, Puerto Rico, Navassa, and the US Virgin Islands. Based on available information and the current BOEM Offshore wind lease planning areas, it is not expected that the Nassau grouper will be greatly impacted by offshore wind development on the US Atlantic coast due to its limited distribution in the range of currently proposed development. However, if development expands, the Nassau grouper would be subject to all effects with respect to offshore wind discussed in section 1.2. Also, as a reef fish that has been documented to utilize natural and artificial reefs, the nassau grouper may benefit from the alteration of soft bottom habitat associated with offshore wind.

1.1.7 Smalltooth Sawfish

The smalltooth sawfish is a cartilaginous fish that live in subtropical to tropical climates. They suffered a decline due to fisheries bycatch and habitat loss, and there is not currently a population estimate for the species (Wiley and Brame 2018)[41].

The US population of the smalltooth sawfish is listed as endangered under the ESA. Critical habitat for the smalltooth sawfish is currently proposed and shown below in *Figure 3.* There is a small section overlapping the RWSC study area in southeast Florida. The smalltooth sawfish is subject to all to all potential effects with respect to offshore wind discussed in section 1.2.

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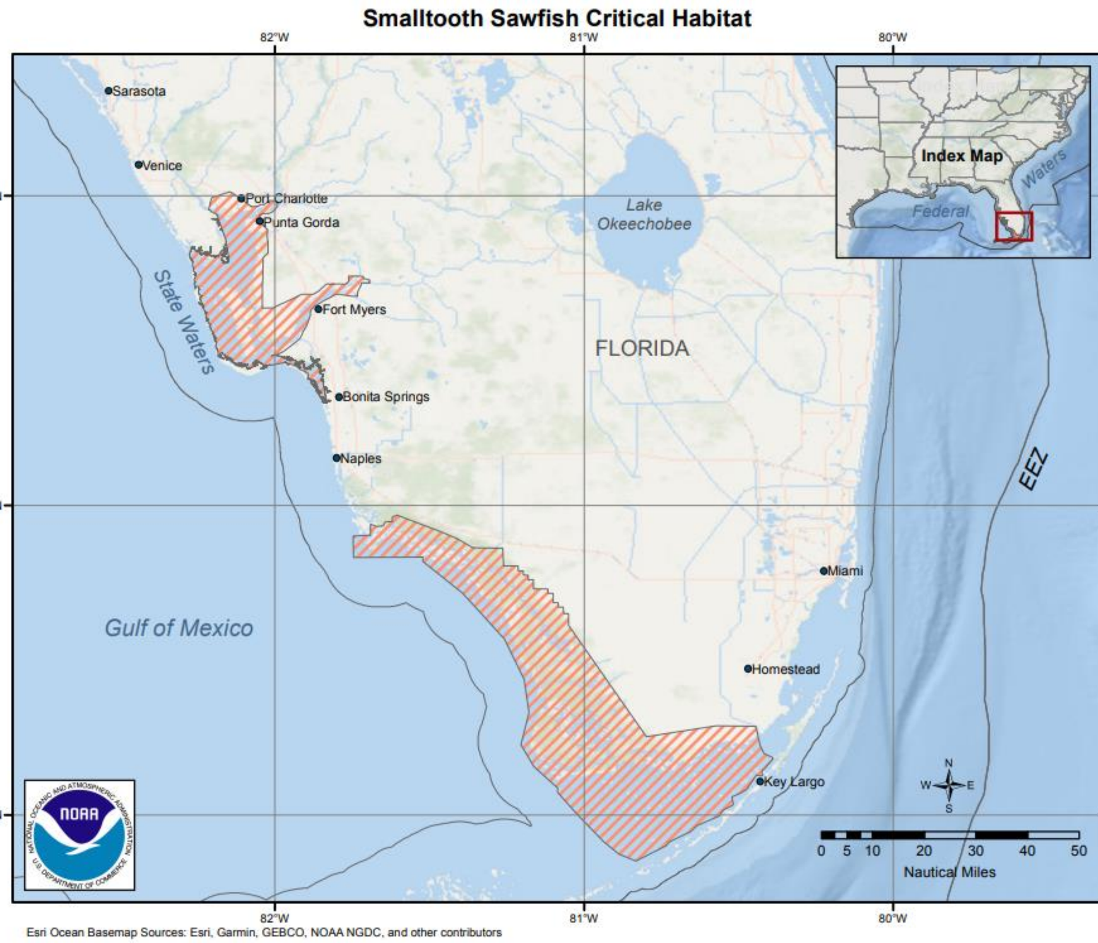
[38] Miller, Margaret H. et al. (2014). Status review report: scalloped hammerhead shark (Sphyrna lewini).
[39] National Oceanic and Atmospheric Administration. (2015). *Endangered and Threatened Species; Determination on the Designation of Critical Habitat for Three Scalloped Hammerhead Shark Distinct Population Segments.* https://www.federalregister.gov/documents/2015/11/17/2015-29262/endangered-and-threatened-species-determination-on-the-designation-of-critical-habitat-for-three
[40] National Marine Fisheries Service. Nassau grouper, Epinephelus striatus (Bloch 1792) : biological report. (2013).
[41] Wiley, Tonya and Brame, Adam (2018). Smalltooth Sawfish (Pristis pectinata) 5-Year Review: Summary and Evaluation of United States Distinct Population Segment of Smalltooth Sawfish.

Figure 3. Smalltooth Sawfish Critical Habitat. Source: NOAA Fisheries[42]



1.1.8 Whitespotted Eagle Ray

The whitespotted eagle ray was recently petitioned to be listed as threatened or endangered under the ESA. It is currently in the 90-day evaluation process. Fishing pressure is a major concern, with added threats from habitat loss and climate change (Defend Them All Foundation 2023)[43].

It is found in tropical to warm temperate waters and is mostly found close to shore. An assessment to determine critical habitat has not yet been completed for the whitespotted eagle ray. The whitespotted eagle ray is subject to all to all potential effects with respect to offshore wind discussed in section 1.2.

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[42] https://www.fisheries.noaa.gov/resource/map/smalltooth-sawfish-critical-habitat-map-and-gis-data

[43] Defend Them All Foundation. Submitted to the US Secretary of Commerce Acting through the National Oceanic and Atmospheric Administration And the National Marine Fisheries Service. (2023). *Petition to List the Whitespotted Eagle Ray (Aetobatus narinari) As Endangered or Threatened Under the Endangered Species Act*

1.2 Potential effects with respect to offshore wind

As a group with varied distributive boundaries, some protected fish are more likely than others to overlap with leased and planned offshore wind areas including cable routes in the Atlantic Ocean. Endangered species are already at risk, so any environmental changes are likely to be more consequential for them. There are multiple potential impacts from offshore wind, and while the switch to renewable energy will slow the effects of climate change in our oceans, wind farm development is likely to negatively affect protected fish. These impacts can be direct or indirect, as there may also be changes to protected fish prey species, local and regional hydrodynamics, or other environmental factors that will in turn effect protected fish. Due to the knowledge gaps regarding protected fish and their life stages, the Subcommittee is aware that there might be unanticipated positive or negative effects.

Offshore wind development will result in the alteration of benthic habitat as a result of hardening, boulder removeal, seabed leveling, dredging, port expansion, and anchoring. Cable placement, scour protection, and the monopiles themselves will all create hard structures where there previously was soft benthic habitat or open water. These alterations and associated changes will have different effects on different species. Loss of large stretches of soft bottom habitat may force species to find different suitable areas to use for habitat, foraging, and other activities. This could result in increased energy expenditures and may decrease individual fitness (Hogan et al. 2023)[44]. The additional hard surfaces will also act as artificial reef structures, providing new habitats and shelter. Structure oriented fish will likely be attracted to the area due to its colonization, which may then to draw in HMS (Degraer et al. 2020)[45]. The increase of fish around each structure may also increase fishing activity, which increases the risk of entanglement in fishing gear, both primarily by ative fishing activity and secondarily through ghost gear that is caught on the hard structures. The alteration of soft benthic habitat will change the ecosystem, and can have both positive and negative effects on different fish species.

A seven-year study on demersal fish and invertebrates was conducted to determine if the Block Island Wind Farm (BIWF) had any beneficial or adverse effects on fish presence in the area. This was the first research of its kind in the United States, as the BIWF was the first US wind farm to be established. Results varied by species, with structure-oriented species having higher capture rates inside the wind farm compared to the reference area following turbine construction. Little skate catch per unit effort decreased while spiny dogfish catches were higher during

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[44] Hogan, Fiona et al. (2023). Fisheries and Offshore Wind Interactions: Synthesis of Science. https://doi.org/10.25923/tcjt-3a69

[45] Degraer, Steven & Carey, Drew & Coolen, Joop & Hutchison, Zoe & Kerckhof, Francis & Rumes, Bob & Vanaverbeke, Jan. (2020). Offshore Wind Farm Artificial Reefs Affect Ecosystem Structure and Functioning: A Synthesis. Oceanography. 33. 48-57. 10.5670/oceanog.2020.405.

construction (Wilber et al. 2022)[46]. An additional study by Wilber et al. (2022)[47] at the BIWF examined the dietary habits of flounder, gadids, and black seabass before construction, during construction, and during operation. They did not find any substantial changes, but noted that mussels and associated mysids were found in diets after construction , indicating their presence on the turbines and foraging by fish. Body condition impacts fluctuated from species to species. For example, silver hake had a slightly higher body condition during operations while multiple species of flounder were found to have decreased body conditions during wind farm operations (Wilber et al. 2022)[48]. While none of the species examined in either Wilber et al. study are protected, the studies give insight as to how different species might react to further wind farm development in the US Atlantic and details the need for further research on this topic.

There has been more research investigating the effect of offshore wind on fish in Europe. Degraer et al. (2018)[49] conducted a study that examined the effects of offshore wind farm construction and operation on fish communities in the North Sea. Overall, they found an increase in fish abundance during the construction phase compared to the time period before construction. There was also a shift in species, where some species became more prevalent, and others less so. There was limited data on effects post-construction. This study highlights that some fish will be attracted to the newly formed hard structures in the water column and their associated hardening of benthic habitats, known as the reef effect. Others may avoid the area, whether it be due to the presence of noise, predators, electromagnetic fields, alterations to the benthic communities, or other factors.

Certain anatomical features of different fish species make them more susceptible to different impacts. For example, sharks, rays, and sturgeon have ampullae of Lorenzini, which are electro-receptive organs, linked to prey detection and navigation. Thus, alterations in ambient electromagnetic fields could impact their ability to feed and migrate normally. The effect of EMF emitted by HVDC subsea cables on Little skate was examined in a study by BOEM, and though Little skate are not protected, this study can help inform the potential behavioral patterns of electro-sensitive species when exposed to EMF introduced by offshore wind farms. The study found that when exposed to EMF, the skates traveled further distances at a slower speed, spent more time closer to the seabed, and made more large turns compared to their

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[46] Dara H Wilber, Demersal fish and invertebrate catches relative to construction and operation of North America's first offshore wind farm, ICES Journal of Marine Science, Volume 79, Issue 4, May 2022, Pages 1274–1288, https://doi.org/10.1093/icesjms/fsac051

[47] Wilber DH, Brown L, Griffin M, DeCelles GR, Carey DA (2022) Offshore wind farm effects on flounder and gadid dietary habits and condition on the northeastern US coast. Mar Ecol Prog Ser 683:123-138. https://doi.org/10.3354/meps13957

[48] Wilber DH, Brown L, Griffin M, DeCelles GR, Carey DA (2022) Offshore wind farm effects on flounder and gadid dietary habits and condition on the northeastern US coast. Mar Ecol Prog Ser 683:123-138. https://doi.org/10.3354/meps13957

[49] Degraer, S., Brabant, R., Rumes, B. & Vigin, L. (eds). 2018. Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: Assessing and Managing Effect Spheres of Influence. Brussels: Royal Belgian Institute of Natural Sciences, OD Natural Environment, Marine Ecology and Management, 136 p.

activity in the control enclosure (Hutchison et al. 2018)[50]. BOEM noted that there is a need to study behavioral responses to higher levels of EMF. Another study examined the effect of submarine HV cables on sub-adult Atlantic sturgeon. Unlike the skate, the sturgeon did not show any significant behavioral changes (McIntyre et al. 2016)[51]. More research is needed on additonal life stages of sturgeon, and other protected fish species to gain a more thorough understanding of the impact that EMF will have on protected fish.

Most teleosts have a swim bladder, which plays an important role in buoyancy maintenance of individual fish. These organs are susceptible to rapid changes in pressure and physical trauma (Gedamke et al. 2016)[52], which can occur through impulsive noise soures which are created during impact pile driving and pre-construction activities such as UXO detonations, HRG surveys, and geotechnical drilling surveys. Multiple studies examined different species of sturgeon and their reaction to high sound pressure levels. Popper et al. (2016)[53] studied the effect of seismic air guns on Pallid sturgeon, and found that single pulses were not lethal, though the effects of multiple exposures remains to be studied. As there will be multiple exposures in each offshore wind farm, and many on a regional scale, this is an important area of continued research. In a study that observed pile driving effects on lake sturgeon, a variety of injuries were reported including a partially deflated swim bladder, renal hematoma, and bruised kidneys (Halvorsen et al. 2012)[54].

In addition to impulsive noise, offshore wind development will add continuous noise to the environment, mainly through wind turbine operation and increased vessel traffic. While continuous noise has lower pressure levels, so is less likely to cause an auditory injury, it can result in other impacts such as behavioral changes and masking of communication. Fish use sound for a variety of activities, including but not limited to, reproduction, feeding, when under threat, and even swimming (Kasumyan 2009)[55]. Noise sources that overlap with the hearing frequency of fish can affect thier ability to communicate via sound, and in some cases have

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[50] Hutchison, Z. L., P. Sigray, H. He, A. B. Gill, J. King, and C. Gibson, 2018. Electromagnetic Field (EMF) Impacts on Elasmobranch (shark, rays, and skates) and American Lobster Movement and Migration from Direct Current Cables. Sterling (VA): US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2018-003.

[51] McIntyre, A.; Janeski, T.; Garman, G.; Deloglos, C.; Filippas, A. (2016). Behavioral responses of sub-adult Atlantic Sturgeon (Acipenser oxyrinchus oxyrinchus) to electromagnetic and magnetic fields under laboratory conditions.

[52] Gedamke, J., Harrison, J., Hatch, L., Angliss, R., Barlow, J., Berchok, C., Caldow, C., Castellote, M., Cholewiak, D., DeAngelis, M. L., Dziak, R., Garland, E., Guan, S., Hastings, M. C., Holt, M., Laws, B., Mellinger, D. K., Moore, S., Moore, T. J., Oleso n, E. M., Pearson-Meyer, J., Piniak, W., Redfern, J. V., Rowles, T., Scholik, A., Smith, A., Soldevilla, M. S., Stadler, J. H., Van Parijs, S. M., & Wahle, C. M. (2016). Ocean noise strategy roadmap. NOAA. Retrieved from https://www.st.nmfs.noaa.gov/cetsound/

[53] Popper AN, Gross JA, Carlson TJ, Skalski J, Young JV, Hawkins AD, et al. (2016) Effects of Exposure to the Sound from Seismic Airguns on Pallid Sturgeon and Paddlefish. PLoS ONE 11(8): e0159486. https://doi.org/10.1371/journal.pone.0159486

[54] Halvorsen MB, Casper BM, Matthews F, Carlson TJ, Popper AN. Effects of exposure to pile-driving sounds on the lake sturgeon, Nile tilapia and hogchoker. Proc Biol Sci. 2012 Dec 7;279(1748):4705-14. doi: 10.1098/rspb.2012.1544. Epub 2012 Oct 10. PMID: 23055066; PMCID: PMC3497083.

[55] Kasumyan, A.. (2009). Acoustic signaling in fish. J. Ichthyol.. 49. 963-1020. 10.1134/S0032945209110010.

direct impacts on their survival. In a study conducted on Ambon damselfish (*Pomacentrus amboinensis*) by Simpson et al. (2016)[56], it was determined that exposure to motorboat sound increased their metabolic rate. This stress response slowed their active response to simulated strikes, and allowed them to be captured by predators at more than twice the rate compared to periods of ambient noise. Size of the turbine and speed of rotation can shift the frequency of created sound. Tougaard et al. (2020)[57] found that turbine operation source levels have lower frequency than ship noise in the same range, though ships move away from the area and turbines remain stationary for the life of the project. Through modeling, they determined that cumulative levels of turbine nosie can be detected up to a few kilometers from the wind farm, with levels shifting in the presence of other loud noise sources (Tougaard et al. 2020)[58]. The farther away a fish is from the turbine or wind farm area, the lower the impact. Due to the regional scale development of offshore wind farms in the study area, operational noise impacts should be studied further.

Any addition of vessels, both in number and in time spent in the area, increases the possibility of vessel strike. Vessel strike of the Atlantic sturgeon and gianta manta ray have been extensively documented (Balazik et al. 2012; Pate and Marshall 2020)[59,60,] but is also listed as a threat to recovery for shortnose sturgeon. Offshore wind development utilizes various types of vessels that range in size and purpose. Current EISs evaluate vessel strike risk based on the estimated increase in vessel number in the project area. The Subcommittee would like to stress the importance of expanding this to include the increased amount of time vessels will be located in the project area, especially if the propellor is constantly running. Size of wheel, depth, and location of vessels should also be assessed with regard to vessel strike in each region.

An increased number of vessels in the area also results in the increase risk of accidental release. This can come in the form of chemical spills, such as fuel and oil, as well release of other trash and debris. Fluids can also leak from turbines and offshore substations themselves. Exposure and/or ingestion of chemicals and debris can negatively impact fish themselves as well as the water quality surrounding the release.

Fish migration and seasonal habitat selection are intrinsically linked to annual oceanographic patterns that vary latitudinally. Any alterations to these patterns or their resulting ecosystem

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[56] Simpson, S., Radford, A., Nedelec, S. et al. Anthropogenic noise increases fish mortality by predation. Nat Commun 7, 10544 (2016). https://doi.org/10.1038/ncomms10544.

[57] Tougaard, Jakob & Hermannsen, Line & Madsen, Peter. (2020). How loud is the underwater noise from operating offshore wind turbines?. The Journal of the Acoustical Society of America. 148. 2885-2893. 10.1121/10.0002453.

[58] Tougaard, Jakob & Hermannsen, Line & Madsen, Peter. (2020). How loud is the underwater noise from operating offshore wind turbines?. The Journal of the Acoustical Society of America. 148. 2885-2893. 10.1121/10.0002453.

[59] Balazik, Matthew & Reine, Kevin & Spells, Albert & Fredrickson, Charles & Fine, Michael & Garman, Greg & Mcininch, Stephen. (2012). The Potential for Vessel Interactions with Adult Atlantic Sturgeon in the James River, Virginia. North American Journal of Fisheries Management. 32. 10.1080/02755947.2012.716016.

[60] Pate, Jessica & Marshall, Andrea. (2020). Urban manta rays: potential manta ray nursery habitat along a highly developed Florida coastline. Endangered Species Research. 43. 10.3354/esr01054.

can have cascading effects on ecosystem function and associated food webs . It is extremely important that effects from offshore wind development, such as wind wakes and associated changes to the thermocline and seasonal nutrient mixing, are fully understood as changes may have large impacts not only on protected fish species but also on the entire ecosystem.

Plumes of turbid water have been observed behind monopiles and further downstream from existing wind farms in Europe. Increased sedimentation also results from potential construction activities such as dredging and port expansion. High levels of suspended sediment in the water can result in a reduction of dissolved oxygen levels in the water. Both decreased oxygen and increased sedimentation in the water can cause physiological stress in Atlantic salmon and Atlantic sturgeon. If the period of exposure increases, the effects of increased turbidity can be lethal (Johnson 2018)[61]. If suspended sediment falls on top of eggs and larvae, they can be buried.

Below, and based on existing research and Subcommittee expertise, the potential short-term and long-term effects of offshore wind on protected fish species are summarized.

Potential short-term effects of offshore wind pre-construction activities

Short term effects from offshore wind are derived from pre-construction activities.

- Noise from seismic surveys

Potential short-term effects of offshore wind construction activities

Short term effects from offshore wind are derived from construction activities.

- Sedimentation/plumes in water column at the turbines and along the cable route
- Impulsive noise from pile driving and HRG surveys
- Exposure to accidental releases
- Exposure to lighting
- Vessel strikes
- Disturbance of benthic habitat from possible leveling, anchoring, boulder removal, dredging and port expansion
- Discharges/intakes/entrainment
- Changes in local hydrodynamic processes

Potential long-term effects of offshore wind operation

[61] Johnson, A. 2018. The Effects of Turbidity and Suspended Sediments on ESA-Listed Species from Projects Occurring in the Greater Atlantic Region. Greater Atlantic Region Policy Series 18-02. NOAA Fisheries Greater Atlantic Regional Fisheries Office. www.greateratlantic.fisheries.noaa.gov/policyseries/. 106p.

Long term effects from offshore wind are derived from operations and maintenance.

- Cumulative impact from the presence of structures in the water column. This includes the piles, turbine masts, scour protection, cable protection, and cables (for floating offshore wind):
    - Changes to oceanography
        - Potential change of ocean stratification and physical water column properties
        - Potential impacts to planktonic prey species
        - Potential impacts on larval transport
    - Artificial reef effect
    - More susceptible to recreational fishing
- Alterations of benthic habitats as a result of hardening, cable placement (including export cables), boulder removal, seabed leveling, dredging, port expansion, anchoring.
- Continuous noise from turbines
- Exposure to accidental releases
- Exposure to chemical contaminants
- Exposure to EMF from cables
- Interaction with or avoidance of monitoring survey gear
- Exposure to lighting

There are additional concerns with regards to project decommissioning and how removing all structures from the water column and seabed will alter the then established environment and associated environmental conditions. These changes will have impacts on species that use created habitat, and expose species to new conditions. It is thought that the impacts of conceptual decomissioning on protected fish may be major. As the life span of each project is expected to be 30 years, the Subcomittee will further investigate potential impacts and research needs for the decommissioning stage at a later date. This includes the review of decommissioned oil and gas platforms in the Gulf of Mexico, the comparison of different methods utilized, and the varying impacts to protected fish populations and their behavior.

All effects discussed in this section have the potential to impact protected fish on the individual project level as well as cumulatively over the broader study area. Both local and regional scale impacts need to be taken into consideration when considering the conservation and management of protected fish species with regard to offshore wind.

1.3 Common data collection methods and approaches

To address the potential effects of offshore wind farm development on protected fish, a variety of methods are currently being employed. The most common method utilized in the RWSC study area for protected fish is acoustic telemetry. Acoustic transmitters are applied to multiple species of protected fish at multiple life stages, and acoustic receivers are stationed along the US Atlantic coast and in some coastal rivers. Some receivers are deployed on bespoke moorings, while others are placed opportunistically on pre-existing structures (such as navigation buoys), which allows for additional detection opportunities. These data are primarily used to understand occupancy, distribution, abundance, residency, rate of movement, and are also being paired with other methods such as eDNA. While it is always beneficial to advance current technologies, the Subcommittee sees great benefit from the better utilization of technologies that are already in existence.

The following categories are used throughout this chapter to describe data collection methods, recognizing that each project is unique and may utilize these methods in varying ways.

Table 4. RWSC Science Plan Actions, Possible Platforms, and Method description. This table summarizes research methods that are currently being used to address research questions with respect to protected fish and offshore wind.

Type of Science Plan Action	Science Plan Action	Possible Platforms	Method Description
Field data collection and analysis	Acoustic telemetry	Animals , Structures that can host receivers	Includes deploying acoustic transmitters on animals and deploying receivers to detect tagged animals.
	Passive Acoustic Monitoring (PAM)	Moorings, Buoys, Gliders, Towed arrays	Hydrophones deployed to record and archive sound produced by animals in the environment. Hydrophones can be stationary or mobile. Reporting can be done in real time or stored and archived.
	Aerial surveys	Planes, Uncrewed vehicles	Standard survey technique. Can be used to count individuals/species and/or to quantify abundance. Of the protected fish, this is mostly utilized for manta rays.
	eDNA	Water samples	Environmental DNA (eDNA) is shed by an organism and can be picked up in the environment. It is currently used to assess presence/absence and gather high level assemblage information[62].

[62] Environmental DNA (eDNA) | US Geological Survey. (2018, June 5). Www.usgs.gov. https://www.usgs.gov/special-topics/water-science-school/science/environmental-dna-edna

	Baited Remote Underwater Videos Stations (BRUVS)	Boats	Deployed in water column or at seafloor and provides visual record of species present in a given area, and some systems can also collect length information. This tool is non destructive and can be used in harder-to-sample areas (e.g., on scour protection).
	Satellite tagging	Animals	Satellite tags are attached to animals, GPS and various environemental data are collected.
	Other tagging	Animals	Different types of tags can be attached to animals internally or externally.
	Acoustic imagery sonar	Boats, Point installations	Side scan sonars, split beam sonars, multibeam sonars and DIDSON/ARIS systems emit beams which result in backscatter that results in seabed imaging.
	Boat-based visual surveys	Boats	Standard survey technique. Can be used to count individuals/species and/or to quantify abundance.
	Opportunistic visual surveys	Aerial, Boats	Surveys that serve another purpose or target other species that opportunistically allow for data collection on protected fish.
	Nets, tows, lines, and traps	Boats	Multiple long standing surveys are conducted along the coast utilizing trawls, longlines, pots/traps, and other fishing gear.
	Holographic camera system	Boats	Records full-field, high resolution distortion-free images in situ.
	Water quality and oceanography	Stationary, Real-time data, Glider	In-situ measurements properties including salinity, dissolved oxygen, temperature, etc.
	Salvage operations	Land-based, Boat-based	Respond to reports of stranded animals (dead or alive/in distress) and take the appropriate steps given the condition of the animal.
	Animal physiology	Boat-based	Physiological measurements including stress hormones from blood, blow, mucus, tissue, fecal samples, etc.

	Biological sampling and measurements	Boat-based	Using captured individuals, collect body measurements and/or samples of biological material such as fin clips.
Non-field actions	Standardizing data collection, analysis, and reporting		Formalization of methods and reporting of methods that should be used to ensure alignment from project to project.
	Historical data collection/compilation		Compiling existing historical data in one place (database) to allow for time series of relevant data collection.
	Outreach and platforms to provide data products and results to stakeholders.		Web based platforms or regional data portals that display the location of existing arrays and receivers, at minimum.
	Coordination and planning		Coordination among all RWSC Subcommittees, the research community, and industry to better utilize all research activities for multiple taxa.
	Manipulative experiments		Multiple replicate experimental units are created and an experimental manipulation (a "treatment") is applied to a random set of these units, with the remaining units being left as controls. This involves ensuring that studies have adequate replication to have a good chance of detecting an observed change of biologically significant magnitude.
	Model development and statistical frameworks		Development and maintenance of species distribution models, habitat suitability models, risk assessment frameworks, population dynamic models, Population Consequences of Disturbance (PCoD) models, cumulative impact assessments, etc.
	Meta-Analysis and Literature Review		Gathering all existing information on protected fish and offshore wind, compiling research priorities, impact literature, assessments of data availability, and life history parameters to estimate effect sizes, variance, and inform models.

	Technology advancement		Includes the development and testing of new field research tools/methods or mitigation options; can also include development of and improvements to data systems.

1.4 Sources of regional-scale distribution information for protected fish

Scientific surveys have taken place region wide for decades. They employ multiple methods, target multiple species, and provide spatial and temporal data for a wide variety of species that they come into contact with. These surveys may encounter various protected fish species, where data is collected, samples are taken, and resuscitation is provided if needed. The federal government, state governments, universities, citizen science programs, and other research organizations have supported this long standing and essential data collection. Tag, sighting, and bycatch data are also collected for some protected fish species, and contribute to what is known about each species. These are all crucial to the monitoring of protected fish, especially given their migration patterns throughout the region.

Despite the long-standing effort, much is still unknown about each protected fish species and all of their life stages. Acoustic telemetry is a data collection method that is regularly deployed for many species of protected fish as well as other taxon in the region. Fish are acoustically tagged in one location, and can be detected in other locations throughout the life of the tag applied. As each entity only monitors their own arrays, researchers collaborate to discover the source of the tags detected on their arrays, and other arrays that their fish are detected on. This allows for an increased knowledge about fish distribution, migration patterns, and seasonality. Many researchers and organizations throughout the region share their tag numbers and location of acoustic arrays to maximize data collection and data sharing. Many researchers utilize data sharing networks and systems, which are described below.

1.4.1 Mid Atlantic Acoustic Telemetry Observation System (MATOS)

"The Mid-Atlantic Acoustic Telemetry Observation System (MATOS) is a web-based tool and database for researchers and natural resource professionals to manage acoustic telemetry data in a searchable, secure database. MATOS allows telemetry researchers to store and share data on acoustic receiver deployments, tag detections, and tag deployments with individuals of their choosing. MATOS users who have uploaded tag deployment data can search the MATOS receiver database to find out where their tags have been detected. The system's mapping capabilities allows users to visualize animal movement. Matos has been designed to be compatible with the Ocean Tracking Network."[63]

1.4.2 Ocean Tracking Network (OTN)

"The Ocean Tracking Network (OTN) is a global aquatic research, data management and partnership platform headquartered at Dalhousie University in Halifax, Nova Scotia, Canada.

[63] What is Matos?. MATOS. (n.d.). https://matos.asascience.com/home/about

OTN's mission is to inform the stewardship and sustainable management of aquatic animals by providing knowledge on their movements, habitats and survival in the face of changing global environments. Since 2008, OTN has been deploying state-of-the-art ocean monitoring equipment and marine autonomous vehicles (gliders) in key ocean locations and inland waters around the world. OTN's technical capabilities expanded in 2020 with the addition of remotely operated vehicles (ROVs) and side scan sonar systems. Researchers around the world are using OTN's global infrastructure and analytical tools to document the movements and survival of aquatic animals in the context of changing ocean and freshwater environments."[64]

1.4.3 The FACT Network

"The FACT Network is a grassroots collaboration of marine scientists using acoustic telemetry and other technologies to better understand and conserve our region's important fish and sea turtle species. The FACT Network originated as the Florida Atlantic Coast Telemetry Network but has since grown to include partners from the Bahamas to the Carolinas and is now known simply as the FACT Network. --It's purpose is to expand the Scale and Cost Effectiveness of Behavioral Studies Through Partnerships and Data Sharing, Encourage New Projects and Student Involvement with an Inclusive Research Atmosphere, and Communicate Findings to Policy Makers and the Public to Guide Coastal Management Decisions."[65]

1.4.4 The Atlantic Cooperative Telemetry Network (ACT)

"A grassroots effort to facilitate data sharing between researchers utilizing acoustic telemetry to gain a greater understanding of a wide variety of aquatic species. What started with 15 researchers working on Atlantic and shortnose turgeon that year has expanded to over 138 from Maine to Florida working with over 95 different species. Researchers maintain their own arrays, so transmitters deployed and array sizes are dependent on seasonal conditions, research needs, and available funding. It is up to the individual researchers to provide information regarding transmitters and arrays. Researches can maintain a level of involvement in the network that is appropriate for their needs and abilities; from just sharing general tag code information to collaborating with other researcher and leveraging other arrays to gain additional funding."[66]

1.4.5 Regional Passive Acoustic Monitoring Network

The RWSC Marine Mammal Subcommittee has been coordinating around the planning and implementation of a regional passive acoustic monitoring network for understanding effects of offshore wind on large whales (e.g., displacement or attraction, changes in behavior).

Not all fish make noises, but those that do would be detected on some of the acoustic systems being deployed to detect large whales. Of the ESA listed fish in the RWSC study area, the

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[64] Home. Ocean Tracking Network. (2023). https://oceantrackingnetwork.org/what-we-do/
[65] Fact network. SECOORA. (2023, June 12). https://secoora.org/fact/
[66] Act. ACT. (2023, February 10). https://www.theactnetwork.com/

Nassau grouper produces sounds that are thought to be made in a period of alarm. Though it is not well understood, Atlantic sturgeon also make noise, and more research should be dedicated to this so that PAM can be better utilized to study them. In addition, many small fish that serve as prey species make sounds that are detected on passive acoustic monitors, and can give a better understanding of the whole ecosystem.

Many of the PAM instruments that are being deployed have also been outfitted with receivers for acoustic telemetry. This is the case for all PAM deployed by the NEFSC. The Protected Fish Species Subcommittee should coordinate with the Marine Mammal Subcommittee to update these existing maps and datasets to make this information more readily available to both groups. Information sharing in this way could also serve to expand the network of acoustic telemetry receivers as opportunities for co-deployment are better understood.

1.4.6 1.4.6 Observer Data and Reports

In the RWSC study area, there are multiple observer programs that collect data from commercial fishing vessels and fish processing plants. The Northeast Fisheries Science Center (NEFSC) Southeast Fisheries Science Center (SEFSC) trains and supports federal observers for their respective regions. Some states also support their own observer programs and data collection. Observer data is essential for the monitoring and conservation of NOAA trust resources, and is used to support stock assessments and fishery management, reduce bycatch, document species, and support the research community. Observers do come into contact with protected fish species, and collect biological information, locational data, and samples (depending on the species).

2 Research Topics: Protected fish and offshore wind in the US Atlantic Ocean

Efforts to address fish and offshore wind have already begun, and this Science Plan hopes to build on existing research to advance the understanding of each of the protected fish species and their interactions with offshore wind farm development. The Subcommittee discussed and recommends data collection and research that would help mitigate and characterize any potential impacts that construction, operation and management, and decommissioning may have on protected fish species.

A key interest of the Subcommittee is to use existing technologies to gain a more thorough understanding of coastal use and migration patterns of all protected fish species, which are currently not well understood.

The Subcommittee also emphasized the need to work with other RWSC Subcommittees to contextualize effects on protected fish within an understanding of effects on other ecosystem components.

Wind turbines themselves provide key areas for study, and the Subcommittee expressed a desire to work with offshore wind companies to better understand how turbines and other structures could house acoustic receivers to add to detection and thus increase the working knowledge about protected fish species and their use in these areas.

The following table lists the RWSC Research Themes, which were decided on by members of multiple RWSC Subcommittees as a way to organize ongoing data collection activities. The research topics and associated reccommendations were articulated based on meetings and correspondence of the Protected Fish Subcommittee as a way to address the research themes as they pertain to protected fish and offshore wind. For additional information abou the organization of this Science Plan, please see Chapter 2: RWSC Science Plan Organization

Table 5. RWSC Research Themes, Research Topics, and science plan actions. This table summarizes science plan actions t investigate research topics which address RWSC research Themes.

		RWSC Science Plan Actions	
RWSC Research Theme	**Research Topic**	**Field data collection methods and analysis**	**Non-field data collection methods and analysis**
Mitigating negative impacts that are likely to occur and/or are severe in magnitude	Evaluate mitigation techniques to limit exposure of protected fish to sedimentation.	Water quality and oceanography	Manipulative experiments, model development and statistical frameworks, Technology advancement
	Understand the increase in vessel traffic (both number of vessels and increased time of vessels in a given area) in offshore wind farm project areas with emphasis on the shallower waters close to ports and estuaries. Also, pair this with the amount and type of light produced by each vessel.	Acoustic telemetry, Satellite tagging, Other tagging, PAM, Aerial surveys, Boat-based visual surveys, Opportunistic visual surveys, eDNA, Salvage operations, etc.	Model development and statistical frameworks, Standardizing data collection, analysis, and reporting
	Better understand the effects of intake and entrainment from HVDC cooling systems on protected fish at all life stages, knowing that some adult species will not be subject to intake or entrainment.	Acoustic telemetry, Satellite tagging	Manipulative Experiments, Historical data collection/compilation, Model development and statistical frameworks
	Assess both primary and secondary entanglement risk to all protected fish species associated with offshore wind. There is the potential for increased recreational fishing near wind turbines	Nets, tows, and lines, Acoustic telemetry, Satellite tagging, Salvage operations	Manipulative experiments, Technology advancement, Model

	which would lead to primary entanglement, as well as an increased possibility of secondary entanglement due to ghost gear and debris attaching to structures in the water. Risk should be assessed for structures associated with both standard and floating offshore wind technologies.		development and statistical frameworks
	Ensure that protected fish species are included in risk modeling that is similarly being applied to other species, e.g., Project WOW	Biological sampling and measurements, Acoustic telemetry, Satellite tagging, Water quality and oceanography	Model development and statistical frameworks, Historical data collection/compilation
	Support the recommendations in the NOAA Fisheries & BOEM Federal Survey Mitigation Strategy	Nets, tows, and lines, Aerial surveys, Boat-based visual surveys, Opportunistic visual surveys	Coordination and planning, Standardizing data collection, analysis and reporting
Detecting and quantifying changes to wildlife and habitats	Collect information on distribution, abundance, behavior, health, reproduction, and other vital population rates of protected fish at all life stages. This includes estuarine and freshwater habitat if the distribution expands into those environments.	Acoustic telemetry, eDNA, satellite tagging, Biological sampling and measurements	Standardizing data collection, analysis and reporting, Coordination and planning, Model development and statistical frameworks
	Utilize historical data collection from multiple sources to generate a baseline of distribution and abundance of protected fish species.		Historical data collection/compilation, Outreach and platforms to provide data products and results to stakeholders, Model development and statistical frameworks
	Coordinate with the Marine Mammal Subcommittee to co-locate acoustic telemetry receivers within a regional long-term archival Passive Acoustic Monitoring network in the US Atlantic Ocean	Acoustic telemetry, PAM	Coordination and planning, Standardizing data collection, analysis, and reporting, Historical data collection/compilation
	Utilize existing projects and gear primarily used for other purposes to increase knowledge on protected fish.	Acoustic telemetry, Boat-based visual surveys, Opportunistic visual surveys, Net, tows, and lines	Standardizing data collection, analysis and reporting, Coordination and planning

Understanding the environmental context around changes to wildlife and habitats	Identify protected fish species habitats and assess the connectivity (movement of individuals) between these habitats.	Acoustic telemetry, Satellite tagging, Other tagging, Holographic camera system, eDNA	Standardizing data collection, analysis and reporting, Model development and statistical frameworks
	Work with the Habitat & Ecosystem Subcommittee to ensure that key oceanographic and habitat data are collected and available to use in coordination with studies on protected fish.	Water quality and oceanography	Coordination and planning; Standardizing data collection, analysis, and reporting
	Work with other Subcommittees to gain a more thorough understanding of whether or not/to what degree turbines and wind farms alter the hydrodynamics, benthic habitat distribution, food resources, stratification and mixing both at the local level directly behind the wind farm and at the cumulative regional level.	Water quality and oceanography, Nets, tows, and lines	Coordination and planning
	Determine any changes in protected fish species related to wind farm construction, operation, and/or maintenance. This includes attraction/avoidance, residency, feeding, fitness, use of area.	Acoustic telemetry, Satellite tagging, Other tagging, PAM, Aerial surveys, Boat-based visual surveys, eDNA, Nets, tows, and lines, Biological sampling and measurements	Coordination and planning; Standardizing data collection, analysis, and reporting, Historical data collection/compilation
	Examine all protected fish species life stages to see if there are any major changes brought on by wind farms. Noted that this is only possible if we have a more thorough baseline understanding of protected fish species and their life stages.	Acoustic telemetry, PAM, Aerial surveys, eDNA, Satellite Tagging, Boat-based visual surveys, Holographic camera system, Nets, tows, and lines, Biological sampling and measurements	Coordination and planning, Standardizing data collection, analysis, and reporting, Historical data collection/compilation, Model development and frameworks
	Examine the effects of EMF on all protected fish species, especially chondrichthyes and sturgeon to see if migration patterns or feeding has been altered in any way.	Acoustic telemetry, Satellite tagging, Boat-based visual surveys, Biological sampling and measurements	Manipulative Experiments, Standardizing data collection, analysis, and reporting, Coordination and planning

	Distinguish (to the best extent possible) between shifts caused by other factors such as climate change.	Acoustic telemetry, Satellite tagging, Other tagging, PAM, Aerial surveys, Boat-based visual surveys, eDNA, Nets, tows, and lines	Model development and statistical frameworks, Historical data collection/compilation, Standardizing data collection, analysis, and reporting
Enhancing data sharing and access	Create an inventory of all ongoing data collection and research projects for protected fish species and offshore wind to encourage a coordinated approach to regional-scale analysis and planning future work.		Coordination and planning, Standardizing data collection, analysis, and reporting, Outreach and platforms to provide data products and results to stakeholders
	Coordinate data collection with projects focused on other taxa (e.g. highly migratory species, sea turtles).		Coordination and planning
	Coordinate data collection and synthesis of existing data efforts at a regional scale including baseline data, population monitoring, and data collected at individual OSW project sites (e.g., post-construction monitoring data) and facilitate pooling of data to obtain the statistical power to examine regional-scale effects		Coordination and planning, Standardizing data collection, analysis, and reporting
	Make locations of acoustic arrays and receivers public and create shared maps for research planning.		Coordination and planning, Outreach and platforms to provide data products and results to stakeholders, Historical data collection/compilation

3 Regional-scale ongoing, pending, and recommended research and data collection activities in the US Atlantic Ocean for protected fish and offshore wind

3.1 Field data collection and analysis

RWSC is organized by subregion along the US Atlantic coast, roughly aligned with current offshore wind development planning areas. RWSC subregions and map are described on page 2 of Chapter 2: Science Plan Organization. Every wind energy area is in a very different ecosystem, though most lie in close proximity to critical estuaries. Given the diversity of each subregion, impacts are likely to be unique to each wind energy area. With this in mind, many protected fish are distributed across multiple subregions and it is important to gain a regional perspective on the changing environments. This section includes projects that span the entire US Atlantic coast/RWSC study area. Projects that are limited to a specific location are found in subsequent sections corresponding to each RWSC subregion.

Throughout the region, PAM deployments for marine mammals may also have acoustic telemetry receivers attached. Detailed information about PAM deployments can be found in the Marine Mammal chapter, though their maps and spreadsheet of PAM locations may not yet capture which monitors are also outfitted with receivers.

Every five years, the status (i.e., threatened or endangered) of ESA-listed fish is reviewed to ensure they maintain the appropriate level of protection under the ESA. The reviews assess whether a species' status has changed since the time of its listing or its last status review, and whether it should be classified differently or delisted. Information gathered during those reviews can help inform management activities intended to support species recovery. Stranding and bycatch data also contribute to distribution information on a regional scale

Each year, NOAA Fisheries funds states' proposals for endangered species research. Projects are announced and recommended for funding on the NOAA Fisheries' Funded Species Recovery Grants to States Proposals page.

Below is a list of region-wide ongoing and pending projects as well as research recommendations from the Subcommittee.

Table 6. Ongoing and Pending Regional Field Data Collection and Analysis. Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Nets, tows, lines, and traps	Northeast Regional Habitat Assessment Data Explorer tool - state and coastal trawl data on US Atlantic coast	Mid-Atlantic Fishery Management Council, New England Fishery Management Council		**Detecting and quantifying changes to wildlife and habitats**
	RPS Multi-Client Survey*	RPS Group	June 2022 - June 2024	

Data Portal	Support for Regional Wildlife Science Collaborative Ocean Portal Products and Services	BOEM, RWSC	Projected Start September 2023	**Outreach and platforms to provide data products and results to stakeholders**
Technology Advancement, Meta-Analysis and literature review	SoundCoop (Passive Acoustic Monitoring National Cyberinfrastructure Center)	NOAA National Centers for Environmental Information	January 2021 – December 2024	**Enhancing data sharing and access**

**The Subcommittee knows that this project exists but currently have little information about it. Principal Investigator contacted.*

Recommendations

Collect information on distribution, abundance, behavior, health, reproduction, and other vital population rates of protected fish at all life stages. This includes estuarine and freshwater habitat if the distribution expands into those environments.

- It is imperative to gain a better understanding of protected species and their migration patterns to assert when and how they are most likely to use the WEAs. Due to the differing ecosystems across the region, and migrations of multiple species of protected fish, it is important that this is done on a region-wide scale for all protected fish species.
- Continue collecting data on protected fish species using current acoustic and satellite telemetry tags and arrays.
    - There are currently many acoustic and satellite telemetry projects occurring throughout the region, including both tagging activities and array monitoring. Fish that are tagged in one subregion are detected in other regions, making this a regional need. The Subcommittee would like to stress the importance of continuing this work.
    - Deploy fine-scale acoustic and satellite telemetry arrays in every leased and proposed Wind Energy Area. This should be paired with acoustic and satellite tagging of protected fish to gain a better understanding of habitat use within each wind energy area. This will also allow researchers to identify any changes in residency or usage of the area by protected fish species.
    - Monitoring of these arrays should start prior to construction when possible, and continue to be monitored throughout the construction period, during operations, as well as during and after decommissioning. This will create a time series, where any change will become apparent.
        - Modeling can be paired with this deployment.
        - Note that tags have limited operating time, so tagging operations will need to continue throughout the life of each project.
- Biological sampling, body measurements and additional metrics will give a more thorough understsanding of each species and life stage.

    - Collected as part of directed studies, or opportunistically when a protected fish species is captured on a scientific survey.

Utilize existing projects and gear primarily used for other purposes to increase knowledge on protected fish.

- Expanding the Buoys of Opportunity Project to other regions outside of the Gulf of Maine. This involves adding acoustic recievers to structures already in the water to expand knowledge on migration patterns and distribution.
    - Require coordination with other entities such as federal agencies, states, researchers, fishermen, industry, eNGOs, etc. to know when and where receivers can be installed.

Understand the increase in vessel traffic (both number of vessels and increased time of vessels in a given area) in offshore wind farm project areas with emphasis on the shallower waters close to ports and estuaries. Also, pair this with the amount and type of noise and light produced by each vessel.

- Increase knowledge on vessel type and activity that leave all protected fish, with emphasis on sturgeon, most susceptible to vessel strike.
    - Increase understanding of coastal transfer and test mitigation measures to prevent vessel strikes. Areas of focus would be for vessels traveling close to shore, near the estuarine environment, in known migration corridors and other areas of spatiotemporal overlap.
        - Expand the scope of current studies on risk to vessel strike. Instead of focusing only on the number of additional vessels per area, target studies on the amount of time propellors are spinning in place, different wheel sizes, and different depths where vessels are present for to each OSW project.
    - Develop tools to better understand if/when vessel strikes occur as well as a standardized reporting platform for vessel strikes of protected fish.
        - Encourage voluntary reporting and data collection for known vessel interactions with protected fish, particularly sturgeon.
    - Develop analyses of vessel and protected fish species co-occurrence that model nearshore vessel traffic and changes to ambient light conditions that could alter fish behavior.
    - Provide increased funding for salvage operations and stranding programs, particularly for Atlantic sturgeon.
        - Stranding hotlines and programs already exist for some protected fish species. However, these programs are largely underfunded, and lack the personell and resources to attend to all reports.
            - Fully studying strandings, both dead and alive, will give researchers a better understanding as to what is affecting the populations in each region and insight as to how to best mitigate these effects.

        - The Subcommittee would like to work with the RWSC Marine Mammal and Sea Turtle Subcommittee to discuss and potentially develop a reporting system for proteced fish strandings, similar to what is currently done for Marine Mammals and Sea Turtles.
- Conduct in situ examinations of noise impacts to protected fish species.
    - All impulsive and continuous noise sources.
        - Impact pile driving, vibratory pile driving, boat noise, turbine operational noise, aircraft, HRG surveys, cable laying activity, etc.

Examine all life stages to see if there is any major changes brought on by wind farms; Determine any changes in protected fish species behavior related to construction. This includes attraction/avoidance, residency, feeding, use of area.

- Again, the prioritziation of baseline data collection for all life stages of all protected fish species is needed in order to determine if changes can be attributed to offshore wind- see the section above titled "Collect information on distribution, abundance, behavior, health, reproduction, and other vital population rates of protected fish at all life stages. This includes estuarine and freshwater habitat if the distribution expands into those environments."
- Design acoustic telemetry studies to optimally detect changes in protected fish species behavior during construction and operation of offshore wind projects.
    - To study early life stages, use dispersal models and plankton cameras.
- Conduct studies in each WEA as well as cable landings/approaches that are most appropriate to the potential alterations to each ecosystem in which they are proposed

Examine the effects of EMF on all protected fish species at each life stage, especially chondrichthyes and sturgeon to see if migration patterns or feeding has been altered in any way.

- Conduct directed studies in situ of effects of EMF from transmission cables on protected fish species occurrence, movement, behavior, and feeding patterns.
    - Studies on EMF have already begun, the Subcommittee would like to build upon current research, and use researcher recommendations such as exposing animals to higher levels of EMF.
    - Research methods should be standardized so that similar studies at each wind energy area can effectively inform the assessment of potential impacts at the regional scale.
    - Studies should be conducted at wind energy areas or sites that mimic wind energy area
        - Cables buried to standard burial depth.
        - Areas where burying the cable is not possible or full burial depth is unable to be achieved.
            - The latter should be prioritized as there is higher potential risk for protected fish species interaction.

Assess both primary and secondary entanglement risk to all protected fish species associated with offshore wind. There is the potential for increased recreational fishing near wind turbines which would lead to primary entanglement, as well as an increased possibility of secondary entanglement due to ghost gear and debris attaching to structures in the water. Risk should be assessed for structures associated with both standard and floating offshore wind technologies.

- Test methods to make lines in the water more visible to megafauna and more rigid to mitigate entanglements.
  - Mantas do not see well, so anything that would make the cables easier to see will be beneficial.
- Continue to support and fund research and testing of ropeless gear to limit the amount of gear in the water.

Distinguish (to the best extent possible) between shifts caused by other factors such as climate change and fisheries.

- The Subcommittee would like to emphasize that without a more thorough comprehension of each life stage of all protected fish species, it will be extremely difficult to distinguish between shifts in species caused by offshore wind versus non offshore wind activities such as climate change and fisheries.
  - Collecting long term data series before and construction will aid in the ability to to distinguish shifts caused by different factors.
- Additional monitoring is needed.

3.2 Coordination and planning

The following activities include the active coordination and planning that occurs through RWSC via the Protected Fish Subcommittee as well as other regional-scale organizations that include protected fish species in their scopes.

Ongoing and pending activities

NOAA Fisheries & BOEM Federal Survey Mitigation Strategy – Northeast US Region: NOAA Fisheries' scientific surveys collect data used in hundreds of species stock assessments and are critical to the agency's responsibility for stewardship of the nation’s living marine resources including fisheries, marine mammals, endangered and threatened species, and the habitats and ecosystems that support these species. These assessments rely on more than 50 long-term, standardized surveys, many of which have been ongoing for more than 30 years. The Federal Survey Mitigation Strategy guides the development and implementation of a program to mitigate impacts of wind energy development on scientific surveys (including both vessel and aerial surveys) over the expected full duration (30+ years) of wind energy development from Maine to North Carolina.

Recommendations

Coordinate data collection and synthesis of existing data efforts at a regional scale including baseline data, population monitoring, and data collected at individual OSW project sites (e.g.,

post-construction monitoring data) and facilitate pooling of data to obtain the statistical power to examine regional-scale effects.

- Provide for means to incorporate future acoustic telemetry and make these data publicly available.
- Coordinate with developers across the region.

Coordinate data collection with projects focused on other taxa (e.g. highly migratory species, sea turtles).

- Coordinate with the Marine Mammal Subcommittee to co-locate acoustic telemetry receivers within a regional long-term archival Passive Acoustic Monitoring network in the US Atlantic Ocean
    - In collaboration with the Marine Mammal Subcommittee, maintain a shareable database and/or map of the coordinates of acoustic telemetry receivers that may be co-located with bottom-mounted PAM hydrophones, and in collaborating with ROSA, do the same for other acoustic telemetry receivers.
    - RWSC staff will coordinate across Marine Mammal and Protected Fish Species Subcommittees to ensure that funders and researchers are aware of opportunities to collaborate on co-deployment of sensors.
- Use Sea Turtle Subcommittee meetings and meetings with ROSA as forums to collaborate on data collection strategies.
    - Currently, there are many sea turlte tags that are detected on arrays primarily set up to study protected fish. This is a great data source for turtle researchers, and should be utilzied to its full extent.
        - Given this information, it is likely that tagged protected fish are detected on sea turtle arrays and this data can and should be incorporated into existing data sets.
- Coordinate with national laboratories and other organizations to develop a database on all research regarding protected fish and offshore wind.
    - Regions that are further behind (time-wise) in development can use existing knowledge to advance technologies and practices to limit negative effects on protected fish.

Work with other Subcommittees to gain a more thorough understanding of whether or not/to what degree turbines and wind farms alter the hydrodynamics, benthic habitat distribution, food resources, stratification and mixing both at the local level directly behind the wind farm and at the cumulative regional level.

- View relevant research topics and recommendations in the Habitat & Ecosystem Chapter
- Work with the Habitat & Ecosystem Subcommittee to ensure that key oceanographic and habitat data are collected and available to use in coordination with studies on protected fish.
- Identify oceanographic and habitat variables of interest with respect to mapping and modeling protected fish species distribution, movement, etc.

Mitigating negative impacts that are likely to occur and/or are severe in magnitude - Ensure that protected fish species are included in risk modeling that is similarly being applied to other species, e.g., Project WOW

- Population Viability Analyses
- Population Consequences of Disturbance (PCOD)
- Population Consequences of Multiple Stressors (PCOMS)

3.3 Standardizing data collection, analysis, and reporting

This section identifies existing entities that colect data and/or provide guidance for standardizing data collection, analysis, and reporting.

Table 7. Ongoing and Pending Regional Stardization of Data Collection, Analysis, and Reporting. Click project names to view full descriptions.

Method(s) and data type(s)	Repository
RWSC Protected Fish Subcommittee	The Protected Fish Subcommittee will maintain situational awareness of data collection and research in the US Atlantic Ocean by coordinating with the entities and groups described in this Science Plan. The Subcommittee will meet regularly to share information and track Science Plan progress.
The Responsible Offshore Science Alliance:	ROSA is a nonprofit organization established in 2019 that leads a collaborative effort to advance research and monitoring on the potential effects of offshore wind on fisheries. is a nonprofit organization dedicated to regional research on the potential impacts of offshore wind on fisheries. They cover Maine serve as an objective meeting place where all sectors can collaborate on science to better inform interactions between the two industries. Our vision is the joint development of data that will enable effective decision-making and policy. We have been building foundational structures to support regional science: defining research priorities, producing tools, and creating the scaffolding to enable collaboration. More than 100 representatives from the fishing industry, offshore wind development, academia, state and federal agencies, and other sectors are now actively working together to advance regional research.
Maine Offshore Wind Research Consortium:	In 2021, the governor and legislature in Maine established the Maine Offshore Wind Research Consortium to better understand the local and regional impacts of floating offshore wind power projects in the Gulf of Maine. The statute directs the Governor's Energy Office (GEO) to serve as the coordinating agency and outlines an Advisory Board with representation from fisheries interests, and the Department of Marine Resources (DMR) and including other state agencies and stakeholders. The Advisory Board is responsible for establishing a research strategy that at a minimum includes the following themes: Opportunities and challenges caused by the deployment of floating offshore wind projects to the existing uses of the Gulf of Maine; Methods to avoid and minimize the impact of floating offshore wind projects on ecosystems and existing uses of the Gulf of Maine; and ways to realize cost efficiencies in the commercialization of floating offshore wind projects. The Maine Offshore Wind Consortium will collaborate closely with other states and regional and national science and research partners, including the National Offshore Wind Research and Development Consortium,

	and the Regional Wildlife Science Collaborative, of which the Governor's Energy Office is a member.
Massachusetts Habitat Working Group on Offshore Wind Energy:	To augment the BOEM Intergovernmental Task Force process and engage directly with key stakeholders, the Executive Office of Energy and Environmental Affairs and the Massachusetts Clean Energy Center (CEC) convenes two working groups for marine habitat and fisheries issues. While the working groups are voluntary and informal, they provide a critically important forum for maintaining a dialogue with key stakeholders, getting their feedback and guidance, and identifying issues and concerns. Input from the working groups has directly resulted in accommodations to avoid important marine habitat, fishing grounds, and marine commerce routes in the designation of the wind energy lease areas. The working groups will continue to provide valuable advice as leaseholders proceed through the next phases of the BOEM wind energy commercial leasing process, including site assessments, environmental and technical reviews, and development of construction and operations plans. The Habitat Working Group on Offshore Wind Energy is comprised of scientists and technical experts from environmental organizations, academia, and state and federal agencies.
NYSERDA Environmental Technical Working Group	The 2018 Offshore Wind Master Plan for New York included the development of collaborative, science-focused Technical Working Groups to advise the State about offshore wind energy development. As defined in the Plan, the Environmental Technical Working Group (E-TWG) advises the State about "measures to avoid, minimize, and mitigate anticipated impacts on wildlife during offshore wind energy development activities," including: Development of wildlife best management practices; Identification of research needs and coordination; Multi-agency coordination for adaptive management; Creation of a framework for an environmental conservation fund. The E-TWG meets up to four times annually. New York State Energy Research and Development Authority (NYSERDA) and other state agencies provide the E-TWG with oversight and direction, and use group recommendations and discussions to inform decision making.
New Jersey Research & Monitoring Initiative	The Research and Monitoring Initiative (RMI) addresses the need for regional research and monitoring of marine and coastal resources during offshore wind development, construction, operation and decommissioning as recommended in the New Jersey Offshore Wind Strategic Plan. Initial funding is provided by developers through New Jersey's Offshore Wind Solicitation 2. The RMI is administered by the NJ Department of Environmental Protection in collaboration with the NJ Board of Public Utilities. The goal of the RMI is ensure that New Jersey adheres to the mandate to protect and responsibly manage its coastal and marine resources as it moves towards a clean energy economy.
NOAA Fisheries and BOEM Federal Survey Mitigation Strategy – Northeast US Region	NMFS Long-term protected species, fisheries, and ecosystem surveys form the backbone of the scientific monitoring system needed for the managemet of wildlife, fisheries, habitats, and ecoystems. In order understand potential changes in wildlife and habitats from offhore wind energy development--it is critical that long-term standarized surveys continue to provide timely, accurate, and precise data on wildlife, habitats, and ecosystems. The need to fully implement the NMFS and BOEM Survey Mitigation Strategy is critical to putting site and regional level studies in the context of population trends and ecosystem conditions. The Strategy calls for the development of a Northeast Survey

	Mitigation Program. This is largely unfunded but it is highlighted as a signficant priority for the region.

Recommendations

Collect information on distribution, abundance, behavior, health, reproduction, and other vital population rates of protected fish at all life stages. This includes estuarine and freshwater habitat if the distribution expands into those environments.

- With ROSA, MATOS, ACT, FACT Network, the research community, and others to convene an Offshore Wind & Acoustic Telemetry Data Collaborative with goals to coordinate on the deployment of acoustic telemetry receivers and acoustic and satellite tags to protected fish species (especially Atlantic sturgeon), and other species of focus within ROSA (e.g., highly migratory species, Atlantic cod) and RWSC (e.g., sea turtles) in the context of offshore wind development. The Data Collaborative would ensure that data are collected and stored consistently such that data can be pooled to develop a set of standardized data products that represent metrics such as distribution, abundance, occupancy, and/or movement.

Make locations of acoustic arrays and receivers public and create shared maps for research planning.

- Require that all new tags/groups submit their data to the Animal Telemetry Network and/or appropriate regional nodes in an agreed upon time frame to allow for publishing. This collection of data will allow for a wider understanding of protected fish species. Data could potentially be utilized in a new and innovative way in the future.
    - Work with researchers and industry to develop a reasonable time frame for data to be submitted.
        - Create process for requesting time extensions on data submission.
    - Encourage industry to require participation in regional networks and make it a condition of funding.

Create an inventory of all ongoing data collection and research projects for protected fish species and offshore wind to encourage a coordinated approach to regional-scale analysis and planning future work.

- Hold a series of special meetings of the Projected Fish Species Subcommittee and ROSA to share details around ongoing funded research and data collection activities related to acoustic telemetry studies of fish species (protected and other) and to identify opportunities for collaboration (on topics including study design, data management, use of results and data product development).
- Informed by the meetings detailed above, convene an Offshore Wind & Acoustic Telemetry Data Collaborative with MATOS, additional members of the research community, and others,with goals to coordinate on the deployment of acoustic telemetry receivers and acoustic and satellite tags to protected fish species (especially

Atlantic Sturgeon), and other species of focus within ROSA (e.g., highly migratory species, cod) and RWSC (e.g., sea turtles) in the context of offshore wind development. The Data Collaborative would ensure that data are collected and stored consistently such that data can be pooled to develop a set of standardized data products that represent metrics such as distribution, abundance, occupancy, and/or movement.
- Ensure that funding is available for meetings and coordination. There are great benefits to collaboration, but participation in meetings takes time away from other activities and will require compensation for continued responsibility.

Support the recommendations in the NOAA Fisheries & BOEM Federal Survey Mitigation Strategy. In collaboration with NOAA Fisheries and BOEM, ensure that the recommendations related to protected fish species surveys in the NOAA Fisheries & BOEM Federal Survey Mitigation Strategy are implemented.

- It is a major priority to support the implementation of the NOAA Fisheries & BOEM Federal Survey Mitigation Strategy in the northeast.
    - As offshore wind development expands into different regions, a strategy for the southeast will need to be developed and implemented.
- In collaboration with NOAA Fisheries and BOEM, ensure that the recommendations related to protected fish species surveys in the NOAA Fisheries & BOEM Federal Survey Mitigation Strategy are implemented.
    - This includes wind energy monitoring throughout the life of each project.
- Funding and resources will need to be given to address project level and cumulative effects of offshore wind farms to scientific surveys.
    - Work with the technology Subcommittee to implement any technological advancements that may be required to continue the long-standing data collection in areas that are no longer accessible or are accessible in a limited extent that will influence continuity of surveys.

3.4 Historical data collection/compilation

To our knowledge, there are currently no active historical data compilation projects in the region for protected fish. There is a benefit to adding existing data to modern databases so that historical data can be used in long-term/time-series analyses and studies.

Recommendations

Better understand the effects of intake and entrainment from HVDC cooling systems on protected fish at all life stages, knowing that some adult species will not be subject to intake or entrainment.

- Compile existing data from the hydropower industry to see how all life stages of fish are impacted with particular emphasis on impingement and entrainment of the early life stages.
    - Power plants and similar projects are required to collect this data. Compiling it will be extremely beneficial to learn about the impact to protected fishes species

especially in their younger life stages. This information can be applied to offshore wind farm development.

Utilize historical data collection from multiple sources to generate a baseline of distribution and abundance of protected fish species.

- Identify repositories and existing datasets that relate to protected fish species and assess their utility.
    - Depending on the temporal range and density of data available, there is the potential to evaluate how the baseline has changed over time.
- The importanctof advancing the baseline knowledge on all protected fish species and their life stages has been reitterated throughout this document. Compiling all available data is a good building block for this process and can help to identify knowledge gaps and inform future research projects.

3.5 Model development and statistical frameworks

The following activities include the development and maintenance of species distribution models, habitat suitability models, risk assessment frameworks, population dynamic models, Population Consequences of Disturbance (PCoD) models, cumulative impact assessments, etc.

Ongoing and pending activities

Breece et al. (2018)[67] developed habitat modeling of Atlantic sturgeon based on satellite data and fisheries independent biotelemetry observations in the mid-Atlantic Bight. It is recommended that this model be utilized for management activities with regard to protected fish and offshore wind species.

Recommendations

Evaluate mitigation techniques to limit exposure of sedimentation.

- Use models that predict patterns of sedimentation/resuspension to estimate potential impacts to protected species.
    - These can be used to advanced current mitigation measures and investigate the development of new measures.

Ensure that protected fish species are included in risk modeling that is similarly being applied to other species, e.g., Project WOW.

∉ Population Viability Analyses
∉ Population Consequences of Disturbance (PCOD)
∉ Population Consequences of Multiple Stressors (PCOMS)

[67] Breece, M.W., Fox, D.A., Haulsee, D.E., Wirgin, I.I. and Oliver, M.J., 2018. Satellite driven distribution models of endangered Atlantic sturgeon occurrence in the mid-Atlantic Bight. ICES Journal of Marine Science, 75(2), pp.562-571.

Better understand the effects of intake and entrainment from HVDC cooling systems on protected fish at all life stages, knowing that some adult species will not be subject to intake or entrainment.

- Model potential impacts of intake and entrainment from HVDC cooling systems to protected fish species.

Understand the increase in vessel traffic (both number of vessels and increased time of vessels in a given area) in offshore wind farm project areas with emphasis on the shallower waters close to ports and estuaries. Also, pair this with the amount and type of light produced by each vessel.

- See section 3.1 Field data collection and analysis recommendations for additional information on this topic.
    - Model the impacts of vessels on protected fish, primarily sturgeon.

Continually evaluate the performance of existing models and statistical frameworks.

- Update as more data and knowledge becomes available.
- Use validation and evaluation results to continually inform and advance model/framework development and application.

3.6 Technology advancement

The following activities include the development and testing of new field research tools/methods or mitigation options; can also include development of and improvements to data systems.

- eDNA technology/methodology development is a tool that continues to rapidly advance, particularly in the accurate and precise assessment of fish population abundance
- Holographic camera systems are recording full-field, high resolution distortion-free images in-situ
    - Machine Learning algorithms have been developed and are being used to identify Atlantic Sturgeon Larvae for the Identification of sturgeon larvae with an autonomous holographic camera system, in the Central Atlantic Subregion.

Recommendations

- Maintain and expand the widespread use of already existing technologies such as acoustic and satelite telmetry.
- Continue to advance technologies to study protected fish distribution and abundance such as eDNA, holographic camera systems, and machine learning.
- Work with the RWSC Technology Subcommittee to stay up to date on all technological advancements and incorporate them into protected fish research.

3.7 Manipulative experiments

Recommendations

Examine the effects of EMF on all protected fish species, especially chondrichthyes and sturgeon to see if migration patterns or feeding has been altered in any way.

- Conduct directed studies laboratory studies of effects of EMF from transmission cables on protected fish species occurrence, movement, behavior, and feeding patterns.
- Research methods should be standardized so that similar studies at each wind farm can effectively inform the assessment of potential impacts at the regional scale.

Understand the amount and type of light produced by each vessel.

- Conduct manipulative experiments to examine the noise impacts to protected fish species.

4 Gulf of Maine ongoing, pending, and recommended research and data collection activities for protected fish and offshore wind

4.1 Focal species and habitats of interest

The Gulf of Maine has a range of marine habitats from deep sea canyons to rocky intertidal zones. These habitats support a wide variety of marine organisms including multiple species of protected fish. The Gulf of Maine connects rivers that are the only remaining wild habitat for Atlantic salmon and are included in the range for Atlantic and shortnose sturgeon and other protected fish species. The range of Atlantic salmon continues east to Canada, so collaboration is needed with international organizations.

4.2 Potential effects of concern

The Gulf of Maine is warming faster than 99% of the waters (Whitney et al. 2022)[68], meaning that the habitat many protected fish species rely on is rapidly changing, potentially altering their ability to fully utilize this space in the future. Warming and other changes to the ecosystem could also allow different species to expand their range into the warmer waters.

The Gulf of Maine is well suited for floating offshore wind due to the availability of wind energy in its deeper waters. Planning for offshore wind in these areas is moving full steam ahead. Many of the same impacts from traditionally anchored piles will apply to floating offshore wind, with the addition of the floating technology that stabilizes the turbines using different techniques and engineering. Some floating systems require additional mooring lines that span

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[68] Whitney, N.M., Wanamaker, A.D., Ummenhofer, C.C. et al. Rapid 20th century warming reverses 900-year cooling in the Gulf of Maine. Commun Earth Environ 3, 179 (2022). https://doi.org/10.1038/s43247-022-00504-8

the water column. While the mooring lines are likely to be thick, they do run the risk of snagging debris and ghost fishing gear, which presents additional risks to protected species.

4.3 Field data collection and analysis

Table 8. Ongoing and Pending Field Data Collection and Analysis in the Gulf of Maine. Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Passive Acoustic Monitoring	NOAA Fisheries Northeast Fisheries Science Center Passive Acoustic Monitoring in the Gulf of Maine	NOAA Fisheries Northeast Fisheries Science Center	March 2020 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Cross-taxa Assessment of Habitat Use and Connectivity Relative to Marine Protected Areas in the Gulf of Maine: Implications for Management	Massachusetts Division of Marine Fisheries, NOAA Fisheries, funded by NCCOS	June 2021 - December 2025	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Naval Undersea Warfare Center (NUWC) Kennebec River and Offshore Acoustic Telemetry Monitoring	Naval Undersea Warfare Center Newport, State of Maine Department of Marine Resources	May 2021 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Merrimack River sturgeons	Merrimack River, Watershed Council, Maine Department of Marine Resources, Massachusetts Division of Marine Fisheries, Massachusetts Division of Fisheries and Wildlife, University of Maine,	April 2008 - December 2025	**Detecting and quantifying changes to wildlife and habitats**

		Massachusetts Natural Heritage Endangered Species Program, National Marine Fisheries Service, New Hampshire Fish and Game Department, New England University, Portsmouth Naval Shipyard		
Acoustic telemetry, Passive acoustic monitoring - archival	NOAA Fisheries Northeast Fisheries Science Center Soundscape and Acoustic Telemetry Monitoring in Stellwagen Bank National Marine Sanctuary	NOAA Fisheries, NOAA Office of National Marine Sanctuaries, US Navy	November 2018 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Tracking seasonal movements of anadromous fishes in the Saco River system using acoustic telemetry	University of Maine, Maine DMR, USGS	June 2022 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Beyond the Rivers- Platforms of Opportunity Within the Gulf of Maine	NMFS, University of Maine	2005- Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Ocean Tracking Network Halifax Line	Ocean Tracking Network	2008- Present	**Detecting and quantifying changes to wildlife and habitats**

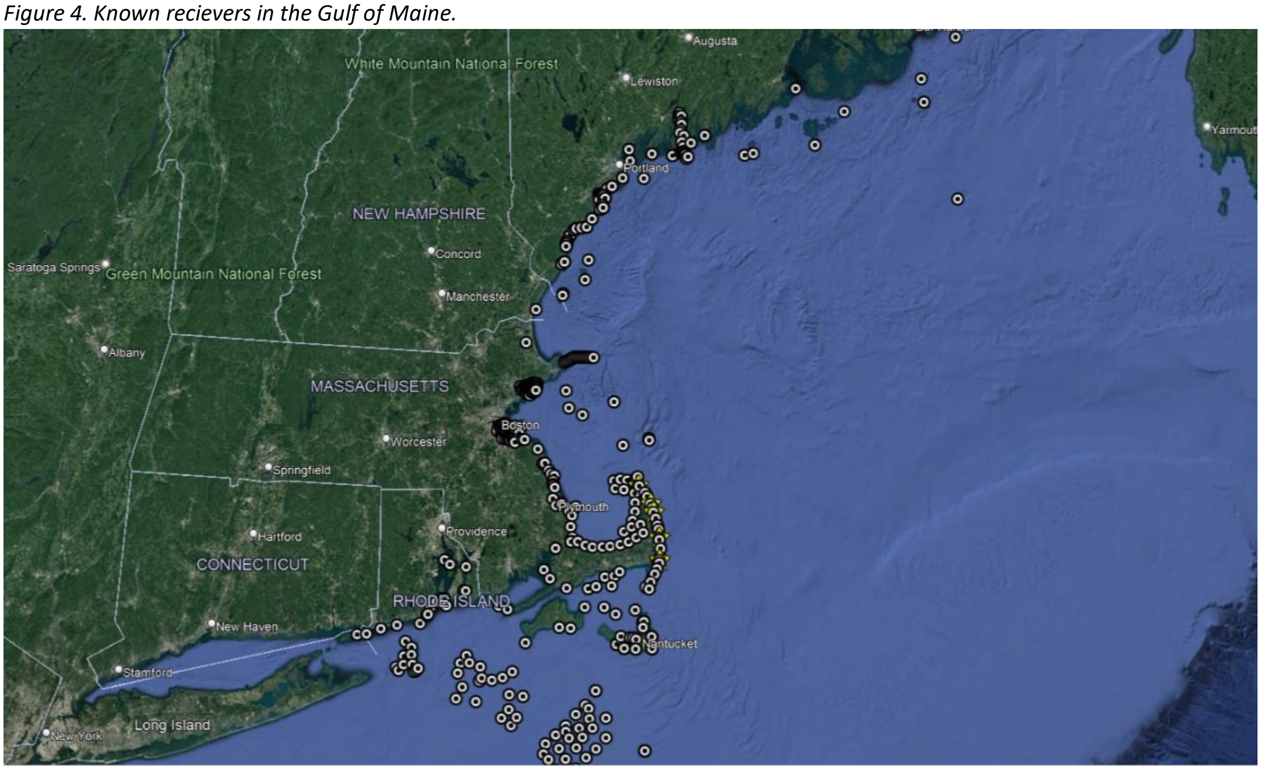
Acoustic telemetry, Other tagging	Salmon for Maine's Rivers-Releasing pre-spawn adults into optimal habitats*	Maine Department of Marine Resources		**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Tag and Release of Post Spawn Kelts in Penobscot River*	University of Maine, Maine DMR		**Detecting and quantifying changes to wildlife and habitats**
PAM, Seafloor imagery and acoustics	RODEO (Real-time Opportunity for Development Environmental Observations)	HDR, Fugro, Subacoustech, University of Rhode Island, "Marine Acoustics, Inc.", WHOI	January 2016 – December 2023	**Detecting and quantifying changes to wildlife and habitats**
PAM, Acoustic telemetry	Passive Acoustic Monitoring for inshore Gulf of Maine	NOAA NEFSC, Maine Department of Marine Resources	2020 - Present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Passive acoustic monitoring	Sanctsound	NOAA Fisheries, NEFSC, NOAA Stellwagen Bank National Marine Sanctuary (SBNMS) , US Navy, NOAA Office of National Marine Sanctuaries, WHOI	January 2018 – December 2022	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Acoustic telemetry	Monitoring of Highly Migratory Species in the Gulf of Maine	University of Maine, Gulf of Maine Research Institute	August 2022 - Present	**Detecting and quantifying changes to wildlife and habitats**

Acoustic telemetry, eDNA, GPS Tagging, Animal physiology, Active acoustics/echosounders, Model development and statistical frameworks	Quantifying marine biodiversity through movements and feeding: Assessing coastal marine ecosystem dynamics near estuary mouths	University of New Hampshire, Gulf of Maine Research Institute, NERACOOS	2022-2027	**Detecting and quantifying changes to wildlife and habitats**
eDNA	Genetics and Genomics Strategic Initiative: Next-generation tools for fisheries stock assessment	NEFSC, Northwest Fisheries Science Center (NWFSC)	2019 - 2023	**Detecting and quantifying changes to wildlife and habitats**

**The Subcommittee knows that this project exists but currently have little information about it. Principal Investigator contacted.*

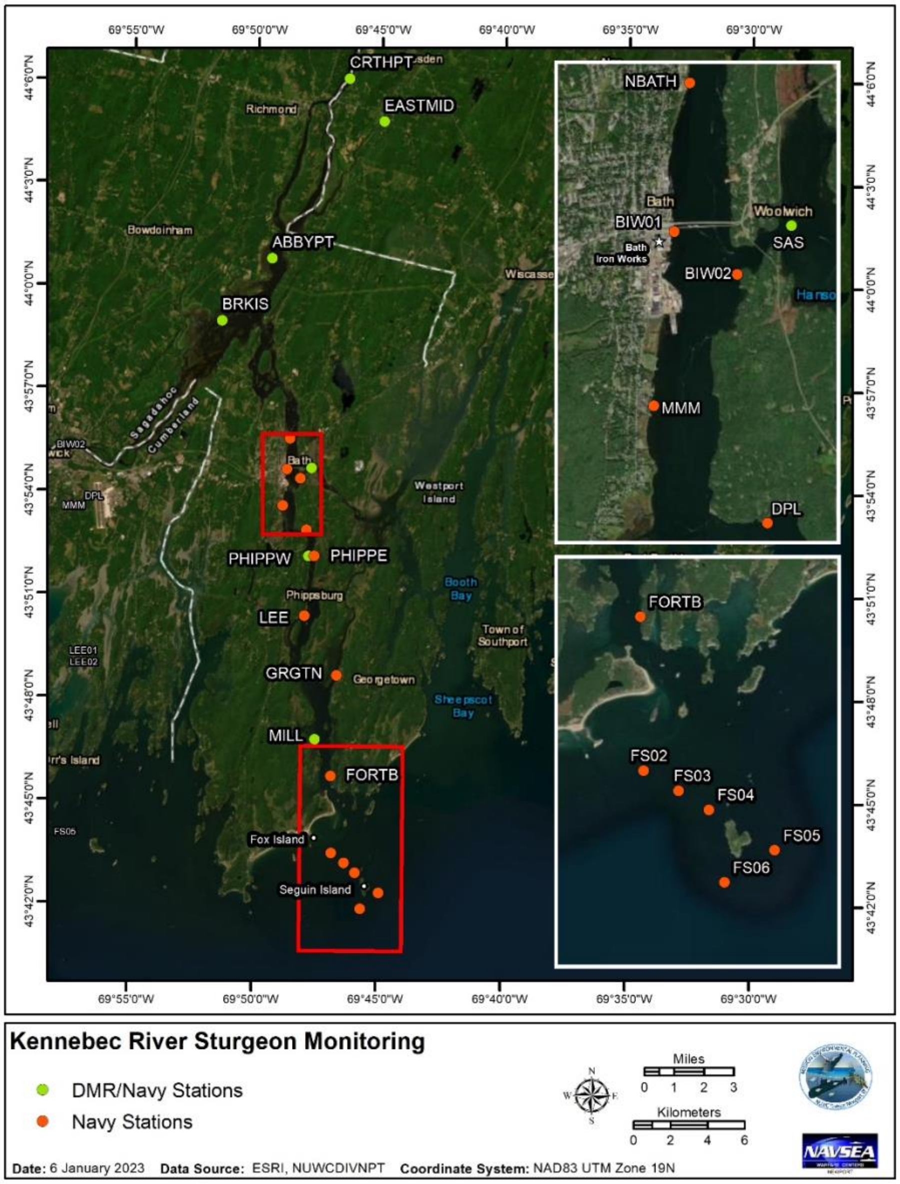
As depicted above, there are many acoustic telemetry projects occurring in the Gulf of Maine. The map below does not include all recievers, but includes those that cooperating researchers were made aware of. It is maintained by many researchers in the Gulf of Maine.

Figure 4. Known recievers in the Gulf of Maine.



The following map shows all recievers that are maintained by the US Navy and Maine DMR in the Gulf of Maine.

Figure 5. Kennebec River Sturgeon Monitoring. Array map that includes Maine DMR and Navy Stations.



Recommendations

Please see all Section 3 Recommendations for the regional scale. In order to capture the bigger picture of regional data, subregional experts must conduct research on their respective regions and compile data. This includes all research reccommendations listed in Section 3 including field data collection and analysis, coordination and planning, standardizing data collection, analysis, and reporting, historical data collection/compilation, model development and statistical frameworks, and manipulative experiments.

- Build a thorough baseline understanding of protected fish species, their life stages, and the spatiotemporal use of The Gulf of Maine as a whole and within proposed WEAs.
    - Continue monitoring all acoustic arrays in the region.
    - Continue tagging all species of protected fish species with satellite and acoustic tags.
        - Prioritize Atlantic salmon, Atlantic sturgeon and shortnose sturgeon in the Gulf of Maine.
    - Deploy a series of acoustic arrays along the coast and offshore
    - Deploy acoustic arrays in all offshore wind lease planning areas, specifically for floating offshore wind.
    - Conduct all telemetry research in conjunction with other research methods such as eDNA and various surveys.
    - Biological sampling, body measurements and additional metrics will give a more thorough understsanding of each species and life stage.
        - Collected as part of directed studies, or opportunistically when a protected fish species is captured on a scientific survey.
- **Develop a more thorough understanding of salmon life stages and their response to EMF exposure. Adults and smolts would be the focus of this study.**
    - The only remaining wild Atlantic salmon are found in this region so this is a priority.
    - Research can be conducted both in situ or in a laboratory setting and utilize multiple methods including acoustic and satelite telemetry, regular tagging, amongst other methods.

4.4 Model development and statistical frameworks

Recommendations

Assess both primary and secondary entanglement risk to all protected fish species associated with offshore wind. There is the potential for increased recreational fishing near wind turbines which would lead to primary entanglement, as well as an increased possibility of secondary entanglement due to ghost gear and debris attaching to structures in the water. Risk should be assessed for structures associated with both standard and floating offshore wind technologies.

- Build off of existing simulation modeling funded by BOEM and other efforts by developers and researchers in the Gulf of Maine. This will lead to a better understand entanglement risk associated with additional cables in the water column as well as any additional impacts produced by the floating technology.

5 Southern New England ongoing, pending, and recommended research and data collection activities for protected fish and offshore wind

5.1 Focal species and habitats of interest

The Southern New England Area encompasses Massachusetts, Rhode Island, and Connecticut including the long island sound. The coast has a variety of habitats, and the waters are influenced by the warmer waters from the Gulf Stream. It is also home to Nantucket Shoals which has high productivity and fish prey congregation. This area is used as a spawning and feeding habitat as well as a migration corridor for many species.

5.2 Potential effects of concern

Offshore Wind Farm development has already begun in the Southern New England region, so all of previously mentioned impacts are of immediate concern. While small in scale, the BIWF was the first in the United States and is located in this subregion. Pile driving has begun for the Vineyard Wind 1 Project, and others are following close behind.

5.3 Field data collection and analysis

Table 9. Ongoing and Pending Field Data Collection and Analysis in Southern New England. Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Acoustic telemetry	Rhode Island Dept. of Environmental Management, Division of Marine Fisheries Acoustic Telemetry Array	Rhode Island Department of Environmental Management Division of Marine Fisheries (RI DEM DMF)	April 2019 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry, PAM	NOAA Fisheries NEFSC Passive Acoustic Monitoring in Massachusetts and Rhode Island	NOAA Fisheries, NEFSC	January 2020 - Present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**

Acoustic telemetry	Narragansett Bay Wind Farm Cable Corridor Monitoring	Rhode Island Department of Environmental Management, Division of Marine Fisheries	January 2023 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry, BRUVs	Using acoustic telemetry and video-based methods to characterize elasmobranch assemblage in Block Island, RI waters.	RI DEM DMF, Atlantic Shark Institute	May 2019 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	CT DEEP array of VEMCO receivers in Long Island Sound and lower Connecticut River, 2018-2022.	Connecticut Department of Energy and Environment Protection	July 2018 - June 2023	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry, Nets, tows, lines, and traps, Water quality and oceanography	South Fork fisheries monitoring	South Fork Wind, CFRF, CCE, INSPIRE Environmental, Stony Brook University, New England Aquarium	January 2020 – December 2026	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Acoustic telemetry	Rhode Island Division of Marine Fisheries Movement Ecology of Recreationally-Significant Coastal Sharks in Southern New England	RI DEM DMF, Atlantic Shark Institute	January 2020 - December 2025	**Detecting and quantifying changes to wildlife and habitats**

Acoustic telemetry	Revolution Wind State Waters Ventless Lobster Trap Survey – Export Cable Route	Rhode Island Department of Environmental Management Division of Marine Fisheries	January 2023 - 2030	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Monitoring highly migratory and demersal fish species presence and movements in the southern New England Wind Energy Area during pre-construction, construction, and operations	Anderson Cabot Center for Ocean Life at the New England Aquarium	2020 - 2026	**Detecting and quantifying changes to wildlife and habitats**
PAM, Acoustic telemetry	Buoys of Opportunity - NOAA Salmon Whale	NOAA, OTN, Dalhousie University	2016 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Acoustic telemetry for HMS	Sunrise Wind, New England Aquarium, INSPIRE	January 2023 - December 2026	**Detecting and quantifying changes to wildlife and habitats**
eDNA	Genetics and Genomics Strategic Initiative: Next-generation tools for fisheries stock assessment	NEFSC, NWFSC	2019 - 2023	**Detecting and quantifying changes to wildlife and habitats**

Recommendations

Please see all Section 3 Recommendations for the regional scale. In order to capture the bigger picture of regional data, subregional experts must conduct research on their respective regions and compile data. This includes all research reccommendations listed in Section 3

including field data collection and analysis, coordination and planning, standardizing data collection, analysis, and reporting, historical data collection/compilation, model development and statistical frameworks, and manipulative experiments.

- Build a thorough baseline understanding of protected fish species, their life stages, and the spatiotemporal use of Southern New England as a whole and within proposed WEAs.
    - Continue monitoring all acoustic arrays in the region.
    - Continue tagging all species of protected fish species with satellite and acoustic tags.
        - Prioritize Atlantic sturgeon and shortnose sturgeon.
    - Deploy a series of acoustic arrays along the coast and offshore
    - Deploy acoustic arrays in all offshore wind lease planning areas, specifically for floating offshore wind.
    - Conduct all telemetry research in conjunction with other research methods such as eDNA and various surveys.
    - Biological sampling, body measurements and additional metrics will give a more thorough understsanding of each species and life stage.
        - Collected as part of directed studies, or opportunistically when a protected fish species is captured on a scientific survey.

6 New York/New Jersey Bight ongoing, pending, and recommended research and data collection activities for protected fish and offshore wind

6.1 Focal species and habitats of interest

The New York/New Jersey Bight region covers Long Island to the Tip of Cape May New Jersey. The region holds estuarine habitat, which supports the life stages of multiple fish species. Ingram et al. (2019)[69] examined Atlantic sturgeon in the New York Wind Energy Area, and found that Atlantic sturgeon are regularly found in this area with peaks from November through January and near absence July through September. In addition, detections of unique fish decreased with an increasing distance from shore, though they did spread throughout the entire array. Environmental factors were also explored, and photoperiod was determined to be a consistent trigger for migration while river temperature and discharge were two additional

[69] Ingram, E.C., Cerrato, R.M., Dunton, K.J. and Frisk, M.G., 2019. Endangered Atlantic Sturgeon in the New York Wind Energy Area: implications of future development in an offshore wind energy site. Scientific reports, 9(1), pp.1-13.

local factors (Ingram et al 2019)[70]. Their results will help guide management measures for sturgeon in this area.

In addition to all current lease areas, NYSERDA has started to plan, and conducted research in the deeper waters along/off the shelf break for floating offshore wind. Research covered multiple topics, including fish, benthic, habitat, and environmental sensivity. Reports about their work are in the process of being drafted and reviewed.

6.2 Potential effects of concern

All potential effects noted previously also occur in the New York/New Jersey bight. With different fish species utilizing the estuarine habitats in this region, vessel strike is of higher concern, especially for Atlantic Sturgeon. With future development of floating offshore wind, the additional impacts presented by floating technologies should alsso be considered.

6.3 Field data collection and analysis

Table 10. Ongoing and Pending Field Data Collection and Analysis in the New York/New Jersey Bight. Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Acoustic telemetry	Continued deployment connector array in marine waters of New York off the Rockaways	Stony Brook University	December 2018 - December 2025	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Nearshore Gates array of Long Island's South Shore, Rockaway-Montauk Point	Stony Brook University; Wildlife Conservation Society, Monmouth University	January 2020 - December 2025	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry, BRUVs	Using acoustic telemetry and video-based methods to characterize elasmobranch assemblage in Block Island, RI waters	Rhode Island Department of Environmental Management, Marine Fisheries Division, Atlantic Shark Institute	May 2019 - Present	**Detecting and quantifying changes to wildlife and habitats**
Active acoustics/echosounders, PAM, Water quality and oceanography	New Jersey Research and Monitoring Initiative Eco-glider Surveys	Rutgers University, New Jersey Department of Environmental Protection (NJ DEP)	September 2022 - December 2025	**Detecting and quantifying changes to wildlife and habitats**

[70] Ingram, E.C., Cerrato, R.M., Dunton, K.J. and Frisk, M.G., 2019. Endangered Atlantic Sturgeon in the New York Wind Energy Area: implications of future development in an offshore wind energy site. Scientific reports, 9(1), pp.1-13.

Acoustic telemetry	BOEM Sand Ridge Phase 2 - Rutgers University Marine Field Station (RUMFS)	Rutgers University; BOEM	November 2022 - December 2024	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Assessing the impact of EMF on local elasmobranch species from an offshore wind farm export cable	School of Marine and Atmospheric Sciences at Stony Brook University	May 2022 - December 2025	**Detecting and quantifying changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Acoustic telemetry	The Maritime Aquarium at Norwalk Long Island Sound Acoustic Array	The Maritime Aquarium at Norwalk	October 2020 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Monmouth University Coastal Fisheries Study	Monmouth University	May 2016 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Acoustic Arrays in Wind Energy Areas	NJ DEP RMI	June 2023	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Ocean Wind 1 Acoustic Telemetry Survey	Rutgers University and Delaware State University	March 2022-2027	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry, Seafloor acoustics	Developing a novel methodology to estimate shortnose sturgeon abundance utilizing acoustic telemetry and side-scan sonar imagery	New York State Department of Environmental Conservation, Cornell University, Delaware State University, University of Delaware, USGS	April 2021 - Present	**Detecting and quantifying changes to wildlife and habitats**
PAM, Acoustic tagging	NOAA Fisheries Northeast Fisheries	NOAA Fisheries	June 2022- Present	**Detecting and quantifying changes**

	Science Center Passive Acoustic Monitoring in the mid-Atlantic			**to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
eDNA	Ocean Wind 1 eDNA Sampling	Monmouth University, Rutgers University, St. Anselm College	March 2022 - 2027	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Understanding of Atlantic Sturgeon Migratory Patterns – Integrating Telemetry and Genetics	University of Delaware, USGS, BOEM	2020- June 2023	**Detecting and quantifying changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats**
Acoustic telemetry	Acoustic telemetry for elasmobranchs, lobsters, horseshoe crabs	Sunrise Wind, Stony Brook University, Cornell University, South Fork Natural History Museum	April 2022 – December 2027	**Detecting and quantifying changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats**
eDNA	Genetics and Genomics Strategic Initiative: Next-generation tools for fisheries stock assessment	NEFSC, NWFSC	2019 - 2023	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Sunrise Wind Export Cable Acoustic Telemetry Study	Stony Brook University School of Marine and Atmospheric Sciences, Monmouth University, Cornell University, Michigan State University	August 2021- 2025	**Detecting and quantifying changes to wildlife and habitats**

Recommendations

Please see all Section 3 Recommendations for the regional scale. In order to capture the bigger picture of regional data, subregional experts must conduct research on their respective regions and compile data. This includes all research reccommendations listed in Section 3 including field data collection and analysis, coordination and planning, standardizing data

collection, analysis, and reporting, historical data collection/compilation, model development and statistical frameworks, and manipulative experiments.

- Build a thorough baseline understanding of protected fish species, their life stages, and the spatiotemporal use of the New York/New Jersey Bight as a whole and within proposed WEAs.
    - Continue monitoring all acoustic arrays in the region.
    - Continue tagging all species of protected fish species with satellite and acoustic tags.
        - Prioritize Atlantic sturgeon in the New York/New Jersey Bight.
    - Deploy a series of acoustic arrays along the coast and offshore
    - Deploy acoustic arrays in all offshore wind lease planning areas, specifically for floating offshore wind.
    - Conduct all telemetry research in conjunction with other research methods such as eDNA and various surveys.
    - Biological sampling, body measurements and additional metrics will give a more thorough understsanding of each species and life stage.
        - Collected as part of directed studies, or opportunistically when a protected fish species is captured on a scientific survey.

7 Central Atlantic ongoing, pending, and recommended research and data collection activities for protected fish and offshore wind

7.1 Focal species and habitats of interest

The Central Atlantic subregion encompasses the area between Cape May, New Jersey and Cape Hatteras North Carolina. Rothermel et al. (2020)[71] examined the near-self region of Maryland, and found that Atlantic sturgeon used this area mainly as a transit route. They primarily occupied warmer bottom temperatures, and had the lowest detection rates in the late spring through early fall (Rothermel et al. 2020)[72].

Haulsee et al. (2020)[73] studied Atlantic sturgeon in the Delaware wind energy area, and found that they occurred year round, though abundance peaked in November and December.

[71] Rothermel, E.R., Balazik, M.T., Best, J.E., Breece, M.W., Fox, D.A., Gahagan, B.I., Haulsee, D.E., Higgs, A.L., O'Brien, M.H., Oliver, M.J. and Park, I.A., 2020. Comparative migration ecology of striped bass and Atlantic sturgeon in the US Southern mid-Atlantic bight flyway. PloS one, 15(6), p.e0234442.

[72] Rothermel, E.R., Balazik, M.T., Best, J.E., Breece, M.W., Fox, D.A., Gahagan, B.I., Haulsee, D.E., Higgs, A.L., O'Brien, M.H., Oliver, M.J. and Park, I.A., 2020. Comparative migration ecology of striped bass and Atlantic sturgeon in the US Southern mid-Atlantic bight flyway. PloS one, 15(6), p.e0234442.

[73] Haulsee DE, Fox DA, Oliver MJ. 2020. Occurrence of Commercially Important and Endangered Fishes in Delaware Wind Energy Areas Using Acoustic Telemetry. Lewes (DE): US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2020-020. 80 p

Distribution shifted seasonally within the WEA from shallower areas in the spring and summer to deeper waters in the fall and winter.

Hager (2019)[74] deployed receivers in the York River watershed, the Lower James River, the Elizabeth River, the mouth of the Chesapeake Bay, and along the Atlantic coast. These receivers detected sturgeon that were tagged all throughout the region, from Maine to Georgia showing that this species is highly migratory and occur region wide.

7.2 Potential effects of concern

All of the potential effects previously mentioned also apply for the Central Atlantic, with emphasis on Atlantic sturgeon which frequent each of the wind energy areas in this subregion. The CVOW Pilot project is already operational in this region.

7.3 Field data collection and analysis

Table 11. Ongoing and Pending Field Data Collection and Analysis in the Central Atlantic. Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Acoustic telemetry	Telemetry movement information for various fish species, mostly Atlantic sturgeon, by Virginia Commonwealth University and Virginia Department of Wildlife Resources	USFWS/Virginia Commonwealth University/ Virginia Department of Wildlife Resources	August 2012 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Smithsonian Environmental Research Center Acoustic Telemetry Arrays (Maryland-Florida)	Smithsonian Environmental Research Center, Coastal Ocean Research and Monitoring Program,	August 2013 - Present	**Detecting and quantifying changes to wildlife and habitats**

[74] Hager, C. 2019. Operation of the Navy's Telemetry Array in the Lower Chesapeake Bay: Final Report for 2013 - 2018. Cumulative Report. Prepared for US Fleet Forces Command and Commander, Navy Region Mid-Atlantic. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470-10-3011, Task Order 53, issued to HDR Inc., Virginia Beach, Virginia. July 2019.

		Maryland Department Natural Resources		
Acoustic telemetry	Smithsonian Environmental Research Center North Carolina Coastal Array	Smithsonian Environmental Research Center, University of North Carolina - Wilmington, Coastal Carolina University	January 2017 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	NOAA Chesapeake Bay Office-Maryland Department of Natural Resources Chesapeake Bay Backbone Northern Array	NOAA Chesapeake Bay Office-NMFS, Maryland Department of Natural Resources	November 2021 - December 2025	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	NOAA Chesapeake Bay Office-Virginia Marine Resource Commission Chesapeake Bay Backbone Southern Acoustic Array	NOAA Chesapeake Bay Office, Virginia Marine Resources Commission	November 2021 - December 2025	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Mallows Bay-Potomac River National Marine Sanctuary Acoustic Telemetry Study	NOAA, Smithsonian Environmental Research Center, Maryland Department of Natural Resources	January 2015 - Present	**Detecting and quantifying changes to wildlife and habitats**

Acoustic telemetry	Aberdeen Proving Ground - Atlantic and shortnose sturgeon Telemetry Project	US Army, State of Delaware. Department of. Natural Resources and. Environmental Control (DNREC) Division of Fish and Wildlife Virginia Commonwealth University	April 2018 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	DNREC Division of Fish and Wildlife Delaware Estuary Acoustic Telemetry Monitoring	DNREC - Division of Fish and Wildlife	January 2009 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry, Seafloor acoustics	Spawning movement behaviors, habitat dependencies and run size of Nanticoke River Atlantic sturgeon	Maryland Department Natural Resources, Delaware Division of Fish and Wildlife, University of Maryland Center for Environmental Science	July 2019 - June 2025	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	NOAA Chesapeake Bay Office Chesapeake Bay Interpretive Buoy System (CBIBS) Collaborative Acoustic Array	Smithsonian Environmental Research Center, NOAA	January 2009 - December 2025	**Detecting and quantifying changes to wildlife and habitats**
Water quality and oceanography	NOAA Chesapeake bay hypoxia buoys	NOAA Chesapeake Bay Office, Maryland Department of Natural Resources	July 2022 - December 2025	**Understanding the environmental context around changes to wildlife and habitats**

Acoustic telemetry	NCDMF Albemarle Sound and OBX Inlet Arrays	North Carolina Division of Marine Fisheries	February 2011 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	NCDMF Cape Fear River Arrays	North Carolina Division of Marine Fisheries, University of North Carolina-Wilmington	February 2011 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	NCDMF Tar-Pamlico and Neuse River Arrays	North Carolina Division of Marine Fisheries	March 2014 - Present	**Detecting and quantifying changes to wildlife and habitats**
Other camera systems, Technology advancement	Identification of sturgeon larvae with an autonomous holographic camera system	Pacific Northwest National Laboratory, Florida Atlantic University, EPRI, Dominion energy	2021-2024	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Adult Atlantic sturgeon telemetry in the York River	US Navy, Chesapeake Scientific LLC, NOAA	August 2013 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry, Biological sampling	Molecular assessment of a stressed Atlantic sturgeon nursery habitat: The Nanticoke River-Marshyhope Creek, Chesapeake Bay	Maryland Department of Natural Resources (DNR)	July 2022 – June 2025	**Detecting and quantifying changes to wildlife and habitats**

Nets, tows, lines, and traps	VIMS Longline Survey	VIMS, NMFS	1973 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Atlantic sturgeon population ecology in the Cape Fear River, North Carolina	University of North Carolina at Wilmington, MATOS	March 2021 - Present	**Detecting and quantifying changes to wildlife and habitats**
Nets, tows, lines, and traps, Water quality and oceanography, Acoustic telemetry, eDNA, Seafloor acoustics, Model development and statistical framework	Fish Fry: Frying Pan Shoals Ecosystem Dynamics	TBD, BOEM	2022-2025	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
Nets, tows, lines, and traps, Water quality and oceanography	Sandbridge Highly Migratory Species: fish distribution on a dredged shoal	BOEM, University of Delaware	January 2021 – December 2025	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**
PAM, Acoustic telemetry	NOAA Fisheries Northeast Fisheries Science Center Passive Acoustic Monitoring in the mid-Atlantic	NOAA Fisheries	June 2022- Present	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**

Acoustic telemetry	Building a Mainstem Chesapeake Bay Telemetry Array: Mid-Bay Segment	University of Maryland Center for Environmental Science	May 2021 - Present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Understanding of Atlantic Sturgeon Migratory Patterns – Integrating Telemetry and Genetics	University of Delaware, USGS, BOEM	2020- June 2023	**Detecting and quantifying changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats**
Acoustic telemetry	Endangered Atlantic Sturgeon Habitat Use in Mid-Atlantic Wind Energy Area	US Department of the Navy, Naval Facilities Engineering Command, Atlantic; Chesapeake Scientific, BOEM	October 2015 – June 2024	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats**
Acoustic telemetry	US Wind - UMCES passive acoustic monitoring array	University of Maryland Center for Environmental Science	January 2014 – December 2028	**Detecting and quantifying changes to wildlife and habitats**
eDNA	Genetics and Genomics Strategic Initiative: Next-generation tools for fisheries stock assessment	NEFSC, NWFSC	2019 - 2023	**Detecting and quantifying changes to wildlife and habitats**

Acoustic telemetry	[Cape Fear Community College Marine Technology Program Cape Fear River Monitoring]	Cape Fear Community College Marine Technology Program	September 2019 - Present	**Detecting and quantifying changes to wildlife and habitats**

Recommendations

Please see all Section 3 Recommendations for the regional scale. In order to capture the bigger picture of regional data, subregional experts must conduct research on their respective regions and compile data. This includes all research reccommendations listed in Section 3 including field data collection and analysis, coordination and planning, standardizing data collection, analysis, and reporting, historical data collection/compilation, model development and statistical frameworks, and manipulative experiments.

- Build a thorough baseline understanding of protected fish species, their life stages, and the spatiotemporal use of the central Atlantic a whole and within proposed WEAs.
    - Continue monitoring all acoustic arrays in the region.
    - Continue tagging all species of protected fish species with satellite and acoustic tags.
        - Prioritize Atlantic sturgeon in the Central Atlantic.
    - Deploy a series of acoustic arrays along the coast and offshore
    - Deploy acoustic arrays in all offshore wind lease planning areas, specifically for floating offshore wind.
    - Conduct all telemetry research in conjunction with other research methods such as eDNA and various surveys.
    - Biological sampling, body measurements and additional metrics will give a more thorough understsanding of each species and life stage.
        - Collected as part of directed studies, or opportunistically when a protected fish species is captured on a scientific survey.

Understand the increase in vessel traffic (both number of vessels and increased time of vessels in a given area) in offshore wind farm project areas with emphasis on the shallower waters close to ports and estuaries. Also, pair this with the amount and type of light produced by each vessel.

∉ This is a region wide recommendation, but it is repeated in this section with particular concern for the Central Atlantic Subregion.

∉ Increase knowledge on vessel type and activity that leave all protected fish, with emphasis on sturgeon, most susceptible to vessel strike.

- Increase understanding of coastal transfer and test mitigation measures to prevent vessel strikes. Areas of focus would be for vessels traveling close to shore, near the estuarine environment, in known migration corridors and other areas of spatiotemporal overlap.

    - Expand the scope of current studies on risk to vessel strike. Instead of focusing only on the number of additional vessels per area, target studies on the amount of time propellors are spinning in place, different wheel sizes, and different depths where vessels are present for to each OSW project.

- Develop tools to better understand if/when vessel strikes occur as well as a standardized reporting platform for vessel strikes of protected fish.
    - Encourage voluntary reporting and data collection for known vessel interactions with protected fish, particularly sturgeon.
- Develop analyses of vessel and protected fish species co-occurrence that model nearshore vessel traffic and changes to ambient light conditions that could alter fish behavior.
- Provide increased funding for salvage operations and stranding programs, particularly for Atlantic sturgeon.
    - Stranding hotlines and programs already exist for some protected fish species. However, these programs are largely under funded, and lack the personell and resources to attend to all reports.
        - Fully studying strandings, both dead and alive, will give researchers a better understanding as to what is affecting the populations in each region and insight as to how to best mitigate these effects.
    - The Subcommittee would like to work with the RWSC Marine Mammal and Sea Turtle Subcommittee to discuss and potentially develop a reporting system for proteced fish strandings, similar to what is currently done for Marine Mammals and Sea Turtles.

8 Southeastern US Atlantic ongoing, pending, and recommended research and data collection activities for protected fish and offshore wind

The Southeastern US Atlantic Subregion covers the rest of the US Atlantic, from Cape Hatteras, North Carolina down the Atlantic coast of Florida.

8.1 Focal species and habitats of interest

Some of the ESA listed species are only found in this subregion including the Nassau grouper and the smalltooth sawfish. The giant manta ray is primarily located in this subregion. as well. There are likely two species of manta off the US east coast, the ESA-listed giant manta ray (*Mobula birostris*) and the reef manta ray (*Mobula alfredi*), which is not ESA-listed. Until 2017, these two species were classified as a single species. More information is needed on these two species so that their conservation can be adequately addressed.

8.2 Potential effects of concern

The potential effects of offshore wind farm development in the southeastern U.S are similar to those discussed on the regional level. However, there no projects in this subregion that are currently under review.

8.3 Field data collection and analysis

Table 12. Ongoing and Pending Field Data Collection and Analysis in the Southeastern US Atlantic. Click project names to view full descriptions.

Method(s)	Project	Lead and Partner Entities	Time period	Research Theme
Acoustic telemetry	Smithsonian Environmental Research Center Acoustic Telemetry Arrays (Maryland-Florida)	Smithsonian Environmental Research Center; Coastal Ocean Research and Monitoring Program, Maryland Department Natural Resources	August 2013 - present	**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Sturgeon movements in Cumberland Sound and the St. Marys River, GA	University of Georgia	2013 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Occurrence and Movements of Atlantic Sturgeon in Georgia and Florida	University of Georgia, US Navy, United States Department of Agriculture, NOAA	2014 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	TEQ Array- FWRI multi-species array*	Florida Fish and Wildlife Conservation Commission		**Detecting and quantifying changes to wildlife and habitats**
Acoustic telemetry	Diadromous Fishes movement in the Intracoastal Waterway, mouth estuaries, and piers	South Carolina Department of Natural Resources (SC DNR)	2010 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Diadromous Fishes movement in the Cooper River, South Carolina	SC DNR	2011 - Present	**Detecting and quantifying changes to wildlife and habitat**

Acoustic telemetry	Diadromous Fishes movement in the Edisto River	SC DNR	2010 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Monitoring Movement and Migration of Giant Manta (Manta birostris) and the Caribbean Manta (Manta sp.cf. birostris) using acoustic telemetry	Georgia Aquarium	2017 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Spotted Eagle Ray Movement Ecology	Florida Atlantic University, Mote	? - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry, Other tagging	Habitat use of oceanic manta rays (Mobula birostris) in the vicinity of marine mineral extraction activities.	Georgia Aquarium, BOEM	2021 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry, Satellite tagging	Site fidelity and movements of manta rays in Florida	Marine Megafauna Foundation	2020 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry, Satellite tagging	NOAA Fisheries Manta Ray Conservation Research	NOAA Fisheries	2021 - Present	**Detecting and quantifying changes to wildlife and habitat**
Satellite tagging, Acoustic telemetry	Acoustic and satellite telemetry inform on movements and habitat use of endangered smalltooth sawfish, Pristis pectinata, in southwest Florida and in the Bahamas	NOAA Fisheries, FSU	2016 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Equipping oceanographic buoys with acoustic receivers in southeast United States	FACT Network, University of South Florida College of Marine Science, East Carolina University	2020 - Present	**Detecting and quantifying changes to wildlife and habitat**

Acoustic telemetry	Diadromous Fishes movement in the Savannah River	SC DNR	2012 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Diadromous Fishes movement in the Santee River, South Carolina	SC DNR	2010 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Pinopolis Lock Sturgeon Monitoring Project	Santee Cooper	2022 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Diadromous Fishes movement in the Great Pee Dee River, South Caroliina	SC DNR	2011 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Diadromous Fishes statewide movement in South Carolina	SC DNR	2010 - Present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry, tagging, Biological sampling	Behavioral and Spatial Ecology of the Threatened Giant Manta Ray (Mobula birostris, formerly Manta birostris)	US Navy, Marine Megafauna, BOEM, NOAA Fisheries, NASA	Spring 2023 – January 2025	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Gray's reef national marine sanctuary*	NOAA, NCCOS		**Detecting and quantifying changes to wildlife and habitats**
Nets, tows, lines, and traps, BRUVS	Southeast Reef Fish Survey Chevron-Video Trap	SC DNR	1990-present	**Detecting and quantifying changes to wildlife and habitat**
Acoustic telemetry	Coastal Receiver Array	SC DNR, GA DNR	2014 - Present	**Detecting and quantifying changes to wildlife and habitat**
Nets, tows, lines, and traps	Coastal Longline Surveys	NCDMF, SCDNR, GADNR	2007 - Present	**Detecting and quantifying changes to wildlife and habitat**
Nets, tows, lines, and traps	Coastal Trawl Survey	SCDNR	1986 - Present	**Detecting and quantifying changes to wildlife and habitat**

Acoustic telemetry, Water quality and oceanography, Biological sampling	The effect of environmental factors on movement patterns and habitat use of young of year scalloped hammerhead sharks (Sphyrna lewini) in the Tolomato River nursery	University of North Florida	2022 - Present	**Detecting and quantifying changes to wildlife and habitat** **Understanding the environmental context around changes to wildlife and habitats** **Determining causality for observed changes to wildlife and habitats**
Acoustic telemetry, Model development and statistical frameworks	Understanding of Atlantic Sturgeon Migratory Patterns – Integrating Telemetry and Genetics	University of Delaware, USGS, BOEM	2020- June 2023	**Detecting and quantifying changes to wildlife and habitats**
PAM, Water quality and oceanography	Atlantic Deepwater Ecosystem Observatory Network (ADEON) – An Integrated System for Long-Term Monitoring of Ecological and Human Factors on the OCS	University of New Hampshire, NOAA SWFSC, National Oceanographic Partnership Program Project (NOPP), BOEM	January 2016 – December 2021	**Detecting and quantifying changes to wildlife and habitats** **Understanding the environmental context around changes to wildlife and habitats**

**The Subcommittee knows that this project exists but currently have little information about it. Principal Investigator contacted.*

Recommendations

Please see all Section 3 Recommendations for the regional scale. In order to capture the bigger picture of regional data, subregional experts must conduct research on their respective regions and compile data. This includes all research reccommendations listed in Section 3 including field data collection and analysis, coordination and planning, standardizing data collection, analysis, and reporting, historical data collection/compilation, model development and statistical frameworks, and manipulative experiments.

- Build a thorough baseline understanding of protected fish species, their life stages, and the spatiotemporal use of the Southeastern US
  - Continue monitoring all acoustic arrays in the region.
  - Continue tagging all species of protected fish species with satellite, acoustic, and external tags.
    - Prioritize the giant manta ray, Nassau grouper, and smalltooth sawfish in this region.
  - Deploy a series of acoustic arrays along the coast and offshore
  - Deploy acoustic arrays in all offshore wind lease planning areas.

        - Conduct all telemetry research in conjunction with other research methods such as eDNA and various surveys.
        - Biological sampling, body measurements and additional metrics will give a more thorough understsanding of each species and life stage.
            - Collected as part of directed studies, or opportunistically when a protected fish species is captured on a scientific survey.

Collect information on distribution, abundance, behavior, health, reproduction, and other vital population rates of protected fish at all life stages. This includes estuarine and freshwater habitat if the distribution expands into those environments.

- Fully understand the differences in habitat use between, and resulting threats to, the two species of manta ray to aid in their conservation.
    - The utilization of multiple field studies would be best to accomplish this utilizing mulitple methods including, but not limited to, aerial surveys, boat-based surveys, and external tagging.
- Fully document Giant manta ray migration.
    - The utilization of multiple field studies would be best to accomplish this employing mulitple methods including, but not limited to, acoustic and satellite telemetry, other tagging, aerial surveys, and boat-based surveys.
- Collect and analyze data to support development of an adult distribution model for smalltooth sawfish.
- Collect and analyze data to suppor development of larval and adult connectivity/distribution models for Nassau grouper.

Assess entanglement risk to all protected fish species associated with potential for increased recreational fishing near wind turbines and increased possibility of ghost gear due to structures in water

- Ghost gear in of itself can capture and drown all protected fish species.
- Prioritize the giant manta ray in this region as they can easily get their cephalic fins entangled in trailing lines and drown.
    - Boat-based surveys, aerial surveys, and salvage response will all be important methods to address this risk.

Other Science Plan Actions

Table 13. Ongoing and Pending Other Science Plan Actions in the Southeastern US Atlantic. Click project names to view full descriptions.

Method(s)	**Project**	**Lead and Partner Entities**	**Time period**	**Research Theme**
Historical data collection/compilation	The Southeast US Marine Biodiversity Observation	University of South Florida (USF), SECOORA, GCOOS, NOAA Atlantic	January 2022 – December 2027	**Understanding the environmental context around**

	Network (MBON): Toward Operational Marine Life Data for Conservation and Sustainability	Oceanographic and Meteorological Laboratory, University of Miami, FWRI, NOAA Office of National Marine Sanctuaries, FL Keys National Marine Sanctuary, University of Porto, Portugal University, UNESCO, Oregon State University		**changes to wildlife and habitats**

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Acronyms

ACT Network: Atlantic Cooperative Telemetry Network

ASMFC: Atlantic States Marine Fisheries

BIWF: BIWF

BOEM: Bureau of Ocean Energy Management

BRUVS: Baited Remote Underwater Video Station

CBIBS: Chesapeake Bay Interpretive Buoy System

CEC: Clean Energy Center

CCE: Cornell Cooperative Extension of Suffolk County

CFMC: Caribbean Fishery Management Council

CFRF: Commercial Fisheries Research Foundation

CT DEEP: Connecticut Department of Energy and Environmental Protection

NJ DEP: New Jersey Department of Environmental Protection

DMR: Department of Marine Resources

DNR: Department of Natural Resources

DNREC: State of Delaware. Department of Natural Resources and. Environmental Control

DPS: Distinct Population Segments

EA: Environmental Assessments

eDNA: Environmental Deoxyribonucleic Acid

EFH: Essential Fish Habitat

EIS: Environmental Impact Statements

EMF: Electromagnetic Field

eNGO: Environmental Non-Governmental Organization

ESA: Endangered Species Act

E-TWG: Environmental Technical Working Group

FACT Network: Florida Atlantic Coast Telemetry Network

FSU: Florida State University

GCOOS: Gulf of Mexico Coastal Ocean Observing System

FWRI: The Fish and Wildlife Research Institute, formerly the Florida Marine Research Institute

GEO: Governor’s Energy Office

HMS: Highly Migratory Species

HVDC: High Voltage Direct Current

IUCN: International Union for Conservation of Nature

MAFMC: Mid-Atlantic Fishery Management Council

MATOS: Mid-Atlantic Acoustic Telemetry Observation System

MMF: Marine Megafauna foundation

MSA: Magnuson-Stevens Fishery Conservation and Management Act

NASA: National Aeronautics and Space Administration

NCEI: National Centers for Environmental Information

NCCOS: National Centers for Coastal Ocean Science

NCDMF: North Carolina Division of Marine Fisheries

NEFMC: New England Fishery Management Council

NEFSC: Northeast Fisheries Science Center

NEPA: National Environmental Policy Act

NERACOOS: Northeastern Regional Association of Coastal Ocean Observing Systems

NMFS: National Marine Fisheries Service

NOAA: National Oceanographic and Atmospheric Administration

NOPP: National Oceanographic Partnership Program

NUWC: Naval Undersea Warfare Center Newport

NWFSC: Northwest Fisheries Science Center

NYSERDA: New York State Energy Research and Development Authority

OSW: Offshore Wind

OTN: Ocean Tracking Network

PAM: Passive Acoustic Monitoring

PCOD: Population Consequences of Disturbance

PCOMS: Population Consequences of Multiple Stressors

RI DEM DMF: Rhode Island Department of Environmental Management Division of Marine Fisheries

RMI: Research and Monitoring Initiative

RODEO: Real-time Opportunity for Development Environmental Observations

ROSA: Responsible Offshore Science Alliance

ROV: Remotely Operated Vehicle

RUMFS: Rutgers University Marine Field Station

RWSC: Regional Wildlife Science Collaborative for Offshore Wind

SAFMC: South Atlantic Fishery Management Council

SBNMS: Stellwagen Bank National Marine Sanctuary

SECOORA: Southeast Coastal Ocean Observing Regional Association

TBD: To Be Determined

UMCES: University of Maryland Center for Environmental Science

UNESCO: The United Nations Educational, Scientific and Cultural Organization

USGS: United States Geological Survey

VIMS: Virginia Institute of Marine Science

WEA: Wind Energy Area

Project WOW: Wildlife and Offshore Wind