Sunrise Wind | Powered by Ørsted & Eversource

# Sunrise Wind Fisheries and Benthic Research Monitoring Plan

April 3, 2024

## Table of Contents

## List of Tables

## List of Figures

## Acronyms and Abbreviations

| | |
|---|---|
| ACCOL | Anderson Cabot Center for Ocean Life |
| ACCSP | Atlantic Coastal Cooperative Statistics Program |
| ACT | Atlantic Cooperative Telemetry |
| AG | Acoustic Gates |
| AIC | Akaike Information Criteria |
| ANOSIM | Analysis of Similarities |
| ANOVA | Analysis of Variance |
| aRPD | Apparent redox potential discontinuity |
| ASMFC | Atlantic States Marine Fisheries Commission |
| BACI | Before-After-Control-Impact |
| BAG | Before-After-Gradient |
| BIWF | Block Island Wind Farm |
| BOEM | Bureau of Ocean Energy Management |
| CFR | Code of Federal Regulations |
| CI | Confidence Interval |
| cm | centimeter |
| CMECS | Coastal and Marine Ecological Classification Standard |
| CPUE | Catch per Unit Effort |
| CTD | Conductivity Temperature Depth |
| DC | Direct current |
| DSLR | Digital single-lens reflex |
| DVR | Digital video recorder |
| ECDF | Empirical cumulative distribution function |
| ECO-PAM | Ecosystem and Passive Acoustic Monitoring |
| EFH | Essential fish habitat |
| EFP | Exempted Fishing Permit |
| EMF | Electromagnetic Fields |
| Eversource | Eversource Investment |
| FGDC | Federal Geographic Data Committee |
| FI | Fullness index |
| FBMP | Fisheries and Benthic Monitoring Plan |
| ft | feet |
| FW | Food weight |
| GAM | Generalized Additive Model |
| GLM | Generalized Linear Model |

| | |
|---|---|
| GPS | Global Positioning System |
| HD | High definition |
| HMS | Highly Migratory Species |
| HPE | Horizontal position error |
| IAC | Inter-Array Cable |
| ITIS | Integrated Taxonomy Information System |
| kg | kilogram |
| km | kilometer |
| LED | Light-emitting diode |
| LCMA2 | Lobster Conservation Management Area 2 |
| LOA | Letter of Acknowledgement |
| LPIL | Lowest possible identification level |
| m | meter |
| MADMF | Massachusetts Division of Marine Fisheries |
| MA/RI WEA | Massachusetts/Rhode Island Wind Energy Area |
| MassCEC | Massachusetts Clean Energy Center |
| MATOS | Mid-Atlantic Acoustic Telemetry Observation System |
| mm | millimeter |
| mi | mile |
| NEAMAP | Northeast Area Assessment and Monitoring Program |
| NEFOP | Northeast Fisheries Observer Program |
| NEFSC | Northeast Fisheries Science Center |
| nMDS | Non-metric Multidimensional Scaling |
| NMFS | National Marine Fisheries Service |
| NMFS-PRD | National Marine Fisheries Service Protected Resources Division |
| NOAA | National Oceanic and Atmospheric Administration |
| NOAA Fisheries/NMFS | NOAA National Marine Fisheries Service (formerly NMFS) |
| NTAP | Northeast Trawl Advisory Panel |
| NTS | Nearshore Trawl Survey |
| NYS | New York State |
| NYSDEC | New York State Department of Environmental Conservation |
| NYSERDA | New York State Energy Research and Development Authority |
| Ocean SAMP | Ocean Special Area Management Plan |
| OCS | Outer Continental Shelf |
| OCS–DC | Offshore Converter Station |
| OnCS–DC | Onshore Converter Station |
| OSW | Offshore wind |

| | |
|---|---|
| PERMANOVA | Permutational Analysis of Variance |
| PV | Plan View |
| QA/QC | Quality Assurance/Quality Control |
| RI CRMC | Rhode Island Coastal Resources Management Council |
| RIDEM | Rhode Island Department of Environmental Management |
| ROM | Rate of movement |
| ROSA | Responsible Offshore Science Alliance |
| ROV | Remotely Operated Vehicle |
| R/V | Research Vessel |
| RWF | Revolution Wind Farm |
| SFEC | South Fork Export Cable |
| SFW | South Fork Wind |
| SIMPER | Similarity Percentages |
| SNECVTS | Southern New England Cooperative Ventless Trap Survey |
| SOD | Sediment oxygen demand |
| SPI | Sediment Profile Imaging |
| SRWEC | Sunrise Wind Export Cable |
| SRWEC-NYS | Sunrise Wind Export Cable – New York State Waters |
| SRWEC-OCS | Sunrise Wind Export Cable – Outer Continental Shelf |
| SRWF | Sunrise Wind Farm |
| SS | Systematic (random) sampling |
| Sunrise | Wind Sunrise Wind LLC |
| TJB | Transition joint bay |
| UHD | Ultra-High Definition |
| USBL | Ultra Short Baseline |
| VMS | Vessel Monitoring System |
| VTR | Vessel Trip Report |
| WEA | Wind Energy Area |
| WTG | Wind Turbine Generator |

# 1.0 INTRODUCTION

Sunrise Wind LLC (Sunrise Wind), a 50/50 joint venture between Orsted North America Inc. (Orsted NA) and Eversource Investment LLC (Eversource), proposes to construct and operate the Sunrise Wind Farm (SRWF) and the Sunrise Wind Export Cable (SRWEC), collectively the Sunrise Wind Farm Project (hereinafter referred to as the Project). The wind farm portion of the Project will be located in federal waters on the Outer Continental Shelf (OCS) in the designated Bureau of Ocean Energy Management (BOEM) Renewable Energy Lease Area OCS-A 0487 (Lease Area).[1] The Lease Area is approximately 30.5 statute miles (mi) east off the coast of Montauk, New York (Figure 1). The Lease Area was awarded through the BOEM competitive renewable energy lease auction of the Wind Energy Area off the shores of Massachusetts and Rhode Island Wind Energy Area (MA/RI WEA). Other components of the Project will be located in New York State (NYS) waters and onshore in the Town of Brookhaven, Long Island, New York. The Project will specifically include the following offshore and onshore components:

**Offshore:**

- up to 94 Wind Turbine Generators (WTGs) at 102 potential locations;
- one Offshore Converter Station (OCS–DC);
- up to 180 mi (290 km) of Inter-Array Cables (IAC); and
- one direct current (DC) submarine export cable, referred to as the SRWEC, within an up to 105-mi (169-km) long corridor.

**Onshore:**

- a landfall location located at Smith Point County Park, Town of Brookhaven, New York;
- an Onshore Transmission Cable, transition joint bays (TJBs) and associated components;
- an Onshore Interconnection Cable;
- a fiber optic cable co-located with the Onshore Transmission and Onshore Interconnection Cables; and
- a new Onshore Converter Station (OnCS–DC) located in proximity to the existing Holbrook Substation.

The Project's components are grouped into four general categories: the SRWF, inclusive of the WTGs, OCS–DC, and IACs; the SRWEC–OCS, inclusive of up to 99.4 mi (160 km) of the SRWEC in federal waters; the SRWEC–NYS, inclusive of up to 5.2 mi (8.4 km) of the SRWEC in state waters; and Onshore Facilities, inclusive of an up to 17.5 mi (28.2 km) Onshore Transmission Cable, a new Onshore Converter Station (OnCS–DC), and Onshore Interconnection Cable. Figure 1 depicts the Project overview and indicates the area within which offshore Project infrastructure will be sited. Limited onshore construction activities under NYS and local jurisdiction began in Q3 2023. Offshore activities (including seafloor

[1]A portion of Lease Area OCS-A 0500 (Bay State Wind LLC) and the entirety of Lease Area OCS-A 0487 (formerly Deepwater Wind New England LLC) were assigned to Sunrise Wind LLC on September 3, 2020, and the two areas were merged and a revised Lease OCS-A 0487 was issued on March 15, 2021. Thus, when using the term "Lease Area" within this document, Sunrise Wind is referring to the new merged Lease Area OCS-A 0487.

preparation activities) are anticipated to begin in Q2 2024. The Project will be commissioned and operational by Q4 2025.

This Fisheries and Benthic Research Monitoring Plan (FBMP) has been developed in accordance with recommendations set forth in "Guidelines for Providing Information on Fisheries for Renewable Energy Development on the Atlantic Outer Continental Shelf" (BOEM 2019), which state that a fishery survey plan should aim to:

- Identify and confirm which dominant benthic, demersal, and pelagic species are using the project site, and when these species may be present where development is proposed;
- Establish a pre-construction baseline which may be used to assess whether detectable changes associated with proposed operations occurred in post-construction abundance and distribution of fisheries;
- Collect additional information aimed at reducing uncertainty associated with baseline estimates and/or to inform the interpretation of research results; and
- Develop an approach to quantify any substantial changes in the distribution and abundance of fisheries associated with proposed operations.

Further, BOEM provides guidance related to specific survey gears that can be used to complete the fisheries monitoring including otter trawl, beam trawl, gillnet/trammel net, and ventless traps. BOEM guidelines stipulate that two years of pre-construction monitoring data are recommended, and that data should be collected across all four seasons. Consultations with BOEM and other agencies are encouraged during the development of fisheries monitoring plans. BOEM also encourages developers to review existing data, and to seek input from the local fishing industry to select survey equipment and sampling protocols that are appropriate for the area of interest. Additional benthic monitoring that is planned for New York state waters is described in a separate monitoring plan.

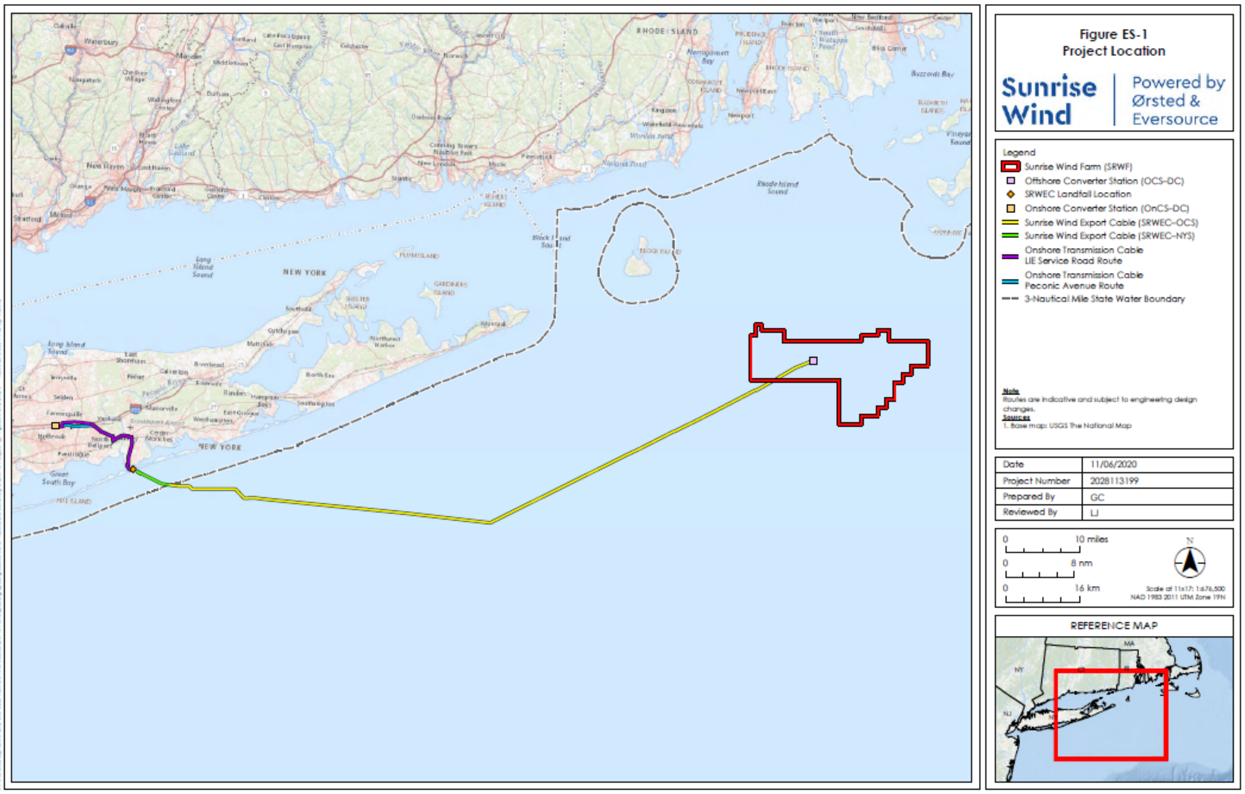



**Figure 1. Map of the Project Area, including the Export Cable route.**

The Rhode Island Coastal Resources Management Council (RI CRMC) also set out monitoring guidelines as part of the Rhode Island Ocean Special Area Management Plan (Ocean SAMP; RICRMC 2010) which stipulate that RI CRMC shall work in conjunction with the Joint Agency Working Group to "determine requirements for monitoring prior to, during, and post construction. Specific monitoring requirements shall be determined on a project-by-project basis and may include but are not limited to the monitoring of coastal processes and physical oceanography, underwater noise, benthic ecology, avian species, marine mammals, sea turtles, fish and fish habitat, commercial and recreational fishing, recreation and tourism, marine transportation, navigation and existing infrastructure, and cultural and historic resources." Further guidance from the RI CRMC (McCann et al. 2013) dictates that "[t]his assessment shall examine the relative abundance, distribution, and different life stages of these species at all four seasons of the year. This assessment shall comprise a series of surveys, employing survey equipment and methods that are appropriate for sampling finfish, shellfish, and crustacean species at the Project's proposed location. Such an assessment shall be performed at least four times: pre-construction (to assess baseline conditions); during construction; and at two different intervals during operation. At each time this assessment must capture all four seasons of the year. This assessment may include evaluation of survey data collected through an existing survey program, if data are available for the proposed site."

This FBMP will be revised through an iterative process, and survey protocols and methodologies have been and will continue to be refined and updated based on feedback received from stakeholder groups. Much of the research described in this plan will be performed on commercial fishing vessels that are contracted for this monitoring. Further, the field work described in the monitoring plan will be performed by independent contractors (e.g., local universities, research institutions, or consulting firms).

**Introduction**

Sunrise Wind is committed to conducting sound, credible science using the following guiding principles:

- Producing transparent, unbiased, and clear results from all research
- Working with commercial and recreational fishermen to identify areas important to them
- Collecting long-term data sets to determine trends and develop knowledge
- Promoting the smart growth of the American offshore wind industry
- Focusing on maintaining access and navigation in, and around, our wind farms for all ocean users
- Completing scientific research collaboratively with the fishing community
- Being accessible and available to the fishing industry
- Utilizing standardized monitoring protocols when possible and building on and supporting existing fisheries research
- Sharing data with all stakeholder groups
- Maintaining data confidentiality for sensitive fisheries dependent monitoring data

# 2.0 SUMMARY OF REGIONAL FISHERIES MONITORING

Fishery dependent and independent data were considered throughout the development of this FBMP. There are several longstanding fishery independent surveys in the vicinity of the Lease Area and along the Sunrise Wind Export Cable route which provide a time-series of information that can be used to characterize the fish and invertebrate communities prior to the start of offshore construction. In addition, several recent case studies provide high-resolution fisheries independent data for the Wind Energy Areas of southern New England. This section provides a brief synopsis of relevant fisheries-independent monitoring.

Data collected during the Northeast Fisheries Science Center (NEFSC) bottom trawl survey between 2003 and 2014 were synthesized to provide an overview of the species composition in each WEA (Guida et al. 2017). In the MA/RI WEA, little and winter skate were the dominant taxa across all seasons (Guida et al. 2017). Ocean pout, Atlantic herring, windowpane flounder, longhorn sculpin, and yellowtail flounder were dominant taxa during the cold season (i.e., winter and spring surveys), while longfin squid, scup, butterfish, northern sea robin, sea scallops, and spiny dogfish were dominant taxa during the fall surveys (Guida et al. 2017). Within the MA/RI WEA, black sea bass, Atlantic cod, ocean quahog, and sea scallops were noted as species that are commonly present and vulnerable to disturbance from the construction and operation of offshore wind farms.

Seasonal trawl surveys conducted by the Massachusetts Division of Marine Fisheries (MADMF) and the Rhode Island Department of Environmental Management (RIDEM) provide a time-series of relative abundance for fish and invertebrate resources in the nearshore waters of southern New England. Trawl surveys have also been carried out in Narragansett Bay for decades by the University of Rhode Island and RIDEM. The New York State Department of Environmental Conservation initiated the nearshore Ocean Trawl Survey on the R/V Seawolf in the fall of 2017, which samples seasonally from Breezy Point to Block Island Sound, and covers a depth range up to 30 m. The Connecticut Department of Energy and Environmental Protection has conducted a spring (March, April, and May) and fall (September and October) trawl survey within Long Island Sound since 1984, with approximately 200 sites sampled annually using a stratified random design. The Northeast Area Assessment and Monitoring Program (NEAMAP) biannual trawl survey conducts sampling each spring and fall in shallow nearshore waters from Cape Hatters northward to Block Island Sound (Bonzek et al. 2017). Some  of the information from these fishery-independent surveys is available through the Northeast Ocean Data Portal (http://www.northeastoceandata.org/) and the Mid-Atlantic Ocean Data Portal (Mid-Atlantic Ocean Data Portal (midatlanticocean.org)), enabling a characterization of the fish and invertebrate resources that may be present in the Lease Area, and also along the SRWEC.

Walsh and Guida (2017) sampled during the spring within the MA/RI WEA using a two-meter beam trawl and an otter trawl net (NEAMAP trawl survey net) and compared the relative abundance, species composition, and length frequency distributions of fish and shellfish that were collected with each sampling gear. The beam trawl more effectively sampled juvenile animals, smaller fish, and invertebrate prey species, while the otter trawl sampled a greater proportion of commercially important demersal and pelagic species. Walsh and Guida (2017) recommended that sampling occur throughout the year to characterize seasonal variation in the species assemblage and suggested that sampling with multiple gear types may provide a more holistic understanding of the fish and invertebrate community.

From December 2015 through April 2016 Siemann and Smolowitz (2017) used scallop dredge surveys to characterize the distribution and habitat preferences of monkfish and flatfish in the southern New England lease areas and used video cameras mounted to a benthic sled to map habitat characteristics. Catches observed in the dredge survey were compared to samples from the NEFSC spring bottom trawl survey (2011 through 2015).

Malek (2015) used beam trawl and otter trawl collections, along with acoustics and seafloor video surveys to evaluate the fine-scale spatial structure of the demersal fish and invertebrate community in Block Island Sound and Rhode Island Sound. This study documented persistent seasonal variability in the fish and invertebrate community, illustrating the need for year-round monitoring to document the potential impacts from offshore wind development. Further, distinct species assemblages were identified, which were influenced by a combination of physical, oceanographic, and biological factors. This study identified summer flounder, silver hake, black sea bass, American lobster, and sea scallops as indicator species that should be considered when assessing the potential impacts of offshore wind development.

The Fish and Fisheries Study, commissioned by the New York State Energy Research and Development Authority (NYSERDA), synthesized habitat data, fishery-independent data, fishery-dependent data, and information provided by stakeholders within an ‘Area of Analysis’ off the coast of New York and New Jersey (Ecology and Environment Engineering, P.C. 2017). While the Sunrise Wind Lease Area does not overlap with the ‘Area of Analysis’, the Sunrise Wind export cable route does cross through this area. The Fish and Fisheries Study provides comprehensive baseline information on the presence, distribution, and habitat use patterns of commercially, recreationally, and ecologically important fish and invertebrate species within the region. The Fish and Fisheries Study also provides spatially explicit data on the geographic patterns of fishing effort and revenue in the area, based on information collected through Vessel Monitoring Systems, Vessel Trip Reports, and stakeholder input.

Estimates of abundance, biomass, and fishing mortality rates derived from stock assessment models can be compared to management reference points to provide a stock-level overview of the health of marine resources that may be found in the Sunrise Wind Lease Area, or along the SRWEC. The stock status of several commercially and recreationally important species in the region is shown in Figure 2. Based on the most recent stock assessment available, of the 16 stocks examined, only the southern Georges/Mid-Atlantic stock of red hake was subject to overfishing (i.e., $F>F_{MSY}$), while seven of the sixteen stocks were considered to be overfished ($B<B_{MSY}$).

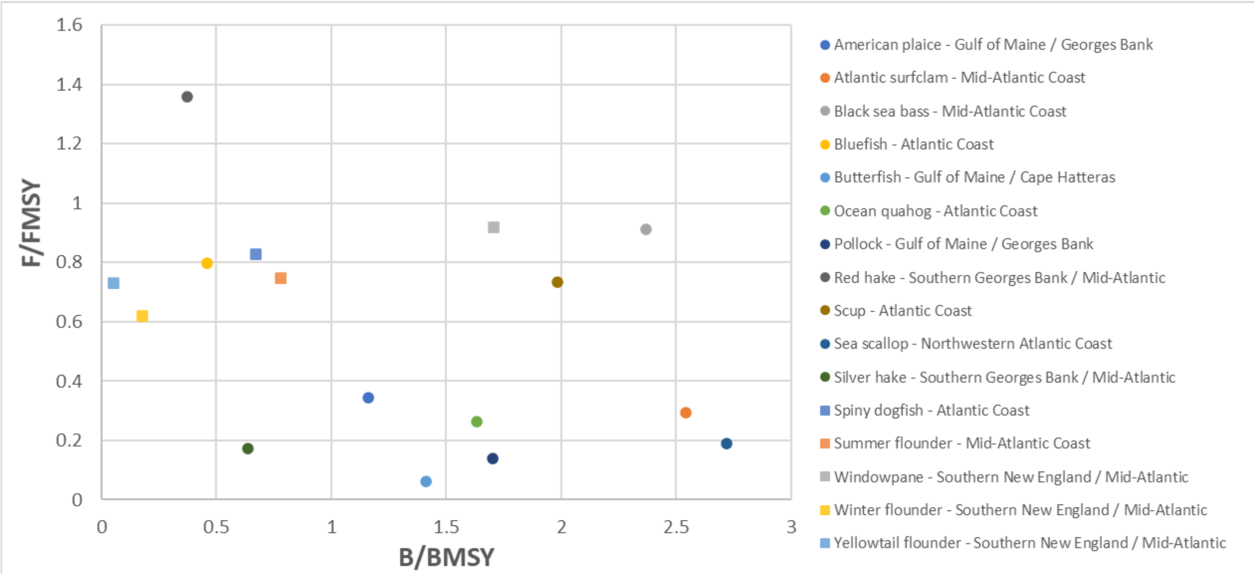



**Figure 2. Kobe plot showing the most recently determined stock status for some of the commercially and recreationally important fish stocks that occur in the Sunrise Wind Lease Area and/or along the Sunrise Wind Export Cable Route (data source: NOAA Fisheries 2021).**

Additional data sources that can be used to characterize the pre-construction community composition in the area include:

- Industry-based trawl surveys for yellowtail flounder (Valliere and Pierce 2007; Cadrin et al. 2013a) and winter flounder (Cadrin et al. 2013b) in southern New England.
- Trawl surveys and ventless trap surveys conducted to assess the Impacts of the Block Island Wind Farm (CoastalVision 2013; Wilber et al. 2018; Carey et al. 2020).
- Fisheries independent surveys for the sea scallop resource including drop camera surveys (Bethoney et al. 2018), dredge surveys (Hart 2015), and towed-camera surveys (NEFSC 2010).
- The Southern New England Cooperative Ventless Trap Survey (SNECVTS) was funded by BOEM to collect pre-construction information on the relative abundance, demographics and distribution of lobster and Jonah crab in the MA/RI WEA (Collie and King 2016). Sampling occurred from May through November in 2014 and 2015, and another season of sampling occurred in 2018 (Collie and King 2016), and provided high-resolution information on the relative abundance, distribution and demographics of lobsters and Jonah crab within the MA/RI WEA.

Several groups have identified lists of priority species for offshore wind monitoring in southern New England, and those lists were used to inform the selection of target species for monitoring at Sunrise Wind. MADMF acknowledged key assessment indicators species for understanding the cumulative impacts associated with wind farm development after considering several metrics including, but not limited to, commercial value, abundance in fishery-independent surveys, vulnerability to construction, and essential fish habitat (EFH; MADMF 2018). The species identified by MADMF (2018) were yellowtail flounder, winter flounder, summer flounder, monkfish, ocean pout, red hake, black sea bass, longfin squid, Atlantic cod, scup, Jonah crab, lobster, ocean quahog, sea scallop, bluefin tuna, little skate, winter skate, and sharks.

MADMF (2018) also recommended that a range prey species be investigated for cumulative impacts, including sand lance, Atlantic herring, menhaden, and Atlantic mackerel.

The northeast regional Habitat Assessment Prioritization Working Group (NMFS 2015) assessed species on the basis of their habitat dependence, along with their cultural and economic significance. Stocks rated as a ‘high’ research priority that overlap with the Sunrise Wind lease area or the Export Cable route include Southern New England/Mid-Atlantic winter flounder, wolffish, summer flounder, black sea bass, Georges Bank haddock, Georges Bank cod, sea scallop, thorny skate, Atlantic surfclam, and witch flounder.

Petruny-Parker et al. (2015) used input from a range of stakeholders to identify sampling tools, research needs, and best practices for monitoring of offshore wind development. The authors noted that sampling should be completed in collaboration with the local fishing industry and should employ a variety of gear types to target a range of species that may be impacted. Their report also identified a list of priority species to be considered during research and monitoring that included alewife, American lobster, Atlantic cod, Atlantic herring, Atlantic sturgeon, black sea bass, blueback herring, bluefish, blue mussels, butterfish, haddock, Jonah crabs, little/winter skates, longfin squid, mackerels, mako shark, menhaden, monkfish, ocean quahogs, pollock, red hake, sea scallops, scup, silver hake, spiny dogfish, striped bass, summer flounder, surf clams, thresher shark, tunas, winter flounder, and yellowtail flounder. Petruny-Parker et al. (2015) also highlighted the need for seasonal sampling prior to construction and recommended that two to three years of monitoring should occur prior to the commencement of offshore construction.

Regional monitoring studies have been recommended to better understand the cumulative impact of offshore wind development on marine resources and the fishing community, and there has been a call for developers to standardize their monitoring approaches to the extent practicable to help understand cumulative impacts of offshore wind development (McCann 2012; MADMF 2018; ROSA 2021). While this FBMP was developed with an emphasis on the species and fisheries that are most important in the SRWF, the monitoring tools and protocols described herein were selected to complement the regional monitoring described above, as well as planned and ongoing data collection efforts by Orsted, other offshore wind developers, and state and federal agencies in the region.

# 3.0 BASELINE CONDITIONS

This section summarizes the existing conditions within the Lease Area and along the SRWEC which were considered in development of this FBMP. Complete details regarding baseline conditions in the Lease Area and along the SRWEC are available in the Project's Construction and Operations Plan (website link to be provided upon publication).

## 3.1 HABITAT CONSIDERATIONS

Species with EFH designations for one or more life stages within the Lease Area and/or along the SRWEC include the following:

- New England Fish – American plaice, Atlantic cod, Atlantic herring, Atlantic wolffish, barndoor skate, haddock, little skate, monkfish, ocean pout, offshore hake, pollock, red hake, silver hake, white hake, windowpane flounder, winter flounder, winter skate, witch flounder, and yellowtail flounder.
- Mid-Atlantic Fish – Atlantic butterfish, Atlantic mackerel, black sea bass, bluefish, scup, and summer flounder.
- Invertebrates – Atlantic sea scallop, Atlantic surfclam, longfin squid, shortfin squid, and ocean quahog.
- Highly Migratory Species – albacore tuna, bluefin tuna, skipjack tuna, and yellowfin tuna, basking shark, blue shark, common thresher shark, dusky shark, porbeagle shark, sandbar shark, sand tiger shark, shortfin mako shark, smooth dogfish, spiny dogfish, tiger shark, and white shark

## 3.2 FISHING ACTIVITY IN THE REGION

Commercial fishing activity in the SRWF and along the SRWEC was characterized using Vessel Monitoring System (VMS) (e.g., Northeast Ocean Data Portal) and federal and state Vessel Trip Report (VTR) data (NOAA Fisheries site, data request, ASMFC, ACCSP), information provided in the Ocean SAMP (RICRMC 2018), through conversations between commercial fishermen and Orsted's fisheries liaisons.

Recently, NOAA Fisheries developed a website presenting fishing effort and revenue data from each proposed offshore wind lease area along the US East Coast[2]. The socioeconomic summaries combine data from VTRs and Dealer Reports to summarize fisheries activity, revenue, and landings annually within each offshore wind lease area. It is acknowledged that the NOAA website does not capture fishing activity for vessels that do not have a VTR requirement (e.g., some highly migratory species permitted vessels and federally permitted lobster and Jonah crab vessels), however, the data summaries do provide a broad overview of the characteristics of fishing effort within each lease site. Several federally permitted fisheries operate in the SRWF. From 2008 through 2019, the highest number of trips taken within the SRWF occurred in 2008, 2009, and 2016 (Table 1). From 2017 through 2019, fewer fishing trips were reported to occur in the SRWF, and fewer vessels fished within the SRWF compared to the prior nine years (Table 1).

[2] https://www.fisheries.noaa.gov/resource/data/socioeconomic-impacts-atlantic-offshore-wind-development

**Table 1. Summary of Federal Economic Fishing Data for the SRWF, by Number of Trips and Vessels, for 2008 to 2019**

| Year | Number of Trips | Number of Vessels |
|---|---|---|
| 2019 | 2,959 | 267 |
| 2018 | 4,003 | 258 |
| 2017 | 4,595 | 286 |
| 2016 | 5,478 | 319 |
| 2015 | 4,846 | 293 |
| 2014 | 5,053 | 319 |
| 2013 | 5,358 | 315 |
| 2012 | 5,051 | 292 |
| 2011 | 4,524 | 265 |
| 2010 | 5,058 | 267 |
| 2009 | 5,929 | 315 |
| 2008 | 5,841 | 329 |

In terms of individual fishing ports, Point Judith, RI and New Bedford, MA accounted for the greatest number of fishing trips within the SRWF in 2019 (Table 2). Point Judith, RI had the greatest number of vessels fish in the SRWF in 2019, while New Bedford, MA, Montauk, NY, Beaufort, NC, and Stonington, CT all had greater than 10 vessels fish in the SRWF during 2019 (Table 2).

**Table 2. Summary of Federal Economic Fishing Data for the SRWF, by Number of Trips and Vessels, for Ports**

| Port | Number of Trips | Number of Vessels |
|---|---|---|
| Beaufort, NC | 30 | 15 |
| Boston, MA | 10 | 4 |
| Cape May, NJ | 5 | 4 |
| Fairhaven, MA | 22 | 8 |
| Hampton, VA | 11 | 9 |
| Little Compton, RI | 187 | 10 |
| Menemsha, NY | 92 | 6 |
| Montauk, NY | 73 | 20 |
| New Bedford, MA | 446 | 80 |
| New London, CT | 39 | 4 |
| Newport News, VA | 11 | 10 |
| Newport, RI | 106 | 6 |
| Point Judith, RI | 1,613 | 93 |
| Point Pleasant, NJ | 16 | 9 |
| Stonington, CT | 68 | 12 |
| Wanchese, NC | 8 | 6 |
| Westport, MA | 92 | 9 |

From 2009 through 2019, the bottom trawl fishery accounted for the highest revenue and landings in the SRWF (Table 3). The VMS data for the groundfish fleet (large-mesh multispecies or northeast multispecies) for the years 2011 to 2016 indicated the highest density of fishing activity in the northwestern portion of the SRWF, with some areas of medium to high effort in the southwestern portion of the Lease Area, and less effort elsewhere in the Lease Area (Appendix A, Figures A-1 and A-2). Other fisheries that routinely operate in the SRWF include the pot fishery for lobsters and crabs, the sink gillnet fishery, the scallop dredge fishery, and the midwater trawl fishery (Table 3). VMS data indicated that the fishery routinely targeted monkfish throughout the SRWF from 2011 to 2016 (Appendix A, Figures A-3 and A-4), and the importance of the monkfish fishery is reflected in the landings data which demonstrate that monkfish provided the greatest mean annual fishery revenue from the SRWF from 2008 through 2019 (Table 4). In 2014 the pelagic fisheries for herring, mackerel, and squid primarily operated in the southwestern portion of the SRWF (Appendix A, Figure A-5). However, fishing intensity increased for pelagic species in the SRWF from 2015 through 2016 and the fishery operated mainly in the northwestern corner of the SRWF (Appendix A, Figure A-6), reflecting the dynamic distribution of these pelagic species. Dredge fisheries for surfclam and ocean quahog operated throughout the SRWF from 2012 to 2014 (Appendix A, Figure A-7), while fishing effort was generally concentrated in western and central portions of the SRWF from 2015 through 2016 (Appendix A, Figure A-8). Scallops represented the second most valuable species harvested in the SRWF Lease Area from 2008 through 2019 (Table 4). The scallop dredge fishing intensity was relatively low throughout the SRWF from 2011 to 2014, but the amount of scallop effort increased in 2015 and 2016; primarily in the central portion of the SRWF Lease Area (Appendix A, Figures A-9 and A-10). Spatial information on lobster and Jonah crab effort is more limited due to reporting requirements in those fisheries, but the Ocean SAMP documents indicate that fixed gear is fished throughout the MA/RI WEA (RICRMC 2018), and the fishery-dependent data indicate that lobsters and Jonah crabs were a notable source of revenue and landings within the SRWF Lease Area (Table 4). The for-hire recreational fishery mainly operates in the northern portion of the MA/RI WEA, including Cox Ledge and the South Fork Wind Farm Project lease area, to the north of the SRW Lease Area (RICRMC 2018).

It is noted that fisheries dependent data is heavily influenced by fisheries management, including seasonal and spatial closures that are designed to limit mortality, protect sensitive habitats or activities (e.g., spawning) or fulfill another management objective. Therefore, the fisheries dependent data summarized within this section (including fisheries effort data presented in Appendix A) should not be assumed to be wholly representative of the underlying abundance and availability of commercially and recreationally important species within the Lease Area.

**Table 3. Summary of revenue and landings from federal VTR data, by gear type, for vessels fishing in the SRWF area from 2009 through 2018 (INSPIRE Environmental 2021a). VTR data requested for SRWF included a 1-km buffer to account for potential activities around the margins of the wind farm.**

| | Annual Average Revenue and Landings from within SRWF | | Annual Average of Total Revenue and Landings from ME to NC | | Percent of Total Species Values in SRWF | |
|---|---|---|---|---|---|---|
| Gear Type | Revenue ($) | Landings (lb) | Revenue ($) | Landings (lb) | % of Revenue | % of Landings |
| Trawl-Bottom | 692,726 | 955,748 | 46,873,675 | 32,325,747 | 1.48 | 2.96 |
| Gillnets | 615,420 | 734,490 | 48,830,995 | 64,380,863 | 1.26 | 1.14 |
| Dredge | 325,759 | 729,330 | 370,548,263 | 115,687,777 | 0.09 | 0.63 |
| Pot | 203,481 | 97,674 | 623,584,075 | 251,757,638 | 0.03 | 0.04 |
| Trawl-Midwater | 23,680 | 203,732 | 14,479,983 | 96,249,236 | 0.16 | 0.21 |
| Hand | 3,543 | 1,206 | 16,476,037 | 5,249,404 | 0.02 | 0.02 |
| Longlines | 918 | 301 | 36,141,740 | 20,608,637 | <0.01 | <0.01 |
| **Total** | 1,865,527 | 2,722,481 | 1,156,934,768 | 586,259,302 | 0.16 | 0.46 |

Source: NOAA Fisheries 2020; Atlantic Coastal Cooperative Statistics Program (ACCSP) 2020b
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.

Revenue is reported in nominal dollars.
“Total” revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.

From 2008 through 2019 federal VTR revenue and landings data from the SRWF indicate that monkfish accounted for the greatest revenue (Table 4). Aside from monkfish, the species or species groups that provided the greatest revenues from the SRWF were scallops, flatfish, skate (wings), lobster, loligo squid, and hakes (Table 4).

Based on federal VTR data, fishing vessels from Rhode Island and Massachusetts accounted for the majority of landings and revenue from the SRWF area between 2009 and 2018 (Table 5).

**Table 4. Summary of revenue and landings from federal VTR data, by individual species, for vessels fishing in the SRWF area from 2009 to 2018 (INSPIRE Environmental 2021a). VTR data requested for SRWF included a 1-km buffer to account for potential activities around the margins of the wind farm.**

| | Annual Average Revenue and Landings from within SRWF | | Annual Average of Total Revenue and Landings from ME to NC | | Percent of Total Species Values in SRWF | |
|---|---|---|---|---|---|---|
| Species | Revenue ($) | Landings (lb) | Revenue ($) | Landings (lb) | % of Revenue | % of Landings |
| Monkfish | 409,960 | 277,068 | 20,227,155 | 19,974,755 | 2.03 | 1.39 |
| Scallops/Bushel | 267,163 | 25,896 | 482,923,974 | 49,154,784 | 0.06 | 0.05 |
| Flounders | 262,740 | 108,886 | 53,134,241 | 23,095,652 | 0.49 | 0.47 |
| Skate Wings | 229,704 | 656,718 | 2,745,248 | 10,558,473 | 8.37 | 6.22 |
| Lobster, American | 143,612 | 30,729 | 508,376,902 | 138,393,661 | 0.03 | 0.02 |
| Squid, Longfin | 120,534 | 100,964 | 28,808,682 | 24,553,538 | 0.42 | 0.41 |
| Hakes | 88,384 | 175,770 | 15,734,072 | 20,616,926 | 0.56 | 0.85 |
| Scup | 78,947 | 128,792 | 9,282,234 | 14,365,155 | 0.85 | 0.90 |
| Quahogs/Bushel | 57,763 | 85,207 | 11,515,763 | 15,885,026 | 0.50 | 0.54 |
| Cod | 50,622 | 20,666 | 14,976,920 | 8,631,140 | 0.34 | 0.24 |
| Crab, Jonah | 46,037 | 59,144 | 10,984,715 | 14,430,188 | 0.42 | 0.41 |
| Herring, Atlantic | 35,617 | 269,766 | 26,547,928 | 166,518,782 | 0.13 | 0.16 |
| Butterfish | 20,939 | 30,032 | 2,182,611 | 3,343,738 | 0.96 | 0.90 |
| Dogfish, Spiny | 15,940 | 88,845 | 3,621,344 | 18,797,259 | 0.44 | 0.47 |
| Black Sea Bass | 14,680 | 3,762 | 8,062,043 | 2,482,044 | 0.18 | 0.15 |
| Whelk, Channeled/Bushel | 5,600 | 752 | 7,209,932 | 1,241,043 | 0.08 | 0.06 |
| Mackerel, Atlantic | 5,015 | 26,616 | 3,889,784 | 16,598,279 | 0.13 | 0.16 |
| Bluefish | 4,086 | 6,184 | 2,795,762 | 4,626,369 | 0.15 | 0.13 |
| Striped Bass | 3,676 | 861 | 18,993,967 | 6,042,232 | 0.02 | 0.01 |
| Squid, Illex | 2,849 | 2,960 | 9,740,364 | 23,566,822 | 0.03 | 0.01 |
| Crab, Rock/Bushel | 2,637 | 4,425 | 905,105 | 1,934,725 | 0.29 | 0.23 |
| Tilefish, Golden | 1,975 | 614 | 5,140,209 | 1,697,154 | 0.04 | 0.04 |
| Cunner | 1,054 | 257 | 20,411 | 6,394 | 5.16 | 4.02 |
| Dogfish, Smooth | 791 | 2,460 | 975,814 | 2,038,524 | 0.08 | 0.12 |
| Tautog | 729 | 232 | 939,764 | 277,524 | 0.08 | 0.08 |
| Weakfish | 494 | 254 | 911,459 | 480,366 | 0.05 | 0.05 |
| Bonito | 325 | 125 | 112,991 | 53,483 | 0.29 | 0.23 |
| Whiting, King, Kingfish | 305 | 345 | 901,080 | 808,024 | 0.03 | 0.04 |
| Sea Raven | 186 | 143 | 2,735 | 2,214 | 6.80 | 6.46 |
| Croaker, Atlantic | 156 | 394 | 7,545,945 | 9,430,649 | <0.01 | <0.01 |
| Pollock | 98 | 98 | 9,248,825 | 10,614,877 | <0.01 | <0.01 |
| Halibut, Atlantic | 75 | 10 | 814,873 | 131,652 | 0.01 | 0.01 |
| Tuna, Little | 73 | 108 | 132,156 | 233,922 | 0.06 | 0.05 |
| Crab, Species Not Specified | 27 | 55 | 104,592 | 234,054 | 0.03 | 0.02 |

| | Annual Average Revenue and Landings from within SRWF | | Annual Average of Total Revenue and Landings from ME to NC | | Percent of Total Species Values in SRWF | |
|---|---|---|---|---|---|---|
| **Species** | **Revenue ($)** | **Landings (lb)** | **Revenue ($)** | **Landings (lb)** | **% of Revenue** | **% of Landings** |
| Sea Robins | 24 | 156 | 20,363 | 111,941 | 0.12 | 0.14 |
| Triggerfish | 21 | 16 | 305,237 | 156,878 | 0.01 | 0.01 |
| Crab, Blue/Bushel | 19 | 23 | 122,113,419 | 101,094,748 | <0.01 | <0.01 |
| Eel, American | 14 | 17 | 11,743,242 | 737,151 | <0.01 | <0.01 |
| Whelk, Knobbed/Bushel | 10 | 5 | 1,072,305 | 652,175 | <0.01 | <0.01 |
| Skate Wings, Clearnose | 8 | 22 | 151,764 | 63,015 | 0.01 | 0.03 |
| Ocean Pout | 6 | 6 | 467 | 565 | 1.28 | 1.06 |
| Redfish, Ocean Perch | 4 | 6 | 4,433,221 | 7,839,842 | <0.01 | <0.01 |
| Shark, Thresher | 4 | 6 | 55,444 | 116,584 | 0.01 | 0.01 |
| Tilefish, Blueline | 4 | 2 | 472,282 | 223,867 | <0.01 | <0.01 |
| Mackerel, Spanish | 2 | 1 | 1,192,721 | 816,870 | <0.01 | <0.01 |
| Mullets | 2 | 3 | 11,018 | 20,601 | 0.02 | 0.01 |
| Scallops, Bay/Shells | 2 | 0 | 3,715,767 | 230,219 | <0.01 | <0.01 |
| Spot | 2 | 7 | 3,139,995 | 2,828,429 | <0.01 | <0.01 |
| **Total** | 1,872,915 | 2,109,408 | 1,417,936,845 | 725,712,313 | 0.13 | 0.29 |

Source: NOAA Fisheries 2020; ACCSP 2020a
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is reported in nominal dollars.
“Total” revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.

**Table 5. Summary of landings and revenue from federal VTR data, by state, for vessels fishing in the SRWF area from 2009 to 2018 (INSPIRE Environmental 2021a). VTR data requested for SRWF included a 1-km buffer to account for potential activities around the margins of the wind farm.**

| | Annual Average Revenue and Landings from within SRWF | | Annual Average of Total Revenue and Landings from ME to NC | | Percent of Total Species Values in SRWF | |
|---|---|---|---|---|---|---|
| State | Revenue ($) | Landings (lb) | Revenue ($) | Landings (lb) | % of Revenue | % of Landings |
| Rhode Island | 1,204,910 | 2,315,036 | 83,805,129 | 83,065,993 | 1.44 | 2.79 |
| Massachusetts | 1,195,615 | 8,029,481 | 547,853,119 | 272,472,579 | 0.22 | 2.95 |
| New York | 50,480 | 36,015 | 53,574,875 | 30,798,644 | 0.09 | 0.12 |
| All Others | 27,542 | 19,678 | 927,861,542 | 818,492,359 | <0.01 | <0.01 |
| Connecticut | 27,043 | 26,087 | 16,233,218 | 8,827,386 | 0.17 | 0.30 |
| New Jersey | 13,752 | 68,792 | 172,916,683 | 160,313,907 | 0.01 | 0.04 |
| **Total** | 2,519,342 | 10,495,089 | 1,802,244,566 | 1,373,970,868 | 0.14 | 0.76 |

Source: NOAA Fisheries 2020; ACCSP 2020a
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is reported in nominal dollars.
"All Others" includes North Carolina, Virginia, Maryland, Delaware, New Hampshire, and Maine.
"Total" revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.

Several federally permitted fisheries are active along the approximately 106 -mi (170 -km) SRWEC. An estimate of revenues and landings associated with the SRWEC were generated using a 10-km wide buffer around the SRWEC (5 km on either side of the SRWEC centerline). The 10 -km buffer was intended to provide a reasonable geographic extent for fisheries that may occur in and around the SRWEC corridor. Based on VTR data, the gear types that generated the greatest revenues and landings along the SRWEC were dredge, bottom trawl, gillnet, pot, midwater trawl, and by hand fisheries (Table 6). VMS data indicate a high density of effort from the sea scallop (Appendix A, Figures A-9 and A-10) and surfclam/ocean quahog fisheries (Appendix A, Figures A-7 and A-8) along portions of the SRWEC during 2011 to 2016, particularly in areas closer to the cable landfall location and near the southwestern corner of the SRWF. There were also areas of high fishing activity for monkfish and large-mesh groundfish-species along the SRWEC in waters nearest the SRWF from 2011 to 2014 (Appendix A, Figures A-1 and A-3), however, the intensity of fishing effort in this area was reduced for both of these fisheries from 2015 through 2016 (Appendix A, Figures A-2 and A-4). Fishing effort for pelagic species (herring/mackerel/squid), increased along the SRWEC route in 2015 to 2016 (Appendix A, Figures A-5 and A-6). VMS data suggest there was little directed fishing effort for Atlantic herring along the SRWEC (Appendix A, Figures A-11 and A-12), while effort in the squid fishery increased from 2015 through 2016, relative to the preceding four years (Appendix A, Figures A-13 and A-14).

**Table 6. Summary of Federal VTR Data, by Gear Type, for Vessels Fishing along the 10-km SRWEC Route Buffer Zone from 2009 to 2018 (INSPIRE Environmental 2021a)**

| | Annual Average Revenue and Landings from within SRWEC Fisheries Study Corridor | | Annual Average of Total Revenue and Landings from ME to NC | | Percent of Total Species Values in SRWEC Fisheries Study Corridor | |
|---|---|---|---|---|---|---|
| **Gear Type** | **Revenue ($)** | **Landings (lb)** | **Revenue ($)** | **Landings (lb)** | **% of Revenue** | **% of Landings** |
| Dredge | 6,078,125 | 11,729,188 | 370,548,263 | 115,687,777 | 1.64 | 10.14 |
| Trawl-Bottom | 2,000,054 | 1,924,041 | 46,873,675 | 32,325,747 | 4.27 | 5.95 |
| Gillnets | 1,045,768 | 909,037 | 48,830,995 | 64,380,863 | 2.14 | 1.41 |
| Pot | 227,393 | 161,283 | 623,584,075 | 251,757,638 | 0.04 | 0.06 |
| Trawl-Midwater | 129,609 | 1,123,851 | 14,479,983 | 96,249,236 | 0.90 | 1.17 |
| Hand | 12,363 | 6,222 | 16,476,037 | 5,249,404 | 0.08 | 0.12 |
| Longlines | 1,502 | 600 | 36,141,740 | 20,608,637 | <0.01 | <0.01 |
| **Total** | 9,494,814 | 15,854,222 | 1,156,934,768 | 586,259,302 | 0.82 | 2.70 |

Source: NOAA Fisheries 2020; ACCSP 2020b
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is reported in nominal dollars.
"Total" revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.

Sea scallops generated the greatest revenue for federally permitted vessels fishing within the 10 -km SRWEC route buffer zone, followed by monkfish, ocean quahog, squid, flounders, skates, and scup (Table 7). Federally permitted vessels with home ports in Massachusetts, New York, and Rhode Island accounted for the vast majority of landings and revenue within the 10 -km SRWEC route buffer zone (Table 8).

**Table 7. Summary of Federal VTR Data, by Top Individual Species, for Vessels Fishing along the 10-km SRWEC Route Buffer Zone from 2009 to 2018 (INSPIRE Environmental 2021a)**

| | Annual Average Revenue and Landings from within SRWEC Fisheries Study Corridor | | Annual Average of Total Revenue and Landings | | Percent of Total Species Values in SRWEC Fisheries Study Corridor | |
|---|---|---|---|---|---|---|
| **Species** | **Revenue** | **Landings** | **Revenue** | **Landings** | **% of Revenue** | **% of Landings** |
| Scallops/Bushel | 5,366,174 | 545,650 | 482,923,974 | 49,154,784 | 1.11 | 1.11 |
| Monkfish | 885,498 | 549,267 | 20,227,155 | 19,974,755 | 4.38 | 2.75 |
| Quahogs/Bushel | 849,674 | 1,349,941 | 11,515,763 | 15,885,026 | 7.38 | 8.50 |
| Squid, Longfin | 676,904 | 598,372 | 28,808,682 | 24,553,538 | 2.35 | 2.44 |
| Flounders | 616,681 | 236,811 | 53,134,241 | 23,095,652 | 1.16 | 1.03 |
| Skate Wings | 227,213 | 652,002 | 2,745,248 | 10,558,473 | 8.28 | 6.18 |
| Scup | 194,697 | 275,921 | 9,282,234 | 14,365,155 | 2.10 | 1.92 |
| Herring, Atlantic | 152,910 | 1,232,545 | 26,547,928 | 166,518,782 | 0.58 | 0.74 |
| Lobster, American | 113,790 | 24,503 | 508,376,902 | 138,393,661 | 0.02 | 0.02 |
| Crab, Jonah | 84,948 | 117,578 | 10,984,715 | 14,430,188 | 0.77 | 0.81 |
| Hakes | 68,292 | 105,459 | 15,734,072 | 20,616,926 | 0.43 | 0.51 |

| | Annual Average Revenue and Landings from within SRWEC Fisheries Study Corridor | | Annual Average of Total Revenue and Landings | | Percent of Total Species Values in SRWEC Fisheries Study Corridor | |
|---|---|---|---|---|---|---|
| **Species** | **Revenue** | **Landings** | **Revenue** | **Landings** | **% of Revenue** | **% of Landings** |
| Black Sea Bass | 54,638 | 14,757 | 8,062,043 | 2,482,044 | 0.68 | 0.59 |
| Striped Bass | 49,574 | 13,259 | 18,993,967 | 6,042,232 | 0.26 | 0.22 |
| Cod | 38,912 | 18,411 | 14,976,920 | 8,631,140 | 0.26 | 0.21 |
| Mackerel, Atlantic | 28,407 | 146,979 | 3,889,784 | 16,598,279 | 0.73 | 0.89 |
| Bluefish | 18,138 | 26,001 | 2,795,762 | 4,626,369 | 0.65 | 0.56 |
| Butterfish | 16,258 | 23,393 | 2,182,611 | 3,343,738 | 0.74 | 0.70 |
| Clam, Surf/Bushel | 9,464 | 13,402 | 28,970,372 | 39,277,659 | 0.03 | 0.03 |
| Dogfish, Spiny | 9,395 | 45,322 | 3,621,344 | 18,797,259 | 0.26 | 0.24 |
| Dogfish, Smooth | 7,897 | 14,025 | 975,814 | 2,038,524 | 0.81 | 0.69 |
| Tilefish, Golden | 7,127 | 2,362 | 5,140,209 | 1,697,154 | 0.14 | 0.14 |
| Eel, American | 5,919 | 288 | 11,743,242 | 737,151 | 0.05 | 0.04 |
| Crab, Rock/Bushel | 3,479 | 6,644 | 905,105 | 1,934,725 | 0.38 | 0.34 |
| Weakfish | 3,071 | 1,737 | 911,459 | 480,366 | 0.34 | 0.36 |
| Whelk, Channeled/Bushel | 2,060 | 507 | 7,209,932 | 1,241,043 | 0.03 | 0.04 |
| Tautog | 2,021 | 640 | 939,764 | 277,524 | 0.22 | 0.23 |
| Whiting, King, Kingfish | 1,676 | 1,838 | 901,080 | 808,024 | 0.19 | 0.23 |
| Squid,/ Illex | 948 | 1,277 | 9,740,364 | 23,566,822 | 0.01 | 0.01 |
| Menhaden | 945 | 9,595 | 36,050,402 | 410,062,789 | <0.01 | <0.01 |
| Croaker, Atlantic | 849 | 1,248 | 7,545,945 | 9,430,649 | 0.01 | 0.01 |
| Bonito | 824 | 417 | 112,991 | 53,483 | 0.73 | 0.78 |
| Whelk, Waved | 755 | 1,180 | 167,288 | 310,836 | 0.45 | 0.38 |
| Cunner | 462 | 171 | 20,411 | 6,394 | 2.26 | 2.67 |
| Tuna, Little | 372 | 574 | 132,156 | 233,922 | 0.28 | 0.25 |
| Pollock | 268 | 289 | 9,248,825 | 10,614,877 | <0.01 | <0.01 |
| Triggerfish | 263 | 172 | 305,237 | 156,878 | 0.09 | 0.11 |
| Crab, Species Not Specified | 260 | 552 | 104,592 | 234,054 | 0.25 | 0.24 |
| Crab, Horseshoe | 257 | 240 | 1,549,706 | 2,075,840 | 0.02 | 0.01 |
| Whelk, Knobbed/Bushel | 182 | 133 | 1,072,305 | 652,175 | 0.02 | 0.02 |
| Sea Robins | 174 | 786 | 20,363 | 111,941 | 0.85 | 0.70 |
| Spot | 158 | 239 | 3,139,995 | 2,828,429 | 0.01 | 0.01 |
| Crab, Blue/Bushel | 128 | 136 | 122,113,419 | 101,094,748 | <0.01 | <0.01 |
| Mackerel, Spanish | 113 | 54 | 1,192,721 | 816,870 | 0.01 | 0.01 |
| Shark, Thresher | 110 | 85 | 55,444 | 116,584 | 0.20 | 0.07 |
| Herring, Blue Back | 93 | 400 | 846 | 3,212 | 10.99 | 12.45 |
| Halibut, Atlantic | 88 | 14 | 814,873 | 131,652 | 0.01 | 0.01 |
| Sea Raven | 84 | 80 | 2,735 | 2,214 | 3.07 | 3.61 |
| Whelk, Lightning | 68 | 32 | 752 | 358 | 9.04 | 8.94 |

| | Annual Average Revenue and Landings from within SRWEC Fisheries Study Corridor | | Annual Average of Total Revenue and Landings | | Percent of Total Species Values in SRWEC Fisheries Study Corridor | |
|---|---|---|---|---|---|---|
| Species | Revenue | Landings | Revenue | Landings | % of Revenue | % of Landings |
| Scallops, Bay/Shells | 64 | 6 | 3,715,767 | 230,219 | <0.01 | <0.01 |
| Skate Wings, Clearnose | 63 | 194 | 151,764 | 63,015 | 0.04 | 0.31 |
| Ocean Pout | 62 | 76 | 467 | 565 | 13.28 | 13.45 |
| Mullets | 39 | 49 | 11,018 | 20,601 | 0.35 | 0.24 |
| Tilefish, Blueline | 34 | 19 | 472,282 | 223,867 | 0.01 | 0.01 |
| Swordfish | 27 | 6 | 4,856,707 | 1,630,752 | <0.01 | <0.01 |
| Shad, American | 25 | 41 | 241,660 | 217,897 | 0.01 | 0.02 |
| Shad, Hickory | 8 | 10 | 32,427 | 102,845 | 0.02 | 0.01 |
| Dolphin Fish, Mahi-Mahi | 4 | 1 | 951,846 | 347,011 | <0.01 | <0.01 |
| Redfish, Ocean Perch | 3 | 5 | 4,433,221 | 7,839,842 | <0.01 | <0.01 |
| Tuna, Skipjack | 2 | 2 | 5,109 | 5,748 | 0.04 | 0.03 |
| Tilefish, Sand | 2 | 1 | 659 | 846 | 0.30 | 0.12 |
| Crevalle | 1 | 1 | 5,236 | 7,147 | 0.02 | 0.01 |
| Perch, White | 1 | 1 | 932,971 | 1,180,489 | <0.01 | <0.01 |
| **Total** | 9,502,553 | 6,035,700 | 1,491,702,826 | 1,180,935,742 | 0.64 | 0.51 |

Source: NOAA Fisheries 2020; ACCSP 2020a
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is reported in nominal dollars.
“Total” revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.

**Table 8. Summary of Federal VTR Data, by State, for Vessels Fishing along the 10-km SRWEC Route Buffer Zone from 2009 to 2018 (INSPIRE Environmental 2021a)**

| | Annual Average Revenue and Landings from within SRWEC Fisheries Study Corridor | | Annual Average of Total Revenue and Landings from ME to NC | | Percent of Total Species Values in SRWEC Fisheries Study Corridor | |
|---|---|---|---|---|---|---|
| State | Revenue ($) | Landings (lb) | Revenue ($) | Landings (lb) | % of Revenue | % of Landings |
| Massachusetts | 6,258,440 | 26,350,839 | 547,853,119 | 272,472,579 | 1.14 | 9.67 |
| New York | 1,827,185 | 1,310,390 | 53,574,875 | 30,798,644 | 3.41 | 4.25 |
| Rhode Island | 1,426,204 | 1,831,279 | 83,805,129 | 83,065,993 | 1.70 | 2.20 |
| New Jersey | 711,336 | 2,656,196 | 172,916,683 | 160,313,907 | 0.41 | 1.66 |
| Connecticut | 596,378 | 349,434 | 16,233,218 | 8,827,386 | 3.67 | 3.96 |
| All Others | 228,405 | 108,253 | 927,861,542 | 818,492,359 | 0.02 | 0.01 |
| **Total** | 11,047,948 | 32,606,391 | 1,802,244,566 | 1,373,970,868 | 0.61 | 2.37 |

Source: NOAA Fisheries 2020; ACCSP 2020a
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is reported in nominal dollars.
"All Others" includes North Carolina, Virginia, Maryland, Delaware, New Hampshire, and Maine.
"Total" revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.

Several fisheries also occur in NY state waters along the SRWEC. From 2009 to 2019 the pots and traps fisheries had mean annual landings of 890,393 pounds in statistical areas 611, 612, and 613 combined, accounting for 92.6 percent of the statewide landings for this gear type (Table 9; ACCSP 2020c). The gillnet fishery represented the second largest fishery, followed by dredge, and other fixed nets. Species with the highest average annual landings by weight for statistical areas 611, 612, and 613 combined included Atlantic surfclam (1,132,898 pounds), menhaden (682,384 pounds), and striped bass (571,352 pounds) (Table 10). For several species, landings from the three statistical areas account for over 90 percent of statewide landings; these species include menhaden, striped bass, scup, horseshoe crab, bluefish, American lobster, summer flounder, longfin squid, whelks, tautog, black sea bass, butterfish, green crab, conchs, skates, and others (INSPIRE Environmental 2021a).

**Table 9. Summary of Landings, by Statistical Area and Gear Type, for State-only Permitted Fishing Vessels from New York from 2009 to 2019 (INSPIRE Environmental 2021a)**

| | Average Pounds Landed per Year (2009-2019) | | | Total Pounds Landed (2009-2019) | | | Total Pounds Landed in New York State Waters (2009-2019) | % Pounds Landed out of Total New York State Waters, by Gear | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Statistical Areas | | | Statistical Areas | | | | Statistical Areas | | |
| Gear Type | 611 | 612 | 613 | 611 | 612 | 613 | | 611 | 612 | 613 |
| Beam Trawls | 6,787 | | | 13,574 | | | 27,149 | 50.0 | | |
| By Hand, Diving Gear | 876 | 785 | 1,618 | 5,257 | 5,493 | 14,565 | 50,631 | 10.4 | 10.8 | 28.8 |
| By Hand, No Diving Gear | 92,293 | 180,262 | 70,911 | 922,925 | 1,802,624 | 709,114 | 3,492,529 | 26.4 | 51.6 | 20.3 |
| Dip Nets | 87,330 | 129,974 | 902 | 785,966 | 1,299,738 | 8,115 | 2,094,418 | 37.5 | 62.1 | 0.4 |
| Dredge | 10,712 | 259,240 | 358,147 | 107,121 | 2,073,918 | 3,223,324 | 5,489,942 | 2.0 | 37.8 | 58.7 |
| Fyke Nets | 879 | 2,835 | 6,281 | 3,515 | 14,176 | 56,532 | 148,445 | 2.4 | 9.5 | 38.1 |
| Gill Nets | 119,850 | 91,198 | 422,030 | 1,198,502 | 911,975 | 4,220,301 | 6,808,594 | 17.6 | 13.4 | 62.0 |
| Hand Line | 325 | 266 | 701 | 2,276 | 2,127 | 2,802 | 14,434 | 15.8 | 14.7 | 19.4 |
| Hook and Line | 241,226 | 85,205 | 71,580 | 2,412,257 | 852,048 | 715,803 | 3,981,848 | 60.6 | 21.4 | 18.0 |
| Not Coded | | 168,974 | 321,497 | | 1,351,794 | 2,250,477 | 35,377,057 | | 3.8 | 6.4 |
| Other Fixed Nets | 496,586 | | 51,744 | 4,469,275 | | 413,955 | 4,906,178 | 91.1 | | 8.4 |
| Other Gears | 27,100 | 13,806 | 8,632 | 81,300 | 41,418 | 17,264 | 143,452 | 56.7 | 28.9 | 12.0 |
| Other Seines | 148,657 | 22,662 | 29,287 | 1,337,916 | 203,959 | 263,581 | 1,805,980 | 74.1 | 11.3 | 14.6 |
| Other Trawls | 12,873 | 2,184 | 27,159 | 90,109 | 6,552 | 81,478 | 178,277 | 50.5 | 3.7 | 45.7 |
| Otter Trawls | 116,127 | 5,312 | 33,500 | 1,161,266 | 15,937 | 201,001 | 1,393,011 | 83.4 | 1.1 | 14.4 |
| Otter Trawls, Bottom | 303,080 | 4,317 | 178,455 | 3,030,797 | 43,168 | 1,606,093 | 4,680,057 | 64.8 | 0.9 | 34.3 |
| Pots & Traps, Lobster | 64,291 | 1,603 | | 642,909 | 11,224 | | 655,590 | 98.1 | 1.7 | |
| Pots and Traps | 353,061 | 436,167 | 101,165 | 3,530,615 | 4,361,672 | 1,011,647 | 9,607,954 | 36.7 | 45.4 | 10.5 |
| Pound Nets | 149,644 | | 17,843 | 1,496,444 | | 142,743 | 1,639,788 | 91.3 | | 8.7 |
| Rakes | | 3,982 | 8,176 | | 35,835 | 32,702 | 171,270 | | 20.9 | 19.1 |
| **Total** | 2,231,697 | 1,408,772 | 1,709,628 | 21,292,025 | 13,033,656 | 14,971,496 | 82,666,604 | 25.8 | 15.8 | 18.1 |

Source: ACCSP 2020c
Notes: Values reflect pounds landed, caught in statistical areas relevant to Sunrise Wind.
Confidential information was redacted from the ACCSP data set.
Blank cells indicate those years when the fishing area had no reported landings or redacted confidential landings.
Average pounds landed were calculated as an arithmetic mean, using the sum of pounds landed and the count of distinct years, ignoring zero years.

**Table 10. Top species landed by New York state-only permitted vessels during 2009-2019 in statistical areas 611, 612 and 613 (INSPIRE Environmental 2021a). The table was truncated to only include species with >80,000lbs of total landings from 2009-2019.**

| | Average Pounds Landed per Year (2009-2019) | | | Total Pounds Landed (2009-2019) | | | Total Pounds Landed in New York State Waters (2009-2019) | % Pounds Landed out of Total New York State Waters, by Species | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Statistical Areas | | | Statistical Areas | | | | Statistical Areas | | |
| Species | 611 | 612 | 613 | 611 | 612 | 613 | | 611 | 612 | 613 |
| Clam, Surf, Atlantic | 6,282 | 426,740 | 699,876 | 12,563 | 2,560,438 | 4,899,134 | 23,024,721 | 0.1 | 11.1 | 21.3 |
| Clam, Quahog, Northern | | | 61,875 | | | 556,879 | 12,017,603 | | | 4.6 |
| Menhadens | 404,906 | 172,771 | 104,707 | 4,049,061 | 1,900,481 | 1,151,779 | 7,101,921 | 57.0 | 26.8 | 16.2 |
| Bass, Striped | 205,430 | 53,489 | 312,433 | 2,259,733 | 588,378 | 3,436,764 | 6,285,503 | 36.0 | 9.4 | 54.7 |
| Scup | 441,670 | 4,801 | 27,117 | 4,858,369 | 52,810 | 298,284 | 5,210,427 | 93.2 | 1.0 | 5.7 |
| Crab, Blue | 7,784 | 355,090 | 22,470 | 85,628 | 3,905,993 | 247,168 | 4,727,543 | 1.8 | 82.6 | 5.2 |
| Crab, Horseshoe | 110,597 | 187,684 | 96,529 | 1,216,571 | 2,064,523 | 1,061,814 | 4,450,252 | 27.3 | 46.4 | 23.9 |
| Bluefish | 267,280 | 19,097 | 87,923 | 2,940,079 | 210,064 | 967,158 | 4,117,315 | 71.4 | 5.1 | 23.5 |
| Clam, Razor, Atlantic | 989 | 235 | 16,106 | 4,946 | 1,174 | 128,852 | 3,530,524 | 0.1 | <0.1 | 3.6 |
| Lobster, American | 185,999 | 14,112 | 34,636 | 2,045,992 | 98,782 | 242,449 | 2,539,913 | 80.6 | 3.9 | 9.5 |
| Flounder, Summer | 128,909 | 19,119 | 24,345 | 1,417,996 | 210,313 | 267,793 | 1,896,102 | 74.8 | 11.1 | 14.1 |
| Whelks | 117,881 | 8,714 | 2,895 | 1,296,687 | 95,853 | 28,949 | 1,421,489 | 91.2 | 6.7 | 2.0 |
| Squid, Longfin | 20,615 | 443 | 108,465 | 226,765 | 2,660 | 1,084,645 | 1,314,070 | 17.3 | 0.2 | 82.5 |
| Whelk, Channeled | 78,783 | 24,474 | 24,213 | 866,614 | 220,262 | 217,915 | 1,304,791 | 66.4 | 16.9 | 16.7 |
| Tautog | 54,737 | 25,065 | 2,051 | 602,110 | 275,716 | 22,562 | 900,530 | 66.9 | 30.6 | 2.5 |
| Bass, Black Sea | 58,778 | 4,693 | 12,244 | 646,558 | 51,623 | 134,680 | 833,258 | 77.6 | 6.2 | 16.2 |
| Butterfish | 60,114 | 1,098 | 4,649 | 661,253 | 10,980 | 51,142 | 723,375 | 91.4 | 1.5 | 7.1 |
| Crab, Jonah | 2,379 | 64,107 | 22,498 | 16,652 | 256,426 | 224,977 | 621,906 | 2.7 | 41.2 | 36.2 |
| Menhaden, Atlantic | | 8,350 | | | 58,451 | | 533,887 | | 10.9 | |
| Crab, Green | 4,010 | 38,772 | 6,541 | 32,076 | 426,497 | 58,872 | 520,989 | 6.2 | 81.9 | 11.3 |
| Skates, Rajidae (Family) | 4,225 | 64 | 33,765 | 46,471 | 193 | 337,648 | 384,312 | 12.1 | 0.1 | 87.9 |
| Scallop, Bay | 30,760 | 10 | 4,436 | 338,355 | 20 | 44,362 | 382,737 | 88.4 | <0.1 | 11.6 |
| Shark, Dogfish, Smooth | 24,614 | 1,165 | 6,051 | 270,750 | 10,483 | 66,561 | 347,794 | 77.8 | 3.0 | 19.1 |
| Crab, Atlantic Rock | 6,192 | 20,678 | 1,601 | 61,922 | 227,456 | 8,006 | 299,974 | 20.6 | 75.8 | 2.7 |
| Skates, Raja (Genus) | 5,228 | | 23,522 | 57,505 | | 235,215 | 292,728 | 19.6 | | 80.4 |
| Silversides, Atherinidae (Family) | 6,818 | 18,391 | 6,996 | 47,729 | 165,520 | 69,961 | 283,210 | 16.9 | 58.4 | 24.7 |
| Eel, American | 3,789 | 12,092 | 5,078 | 41,680 | 133,014 | 55,857 | 256,128 | 16.3 | 51.9 | 21.8 |
| Herring, Atlantic | 12,498 | 436 | 5,154 | 137,473 | 3,492 | 36,076 | 177,041 | 77.7 | 2.0 | 20.4 |
| Crabs, Spider | 8,224 | 9,224 | 3,471 | 57,567 | 64,570 | 20,824 | 176,461 | 32.6 | 36.6 | 11.8 |
| Weakfish | 8,038 | 1,294 | 6,549 | 88,419 | 14,238 | 72,041 | 174,698 | 50.6 | 8.1 | 41.2 |
| Goosefish | 833 | | 9,441 | 8,331 | | 103,851 | 112,286 | 7.4 | | 92.5 |
| Searobins, North American | 10,484 | 246 | 2,722 | 83,871 | 1,721 | 21,774 | 107,366 | 78.1 | 1.6 | 20.3 |
| Windowpane | 6,736 | | 2,386 | 74,094 | | 26,242 | 101,200 | 73.2 | | 25.9 |
| Whelk, Knobbed | 6,915 | 1,499 | 2,934 | 76,069 | 7,497 | 17,602 | 101,168 | 75.2 | 7.4 | 17.4 |

| | Average Pounds Landed per Year (2009-2019) | | | Total Pounds Landed (2009-2019) | | | Total Pounds Landed in New York State Waters (2009-2019) | % Pounds Landed out of Total New York State Waters, by Species | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Statistical Areas | | | Statistical Areas | | | | Statistical Areas | | |
| Species | 611 | 612 | 613 | 611 | 612 | 613 | | 611 | 612 | 613 |
| Conchs | 45,968 | | 320 | 91,935 | | 320 | 92,255 | 99.7 | | 0.3 |
| Herrings, River | | 8,089 | | | 88,974 | | 89,152 | | 99.8 | |

Source: ACCSP 2020c
Notes: Values reflect pounds landed, caught in statistical areas relevant to Sunrise Wind.
Confidential information was redacted from the ACCSP data set.
Blank cells indicate those years when the fishing area had no reported landings or redacted confidential landings.
Average pounds landed were calculated as an arithmetic mean, using the sum of pounds landed and the count of distinct years, ignoring zero years.

# 4.0 SURVEY METHODS

## 4.1 TRAWL SURVEY

### 4.1.1 Survey Design

Sunrise Wind has contracted with scientists at the University of Massachusetts Dartmouth School for Marine Science and Technology (SMAST) and the Commercial Fisheries Research Foundation (CFRF) to execute a seasonal (i.e., four sampling events per year, approximately three months apart) trawl survey using an asymmetrical Before-After-Control-Impact (BACI) experimental design. The trawl survey at Sunrise Wind will be carried out synoptically with the trawl survey at the Revolution Wind Farm (RWF) lease area. Using the same survey vessel and scientific crew will improve the consistency of the monitoring and data collection between the two projects/lease areas. As discussed below, the same reference areas will be used for both lease sites.

The trawl survey will be conducted in collaboration with the F/V *Heather Lynn*. The otter trawl fishery is active within the Sunrise Wind lease area, and this gear type generates the greatest revenue within the Lease Area (Table 3). An otter trawl survey is an appropriate sampling gear for the Sunrise Wind Lease Area and the nearby control sites because this gear had broad selectivity and will effectively sample for multiple species, including groundfish (e.g., winter flounder, windowpane flounder, yellowtail flounder, Atlantic cod), monkfish, skates (e.g., winter and little skates), red hake, longfin squid, and others.

The primary objective of the pre-construction monitoring is to investigate the relative abundance (i.e., kilograms [kg]/tow) of fish and invertebrate resources in the SRWF Area ("SRW impact") and reference areas ("control") over time. The pre-construction trawl survey monitoring will also collect demographic information on fish and invertebrates including size structure, fish condition, diet, and reproductive status. The original target was to complete two years of sampling (i.e., eight seasonal trawl surveys) prior to the commencement of offshore construction, with the intention to begin sampling in the winter of 2021/2022. SMAST applied to NMFS for a Letter of Acknowledgement (LOA) to execute the survey, and the LOA was granted in November 2021. However, when the LOA was received, SMAST was informed that additional ESA and MMPA consultations were required prior to the start of any in-water activities. Upon further discussions with BOEM and NMFS, it was decided to begin the survey after receipt of the Biological Opinion to protect the Project in the event of an incidental take of a protected species. The Biological Opinion was received on September 28, 2023. The first bottom trawl survey trip occurred from November 2 through November 7, 2023. Sampling will continue during Project construction, and a minimum of two years of monitoring will be completed following offshore construction, with the duration of post-construction monitoring also informed by ongoing guidance for offshore wind monitoring that is being developed cooperatively through the Responsible Offshore Science Alliance (ROSA)[3].

The objectives associated with the trawl survey are as follows:

- **Objective 1**: Evaluate changes in the relative abundance of commercially important fish and invertebrate species between SRWF and the control areas pre-construction, during construction, and post-construction.

[3] ROSA Offshore Wind Project Monitoring Framework and Guidelines, March 2021 https://e9f0eb5f-7fec-4e41-9395-960128956e6f.filesusr.com/ugd/99421e_b8932042e6e140ee84c5f8531c2530ab.pdf

- **Objective 2**: Assess changes in the size structure of commercially important fish and invertebrate species between SRWF and the control areas pre-construction, during construction, and post-construction.
- **Objective 3**: Investigate changes in the composition of fish and invertebrate species between SRWF and the control areas pre-construction, during construction, and post-construction.
- **Objective 4:** Evaluate changes in the diet composition of black sea bass and summer flounder between SRWF and the control areas pre-construction, during construction, and post-construction.

The use of an asymmetrical BACI sampling design will allow for quantitative comparisons of relative abundance and demographics to be made before and after construction, and between the reference areas and SRWF area (Underwood 1992; Smith et al. 1993). Further, the replication of sampling across both time and space increases the ability to demonstrate that a change in abundance was caused by a human activity (Underwood 1992).

In order to maximize the utility of the monitoring, the trawl survey will utilize the sampling gear and protocols of the NEAMAP survey (Bonzek et al. 2008, 2017). The use of standardized survey methods will allow the data collected at SRWF, RWF, and the reference areas to be evaluated at multiple spatial scales (e.g., project specific scale and regional scale). NEAMAP trawl survey gear will also be employed within the Orsted Ocean Wind lease area off New Jersey, and South Fork Wind is also completing a trawl survey using a NEAMAP survey net along the South Fork Export Cable route in New York state waters. Further, to achieve consistency amongst developers, the survey methods and trawl net are consistent with the pre-construction data being collected by Vineyard Wind in their lease areas (He and Rillahan 2020). To maximize the regional comparability of the data that is collected, concerted efforts will be made to ensure that the timing of the SRWF trawl survey coincides with the NEFSC spring and fall bottom trawl surveys when the R/V *Bigelow* is operating in southern New England.

### 4.1.2 Sampling Stations

As mentioned above, the trawl surveys at SRWF and RWF will be executed simultaneously using the same vessel, sampling gear, and scientific crew, and catch rates at both the SRW and RWF impact areas will be compared to the same two reference areas. An examination of benthic habitat data, VMS data, and input from local fishermen indicated that a limited portion of the RWF lease area can be sampled safely and effectively using the NEAMAP trawl survey net. Therefore, the RWF Project area for the trawl survey was limited to the northern portion of the RWF lease area (Figure 3), which encompasses an area of approximately 125 $km^2$. The two reference areas proposed for the trawl survey (Figure 3) are also 125 $km^2$. The entire SRW lease area is approximately 445 $km^2$. In order to sample an equivalent amount of area (125 $km^2$) within the SRW impact site, it is proposed that the SRW trawl survey impact area be limited to the western portion of the lease site. This greatest concentration of effort by the large mesh otter trawl fleet occurred in this portion of the lease site from 2011 through 2016 (Figures A-1 and A-2).

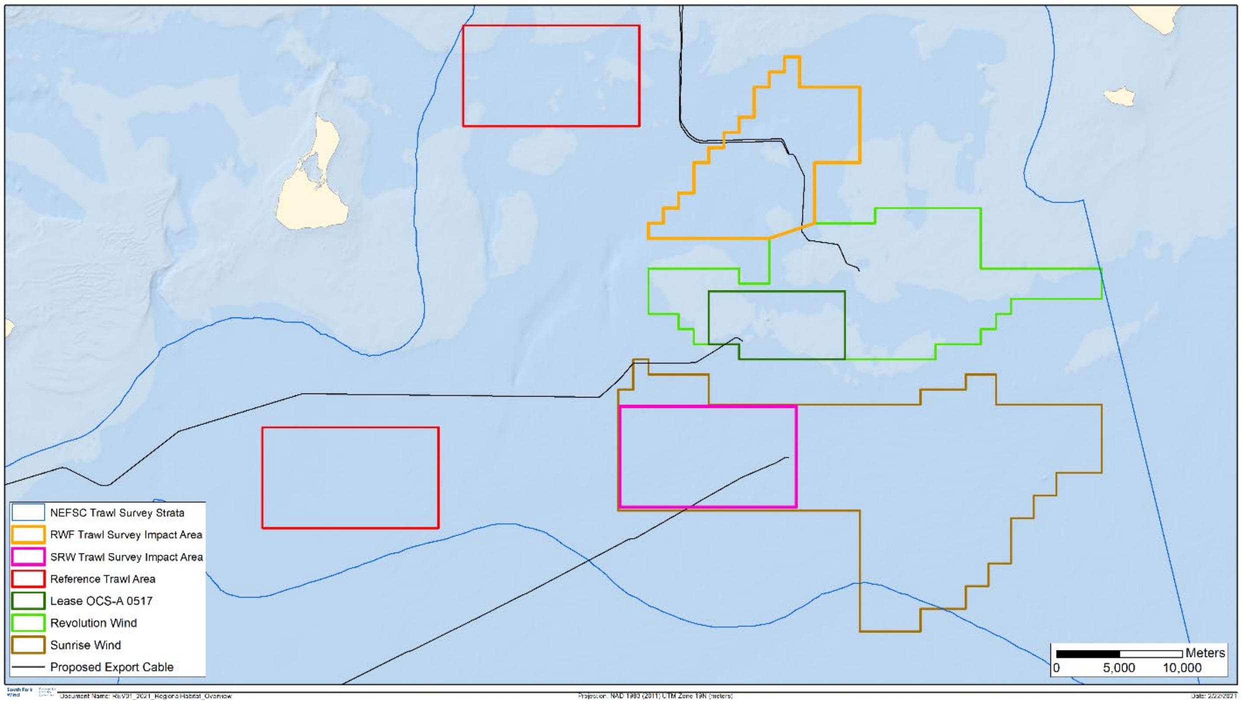



**Figure 3. Location of the RWF lease site, the planned RWF Project area for the trawl survey (northern portion of RWF lease site, outlined in orange), the SRW lease site (outlined in brown), and the planned location of the impact area with SRW (outlined in pink). Also shown are the locations of the two planned reference areas (outlined in red).**

The trawl survey will be executed using an asymmetrical BACI design, and trawl survey observations from the reference areas will serve as a regional indicator of relative abundance for fish and invertebrate species in an area outside of the direct influence of the Project and other offshore wind development. Two reference areas (Figure 3) were selected after considering several sources of information. Firstly, the locations of SRW and RWF were evaluated relative to the survey strata used on the NEFSC trawl survey. The NEFSC trawl survey is the only regional trawl survey with spatial coverage that overlaps these lease areas. The RWF lease area is located entirely within NEFSC trawl survey Stratum 1050 (Figure 4), and the SRW area is also located almost entirely within strata 1050. Stratum 1050 covers an area of approximately 5,213 $km^2$ and includes waters ranging from 27 to 55 m in depth (Politis et al. 2014). The entire SRW lease area is approximately 445 $km^2$. In an effort to maintain consistency with the stratification employed on the NEFSC survey, the reference areas were also sited within trawl survey 1050. Based on bathymetric data provided by the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010), the depth within the SRW trawl survey Project area ranges from 41 to 54 m, and the mean depth is 49 m (Figure 5). The depth within the northern reference area ranges from 21 to 41 m (mean depth = 36 m), while depths in the southern reference area range from 41 to 55 m (mean depth = 50 m).

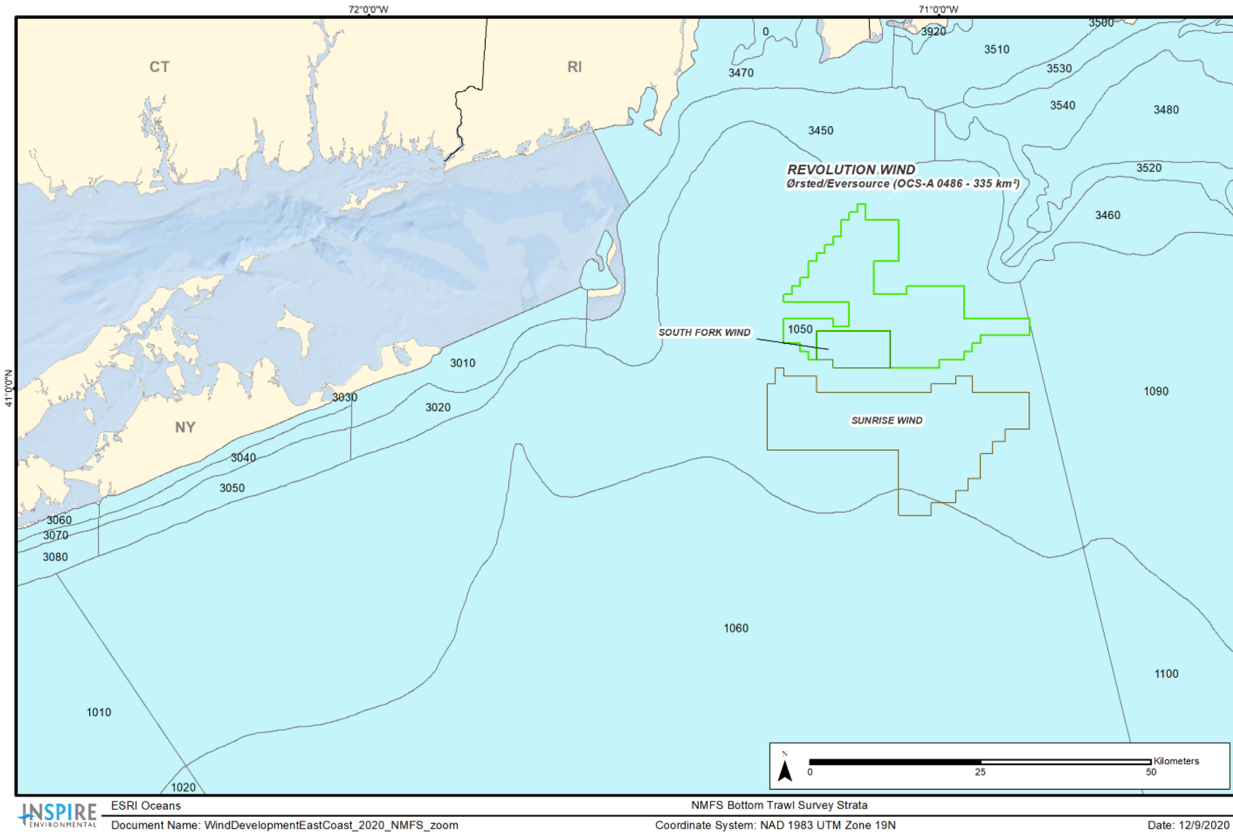



**Figure 4. Location of the Revolution Wind, South Fork Wind, and Sunrise Wind lease sites relative to the survey strata used during the NEFSC bottom trawl survey. Nearly all of the Sunrise Wind Farm lease area is located within NEFSC survey Stratum 1050.**

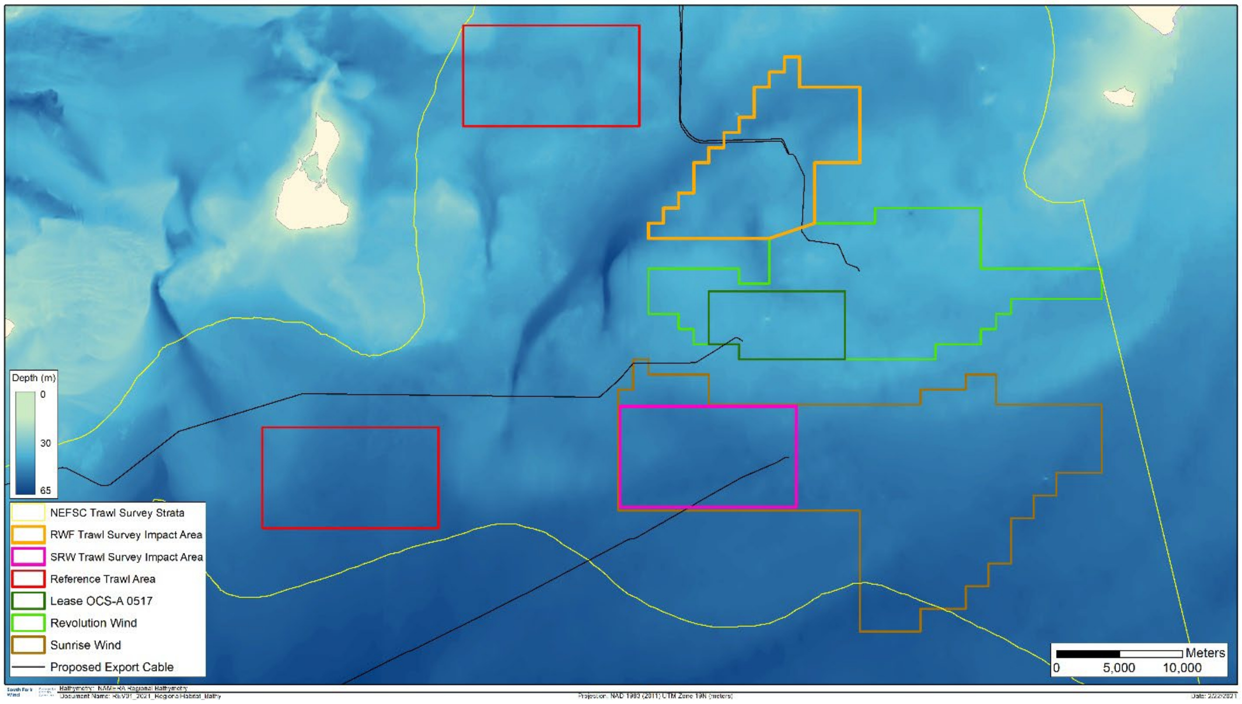



**Figure 5. Bathymetric map of the SRWF and RWF lease areas and the planned reference areas for the trawl survey. Bathymetric data is shown in meters and was derived from the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010).**

Consideration was also given to the benthic habitat present at the SRWF, and reference areas were selected with similar benthic habitats as in the SRWF. Based on benthic habitat data provided from the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010), the substrates within the planned footprint of the SRW trawl survey are diverse and include: moderate flat sand, shallow depression sand, moderate depression sand, moderate depression gravel, and moderate flat gravel (Figure 6). Further information on benthic habitats within SRW have also been collected through dedicated habitat mapping surveys (INSPIRE Environmental, 2021e) The benthic habitats within the northern reference area include shallow depression gravel, moderate flat gravel, moderate flat sand, high flat gravel, and high flat sand. The habitats within the southern reference area are slightly less diverse, and are primarily comprised of shallow depression sand, moderate flat sand, and moderate depression sand.

VMS data from the Mid-Atlantic Ocean Data Portal indicate that there were generally low to moderate levels of otter trawl activity by large vessels (i.e., >65 ft) from 2011 through 2016 (Appendix A, Figures A-1 and A-2), although there was relatively high trawling effort in the western portion of the Lease Area from 2011 through 2014 (Appendix A, Figure A-1). Similar levels of trawling activity were generally observed within the northern and southern reference areas (Figure 3).

Care was also taken to locate the reference areas in locations that are not currently known to be planned for future offshore wind development. Similarly, reference areas were not sited in locations that intersected with export cable routes. Modifications to the locations of the reference areas may be considered based on input received from the local fishing industry, following feedback received at agency meetings, or following discussion with the scientific contractor and/or fishermen that are selected to execute the trawl survey.

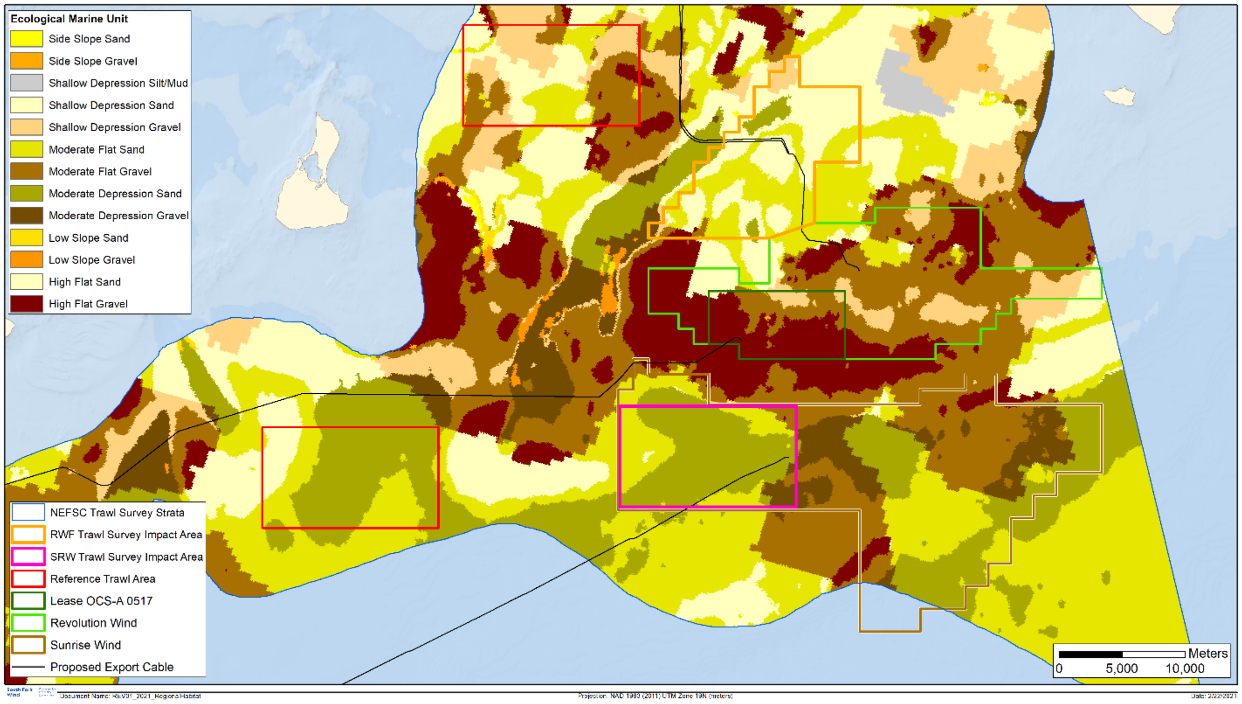



**Figure 6. Benthic habitats within the RWF and SRW trawl survey study areas, and within the reference areas. Benthic habitat data was derived from the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010).**

Consistent with the study design used by Vineyard Wind during their trawl survey (He and Rillahan 2020), a spatially balanced design will be used to assign random tow locations within the SRW trawl survey area and reference areas during each seasonal survey. The SRWF and reference areas will each be divided into 15 grid cells, and one randomly chosen location will be sampled within each grid cell during each seasonal trawl survey. The spatially balanced design will ensure that sampling effort is distributed throughout the SRWF and reference areas. Within the SRWF and the reference areas, the sampling density associated with each seasonal survey will be one station per 8.3 $km^2$. The order in which the reference areas and the SRWF trawl survey are conducted will be randomized prior to the start of each survey.

The location of trawl sampling stations may be subject to change due to the presence of fixed gear (e.g., lobster pots), or other factors that may preclude a randomly selected location from being sampled safely. Therefore, alternate sampling locations will be randomly chosen within each grid cell for each seasonal survey. If a primary sampling location is found to be untrawlable based on the captain’s professional judgement, sampling will instead occur at one of the randomly selected alternate sampling locations. If any marine mammals or sea turtles are sighted prior to the start of, or in the vicinity of a trawl tow, sampling will be delayed at that location or an alternate tow will be selected in order to minimize the risk of an interaction. Sunrise Wind will work with the scientific contractor(s) and captain and crew of the trawl vessel(s) to evaluate whether activities associated with cable installation (e.g., cable protection), or other construction activities, will impact the execution of the trawl survey after the wind farm is constructed.

**Survey Methods**

A power analysis was conducted using trawl survey data from the Block Island Wind Farm (BIWF) and NEFSC trawl survey datasets (Appendix B). NEFSC trawl survey data from 2010 through 2018 were obtained from Phil Politis (Northeast Fisheries Science Center Bottom Trawl Program Lead, personal communication, June 2021), and only tows from Stratum 1050 were used to inform the power analysis. From 2010 through 2018, the NEFSC trawl survey sampled in the spring and fall. Monthly catch data from the two reference sites sampled during the BIWF trawl survey were also reviewed to determine the extent to which the seasonal NEFSC trawl survey captured intraannual biomass peaks for different species of interest. Power analysis represents the relationships among the four variables involved in statistical inference: sample size (N), effect size, and type I (α) and type II (β) error rates (Cohen 1992). Of primary interest for this study is the interaction between temporal and spatial variables, specifically the contrast between the temporal change at the SRWF and the average temporal change at the reference sites (Equation 2 in Appendix B). Power curves were constructed to demonstrate how statistical power for the interaction contrast varies as a function of the variance in the catch data, the effect size (i.e., the percent change at the SRWF site relative to the reference sites), sample size (i.e., number of trawl tows per area in each season), and the number of reference sites that are sampled (Appendix B, Figures B-7 and B-8 in). When analyzing for changes in relative abundance, achieving a statistical power of at least 0.8 is intended, which is generally considered to be the minimum standard for scientific monitoring (Cohen 1992). This ensures that the monitoring will have a probability of at least 80 percent of detecting an effect of the stated size when it is actually present. A single alpha (0.10) was used for the power analysis, and the power analysis was completed assuming two years of pre-construction and post-construction monitoring will be completed.

A sample size of 15 trawl tows per area will be targeted per season in each year at the start of the survey. Based on the results of the power analysis (Appendix B, Figure B-7), this level of sampling is expected to have at least 80 percent power to detect a 33 percent temporal decrease for those species with Coefficient of Variations (CVs) ≤ 1.2, and approximately a 40 percent temporal decrease for species with CVs ≤ 2.0. Further, the use of an asymmetrical BACI design, with two rather than one reference areas, leads to gains in power for a given level of sampling intensity at the SRWF (Appendix B, Figure B-8). An examination of the NEFSC and BIWF trawl survey data indicates that most species exhibited moderate to high levels of interannual and intraannual (e.g., seasonal or monthly) variability in catch rates (Appendix B, Figures B-2 to B-6 and Table B-4). Given the magnitude of variability in catch rates that will likely be exhibited in the SRW trawl survey, it is not practicable to attempt to capture a small effect size (e.g., 25 percent) for fish and invertebrate species. This power analysis assumes that the variance in the catch rates during the SRW trawl survey will be similar to the variance observed during the BIWF and NEFSC trawl surveys. Following the first year (i.e., four seasonal sampling events) of trawl survey data the observed variability will be calculated for abundant species in the catch. The achievable effect sizes will also be identified following the first year of the survey, once the realized magnitude of variability is better understood, and once regional guidance regarding target effect sizes has been formalized through ROSA. All efforts will be made to maintain consistent sampling protocols throughout the duration of the survey to minimize measurement error as another source of variance. Given the predicted power of the study design for the anticipated magnitude of variability (i.e., range of CVs from 0.8 to 2.0), the sample sizes proposed for the first year of the trawl survey are robust.

The proposed seasonal sampling intensity equates to an annual sampling target of 180 tows per year across the SRWF and reference areas. For comparative purposes, from 2010 through 2018, the NEFSC trawl survey completed four or five tows in Stratum 1050 during each spring and fall trawl survey (i.e., eight to ten tows per year).

### 4.1.3 Trawl Survey Methods

All survey activities will be subject to rules and regulations outlined under the Marine Mammal Protection and the Endangered Species Acts. Efforts will be taken to reduce Atlantic sturgeon, marine mammal, sea turtle, and seabird injuries and mortalities caused by incidental interactions with fishing gear. For example, deploying trawl gear will be delayed if marine mammals or sea turtles are sighted in the vicinity of the sampling station. All gear restrictions, closures, and other regulations set forth by take reduction plans (e.g., Harbor Porpoise Take Reduction Plan, Atlantic Large Take Whale Reduction Plan) will be adhered to as with typical scientific fishing operations to reduce the potential for interaction or injury.

The trawl survey will be carried out on a seasonal basis, with four surveys planned for each year. From 2010 through 2018 the NEFSC spring survey sampled in Stratum 1050 in March, April, and May, while the NEFSC fall trawl survey sampled Stratum 1050 in September and October. In order to achieve temporal overlap with the NEFSC trawl survey, and maintain consistent seasonality with the Vineyard Wind trawl survey the seasons for the SRW trawl survey will be defined as follows:

- 'Winter' survey months: January, February, and March
- 'Spring' survey months: April, May, and June
- 'Summer' survey months: July, August, and September
- 'Fall' survey months: October, November, and December.

To the extent practicable, concerted efforts will be made to ensure that the timing of the SRW trawl survey coincides with the NEFSC spring and fall bottom trawl surveys when the R/V Bigelow is operating in southern New England. Within a seasonal sampling event, the replicate tows within the SRWF and reference areas will be completed within as few days as possible, given practical constraints imposed by weather or other factors (e.g., mechanical issues with vessel). Efforts will also be made to have consistent timing between seasonal surveys (e.g., three months), to the extent possible.

The trawl survey will be executed using the trawl net that was designed by the Northeast Trawl Advisory Panel (NTAP) for the NEAMAP trawl survey. The NEAMAP survey net is a 400 x 12 -cm three-bridle four-seam bottom trawl, and the net is paired with Thyboron, Type IV 168 cm (66 in) trawl doors (Bonzek et al. 2017). Several aspects of the net design make it an appropriate tool for sampling a wide range of species and size classes. The trawl is designed to achieve a relatively large vertical opening, and the use of a 'flat sweep' (i.e., 8 -cm (3 -in) cookie groundgear) allows that net to maintain close contact with the bottom and sample effectively for species that are closely associated with the benthos. A 2.5 -cm (1-in) knotless cod end liner will be used to sample marine taxa across a broad range of size and age classes.

Net mensuration equipment will be used during the survey to provide the captain and scientific crew with real-time information on door spread, wing spread, and headrope height. This information also allows the area swept ($km^2$) to be calculated for each tow, which is needed in order to estimate absolute abundance. In order to promote consistency amongst samples, Orsted will work with the scientific contractor selected to execute the survey to establish a set of gear performance criteria to objectively compare the observed trawl geometry against the optimal geometry (e.g., Bonzek et al. 2017). The position, heading, and speed of the vessel will be monitored throughout each tow using a software program that is integrated with a GPS unit (e.g., NEFSC Fisheries Logbooks Data Recording System, or similar). A temperature logger attached to the trawl net will be used to record bottom temperature continuously (e.g., every 30 seconds) during trawling.

**Survey Methods**

Similar to the methods employed on the NEAMAP survey and other regional surveys (e.g., MADMF biannual trawl survey), all tows will be completed during daylight hours, and the target tow duration will be 20 minutes. The tow will begin when the winches are locked and an acceptable net geometry is established. A target tow speed range of 2.9 to 3.3 knots will be used. The amount of wire set with each trawl to achieve the target net geometry will be left to the professional judgement of the captain, dependent upon the depth and the in-situ conditions.

Animals collected in each trawl sample will be sorted, identified to the species level, weighed, and enumerated consistent with the sampling approach of NEAMAP. Taxonomic guides that can be utilized to assist with species identification include *NOAA's Guide to Some Trawl-Caught Marine Fishes* (Flescher 1980), *Bigelow and Schroeder's Fishes of the Gulf of Maine* (Collette and Klein-MacPhee 2002), Kells and Carpenter's (2011) *Field Guide to Coastal Fishes from Maine to Texas.* Species will be identified consistently with the Integrated Taxonomy Information System (ITIS). The following information will be collected for each trawl that is sampled; catch per unit effort (CPUE), species diversity, and size structure of the catch. All species captured will be documented for each valid trawl sample. When large catches occur, sub-sampling may be used to process the catch, at the discretion of the lead scientist. The three sub-sampling strategies that may be employed are adapted from the NEAMAP survey protocols and include straight subsampling by weight, mixed subsampling by weight, and discard by count sampling (Bonzek et al. 2008). The type of sub-sampling strategy that is employed will be dependent upon the volume and species diversity of the catch. The biomass (weight, kg) of each species will be recorded on a motion-compensated marine scale that has been calibrated according to the manufacturer's specifications and used to calculate CPUE. Length will be recorded for the dominant species (i.e., most commonly encountered species), and priority species, in the catch. To assess the condition of individual organisms, up to 100 individuals of each species (and size class) will be measured (to the nearest cm) and weighed on a motion-compensated balance. Length (e.g., total length, fork length) will be recorded for each species consistent with the measurement type specified in the Northeast Observer Program Biological Sampling Guide. After sampling, all catch will be returned to the water as quickly as possible to minimize incidental mortality, aside from the summer flounder and black sea bass that will be sacrificed to stomach content analysis.

Biological samples will be collected for the commercial finfish species of primary interest in the reference and SRWF areas. In order to be consistent with the regional trawl surveys, a length-stratified design will be used to ensure samples are collected across all size and age classes for each species. The following list of priority species will be considered for biological sampling, but the list may be modified based on input from regional stakeholders and feedback from the scientific contractor(s) selected to perform this work; Atlantic cod, American lobster, black sea bass, summer flounder, winter flounder, Atlantic herring, monkfish, and yellowtail flounder. Biological sampling will include measuring the length and weight of individuals, and macroscopic evaluation of sex and maturity stage consistent with the sex and maturity classification used by the Northeast Fisheries Science Center (Burnett et al. 1989). Sex and maturity stage collected during the seasonal trawl surveys can be considered alongside of other fisheries independent data and used to inform the spatiotemporal distribution of spawning within the area, and the maturity data can also be considered when evaluating the relative condition of individual fish, as sex and maturity stage can influence relative condition (Galloway and Munkittrick 2006; Wuenschel et al. 2009). In addition, Sunrise Wind will purchase an additional 100 acoustic transmitters that can be used to opportunistically tag Atlantic cod captured during the trawl survey to support the ongoing BOEM-funded Atlantic cod spawning study that is occurring throughout the MA/RI WEA.

Biological data for individual lobsters will be sampled consistently with the protocols used by the MADMF and RIDEM during their ventless trap surveys. Data collected for individual lobsters will include:

- Carapace length: Measured to the nearest millimeter (mm) using calipers.
- Sex: Determined by examining the first pair of swimmerets.
- Eggs: Examine the underside of the carapace for the presence or absence of eggs. The gross egg stage will be characterized according to the following categories:
    - Absent
    - Brown (partially developed with eyespot present and will hatch in this calendar year)
    - Green (newly spawned with no eyespot present)
    - Green with eyes (small eyespot present, but will not hatch in this calendar year)
- V-notch status: present or absent (according to the LCMA2 [Lobster Conservation Management Area 2] definition)
- Cull status: Examine the claws for condition (claws missing, buds, or regenerated)
- Incidence of shell disease: Shell disease will be characterized according to four categories:
    - Absent
    - Light (1-10 percent of the shell)
    - Moderate (11-50 percent)
    - Heavy (> 50 percent).
    - Mortality: alive or dead

Following seven years of data collection during the Block Island Wind Farm trawl survey, INSPIRE Environmental (2021b) recommended that future diet composition studies concentrate sampling efforts on a small number of focal species with different trophic niches, rather than trying to characterize changes in prey composition for a wide range of species. Following that recommendation, stomach content analysis will be performed for two recreationally and commercially important species, black sea bass and summer flounder, to examine their prey composition and evaluate whether diet composition changes between the SRWF and reference areas prior to and after construction. An examination of catch rates from the NEFSC bottom trawl survey and the BIWF trawl survey (Appendix B) indicate that the catch rates of these species in the trawl survey are likely to be sufficient to allow for comprehensive sampling of diet composition. Due to their behavior and biological characteristics, better understanding whether the development of offshore wind affects the diet of these two species is of ecological importance, and of interest to fishermen and managers.

Both black sea bass and summer flounder were identified as potentially serving as “key assessment indicator species” to understand the ecological impacts associated with offshore wind development (MADMF 2018). Malek (2015) identified both summer flounder and black sea bass as indicator species that should be considered when assessing the potential impacts of offshore wind development. Black sea bass and summer flounder were also noted as priority research species by Petruny Parker et al. (2015) and the Northeast Regional Habitat Assessment Prioritization Working Group (NMFS 2015). In addition, Guida et al. (2017) identified black sea bass as a species that was vulnerable to construction within the MA/RI WEA. A recent modeling study (Friedland et al. 2021) that used 43 years of data from the NEFSC trawl survey found that black sea bass are highly dependent on habitats in the wind energy areas during the spring and fall, while summer flounder are highly dependent on these habitats in the fall, making these species good candidates for further investigation related to their diet composition and feeding behavior.

**Survey Methods**

Black sea bass are characterized as opportunistic benthic omnivores, which consume a range of food including crustaceans, mollusks, and fish (Bigelow and Schroeder 1953; Kendall 1977; Drohan et al. 2007). Black sea bass are strongly associated with structured habitats including rocky reefs, cobble and rock fields, mussel beds, and stone coral patches (Drohan et al. 2007), and monitoring results from BIWF demonstrated an increased abundance of black sea bass near the turbine foundations following construction (HDR 2019). This observation at BIWF has led some stakeholders to express consternation about the potential trophic interactions associated with local increases in black sea bass abundance, out of concern that black sea bass will consume juvenile lobsters within the wind farm site following construction.

Adult summer flounder have been characterized as opportunistic feeders that prey primarily on fish and invertebrates, with the following fish species often included in their diet; windowpane flounder, winter flounder, pipefish, menhaden, bay anchovy, red hake, silver hake, scup, Atlantic silverside, sand lance, bluefish, weakfish, and mummichogs (Packer et al. 1999, and references therein). Summer flounder have also been reported to feed on a variety of benthic invertebrates including small bivalve and gastropod mollusks, small crustaceans, marine worms, sand dollars, and squid (Packer et al. 1999, and references therein).

Up to 10 animals will be sacrificed for stomach content analyses from each trawl that is sampled, with no more than five individuals of either species sampled from a single trawl. The target sampling intensity is to analyze 200 samples per species, in each area, during the two-year pre-construction sampling period. Cumulative prey curves provide an estimate of how prey diversity increases as a function of sample size and can help determine the sampling levels needed to adequately characterize diet composition (Chipps and Garvey 2006). Cumulative prey curves were derived for summer flounder and black sea bass based on stomach content analysis performed during the BIWF trawl survey. For summer flounder, the prey curves were created by time period (baseline and operation) and area (BIWF impact and reference sites) combinations and demonstrate that approximately 40 samples were needed within each combination of time and area factors to characterize their prey composition (Figure 7), although not all prey curves approached the asymptote at the same rate. For black sea bass, stomach contents were only monitored during the final (i.e., post-construction) year of the trawl survey, but the prey curves suggest that approximately 40 samples should be sufficient to adequately characterize their diet in each area and time period (Figure 8). By focusing stomach sampling on summer flounder and black sea bass, it is anticipated that the SRWF trawl survey will collect hundreds of samples for each species in both the impact and reference areas across all the three phases of the project, allowing for a rigorous examination of changes in diet composition over time. Each fish sampled for stomach content analysis will be measured (to the nearest cm) and weighed (to the nearest gram) individually before the stomach is removed to permit assessment of relative condition. All prey items will be identified to the lowest possible identification level (LPIL), counted, and weighed. Following the first year of pre-construction monitoring, cumulative prey curves will be produced to evaluate whether the sampling intensity should be modified in subsequent years.

During outreach meetings with the Rhode Island Fishermen’s Advisory Board, concerns were raised that the construction and operation of the Sunrise Wind Farm would lead to sub-lethal impacts on sea scallops, particularly with regards to meat quality. In response to this concern, Sunrise Wind will conduct meat quality sampling for scallops that are captured during the trawl survey. The meat quality sampling protocols will be consistent with the sampling that is being performed by CFRF during the South Fork Wind

Farm beam trawl survey. During the trawl survey, meat quality and biological condition will be evaluated for a subset of scallops (up to 10 individuals per tow). Sunrise Wind also notes that researchers at CFRF were recently awarded a grant through the scallop Research Set Aside program[4] to develop standardized protocols for assessing the biological condition of scallops. Therefore, we will collaborate with CFRF during the trawl survey to ensure that scallops are being sampled consistently with the protocols that are developed as a result of that project.

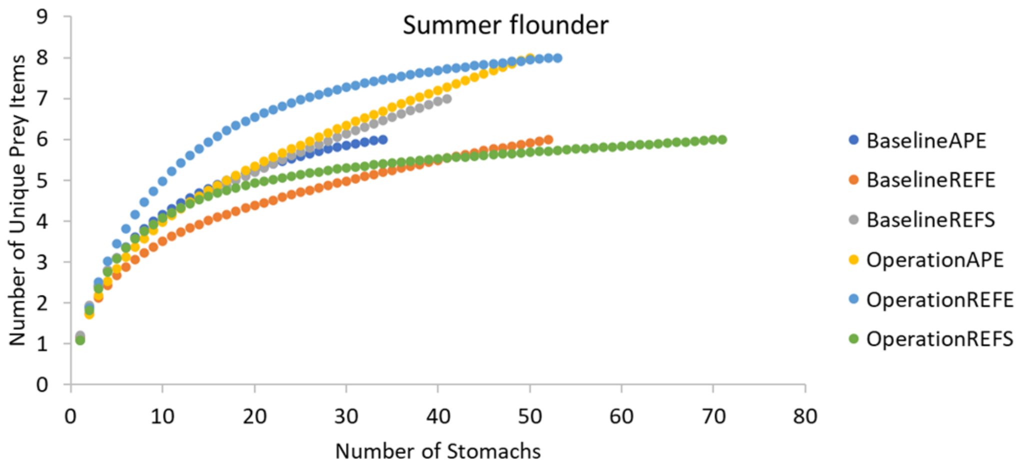



**Figure 7. Cumulative prey curves for summer flounder observed during the BIWF trawl survey, in the impact area (APE) and reference areas (RFE and REFS) during the baseline and operation monitoring periods. Figure provided by INSPIRE Environmental (Wilber et al. 2022).**

[4] Sea Scallop Research Set-Aside Projects Selected for 2022–2023 | NOAA Fisheries

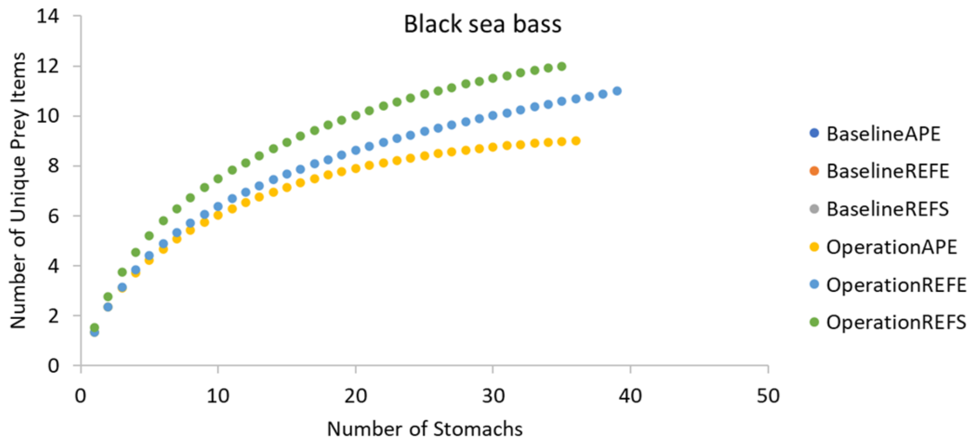



**Figure 8. Cumulative prey curves for black sea bass observed during the BIWF trawl survey, in the impact area (APE) and reference areas (RFE and REFS) during the operation monitoring period. Figure provided by INSPIRE Environmental (Wilber et al. 2022).**

Hydrographic data will be collected at each trawl station. A Conductivity Temperature Depth (CTD) sensor (or similar) will be used to sample a vertical profile of the water column at each trawl station. The CTD profile may be obtained at the start or end of the tow, at the discretion of the chief scientist. Bottom water temperature will be recorded at regular intervals (e.g., every 30 seconds) throughout the duration of each tow either using a temperature logger mounted on the trawl net or using temperature sensors that are part of the net mensuration hardware.

In accordance with Term and Condition #10 of the Project Biological Opinion, at least one member onboard the trawl survey must have completed NMFS Northeast Fisheries Observer Program training with the previous five years or completed a Protected Species Training Plan which provides instruction in the safe handling and reporting of protected fish species, sea turtles and marine mammals (Appendix C). If any protected species are captured during trawling the handling, reporting and release of those animals will take priority over the rest of the catch. The crew will follow the sampling and reporting protocols described for the Northeast Fisheries Observer Program (NEFOP) in the Observer On-Deck Reference Guide (NEFSC 2016). Reporting of interactions with marine mammals, such as small cetaceans and pinnipeds, will also be done in accordance with the Biological Opinion for the Project. Due to the potential for communicable diseases all physical sampling and handling of marine mammals and seabirds will be limited to the extent Orsted health and safety assessments and plans allow.

### 4.1.4 Trawl Station Data

The following data will be collected during each sampling effort:

- Station number
- Latitude and longitude at the start and end of the tow
- Time at the start and end of the tow
- Heading

- Water depth at the start and end of the tow
- Wind speed
- Wave height
- Weather conditions (e.g., cloud cover, precipitation)
- Tow speed (average in knots)
- Gear condition/performance code at the end of the tow
- Oceanographic data, as collected using a CTD and a temperature logger (see Section 4.1.3).

### 4.1.5 Data Management and Analysis

All field data will be reviewed for errors before being transcribed into a relational database. Quality control checks will be performed on database tables by running standardized, systematic queries to identify anomalous data values and input errors. Species names (common and scientific) will be verified and tabulated for consistency. All data used in analysis will be exported from the relational database.

Annual reports will be prepared after the conclusion of each year of sampling and shared with State and Federal resource agencies. Following the conclusion of the survey, one final report will also be produced synthesizing the findings of the pre- and post-construction evaluations. Sunrise Wind will also coordinate with their scientific Contractor(s) to disseminate the annual monitoring results through a webinar or an in-person meeting, and this meeting will also offer an open forum for federal, state, and academic scientists, as well as members of the local fishing industry, to ask questions or provide feedback on the data collection protocols.

The first two years of trawl surveys will provide additional fisheries-independent data to allow for characterization of the pre-construction fish and invertebrate community structure in both the SRWF and reference areas. For the pre-construction monitoring, the results presented in annual reports will focus on descriptive and quantitative comparisons of the fish and invertebrate communities in the SRWF and the reference areas to describe spatial, seasonal, and annual differences in relative abundance, species composition, frequency of occurrence for each species (e.g., presence/absence), and demographic information for individual fish such as length, weight, diet, and relative condition. For the dominant (i.e., most abundant) species in the catch, relative abundance will be compared amongst the reference and SRWF areas using descriptive statistics (e.g., mean, range) and length frequency data will be compared among areas using descriptive statistics, graphical techniques (empirical cumulative distribution function [ECDF] plots), and appropriate statistical hypothesis tests (e.g., the Kolmogorov-Smirnoff test, $\alpha = 0.05$). Species composition can be compared amongst the SRWF and reference areas using a Bray-Curtis Index and multivariate techniques (e.g., Analysis of Similarities [ANOSIM] or cluster analysis).

By continuing sampling during and after construction, the trawl survey will allow quantification of any detectable changes in relative abundance, demographics, or community structure associated with proposed operations. The BACI design for this survey plan allows the catch of numerically dominant species to be compared between the before and after construction periods in the two treatment types (reference and SRWF), using appropriate statistical modeling. The use of reference areas will ensure that broader regional changes in demersal fish and invertebrate community structure will be captured and delineated from potential impacts of the proposed Project. Analyses presented in the final synthesis report will focus on identifying changes in the fish community in the SRWF between pre-, during, and post-construction that did not also occur at the reference areas that could be attributed to either construction or operation of the wind turbines.

**Survey Methods**

The primary research question to be addressed is what magnitude of difference in the temporal changes in relative abundance are observed between the reference and SRWF areas. This question will be addressed using point estimates and 90 percent confidence intervals (90CIs) contrasting the temporal changes between areas. This research question can also be framed using the following null and two-tailed alternative hypotheses:

- $H_Ø$ - Changes in relative abundance (CPUE) between time periods (before and after) will be statistically indistinguishable between the reference and SRWF areas.
- $H_1$ - Changes in CPUE between time periods (before and after) will be statistically different between the reference and SRWF areas.

In this design, there are multiple years within each time period and multiple sites within the Control treatment. At a minimum Area (i.e., SRWF impact area, and two reference areas), and time period (or year) must be included in the model to allow estimation of the BACI interaction contrast. Environmental covariates (e.g., temperature, depth, and salinity) can also be included in the abundance model, either as linear or quadratic factors. The data logger attached to the trawl net will be used to record bottom temperature continuously during each tow, and the mean temperature for each tow can be included in the relative abundance model. The salinity at each tow will be informed by the CTD deployment, and depth will be calculated based on the average depth recorded at the start and end of the tow. The benthic habitat data provided by Greene et al. (2010) will be used to classify the dominant habitat present in each grid cell, allowing benthic habitat to be treated as a random effect within the model. Model selection will be conducted using Akaike Information Criteria (AIC) and residual diagnostics, and forward and backward stepwise elimination will be used to select the most parsimonious model (Venables and Ripley 2002).

This asymmetrical BACI design is not suited to analysis with a simple two-factor Analysis of Variance (ANOVA) model; instead generalized linear models (GLMs) or generalized additive models (GAMs) will be used to describe the data and estimate the 90 percent CI on the BACI contrast. The interaction contrast that will be tested is the difference between the temporal change (i.e., average over the post-operation period minus the average over the pre-operation period) at the SRWF and the average temporal change at the reference areas. A statistically significant impact would be indicated by a 90 percent CI for the estimated interaction contrast that excludes zero changes. A 90 percent CI is proposed to increase the power of the tests, i.e., increase the probability of identifying a significant impact of wind farm operation. This approach provides 90 percent confidence in the two-tailed hypothesis of “no difference”, and 95 percent confidence in each of the one-tailed hypotheses (i.e., change at the reference areas is less than at the SRWF, and change at the reference areas is greater than at the SRWF).

If desired, absolute abundances estimates can be derived for commonly sampled species. Estimation of absolute abundance will require assumptions regarding the efficiency of the survey gear and the availability of species to the trawl. Data on tow speed and tow duration collected by the chief scientist can be combined with the trawl geometry data collected using the net mensuration sensors to estimate the area swept during each tow.

Length frequency data will be analyzed for the dominant species in the catch. The first question to be addressed is how the size structure of these species change over time (before vs. after construction). The second question to be addressed is how the size structure of these species varies between areas (SRWF vs. reference areas). To answer both questions, length frequency data will be compared between times and locations for common species using descriptive statistics (e.g., range, mean) and graphical and statistical comparisons using ECDFs, a Kolmogorov-Smirnov test (Sokal and Rohlf 2001), or another appropriate method such as cluster sampling (Nelson 2014) based on the characteristics of the data.

**Survey Methods**

A secondary objective associated with the trawl survey is to evaluate fish condition. For priority species that are subject to detailed biological sampling, fish condition will be compared between areas, and across time, to examine whether fish condition is influenced by the construction and operation of the Project. For commonly sampled species, condition indices (Jakob et al. 1996) will be calculated for individual fish as its residual from the log10-log10 regressions of mass (kg) to length (cm). For each species the fish condition data will be fit with a GAM or GLM that best describes the data, and the 90 percent CI will be estimated for the relevant spatial and temporal contrasts. Given the migratory nature of many of the species that will be investigated, and the uncertainty of where these species have foraged, a change in fish condition may not necessarily be considered as an impact attributable to the construction and operation of the wind farm. However, this information can be evaluated to consider whether fish condition (a proxy for fish health) changes over time and between areas after the wind farm is constructed.

Another secondary objective associated with the monitoring is to evaluate species composition, which will be compared between areas and time periods to examine whether the construction and operation of the wind farm led to changes in the species composition within the SRWF. This research question can be examined using the following null and two-tailed hypotheses:

- $H_{\emptyset}$ - Changes in species composition between time periods (before and after) will be statistically indistinguishable between the reference and SRWF areas.
- $H_1$ - Changes in species composition between time periods (before and after) will be statistically different between the reference and SRWF areas.

Species composition will be compared before and after construction using techniques such as calculating a Bray-Curtis Index or performing multivariate analyses (e.g., Permutational ANOVA [PERMANOVA], ANOSIM). Additional data analyses will be performed as appropriate based on the nature of the data that is collected (i.e., models will be fit to the data using appropriate error distribution).

Another secondary objective is to investigate diet composition for commercially and recreationally important species in the region. For diet data, the primary question that will be asked is whether the prey composition of black sea bass or summer flounder changes following the construction of the wind farm. This research question can be addressed for each species using the following null and two-tailed hypotheses:

- $H_{\emptyset}$ - Changes in prey composition between time periods (before and after) will be statistically indistinguishable between the reference and SRWF areas.
- $H_1$ - Changes in prey composition between time periods (before and after) will be statistically different between the reference and SRWF areas.

Seasonal diet data for focal species will be obtained from stomach contents, and prey composition will be calculated separately for each species as the mean proportional contribution (Wk) of each prey item (Buckel et al. 1999; Bonzek et al. 2008) by season and area, where:

$$\%W_k = \frac{\sum_{i=1}^{n} M_i q_{ik}}{\sum_{i=1}^{n} M_i} * 100$$

$$q_{ik} = \frac{w_{ik}}{w_i},$$

and where

$n$ is the total number of trawl tows that collected the fish species of interest,

$M_i$ is the sample size (counts) of that predator species in trawl sample *i*,

$w_i$ is the total weight of all prey items in the stomachs of all fish analyzed from trawl sample *i*, and

$w_{ik}$ is the total weight of prey type *k* in these stomachs.

Potential seasonal differences in prey composition will be explored for each focal species using multivariate techniques (e.g., PERMANOVA, Non-metric Multidimensional Scaling [nMDS], ANOSIM, and Similarity Percentages [SIMPER]). A stomach fullness index (FI) will be calculated for each fish analyzed. The difference between full and empty stomach weights will be determined to obtain the total weight of food (FW). The ingested food weight (FW) is expressed as a percentage of the total fish weight according to a formula defined by Hureau (1969) as cited by Ouakka et al. 2017.

FI = FW / fish weight x 100

Following the first complete year of trawl sampling (e.g., completion of four seasonal sampling events), cumulative prey curves (Chipps and Garvey 2006) will be used to assess the adequacy of the sampling for diet data. For each species, the cumulative number of prey types will be plotted against the number of stomachs examined. The point at which the curves reach the asymptote can be used to estimate the minimum number of stomachs that are needed to adequately characterize the prey composition (Chipps and Garvey 2006), and, if necessary, this information can be used to refine sample sizes in subsequent years.

Beyond the analyses described above, additional analyses will focus on evaluating the comparability of the SRWF trawl survey data with observations from other trawl surveys in the region, including the NEFSC and NEAMAP trawl surveys, as well as observations from trawl surveys completed at other lease sites (e.g., Vineyard Wind trawl survey). They use of the NEAMAP sampling protocols and trawl net will help facilitate these comparisons, which will provide valuable regional context to further evaluate whether the results observed at the wind farm are due to offshore wind development, or whether they are indicative of broader regional trends. These comparisons can be made at a variety of scales (e.g., lease site, NEFSC sampling strata, or stock area) as appropriate for the species and biological index of interest. The additional analyses may include an evaluation of several indices, including relative abundance, fish condition, and size structure.

**Survey Methods**

An adaptive sampling strategy will be employed, whereby data collected early in the study will be analyzed to assess statistical power and modify the sampling scheme or sampling intensity as needed (Field et al. 2007). Upon completion of the first four seasonal surveys, the power analysis will be updated to evaluate the power of the sampling design. A measure of variability associated with the relative abundance estimates for the dominant species in the catch will be calculated and the *a priori* power analysis (i.e., Appendix B) will be updated with these estimates. The proposed design (i.e. 15 trawls tows per area per season per year) is expected to detect a decrease of 33 to 40 percent at the APE for most species, with a minimum 80 percent power and 90 percent confidence (Section 4.1.2, and Appendix B, Figure B-7). Power curves will be used to demonstrate how statistical power varies as a function of effect size and sample size (i.e., number of trawl samples per area). When analyzing changes in the relative abundance of dominant species in the catch, attaining a statistical power of at least 0.8 is intended to ensure that the monitoring will have a probability of at least 80 percent of detecting an effect of the stated size when it is actually present. A two-tailed alpha of 0.10 will be evaluated during the power analysis. There is a direct relationship between the magnitude of the effect size and the statistical power of the analysis, with greater power associated with larger effect sizes. The results of the power analysis will be considered and can be used to modify the monitoring protocols in subsequent years. The decision to modify sampling will be made after evaluating several criteria including the amount of variability in the data, the statistical power associated with the study design, and the practical implications of modifying the monitoring protocols.

## 4.2 ACOUSTIC TELEMETRY – HIGHLY MIGRATORY SPECIES

### 4.2.1 Background

Passive acoustic telemetry can monitor animal presence and movements across a range of spatial and temporal scales. For instance, each acoustic receiver provides information on the presence of tagged individuals on the scale of tens to hundreds of meters. Acoustic receivers also offer continuous monitoring, allowing for behavior, movements, and residence of tagged individuals to be investigated at a fine temporal scale (e.g., minutes to hours) and in relation to cyclical events (e.g., day/night, tide,). By leveraging observations collected across individual receivers, and more broadly across receiver arrays, telemetry can also monitor animal presence and movement over a range of spatial scales (tens to hundreds of kilometers) and time scales (e.g., months to years). Therefore, passive acoustic telemetry is an ideal technology to monitor presence, residency, and movements of species within WEAs and to evaluate short and long-term impacts of wind energy projects on these movement parameters.

The use of passive acoustic telemetry has grown dramatically over the past decade and continues to grow each year (Hussey et al. 2015; Freiss et al. 2021). As a result of this rapid growth, hundreds to thousands of acoustic receivers are deployed each year in the northwest Atlantic from the Gulf of St. Lawrence to the Gulf of Mexico, each of which is capable of detecting the thousands of active transmitters that are currently deployed on at least 40 species including, among many others, Atlantic sturgeon, striped bass, sea turtles, sharks, bluefin tuna, and black sea bass.

Acoustic telemetry has been used to investigate the behavior and movements of fish species in offshore wind areas. Reubens et al. (2013a) monitored juvenile cod residency patterns, habitat use, and seasonal movement at the C-Power offshore wind farm in the North Sea and found that the majority of cod aggregated near the foundations and were resident within the wind farm for extended periods of time in the summer and autumn. Winter et al. (2010) tagged sole (n=40) and cod (n=47) with acoustic transmitters and tracked their movements within the Egmond aan Zee wind farm of the Dutch North Sea coast and a nearby reference area and concluded that sole did not exhibit avoidance of the wind farm, nor did they appear to be attracted to the foundations. Instead, seasonal movements were interpreted as occurring at spatial scales larger than the wind farm. Karama et al. (2020) monitored tagged Japanese yellowtail (a highly mobile species) and red sea bream around an offshore wind turbine near the Goto Islands (Japan) over the course of a year and found that both species exhibited low affinity and residency around the turbine throughout all seasons. Acoustic telemetry has also been used to evaluate the interactions of marine organisms with power transmission cables. Klimley et al. (2017) monitored the movements of green sturgeon and salmon smolts in relation to the Trans Bay Cable within the San Francisco Estuary and concluded that the Cable did not impact the migration success of either species. Similarly, Westerberg and Lagenfelt (2008) studied the movements of European eels in the Baltic Sea around an AC power cable and observed that the swimming speed of the eels was reduced near the cable, but that the cable did not act as an impediment to migration.

BOEM has funded several studies to collect baseline data using acoustic telemetry for species such as Atlantic sturgeon, striped bass, and winter skate, as well to investigate the seasonal movements and spawning behavior of cod within the MA/RI WEAs. The BOEM funded Atlantic cod telemetry project was conducted from November 2019 through March 2023 by a group of researchers from the Massachusetts Division of Marine Fisheries, University of Massachusetts Dartmouth School for Marine Science and Technology, NOAA, the Woods Hole Oceanographic Institution, and the Nature Conservancy. Ten acoustic receivers were deployed to monitor cod in the MA/RI WEA, 100 Vemco V16 acoustic transmitters were deployed in large reproductively mature cod. Atlantic cod has been recognized as a priority species for offshore wind monitoring by several groups (e.g., NMFS 2015; Petruny Parker et al. 2015; MADMF

2018), and cod have been identified as a species that is vulnerable to disturbance from the construction and operation of offshore wind farms (Guida et al. 2017).

Another acoustic telemetry project is also ongoing within the MA/RI WEA. In 2020, INSPIRE Environmental and the Anderson Cabot Center for Ocean Life (ACCOL) at the New England Aquarium received funding through the Massachusetts Clean Energy Center (MassCEC) to use acoustic telemetry to monitor the presence and persistence of Highly Migratory Species (HMS) at popular recreational fishing grounds within the MA/RI WEA. Thirteen acoustic receivers were deployed in July 2020 at three popular recreational fishing sites within the MA/RI WEAs identified through a previous recreational fishing survey carried out by the ACCOL (Kneebone and Capizzano 2020; Figure 9). These receivers were deployed strategically and in conjunction with the Atlantic cod receiver array, to maximize spatial coverage for both projects. The project is focusing on monitoring bluefin tuna, shortfin mako sharks, and blue sharks, which are three of the most commonly captured and targeted species by the offshore recreational community in southern New England (NOAA 2019) and were identified as priority species for monitoring the potential impacts of offshore wind in the MA/RI WEA (MADMF 2018). Shortfin mako sharks and tuna were also identified by Petruny Parker et al. (2015) as priority species for monitoring, and EFH is present within the study area for all three of the HMS. For-hire tagging trips using local charter vessels were conducted in 2020 and have continued in 2021 to target and tag 20 individuals of each of the three HMS species listed above (60 tags in total).

This acoustic telemetry monitoring effort will build off of these baseline studies by including five additional years of data collection, an expansion of the receiver array, and the deployment of an additional 150 acoustic transmitters for HMS. The project will be overseen by ACCOL at the New England Aquarium, with Dr. Jeff Kneebone serving as the Principal Investigator. ACCOL will partner with INSPIRE Environmental to execute the field work, data analysis, and reporting.

The primary objectives associated with the acoustic telemetry monitoring are as follows:

- **Objective 1**: Evaluate changes in HMS presence, residency, and movements between pre-construction, construction, and post-construction.
- **Objective 2**: Evaluate HMS connectivity among Orsted/Eversource lease sites.
- **Objective 3**: Monitor tagged HMS at spatial scales greater than the Orsted/Eversource Project areas.

### 4.2.2 Acoustic Telemetry Methods

Orsted and Eversource, through the South Fork Wind (SFW) project, have already provided financial support to the ongoing cod and HMS acoustic telemetry studies. SFW provided funds to the cod telemetry project team to purchase six additional VR2W receivers, which permitted the deployment of their full receiver array after some receivers were lost early in the project. SFW also purchased mooring equipment (e.g., line, buoys, anchors) to retrofit the receiver moorings for the cod telemetry study to help minimize the loss of receivers and allow the project to meet its monitoring objectives. SFW also provided financial support to the HMS telemetry project to purchase, deploy, and maintain four VR2-AR receivers year-round, with the intention of improving the resolution of the broader MA/RI WEA acoustic receiver array, particularly during the cod spawning season. As part of the Orsted Ecosystem and Passive Acoustic

**Survey Methods**

Monitoring (ECO-PAM) project[5], an acoustic receiver was deployed near SFW (41.06N, 70.83W) in July 2020, and that receiver is maintained by Mark Baumgartner at Woods Hole Oceanographic Institution.

The current HMS receiver array was expanded from 17 to 32 receivers starting in May of 2022 and will achieve monitoring across the Orsted/Eversource lease sites (Sunrise Wind, Revolution Wind, South Fork Wind and Lease Area 500) within the MA/RI WEA (Figure 9). The array is comprised of 13 Vemco VR2-AR (acoustic release) receivers that were purchased through the INSPIRE Environmental/ACCOL MassCEC project, and 19 additional VR2-AR receivers that were purchased by Orsted specifically for this monitoring activity. The full receiver array will be maintained year-round continuously through at least 2026. When combined with the baseline collected during the MassCEC-funded pilot project this work will continue monitoring throughout the pre-construction, construction, and post-construction periods of the Sunrise Wind, Revolution Wind, and South Fork Wind projects. The receivers will also continue to gather valuable data at popular recreational fishing grounds within the OCS-A 0500 lease area. In addition, the HMS receiver array deployed during this monitoring study will continue to allow for detection of tagged cod, and all detections of tagged cod will be shared with that research team. The receivers will remain in the water year-round throughout the duration of the study to provide monitoring during the presumed cod spawning period of December through March (Cadrin et al. 2020; Dean et al. 2020). A Notice to Mariners will be issued prior to deployment of the receivers and any time receiver locations are changed or adjusted to alert area stakeholders of the receiver positions and avoid any potential gear conflicts.

Vemco model VR2-AR receivers were rigged using standard procedures outlined by Vemco for benthic deployment[6]. The VR2-ARs are maintained using a Vemco VR-100 unit that communicates wirelessly to the receivers. The VR2-AR receivers are equipped with acoustic release mechanisms that allow instrument retrieval without the need for surface buoys and vertical lines in the water column. Ropeless technology (Acoustic Release Buoys) was selected to minimize risks to marine mammals and other protected species. The receivers were deployed approximately two meters from the benthos, and two small floats keep the receiver oriented vertically in the water column to maximize the detection radius. Retrieval is performed with wireless communication from a VR100 aboard the vessel that triggers the release, using a push-off titanium pin and an attached floatation buoy to bring the released receiver to the surface. The receivers are rigged inside a pop-up canister (Mooring Systems Inc) to enable to moorings to be retrieved during download trips, and to enable the moorings (75 pounds steel pyramid anchors) to be removed from the study site at the end of the monitoring.

Trips to download and maintain the acoustic receivers will be conducted in the spring and fall of each year of the project. During each trip, receivers will be summoned, downloaded, and cleaned of any biofouling. They will be re-rigged and re-deployed at sea. Receiver deployment and maintenance will be done primarily in collaboration with a local commercial fishing vessel.

---

[5] Orsted ECO-PAM (axds.co)
[6] https://www.vemco.com/wp-content/uploads/2015/01/vr2ar-deploy-tips.pdf

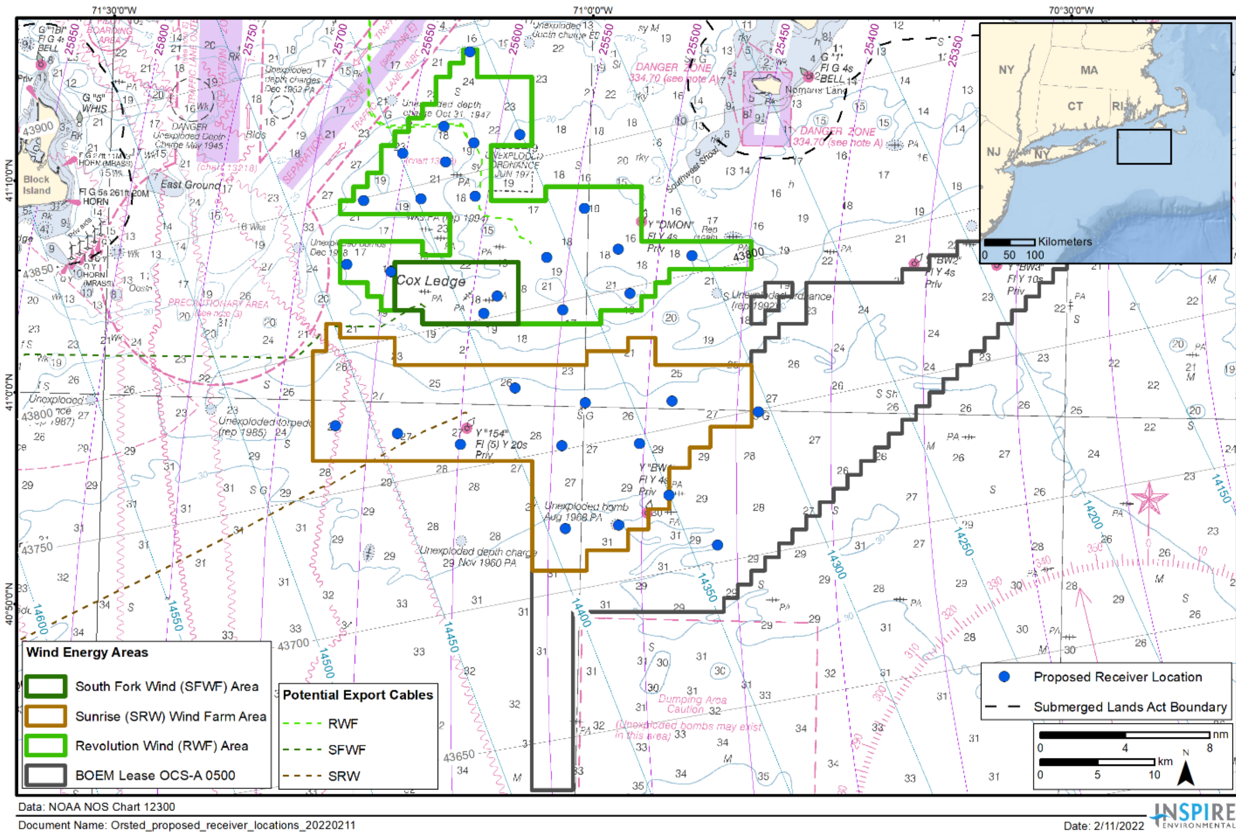



**Figure 9. Current locations of acoustic receivers within Orsted/Eversource lease sites.**

Acoustic receivers will monitor for the presence of the 60 Vemco V16 high power transmitters that were deployed on HMS as part of the 2020 – 2021 MassCEC project. An additional 50 transmitters were deployed in 2023, with another 100 deployed in 2024 and 2025 on HMS (target of 50 transmitter releases per year) as part of this monitoring plan. These transmitters emit unique, coded signals every 60 – 120 seconds and have an estimated battery life ranging from 1000 – 2500 days, depending upon the specifications of the transmitters. Therefore, long-term monitoring of HMS will occur throughout and beyond the duration of the project. The VR2-AR receivers will also monitor and record water temperature and ambient noise every hour throughout the entirety of the study.

HMS are caught with rod and reel using traditional methods for the area and are tagged either internally or externally with acoustic transmitters, depending on the species and size of the animal. Bluefin tuna and smaller sharks will be tagged internally, and larger sharks will be tagged externally. External transmitters will be rigged on stainless, multi-strand cable and implanted into the dorsal musculature of the animal with a small titanium anchor. Internal transmitters will be implanted using standard surgical techniques outlined in the approved New England Aquarium Animal Care and Use Protocol.

The VR2-AR receivers will also opportunistically collect detection data from the thousands of marine organisms that are currently being tracked in the northwest Atlantic using acoustic transmitters including fish, invertebrates, sharks, sea turtles, and marine mammals. At present, the majority of acoustic receivers deployed in southern New England are located close to shore, often in estuaries and bays. Therefore, establishing a robust, long-term acoustic receiver network in the offshore waters of the continental shelf will help fill spatial gaps in acoustic telemetry monitoring in southern New England, and provide valuable data to supplement the dozens of ongoing telemetry studies in the region.

### 4.2.3 Outreach for the HMS Acoustic Telemetry Study

Proactive outreach and engagement efforts have occurred to alert fishermen and regulatory agencies of the planned acoustic monitoring studies at SRW and other Orsted lease sites in southern New England, and several mitigating steps have been taken to minimize the likelihood of interactions between the acoustic receivers and mobile gear fishing effort. The proposed methods for the HMS telemetry study were presented to state and federal agencies starting in 2021, including meetings with staff at BOEM, NOAA, RIDEM, MADMF, MACZM, NYDPS, NYDOS, NYDEC, and RICRMC. The HMS acoustic telemetry study was also presented to fishing industry groups such as the NYSERDA Environmental-Technical Working Group and Fisheries-Technical Working Group, as well as the RICRMC Fishermen's Advisory Board and the Massachusetts Fisheries Working Group.

Beyond these formal meetings, the Orsted Marine Affairs team also conducted extensive outreach for both telemetry projects. The outreach started in the winter of 2022 and continued prior to the deployment of the receiver array. Communication and outreach will continue throughout their deployment. Outreach thus far has included providing fishermen with nautical charts that included the proposed and actual locations of acoustic receivers, and with fact sheets that provided information about the HMS telemetry study (see Appendix C). At the request of local fishermen, the proposed receiver locations were overlaid on nautical charts, to help them better understand the potential for interactions between the receiver arrays and their fishing effort. Sunrise Wind also worked with a New Bedford-based marine electronics company to upload GIS shapefiles of the proposed receiver locations to USB drives, which the fishermen can plug into their wheelhouse computers to evaluate how the proposed receiver locations intersect with their fishing locations. Conversations with fishermen focused around understanding the potential for interactions between the acoustic receivers and fishing effort, particularly mobile fishing gear. Input from Orsted's Fisheries Liaisons and Fisheries Representatives were also used to identify areas of consistent mobile gear effort. The developers with lease sites in southern New England also hosted Joint Developers Port Hours in April 2022 in New Bedford, MA, Pt. Judith, RI, and Montauk, NY to gather feedback from fishermen on the proposed locations of the HMS receivers at the offshore lease sites, including Sunrise Wind.

Based on the feedback received, some of the HMS receiver locations that were originally proposed by the researchers have been revised to minimize the likelihood of gear interactions. For the HMS telemetry study, receiver locations were chosen in areas with hard bottom or 'hangs' wherever possible, in order to limit and potential interactions with mobile gear fishing effort. In addition, several of the proposed HMS receiver locations were moved to avoid areas with high densities of mobile gear fishing effort, particularly proposed receiver locations within the northeastern portion of the Revolution Wind lease area. We will continue to work with the research team at the New England Aquarium and Inspire Environmental to modify the receiver locations based on additional feedback that is received during deployment of the receivers.

**Survey Methods**

Sunrise Wind has also developed a robust communication plan to ensure that the fishing industry is given advance notice of planned field activities. Orsted issued Mariners Briefings before any of the receivers are deployed, and the Mariners Briefing are distributed electronically and posted on the Orsted website[7]. The Orsted Marine Affairs team also disseminates information about the timing and location of receiver deployments to the United States Coast Guard, who then include this information in their Local Notice to Mariners briefing. If there are significant changes to the receiver locations from what was disseminated to the fishing industry, Sunrise Wind will work with the Orsted Marine Affairs team to issue an updated Mariners Briefing as soon as possible. In addition, updated Mariners Briefings will be disseminated throughout the duration of the project if the receiver positions change from their original locations (e.g., following a download trip).

### 4.2.4 Data Management and Analysis

**Scope of monitoring -** Due to the highly mobile nature and anticipated large home range of HMS, monitoring will occur in aggregate over the Revolution Wind, Sunrise Wind, and South Fork Wind Project areas. Data aggregation will serve as a more biologically and ecologically appropriate manner to examine impacts on species that can use large areas of the southern New England region over variable periods of time (e.g., days to months). Accordingly, the data analyses described below will be performed, at a minimum, using all acoustic detection data collected by the 36 receivers deployed in the Revolution Wind, Sunrise Wind, and South Fork Wind Project areas. Finer-scale monitoring of HMS activity within each individual project area will be accomplished if sufficient data are available over the time series.

**Additional data sources -** Acoustic telemetry has recently been adopted as a multi-species monitoring platform throughout several MA/RI and MA offshore wind leases. Thus, monitoring opportunities under this plan will be bolstered and expanded through collaboration, cooperation, and data sharing with ongoing projects funded by other developers/entities. Efforts will be made to establish working relationships or formal agreements among various telemetry projects to maximize the amount of data that will be included in this monitoring plan. For example, detection data from acoustic transmitters that are deployed on HMS as part of non- Orsted/Eversource monitoring projects may be used in this monitoring plan contingent upon the establishment of a data sharing agreement with the entity that purchased the transmitter. Similarly, detection data for Orsted/Eversource transmitters that are logged by receivers deployed in other MA/RI or MA lease areas may be included in the analyses outlined in this monitoring plan. The potential for data sharing and cooperation across offshore wind projects will become more apparent over time as data sharing agreements are reached amongst developers (see Data Sharing section below). However, there is great potential to establish acoustic telemetry as a regional monitoring platform across numerous lease areas during the project period (2021 – 2026).

**Reporting -** Annual reports will be prepared after the conclusion of each year of telemetry monitoring and shared with state and federal resource agencies. Following the conclusion of the monitoring study, one final report will also be produced synthesizing the findings of the pre- and post-construction evaluations. Sunrise Wind will also coordinate with their research partners at the New England Aquarium and INSPIRE Environmental to disseminate the annual monitoring results through a webinar or an in-person meeting, and this meeting will also offer an open forum for federal, state, and academic scientists, as well as members of the local fishing industry, to ask questions or provide feedback on monitoring approach.

[7] Offshore Wind Farm Information for Mariners | Ørsted (orsted.com)

**Data Analysis -** The detection data will be compiled after each download and analyzed with the overall goal of establishing information on species presence and persistence across the Orsted/Eversource lease areas in the MA/RI WEA. Several metrics will be analyzed including short- and long-term presence, site fidelity (i.e., residency/persistence), fine- and broad-scale movement patterns, and inter-annual presence (i.e., whether individuals return to the receiver array each year). Deliverables will include detailed detection history plots for each tagged individual that depict all detections logged for an animal by individual receivers, as well as by all receivers, over each year of monitoring. Summary tables and figures will be generated that describe: the total number of receivers an individual and/or species was detected on in the broader receiver array as well as in each project area, the number of times each fish was detected by each receiver, movements between individual receivers and project areas, and monthly/seasonal/annual patterns in presence and persistence in relation to environmental conditions (e.g., sea surface or bottom water temperature, photoperiod).

To examine animal home range, an estimation of individual and species' utilization distribution will be made using statistical analyses such as the Brownian Bridge Movement Model (e.g., Dean et al. 2014; Zemeckis et al. 2019) or a spatial point process model (Winton et al. 2018), both of which are effective when used with passive acoustic telemetry data. Connectivity and movements between receiver locations will be examined using a network analysis, which has been used previously to examine movements and space use with passive acoustic telemetry data (e.g., Lea et al. 2016). Analytical techniques for telemetry data are constantly evolving, therefore, using novel statistical methods to analyze data will be considered, such as state-space or multi-state models, should they become available during the course of the study. As appropriate, information on sea surface temperature, bottom water temperature (measured hourly by each receiver), season (or month), water depth, photoperiod, and substrate type will be integrated into all analyses to examine the influence of physical processes and environmental conditions on each metric.

The acoustic telemetry data can be evaluated across a range of spatial scales, depending on the scale of interest. To examine the factors that influence presence/absence of HMS at individual or groups of receivers, individual project areas, or the broader acoustic receiver array, a series of logistical regressions will be constructed. Regressions will test whether a series of fixed or mixed effects (e.g., water temperature, month, photoperiod, distance from construction location, distance from inter-array cable or export cable) influence the presence or absence of a species (the response variable). External data collected on ambient noise levels may be included in these regressions, as appropriate.

To examine potential effects of construction and operation on HMS, all analyses will be structured around the following objectives and hypotheses:

**Objective 1:** Evaluate changes in HMS presence, residency, and movements between pre-construction, construction, and operation.

HMS presence in southern New England has been documented to be driven by environmental (e.g., water temperature, photoperiod) or biological/physiological (e.g., ontogeny, thermal tolerance) factors. Thus, the presence, persistence, and movements of HMS in the Revolution Wind, Sunrise Wind, or South Fork Wind project lease areas likely varies naturally from month to month or year to year.

Accordingly, baseline and pre-construction levels for several standard metrics related to the presence/residency and movements for each species throughout the entire HMS receiver array including: minimum, maximum, and mean annual/seasonal residency times, presence in relation to environmental conditions (e.g., surface and bottom water temperature), nature of movement (e.g., long-term presence vs. transit/migratory corridor), and inter-annual patterns in presence/residency or movement (e.g., present in acoustic array annually, or sporadic, inconsistent presence over multiple years). These metrics will serve as the basis by which to examine the potential impacts of construction and operation of the Projects.

To examine impacts of construction or operation, the aforementioned metrics will be created for each species during the construction and operations (if appropriate) phases of each project. For example, decreased residency times or the avoidance of an area that is otherwise biologically or environmentally-suitable for a species may be an indication of spatial displacement resulting from construction or operational activities. In contrast, more frequent detection (observation) or extended residency times of HMS in certain areas may be indicative of aggregation in response to the presence of fixed structures such as wind turbines.

$H_0$: HMS presence and movements are driven by environmental features (e.g., water temperature, prey distribution) and animal biology or physiology and are not affected by construction or operation of offshore wind projects.

$H_1$: HMS presence and movements are affected by construction or operation of offshore wind projects.

**Objective 2**: Evaluate HMS connectivity among Orsted/Eversource lease sites.

Given the differing construction timelines of the Revolution Wind, Sunrise Wind, and South Fork Wind projects, individual acoustic receivers will be monitoring locations that are at different stages of project development (e.g., pre-construction, construction, operation). To examine potential effects of construction or operation on HMS presence and movements in adjacent Orsted/Eversource lease sites/Project areas that are at an earlier stage of development, the metrics outlined in Objective 1 for all projects in a given phase will be calculated. For example, if construction has begun in South Fork Wind, the standard metrics for South Fork Wind will be compared to those of Revolution Wind and Sunrise Wind (which will still be in the pre-construction phase). If appropriate, the aforementioned logistic regression will be employed to test whether proximity to the construction site (e.g., linear distance away) impacts presence or avoidance for individual animals, or for species.

$H_0$: HMS presence and movements are driven by environmental features (e.g., water temperature, prey distribution) and animal biology or physiology and are not affected by construction or operation of offshore wind projects.

$H_1$: HMS presence and movements are affected by construction or operation of offshore wind projects.

**Objective 3**: Monitor tagged HMS at spatial scales greater than the Orsted/Eversource Project areas.

In addition to the local-scale acoustic monitoring achieved by the proposed HMS receiver array, regional or broad-scale movement data will be accomplished through data sharing with related HMS monitoring projects in other offshore wind lease areas, and through regional telemetry data sharing programs (e.g., Mid-Atlantic Acoustic Telemetry Observation System [MATOS], see Data Sharing section below). The first priority will be to establish data sharing agreements with other developers that will carry out acoustic telemetry monitoring for HMS at their lease sites. Sharing transmitter metadata and acoustic detection data across projects will permit 1) the monitoring of a larger number of HMS in the Orsted acoustic array, and 2) the monitoring of HMS tagged under this monitoring plan that are detected in adjacent receiver arrays in MA/RI or MA WEAs. Such data sharing will enable monitoring on a more regional level, which is more appropriate for highly mobile fishes, such as HMS, and this regional scale monitoring will help to elucidate cumulative impacts for these species. The statistical tests and analyses presented herein will be adjusted to incorporate all available data and adjust the spatial and temporal extent of this broader monitoring plan as appropriate.

Participation in regional telemetry data sharing networks will provide detection data from tagged animals under this program wherever else they are detected in the greater Atlantic region. Any detection data obtained through Sunrise Wind's participation in regional telemetry data sharing networks will be incorporated into the analyses as appropriate, particularly to examine the distribution and movements of species beyond the confines of Orsted lease areas in southern New England. Information on the presence of tagged HMS beyond the receiver array in the Orsted Project areas will be particularly important to evaluate whether the lack of detection/observation of an individual (or species) is due to the avoidance of the area (i.e., presence in some other region) or tag loss or mortality (i.e., lack of detection of a tag over extended periods provides evidence of tag shedding or mortality). This analysis will also help to better understand connectivity between offshore wind development areas and adjacent habitats throughout the Northwest Atlantic.

**Data sharing -** All detection data from Atlantic cod that were tagged as part of the BOEM-funded telemetry study will be provided to the Principal Investigators of that study, and the data can be used to evaluate several metrics including site fidelity, residence times, and spatial distribution of cod throughout the Sunrise Wind, South Fork Wind, and Revolution Wind lease areas. The high-resolution data collected using acoustic telemetry can be utilized to improve the understanding of cod habitat use and spawning behavior in the region. The year-round deployment of the receiver array will improve monitoring during the winter cod spawning season, which is a time period that is not well sampled by the existing fishery independent surveys, and for which there is limited fishery-dependent data collected for the recreational fishery. Given that the cod transmitters being deployed by the BOEM-funded telemetry study have an expected battery life of 1400 days, cod detections should be recorded throughout the duration of this monitoring effort. Maintaining the receiver array over several years will provide valuable information of spawning site fidelity, interannual variability of habitat use, and the influence of offshore wind development on cod behavior.

All detection data for other species recorded by the acoustic receivers in this Project will be distributed to researchers through participation in regional telemetry networks such as the Ocean Tracking Network or MATOS. Any detection data that collected for transmitters that are not deployed as part of this HMS monitoring effort will be compiled and disseminated to the tag owners every six months (it is the policy of regional data sharing programs that the 'owner' of the data is the entity that purchased and deployed the transmitter, not the entity that detected it on their receiver). The research team will also approach each transmitter's owner to request the inclusion of their data (i.e., metadata on the species detected, number of detections, amount of time the animal was detected in the Orsted receiver array, etc.) in any analyses performed. Ultimately, participation in these large data sharing networks will increase both the spatial and temporal extent of monitoring for species tagged as part of this research effort and permit the collection of data on the presence and persistence of other marine species tagged with acoustic transmitters (e.g., Atlantic sturgeon, striped bass, white sharks) in and around Orsted lease sites at no additional cost. If a large amount of detection data is obtained for a given species over the course of monitoring, the research team will engage in conversations with the owner(s) of detected transmitters to explore the potential of adding those species to this monitoring plan. Thus, the choice to use acoustic telemetry in the Orsted monitoring framework provides the potential to expand the monitoring efforts described herein beyond HMS and Atlantic cod.

Due to the proven ability of acoustic telemetry to monitor a large number of animals over variable spatial and temporal extents, this technology has already been adopted in several wind energy-related projects along the US east coast. Given this, there is growing potential for coordination and data sharing across projects. However, in order to achieve efficient and successful coordination and data sharing, project leaders need to be aware of ongoing telemetry projects in the region and establish data sharing plans before or during the early stages of projects. Currently Orsted and other developers with lease sites in southern New England are working to develop an inter-developer agreement related to acoustic telemetry data sharing and standards. Once it is finalized, this agreement will be disseminated to serve as a model for data sharing among offshore wind telemetry projects moving forward.

## 4.3 ACOUSTIC TELEMETRY – SUNRISE WIND EXPORT CABLE

### 4.3.1 Background

The Sunrise Wind Project will use one DC submarine export cable (SRWEC), within an up to 105 -mi (169 -km) corridor to transmit power to shore at Smith Point County Park in the Town of Brookhaven, New York. The DC magnetic field generated by the SRWEC will combine via vector addition with the Earth's geomagnetic field. In other words, the DC field from the SRWEC may affect both the magnitude and direction of the natural DC field in proximity to the cable. The cable will use materials such as grounded metallic sheaths and steel armoring, to shield the electric current from entering the marine environment (Snyder et al. 2019). However, the SRWEC will be a source of a static magnetic field that will modify the ambient static geomagnetic field. The movement of electric charges in a static magnetic field around the cable will produce a weak electric field. The strength of the magnetic field, and the induced electrical field, are dependent upon the amount of electrical current (Amperes) flowing through the cable.

Many fish species have evolved the ability to detect and respond to the Earth's magnetic field (i.e., magnetosensitivity), and fish and elasmobranchs are thought to use their magnetic sense in concert with their other senses to guide their migrations (Snyder et al. 2019). Based on modeling results, the magnetic fields generated by the DC cables on the overlying seabed at peak loading levels are projected to be well below the levels detectable by finfish, and slightly above detectable levels documented to elicit minor behavioral changes in crustaceans and elasmobranchs (Exponent 2021). Available field studies have shown these magnetic fields will not result in adverse population-level effects to elasmobranch species (Exponent 2021). The strength of the magnetic fields will diminish quickly with distance from the cable (Snyder et al. 2019), creating a detectable difference from Earth's natural geomagnetic field only within the immediate vicinity of the SRWEC (Exponent 2021). In addition, because the magnitude of the magnetic field varies as a function of distance from the cable, species that have close associations with benthic habitats will have the greatest exposure to electromagnetic fields (EMF) from the cable (Exponent 2021).

Evaluating the potential impacts of EMF from undersea power transmission cables has been one of the major research priorities identified by stakeholders (e.g., commercial and recreational fishermen) during the development of fisheries monitoring guidance related to offshore wind (ROSA 2021), and there have been calls to focus monitoring efforts related to specific stressors associated with the construction and operation of offshore wind farms, particularly EMF (Petruny-Parker at al. 2015; MADMF 2018). Stakeholders have expressed concerns that the SRWEC may affect the migratory behaviors of commercially and recreationally important species. In some cases, it has been suggested that offshore wind export cables might pose a barrier to migration by electrosensitive or magnetosensitive species, although there is no evidence to support this speculation (Snyder et al. 2019). Acoustic telemetry has been recognized as a suitable monitoring approach to assess the in-situ movements of lobsters, crabs, and elasmobranchs, and to evaluate whether EMF influences the movement ecology of marine organisms (Petruny-Parker et al. 2015). Prior acoustic telemetry studies (e.g., Kavet et al. 2016; Klimley et al. 2017) have demonstrated the utility of using acoustic telemetry to evaluate the behavioral responses of individual fish to EMF produced by bridges and undersea power cables.

**Survey Methods**

In this study, an acoustic telemetry receiver network will be established along the route of the SRWEC, and dedicated telemetry tagging will occur to evaluate the potential impacts associated with the operation of the SRWEC on important marine species. The focal species for this study were chosen based on several factors including their known sensitivity to EMF, their ecological significance or importance to regional commercial and recreational fisheries, and their geographic overlap with the SRWEC. Monitoring efforts will focus on species associated with the benthos, given that they will experience the greatest potential impacts from EMF (Snyder et al. 2019). The species selected for telemetry monitoring are; American lobsters, horseshoe crabs, winter skates, sandbar sharks, sand tiger sharks, dusky sharks, and smooth dogfish.

Elasmobranchs exhibit sensitivity to both electric and magnetic fields (Snyder et al. 2019), and studies have shown that they use the Earth's magnetic field to guide their migrations (Keller et al. 2021). Specialized sensory organs, ampullae of Lorenzini, allow elasmobranchs to sense electrical fields which are used to help locate predators, prey, and find mates. Prior research suggests that species which possess these specialized organs are considered the most likely to exhibit a behavioral reaction in response to undersea power cables associated with offshore wind projects (Snyder et al. 2019). Several species of elasmobranchs occur within the footprint of the SRWEC, with some species using the area seasonally, and others displaying more resident habitat use within the region. In particular, recent acoustic telemetry monitoring efforts have documented the seasonal presence of several elasmobranch species at the New York Department of Environmental Conservation (NYSDEC) Center Moriches Artificial Reef area which is in close proximity to the SRWEC route (Bradley Peterson, personal communication), including sandbar sharks, sand tiger sharks, dusky sharks, and smooth dogfish. These elasmobranchs feed on benthic fish and crustacean prey including flounder, goosefish, skates, rays, dogfish, and blue crabs. This benthic foraging behavior may expose them to potential magnetic fields associated with the cable.

In the past 25 years, regulations to protect certain elasmobranch species have been established in US waters. Due to their decreasing population trends, sandbar, dusky, and sand tiger sharks are federally prohibited species, and sand tiger sharks and dusky sharks have been listed as a 'species of concern' (Endangered and Protected Species Act 2004). To aid in the conservation of these species, NYSDEC prohibits commercial and recreational fishermen from retaining these three species. Since 2008, NOAA's Atlantic Highly Migratory Species Management Division has required that any prohibited shark species caught in state or federal waters must be immediately released with minimum injury and without removing it from the water. This control, combined with quota reductions, time-area closures and other management measures appear to be easing some pressure on their populations in US waters. Finally, stocks of the dusky sharks have been severely overfished off the eastern coast of the US. While commercial and recreational fishing for this species has been prohibited since 2000, the effectiveness of the ban has been limited due to the high bycatch mortality of dusky sharks on multi-species gear. These three species of elasmobranchs were selected as target species due to their protected status and bottom foraging behavior. Prior studies have demonstrated that sandbar sharks can detect, and in some cases will respond to, magnetic-field deviations (Nestler et al. 2010; Anderson 2018). Finally, smooth dogfish was selected as a target species due to its benthic foraging behavior and its importance as a commercially targeted species.

Winter skates, which support a valuable commercial fishery, have been recognized as a priority species for understanding the potential impacts associated with EMF, given their close association with the benthos, their sensitivity to both electric and magnetic fields, and their overlap in distribution with the wind energy areas (Petruny-Parker et al. 2015; MADMF 2018; Snyder et al. 2019). Recent field studies by Hutchinson et al. (2018, 2020a) have demonstrated that skates exposed to a DC cable exhibited behavioral changes compared to a control group, including modified swimming behavior and greater time spent near the sea floor.

**Survey Methods**

Understanding the potential impacts of EMF on American lobster has been identified as a monitoring priority (Petruny Parker et al. 2015; MADMF 2018). Lobsters migrate seasonally through habitats along the SRWEC route and have demonstrated changes in behavior when exposed to EMF from an HVDC power cable, although the cable did not act as a barrier to migration (Hutchinson et al. 2018, 2020a). Modeling results associated with the SRWEC estimated that the magnetic-field levels at the seabed immediately above the buried SRWEC calculated at peak loading are slightly higher than DC magnetic fields that caused minor changes in lobster behavior and distribution, indicating that large crustaceans will be able to detect the elevated magnetic field, but only when in close proximity to the cable during peak loading (Exponent 2021).

In addition to these target elasmobranchs, other ecologically or commercially important species have been detected at the NYSDEC Center Moriches Artificial Reef area two miles east of the SRWEC corridor including horseshoe crabs, Atlantic sturgeon, and striped bass. The south shore of Long Island is a critical habitat for horseshoe crab spawning with some of the highest abundances in areas including the benthos where the SRWEC will traverse (Sclafani et al. 2009; Sclafani et al. 2020). Since horseshoe crabs are a commercially important species harvested for bait and their blood which is used to detect the presence of bacterial contaminants in vaccines (including the Covid-19 vaccine), they will also be examined in this study. Horseshoe crabs have been listed as "Poor" status in New York State by the Atlantic States Marine Fisheries Commission (ASMFC 2019; Smith et al. 2017) and their declines in recent decades throughout the US East Coast resulted in them being listed as "Vulnerable" on the International Union for the Conservation of Nature (IUCN) Red List. Furthermore, they have also been listed as a priority species for assessment of effects of EMF from undersea power cables by BOEM (Normandeau et al. 2011) and hence they will also be examined in this study. Atlantic sturgeon are known to be sensitive to both electric and magnetic fields (Snyder et al. 2019; Exponent 2021), have a strong affinity to the benthos, and are a priority for monitoring due to their current population status which is considered as 'threatened' under the Endangered Species Act.

Sunrise Wind will work with researchers at Stony Brook University, Cornell Cooperative Extension, and the Shark Research and Education Program at the South Fork Natural History Museum to conduct a multi-year acoustic telemetry study to assess the potential impacts of the SRWEC on the behavior and migratory patterns of commercially and ecologically important species in coastal waters south of Long Island. The specific objectives associated with this monitoring study are as follows:

1. Implant or attach acoustic transmitters on lobsters, horseshoe crabs, winter skates, smooth dogfish, sandbar sharks, dusky sharks, and sand tiger sharks.

2. Deploy an array of acoustic receivers at the nearshore area of the SRWEC landfall that extend outside of the existing receiver arrays deployed by Stony Brook University at Rockaway, Jones Beach, Fire Island, East Hampton, and Montauk, that is designed to capture fine-scale behaviors.

3. Evaluate effects of EMF on behavior and movement on targeted species before, during, and after construction.

4. Estimate movement metrics including depth, two-dimensional position, and residency for telemetered individuals.

5. Maintain the offshore and nearshore Sunrise Wind Receiver Arrays and collect data on the individuals tagged by Stony Brook University and partnering organizations along the east coast.

### 4.3.2 Acoustic Telemetry Methods

The study commenced in 2022, and will continue through 2027, encompassing all three phases of cable installation (before, during, and after installation). The receiver array was deployed in July of 2022, and dedicated tagging trips commenced shortly after the receiver array was deployed. The receiver array deployed in 2022 consisted of 32 receivers. However, in the spring of 2023 it was discovered that receivers in shallow water had been buried in the sand and were not able to be retrieved. It was also discovered that some receivers were likely caught by commercial fishing gear and were not found. It was decided not to replace these receivers and the array reduced from 32 to 21 acoustic receivers (Figure 10).Capture and tagging of study animals will occur from a variety of vessels and projects. The expertise of the South Fork Natural History Museum Shark Group will assist in capturing and tagging of elasmobranchs. In addition, if necessary, hook and line will be used from Stony Brook University vessels to capture elasmobranchs for tagging. The Principal Investigators will attain all required research and scientific collection permits prior to commencing the tagging efforts.

Long-term projects established between NYSDEC and Stony Brook University (SBU) provide an additional platform for tag deployment. The Nearshore Trawl Survey (NTS) and the Acoustic Gates (AG) projects provide regular opportunities to capture specimens in the coastal ocean and estuaries in the New York Bight. The NTS carries out five surveys per year along the coast of Long Island, New York, sampling 25 stations per cruise. The AG project deploys over 150 acoustic tags per year in estuarine and coastal waters along the south shore of New York.

Surgical procedures will follow approved Stony Brook University Institutional Animal Care and Use Committee approved protocols. Briefly, all elasmobranch individuals will be measured for total length to the nearest mm and placed in tonic immobility along the side of the boat before surgery. Transmitters will be surgically placed through an incision into the peritoneal cavity, then closed with two or three simple interrupted sutures. Individuals will be monitored after surgery, then released. Horseshoe crabs and lobsters will have the transmitters epoxied to their exoskeleton and released following the methods described in Brousseau et al. (2004).

Sandbar sharks, sand tiger sharks, dusky sharks, smooth dogfish and winter skates: A target sample size of 25 individuals per shark species were implanted with acoustic transmitters with sensors for depth and temperature (V16TP; 69 kHz, high-power output = 158 microPascals (dB re 1 μPa) at 1 m, random transmitter delay = 120 s, life span = 2,435 d) in 2022. These tags transmit presence, temperature (with an accuracy of ± 0.5 °C), and depth (estimated via pressure with an accuracy of ± 1.5 m at a depth of 17 m) data as an acoustic receiver detects them. In addition, 25 winter skates were implanted with acoustic tags without depth or temperature sensors (V16; 69 kHz, high-power output = 158 dB re 1 μPa at 1 m, random transmitter delay = 120 s, life span = 3,508 d). An additional 125 transmitters (target of 25 transmitters for each species) have been or will be deployed annually in 2023, 2024, and 2025.

Horseshoe crabs and lobsters: A annual target sample size of up to 50 individuals of each species will be tagged with either a V13 (69 kHz, high-power output = 151 dB re 1 μPa at 1 m, random transmitter delay = 180 s life span = 648 d) or a V16 (69 kHz, 158 dB re 1 μPa at 1 m, random transmitter delay = 120 s, life span = 2,435 d) accelerometer transmitter. Tagging commenced in 2022, and a target of 50 transmitters will be deployed annually on each species in 2022, 2023, 2024, and 2025.

Atlantic sturgeon, and additional telemetered individuals: Detection data for sturgeon will be obtained from Stony Brook University's ongoing tagging efforts, including >300 telemetered sturgeon with active transmitters. In addition, a total of 223 elasmobranchs have been tagged by Stony Brook University since 2016 including the following: 45 sandbar sharks, 96 smooth dogfish, 39 spiny dogfish, 13 sand tiger sharks, and 30 winter skate. Provided that sufficient detections are recorded, these individuals will be included in analyses conducted for this monitoring effort, along with the explicitly deployed transmitters as part of this monitoring study.

Positional monitoring of tagged individuals will be accomplished using an array of acoustic receivers to monitor fine-scale movements near the SRWEC landing site (Figures 10). This fine-scale positional array will be used to evaluate movement around the SRWEC with high spatial resolution. Temperature (mean, min, max) will be recorded every three hours on all VR2AR-X receivers providing information to evaluate environmental drivers of the presence/absence of telemetered individuals in the study area.

The near-shore fine-scale positioning array will provide high-resolution information on the two-dimensional or three-dimensional movements (depending on the type of transmitter) of individuals in the vicinity of the SRWEC. The receivers in the nearshore fine-scale positional array (Figure 10) are spaced approximately 300 m apart. The VR2AR-X receivers are equipped with built-in transmitters to sync with adjacent receivers (Vemco Positioning System), enabling the two-dimensional position of tagged individuals to be evaluated with high precision. Additionally, telemetered elasmobranchs tagged with V16TP transmitters can be positioned in three dimensions (latitude, longitude, and depth) within the fine-scale positioning array.

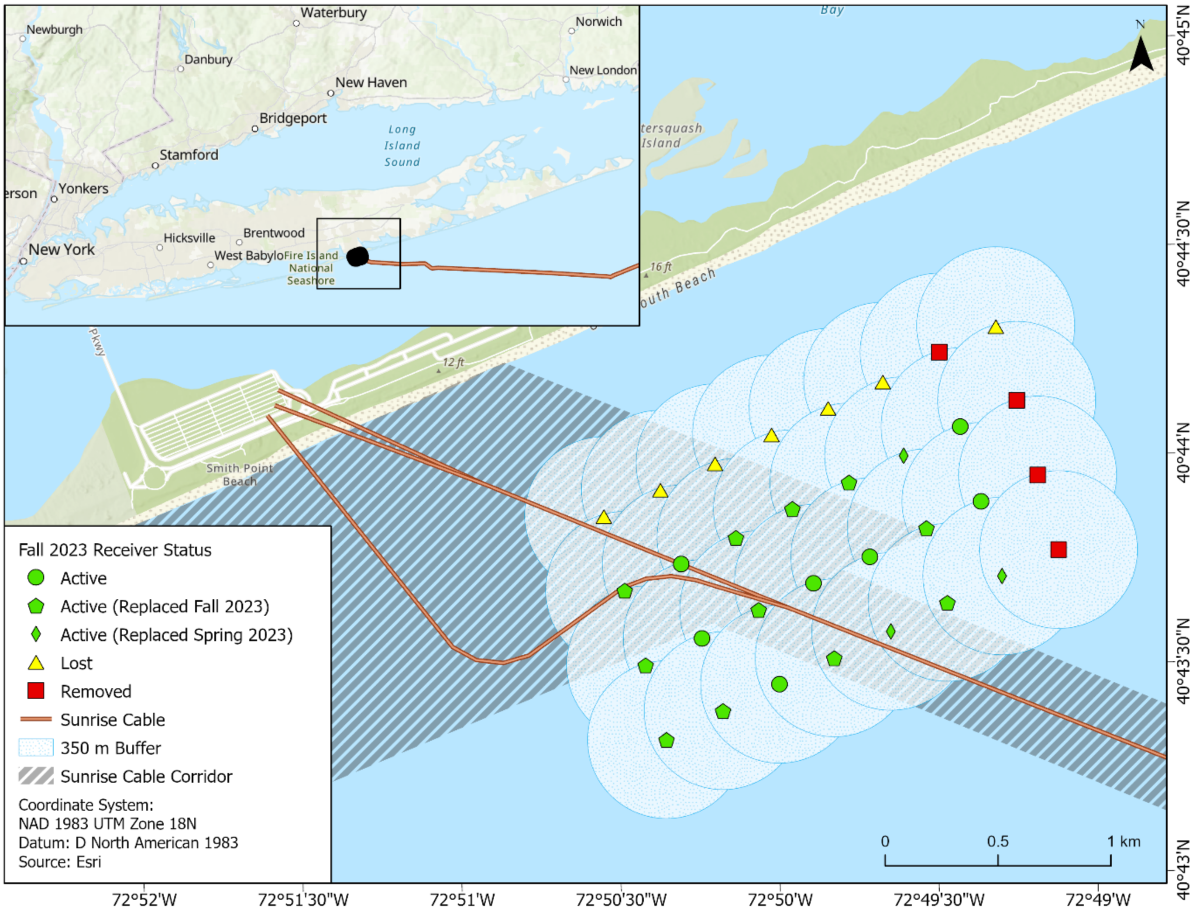



**Figure 10. The acoustic telemetry array deployed along the SRWEC. Multiple receivers were believed to be either buried in the sand (yellow triangles) and caught by commercial fishing gear (red squares).**

The VR2AR-X receivers are equipped with acoustic release mechanisms that allow instrument retrieval without the need for surface buoys and vertical lines in the water column. Ropeless technology was selected to minimize risks to marine mammals and other protected species. The receivers will be deployed approximately two meters from the benthos, and two small floats keep the receiver oriented vertically in the water column to maximize the detection radius. Retrieval is performed with wireless communication from a VR100 aboard the vessel that triggers the release, using a push-off titanium pin and an attached floatation buoy to bring the released receiver to the surface.

The entire receiver array will be downloaded twice per year, during which time the receivers will be cleaned of any biofouling, and the batteries will be replaced as needed. The receivers will be rigged inside a pop-up canister (Mooring Systems Inc, described in Section 4.2.2)) to enable to moorings (75 pounds pyramid anchors) to be retrieved during download trips, and to enable to moorings to be removed from the study site at the end of the monitoring. Downloading the receiver arrays twice per year will help to mitigate receiver loss and will also promote a greater probability of data integrity and allow any lost receivers to be replaced with no more than a 6-month gap in data at any one location. The potential for receiver losses will also be mitigated by deploying the receiver arrays strategically in areas with limited mobile gear fishing effort. A notice to Mariners was issued prior to deployment of the receivers and will be issued any time receiver locations are changed or adjusted to alert stakeholders of the receiver positions and avoid any potential gear conflicts.

The telemetry methods planned for the SRWEC are designed to be compatible with and complementary to other planned and ongoing offshore wind-related acoustic telemetry monitoring efforts that are funded by Orsted/Eversource. Sunrise Wind, Revolution Wind, and South Fork Wind are funding a multi-year acoustic telemetry study to investigate the movements and behavior of HMS within the WEA's (see Section 4.2). In addition, South Fork Wind has partnered with researchers at Stony Brook University, Cornell Cooperative Extension, and Monmouth University to carry out a five-year acoustic telemetry monitoring study in New York state waters to investigate the potential impacts of the South Fork Export Cable (SFEC) on the following commercially and recreationally important species; striped bass, black sea bass, winter skate, summer flounder, and winter flounder (Figure 11, Inset map C). Acoustic telemetry monitoring along the SFEC commenced in August 2021, with the research target to deploy 620 transmitters over the course of the five-year study. These animals will be tracked using an array of approximately 41 VR2-AR receivers. The SFEC will make landfall at East Hampton, NY, which is approximately 35 miles from the landfall of the SRWEC.

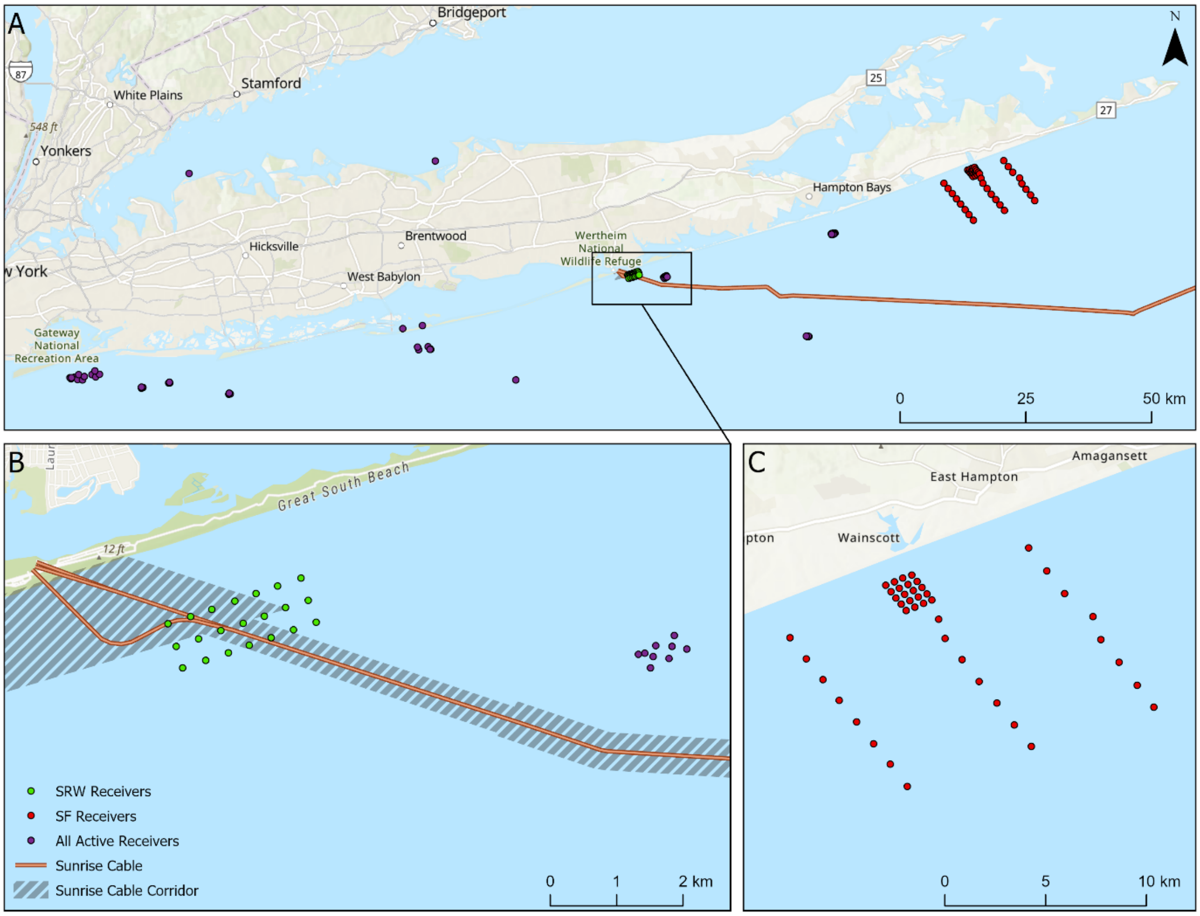



**Figure 11. Existing receiver arrays along the south coast of Long Island that are currently maintained by Dr. Michael Frisk's lab at Stony Brook University. The receivers deployed for the SFEC monitoring study are shown in Inset Map C. Receiver arrays planned for this project are also included in the map (Inset Map B).**

Throughout the northwest Atlantic, researchers are maintaining acoustic receiver arrays and tracking telemetered fishes. The Principal Investigators are involved in a wide range of acoustic telemetry networks and maintain receiver arrays in the coastal ocean and estuaries in the New York Bight. All telemetered fish that are tagged as part of the Principal Investigator's ongoing efforts will be included in the analyses. Inclusion of these transmitters will greatly increase the number and species of telemetered individuals in the proposed study. For example, the New York Bight Acoustic Network run by Dr. Frisk's research group maintains a receiver array network from Rockaways to Montauk, NY, deploys acoustic receivers as "gates" across all inlets to Great South Bay, NY, and tags over 150 fish per year (Figure 12). Dr. Sclafani maintains an acoustic array for horseshoe crabs in Moriches Bay, NY, and Dr. Peterson runs an artificial reef acoustic tagging and tracking network in the coastal ocean that includes Fire Island, Moriches, and Shinnecock Artificial Reefs, as well as Shinnecock Inlet and Peconic Bay. In addition, the receiver array at the nearby SFEC route, as well as the receiver array offshore at the Orsted/Eversource lease sites within the MA/RI WEA will allow for the movements of tagged animals to be tracked across multiple habitats during their cross-shelf migrations and will allow for an evaluation of connectivity between nearshore and offshore habitats. The synergies between these ongoing projects will place the results in a regional context as individuals migrate along the Northeast US shelf.

### 4.3.3 Outreach for the Sunrise Wind Export Cable Acoustic Receivers Arrays

Proactive outreach and engagement efforts have occurred to alert fishermen and regulatory agencies of the planned acoustic monitoring studies along the SRWEC, and several mitigating steps have been taken to minimize the likelihood of interactions between the acoustic receivers and mobile gear fishing effort. The proposed methods for this acoustic telemetry study were presented to state and federal agencies starting in 2021, including meetings with staff at BOEM, NOAA, RIDEM, MADMF, MACZM, NYDPS, NYDOS, NYDEC, and RICRMC. The SRWEC telemetry studies were also presented to fishing industry groups such as the NYSERDA Environmental-Technical Working Group and Fisheries-Technical Working Group, as well as the RICRMC Fishermen's Advisory Board and the Massachusetts Fisheries Working Group.

Beyond these formal meetings, the Orsted Marine Affairs team also conducted extensive outreach for the SRWEC telemetry project. That outreach started in the winter of 2022, and continued prior to the deployment of the receiver array. Communication and outreach will continue throughout their deployment. Outreach thus far has included providing fishermen with nautical charts that included the locations of acoustic receivers, and with fact sheets that provided information about this telemetry project (see Appendix D). At the request of local fishermen, the proposed receiver locations were overlaid on nautical charts, to help them better understand the potential for interactions between the receiver arrays and their fishing effort. Sunrise Wind also worked with marine electronics companies to upload GIS shapefiles of the proposed receiver locations to a USB drive, which the fishermen can plug into their wheelhouse computers to evaluate how the proposed receiver locations intersect with their tow tracks. Conversations with fishermen focused around understanding the potential for interactions between the acoustic receivers and fishing effort, particularly mobile gear fishing effort. Input from Orsted's Fisheries Liaisons and Fisheries Representatives were also used to identify areas of consistent mobile gear effort.

Feedback from fishermen, particularly those homeported in Long Island, was used to modify the proposed receiver locations for both the inshore and offshore arrays along the Sunrise Wind Export Cable Route. Fishermen from Long Island stated that the proposed locations for the inshore receiver array overlapped substantially with their seasonal squid fishery, which primarily occurs in the late spring, and again in late summer or early fall. In response to this feedback, we worked with the researchers at Stonybrook University and Cornell Cooperative Extension to move these receivers further inshore, into shallower water where there is anticipated to be less potential for interactions with the otter trawl fishery. Conversations with scallop and trawl fishermen revealed that the proposed locations of receivers in the offshore array was likely going to overlap with areas of mobile gear fishing effort, including fisheries targeting scallops, squid, and summer flounder. As we were unable to identify a location that would eliminate conflicts with mobile fishing gear effort, the offshore receiver array has been removed from the scope of the study.

Sunrise Wind has also developed a robust communication plan to ensure that the fishing industry is given advance notice of planned field activities. Orsted issued a Mariners Briefing before any of the receivers were deployed, and the Mariners Briefing was distributed electronically and posted on the Orsted website[8]. The Orsted Marine Affairs team also disseminated information about the timing and location of receiver deployments to the United States Coast Guard, who then included this information in their Local Notice to Mariners briefing. An updated Mariners Briefing was issued after deployment with the precise locations. In addition, updated Mariners Briefings will be disseminated throughout the duration of the project if the receiver positions change from their original locations (e.g., following a receiver download trip).

### 4.3.4 Data Analysis and Data Sharing

The primary research objective is to evaluate the effects of EMF on the movement of sandbar sharks, sand tiger sharks, dusky sharks, spiny dogfish, Atlantic sturgeon, horseshoe crab, and lobster. The following hypothesis will be tested to evaluate any potential impacts associated with the operation of the SRWEC.

**$H1_a$**: Movements and behavior of teleost, elasmobranchs, horseshoe crab, and lobster species will not be impacted during wind farm operation by the EMF produced by the SRWEC.

**$A_{a1}$**: Rate of movement is different within the cable array pre- and post cable powering.

**$A_{a2}$**: Residency is different within the cable array pre- and post cable powering. **$A_{a3}$**: Depth preference is different within the cable array pre- and post cable powering.

**$A_{a4}$**: Acceleration is different within the cable array pre- and post cable powering. .

**$A_{a5}$**: Counts of unique detections are different within the cable array pre- and post cable powering.

**Statistical analysis -** The design of the receiver array allows for a traditional test(s) of $H1_a$. GLMs will be utilized to evaluate the hypothesis for each species. GLMs provide a flexible modeling approach that allows for continuous and categorical predictors and can utilize any distribution in the exponential family (Nelder and Wedderburn 1972) for response variables, including count, proportions, presence-absence, and continuous data. GLMs have been successfully applied to acoustic telemetry data to analyze drivers of fish behavior (Ziegler et al. 2019; Ingram et al. 2019). The approach can be tailored to evaluate the alternative hypotheses utilizing various statistical distributions suited for the variety of response variables and a mixture of categorical and continuous predictors. In addition, covariates can be included such as temperature, season, photoperiod, etc. to determine important drivers of behavior and improve model statistical fit and performance.

Detailed temporal and spatial behavior will be estimated for animals detected within the fine-scale array. The fine-scale array provides two-dimensional and three-dimensional (for animals with depth tags) positioning. Fine-scale positioning is performed by Vemco utilizing the company's software and analysts. The Vemco approach focuses on three metrics: yield, precision, and accuracy to characterize spatial and temporal behavior. To position a telemetered individual, it needs to be detected by three time-synchronized receivers. The rate of valid detections can be influenced by weather conditions, temperature, and other factors and is measured as the yield of transmissions successfully detected in the array. The

[8] Offshore Wind Farm Information for Mariners | Ørsted (orsted.com)

precision and accuracy of positions are estimated by Vemco and provided as part of the positioning service. The project research team have consulted with Vemco for receiver positioning designs to produce robust results in constructing the array design. Processed data consist of tag identification, detection time, latitude, longitude, depth, and an estimate of the horizontal position error (HPE) for each relocation. The result can provide a highly resolved analysis of spatial and temporal behavior showing specific movement tracks for individual animals throughout the receiver array.

In this project, the position of all tagged fish detected within the fine-scale array will be evaluated to determine if spatial and/or temporal trends exist for individual species and the species assemblage. The positioning approach will provide detailed movements and can indicate areas of high habitat use, trajectories (e.g., tortuous or linear), and rate of movement (ROM). The temporal and spatial analysis will address $H1_a$ by providing a detailed view of behavior along the SRWEC. In addition to positioning, the fine-scale array produces metrics that can be used to evaluate the effects of EMF. Unique counts, residence, depth, and specific pathways for all species telemetered will be used to estimate behavior and use of each receiver location within the cable array. These metrics will be statistically compared to evaluate whether telemetered individuals at receivers close to the export cable show different behavior than at receivers further away.

Finally, a network connectivity analysis will be conducted to determine areas of high habitat connectivity and use. A network connectivity analysis provides estimates of the level of habitat use of nodes (receivers) and connectivity to other nodes (movement path) in the network (Bopp et al., 2021). The approach estimates degree and eigenvector centrality to evaluate habitat use and linkages throughout the array (Lookingbill et al. 2010; Jacoby et al. 2012; Ledee et al. 2015). Degree centrality is a measure of the number of direct connections to a node and can be calculated as the number of movement connections into a node, out of a receiver node, or as a total for both directions. Degree centrality can be perceived as a proxy of important connection centers within a network, or “hubs.” Eigenvector centrality quantifies the relative influence a location (node) has on overall habitat connectivity in the network. It incorporates a node’s own degree centrality and the degree centrality of each receiver connected to it and is a proxy of preferred space-use by animals.

Network analyses will include all species and covariates (temperature, season, etc.) to determine environmental and seasonal trends and strengthen model fit and performance. Specifically, the analysis will determine if habitats along the cable EMF shows increased or decreased connectivity and use by telemetered individuals. The network analysis will also determine if connectivity and habitat use changed during pre-construction, construction, and post-construction periods.

**Reporting -** Annual reports will be prepared after the conclusion of each year of telemetry monitoring and shared with state and federal resource agencies. Following the conclusion of the monitoring study, one final report will also be produced synthesizing the findings of the pre- and post-construction evaluations. Sunrise Wind will also coordinate with their research partners at Stony Brook University and Cornell University to disseminate the annual monitoring results through a webinar or an in-person meeting, and this meeting will also offer an open forum for federal, state, and academic scientists, as well as members of the local fishing industry, to ask questions or provide feedback on monitoring approach.

**Data Sharing -** Downloaded acoustic data will be uploaded to the MATOS and Atlantic Cooperative Telemetry Network (ACT_MATOS). ACT_MATOS is a secured data portal where archived acoustic telemetry data and matched transmitter detections are shared and distributed between researchers. Data collected to address the objectives of the SRWEC monitoring study will be shared to a limited extent until two years after completion of the project. This is to allow the students and PI’s to complete dissertations and publish research in peer-reviewed publications. The ability of researchers to complete dissertations and research papers is fundamental to the academic process. Detections of telemetered individuals that were tagged by other researchers will be provided to MATOS following each receiver download event. Telemetered individuals that were tagged as part of this research project will be uploaded on MATOS with the tag identification and species; additional metadata will not be uploaded until two years after completion of the project (e.g., length, weight, date of capture).

## 4.4 SCALLOP SURVEY

### 4.4.1 Background and Objectives

Following a review of the draft fisheries monitoring plan, we received feedback from staff at NOAA and RI CRMC, as well as from members of the Fishermen's Advisory Board to include a survey to investigate changes in the abundance and biomass of sea scallops (*Placopecten magellanicus*) in the Sunrise Wind Fisheries and Benthic Research Monitoring Plan. In response to that feedback, SRW has amended this plan to include an optical survey for scallops within the lease site and a nearby control area. Scallops have been previously recognized as an indicator species that should be prioritized for monitoring the impacts of offshore wind development (e.g., Malek, 2015; Petruny-Parker et al., 2015, NMFS, 2015; MADMF, 2018). Beyond assessing changes in the relative abundance of scallops, members of the Fishermen's Advisory Board also expressed concern about the potential for sublethal impacts to sea scallops, namely scallop meat quality. In response to this feedback, SRW has also updated the monitoring plan to include an examination of meat quality for scallops captured during the trawl survey (see Section 4.1.3).

Based on the most recent assessment (NEFSC, 2018) the Atlantic sea scallop stock is not overfished and is not experiencing overfishing. Biomass was estimated to be 2.7 times greater than the management target, and the estimated fishing mortality rate (0.12) was much lower than the target fishing mortality reference point (0.64). Biomass in 2017 was the highest estimated value in the assessment time series (1975-2017), with recent biomass increases driven in large part by the exceptionally large year classes observed in 2012 on Georges Bank and in 2013 in the Mid-Atlantic.

There are three fisheries-independent indices of abundance and biomass that are currently used as inputs to the scallop stock assessment model: the drop-camera survey conducted by the SMAST, the Habitat Mapping Camera (HabCam) survey that is conducted by Coonamessett Farm Foundation (CFF) and the Northeast Fisheries Science Center (NEFSC), and dredge surveys that are carried out by the NEFSC and the Virginia Institute of Marine Science (VIMS). HabCam survey data collected from 2011-2017 was included in the most recent scallop assessment (NEFSC, 2018). That report also noted that optical surveys may perform better than dredge surveys in areas with dense scallop aggregations because the efficiency of the survey dredge can be reduced at high densities (NEFSC, 2018). Optical surveys also offer the advantage of accurately documenting areas containing abundances of recently settled juvenile scallops, which may not be sampled as effectively by dredge surveys (Rudders, 2015).

In 2019, scallop landings were nearly 61 million pounds, equating to an ex-vessel revenue of $569.9 million to the US fishing fleet, with the majority of scallops landed by vessels from Massachusetts and New Jersey (NMFS, 2021). The sustainable management of scallops, combined with the high ex-vessel value, has contributed to the profitability of the scallop fishery. In 2015 and 2016, there was directed fishing effort for scallops within the SRW lease area, primarily in the central portion of the lease site, where fishing effort (as characterized using VMS, or vessel monitoring system) ranged from 'medium-low' to 'very high' (Figure A-10). There was also fishing effort for scallops in the central portion of the SRW lease site from 2011 through 2014 (Figure A-9), albeit at lower densities than were observed from 2015 to 2016. Based on VMS data from 2011 through 2016, there were also directed fishing activities for scallops along the SRWEC route, and the level of directed fishing effort was characterized as ranging from 'low' to 'high'.

Sunrise Wind will partner with researchers at CFF to carry out habitat monitoring surveys for sea scallops and other benthic organisms within SRWF and a nearby control area utilizing CFF's HabCam V3, and the survey will be executed using a BACI design. Consistent with other fisheries-independent surveys for scallops in the region, the survey will be executed once per year, targeting sampling in the summer months between May-September, which is consistent with the timing of the annual scallop assessment surveys. The target is to achieve two years of pre-construction monitoring, to continue monitoring during construction, and to monitor for at least two years after construction is completed. Surveys were completed in July 2022 and July 2023. This survey has been and will continue to be carried out in collaboration with a local scallop vessel(s) (e.g., the F/V Kathy Marie was used for the 2022 and 2023 suveys). The primary objective of the HabCam survey is to investigate the relative abundance of scallops and other benthic species in the SRWF Area ("SRW impact") and reference area ("control") over time. Utilization of the HabCam survey equipment and protocols will ensure that the data collected as part of this fisheries monitoring plan will be compatible and standardized with fisheries-independent data that is used to inform scallop science, stock assessment, and management. The HabCam monitoring approach is particularly well-suited to sampling within the lease area following construction, as it is an advanced, non-lethal sampling tool that has minimal impact on marine species and benthic habitats, and poses negligible risks to protected species.

The objectives associated with the HabCam V3 survey are as follows:

- **Objective 1**: Evaluate changes in the relative abundance of scallops between SRWF and the control area pre-construction, during construction, and post-construction.
- **Objective 2**: Assess changes in the size structure of scallops between SRWF and the control areas pre-construction, during construction, and post-construction.
- **Objective 3**: For species that are imaged with sufficient frequency, investigate changes in the composition of fish and invertebrate species (e.g., skates, flounder, echinoderms, sponges) between SRWF and the control area pre-construction, during construction, and post-construction.
- **Objective 4**: Determine habitat types and analyze changes between SRWF and the control area pre-construction, during construction, and post-construction.

### 4.4.2 HabCam Survey Design

Figure 12 shows the proposed control area and survey track within the SRWF, along with a proposed survey track within the control area. The systematic zigzag track within SRWF and the control area will span approximately 250 nautical miles (nm). The transects will run in North-South direction to survey across depth contours and allow CFF to maintain similar tracks after construction begins and is completed. The survey tracks will be spaced approximately 3 nm apart, which translates to a transect every 3rd row of turbines, assuming the turbines will be built 1 nm apart, as is currently proposed. Some variation to the proposed 3nm spacing may occur as needed to avoid obstacles such as obstruction, fixed gear, other survey equipment, or any future changes to the turbine layout. A similar survey track and level of sampling intensity will also be completed within the control area. The survey will follow an "intensive" sampling design as described by the NEFSC and NOAA Research Set Aside Program (RSA) as having transects that are spaced approximately 4 nm apart. Additionally, the annotation rate of 1:100 images will allow for analysis of the sampled areas to occur at a spatial resolution that is consistent with the current RSA-funded scallop stock assessment surveys.

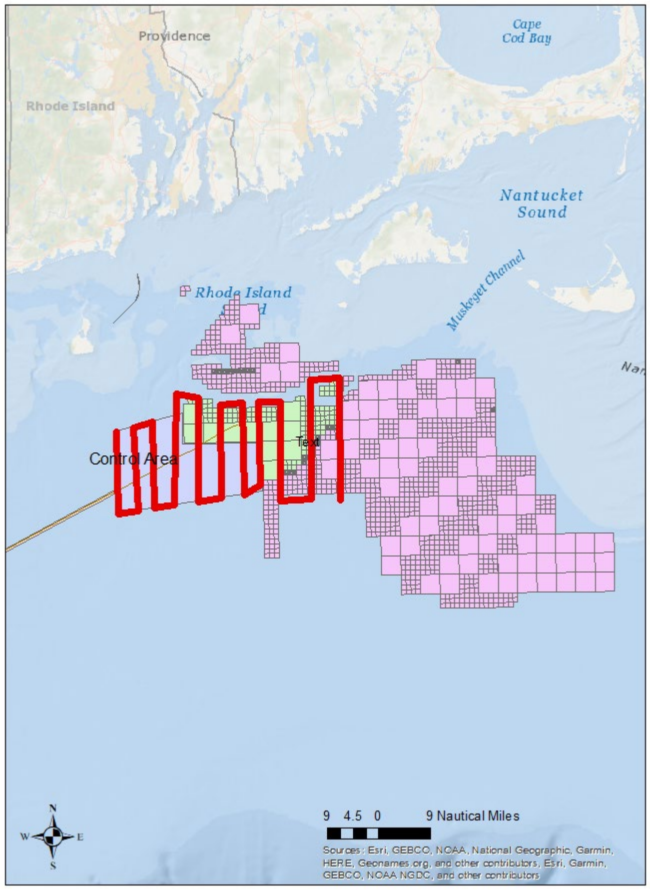



**Figure 12: Map of indicative monitoring track (red zigzag) in Sunrise Wind Farm lease area and proposed nearby control area. Transects are ~3 nm, with variations between some transects necessary to avoid obstacles.**

**Survey Methods**

For this survey, CFF towed its dual-array camera system continuously through similar tracks within the SRWF and the control area which was mutually decided upon between Orsted and CFF based on a number of factors. The proposed control area in Figure 12 is a polygon just southwest of the current

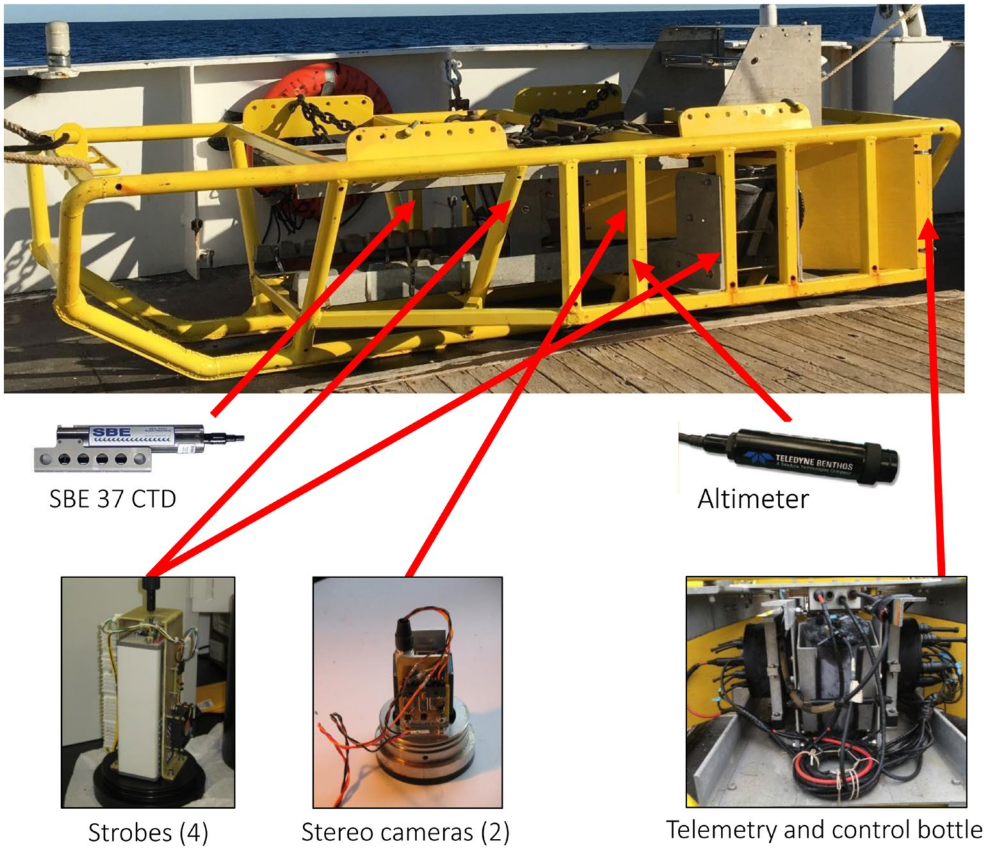



**Figure 13:** Figure showing the HabCam v3 vehicle and key components.

SRWF lease area to be surveyed Based on VMS and/or VTR (vessel trip report) data, the areas appear to have relatively similar levels of vessel traffic and fishing effort for many groundfish and invertebrate species. The sediment types (primarily sand and cobble with small boulders) are also similar between the two areas. The control area has a similar depth profile as the adjacent SRWF, with depths ranging from 30- 60m. The proposed control area is southwest of the SRWF area and the proposed cable route runs through the site. Modifications to the location of the reference area may be considered based on input received from stakeholders.

**4.4.3 HabCam Survey Methods**

The HabCam V3 system is a towed, dual-array camera system that is flown approximately 1.5-2.5 meters above the seafloor behind a vessel (Figure 13). The survey is conducted by towing the HabCam system on a fiber optic tether on a hydraulic winch system. The HabCam is towed along a predetermined zigzag track which transverses depth contour lines at an average speed of ~4.5 nm/hour. The camera system captures approximately 6 images per second of benthic habitats. In addition, the HabCam system has integrated sensors to measure a suite of environmental variables such as bottom temperature, conductivity, and salinity throughout each transect. The field of view (FOV) associated with each image differs depending on the altitude and orientation of the HabCam but is generally around 1.5$m^2$ for each image. All images collected are stored as raw TIFF files and TIFF files are processed onboard using Linux-based commands at a rate of 1:10 to smaller jpeg files to facilitate onboard annotations. Processing every 10th image allows researchers to modify annotation rates as needed while avoiding annotating overlapping images or double counting individual animals. For annotations both onboard and in the lab, CFF will utilize a version of open-source software developed by the Visual Geometry Group (VGG) at Oxford University which has been updated and modified for CFF's HabCam survey needs. This annotation software has been used since 2020 to annotate imagery for the annual RSA-funded stock assessment surveys that are conducted by CFF. Additionally, a version of the software has been modified by CFF for use in its autodetection projects using HabCam imagery. The high-resolution digital cameras used on the HabCam system allow for fish to be identified to the species level, with the occasional exception of little and winter skates, which can be difficult to identify to species when individuals are smaller sizes.

Annual monitoring for the SRWF and control area will take place during the summer months from May-September, which is consistent with data collection timing for the annual sea scallop stock assessments. Surveys will typically occur after CFF has completed the annual RSA-funded stock assessment surveys, which are normally completed by the end of July each year. The survey will operate 24 hours per day, consistent with the methods that are used during the RSA-funded surveys. The images will be annotated at regular intervals throughout each transect, which will enable the abundance and distribution of scallops to be evaluated and mapped as a function of distance from the nearest turbine foundation.

CFF is not required to apply for a Letter of Acknowledgement (LOA) or an Exempted Fishing Permit (EFP) from NOAA Fisheries, as it does not harvest/collect species or any materials from the ocean during its HabCam surveys.

#### 4.4.4 HabCam Station Data

The HabCam V3 collects data continuously throughout its track, capturing approximately six images per second along with various associated location and environment-specific metadata. Images will be annotated at a target rate of 1:100, which is approximately one image annotated or "station" every 40 meters, or about 5,000 images annotated per 24-hour period. As each image captured is integrated with environmental and location data, each image represents a holistic picture of the ecosystem at a specific place in time, and each annotated image can therefore be considered its own "sampled station". The following data will be collected for each HabCam image /sampled station:

- Latitude and longitude
- Date and time
- Water depth
- The altitude of the vehicle (meters above seafloor)
- Conductivity and temperature
- Biological data including species ID and counts
- Benthic sediment information
- Length information for sea scallops

### 6.1.5 Data Management and Analysis

A copy of all tables, images, and raw data will be supplied to Orsted after each survey, in line with the timing of the annual report. Data collected will go through rigorous Quality Assurance and Quality Control (QA/QC) checks to ensure data is reliable, complete, and accurate. All annotators will be trained by appropriate staff and will complete annotation training sets prior to annotating images that are collected as part of this monitoring plan. Annotations will be verified by highly trained annotators at a minimum rate of 50%. New annotators will undergo a higher level of QA/QC until PIs are satisfied with data reliability. Data tables will be formatted in a manner consistent with those currently generated for the annual RSA-funded surveys, which are used in stock assessments generated by the NEFSC.

Counts and scallop biomass estimates per image and per $m^2$ will be generated using the standard methodology described below. Annotations from image data will be converted to abundance and biomass estimates after the FOV of each image is calculated using vehicle altitude, pitch, and roll to estimate optical survey coverage and pixel size in mm. To generate abundance estimates, counts per image for scallops, other important invertebrates, and fish species will be converted to counts per $m^2$ using the FOV for each image. Scallop biomass will be estimated by generating meat weight estimates for all measured scallops. Scallop lengths or widths in pixels will be converted to shell heights in millimeters using the FOV calculations and an equation to convert shell widths to shell heights as needed. Scallop biomass per image will be derived based on the area-specific shell height/meat weight equations used for scallop assessment during each survey year; these equations are determined during discussions with NEFSC, the staff at the New England Fisheries Management Council (Wilhelmsson), and scientists on the scallop survey teams before scallop biomass estimates are submitted to the NEFSC and NEFMC in the late summer each year. Images from the cable corridor in the SRWF and control area will be excluded from any analyses on the impacts of wind farm construction or operation.

Abundance estimates for important benthic fish and invertebrate species and biomass estimates (for scallops only) will be derived using two methods:

1) a stratified mean estimation by depth, with images aggregated over 1000-2000m segments to minimize spatial autocorrelation along tracks, and
2) ordinary kriging of per-image biomass or abundance estimates using the “variogram” function in the R package “gstat” (Pebesma, 2004).

Length frequency data will be analyzed for the sea scallops observed in the HabCam images. Differences in the size structure of scallops (1) between SRWF and the control site and (2) before, during, and after construction at each site will be assessed using cumulative frequency analysis. Maps showing the distribution of scallops and other key species will also be provided.

Data collected before construction begins will be used to assess variability in scallop and other benthic species abundances in the Sunrise Wind and control areas using a mixed model framework, with abundance modeled as a function of location, habitat type, and environmental variables including temperature and depth. A similar spatially explicit modeling framework will also be used to assess the impacts of wind construction phases on distributions of scallops and other benthic species, including the same factors related to habitat type, environmental variables, and location relative to wind turbine bases. This analysis will follow the survey designs and statistical analysis approved through a rigorous peer-review process being conducted for a similar offshore wind research project that was recently funded by the Department of Energy and BOEM.  The peer-reviewed modeling methods that will be developed during this research effort can be applied to the data collected during the HabCam survey at Sunrise Wind to help promote a more consistent and regional approach to offshore wind monitoring.

Annual reports will be prepared after the conclusion of each year of sampling and shared with State and Federal resource agencies. Following the conclusion of the survey, one final report will also be produced synthesizing the findings of the pre-and post-construction evaluations. Sunrise Wind will also coordinate with CFF to disseminate the annual monitoring results through a webinar or an in-person meeting, and this meeting will also offer an open forum for federal, state, and academic scientists, as well as members of the local fishing industry, to ask questions or provide feedback on the data collection protocols. Following each annual report, and after data have undergone QA/QC, data should be shared with the sea scallop PDT at one of its regularly scheduled meetings, or during a Northeast Fisheries Management Council meeting, as appropriate.

The first two years of the HabCam camera survey will provide pre-construction fisheries-independent data that can be used to characterize scallops and other benthic organisms within SRWF and the reference control area. For the pre-construction monitoring, the results presented in annual reports will focus on descriptive and quantitative comparisons of invertebrate and fish communities in the SRWF and the reference control area to describe variability in species relative abundance and distributions and species diversity. This will include summary statistics for the dominant (i.e., most abundant) species as well as the analyses described above.

By continuing sampling during and after construction, the HabCam survey will allow quantification of any detectable changes in relative abundance, demographics, or community structure associated with proposed operations. The relative abundance of the most dominant species in the SRWF and reference control area will be analyzed using mixed models with a BACI design, with a factor accounting for construction period (“before”, “during”, and “after”) included in the models in addition to location, habitat type, and environmental variables like temperature and depth. Sampling in the reference control area will ensure that broader regional changes in invertebrate and fish communities can be accounted for and separated from the potential impacts of the SRWF construction. If possible, the models will include variables to account for fishing pressure in the SRWF and reference control area. Analyses presented in the final synthesis report will focus on identifying changes in the communities of scallops and other benthic organisms in the SRWF between pre-, during, and post-construction that did not also occur at the reference area that could be attributed to either construction or operation of the wind turbines.

Beyond the analyses described above, additional analyses will focus on evaluating the comparability of the SRWF HabCam survey data with observations from other fishery-independent scallop surveys in the region, as well as observations from scallop surveys completed at other lease sites (e.g., Vineyard Wind drop camera survey). The use of the standardized HabCam sampling methodology will help facilitate these comparisons, which will provide valuable regional context to further evaluate whether the results observed at the wind farm are due to offshore wind development, or whether they are indicative of broader regional trends. These comparisons can be made at a variety of scales (e.g., lease site, NEFSC sampling strata, or stock area).

## 4.5 BENTHIC MONITORING

Installation and operation of offshore wind (OSW) projects can disturb existing benthic habitats and introduce new habitats. The level of impact and recovery from disturbance can vary depending on existing habitats at the site (Wilhelmsson and Malm 2008; HDR 2020). Physical disturbance associated with cable and foundation installation can temporarily affect the benthic environment, removing or damaging existing fauna. Over time, the introduction of novel hard substrata (OSW foundations, scour protection layers, and cable protection layers) can lead to extensive biological growth on the introduced surfaces with a complex pattern analogous to shoreline intertidal to subtidal zonation (artificial reef effect, Petersen and Malm 2009; Reubens et al. 2013b; Degraer et al. 2020). Depending on the community composition and density, this biological growth may lead to substantial shifts in the transfer of energy from the water column to other compartments of the ecosystem including the sediments and upper trophic levels. For example, it is expected that increased biomass of filter feeders inhabiting the novel OSW hard surfaces will facilitate the export of organic material from the water column to the benthos and to higher trophic levels.

Observations from existing OSW projects, in Europe and at the BIWF, lead to several prevailing hypotheses of likely benthic effects related to the planned Sunrise Wind Project including:

1. Introduction of novel surfaces (foundations, scour protection, and cable protection layers) will develop epifauna that vary with depth (WTG foundations) and change over time. *[Hard Bottom – Novel Surfaces]*[9] (as reviewed in Langhamer 2012).

2. The artificial reef effect (epifaunal colonization) associated with the offshore wind structures will lead to enrichment (fining and higher organic content) of surrounding soft bottom habitats. [*Soft Bottom – WTG-associated*] (e.g., Lefaible et al. 2019).

3. Physical disturbance of soft sediments from cable installation will temporarily disrupt function of the infaunal community, community function is expected to return to pre-disturbance conditions. [*Soft Bottom – Cable-associated*] (e.g., Kraus and Carter 2018).

The consequences of these predicted effects may affect the role of soft and novel hard bottom habitats in providing food resources, refuge, and spawning habitat for commercial fish and shellfish species (Reubens et al. 2014; Krone et al. 2017).  Another hypothesis involving the effects of construction on natural native hard bottom will be monitored at adjacent lease areas to the north of Sunrise Wind, where native hard bottom habitat is more prevalent. Hard bottom at SRWF is limited in spatial extent, making up only 3.5 percent of the benthic environment in the lease area, of which 1.1 percent is described as glacial drift and 2.4 percent is areas with low to high boulder densities (Figure 12 as described in the benthic habitat mapping report [INSPIRE 2021e]). Also, the planned layout has been revised to specifically avoid hard bottom areas by micrositing foundation positions particularly in the northwest portion of the lease area. Sunrise Wind will continue micrositing efforts as design and construction plans are further refined and anticipates boulder clearance and relocation to be minimal.

This operational monitoring plan is organized according to three prevailing hypotheses associated with the Sunrise Wind project and describes the overall approach to tracking changes in both the novel hard

[9] Boulders are not prevalent at the SRWF or along the SRWEC-OCS. As such, boulder relocation will be minimal. Therefore, the recolonization of relocated boulders will not be monitored at SRWF or along the SRWEC-OCS.

bottom and soft bottom habitats associated with OSW development, specifically at the SRWF and SRWEC-OCS. A separate benthic monitoring survey for the SRWEC-NYS will be conducted within NYS waters, which is presented in a separate monitoring plan (INSPIRE Environmental 2022.). A comprehensive outline of the benthic monitoring plan, including the hypotheses, sampling schedule, and general approach for each monitoring component is provided in Table 11. Benthic monitoring that is planned for New York State waters is described in a separate monitoring plan.

Novel hard bottom habitat monitoring at turbine foundations, scour protection layers, and cable protection layers will focus on measuring changes in percent cover, species composition and volume of macrofaunal attached communities (native and non-native species groups) and physical characteristics (rugosity, boulder density). These parameters will serve as proxies for resulting changes to the complex food web.

Soft bottom habitat monitoring will focus on measuring physical factors and indicators of benthic function (bioturbation and utilization of organic deposits, Simone and Grant 2020), which will serve as proxies for functional changes in the community composition (as described in more detail in Sections 4.5.2 and 4.5.5.2). It is expected that the introduction of fines and organic content sourced from the epibenthic community on the WTG foundations will support increased deposit feeding benthic invertebrate communities in the soft sediments around the structures. This monitoring plan is not designed to answer research questions about specific causes and effects on individual species.

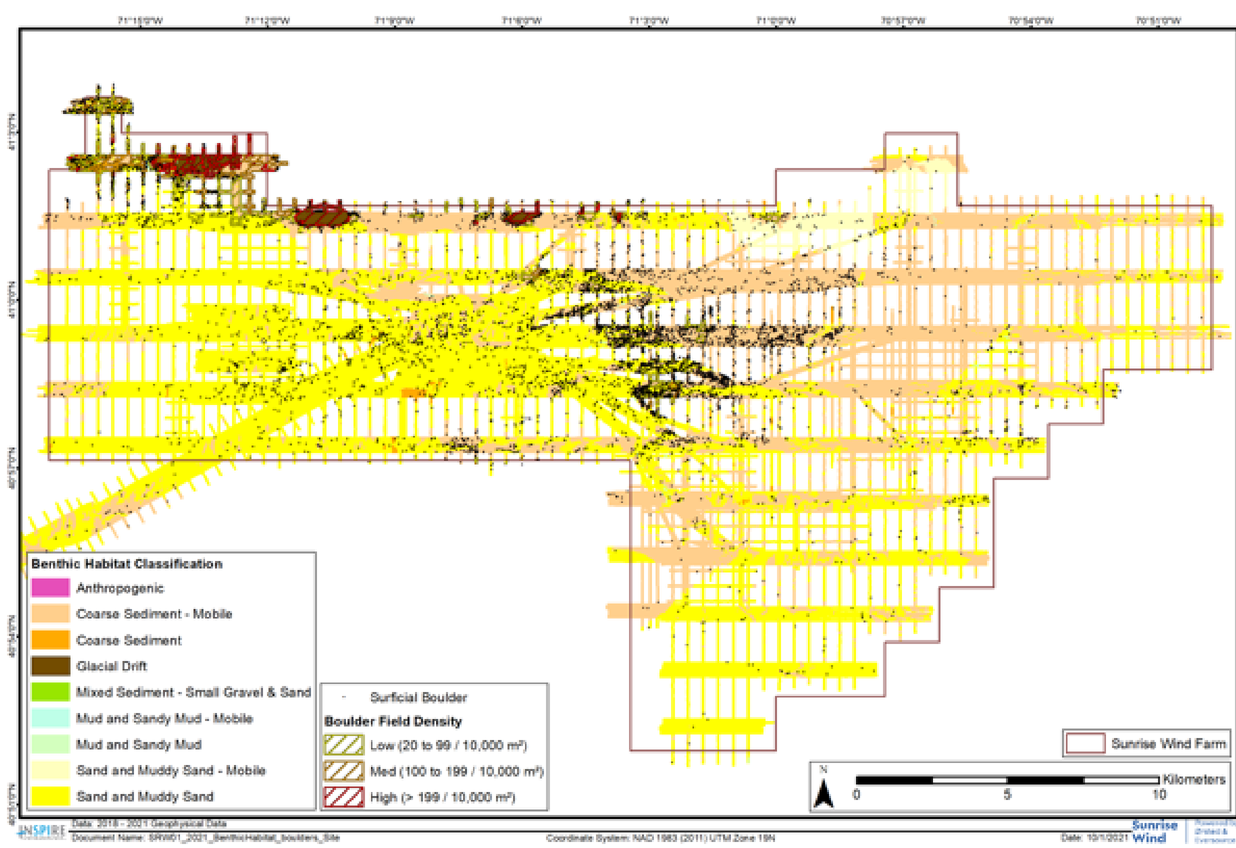



**Figure 14:** Benthic habitat types, boulder fields and individual large boulders (>0.5 m) mapped at the SRWF. Figure derived from the Benthic Habitat Report (INSPIRE 2021).

**Table 11. Summary of the Benthic Monitoring Plan Including Hypotheses, Approach, and Sampling Schedules for Each Component**

| Novel Hard Bottom Habitats | | Soft Bottom Habitats | |
|---|---|---|---|
| WTG Foundations and Scour Protection Layers | Cable Protection Layers (SRWEC-OCS) | WTG-associated | Cable-associated |
| Hypothesis: epifaunal community will vary with water depth (zonation with light and tide); successional development over time | Hypothesis: successional colonization of epifaunal community over time is expected | Hypothesis: WTG epifaunal growth will result in sediment fining and higher organic content in surrounding soft bottom, this will support deposit feeding benthic inverts. Effects will decrease with increasing distance from WTG. | Hypothesis: After initial physical disturbance during construction, soft sediment community function expected to return to pre-conditions; effects will decrease with increasing distance from cable |
| Approach: Use ROV/video to measure changes in % cover, identify key or dominant species, and volume (biomass), compare across depths and habitat strata | Approach: Use ROV/video to measure changes in % cover, identify key or dominant species, and volume (biomass), compare across habitat strata | Approach: Use SPI/PV to measure changes in benthic function over time and with distance from WTGs | Approach: Use SPI/PV to measure changes in benthic function over time and with distance from cable centerline |
| Design: stratified random selection of WTG foundations within benthic habitat strata [same WTGs and soft bottom] | Design: stratified random selection of cable protection layer areas within benthic habitat strata | Design: stratified random selection of WTG foundations within benthic habitat strata [same locations as novel hard bottom survey]; BAG design at each selected WTG | Design: stratified random selection of cable segments within benthic habitat strata; BAG at each selected cable segment |
| Y0 – late summer after construction<br>Y1- ROV/video<br>Y2- ROV/video<br>Y3- ROV/video<br>Y5 – ROV/video | Y0 – ROV/video, late summer after construction<br>Y1- ROV/video<br>Y2- ROV/video<br>Y3- ROV/video<br>Y5 – ROV/video | Pre seabed prep – within 6 mo prior<br>Y0 – late summer after construction<br>Y1 – SPI/PV<br>Y2 – SPI/PV<br>Y3 – SPI/PV<br>Y5 – SPI/PV | Y0 – late summer after construction<br>Y1 – SPI/PV<br>Y2 – SPI/PV<br>Y3+ – TBD, after SRWEC-OCS installation if benthic function indistinguishable from baseline and no difference with distance from cable line, no further monitoring required. |

### 4.5.1 Novel Hard Bottom Habitats Monitoring

Hypothesis 1: Introduction of novel offshore wind surfaces will develop epifauna that vary with depth (WTG foundations) and change over time.

The hard bottom monitoring will include an examination of three types of OSW novel surfaces: WTG foundations (including scour protection layers), cable protection layers (SRWEC-OCS), and the converter substation foundation (OCS-DC jacket). The primary objective of the novel hard bottom survey is to measure changes over time of the nature and extent of macrobiotic cover of hard bottom associated with OSW development. Macrofaunal percent cover, identification of species to the lowest practicable taxonomic unit), and the relative abundance of native and non-native organisms will be documented using a Remotely Operated Vehicle (ROV) and video surveying approach. Distinguishing non-native organisms will likely require physical sampling for accurate identification, which will be facilitated by a sampling arm attached to the ROV.

It is expected that the epifaunal community that colonizes the WTG foundations will vary with water depth, dictated by the availability of light and tides, similar to zonation patterns commonly observed at rocky intertidal habitats. Previous studies in Europe and at the BIWF found biological growth led to dense accumulations of filter feeding mussels on the turbine foundations followed by amphipods, tunicates, sponges and sea anemones in the subtidal (De Mesel et al. 2015; HDR 2020; Wilber et al. 2021; Hutchison et al. 2020b). Other studies have tracked and documented vertical zonation of epibenthic communities along the surface of wind turbine structures (Bouma and Lengkeek 2012; Hiscock et al. 2002; HDR 2020). At any given depth of the offshore wind structure, the epifaunal species composition is expected to develop successionally, with rapid opportunistic organisms pioneering the site and being replaced by more long-lived established species. Tracking the changes in species composition and density (percent cover) will inform predictions about changes in prey availability to fish and will be integrated with results of the stomach content data obtained for summer flounder and black sea bass during the trawl survey.

#### 4.5.1.1 Technical Approach – Video Imagery

To accomplish the objectives of the novel hard bottom monitoring, high resolution video imagery captured using an ROV will be employed. Video imagery will be used to document epifaunal community characteristics on the novel hard surfaces (WTG foundations and scour protection layers, OCS-DC jacket, cable protection layers).

State of the art underwater video at predefined depth intervals along the turbine foundations and OCS-DC jacket will capture high resolution images that will be analyzed using photogrammetry methods. Photogrammetry is the process in which imagery is interpreted to provide detailed information about the physical objects observed in space. Photogrammetry generates high-resolution, photo-realistic 3D models from static images captured from multiple perspectives. By digitally reconstructing segments of the foundations and jackets at predefined depth intervals, the resulting model can be analyzed for quantitative variables including percent cover, standing biomass, and abundance of individual taxa of interest (as reviewed in Marre et al. 2019). Collecting imagery and constructing spatial photogrammetric models of segments of the structures soon after construction will provide initial reference conditions that can be used to track biological changes over time following subsequent years of data collection. Biological data obtained through photogrammetry can be used to estimate ecological functions including secondary production, and physiological rates such as biodeposition associated with the epifaunal community. These biological processes have implications to the transfer of energy to higher trophic levels and to the sediments at the base of the novel structures. This approach will provide an estimate of the increase in standing stock biomass at the basal trophic levels where filtering feeding epifauna (e.g., blue mussels, sea squirts) exist. This information can inform ecosystem models that seek to understand how these changes to the basal trophic level may alter food web dynamics, objectives that are beyond the scope of this monitoring plan.

#### 4.5.1.2 Survey Design

An ROV video survey is planned to monitor novel hard bottom habitats (WTG foundations and scour protection layers, OCS-DC jacket, cable protection layers) within subareas of the SRWF. A stratified random design, with benthic habitat types as strata, will be used to select the WTG foundations and cable protection areas that will be monitored. There is only one OCS-DC jacket in the project design; it will be selected for monitoring. The same WTG foundations and the OCS-DC jacket selected for this novel hard bottom survey will be monitored as part of the soft sediment survey (see Section 4.5.2.2). This will help facilitate synthesis between the degree of enrichment in the surrounding soft sediments and the epifaunal community composition and density colonizing the turbine foundations at any given time and location.

Benthic habitat mapping results (INSPIRE 2021e) will inform the number of sampling strata. No more than four to five distinct benthic habitats are expected based on preliminary habitat mapping analysis at SRWF (Figure 13) and along the SRWEC-OCS (Figure 14). Within each habitat strata three WTG locations (SRWF) or cable protection areas (SRWEC-OCS) will be randomly selected. As soon as practicable, following the completion of the foundation and cable installation, an ROV will be used to collect reference video imagery of the underwater surfaces (i.e., turbine foundations down to the scour protection layer, cable protection area). Continuous video imagery will be collected down the length of the selected foundations to provide general context on the community composition and how and where dominant species shift with depth. Then, high resolution still imagery will be collected at discrete randomly placed and replicated quadrats (four replicates per depth stratum) within pre-defined depth intervals as informed by the continuous video footage. These depth intervals will be dependent on the community composition shifts with depth as seen in the continuous video footage. The still images, collected at multiple angles around the quadrat, will be used to identify organisms to the lowest taxonomic level. These still images will be used to construct 3D models of that patch or quadrat to derive an estimate of biomass or biovolume at these discrete locations. An average biomass will be calculated for each depth interval and extrapolated up to the entire turbine foundation. This approach is expected to provide a higher accuracy in biomass estimation than attempting to construct a less-resolved 3D model of the entire monopile. Additionally, this approach is expected to optimize species identification by capturing a high density of clear and higher-resolution still imagery.

The survey will be repeated at annual intervals indicated in Table 11, coinciding with the soft bottom Sediment Profile and Plan View Imaging (SPI/PV) survey. The visual surveys of the WTG foundations will occur around the circumference of the structures at different elevations from the sediment surface (including the scour protection layer) to the water surface. Data will be collected on the percent cover of macrofauna and macroalgae, composition of native and non-native organisms, and distribution of key suspension feeding organisms that could contribute to benthic enrichment (e.g., mussels, tunicates, tube-building amphipods). Beyond informing an understanding of the colonization and community composition associated with the novel substrates, this information will also be considered as explanatory variables for the magnitude and range of benthic enrichment observed in the soft bottom habitat surrounding the turbines.

The sampling schedule for this component will mirror the WTG soft bottom habitat monitoring schedule (Table 11). Monitoring at the novel habitats will begin after construction is complete (i.e., after all infrastructure has been installed) during late summer or early fall, and sampling will be repeated annually at time intervals of 1, 2, 3, and 5 years after construction. If a stable hard bottom community is not observed within the timeframe of this monitoring program, the Sunrise team will confer with NOAA and BOEM to determine the need and extent for any additional years of monitoring. Sampling will occur during late summer or early fall to capture peak biomass and diversity of benthic organisms, and the seasonal timeframe of sampling is intended to be in alignment with previous and planned regional studies. Benthic habitats, particularly hard bottom habitats, in the northwest Atlantic are generally stable with little seasonality in the absence of physical disturbance or organic enrichment (Steimle 1982; Reid et al. 1991; Theroux and Wigley 1998; HDR 2020).

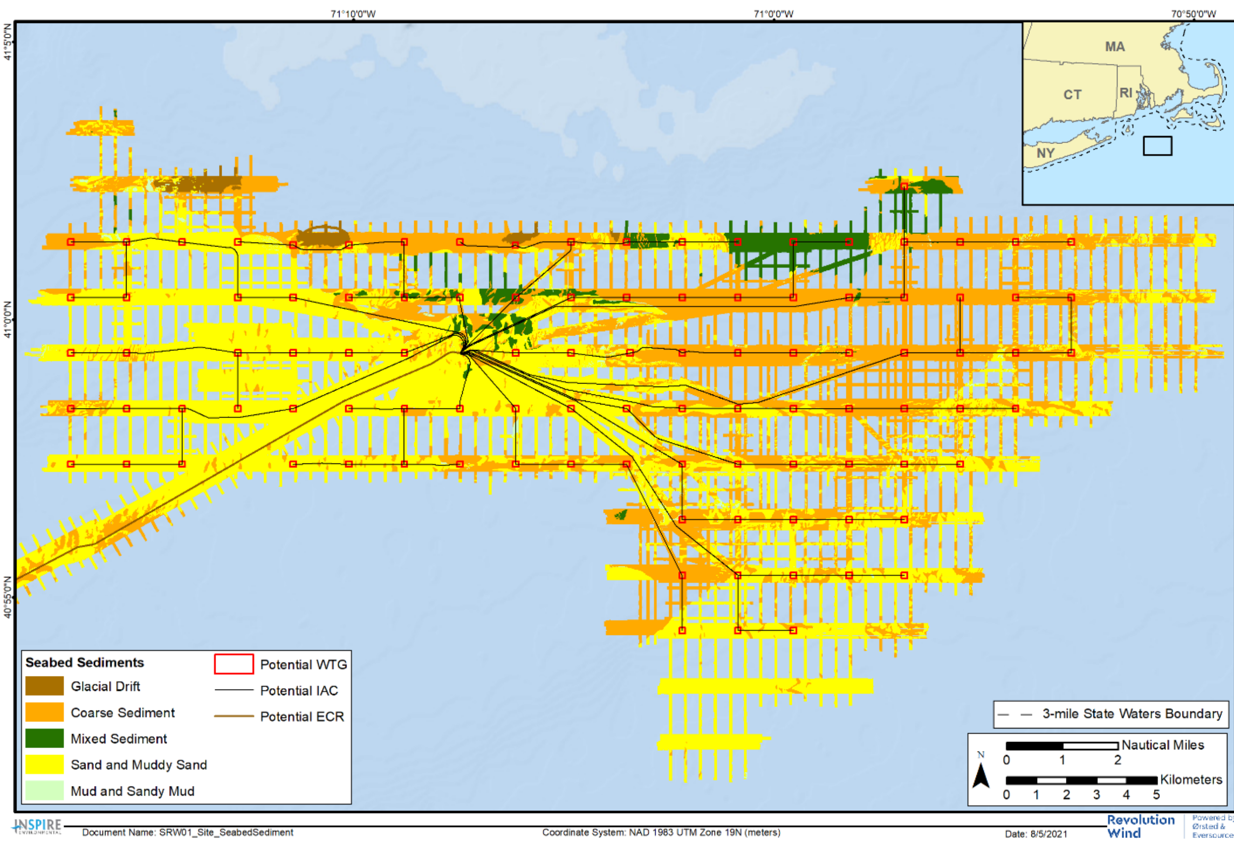



**Figure 15.** **Preliminary seafloor sediment map around planned turbine and cable installations at the SRWF. Turbine foundations for both the novel surfaces and soft bottom monitoring will be randomly selected stratified by habitat type.**

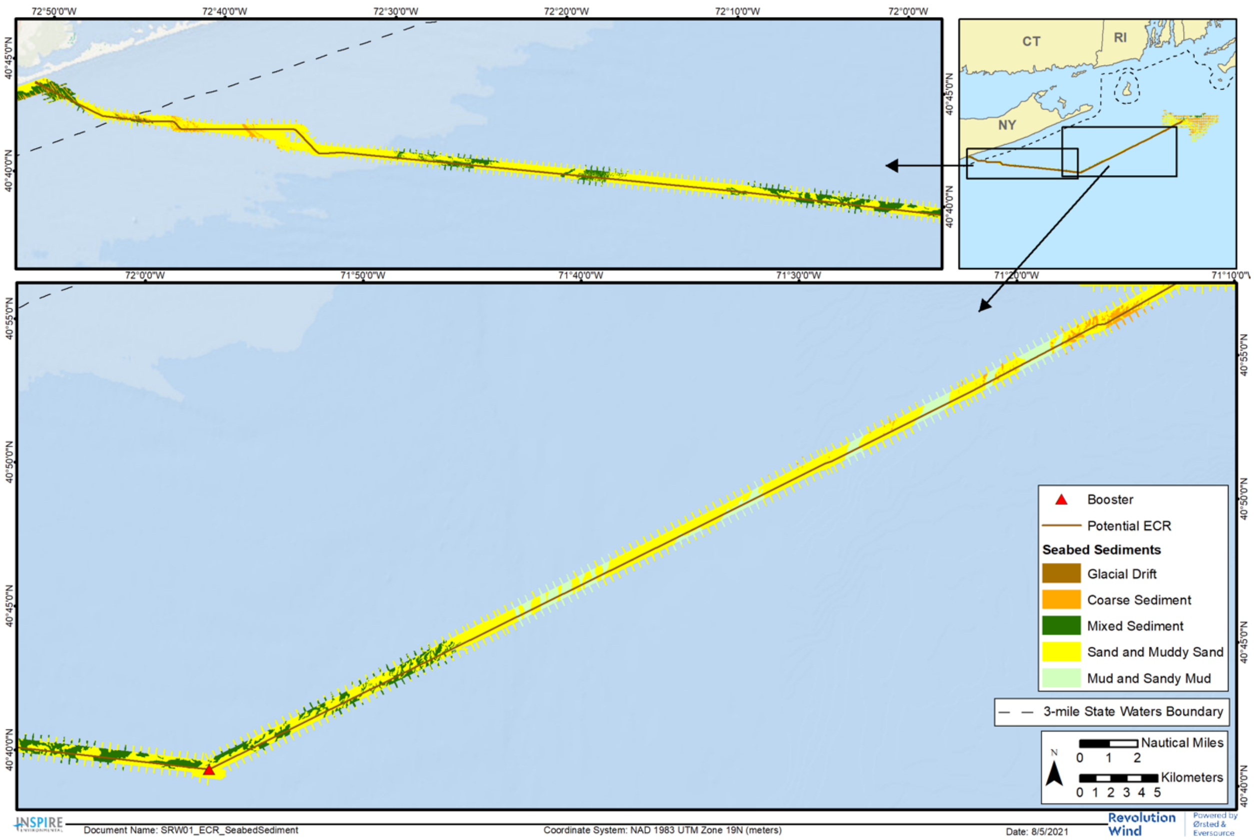



**Figure 16. Preliminary seafloor sediment map around planned cable installations along the SRWEC-OCS. Cable protection areas will be randomly selected, stratified by habitat type, for monitoring.**

## 4.5.2 Soft Bottom Monitoring

Hypothesis 2: The artificial reef effect (epifaunal colonization) associated with the offshore wind novel structures will lead to enrichment (fining and higher organic content) of surrounding soft bottom habitats.

Hypothesis 3: Physical disturbance of soft sediments from cable installation will temporarily disrupt function of the infaunal community, community function is expected to return to pre-disturbance conditions.

The soft bottom monitoring will include an examination of two OSW components: WTG/OCS-DC foundation-associated and export cable-associated soft bottom. The overall objective of the soft bottom benthic monitoring survey is to measure potential changes in the benthic function of soft bottom habitats over time, and to assess whether benthic function changes with distance from the base of the WTG foundations or SRWEC-OCS centerline. A high density of fishing activity (trawling and dredging) occurs in the SRW Project area. This was particularly evident through the geophysical data collected in the Project area (Figure 15). Frequent trawling and dredging activity is likely a significant source of disturbance on the soft sediment habitats in the area. Fishing activity will be considered during survey planning and will be accounted for during data interpretation as a potential press disturbance (described in more detail in 4.5.2.2).

Benthic functioning of the soft bottom habitats will be captured by documenting physical parameters (grain size major mode) and biological factors (bioturbation and utilization of organic material) with a SPI/PV system. It is expected that the epibenthic community that colonizes the WTG foundations and OCS-DC jacket will supply organic matter to the sediments below through filtration, biodeposition, and general deposition of detrital biomass. This organic material sourced from the biological activity of the epibenthic community on the wind structures will likely alter the infaunal community activity, increasing sediment oxygen demand and promoting the activity of deep-burrowing infauna. Based on benthic monitoring results in other offshore wind farms, the effects of the WTG foundation on the surrounding soft sediment habitat are expected to decrease with increasing distance from the WTG (as reviewed in Degraer et al. 2020).

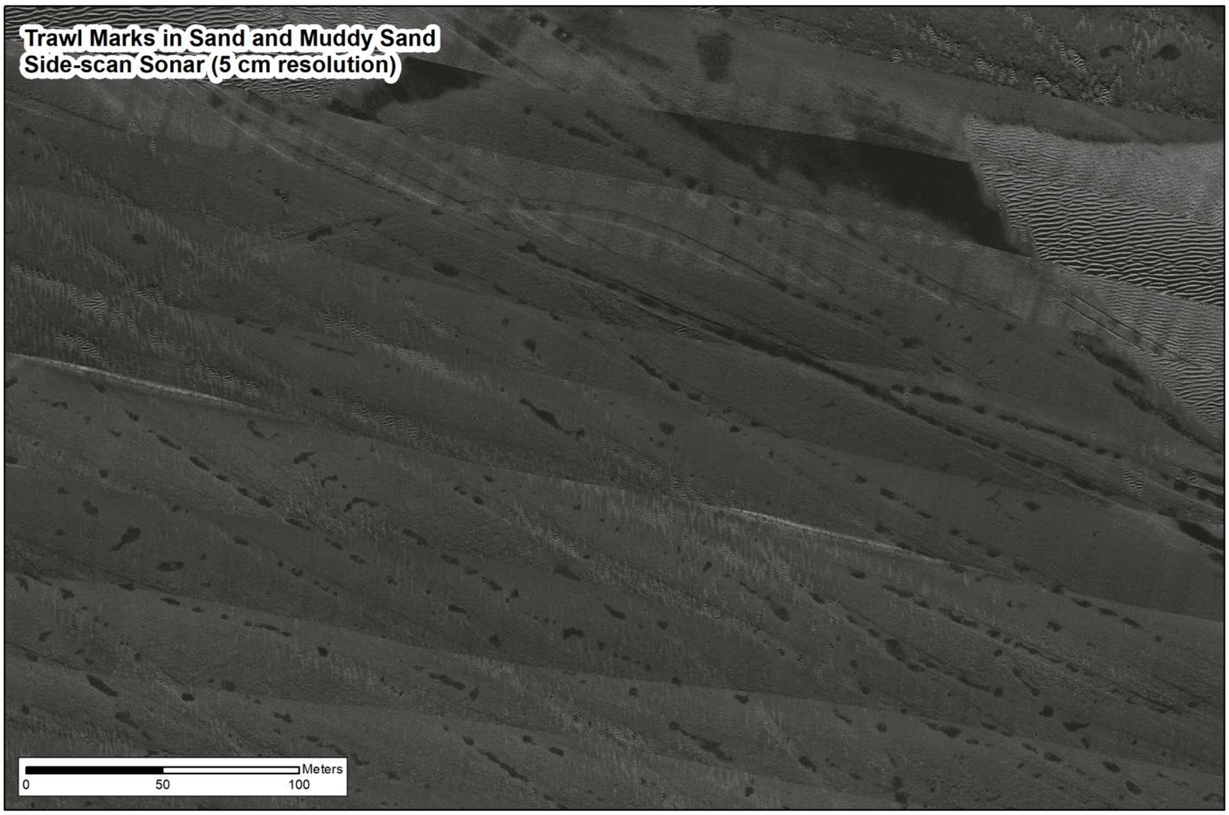



**Figure 17. Side-scan sonar data in an area of Sand and Muddy Sand at the SRW Project area, demonstrating high fishing activity as evidenced by numerous trawl marks across the sediment surface.**

#### 4.5.2.1 Technical Approach – Sediment profile and plan view imaging (SPI/PV)

SPI/PV will be used as the monitoring approach for the soft sediment habitat surveys. The SPI and PV cameras are state-of-the-art monitoring tools that capture benthic ecological functioning within the context of physical factors. The PV system captures high-resolution imagery over several meters of the seafloor, while the SPI system captures the typically unseen, sediment–water interface in the shallow seabed. SPI/PV provides an integrated, multi-dimensional view of the benthic and geological condition of seafloor sediments and will support characterization of the function of the benthic habitat, physical changes, and recovery from physical disturbance following the construction and during operation of SRWF and SRWEC-OCS. Additionally, PV data will be used to characterize surficial geological and biotic (epifaunal) features of hard-bottom areas within the sampling area but will not replace the dedicated novel hard bottom monitoring survey (Section 4.5.1). In addition to characteristics associated with site assessment and Coastal and Marine Ecological Classification Standard (CMECS) descriptors, the SPI/PV system will collect quantitative data on measurements associated with physical and biological changes related to benthic function (bioturbation and utilization of organic material) that might result from construction and operation of SRWF and SRWEC-OCS. The SPI/PV approach documents small-scale physical characteristics of soft sediment environments including the presence, frequency, and size of sediment features such as sand ripples, and the sediment grain size major mode. Organic matter processing by the benthic community (macrofauna and microbial communities) can be evaluated by measuring apparent redox potential depths in the sediment column and depths of bioturbation. Details of these measurements are in Section 4.5.5.2 and are standard tools for assessing the response to disturbance and enrichment (Germano et al. 2011).

The SPI/PV imagery approach is more cost effective and comprehensive than benthic infaunal sampling approaches. Lower operating costs of SPI/PV collection compared to sediment grab sample collection and analysis, allows for greater spatial resolution with a higher density of stations. In addition, SPI/PV imagery documents aspects of the sediment architecture that is entirely missed during benthic infaunal sample collection. This spatial and contextual information, such as oxygen penetration depths (apparent redox potential discontinuity [aRPD] depth), infaunal bioturbation depths, and small-scale grain size vertical layering are critical pieces to assessing the ecological functioning of soft sediment habitats. Specifically, ecological functions related to organic matter processing, secondary production, and the forage-value of the benthic community are of particular importance when assessing impacts of OSW development on soft sediment habitats. Taxonomic analysis of sediment grab samples provides information on the benthic community composition (specifically, which species are there) and infaunal abundances at any given location and time. But, without making substantial inferences to relate presence and species counts to biological activity and further ecological value or function, the sediment grab approach is severely limited in its ability to assess impacts of offshore wind development on soft sediment functioning. Further, given the inherently dynamic and patchy nature of infaunal populations, benthic community count data generally requires extensive replication, substantial transformations for normalization, and overextending inferences to relate species composition to function. SPI/PV imagery provides an effective snapshot of the overall ecological health and condition of the sediments as reflected and integrated over time and space by the continuous activity of the infaunal and epifaunal communities present (Germano et al. 2011). It is this holistic community activity, not necessarily the identity of community members, that requires careful assessment to determine impacts of OSW on soft sediment habitats.

#### 4.5.2.2 Survey Design

The soft bottom habitat monitoring will be conducted using a Before After Gradient (BAG) survey design to determine the spatial scale of potential impacts on benthic habitats and biological communities at the SRWF and along the SRWEC (Section 4.5.2.2). A separate benthic monitoring survey for the SRWEC-NYS will be conducted within NYS waters, which is presented in a separate monitoring plan (INSPIRE Environmental in prep.). At the SRWF, a single benthic survey was conducted in August 2023, to document benthic habitats prior to disturbance. Along the SRWEC-OCS, the benthic habitats are already documented in sufficient detail, and no additional pre-construction benthic monitoring will be conducted (INSPIRE 2021c and INSPIRE 2021e). Subsequent surveys will be conducted in the same seasonal time frame at time intervals of 1, 2, 3, and 5 years after construction (Table 11). Following five years, if the soft sediment habitat has not recovered from the construction activity, Sunrise Wind will confer with NOAA and BOEM to determine the need and extent for any additional years of monitoring.  Sampling will occur during late summer or early fall to capture peak biomass and diversity of benthic organisms in alignment with previous studies (Deepwater Wind South Fork 2020; HDR 2020; NYSERDA 2017; Stokesbury 2013, 2014; LaFrance et al. 2010, 2014). Benthic habitats in the northwest Atlantic are generally stable with little seasonality in the absence of physical disturbance or organic enrichment (Steimle 1982; Reid et al. 1991;

Theroux and Wigley 1998; HDR 2020). Further details on the survey designs associated with the sampling at the base of the WTGs and along the SRWEC are provided in Section 4.5.2.2, respectively.

***Sampling Stations – Foundation Bases (SRWF)***

This survey is designed to investigate the hypothesis that colonization by epifaunal filter feeders on the WTG/OCS-DC foundations will result in changes to the surrounding soft bottom benthic habitat by supplying organic matter to the sediment through filtration, biodeposition, and general deposition of detrital material. Enrichment of soft bottom habitats from the artificial reef effect will lead to fining and higher organic content of surrounding soft bottom habitats, which is expected to be most pronounced down current and weaker up current. It is expected that evidence of sediment enrichment will dissipate with distance from the WTG/OCS-DC foudnations.

The objective for the soft bottom benthic survey at the base of the turbine foundations is to measure benthic community function and physical characteristics over time along a spatial gradient from the foundation. To accomplish this, a BAG survey design will be used for statistical evaluation of the spatial and temporal changes in the benthic habitat (Underwood 1994; Methratta 2020). Data will be collected before and after installation and operation of SRWF at stations oriented along a gradient from select WTG foundations (Figure 16). This BAG design is based on an understanding of the complexities of habitat distribution at SRWF (habitat mapping report results pending), and an analysis of benthic monitoring results from European wind farms and the RODEO study at BIWF (HDR 2020; Coates et al. 2014; Dannheim et al. 2019; Degraer et al. 2018; Lefaible et al. 2019; Lindeboom et al. 2011). The proposed BAG survey design eliminates the need for a reference area, as this design is focused on sampling along a spatial gradient within the area of interest rather than using a control location that may not be truly representative of the conditions within the area of interest (Methratta 2020). This design also allows for the examination of spatial variation within the wind farm and does not assume homogeneity across sampling stations (Methratta 2020).

The same WTG foundations (and the OCS-DC foundation) selected for the novel surfaces survey (Section 4.5.1.2) will be selected for this soft sediment survey (triplicate WTG foundations randomly selected within each pre-defined habitat type stratum). Data on the mean currents near SRWF will be used to establish up current and down current transects extending from each selected WTG foundation. Two belt transects (25 m wide) of SPI/PV stations will be established, one up current and the other down current of the selected turbine locations (Figure 16). Pre-construction transects will begin at the center point of the planned foundation with two stations at equal intervals up to the maximum planned extent of the scour protection area (30 m) and then at intervals of 0-10 m, 15-25 m, 40-50 m, 90-100 m, 190-200 m, and 900 m extending outward from the edge of the scour protection area (i.e., a single station at each of eight distance intervals in two directions from each turbine sampled; Figure 16). Post-construction transects will repeat this design at the same turbines and the same sampling distance intervals. These distances were chosen based on recent research indicating that effects of turbines on the benthic environment occur on a local scale (e.g., Lindeboom et al. 2011; Coates et al. 2014; Degraer et al. 2018; HDR 2019). In the Belgian part of the North Sea, gradient sampling of benthic habitat within wind farms was conducted at close stations and far stations that were up to 500 m away from the turbine foundations (Lefaible et al. 2019). However, recent data from Belgium indicates some level of enrichment has been recorded between 200-250 m from the turbines after eight years (personal comm. S. Degraer, 4/29/2020). If following the five years of monitoring at SRWF, data suggests adverse impacts attributable to organic matter over-enrichment in the sediments with signs of impairment (e.g., diffusional aRPD depths, low infaunal successional stage), Surnise Wind will confer with NOAA and BOEM to determine the need and extent for additional years of monitoring.

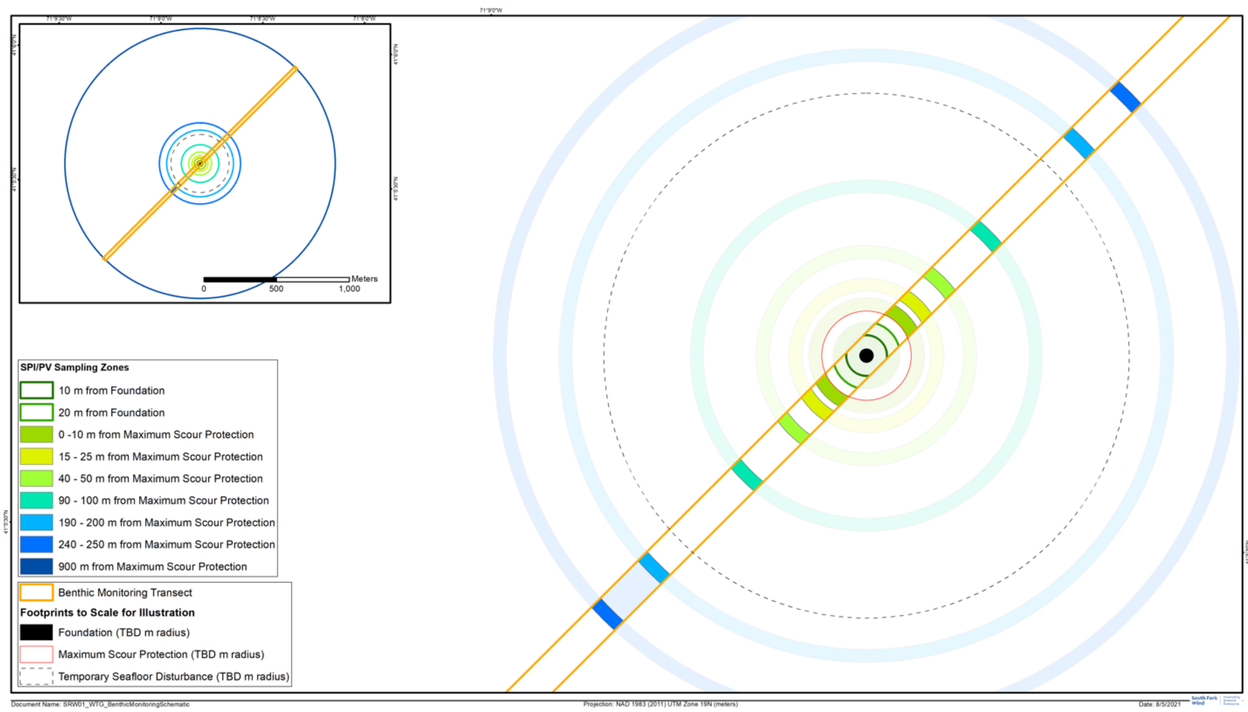



**Figure 18. Proposed soft bottom benthic survey sampling design at a wind turbine foundation, the exact radius for scour protection is subject to change. See Section 1.2.2.1 for more details.**

***Sampling Stations – Export Cable (SRWEC-OCS)***

The objective for the soft bottom benthic survey along the SRWEC-OCS is to examine the effects of installation and operation of an export cable on the benthic habitat over time and along a spatial gradient with distance from the cable centerline. Note that monitoring epifaunal growth on the cable protection material along the SRWEC-OCS will be conducted with the novel hard bottom component of this program (see section 4.5.1). The primary effect of cable installation in the corridor is physical disturbance of the sediment with sediment resuspension and temporary loss of infauna. Effects of installation and operation of the cable are expected to be roughly equivalent along the length of the cable within similar benthic habitat types and within areas that experience similar levels of fishing activity. Some effects associated with the installation may be altered by dredging or trawling activities as well as bottom sediment transport from tides and waves. The sampling design is intended to estimate effects along a spatial gradient away from the cable and will not estimate mean changes along the entire SRWEC route. Any potential impacts of the cable on soft bottom habitats are expected to decrease over time since installation and with distance from the SRWEC-OCS centerline.

To accomplish the goals of this survey, SPI/PV data will be collected after installation and during operation of the SRWEC at selected locations, using a BAG design, like that proposed for the soft sediments around the turbine foundations (Section 4.5.2.2) (Underwood 1994; Methratta 2020). The benthic habitats along the SRWEC are already documented in sufficient detail (INSPIRE 2021c and INSPIRE 2021e), and no additional pre-construction benthic monitoring will be conducted. Details describing the BAG design approach and its value in evaluating potential temporal and spatial changes following construction are provided in the section above (Section 4.5.2.2).

The soft bottom survey sample design will focus on sampling at representative sections of the SRWEC-OCS based on mapped habitat types as informed by the habitat mapping report as well as reported fishing activity using VMS data (2015-2016 or the most recent available data). Based on benthic habitat mapping results, it is expected that there will be a maximum of three predominant benthic habitat types along the route (Figure 14; INSPIRE 2021e). Fishing activity along the SRWEC will be grouped into two broad categories: high and low density of fishing activity (Figure 17). Sampling strata will be selected to include, to the extent possible, each benthic habitat type within each category of fishing activity (3 habitat types x 2 levels of fishing). At triplicate locations (each approximately 1 km apart) within each sampling stratum, a 25 m wide belt transect will be laid perpendicular to the cable route (three replicate transects per habitat x fishing activity stratum) (Figure 17). Along each transect, a total of 16 stations will be sampled, at each station triplicate SPI/PV images will be collected and analyzed. Near the centerline these stations will be distributed roughly 10 m apart and the distance intervals between stations will increase with distance from the centerline (Figure 17). The selected sampling locations and sampling intervals relative to the cable will remain fixed for the duration of the surveys. More details of habitat distribution are be provided in the habitat mapping report (INSPIRE 2021e).

Sampling along the SRWEC will occur within the first calendar year post installation (Y0) and at year 1 and year 2 during operation. After year 2, if benthic function measured with SPI/PV is indistinguishable from baseline conditions, and no difference is observed with distance from cable centerline, no further monitoring will occur. Alternatively, if benthic function is impaired (aRPD and or successional stage) and differences along the SRWEC-OCS persist compared with baseline and with distance from cable centerline, monitoring will continue at defined intervals until the benthos resemble baseline conditions or are no longer impaired (up to a maximum of five years of monitoring). If after five years, data suggests continues signs of impairment or lack of benthic recovery, Sunrise Wind will confer with NOAA and BOEM to determine the need and extent for additional years of monitoring. Specific metrics that will be obtained from SPI/PV to assess benthic function are described in more detail in Section 4.5.5.2. An additional benthic survey of the SRWEC-NYS will be conducted within NYS waters, which is presented in a separate monitoring plan (INSPIRE Environmental 2022).

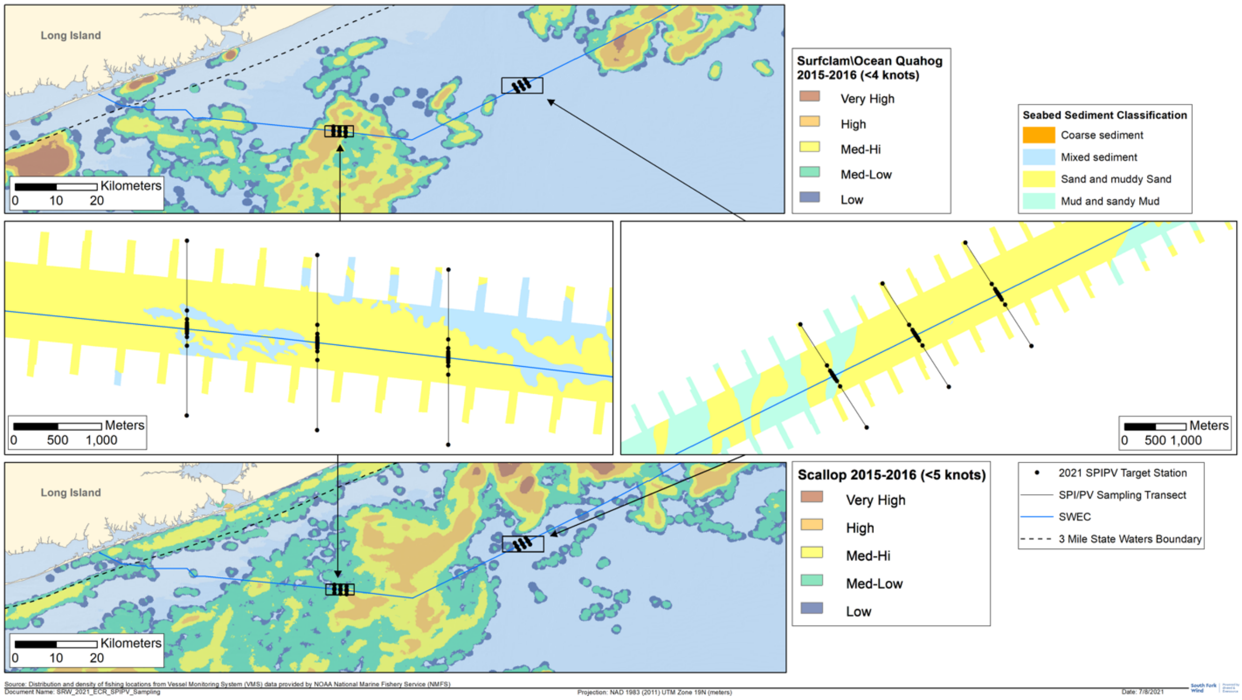



**Figure 19. Proposed soft bottom benthic survey sampling design along the SRWEC with black dots indicating SPI/PV stations situated along triplicate transects perpendicular to the SRWEC within an area of high bivalve fishing intensity and an area of low bivalve fishing intensity. See Section 4.4.2.2 for more details.**

### 4.5.3 Overview of Field Methods

The Field Lead Scientist will ensure that data are collected according to the established protocols and that all forms, checklists, field measurements, and instrument calibrations are recorded correctly during field sampling. For-hire vessels will be selected based on criteria including survey suitability, experience, safety record, knowledge of the area, and cost. All survey activities will be conducted with strict adherence to Orsted health and safety protocols to reduce the potential for environmental damage or injury.

Accurate vessel heading and differential position accuracy within a meter will be achieved using a V102 Hemisphere vector antenna (or equivalent) on the vessel. During mobilization, the navigator will conduct a positional accuracy check on the antenna by placing the antenna on a known GPS point and ensuring the antenna's position falls within a meter of the known coordinates. During operations, HYPACK Ultralite software will receive positional data from the antenna in order to direct the vessel to sampling stations.

#### 4.5.3.1 Video Collection

High resolution video and still images will be acquired at targeted hard bottom areas and turbine foundations with a compact ROV comparable to a Seatronics Valor ROV (https://geo-matching.com/rovs-remotely-operated-underwater-vehicles/valor). The positioning components of the ROV would include a surface differential positioning system, an Ultra Short Baseline (USBL), as well as ROV-mounted motion and depth sensors. The USBL transceiver will communicate with geophysical beacons mounted onto the ROV allowing for the vehicle's depth and angle in relation to the transceiver to be known. Adding in the motion and depth sensors on the ROV, all this information will be connected into the ROV navigation software simultaneously tracking both the vessel's position and the ROV's position accurately.

In addition to accurate ROV positioning components, the vehicle will be equipped with powerful thrusters in both horizontal and vertical directions, creating confidence for operating in areas with higher currents. The vehicle will also be equipped with several pilot aids including, auto heading, auto depth, and auto hover. Using these tools, the ROV cameras can focus on any specifically selected habitat features during the survey allowing for better visual observations by scientists.

The ROV will supply live video feed to the surface using high definition (HD) video and ultra-high definition (UHD) still cameras. One pair of cameras will be downward facing to observe and capture high resolution images of seafloor surface conditions while another pair will face forward to collect data on vertical surfaces and avoid collisions. Details on high lumen light-emitting diode (LED) lights will be mounted onto the ROV frame to increase visibility and aid in species identification. With sufficient lighting the images transferred to the surface will be clear, allowing for real time observations and adaptive sampling. The recorded video will be transferred to the surface through the ROV's umbilical and recorded using a Digital SubSea Edge digital video recorder (DVR) video inspection system (or equivalent). The system will provide simultaneous recording of both high-definition cameras as well as the ability to add specific transect data overlays during operations. The data overlay will include ROV position, heading, depth, date and time as well as field observations.

High resolution underwater imagery can provide preliminary information about the identity of encrusting fauna, including non-native organisms (Figure 18). However, because some species, such as *Didemnum vexillum,* require microscopic investigation to accurately identify, samples will be collected to confirm species identified in the still images. The ROV will contain a manipulator arm and basket to collect voucher specimens of encrusting species to ensure accurate identification. The option to collect a specimen sample for identification, will be made by the chief scientist, who will be familiar with the potential non-native organisms in the area. The chief scientist will consult the National Estuarine and Marine Exotic

Species Information System, a database maintained by the Smithsonian Environmental Research Center, when determining the need for a voucher specimen.

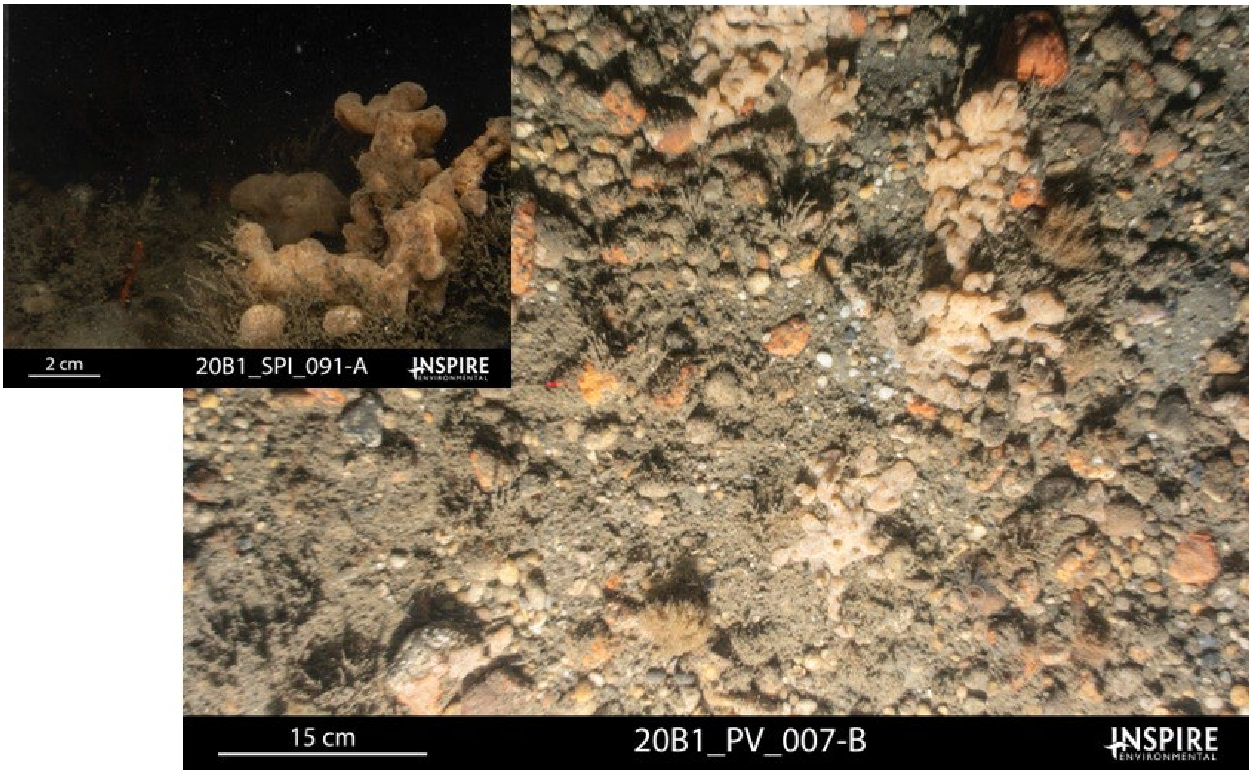



**Figure 20. Examples of high-resolution SPI and PV imagery of an encrusting organism that is potentially D. vexillum, a non-native colonial tunicate; these images were not collected within the SRW Project area**

### 4.5.3.2 Sediment Profile and Plan View Image Collection

By combining SPI and PV paired imagery, the SPI/PV sampling approach allows for the assessment of benthic functioning over a spatial scale of several square meters at each station. PV images provide a larger field-of-view than SPI images, or sediment grab samples, and provide valuable information about the landscape ecology and sediment topography in the area where the pinpoint "optical core" of the SPI is taken. Distinct surface sediment layers, textures, or structures detected in SPI can be interpreted considering the larger context of surface sediment features captured in the PV images. The scale information provided by the underwater lasers allows for accurate organismal density counts and/or percent cover of attached epifaunal colonies, sediment burrow openings, larger macrofauna and/or fish which are missed in the SPI cross section. A field of view is calculated for each PV image and measurements are taken of specific parameters outlined in the survey workplan.

The SPI/PV surveys associated with the soft bottom monitoring components (at the SRWF and along the SRWEC) will be conducted from research vessel(s) with scientists onboard to collect images utilizing a SPI/PV camera system. Collecting seafloor imagery does not require disturbance of the seafloor or collection of physical samples. Once the vessel is within a five-meter radius of the target location, the SPI/PV camera system will be deployed to the seafloor. As soon as the camera system contacts the seafloor the navigator will record the time and position of the camera electronically in HYPACK as well as the written field log. This process will be repeated for the targeted number of SPI/PV replicates per sampling station; three SPI/PV replicate pairs will be collected and analyzed at each station. Results from the targeted number of replicates with suitable quality images will be aggregated to provide a summary value for each metric by station (mean, median, or maximum depending on the metric, see Section 4.5.5.2). After all stations have been surveyed the navigator will export all recorded positional data into a Microsoft Excel© spreadsheet. The Excel sheet will include the station name, replicate number, date, time, depth, and position of every SPI/PV replicate.

Acquisition and quality assurance/quality control of high-resolution SPI images will be accomplished using a Nikon D7100 or D7200 digital single-lens reflex (DSLR) camera with a 24.1-megapixel image sensor mounted inside an Ocean Imaging Model 3731 pressure housing system. An Ocean Imaging Model DSC PV underwater camera system, using a Nikon D7100 or D7200 DSLR, will be attached to the SPI camera frame and used to collect PV photographs of the seafloor surface at the location where the SPI images are collected. The PV camera housing will be outfitted with two Ocean Imaging Systems Model 400 37 scaling lasers. Co-located SPI and PV images will be collected during each “drop” of the system. The ability of the PV system to collect usable images is dependent on the clarity of the water column, while the ability of the SPI system to collect usable images is dependent upon the penetration of the prism.

### 4.5.4 Data Entry and Reporting

Data management and traceability is integral to analysis and accurate reporting. The surveys will follow a rigorous system to inspect data throughout all stages of collection and analysis to provide a high level of confidence in the data being reported. Following data entry, all digital logs will be proofread using the original handwritten field log. This review will be performed by someone other than the data entry specialist.

SPI and PV image QC checks include comparison of date/time stamps embedded in the metadata of every SPI and PV image to the field log and navigation times to ensure that all images are assigned to the correct stations and replicates. Computer-aided analysis of SPI/PV images will be conducted to provide a set of standard measurements to allow comparisons among different locations and surveys. Measured parameters for SPI and PV images will be recorded in Microsoft Excel© spreadsheets. These data will be subsequently checked by senior scientists as an independent quality assurance/quality control review before final interpretation. Spatial distributions of SPI/PV parameters will be mapped using ArcGIS.

During field operations, daily progress reports will be reported through whatever means are available (email, text, phone). Upon completion of the survey all analyzed images as well as a data report with visualizations will be provided. Options for optimal data sharing including images, video, and analysis results will be considered and determined at a future date. Possible delivery methods include an Azure database, a secure fileshare, and/or an interactive popup map. Interactive popup maps allow users to explore still and video imagery concurrent with geophysical data, project-specific boundaries and locations (e.g., WTGs, IAC), and interpretative data obtained from the imagery (e.g., presence of non-native taxa).

Sunrise Wind is working to create a data access process and protocols that are transparent and long-lasting. Through engagement with on-going discussions with ROSA, data access and regional data sharing guidance are being developed. Data will also be made available in accordance with Section 12.07 of the OREC Agreement with NYSERDA.

### 4.5.5 Data Analysis

#### 4.5.5.1 Hard Bottom Video Imagery

Video imagery will be reviewed during acquisition and observations will be logged to document species and geological features for each video transect. An experienced video analyst will view logs, photos and videos and confirm or add annotations. The video system will have the capability of taking still images from all the input video signals to document features of interest.

For the turbine foundation and cable protection surveys (Section 4.5.1), the focus of the analysis will be biological features (e.g., percent cover of encrusting epifauna), identifying any non-native organisms, identifying the key epifauna inhabiting the novel substrate, and quantifying the biomass of the dominant members of the epifaunal communities. Biomass estimation will be achieved through photogrammetry methodology as described in Section 4.5.1.1. Video from the ROV will provide quantitative details of habitat characteristics and quality, including categorical levels for the presence of fish and decapods, presence of refuge and surrounding substrata (sediment type), and the percent cover of emergent fauna.

#### 4.5.5.2 Soft Bottom Sediment Profile and Plan View Imagery

Seafloor geological and biogenic substrates captured in SPI/PV imagery will be described using the Coastal and Marine Ecological Standard (CMECS; FGDC 2012), in particular the Substrate and Biotic CMECS metrics. Where applicable, measurements of gravel sizes (predominant, minimum, maximum) will be collected from the PV imagery. The presence of sensitive taxa (e.g., slow growing species) and ecologically valuable taxe (e.g., biogenic-structure forming taxa such as emergent fauna) in the SPI and PV imagery will be documented. Replicate images taken at each station will be summarized to a single value per analytical metric per station (e.g., predominant CMECS Substrate Subgroup, maximum infaunal successional stage, maximum and median feeding void depth, and mean aRPD depths). Measurement and interpretation of these indicators are presented in previous benthic assessment reports for SRW (INSPIRE Environmental 2021c, 2021d). Additionally, the benthic macrohabitat (*sensu* Greene et al. 2007) types gleaned from the SPI/PV imagery of the Project area will be described. Differences in abiotic and biotic composition of macrohabitats will be compared between pre- and post-construction surveys. In particular, species composition and total percent cover of attached fauna on the scour mat and changes in benthic community with distance from the scour protection layer will be evaluated.

SPI/PV provides a more holistic assessment of benthic functioning that captures the relationship between infauna and sediments compared with infaunal abundance assessments using sediment grab sampling (Germano et al. 2011; see Section 4.4.2.1). Although infaunal abundance and density measurements are not generated from SPI/PV analysis, other metrics that will be collected as part of the benthic biological assessment include lists of infaunal and epifaunal species, the percent cover of attached biota visible in PV images, presence of sensitive and non-native species, and the infaunal successional stage (Pearson and Rosenberg 1978; Rhoads and Germano 1982; Rhoads and Boyer 1982).

SPI/PV is an effective tool in assessing changes in benthic function of soft sediments in response to offshore wind development. Ecologically important benthic functions of soft sediment communities on the outer continental shelf of the northwest Atlantic include the provision of biogenic structures as habitat, facilitating organic matter processing (carbon and nutrient cycling), and the provision of food to upper trophic levels (secondary production). These ecosystem functions are detectable using data obtained from SPI/PV imagery.

SPI/PV is an effective means to assess the presence and relative distribution of biogenic structure forming fauna in soft sediment environments. Common emergent fauna in this environment includes cerianthids (burrowing anemone) and corymorpha (soft sediment hydroids). Other biogenic structure forming organisms in this environmental context include podocerid amphipods and sea whips (although, these typically occur on coarser sediments). Biogenic structure forming organisms are often difficult to capture using traditional sediment grab sampling as they are able to effectively evade collection. Also, sediment grab collection is destructive sampling, which should be avoided in areas with sensitive benthic organisms. High resolution SPI and plan view imaging can non-invasively identify and quantify these emergent and structure-forming fauna as demonstrated in the baseline benthic characterization studies at the Sunrise Wind Lease Area and planned export cable route (Appendix M1 to the COP). The presence and densities of these emergent and structure-forming fauna can be obtained using the SPI/PV approach, and any changes in spatial distributions in response to offshore wind development can be detected through this proposed monitoring survey design.

SPI/PV is an effective means to assess the degree of, and changes to, organic matter processing and cycling in soft sediments. Benthic communities in soft sediments serve an important role in facilitating organic matter processing and cycling. The ability of soft sediment communities to process organic matter delivered from the water column is highly dependent on the benthic community activity, specifically bioturbation, bioirrigation, and sediment mixing by shallow and deep-burrowing organisms. These infaunal activities deliver oxygenated water to the sediment column, facilitating aerobic respiration of organic matter. The degree of organic matter processing can be assessed by measuring the depth of oxygen penetration into the sediment column, which can be done through SPI analysis (apparent redox discontinuity [aRPD] depth). Other indicators of benthic organic matter processing include infaunal succession stage, feeding voids, methane, and presence of *Beggiatoa*. Of these, the successional stage and aRPD depth have the strongest predictive power for benthic functional response to physical disturbance and organic enrichment (Germano et al. 2011) and will be the key metrics used during the soft bottom surveys. Because the epifaunal growth on the novel wind turbine structures is likely to increase the delivery of organic matter to the sediments below, organic matter processing and sediment respiration is likely to increase in these adjacent soft sediments, causing a decrease in the depth of oxygen penetration into the sediment column (aRPD depth). SPI is an effective approach in assessing this change in organic matter processing with distance from the turbine as SPI analysis can accurately assess and detect changes in aRPD depths and bioturbation depths.

Soft sediment benthic communities can be important prey to upper trophic levels. Although SPI/PV imagery does not provide estimates of biomass or detailed taxonomic identification, these metrics, which can be obtained through sediment grab sampling, do not necessarily relate to the value of any given benthic community as prey resource. Regional and interannual variability in biomass and species composition is not likely to reflect changes in prey availability or value in the ecosystem. This natural variability is not likely to be ecologically meaningful. SPI/PV imagery can provide information on the level of succession of benthic community present after a physical (or chemical) disturbance.

Infaunal successional stage describes the biological status of a benthic community and is useful in quantifying the biological recovery after a disturbance. Organism–sediment interactions in fine-grained sediments follow a predictable sequence of development after a major disturbance (Pearson and Rosenberg 1978; Rhoads and Germano 1982; Rhoads and Boyer 1982). This continuum is divided subjectively into four stages: Stage 0, indicative of a sediment column that is largely devoid of macrofauna, occurs immediately following a physical disturbance or in close proximity to an organic enrichment source; Stage 1 is the initial recolonizing by tiny, densely populated polychaete assemblages; Stage 2 is the start of the transition to head-down deposit feeders; and Stage 3 is the mature, equilibrium community of deep-dwelling, head-down deposit feeders. The presence of feeding voids in the sediment column is evidence of an active Stage 3 community. If the level of organic enrichment exceeds the capacity of the benthic community to consume the deposits the successional stage will revert to Stage 1, aRPD depths will be visible but very shallow, and eventually methane and *Beggiatoa* will appear as diagnostic conditions of organic over enrichment (Germano et al. 2011).

The aRPD depth is a measure of the depth within the sediment column where dissolved oxygen concentrations are depleted. This depth is dependent on several factors but is largely determined by the amount of organic matter load to the sediments (organic matter decomposition consumes oxygen) and the amount of bioturbation by macrofaunal organisms (bioturbation mixes oxygen from surface waters deep into the sediments). With SPI analysis, the aRPD depth is described as “apparent” because of the potential discrepancy between where the sediment color shifts and the complete depletion of dissolved oxygen concentration occurs. In sandy sediments that have very low sediment oxygen demand (SOD), the sediment may lack a visibly reduced layer even if a redox potential discontinuity (RPD) is present. Because the determination of the aRPD requires distinction of optical contrast between oxidized and reduced particles, it is difficult, if not impossible, to determine the depth of the aRPD in well-sorted sands of any size that have little to no silt or organic matter in them. When using SPI technology on sand bottoms, estimates of the mean aRPD depths are often indeterminate with conventional white light photography. It is expected that as sediments surrounding the WTGs will increase in organic enrichment and fines, the aRPD will become more ‘apparent’ and provide a quantitative measure of enrichment. The aRPD has been shown to be a sensitive and specific indicator of hypoxic conditions experienced over the preceding 1 day to 4 weeks (Shumchenia and King 2010), and to be correlated to concurrent *in situ* dissolved oxygen concentrations (Sturdivant et al. 2012).

### 4.5.6 Statistical Analyses

The planned statistical analyses are summarized by survey type in Table 12.

For the novel hard bottom datasets (triplicate WTG foundations randomly selected within each of the pre-defined habitat types), the influence of depth and habitat type on benthic colonization will be explored using the 90 percent confidence interval for select metrics gleaned from the video footage (Table 12). The biological features obtained from the video footage will focus on characteristics that reflect habitat quality including the relative abundance of native versus non-native taxa present, and the biomass of epifauna. Growth of macrobiotic cover will be summarized for each sampling frame from observations taken with the ROV video. The metrics that will be assessed for each sampling frame include mean macrobiotic cover and relative abundance of native vs. non-native species and species composition (identified to the LPIL). Additional exploratory graphical displays will be used to visualize and describe spatial and temporal patterns in the data.

For the soft bottom datasets (BAG design at the base of the turbines and at selected locations along the SRWEC), data analysis will include exploratory multivariate approaches (e.g., nMDS) to identify patterns among responses (SPI/PV metrics, e.g., aRPD, successional stage, feeding voids, presence of methane or *Beggiatoa*) and predictors (e.g., quantitative or categorical epifaunal/epifloral cover estimates on the turbine foundations; and distance from the turbine). Covariates in the model for the turbine foundation dataset will include habitat type (categorical) and direction (categorical); variability among turbines will provide site-wide random error. For individual metrics that are consistently measured across stations (e.g., aRPD), parametric or non-parametric regression (e.g., generalized modeling such as GLM or GAM; or regression trees) will be applied if the data prove to be sufficient and appropriate for these tools. Additionally, graphical methods and descriptive statistics will be used to assess changes in the SPI/PV metrics over time and as a function of distance and direction from the turbines. These graphical techniques may help to elucidate the spatial scale at which the greatest changes in benthic habitat quality occur.

**Table 12. Summary of Planned Statistical Analyses for the Benthic Monitoring Surveys at SRWF**

| Survey | Report Section | Area | Design Type | Design Overview | Number of Replicates | Expected number of structures or SPI/PV stations per survey year | Design details | Metrics of Interest | Research Question | Post-Construction Statistical Methods |
|---|---|---|---|---|---|---|---|---|---|---|
| Novel Surfaces Surveys | 4.5.1.2 | SRWF | SS | WTG foundations; random samples stratified by habitat type; single season. OCS-DC foundation will also be sampled | **3 replicate WTGs per stratum** | OCS-DC jacket + [3(to4) habitats x 3 WTGs] = **~10-13 structures** | **Sampling frame =** turbines with mobile sediment classes **Observational unit** = imaged quadrat (at systematically sampled intervals within frame) **Response variable** = macrobiotic cover, relative abundance of native vs non-native. **Error variance** = among samples within same area | **ROV**: cover (macrobiota, relative abundance of native vs. invasive). | What is the magnitude of difference in mean response with elevation (WTG foundation) and across habitat type, at each survey event? | Estimate 90% CI on the difference of means for discrete depth intervals and WTG's blocked by habitat type, at each survey event. Compare the temporal profiles between depths and WTGs by habitat type |
| | | SRWEC-OCS | SS | Cable Protection; random samples stratified by habitat type; single season. | **3 replicate cable protection areas per stratum** | 3(to4) habitats x 3 Cable protection areas = **~9-12 structures** | **Sampling frame =** cable protection areas with mobile sediment classes **Observational unit** = imaged quadrat (at systematically sampled intervals within frame) **Response variable** = macrobiotic cover, relative abundance of native vs non-native. **Error variance** = among samples within same area | **ROV**: cover (macrobiota, relative abundance of native vs. invasive). | What is the magnitude of difference in mean response with habitat type, at each survey event? | Estimate 90% CI on the difference of means for cable protection blocked by habitat type, at each survey event. Compare the temporal profiles between cable protection areas by habitat type |
| Soft Bottom Surveys | 4.5.2.2 | SRWF | BAG | Impact only (no reference sites); stns at distances ranging from ~10 m to ~900 m from turbines; 2 directions from each turbine along prevailing current; single season | **3 replicates WTGs per stratum** | 10(to 13 structures) x 2 transects x 8 stations = **160 to 208 SPI/PV stations** | **Sampling frame** = turbines with mobile sediment classes up/down current **Observational unit** = SPI/PV station (turbines randomized first survey event, then fixed throughout study; stations randomized every survey; replicate images are subsamples) **Response variable** = mean or max per station depending on metric. **Error variance** = among stations at the same distance-direction (turbines provide replication) | **SPI**: aRPD, Successional Stage, penetration, methane, *Beggiatoa*<br><br>**PV**: cover (macrobiota, shells, cobble), presence/absence of sensitive or invasive species | What is the pattern of temporal change in metrics relative to direction and/or distance from turbine? | Fit a parametric generalized model (e.g. GLM, GLMM or GAM) or non-parametric regression tree that best describes the data. Compare the temporal profiles across spatial gradients.<br><br>Calculate similarity between stations; graphically depict relationships between stations from different years, directions, or distances with nMDS. |
| | | SRWEC- | BAG | Impact only (no | **3 replicate** | 3 habitat | **Sampling frame** = soft bottom | **SPI**: aRPD, | What is the | Fit a parametric |

**Survey Methods**

| Survey | Report Section | Area | Design Type | Design Overview | Number of Replicates | Expected number of structures or SPI/PV stations per survey year | Design details | Metrics of Interest | Research Question | Post-Construction Statistical Methods |
|---|---|---|---|---|---|---|---|---|---|---|
| | | OCS | | reference sites); stns at distances ranging from ~5 m to ~1 km from cable; ≥ 3 transects within each habitat stratum. | **transects per habitat x fishing activity stratum** | strata x 2 fishing activity levels x 3 transect replicates x 16 stations along each replicate transect = **288 SPI/PV stations** | areas of SRWEC-OCS<br>**Observational unit** = SPI/PV station (transects randomized first survey event, then fixed throughout study; stations randomized every survey; replicate images are subsamples)<br>**Response variable** = mean or max per station depending on metric.<br>**Error variance** = among stations at the same distance-direction (transects provide replication) | Successional Stage, penetration methane, *Beggiatoa*<br><br>**PV**: cover (macrobiota, shells, cobble), presence/absence of sensitive or invasive species, | pattern of temporal change in metrics relative to distance from export cable? | generalized model (e.g. GLM, GLMM or GAM) or non-parametric regression tree that best describes the data. Compare the temporal profiles across spatial gradients.<br><br>Calculate similarity between stations; graphically depict relationships between stations from different years, directions, or distances with nMDS. |

Definitions:
BAG = before after gradient
90% CI = 90% confidence interval
nMDS = non-parametric Multidimensional Scaling
SS = Systematic (random) sampling

# 5.0 REFERENCES

Anderson, J.M. 2018. Perception & Use of Magnetic Field Information in Navigation Behaviors in Elasmobranch Fishes (Doctoral dissertation, University of Hawai'i at Mānoa).

Atlantic Coastal Cooperative Statistics Program (ACCSP). 2020a. Data Warehouse, Non-Confidential Commercial Landings (2009-2018), Summary; using Data Warehouse [online application], Arlington, VA: Available at https://www.accsp.org; Public Data Warehouse; accessed (February 2020).

Atlantic Coastal Cooperative Statistics Program (ACCSP). 2020b. Commercial landing data processed by Atlantic Coastal Cooperative Statistics Program, provided to INSPIRE Environmental, April 2020.

Atlantic Coastal Cooperative Statistics Program (ACCSP). 2020c. Commercial landing data processed by Atlantic Coastal Cooperative Statistics Program, provided to INSPIRE Environmental, May 2020.

Atlantic States Marine Fisheries Commission (ASMFC). 2019. 2019 Horseshoe crab benchmark stock assessment and peer review report. May 1, 2019. 316 pp.

Bethoney, N.D. and K.D.E. Stokesbury. 2018. Methods for Image-based Surveys of Benthic Macroinvertebrates and Their Habitat Exemplified by the Drop Camera Survey for the Atlantic Sea Scallop. J Vis Exp. 2018; (137): 57493.

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. U.S. Fish Wildl. Serv., Fish. Bull. 74: 1-577.

Bonzek, C.F., J. Gartland, R.A. Johnson, and J.D. Lange Jr. 2008. NEAMAP Near Shore Trawl Survey: Peer Review Documentation. A report to the Atlantic States Marine Fisheries Commission.

Bonzek, C.F., J. Gartland, D.J. Gauthier, and R.J. Latour. 2017 Northeast Area Monitoring and Assessment Program (NEAMAP) Data collection and analysis in support of single and multispecies stock assessments in the Mid‐Atlantic: Northeast Area Monitoring and Assessment Program Near Shore Trawl Survey. Virginia Institute of Marine Science, College of William and Mary. https://doi.org/10.25773/ 7206-KM61.

Bopp, J.J., M. Sclafani, M.G. Frisk, K. McKown, C. Ziegler-Fede, D.R. Smith, R.M. Cerrato. 2021. Telemetry reveals migratory drivers and disparate space use across seasons and age-groups in American horseshoe crabs. Ecosphere 12(10): e03811

Bouma S. and W. Lengkeek. 2012. Benthic communities on hard substrates of the offshore wind farm Egmond aan Zee (OWEZ). Bureau Waardenburg bv. Consultants for environment & ecology, Culemborg, The Netherlands, 84 pp.

Brousseau, L.J., Sclafani, M., Smith, D.R., and Carter, D.B. 2004. Acoustic-tracking and radio-tracking of horseshoe crabs to assess spawning behavior and subtidal habitat use in Delaware Bay, North American Journal of Fisheries Management, 24: 1376-1384.

Buckel, J.A., D.O. Conover, N.D. Steinberg, and K.A. McKown. 1999. Impact of age-0 bluefish (*Pomatomus saltatrix*) predation on age-0 fishes in the Hudson River estuary: evidence for density dependent loss of juvenile striped bass (*Morone saxatilis*). Canadian Journal of Fisheries and Aquatic Science, 56:275-287.

Bureau of Ocean Energy Management (BOEM). 2019. Guidelines for providing information on fisheries for renewable energy development on the Atlantic outer continental shelf pursuant to 30 CFR Part 585. Office of Renewable Energy Programs. June 2019.

Burnett, J., L. O'Brien, R.K. Mayo, J.A. Darde, and M. Bohan. 1989. Finfish maturity sampling and classification schemes used during Northeast Fisheries Science Center Bottom Trawl Surveys, 1963-89. NOAA technical Memorandum MNFS-F/NEC-76. 16 pp.

Cadrin, S.X., A. Barkley, G. DeCelles, and S. Follet. 2013a. An industry-based survey for yellowtail flounder in southern New England. Final Report Submitted to Commercial Fisheries Research Foundation. NOAA Award Numbers: NA09NMF4720414/NA10NMF4720285. 44 pp.

Cadrin, S.X., G. DeCelles, S. Roman, E. Barlow, N. Pearsall, and J. Jordan. 2013b. An industry-based survey for winter flounder in southern New England. Final Report Submitted to Commercial Fisheries Research Foundation. NOAA Award Numbers: NA09NMF4720414/NA10NMF4720285. 47 pp.

Cadrin, S.X., D.R. Zemeckis, M.J. Dean, and J. Cournane. 2020. Chapter 7. Applied Markers. In: An Interdisciplinary Assessment of Atlantic Cod (*Gadus morhua*) Stock Structure in the Western Atlantic Ocean (McBride, R.S., and R.K. Smedbol, eds.). NOAA Technical Memorandum (in press).

Carey, D.A., D.H. Wilber, L.B. Read, M.L. Guarinello, M. Griffin, and S. Sabo. 2020. Effects of the Block Island Wind Farm on coastal resources: lessons learned. Oceanography, 33(4): 36-47.

Chipps, S.R. and J.E. Garvey. 2006. Chapter 11: Assessment of Food Habits and Feeding Patterns. In: Analysis and Interpretation of Freshwater Fisheries Data (eds: C.S. Guy and M.L. Brown). American Fisheries Society. Bethesda, MD.

CoastalVision. 2013. Deepwater Wind Block Island Wind Farm Revised Draft Ventless Trap Survey Plan.

Coates, D.A., Y. Deschutter, M. Vincx, and J. Vanaverbeke. 2014. Enrichment and shifts in macrobenthic assemblages in an offshore wind farm area in the Belgian part of the North Sea. Marine Environmental Research, 95: 1–12.

Cohen, J. 1992. A power primer. Psychological Bulletin. 112: 155-159.

Collette, B.B. and G. Klein-MacPhee. 2002. Bigelow and Schroeder's Fishes of the Gulf of Maine. Third Edition. Smithsonian Institution Press. Washington D.C. 748 pp.

Collie, J. and J. King. 2016. Spatial and temporal distributions of lobsters and crabs in the Rhode Island Massachusetts wind energy area. OCS Study BOEM 2016-073. 58 pp.

Dannheim, J., L. Bergström, S.N.R. Birchenough, R. Brzana, A.R. Boon, J.W.P. Coolen, J. Dauvin, I. De Mesel, J. Derweduwen, A.B. Gill, Z.L. Hutchison, A.C. Jackson, U. Janas, G. Martin, A. Raoux, J.Reubens, L. Rostin, J. Vanaverbeke, T.A. Wilding, D. Wilhelmsson, and S. Degraer. 2019.

Benthic effects of offshore renewables: identification of knowledge gaps and urgently needed research. ICES Journal of Marine Science 77: 1092–1108.

De Mesel, I., F. Kerckhof, A. Norro, B. Rumes, and S. Degraer. 2015. Succession and seasonal dynamics of the epifauna community on offshore wind farm foundations and their role as stepping stones for non-indigenous species. Hydrobiologia, 756(37):37–50.

Dean, M., W.S. Hoffman, D.R. Zemeckis, and M.P. Armstrong. 2014. Fine-scale and gender-based patterns in behavior of Atlantic cod (*Gadus morhua*) on a spawning ground in the western Gulf of Maine. ICES Journal of Marine Science, 71(6): 1474-1489.

Dean, M., G. DeCelles, D. Zemeckis, and T. Ames. 2020. Chapter 2: Early Life History: Spawning to Settlement. In: An Interdisciplinary Review of Atlantic Cod (*Gadus morhua*) stock structure in the western North Atlantic Ocean (McBride, R.S., and R.K. Smedbol, eds.). NOAA Technical Memorandum. U.S. Department of Commerce. Woods Hole, MA.

Deepwater Wind South Fork 2020. South Fork Wind Research and Monitoring Plan. September 2020. Prepared by South Fork Wind, LLC and INSPIRE Environmental. 68pp.

Degraer, S., Brabant, R., Rumes, B., and Vigin, L. 2018. Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: Assessing and Managing Effect Spheres of Influence. Royal Belgian Institute of Natural Sciences, OD Natural Environment, Marine Ecology and Management, Brussels, Belgium. 136 pp.

Degraer, S., D.A. Carey, J.W.P. Coolen, Z.L. Hutchison, F. Kerckhof, B. Rumes, and J. Vanaverbeke. 2020. Offshore wind farm artificial reefs affect ecosystem structure and functioning: A synthesis. Oceanography 33(4):48–57, https://doi.org/10.5670/ oceanog.2020.405.

Drohan, A.F., J.P. Manderson, and D.B. Packer. 2007. Essential Fish Habitat Source Document: Black Sea Bass, *Centropristis striata*, Life History and Habitat Characteristics. Second edition. NOAA Technical Memorandum NMFS-NE-200. 78 pp.

Ecology and Environment Engineering, P.C. 2017. New York State Offshore Wind Master Plan: Fish and Fisheries Study. NYSERDA Report 17-25l. 202 pp.

Endangered and Threatened Species; Establishment of Species of Concern List, Addition of Species to Species of Concern List, Description of Factors for Identifying Species of Concern, and Revision of Candidate Species List Under the Endangered Species Act. 2004. 69 FR 19975 (April 15, 2004).

Exponent 2021. Sunrise Wind Farm Project Appendix J1 Offshore EMF Assessment. Revision 2 – December June 1, 2021. Prepared for Sunrise Wind. 108 pp.

Federal Geographic Data Committee (FGDC). 2012. Coastal and Marine Ecological Classification Standard. FGDC-STD-018-2012. Marine and Coastal Spatial Data Subcommittee. June 2012. 343 pp. Reston, VA.

Field, S.A., P.J. O'Connor, A. Tyre, and H.P. Possingham. 2007. Making monitoring meaningful. Austral Ecology, 32: 485-491.

**References**

Flescher, D.D. 1980. Guide to Some Trawl Caught Marine Fishes from Maine to Cape Hatteras, North Carolina. NOAA Technical Report NMFS Circular 431. March 1980.

Freiss, C., Lowerre-Barbieri, S.K., Poulakis, G., and 34 others. 2021. Regional-scale variability in movement ecology of marine fisheries revealed by an integrative acoustic tracking network. Marine Ecology Progress Series, 663: 157-177.

Friedland, K.D., E.T. Methratta, A.B. Gill, S.K. Gaichas, T.H. Curtis, E.M. Adams, J.L. Morano, D.P. Craer, M.C. McManus, and D.C. Brady. 2021. Resource occurrence and productivity in existing and proposed wind energy lease areas on the northeast US shelf. Frontiers in Marine Science, doi: 10.3389/fmars.2021.629230.

Galloway, B.J., and K.R. Munkittrick. 2006. Influence of seasonal changes in relative liver size, condition, relative gonad size and variability in ovarian development in multiple spawning fish species used in environmental monitoring programs. Journal of Fish Biology, 69(6): 1788-1806.

Germano, J.D., D.C. Rhoads, R.M. Valente, D. Carey, and M. Solan. 2011. The use of Sediment Profile Imaging (SPI) for environmental impact assessments and monitoring studies: Lessons learned from the past four decades. Oceanography and Marine Biology: An Annual Review 49: 247-310.

Greene, H.G., J.J. Bizzarro, V.M. O'Connell, C.K. Brylinksky. 2007. Construction of Digital Potential Marine Benthic Habitat Maps Using a Coded Classification Scheme and its Application. in Todd, B.J., and Greene, H.G., eds., Mapping the Seafloor for Habitat Characterization: Geological Association of Canada, Special Paper 47.

Greene, J.K., M.G. Anderson, J. Odell, and N. Steinberg, eds. 2010. The Northwest Atlantic Marine Ecoregional Assessment: Species, Habitats and Ecosystems. Phase One. The Nature Conservancy, Eastern U.S. Division, Boston, MA.

Guida, V., A. Drohan, H. Welch, J. McHenry, D. Johnson, V. Kentner, J. Brink, D. Timmons, and E. Estela- Gomez. 2016. Habitat Mapping and Assessment of Northeast Wind Energy Areas. Sterling, VA: US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2017-088. 312 p.

Hart, D. 2015. Northeast Fisheries Science Center Scallop Dredge Surveys. Prepared for the Sea Scallop Survey Review, March 2015. Available online: https://www.cio.noaa.gov/services_programs/prplans/pdfs/ID321_Draft_Product_1-NEFSC_Dredge.pdf

HDR. 2019. Benthic Monitoring during Wind Turbine Installation and Operation at the Block Island Wind Farm, Rhode Island – Year 2. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2019-019. 318 pp.

HDR. 2020. Benthic and Epifaunal Monitoring During Wind Turbine Installation and Operation at the Block Island Wind Farm, Rhode Island – Project Report. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2020-044. Volume 1: 263 pp; Volume 2:380 pp.

He, P. and C. Rillahan. 2020. Vineyard Wind Demersal Trawl Survey: 2019/2020 Annual Report. 501 North Study Area. August 2020. Prepared for Vineyard Wind, LLC.

Hiscock, K., H. Tyler-Walters, and H. Jones. 2002. High Level Environmental Screening Study for Offshore Wind Farm Developments – Marine Habitats and Species Project. Report from the Marine Biological Association to The Department of Trade and Industry New & Renewable Energy Programme. (AEA Technology, Environment Contract: /35/00632/00/00.)

Hureau, J.C. 1969. Biologie comparee de quelques poissons anarctiques (Nototheniidae). Bulletin of the Institut Oceanographique Monaco 68:1í44.

Hussey, N.E., S.T. Kessel, K. Aarestrup, S.J. Cooke, P.D. Cowley, A.T. Fisk, R.G. Harcourt, K.N. Holland, S.J. Iverson, J.F. Kocik, and J.E.M. Flemming. 2015. Aquatic animal telemetry: a panoramic window into the underwater world. Science, 348(6240), p.1255642.

Hutchison Z., P. Sigray, H. He, A. 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. Report by University of Rhode Island, Cranfield University, and FOI (Swedish Defense Research Agency).

Hutchison, Z.L., A.B. Gill, P. Sigray, H. He, and J.W. King. 2020a. Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom-dwelling marine species. Scientific Reports. 10(1):1-15.

Hutchison, Z.L., M. LaFrance Bartley, S. Degraer, P. English, A. Khan, J. Livermore, B. Rumes, and J.W. King. 2020b. Offshore wind energy and benthic habitat changes: Lessons from Block Island Wind Farm. Oceanography 33(4):58–69, https://doi.org/10.5670/oceanog.2020.406.

Ingram, E.C., R.M. Cerrato, K.J. Dunton, and M.G. Frisk. 2019. Endangered Atlantic Sturgeon in the New York Wind Energy Area: implications of future development in an offshore wind energy site. Scientific Reports, 9:12432

INSPIRE Environmental. 2021a. Commercial and Recreational Fisheries technical report. Sunrise Wind Farm Project. Technical report by INSPIRE Environmental prepared for Sunrise Wind, LLC. June 2021.

INSPIRE Environmental. 2021b. Block Island Wind Farm Demersal Fish Trawl Survey: Synthesis Report Years 1-7, October 2012 through September 2019. March 2021. Prepared for Deepwater Wind Block Island, LLC. 261 pp.

INSPIRE Environmental. 2021c. Benthic Resources Characterization Report – Federal Waters Sunrise Wind Farm Project. Prepared for Stantec and Sunrise Wind. June 2021.

INSPIRE Environmental. 2021d. Benthic Resources Characterization Report – New York State Waters Sunrise Wind Farm Project. Prepared for Stantec and Sunrise Wind. June 2021.

INSPIRE Environmental. 2021e. Benthic Habitat Mapping to Support Essential Fish Habitat Consultation, Sunrise Wind Farm. Prepared for Sunrise Wind LLC.

INSPIRE Environmental. 2022. Sunrise Wind Benthic Monitoring Plan - New York State Waters. Prepared for Sunrise Wind.

Jacoby, D.M.P., E.J. Brooks, D.P. Croft, and D.W. Sims. 2012. Developing a deeper understanding of animal movements and spatial dynamics through novel application of network analyses. Methods in Ecology and Evolution, 3:574-583.

Jakob, E.M., S.D. Marshall, and G.W. Uetz. 1996. Estimating fitness: a comparison of body condition indices. Oikos, 77: 61-67.

Karama, K.S., Y. Matsushita, M. Inoue, K. Kojima, K. Tone, I. Nakamura, and R. Kawabe. 2020. Movement pattern of red seabream *Pagrus major* and yellowtail *Seriola quinqueradiata* around offshore wind turbines and the neighboring habitats near Goto Islands, Japan. Aquaculture and Fisheries, https://doi.org/10.1016/j.aaf.2020.04.005

Kavet, R., M.T. Wyman, A.P. Klimley, and X. Vergara. 2016. Assessment of potential impact of electromagnetic fields from undersea cable on migratory fish behavior. Electric Power Research Institute (EPRI) for the US Department of Energy and US Department of the Interior, Bureau of Ocean Energy Management.

Keller, A.B., N.F. Putman, R.D. Grubbs, D.S. Portnoy, and T.P. Murphy. 2021. Map-like use of Earth's magnetic field in sharks. Current Biology, DOI:https://doi.org/10.1016/j.cub.2021.03.103.

Kells, V. and K. Carpenter. 2011. A Field Guide to Coastal Fishes from Maine to Texas. Johns Hopkins University Press, 448 pp.

Kendall, A.W. 1977. Biological and fisheries data on black sea bass, *Centropristis striata* (Linnaeus). Sandy Hook Lab., Northeast Fish. Cent., Nat. Mar. Fish. Serv., NOAA Tech. Ser. Rep. 7: 1-29.

Klimley, A.P., M.T. Wyman, and T. Kaven. 2017. Chinook salmon and green sturgeon migrate through San Francisco estuary despite large distortions in the local magnetic field produced by bridges. PLoS ONE, 12(6): e0169031.

Kneebone, J. and C. Capizzano. 2020. A comprehensive assessment of baseline recreational fishing effort for highly migratory species in southern New England and the associated wind energy area. Final report submitted to Vineyard Wind LLC. May 4, 2020. Available online at: https://www.vineyardwind.com/fisheries-science.

Kraus, C. and L. Carter. 2018. Seabed recovery following protective burial of subsea cables – Observations from the continental margin. Ocean Engineering, 157: 251-261.

Krone, R., G. Dederer, P. Kanstinger, P. Krämer, and C. Schneider. 2017. Mobile demersal megafauna at common offshore wind turbine foundations in the German Bight (North Sea) two years after deployment - increased production rate of Cancer pagurus. Marine Environmental Research, 123:53–61, https://doi.org/10.1016/j.marenvres.2016.11.011.

LaFrance, M., King, J.W., Oakley, B.A. & Pratt, S. 2014. A comparison of top-down and bottom-up approaches to benthic habitat mapping to inform offshore wind energy development. Continental Shelf Research (2014). http://dx.doi.org/10.1016/j.cer.2014.007.

LaFrance, M., Shumchenia, E., King, J.W., Pockalny, R., Oakley, B. Pratt, S. & Boothroyd, J. 2010. Chapter 4. Benthic habitat distribution and subsurface geology in selected sites from the Rhode

Island Ocean Special Area Management Study Area In: Rhode Island OCEAN SAMP. Volume 2. Coastal Resources Management Council, October 12, 2010.

Langhamer, O. 2012. Artificial reef effect in relation to offshore renewable energy conversion: State of the Art. The Scientific World Journal. doi:10.1100/2012/386713

Lefaible, N., L. Colson, U. Braeckman, and T. Moens. 2019. Evaluation of turbine-related impacts on macrobenthic communities within two offshore wind farms during the operational phase. In Degraer, S., Brabant, R., Rumes, B. & Vigin, L. (eds). 2019. Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: Marking a Decade of Monitoring, Research and Innovation. Brussels: Royal Belgian Institute of Natural Sciences, OD Natural Environment, Marine Ecology and Management, 134 p.

Lea, J.S.E., N.E. Humphries, R.G. von Brandis, C.R. Clarke, and D.W. Sims. 2016. Acoustic telemetry and network analysis reveal the space use of multiple reef predators and enhance marine protected area design. Proceedings of the Royal Society B, 283: 20160717.

Ledee, E.J.I., M.R. Heupel, A.J. Tobin, D.M. Knip, and C.A. Simpfendorfer. 2015. A comparison between traditional kernel-based methods and network analysis: an example from two nearshore shark species. Animal Behaviour, 103:17-28.

Lindeboom, H.J., H.J. Kouwenhoven, M.J.N. Bergman, S. Bouma, S. Brasseur, R. Daan, R.C. Fijn, et al. 2011. Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environmental Research Letters, 6: 1-13.

Lookingbill, T.R., R.H. Gardner, J.R. Ferrari, and C.E. Keller. 2010. Combining a dispersal model with network theory to assess habitat connectivity. Ecological Applications, 20:427-441.

Malek, A. 2015. An Investigation of the Fisheries Ecosystem Dynamics in Rhode Island's Nearshore Waters. Open Access Dissertations. Paper 352. https://digitalcommons.uri.edu/oa_diss/352

Marre G, Holon F, Luque S, Boissery P and Deter J (2019) Monitoring Marine Habitats With Photogrammetry: A Cost-Effective, Accurate, Precise and High-Resolution Reconstruction Method. Front. Mar. Sci. 6:276. doi: 10.3389/fmars.2019.00276

Massachusetts Division of Marine Fisheries (MADMF). 2018. Recommended regional scale studies related to fisheries in the Massachusetts and Rhode Island-Massachusetts offshore wind energy areas.

McCann, J. 2012. Developing Environmental Protocols and Modeling Tools to Support Ocean Renewable Energy and Stewardship. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Herndon, VA., OCS Study BOEM 2012-082, 626 pp.

Methratta, E. 2020. Monitoring fisheries resources at offshore wind farms: BACI vs. BAG designs. ICES Journal of Marine Science. doi:10.1093/icesjms/fsaa026.

National Marine Fisheries Service (NMFS). 2015. Regional habitat assessment prioritization for northeastern stocks. Report of the Northeast Regional Habitat Assessment Prioritization Working

Group. Internal report, NMFS White Paper. Office of Science and Technology, NMFS, NOAA. Silver Spring, MD. 31 pp.

National Oceanic and Atmospheric Administration (NOAA). 2019. 2018 Stock Assessment and Fishery Evaluation (SAFE) Report for Atlantic Highly Migratory Species. Highly Migratory Species Management Division. Silver Spring, MD. 250 pp.

National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries). 2020. Vessel Trip Report (VTR) data processed by Northeast Fisheries Science Center Social Sciences Branch, provided to INSPIRE Environmental, March 2020.

National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries). 2021. Stock Condition. Retrieved from www.st.nmfs.noaa.gov/stocksmart. 03/17/2021.

Nelder, J.A. and R.W.M. Wedderburn. 1972. Generalized Linear Models. Journal of the Royal Statistical Society, Series A 135:370-384.

Nestler, E., A. Pembroke, and W. Bailey. 2010. Effects of EMFs from undersea power lines on marine species. Energy Ocean International, Ft. Lauderdale, FL.

Nelson, G.A. 2014. Cluster sampling; a pervasive, yet little recognized survey design in fisheries research. Transactions of the American Fisheries Society, 143(4): 926-938.

New York State Energy Research and Development Authority (NYSERDA). 2017. New York State Offshore Wind Master Plan: Fish and Fisheries Study. NYSERDA Report 17-25j. 140 pp.

Normandeau Associates, Exponent, T. Tricas, and A. Gill. 2011. Effects of EMFs from undersea power cables on elasmobranchs and other marine species. Final Report. OCS Study BOEMRE 2011-09. 426 pp.

Northeast Fisheries Science Center (NEFSC). 2010. 50th Northeast Regional Stock Assessment Workshop: Assessment Report. Northeast Fisheries Science Center Reference Document 10-17.

Northeast Fisheries Science Center (NEFSC). 2016. Fisheries Sampling Branch Observer On-Deck Reference Guide 2016. U.S. Department of Commerce, NOAA Fisheries Service. Woods Hole, MA.

Northeast Fisheries Science Center (NEFSC). 2018) 65th Northeast Regional Stock Assessent Workshop (65th SAW) Assessment Summary Report. Northeast Fisheries Science Center Reference Document 18-08

Ouakka, K., A. Yahyaoui, A. Mesfioui, and S. El Ayoubi. 2017. Stomach fullness index and condition factor of European sardine (*Sardina pilchardus*) in the south Moroccan Atlantic coast. AACL Bioflux 10: 56-63.

Packer, D.B., S.J. Griesbach, P.L. Berrien, C.A. Zetlin, D.L. Johnson, and W.W. Morse. 1999. Essential fish habitat source document: summer flounder, *Paralichthys dentatus*, life history and habitat characteristics. NOAA technical Memorandum NMFS-NE-151.

**References**

Pearson, T.H. and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology an Annual Review 16: 229–311.

Petersen, J.K., and Malm, T. 2009. Offshore wind farms: threats to or possibilities for the marine environment. Ambio, 35(2): 75-80.

Petruny-Parker, M., A. Malek, M. Long, D. Spencer, F. Mattera, E. Hasbrouck, J. Scotti, K. Gerbino, and J. Wilson. 2015. Identifying Information Needs and Approaches for Assessing Potential Impacts of Offshore Wind Farm Development on Fisheries Resources in the Northeast Region. US Dept. of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Herndon, VA. OCS Study BOEM 2015-037. 79 pp.

Politis, P.J., J.K. Galbraith, P. Kostovick, and R.W. Brown. 2014. Northeast Fisheries Science Center bottom trawl survey protocols for the NOAA Ship Henry B. Bigelow. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 14-06; 138 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026 or online at http://nefsc.noaa.gov/publications/

Reid, R.N., D.J. Radosh, A.B. Frame, and S.A. Fromm. 1991. Benthic macrofauna of the New York Bight, 1979-1989. NOAA Technical Report NMFS-103; 50 p.

Responsible Offshore Science Alliance (ROSA). 2021. Offshore wind project monitoring framework and guidelines. March 2021. Available online at Resources | ROSA 2021 Updated (rosascience.org).

Reubens, J.T., F. Pasotti, S. Degraer, and M. Vincx. 2013a. Residency, site fidelity and habitat use of Atlantic cod (*Gadus morhua*) at an offshore wind farm using acoustic telemetry. Marine Environmental Research, 50: 128-135.

Reubens, J.T., U. Braeckman, J. Vanaverbeke, C. Van Colen, S. Degraer, and M. Vincx. 2013b. Aggregation at windmill artificial reefs: CPUE of Atlantic cod (Gadus morhua) and pouting (Trisopterus luscus) at different habitats in the Belgian part of the North Sea. Fish. Res. 139:28-34.

Reubens, J.T., S. Degraer, and M. Vincx. 2014. The ecology of benthopelagic fishes at offshore wind farms: A synthesis of 4 years of research, Hydrobiologia 727:121-136,

Rhoads, D.C. and J.D. Germano. 1982. Characterization of organism-sediment relations using sediment profile imaging: An efficient method of remote ecological monitoring of the seafloor (REMOTS System). Marine Ecology Progress Series 8:115–128.

Rhoads, D.C. and L.F. Boyer. 1982. The effects of marine benthos on physical properties of sediments. pp. 3-52. In: Animal-Sediment Relations. McCall, P.L. and M.J.S. Tevesz (eds). Plenum Press, New York, NY.

Rhode Island Coastal Management Council (RICRMC). 2010. Rhode Island Ocean Special Area Management Plan (Ocean SAMP). Volume 1. Adopted October 19, 2010. 1021 pp.

Rhode Island Coastal Resources Management Council (RICRMC). 2018. Regulatory Standards of the Ocean SAMP (650-RICR-20-05-11.10). Subsequently amended effective October 6, 2019.

**References**

Rudders, D., 2015. Virginia Institute of Marine Science Dredge Survey Methods Report. From: http://www.cio.noaa.gov/services_programs/prplans/pdfs/ID310_Draft_Product_2-VIMS%20S_Methods%20Review.pdf

Sclafani, M., Brousseau, L, McKown, K., Maciscalco and D.R. Smith. 2009. T-3-1 Study 5: Horseshoe Crab Spawning Activity Survey – Final Report. Cornell Cooperative Extension of Suffolk County, Marine Program. Cornell University.

Sclafani, M., R. Cerrato, J. Bopp, B. Udelson, K. Morris, J. Costanzo, J. Schwerzmann. 2020. New York State Horseshoe Crab Spawning and Tagging Program Final Report: 2015- 2019. Cornell Cooperative Extension of Suffolk County, Marine Program. Cornell University. Shumchenia, E. and J. King. 2010. Evaluation of sediment profile imagery as a tool for assessing water quality in Greenwich Bay, Rhode Island, USA. Ecol. Indic. 10: 818-825.

Siemann, L., and Smolowitz, R. 2017. Southern New England Juvenile Fish Habitat Research Paper. OCS Study BOEM 2017-028.

Simone, M. and J. Grant. 2020. Visually-based alternatives to sediment environmental monitoring. Mar. Poll. Bull. 158. https://doi.org/10.1016/j.marpolbul.2020.111367

Smith, E.P., D.R. Orvos, and J. Cairns. 1993. Impact assessment using the before-after-control- impact (BACI) model: comments and concerns. Canadian Journal of Fisheries and Aquatic Sciences, 50: 627-637.

Smith, D.R., H.J. Brockmann, M.A. Beekey, T.L. King, M.J. Millard, and J. Zaldivar-Rae. 2017. Conservation status of the American horseshoe crab, (Limulus polyphemus): a regional assessment. Reviews in Fish Biology and Fisheries, 27: 135-175.

Snyder, D.B., W.H. Bailey, K. Palmquist, B.R.T. Cotts, and K.R. Olsen. 2019. Evaluation of Potential EMF Effects on Fish Species of Commercial or Recreational Fishing Importance in Southern New England. OCS Study BOEM 2019-049. US Dept. of the Interior, Bureau of Ocean Energy Management, Headquarters, Sterling, VA.

Sokal, R.R. and F.J. Rohlf. 2001. Biometry. Third Edition. W.H. Freeman and Company. USA. 850 pp.

Steimle, F. 1982. The benthic macroinvertebrates of the Block Island Sound. Estuarine Coastal and Shelf Science 15: 1-16.

Stokesbury, K.D.E. 2013. MA Windfarm Survey, Final Report. School for Marine Science and Technology (SMAST), University of Massachusetts Dartmouth.

Stokesbury, K.D.E. 2014. MA Windfarm Survey, Final Report. School for Marine Science and Technology (SMAST), University of Massachusetts Dartmouth.

Sturdivant, S.K., R.J. Díaz., and G.R. Cutter. 2012. Bioturbation in a declining oxygen environment, in situ observations from Wormcam. PLoS ONE 7(4): e34539.

Theroux, R.B. and R.L. Wigley. 1998. Quantitative composition and distribution of the macrobenthic invertebrate fauna of the continental shelf ecosystems of the northeastern United States. U.S. Dep. Commer. NOAA Tech. Rep. NMFS 140, 240 pp.

**References**

Underwood, A.J. 1992. Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. Journal of Experimental Marine Biology and Ecology, 161: 145-178.

Underwood, A.J. 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecol Appl 4: 3–15.

Valliere, A. and S. Pierce. 2007. Southern New England Industry-Based Yellowtail Flounder Survey, 20032005. Report to the National Marine Fisheries Service Contract EA 1337-03-CN-00112.

Venable, W.N. and B.D. Ripley. 2002. Modern Applied Statistics in S: Fourth Edition. Springer Publishing.

Walsh, H.J. and V.G. Guida. 2017. Spring occurrence of fish and macro-invertebrate assemblages near designated wind energy areas on the northeast U.S. continental shelf. Fishery Bulletin, 115: 437-450.

Westerberg, H. and I. Lagenfelt. 2008. Sub-sea power cables and the migration behavior of the European eel. Fisheries Management and Ecology, 15: 369-375.

Wilber D.H., D.A. Carey, and M. Griffin. 2018. Flatfish habitat use near North America's first offshore wind farm. Journal of Sea Research 139: 24–32.

Wilber, D., L. Read, M. Griffin, and D. Carey. 2021. Block Island Wind Farm Demersal Fish Trawl Survey, Final Synthesis Report – Years 1 to 7, October 2012 through September 2019. Prepared by INSPIRE Environmental, Newport, RI for Deepwater Wind Block Island, LLC, Providence, RI. 103 pp. ++ Appendices.

Wilber D.H., L.B. Read, M. Griffin, G.R. DeCelles, and D.A. Carey. 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

Wilhelmsson, D., and Malm, T. 2008. Fouling assemblages on off- shore wind power plants and adjacent substrata. Estuarine Coastal and Shelf Science, 79: 459–466.

Winter, H.V., G. Aarts, and O.A. van Keeken. 2010. Residence time and behavior of sole and cod in the offshore wind farm Egmond aan Zee (OWEZ). IMARES Report number C038/10. 50 pp.

Winton, M.V., J. Kneebone, D.R. Zemeckis, and G. Fay. 2018. A spatial point process model to estimate individual centres of activity form passive acoustic telemetry data. Methods in Ecology and Evolution, 9: 2262-2272.

Wuenschel, M.J., K.W. Able, and D. Byrne. 2009. Seasonal patterns of winter flounder *Pseudopleuronectes americanus* abundance and reproductive condition on the New York Bight continental shelf. Journal of Fish Biology, 74: 1508-1524.

Zemeckis, D.R., M.J. Dean, A.I. DeAngelis, S.M. Van Parijs, W.S. Hoffman, M.G. Baumgartner, L.T. Hatch, S.X. Cadrin, and C.H. McGuire. 2019. Identifying the distribution of Atlantic cod spawning using multiple fixed and glider-mounted technologies. ICES Journal of Marine Science, 76(6): 1610-1625.

**References**

Ziegler, C.M., J.P. Zacharias, and M.G. Frisk. 2019. Migration diversity, spawning behavior, and habitat utilization of winter flounder. Canadian Journal of Fisheries and Aquatic Sciences, 76:1503-1514.

# APPENDICES

# APPENDIX A - VMS MAPS OF FISHING ACTIVITY

## Appendix A - VMS Maps of Fishing Activity

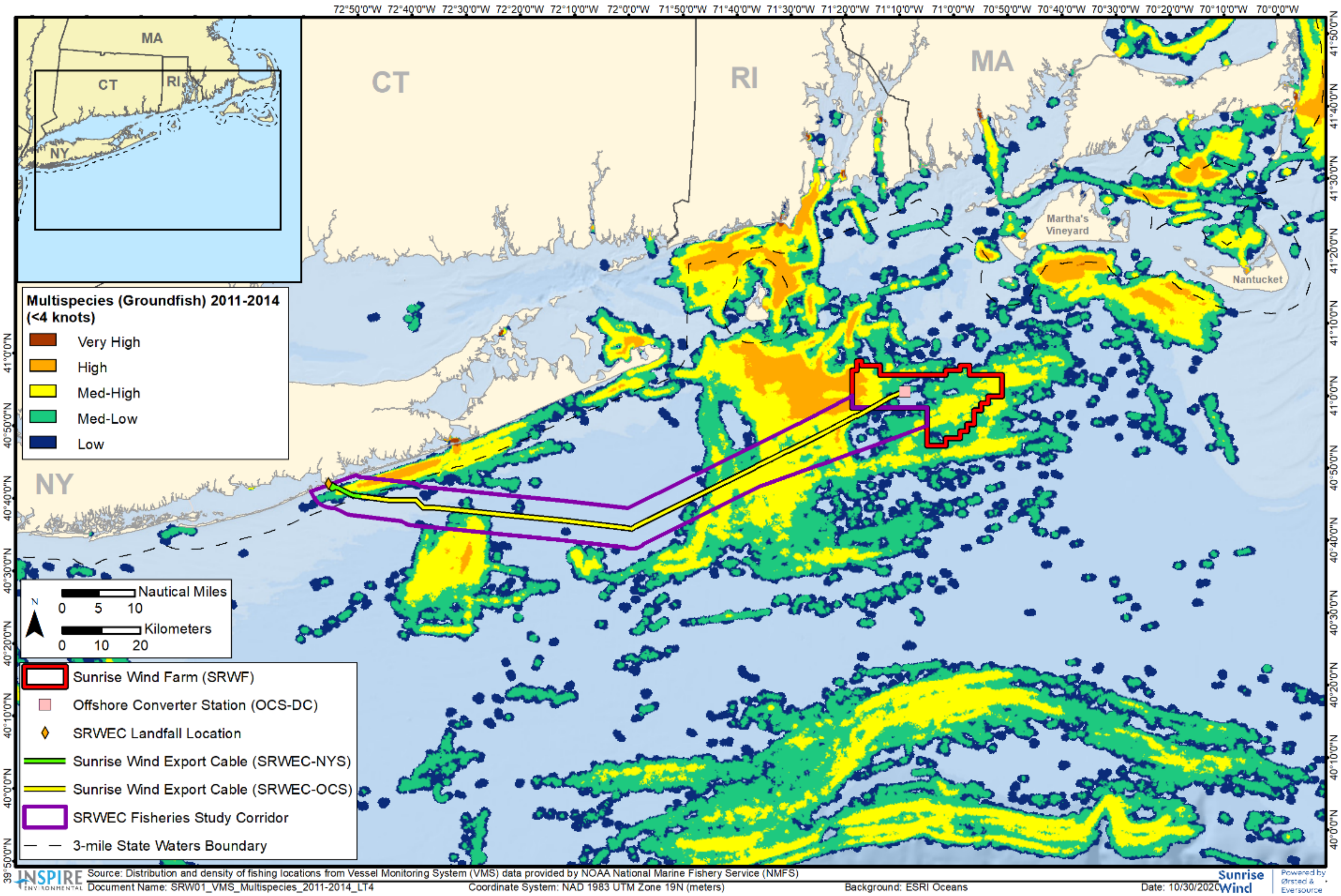



**Figure A-1. VMS Map of Vessel Intensity for Large-mesh Multispecies (Groundfish) Fishing, 2011 to 2014**

## Appendix A - VMS Maps of Fishing Activity

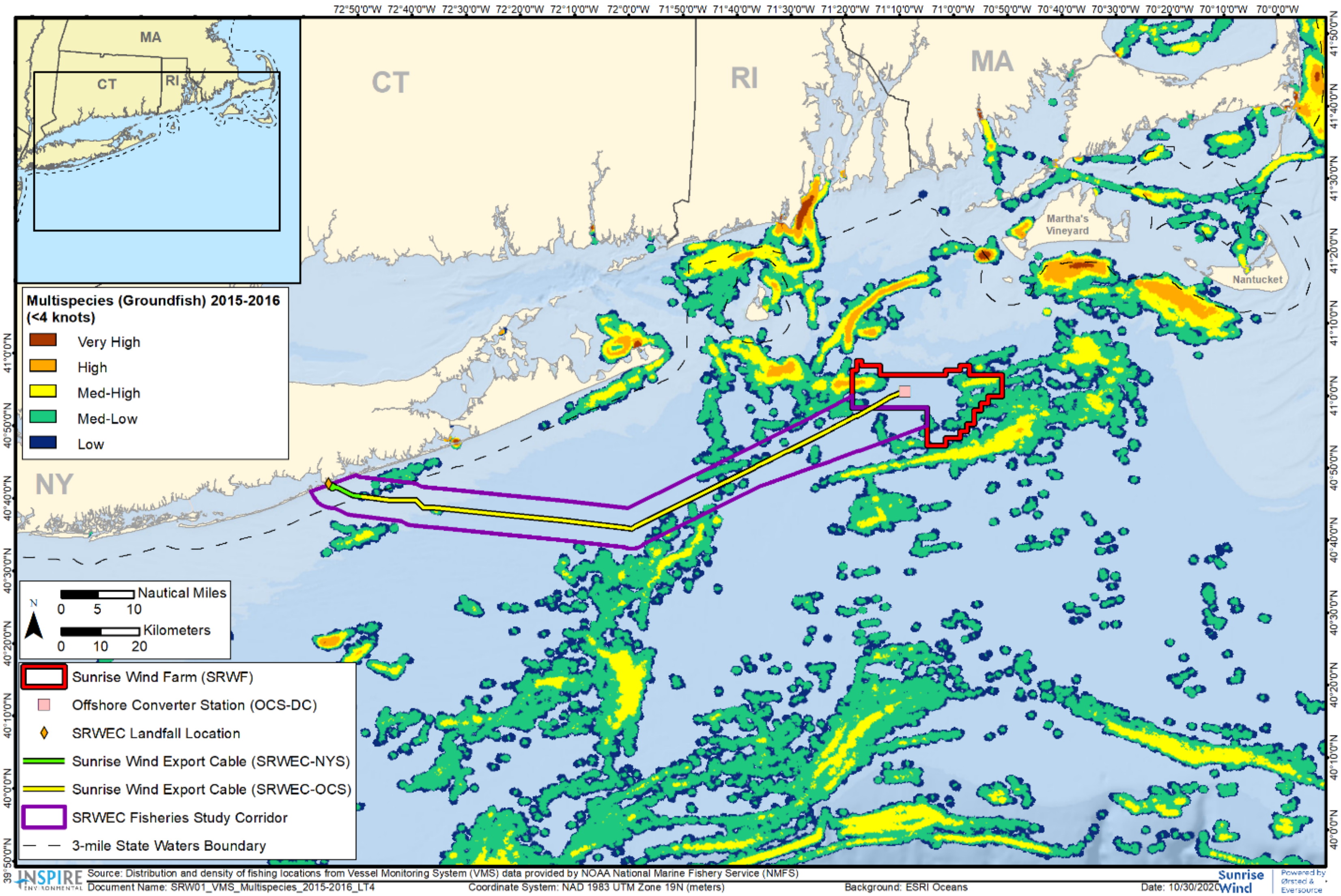



**Figure A-2.** **VMS Map of Vessel Intensity for Large-mesh Multispecies (Groundfish) Fishing, 2015 to 2016**

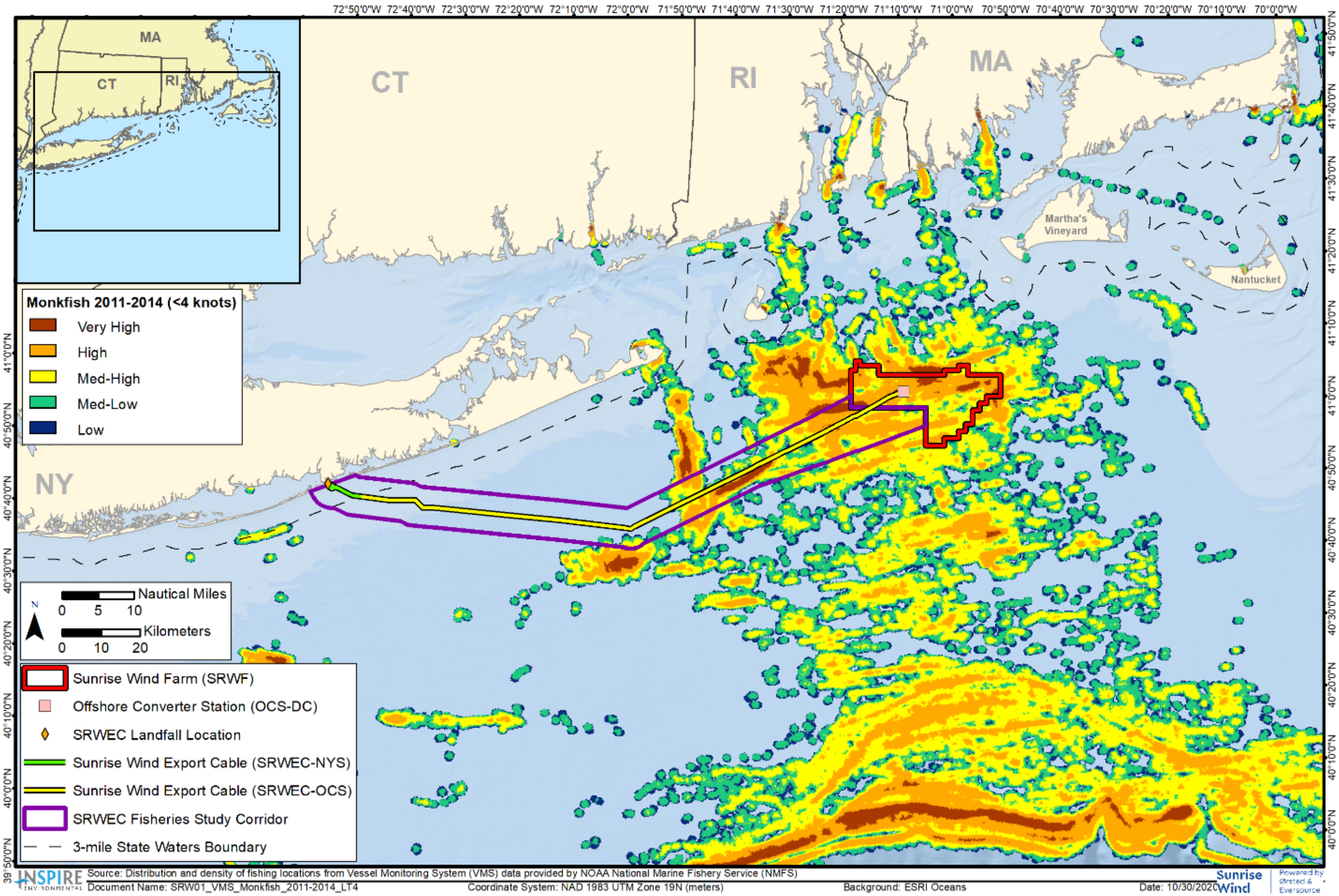



**Figure A-3. VMS Map of Vessel Intensity for Monkfish Fishing, 2011 to 2014**

## Appendix A - VMS Maps of Fishing Activity

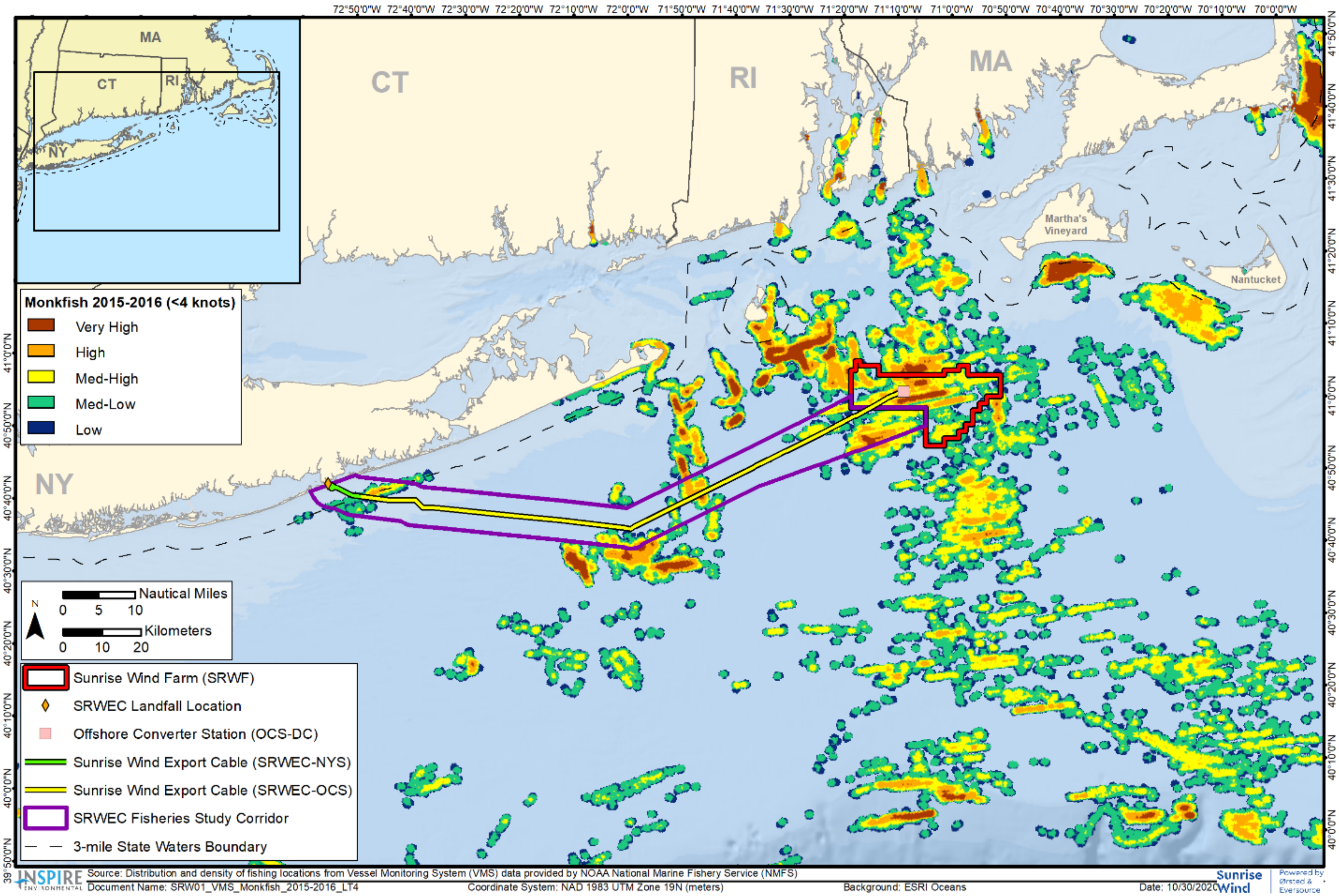



**Figure A-4. VMS Map of Vessel Intensity for Monkfish Fishing, 2015 to 2016**

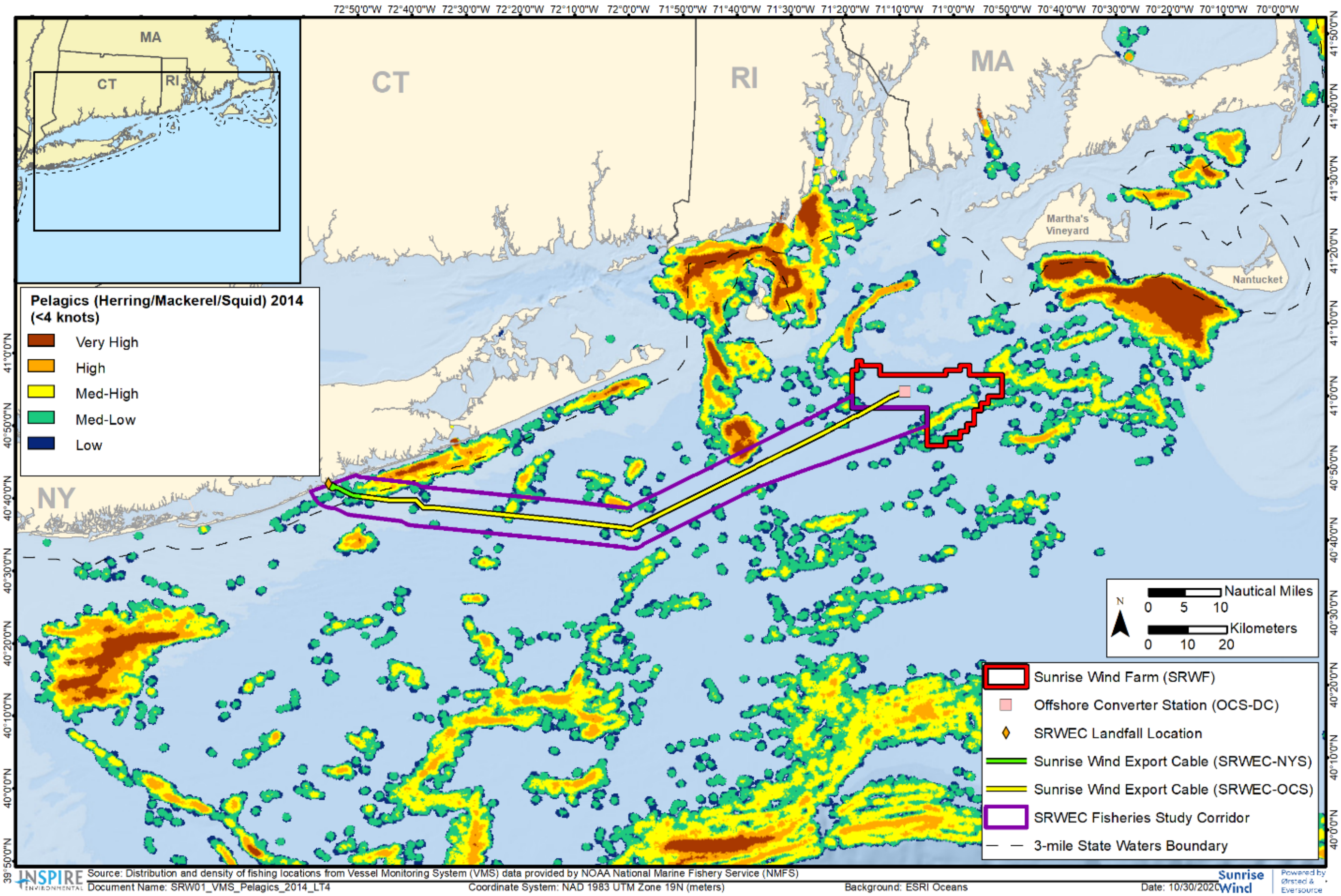



**Figure A-5. VMS Map of Vessel Intensity for Pelagic Species (Herring/Mackerel/Squid) Fishing, 2014**

**Appendix A - VMS Maps of Fishing Activity**

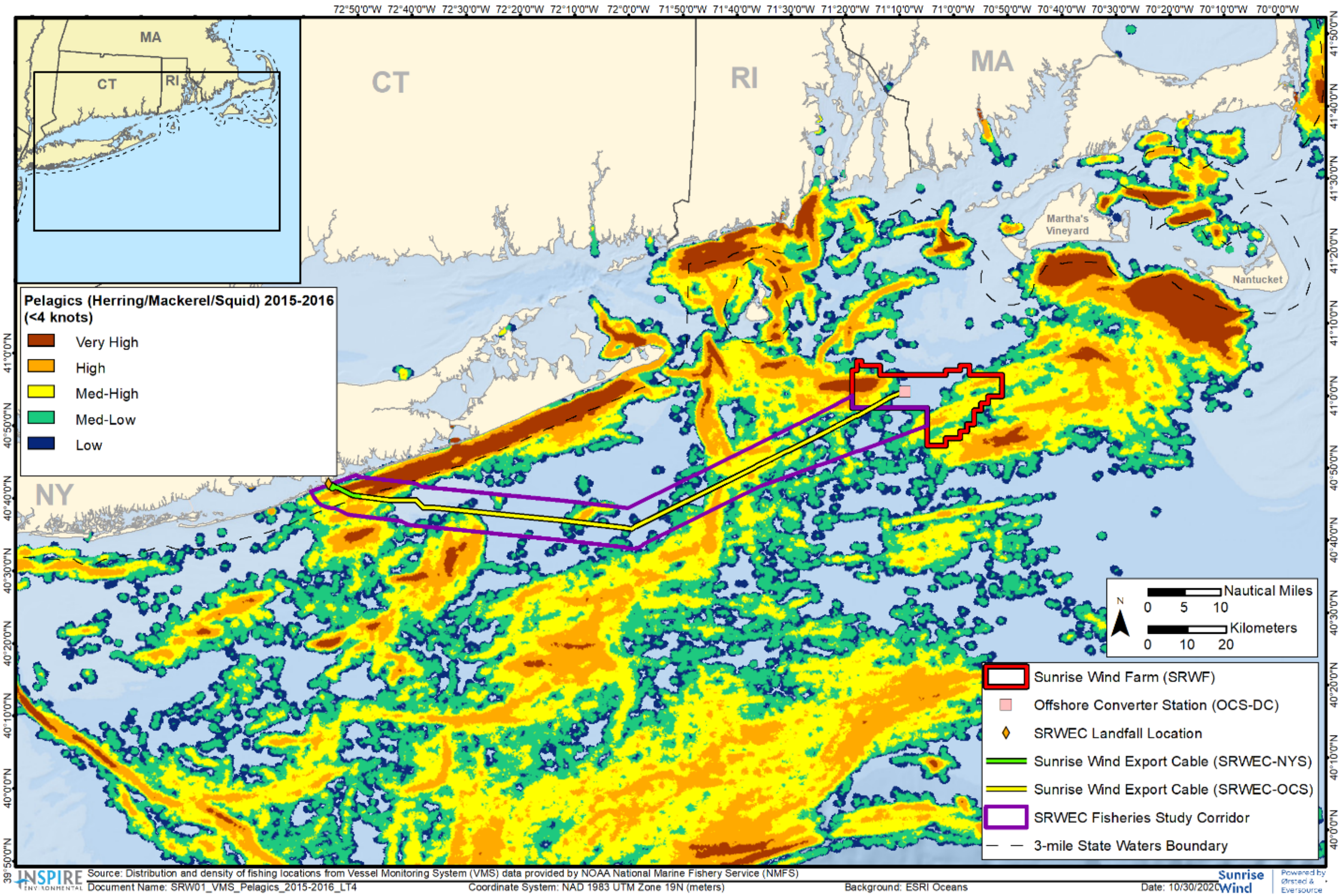



**Figure A-6. VMS Map of Vessel Intensity for Pelagic Species (Herring/Mackerel/Squid) Fishing, 2015 to 2016**

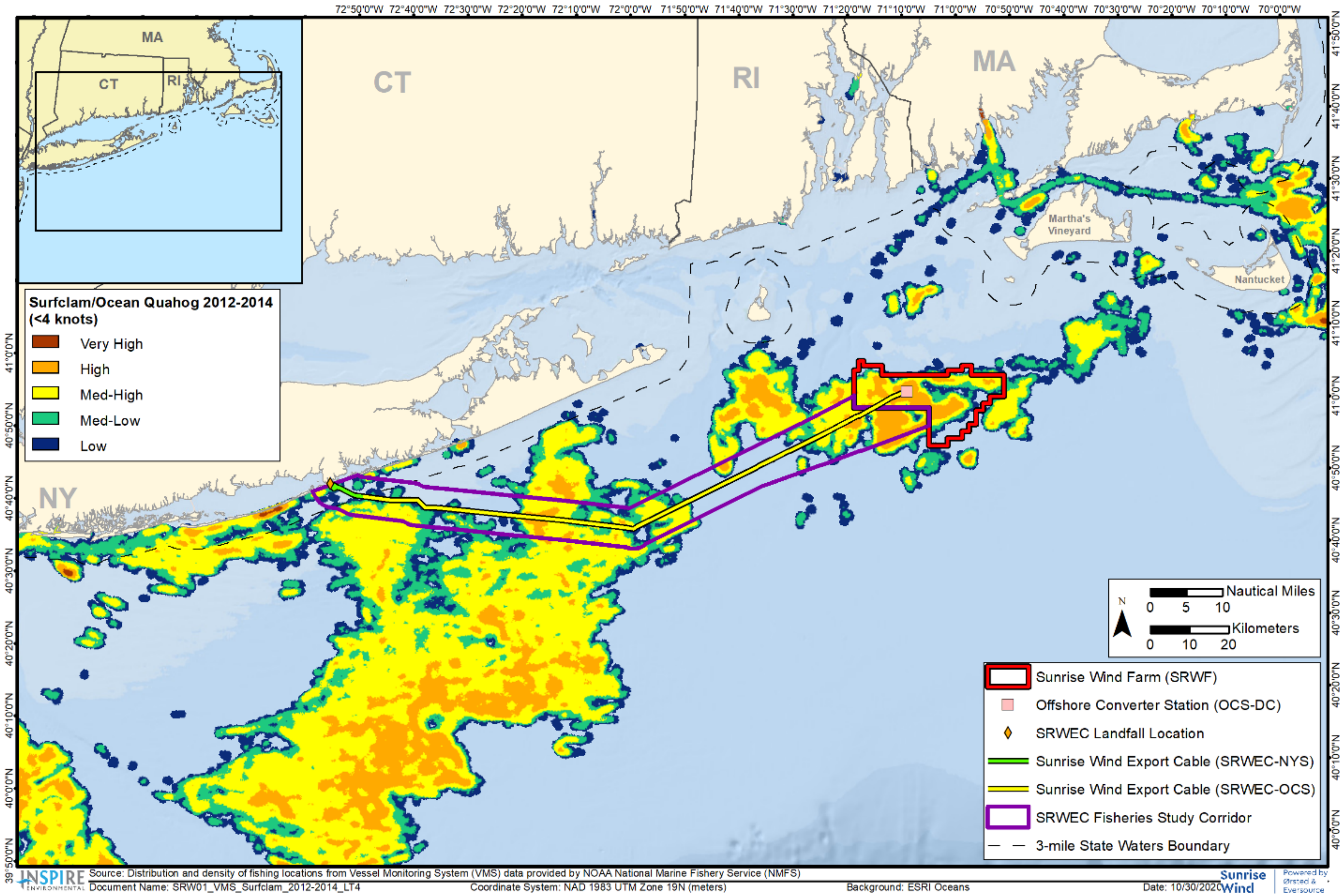



**Figure A-7. VMS Map of Vessel Intensity for Surfclam/Ocean Quahog Fishing, 2012 to 2014**

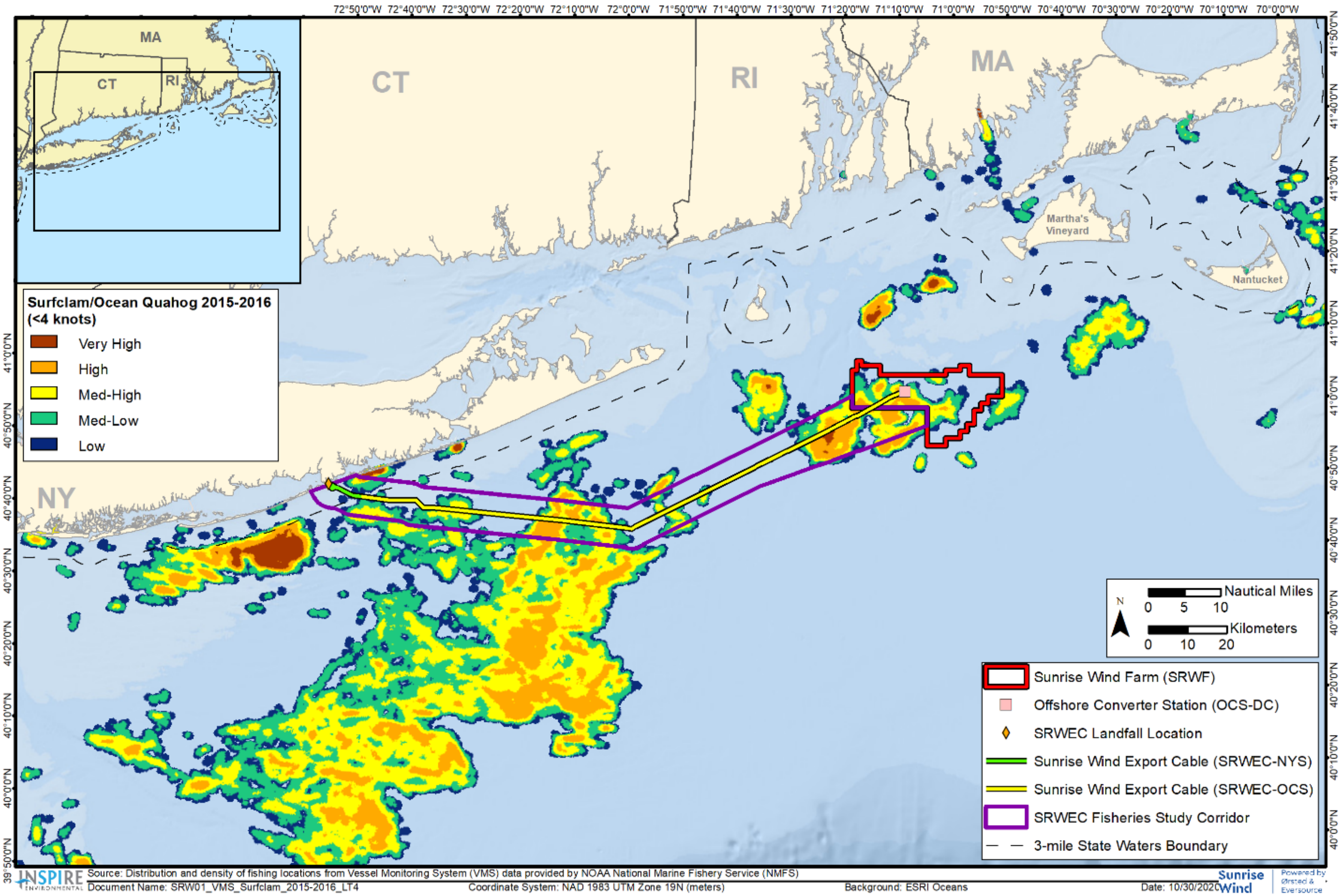



**Figure A-8. VMS Map of Vessel Intensity for Surfclam/Ocean Quahog Fishing, 2015 to 2016**

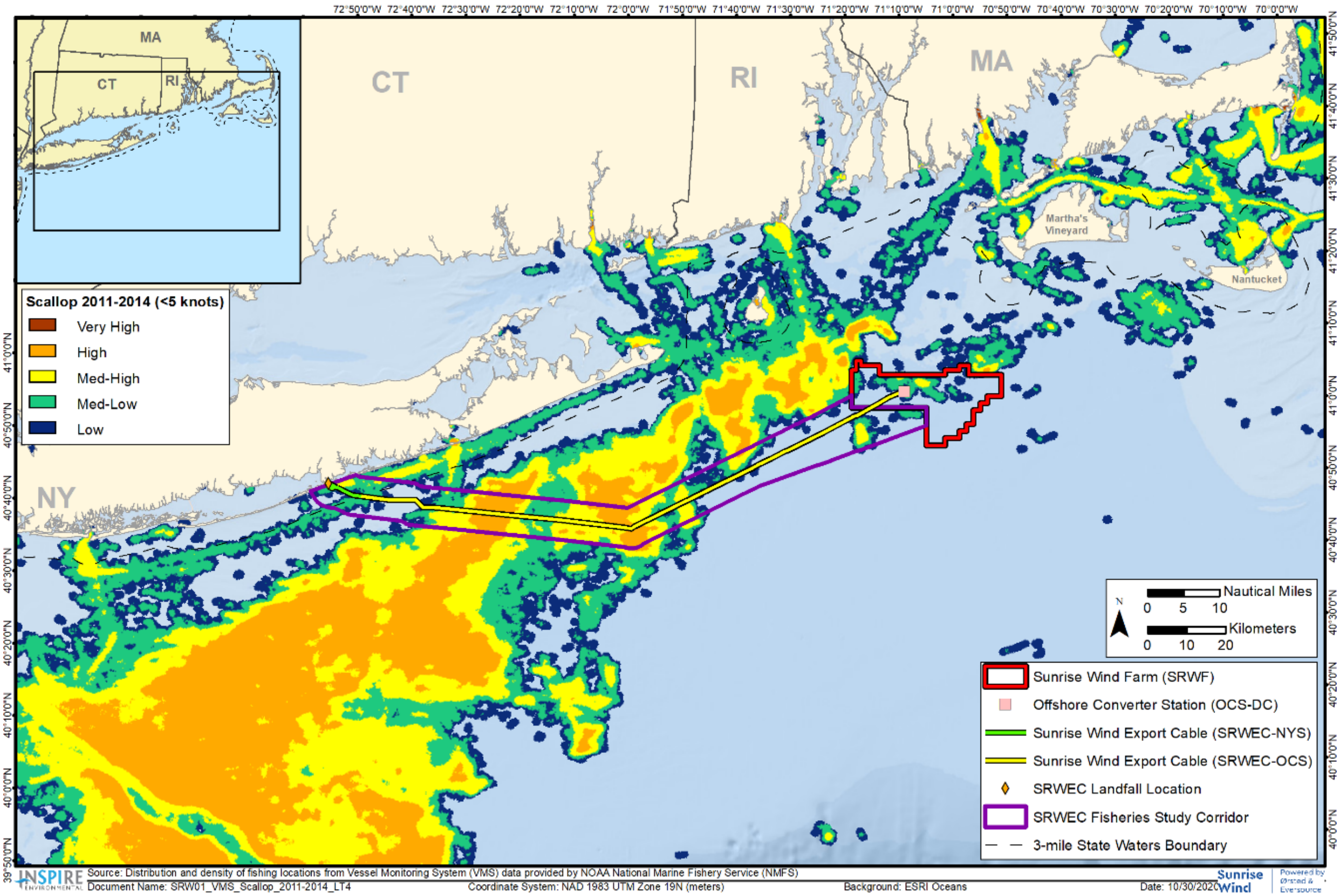



**Figure A-9. VMS Map of Vessel Intensity for Sea Scallop Fishing, 2011 to 2014**

**Appendix A - VMS Maps of Fishing Activity**

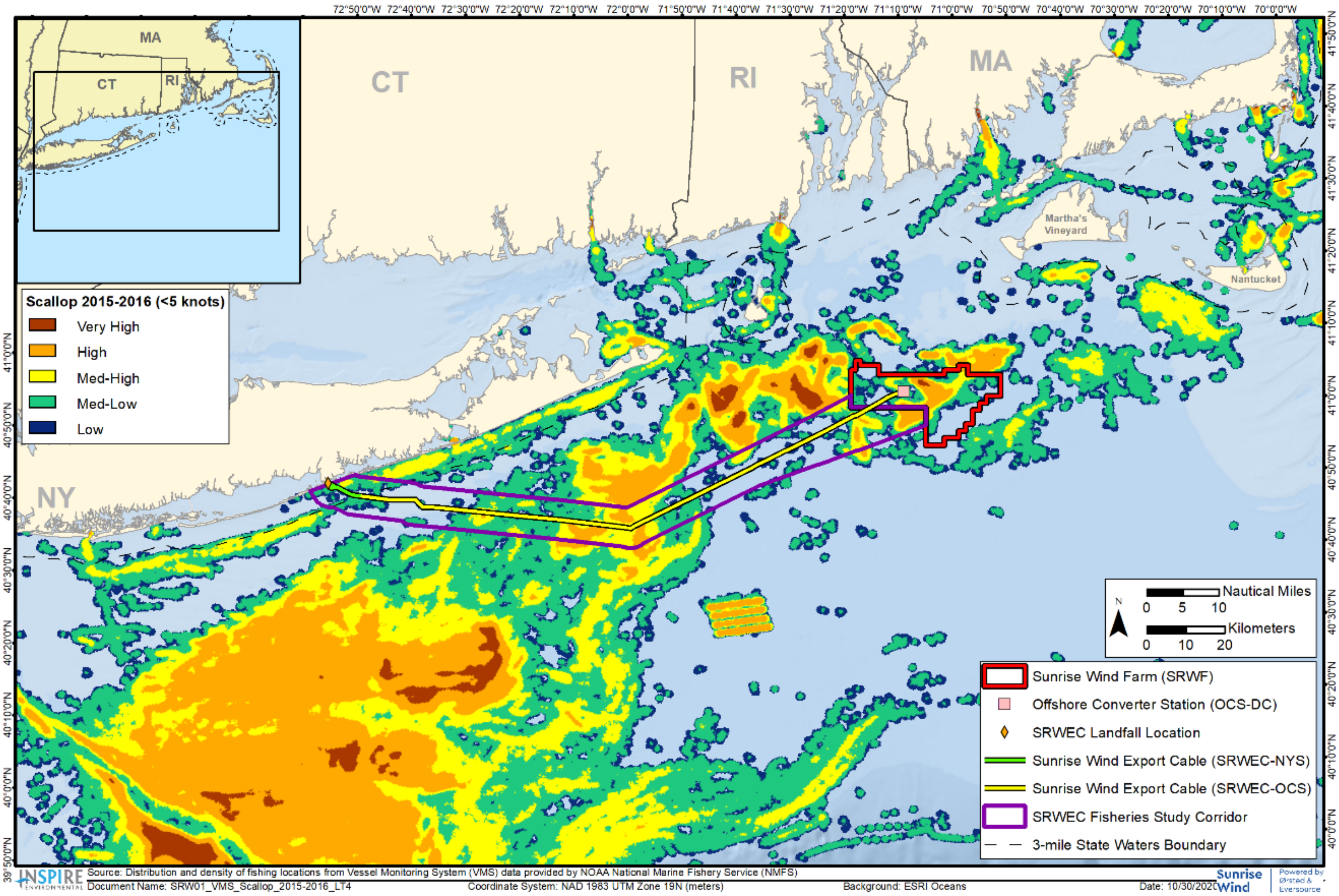



**Figure A-10. VMS Map of Vessel Intensity for Sea Scallop Fishing, 2015 to 2016**

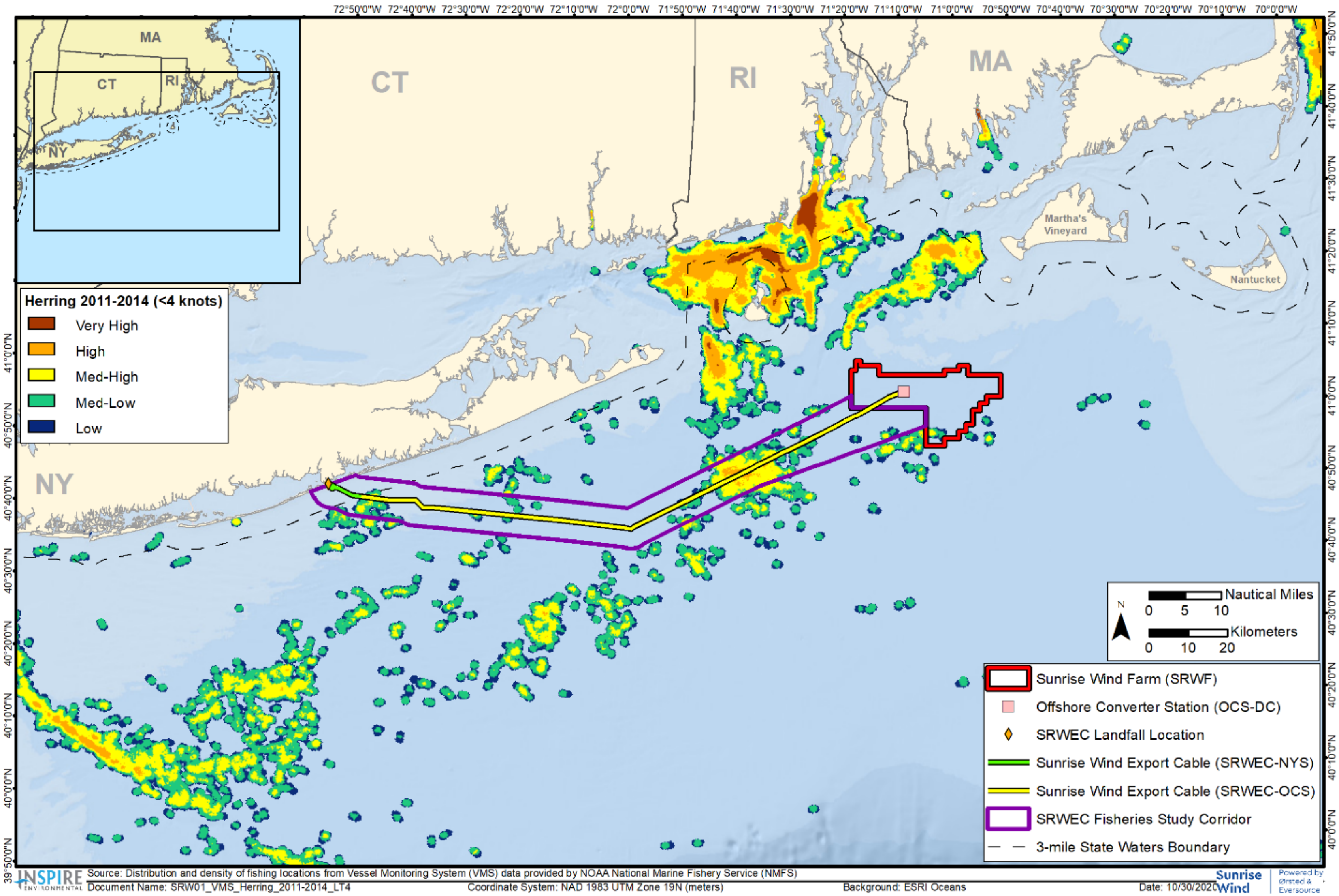



**Figure A-11. VMS Map of Vessel Intensity for Atlantic Herring Fishing, 2011 to 2014**

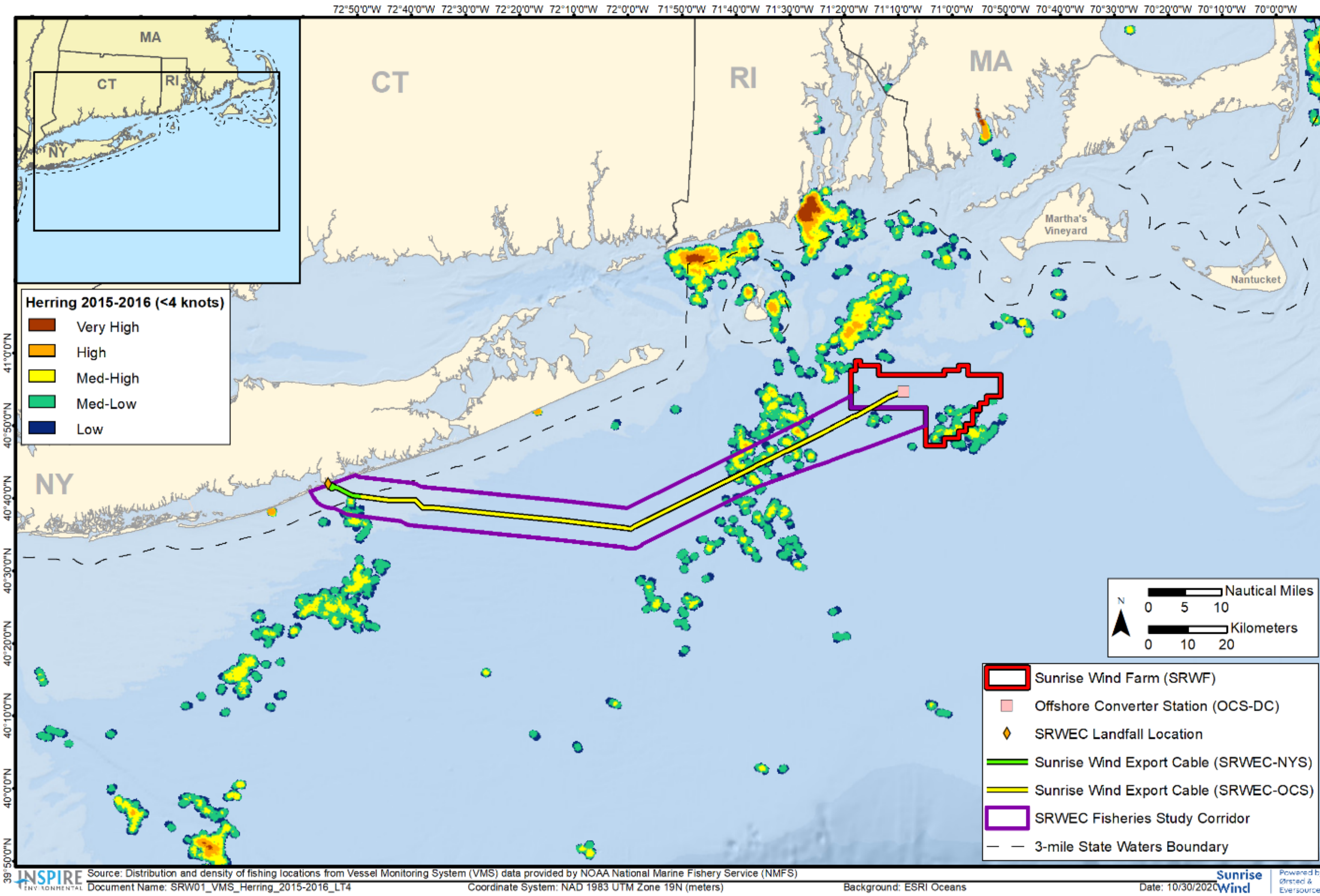



**Figure A-12. VMS Map of Vessel Intensity for Atlantic Herring Fishing, 2015 to 2016**

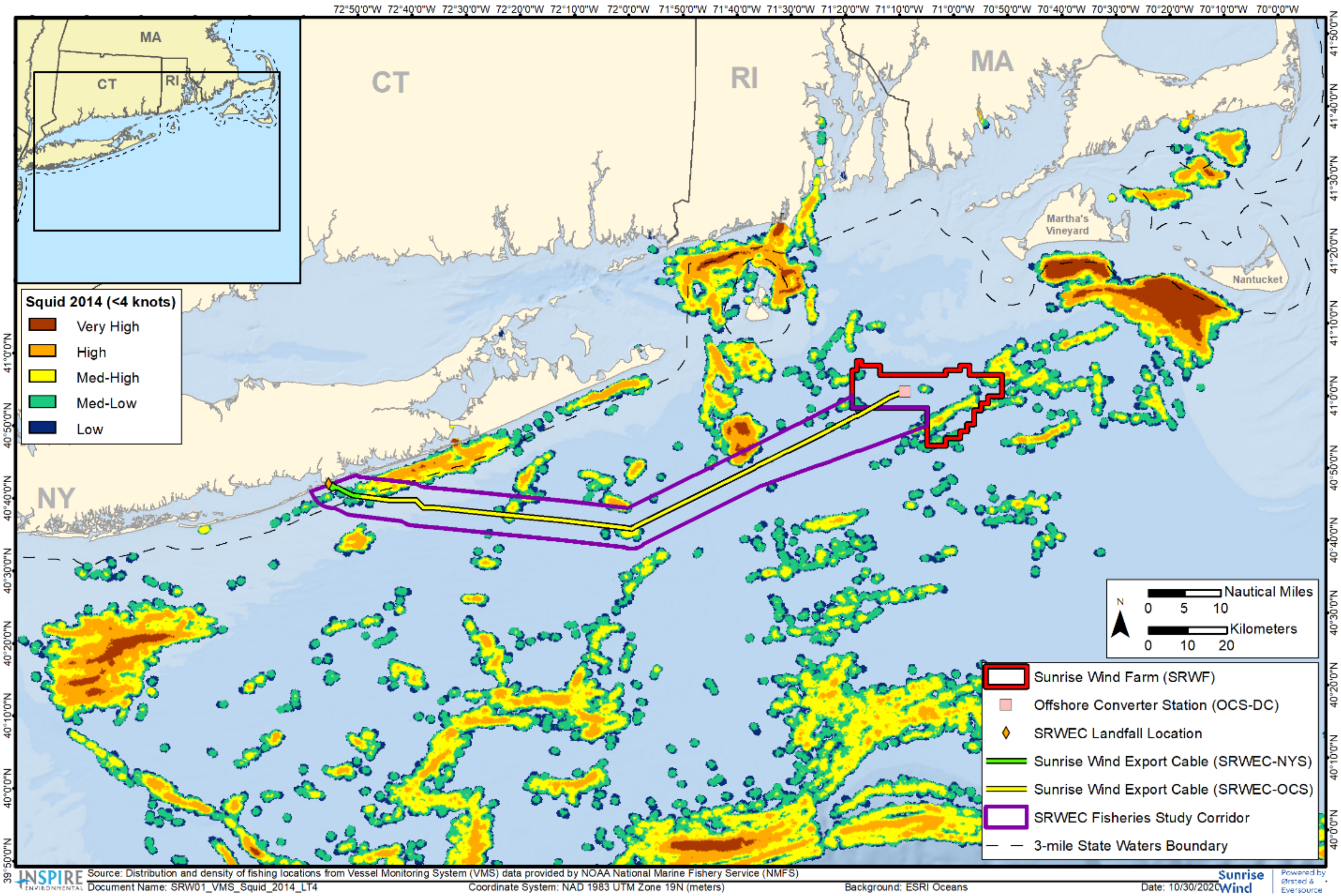



**Figure A-13. VMS Map of Vessel Intensity for Squid Fishing, 2014**

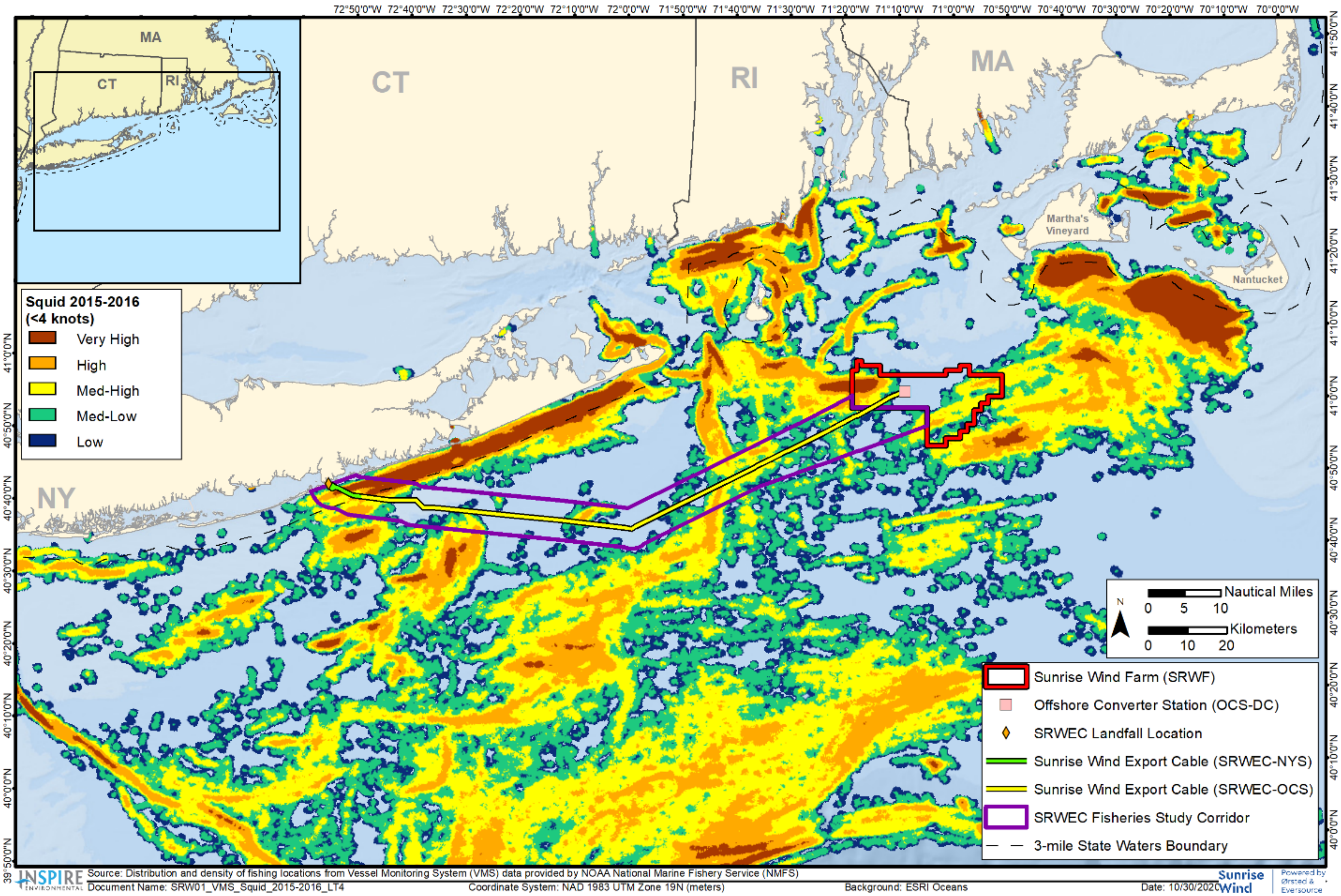



**Figure A-14. VMS Map of Vessel Intensity for Squid Fishing, 2015 to 2016**

# APPENDIX B – TRAWL SURVEY POWER ANALYSIS

# Appendix B: Trawl Survey Power Analysis

Prepared by Lorraine Brown
EXA Data and Mapping

## 1.0 Introduction

For the otter trawl survey, an asymmetrical BACI design is planned at both the Sunrise Wind Farm (SRWF) and the Revolution Wind Farm (RWF) project area. The trawl survey will use NEAMAP survey gear and sampling protocols and is intended to capture a range of benthic and pelagic fish species, as well as commercially important invertebrate species.

This appendix covers two topics:

1. A review of existing trawl survey datasets in the vicinity of SRWF and RWF project areas, including data from the NEFSC trawl survey (Politis et al. 2014) and data collected in the reference areas during the BIWF trawl survey (Wilber et al. 2020). These datasets were evaluated to establish the proximate range of a meaningful effect size in measuring change over time, as well as reasonable ranges for interannual and intraannual variability (i.e., the coefficient of variation [CV]) to use in the power analyses.
2. A power simulation study for a BACI design and analysis contrasting fish/invertebrate biomass between an impact area and reference areas. Effect sizes and CVs were derived from the NEFSC and BIWF trawl survey datasets (Topic 1 above).

## 2.0 Power Analysis Elements

A statistical power analysis requires specification of the following:

- Study design specifics (e.g., number of replicates, number of sites, number of seasons/sampling events, sampling duration before and after construction), and their structure (e.g., random trawls as independent replicates within each site and sampling event, or fixed trawls nested within sites and repeatedly sampled over time).
- The statistical model, which is determined by the study design (previous bullet) and characteristics of the data (e.g., catch data as biomass might be modeled with a generalized linear or additive model with normal errors and a log-link; catch data as counts might be modeled with a generalized linear or additive model with Poisson errors, or with a negative binomial if the count data are over-dispersed; presence/absence data might be modeled with logistic regression and binomial errors).

A statistical power analysis relates the following four elements; given three of these elements, the fourth can be estimated:

- **Effect size (Δ)** is a measure of change in the data that the study design and modelling approach will be used to estimate. Measures of effect size can be summarized in a number of different ways (e.g., Durlak 2009); standardized effect sizes such as the magnitude of difference expressed as a percent of the standard deviation are useful for comparisons across studies. These can be difficult to understand, however; and when the unit of measure itself is meaningful (e.g., catch ratios) it is more useful to present results in terms of unstandardized effect sizes. For the purposes of this appendix, unstandardized effect sizes are expressed as the temporal change at the impact site relative to temporal change at the reference sites (Eq. 1). Since this value is not standardized to variance, power for different relative change values (effect sizes) is evaluated across a range of variance estimates.

The relative proportional change (PC) at the impact site is the proportional change between periods of the mean catch per tow at the Impact site relative to the proportional change between periods of the mean catch per tow at the Reference site(s) minus one:

$$\text{Effect Size as Proportional Change (PC)} = \left[\frac{(\bar{X}_{Impact,After}/\bar{X}_{Impact,Before})}{(\bar{X}_{Reference,After}/\bar{X}_{Reference,Before})} - 1\right] \quad \text{[Eq. 1]}$$

The same PC could represent any number of ratios. For example, a PC of –0.33 (-33 percent) could represent a 33 percent decrease in catch at the impact site and no change at the reference site(s) (i.e., 0.67/1 -1 = -0.33). This PC of -0.33 could also represent a 50 percent decrease at the impact site and a 25 percent decrease at the reference site (i.e., 0.5/0.75-1= -0.33); or a 20 percent decrease at the impact site and 20% increase at the reference (i.e., 0.8/1.2-1 = -0.33); or other similar combinations that yield a PC value of -0.33.

In the context of statistical power analysis, a threshold effect size considered to be meaningful ($\Delta_M$) is specified and the probability this difference would be statistically significant at the designated α, is the power (power = 1-β, where β is the type II error). Outside of statistical power analysis, observed effect size or level of change is a way of summarizing the metric of interest that can be compared across studies, and is not inherently tied to statistical significance or statistical power. In fact, the observed proportional changes among reference areas are used to establish what constitutes a meaningful threshold effect size or level of proportional change ($\Delta_M$) for impact studies.

- **Power** (1-β, where β is the Type II error) is the probability of rejecting the null hypothesis when the difference in the data exceeds a threshold effect size ($\Delta_M$). In the BACI design setting, it is the probability of finding the interaction BACI contrast to be statistically significant when a proportional change of size $\Delta_M$ is present in the populations.
- **Alpha (α)** is the Type I error, or the probability of rejecting the null hypothesis in error because the true difference is null. The value α is typically fixed, at 0.05 or 0.10 (95 percent or 90 percent confidence). For power estimated through simulations, α is estimated as the percent of significant outcomes when the proportional change imposed on the data was 0. For this study, α = 0.10 was used for the two-tailed null hypothesis which allows us to say whether results are significantly greater than or less than one (the one-tailed hypotheses), with 95 percent confidence (α = 0.05) on each side.
- **Sample size** encompasses the number of sites, replicates, and time periods that are sampled and determines the degrees of freedom for the statistical tests. In this analysis, the overall design was set (i.e., 1 impact site and 2 reference sites; 2 years of monitoring before and after construction, and 4 seasonal trawl surveys per year) and sample size refers to the number of tows per season in each area. Precision for the annual estimates can be improved by appropriate survey timing (i.e., surveys are timed to not miss the seasonal peaks in biomass/abundance), using consistent survey methods, and greater replication (tows per season, years per period, or areas per location). All else being equal, as replication increases, the precision estimates for the model parameters increase. This will result in higher power for a specific level of change, or a smaller detectable level of change for a specific level of power.

# 3.0 Review Existing Datasets

Station level catch data from the NEFSC trawl survey was provided by Phil Politis. The data request was limited to species of recreational and commercial importance that were expected to occur in Strata 1050. The NEFSC (Politis et al. 2014) trawl dataset was used to establish 1) a proximate range of proportional change over time, and 2) the expected distributional form for the catch as biomass and reasonable variance estimates. The NEFSC dataset was screened to only include:

- tows from Stratum 1050, which includes the location for the SRWF and RWF projects (Figure B-1).
- selected species of commercial and recreational importance (Table B-1).

This NEFSC survey design included four to five (random) replicate tows per season in survey strata 1050 from Spring (late March to early May) and Fall (late September to early October) in the years 2010 to 2018, with replicate tows for each season generally occurring on the same day. This dataset provides an adequate representation of the spatial variance among tows during each survey event (i.e., the within-season variability) for this approximately 5,100 $km^2$ stratum and provides estimates of the natural levels of inter-annual changes in catch. The NEFSC trawl survey is limited to spring and fall. Therefore, monthly data from the Block Island Wind Farm (BIWF) trawl survey were also reviewed (Section 3.2) to determine the extent to which the seasonal NEFSC trawl survey captured intraannual biomass peaks for different species of interest. Given that biomass and abundance can vary substantially throughout the course of the year within the proposed Project area, it is important to ensure that this intraannual variability is accounted for when estimating the expected variance for the species of interest in the seasonal trawl survey.

The tows in the NEFSC dataset are at a lower spatial density than what is planned for the trawl survey. We expect the NEFSC estimates of spatial variance to be conservatively high relative to the variance expected from the RWF monitoring, because the trawl survey will occur over a smaller spatial area, so less spatial heterogeneity may be expected amongst replicate tows. The trawl survey will maintain the same spatial sampling densities within the two impact areas and the two reference areas (i.e., all sampling areas will be approximately the same size, and within the boundaries of Stratum 1050).

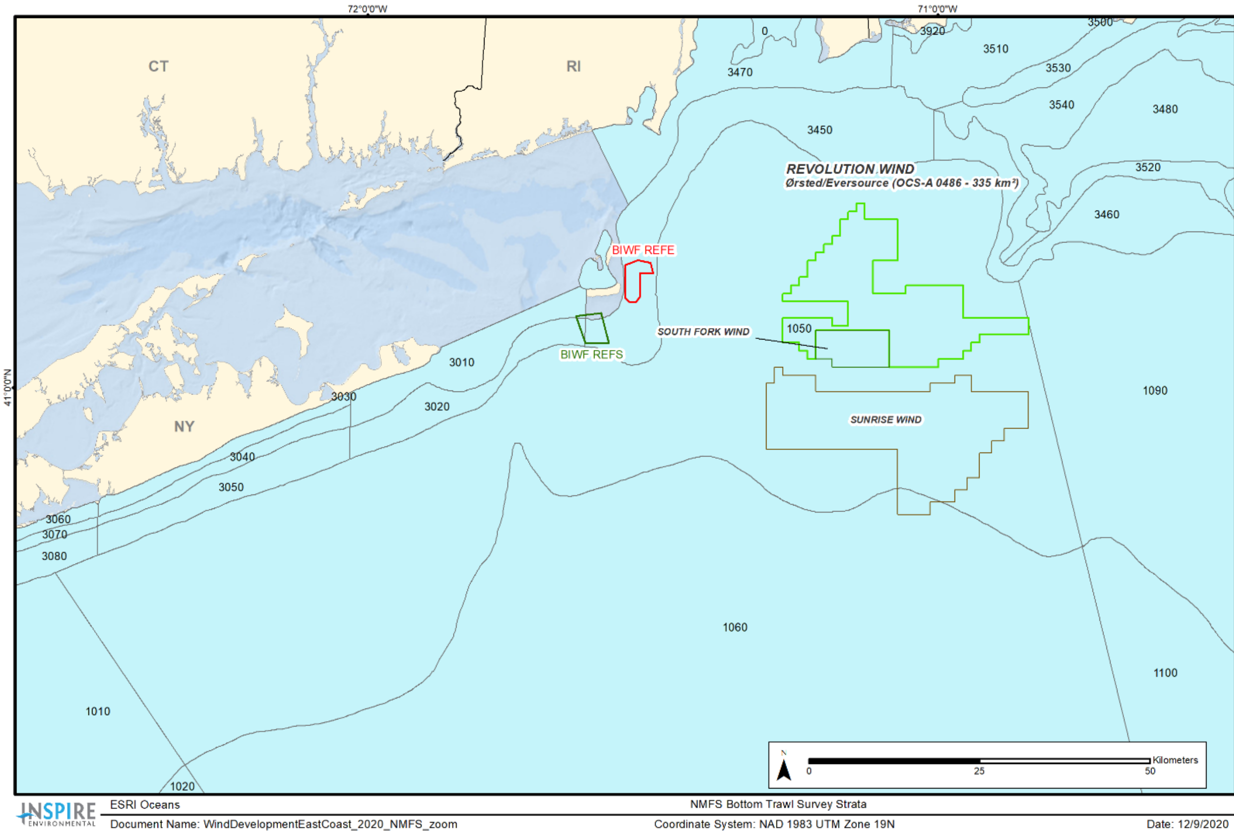



**Figure B-1. Map of NEFSC strata and the Sunrise Wind and Revolution Wind project areas. Trawl survey data sampled in strata 1050 from 2010-2018 were used in the analysis. The reference sites used in the BIWF Trawl survey (REFE and REFS) are also shown.**

**Table B-1. Summary of total catch (biomass, kg) for individual fish and invertebrate species from the NEFSC trawl survey (Politis et al. 2014) sampled in Stratum 1050 from 2010 through 2018. These catch data were used in this analysis.**

| Species | Total biomass (kg) |
|---|---|
| Longfin squid | 523 |
| Little skate | 6422 |
| Summer flounder | 507 |
| Windowpane flounder | 119 |
| Winter skate | 2709 |
| Winter flounder | 481 |
| Butterfish | 587 |
| Atlantic herring | 580 |
| Black sea bass | 276 |
| Silver hake | 576 |
| Scallop | 418 |
| Yellowtail flounder | 277 |
| Scup | 1471 |
| Red hake | 29 |
| Atlantic mackerel | 17 |
| Goosefish | 124 |
| Bluefish | 50 |
| Atlantic menhaden | 0 |
| Channeled whelk | 0 |
| Knobbed whelk | 0 |
| Spanish mackerel | 0 |
| Tautog | 0 |
| Minimum | 0 |
| Maximum | 6422 |
| Median | 276 |

To demonstrate the seasonal variability in mean catch rates in stratum 1050, a summary of the mean catch per tow (kg) for the species shown in Table B-1 is presented by season and year in Figure B-2.

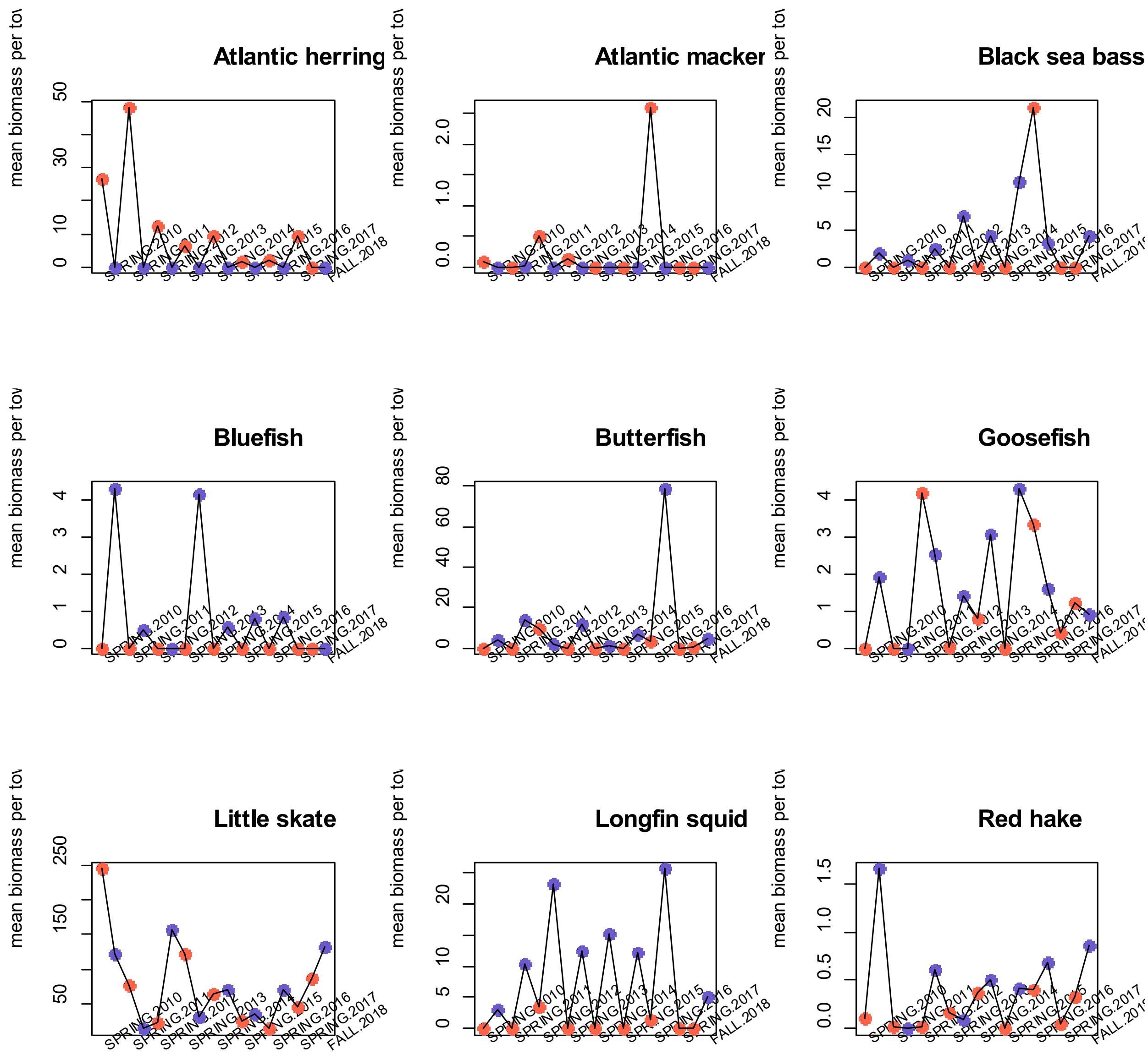



**Figure B-2a. Mean seasonal catch per tow (kg) across season and year, for selected species (Atlantic herring to Red hake) sampled in strata 1050 during the NEFSC seasonal trawl survey from 2010 through 2018. The orange dots represent spring surveys, blue dots represent fall surveys.**

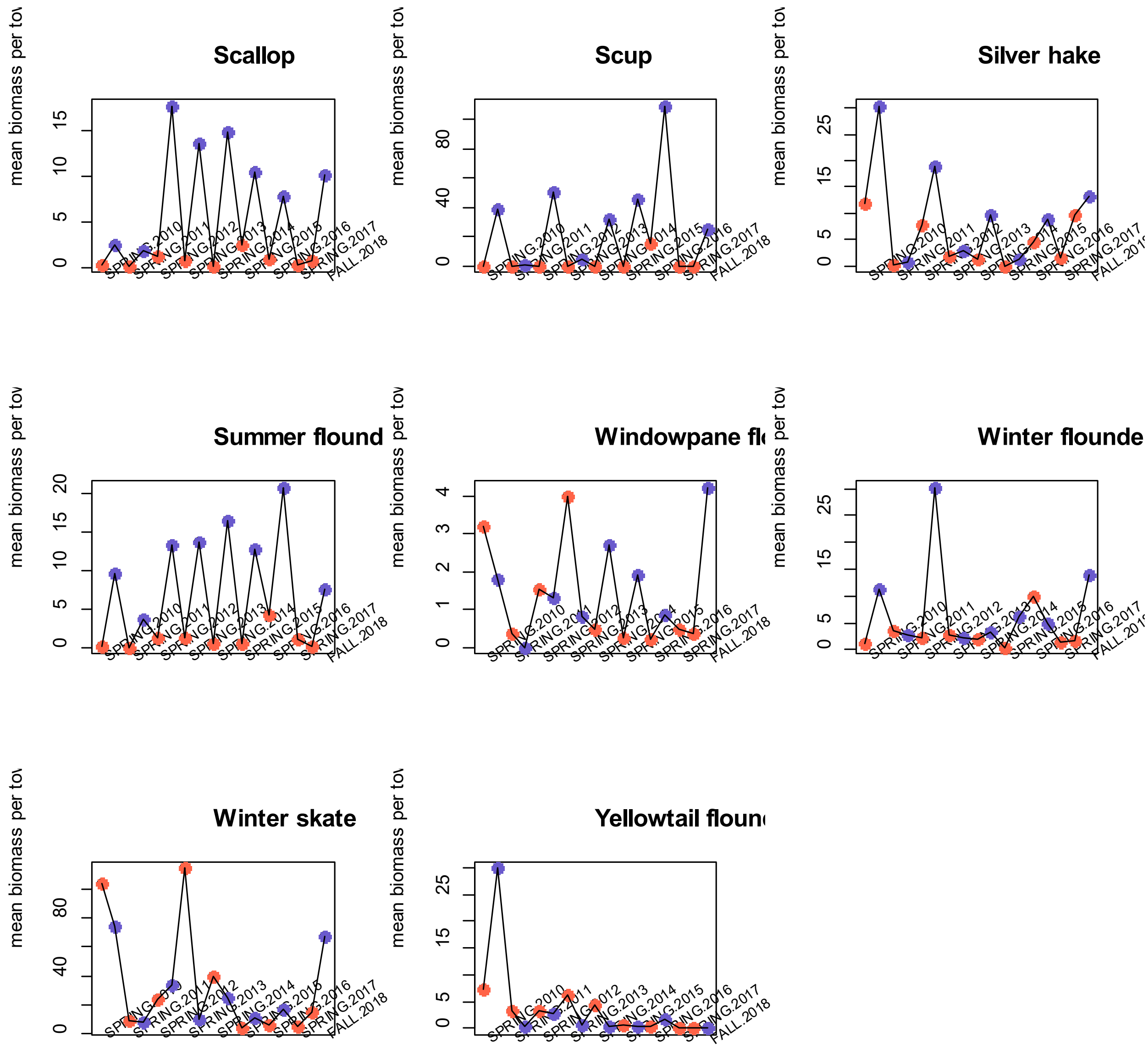



**Figure B-2b. Seasonal catch per tow (kg) across season and year, for selected species (Scallop to Yellowtail flounder) sampled in strata 1050 during the NEFSC seasonal trawl survey from 2010 through 2018. The orange dots represent spring surveys, blue dots represent fall surveys.**

## 3.1 Block Island Wind Farm Trawl Survey Data

Intraannual variation in catch rates (kg/tow) were examined for several species from the monthly trawl survey that occurred over seven years at the two reference areas used in the Block Island Wind Farm (BIWF) monitoring. The monthly BIWF trawl survey data were reviewed to determine the extent to which the NEFSC trawl surveys, which are limited to spring and fall, may miss intraannual biomass peaks. The monthly means from seven years are plotted in Figure B-3 (REFE area) and Figure B-4 (REFS area) for the species of primary commercial and recreational interest. Monthly variation in catch rates was observed at a relatively fine spatial scale (i.e., between the two reference sites) for some species in the BIWF trawl survey, such as windowpane flounder and little skate, which illustrates the advantages that can be gained by using multiple reference sites to monitor changes in abundance over time.

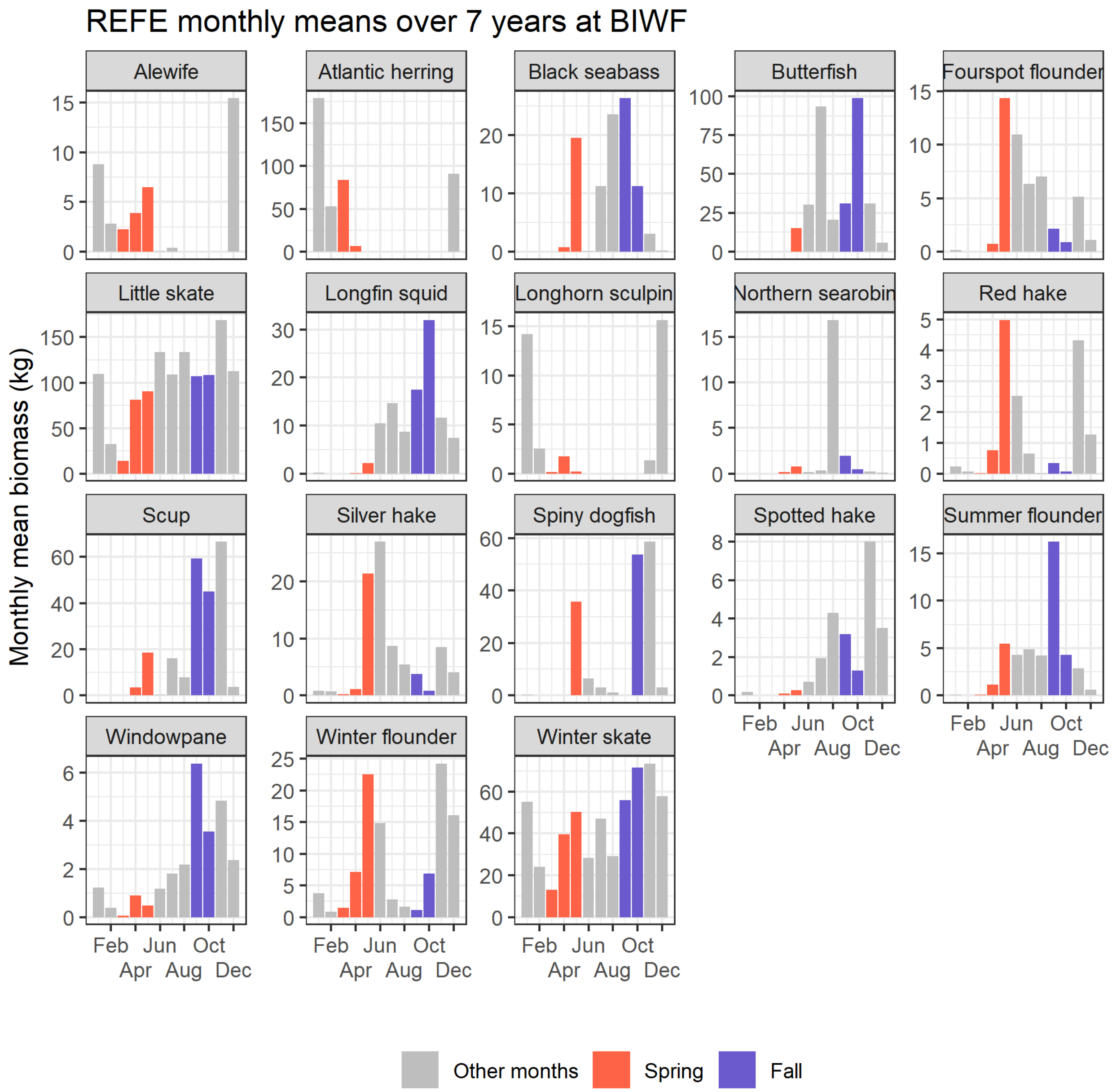



**Figure B-3. Monthly mean biomass (kg) averaged over seven years (from October 2012 to September 2019) for dominant species from the eastern reference area (REFE) from the BIWF trawl survey monitoring. The months that were also sampled in the NEFSC trawl survey are colored orange (spring) and blue (fall).**

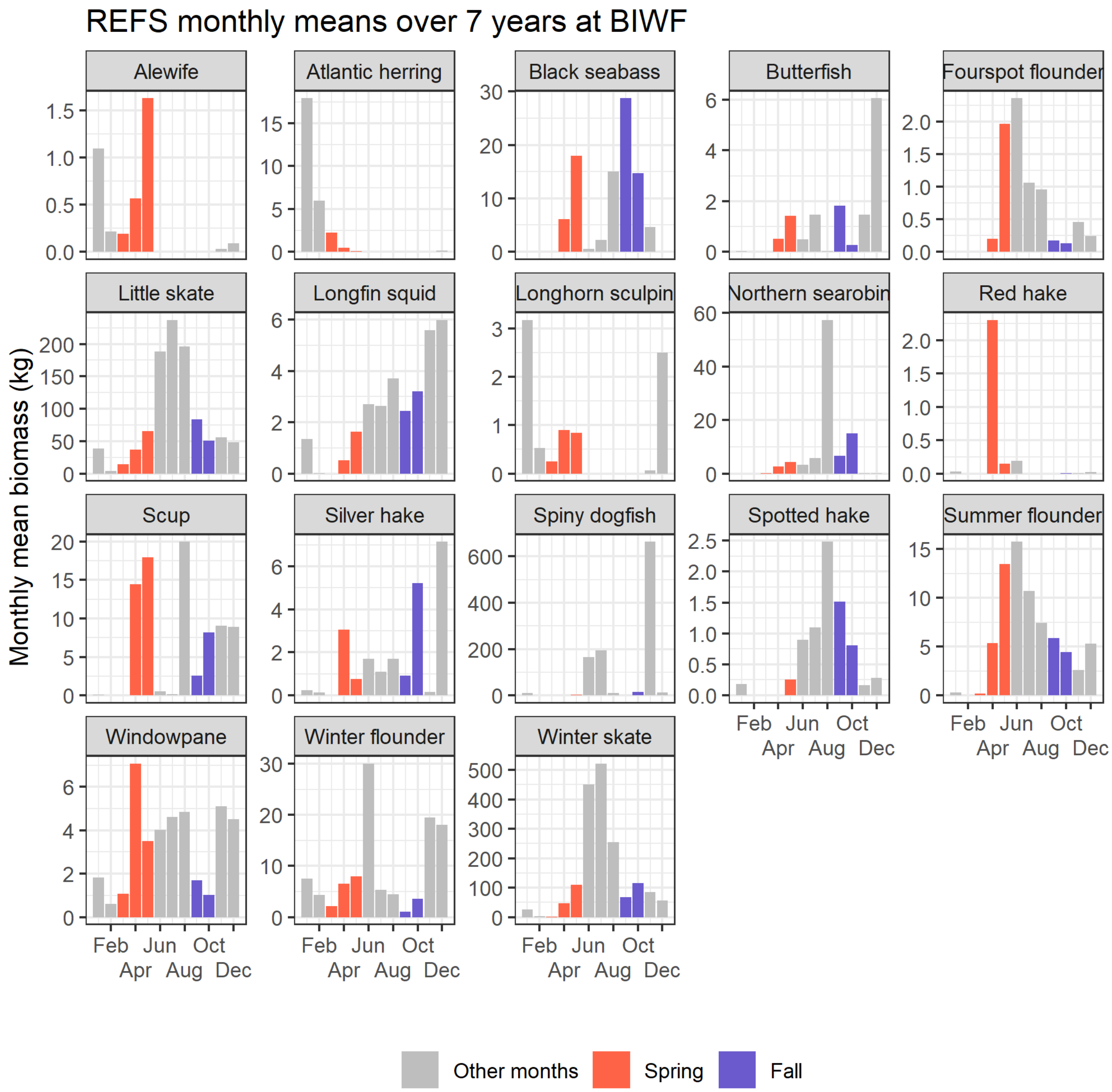



**Figure B-4. Monthly mean biomass from October 2012 to September 2019 (averaged over seven years) for dominant species from the southern reference area (REFS) from the BIWF trawl survey monitoring. The months that were also sampled in the NEFSC trawl survey are colored orange (spring) and blue (fall).**

### 3.2 Reference Effect Sizes

Using the NEFSC and BIWF reference datasets, the proportional change in mean annual biomass (averaged across seasons) between subsequent 2-year time periods, was calculated as:

$$Reference\ Proportional\ Change = \left(\bar{X}_{2,3}/\bar{X}_{0,1} - 1\right) \qquad \text{[Eq. 2]}$$

where

$\bar{X}_{0,1}$ = The two year mean from all seasons in years *i* and *i+1.*

$\bar{X}_{2,3}$ = The two year mean from all seasons in years *i+2* and *i+3.*

For [Eq. 2] note that for the NEFSC dataset, *i*= 2010 through 2014, the annual means were calculated from data from two seasons per year, and where *i* =2014, the mean from 2014 and 2015 was compared to mean from 2016 and 2018 (due to incomplete sampling in 2017). For BIWF REFE and REFS datasets, *i*= 2012 through 2015, and the annual means were calculated from data from four seasons per year (the months January, April, July, and September were subsampled from the monthly time series).

The ranges of relative percent change (proportion x 100) from these extant datasets provide context for generating realistic effect sizes (PC values) to be used in the power calculations. Results are summarized for the NEFSC dataset in Table B-2 and Figure B-5, and for BIWF Reference areas in Table B-2 and Figure B-6. The effect sizes or percent change values [derived from Eq. 2] have a natural lower bound of -100 percent, and an unlimited upper bound.

**Table B-2. Summary of effect sizes as percent change (100 x Eq. 2) by species for reference area datasets from NEFSC and BIWF (results sorted by median value).**

| | NEFSC (n=9) | | | BIWF Reference Areas (n=8) | | |
|---|---|---|---|---|---|---|
| Species | Minimum | Median | Maximum | Minimum | Median | Maximum |
| Spiny dogfish | | n/a | | -98% | -85% | 7250% |
| Atlantic herring | -81% | -75% | -41% | -91% | -36% | 17% |
| Yellowtail flounder | -76% | -61% | -35% | | n/a | |
| Longhorn sculpin | | n/a | | -90% | -60% | -5% |
| Bluefish | -67% | -39% | 837% | | n/a | |
| Winter skate | -78% | -38% | 90% | -52% | -16% | 105% |
| Silver hake | -54% | -36% | 98% | -50% | 812% | 1690% |
| Little skate | -51% | -27% | 58% | -46% | -29% | 56% |
| Windowpane flounder | -42% | -23% | 94% | -56% | -31% | 42% |
| Alewife | | n/a | | -75% | -22% | 1170% |
| Fourspot flounder | | n/a | | -56% | -20% | 41% |
| Butterfish | -53% | -15% | 663% | -89% | -1% | 299% |
| Scallop | -32% | -11% | 497% | | n/a | |
| Goosefish | -21% | 1% | 165% | | n/a | |
| Longfin squid | -26% | 17% | 127% | -37% | -14% | 3% |
| Summer flounder | 7% | 22% | 101% | -56% | -16% | 73% |
| Red hake | -32% | 33% | 78% | -38% | 154% | Inf |
| Scup | -28% | 41% | 362% | -23% | 176% | 811% |
| Winter flounder | -75% | 89% | 162% | -33% | -5% | 25% |
| Spotted hake | | n/a | | -62% | 175% | 1590% |
| Black sea bass | 80% | 232% | 258% | -71% | 47% | 629% |
| Northern sea robin | | n/a | | 62% | 334% | 2360% |
| Atlantic mackerel | -100% | 458% | Inf | | n/a | |
| Minimum | -100% | -75% | -41% | -98% | -85% | -5% |
| Median | -51% | -11% | 114% | -56% | -15% | 105% |
| Maximum | 80% | 458% | 837% | 62% | 812% | 7250% |

n/a=not available. The NEFSC summaries are presented only for those species requested by Orsted from NEFSC. The BIWF summaries are presented for species included in the RI CRMC's Ocean Special Area Management Plan (OSAMP) of recreational and commercial species of concern and/or which had sufficient catch to allow for estimation of relative effect sizes.

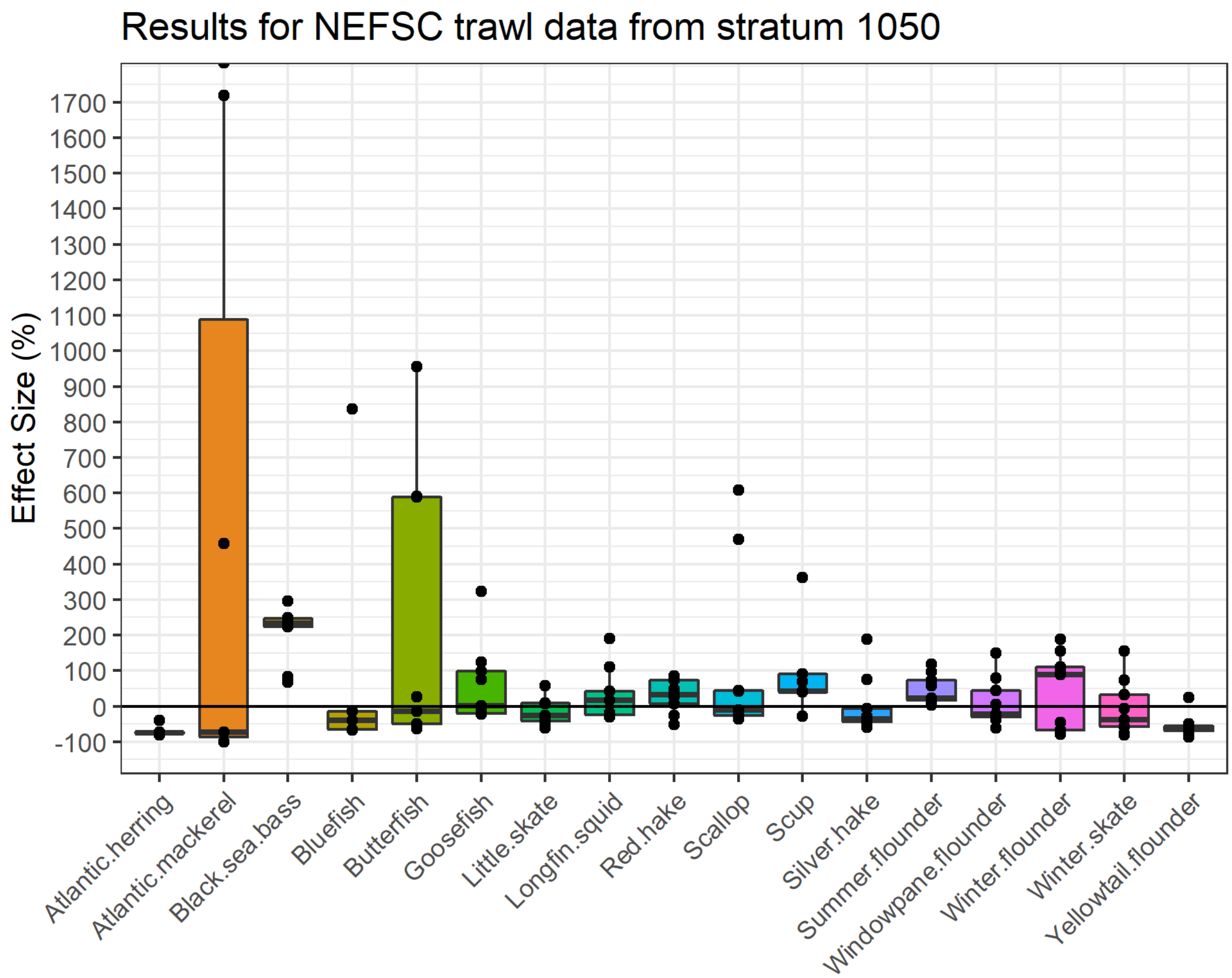



**Figure B-5. Boxplots showing the distribution of effect sizes as relative percent change (100 x Eq. 2) by species for NEFSC dataset (2010 – 2018). Scale of y-axis was truncated to -100% to 1700% to allow greater distinction of the values less than zero.**

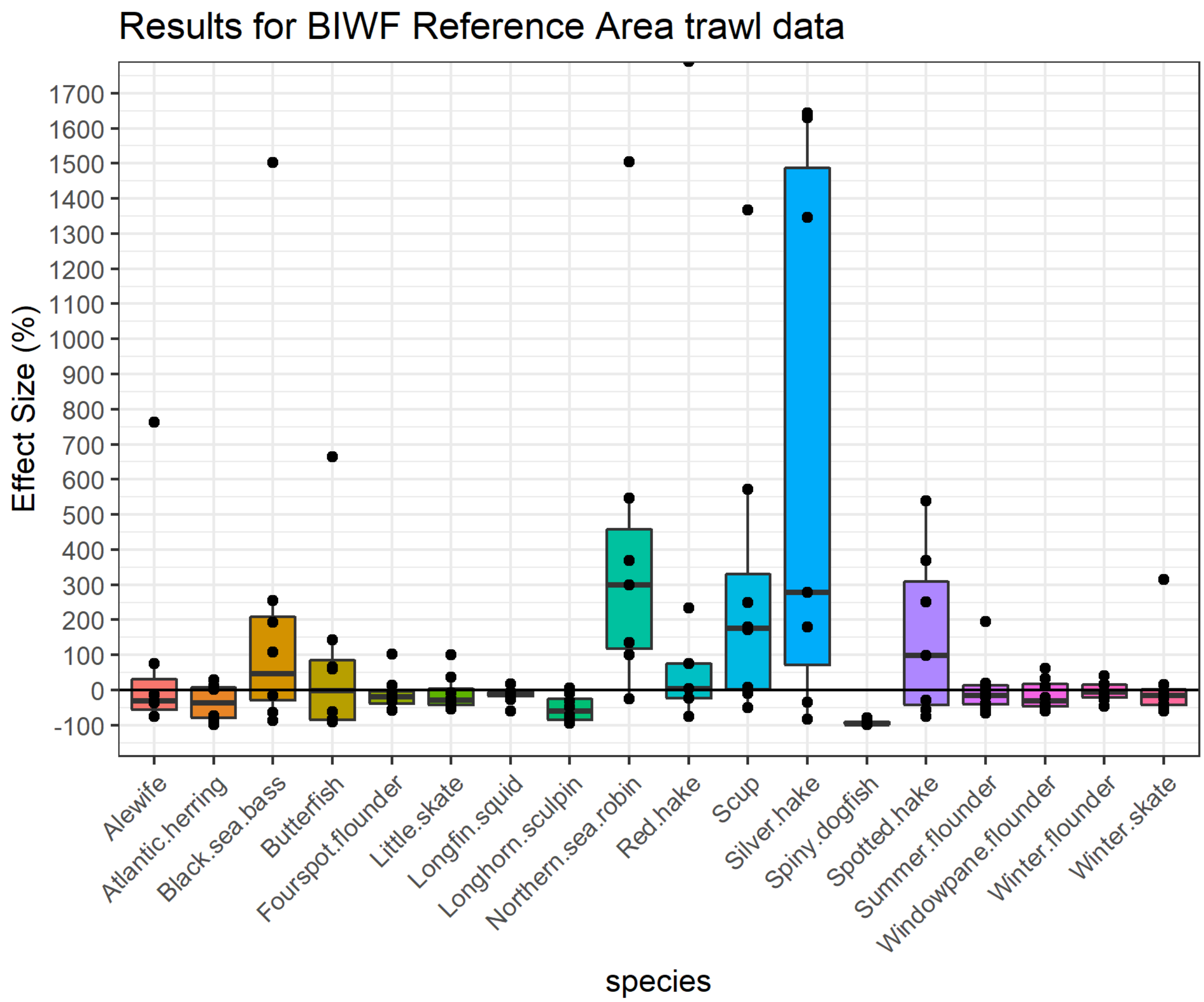



**Figure B-6. Boxplots showing the distribution of effect sizes as relative percent change (100 x Eq. 2) by species for BIWF reference areas (2012/2013 – 2018/2019). Scale of y-axis was truncated to -100% to 1700% to allow greater distinction of the values less than zero.**

Over the nine-year period for the NEFSC dataset, nine of the 17 species had decreases in more years than increases (median values < 0) with median relative percent decreases ranging from -11 to -75 percent. For the BIWF Reference area dataset over the seven-year period 12 of the 18 species had decreases in more years than increases, with median relative percent decreases ranging from -1 to -85 percent.

The results demonstrate the substantial interannual variability that can occur for many species in the region, particularly when survey data are analyzed on a fine spatial scale (which reduces the number of observations). The data suggest that it may be reasonable to attempt to detect effect sizes on the order of 50 percent for some species (e.g., longfin squid), but for other species that display greater interannual variability (e.g., butterfish) detecting anything smaller than a 50 percent relative change may not be possible given practical constraints and the underlying natural variability in abundance and availability associated with those populations.

### 3.3 Coefficient of Variation

Catch (kg) per tow is naturally bounded by zero and the distribution tends to be skewed with most catches around the median value and large catches in a few tows, approximating a lognormal distribution. The NEFSC biomass data from replicate tows within a single season in Stratum 1050 were too sparse to adequately test this (n=4 to 5 per season within Strata 1050), but the data generally fit this description. For the lognormal distribution, the standard deviation (SD) is proportional to the mean and the coefficient of variation (CV = SD/mean) on the original scale is used to summarize variability in catch rates independent of the mean. A summary of the seasonal CV values for the NEFSC dataset is shown in Table B-3. For conservative sample size estimates in the power analyses (Section 4.0), the observed range of median to maximum CV values across seasons, years, and species were used (0.8 to 2.2)

**Table B-3. Summary of seasonal variance estimates for catch (biomass, kg) for the individual fish and invertebrate species from NEFSC trawl survey in Stratum 1050 that were used in this analysis.**

| | | Seasonal Coefficients of Variation (CVs) Summarized across Seasons and Years | | |
|---|---|---|---|---|
| **Species** | **Number of Seasons with Catch** | **Minimum** | **Median** | **Maximum** |
| Longfin squid | 10 | 0.4 | 0.8 | 1.4 |
| Little skate | 17 | 0.4 | 0.9 | 1.6 |
| Summer flounder | 17 | 0.4 | 0.9 | 2.2 |
| Windowpane flounder | 16 | 0.3 | 1.0 | 1.8 |
| Winter skate | 17 | 0.4 | 1.1 | 1.9 |
| Winter flounder | 17 | 0.8 | 1.2 | 1.8 |
| Butterfish | 11 | 0.6 | 1.3 | 2.0 |
| Atlantic herring | 12 | 0.8 | 1.3 | 2.2 |
| Black sea bass | 13 | 0.6 | 1.4 | 2.2 |
| Silver hake | 17 | 0.8 | 1.4 | 2.1 |
| Scallop | 17 | 0.8 | 1.5 | 2.2 |
| Yellowtail flounder | 16 | 0.6 | 1.5 | 2.2 |
| Scup | 10 | 0.7 | 1.6 | 2.2 |
| Red hake | 16 | 0.8 | 1.7 | 2.2 |
| Atlantic mackerel | 5 | 1.7 | 1.8 | 2.0 |
| Goosefish | 14 | 0.9 | 1.8 | 2.2 |
| Bluefish | 6 | 1.5 | 2.1 | 2.2 |
| Minimum | 5 | 0.3 | 0.8 | 1.4 |
| Median | 16 | 0.7 | 1.4 | 2.2 |
| Maximum | 17 | 1.7 | 2.1 | 2.2 |

# 4.0 Power Analysis

## 4.1 The Study Design and Model

An asymmetrical BACI design was tested in this power analysis, with the design variables as specified in Table B-4. For comparison, a symmetrical BACI (i.e., one impact and one reference area) was evaluated for power using a limited scenario (i.e., a single CV).

**Table B-4. Design for Sunrise Wind trawl survey power simulation study**

| Set study design variables |
|---|
| • Impact Areas = 1 impact area |
| • Reference Areas = 2 control/reference areas |
| • Habitat Strata = 1 |
| • Frequency = four seasons per year |
| • Number of years Before impact = 2<br>• Number of years After impact = 2 |
| Variables altered in the power analysis |
| • Number of replicate (random) trawls per season in each area (n): 5, 10, 12, 14, 16, 20, 30, 40 |
| • Proportional Change (PC) of Impact / Reference : -25%, -33%, -40%, -50%, -70% (Section 3.3) and 0% (for Type I error) |
| • CVs: 0.8, 1.0, 1.2, 1.4, 1.8, 2.2 (Section 3.4) |
| • A two-tailed α = 0.10 |

For a saturated model that estimates the mean catch (kg) for each season, year, and location, the BACI interaction contrast is described as

$$\left(\bar{X}_{Impact,Before} - \bar{X}_{Impact,After}\right) - \left(\bar{X}_{Control,Before} - \bar{X}_{Control,After}\right) \quad \text{[Eq. 3]}$$

where

$\bar{X}_{Impact,Period}$ = The two-year log-scale mean biomass per tow (kg) from the Impact area, averaged across four seasons in all years of the *Period* (Before or After).

$\bar{X}_{Control,Period}$ = The two-year log-scale mean biomass per tow (kg) averaged across the two Reference areas, and four seasons in all years of the *Period* (Before or After).

## 4.2 Simulation methods

The power analysis used a simulation approach to generate significance values for a range of CV estimates, effect sizes (PC values), and a range of sample sizes (Table B-4). Given the substantial intraannual variability that is present amongst the fish populations in the region (Figures B-2, B-3, and B-4), accounting for seasonality is important when estimating statistical power. Therefore, seasonality for this four-season sampling design was imposed as two seasons with the same mean catch per tow μ, and the other two seasons having mean 0.25μ (a 75% decrease). Note that this is just one of several permutations that could be used to simulate the seasonal variability that is anticipated to be present in the trawl survey catch rates. The effect size (PC) was imposed on every season during the After period. Note that proportional changes on the original scale become additive changes on the log-scale; consequently, log-scale changes are a function only of the PC value and do not depend on the starting mean value. Code was written in (R Core Team 2020) to conduct the simulations; the R code is included as an addendum to this appendix.

For a given CV, PC, and sample size (n), the following steps were performed m=1000 times:

1. From a log-normal distribution with mean μ and CV, simulate *n* values of catch data for 2 seasons in each year of the Before period, for all Impact and Reference areas. Repeat with mean 0.25μ for the other 2 seasons of each year of the Before period, for all Impact and Reference areas.
2. Repeat step 1 for each year of the After period for the two Reference areas.
3. Repeat step 1 for each year of the After period for the Impact area, but with a reduced mean equal to (1+PC)μ for 2 seasons, and mean 0.25 x (1+PC)μ for the other 2 seasons.
4. Fit the saturated model to the log-transformed biomass data (i.e., a separate coefficient for every area-period-season-year).
5. Calculate the BACI interaction contrast, and save the p-value.
6. Repeat m=1000 times for 1000 simulation replicates.
7. Count the number of times out of m that the p-value was < 0.10, and store this simulated power estimate for that combination of CV, PC, and n.

Repeat Steps 1-7 for each combination of CV, PC, and n.

### 4.3 Results

The simulation power results for a design with one impact and two reference areas are shown in Table B-5 and Figure B-7. Using an asymmetrical BACI design with two reference areas increases the statistical power of the survey design when compared to a BACI approach that relies on a single reference area (Figure B-8).

**Table B-5. Simulated power for the BACI interaction contrast within a saturated model (see text) for a range of variance (CV), effect sizes (% change), and sample sizes (n) per season per area, and using a two-tailed α = 0.10 and a design with one impact and two reference areas. The 0% change illustrates the type I error. Results with power 80% and above are shaded.**

| % Change | Sample Size (n) | CV=0.8 | CV=1.0 | CV=1.2 | CV=1.4 | CV=1.8 | CV=2.2 |
|---|---|---|---|---|---|---|---|
| 0 | 5 | 0.10 | 0.10 | 0.13 | 0.12 | 0.12 | 0.09 |
| 0 | 10 | 0.09 | 0.11 | 0.10 | 0.11 | 0.10 | 0.10 |
| 0 | 20 | 0.10 | 0.11 | 0.10 | 0.11 | 0.09 | 0.09 |
| 0 | 30 | 0.11 | 0.11 | 0.10 | 0.09 | 0.10 | 0.10 |
| 0 | 40 | 0.09 | 0.10 | 0.09 | 0.10 | 0.11 | 0.09 |
| -25% | 5 | 0.46 | 0.35 | 0.29 | 0.29 | 0.22 | 0.20 |
| -25% | 10 | 0.66 | 0.53 | 0.49 | 0.41 | 0.33 | 0.31 |
| -25% | 20 | 0.92 | 0.80 | 0.73 | 0.66 | 0.55 | 0.48 |
| -25% | 30 | 0.98 | 0.94 | 0.86 | 0.80 | 0.69 | 0.62 |
| -25% | 40 | 1 | 0.96 | 0.94 | 0.89 | 0.79 | 0.73 |
| -33% | 5 | 0.66 | 0.54 | 0.46 | 0.42 | 0.35 | 0.30 |
| -33% | 10 | 0.91 | 0.80 | 0.72 | 0.66 | 0.54 | 0.47 |
| -33% | 20 | 1.00 | 0.97 | 0.92 | 0.88 | 0.79 | 0.71 |
| -33% | 30 | 1 | 1 | 0.90 | 0.97 | 0.92 | 0.86 |
| -33% | 40 | 1 | 1 | 1 | 0.99 | 0.97 | 0.94 |
| -40% | 5 | 0.85 | 0.71 | 0.63 | 0.56 | 0.46 | 0.43 |
| -40% | 10 | 0.98 | 0.92 | 0.88 | 0.81 | 0.72 | 0.63 |
| -40% | 20 | 1 | 1 | 0.99 | 0.97 | 0.91 | 0.89 |
| -40% | 30 | 1 | 1 | 1 | 1 | 0.99 | 0.96 |
| -40% | 40 | 1 | 1 | 1 | 1 | 1 | 0.99 |
| -50% | 5 | 0.97 | 0.92 | 0.86 | 0.80 | 0.65 | 0.60 |
| -50% | 10 | 1 | 1 | 0.99 | 0.96 | 0.91 | 0.85 |
| -50% | 20 | 1 | 1 | 1 | 1 | 0.99 | 0.98 |
| -50% | 30 | 1 | 1 | 1 | 1 | 1 | 1 |
| -50% | 40 | 1 | 1 | 1 | 1 | 1 | 1 |
| -70% | 5 | 1 | 1 | 1 | 0.99 | 0.98 | 0.94 |
| -70% | 10 | 1 | 1 | 1 | 1 | 1 | 1 |
| -70% | 20 | 1 | 1 | 1 | 1 | 1 | 1 |
| -70% | 30 | 1 | 1 | 1 | 1 | 1 | 1 |
| -70% | 40 | 1 | 1 | 1 | 1 | 1 | 1 |

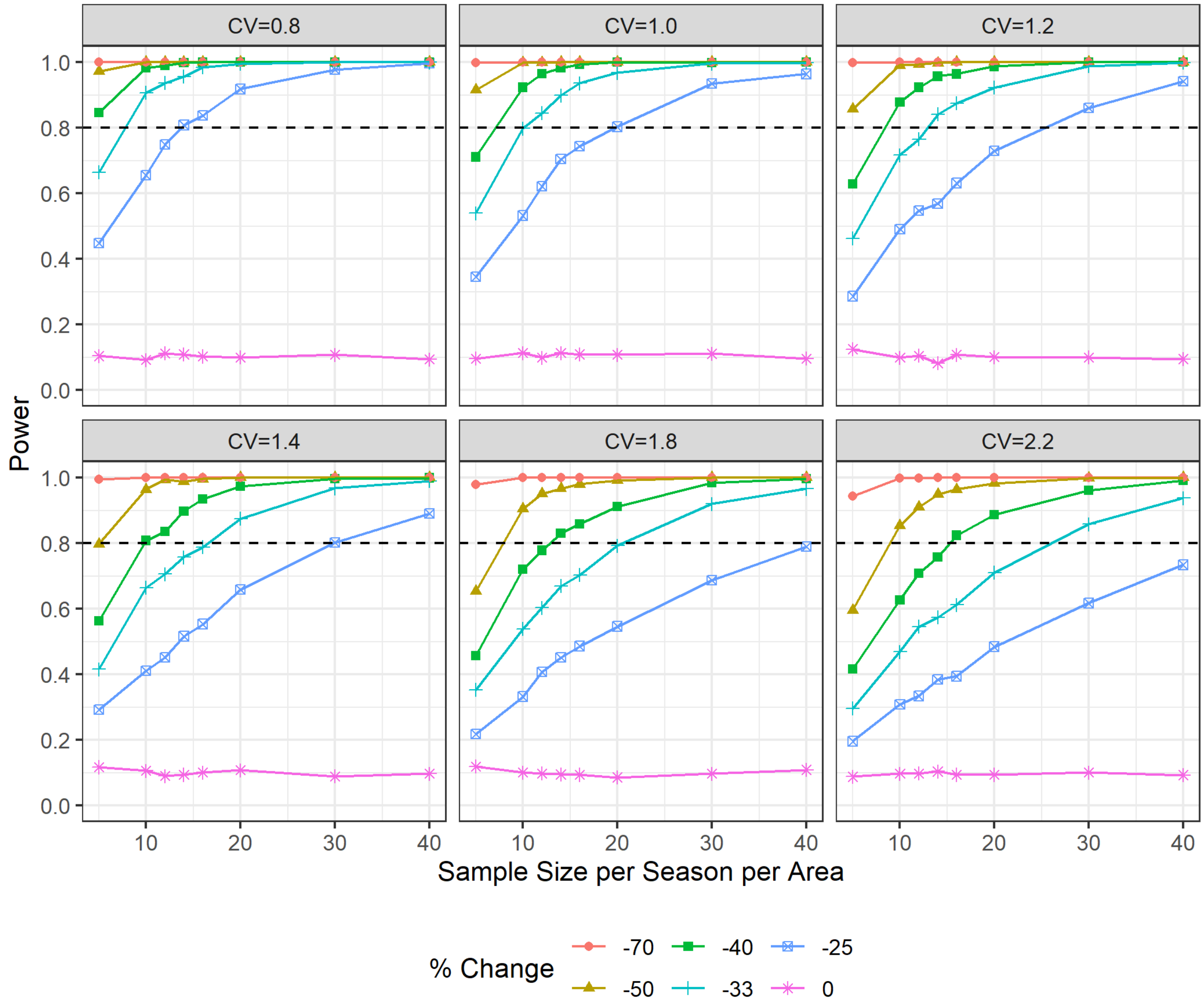



**Figure B-7. Power curves for the BACI interaction contrast within a saturated model (see text) for a range of variance (CV), effect sizes (negative % Change) and seasonal sample sizes in each area (n) and using a two-tailed α = 0.10. The 0% change illustrates the type I error.**

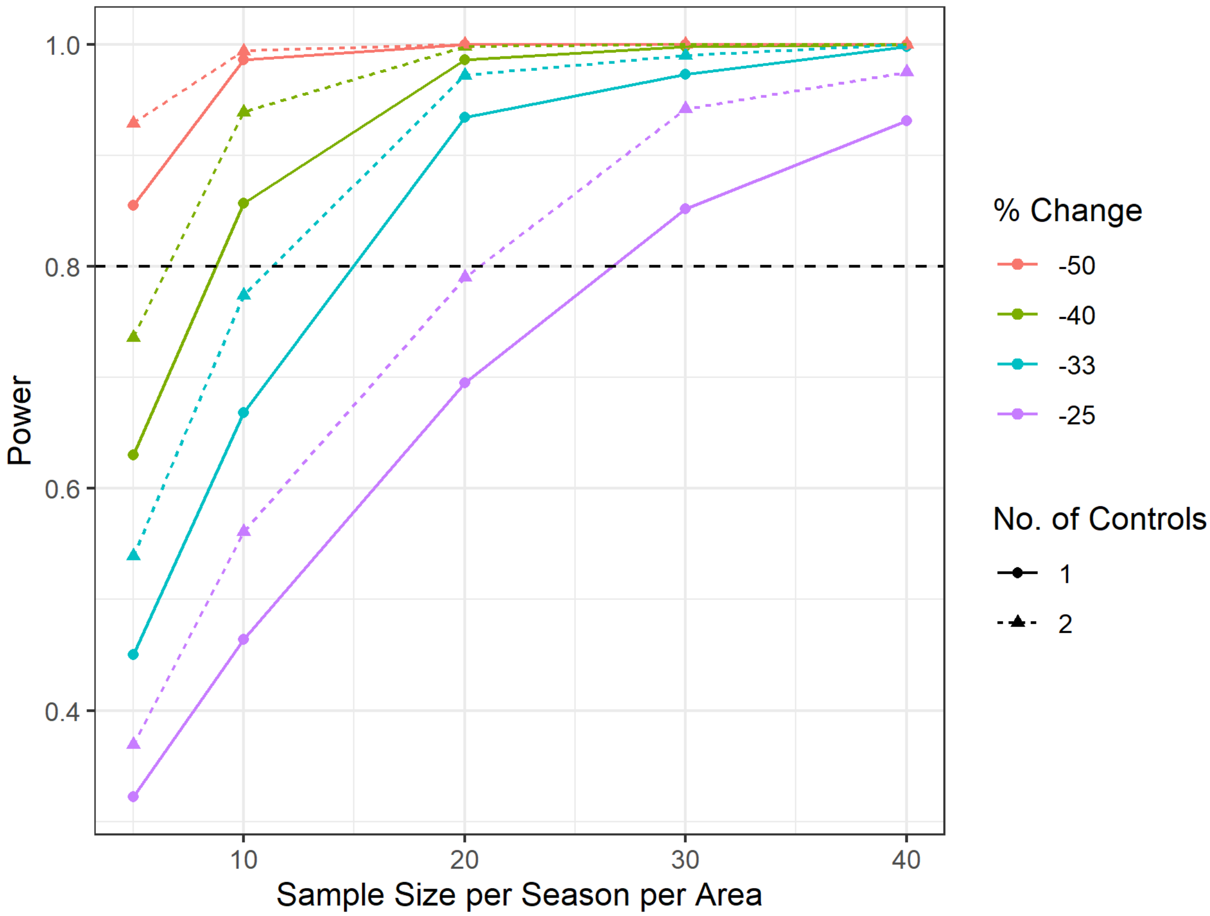



**Figure B-8. Power curves to illustrate the differences in power between designs with one or two reference areas for a range of effect sizes (negative % Change), and a single CV = 1.0.**

# 5.0 Summary and Conclusions

- Data from regional trawl surveys demonstrate that fish species in the region generally exhibit moderate to high levels of natural variability (both seasonal and annual), especially when the data are analyzed on a relatively small spatial scale, which limits the number of observations.
- Given the underlying variability in catch rates that will likely be exhibited in the SRWF and RWF trawl survey, it is not practicable to attempt to document a small effect size (e.g., 25 percent relative decrease) for fish and invertebrate species.
- For species that may be expected to demonstrate lower median CV's (e.g., 0.8-1), a seasonal sampling intensity of 10 tows/area would yield >80 percent power of detecting an effect size of 33 percent relative decrease or greater.
- For species that may be expected to demonstrate higher median CV's (e.g., 1.2 – 1.4), a seasonal sampling intensity of 10 tows/area would yield >80 percent power of detecting an effect size of 40 percent relative decrease or greater.
- For species that demonstrate higher variability in trawl survey catch rates (e.g., CVs > 1.4) a seasonal sampling intensity of 10 tows/area would only be capable of detecting larger changes in catch rates (e.g., ≥50 percent relative decrease).
- Including a second reference site improves the statistical power of the design for a given level of sampling intensity.
- This power analysis will be re-visited after the first year of the trawl survey. The observed CV values will be evaluated to determine whether sampling intensity needs to be modified to achieve the desired level of statistical power.
- Simulation results indicate that taking conservatively higher sample sizes in the first year and adapting to a lower sampling effort in subsequent years (e.g., 15 tows the first year and 10 tows in subsequent years) results in a marginal increase in power (i.e., power increases from 80 to 81 percent for CV=1 and PC=-33 percent) compared to sampling 10 tows in every year. On the other hand, taking fewer samples in the first year and adapting to greater sampling effort in subsequent years (e.g., 10 tows the first year and 15 tows in subsequent years) results in a small decrease in power (i.e., power is reduced from 93 to 90 percent for CV=1 and PC=-33%) compared to sampling 15 tows every year.

# 6.0 References

Durlak, J.A. 2009. How to Select, Calculate, and Interpret Effect Sizes, Journal of Pediatric Psychology 34(9) pp. 917–928.

Politis PJ, Galbraith JK, Kostovick P, Brown RW. 2014. Northeast Fisheries Science Center bottom trawl survey protocols for the NOAA Ship Henry B. Bigelow. Northeast Fish Sci Cent Ref Doc. 14-06; 138 p. Online at: https://doi.org/10.7289/V5C53HVS

R Core Team. 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Wilber, D., L. Read, M. Griffin, and D. Carey. 2020. *Block Island Wind Farm Demersal Fish Trawl Survey Synthesis Report – Years 1 to 6, October 2012 through September 2018.* Technical report prepared for Deepwater Wind, Providence, RI. 80 pp.

# APPENDIX C – Sunrise Wind Protected Species Training Plan

*Training Plan for Fisheries Surveys Scientists in fulfillment of Biological Opinion Conditions*

This training plan was created to address Reasonable and Prudent Measures (RPM) and Terms and Conditions listed in the Sunrise Wind Biological Opinion. Further this plan addresses mitigation, monitoring and reporting measures for Endangered Species Act relevant to Sunrise Wind fisheries monitoring surveys, as listed in Appendix A of the Sunrise Wind Biological Opinion. These include protected species awareness and identification, offshore roles/responsibilities, marine trash and debris awareness training, and all communication, monitoring, and operational procedures for this fisheries monitoring survey.

In accordance with the Terms and Conditions #10 of the Sunrise Wind Biological Opinion:
'To implement RPM 4 for trawl surveys:

a) At least one of the survey staff onboard the trawl survey vessels must have completed NMFS Northeast Fisheries Observer Program (NEFOP) training within the last 5 years or other training in protected species identification and safe handling (inclusive of taking genetic samples from Atlantic sturgeon); documentation of training must be submitted to NMFS GARFO at least 7 calendar days prior to the start of the trawl surveys and at any later time that a different NEFOP trained observer is deployed on the survey.

b) If Sunrise Wind will deploy non-NEFOP trained survey personnel in lieu of NEFOP-trained observers, BOEM, BSEE, and/or Sunrise Wind must submit a plan to NMFS describing the training that will be provided to those survey observers. This Observer Training Plan for Trawl Surveys must be submitted as soon as possible after issuance of this Opinion but no later than 15 calendar days prior to the start of trawl surveys for which a non-NEFOP trained observer will be deployed. BOEM, BSEE, and Sunrise Wind must obtain NMFS GARFO's concurrence with this plan prior to the start of any such trawl surveys. This plan must include a description of the elements of the training (i.e., curriculum, virtual or hands on, etc.) and identify who will carry out the training and their qualifications. Once the training is complete, confirmation of the training and a list of trained survey staff must be submitted to NMFS; this list must be updated if additional staff are trained for future surveys. In all cases, a list of trained survey staff must be submitted to NMFS at least one business day prior to the beginning of the survey.'

Sunrise Wind researchers at the Commercial Fisheries Research Foundation (CFRF) undertook a combination of trainings from Lynker, NOAA and former NEFOP observer and current NOAA Cooperative Research employee Ben Church to satisfy the protected species identification and safe handling requirement outlined in the above Biological Opinion Term and Condition.

Sunrise Wind researchers at the School for Marine Science and Technology (SMAST) undertook a combination of trainings from AIS, NOAA and former NEFOP observer and current NOAA Cooperative Research employee Ben Church to satisfy the protected species identification and safe handling requirement outlined in the above Biological Opinion Term and Condition.
The Lynker course entitled 'Protected Species Training for CFRF' (agenda attached) was designed specifically for CFRF staff with instruction in the:

- Identification, safe handling, measuring, resuscitation, reporting requirements and release of sea turtles.
- Identification, safe handling, measuring, Passive Integrated Transponder (PIT) tag scanning reporting requirement and release of sturgeon.
- Identification, observing responsibilities and reporting of marine mammals; and
- Identification of sea birds

This was a virtual training and was conducted by Stephanie DePasquale and Jordan Katz, both of Integrated Statistics (resumes attached).

The AIS course entitled 'AIS Protected Species Sampling Training Course' is a reoccurring course (agenda attached) with instruction in the:

- A review of relevant federal legislation
- Sea Turtle identification and incidental take duties and sampling (including safe handling, data collection, report submission, resuscitation and release).
- Marine mammal species identification incidental take duties and sampling (including safe handling, data collection, report submission, resuscitation and release).
- Sturgeon identification and incidental take duties & sampling safe handling (including safe handling, data collection, report submission, resuscitation and release).

This was a virtual training and was conducted by Lauren Wahl and Sarah Fortuna, both AIS protected species program managers.

CFRF and SMAST staff took the NOAA Atlantic Highly Migratory Species Safe Handling, Release and Identification Workshop provided further instruction in the identification, safe handling and release of sawfish and sturgeon, sharks and rays, sea turtles and marine mammals. This was an in-person training offered by NOAA and all training materials can be found here (Atlantic Highly Migratory Species Safe Handling, Release, and Identification Resources | NOAA Fisheries).

CFRF and SMAST staff also received video instruction on species identification, photography, genetic sampling extraction (including sample size and location), preservation and labelling and PIT tag scanning of sturgeon (https://www.dropbox.com/scl/fo/iobjwgbl6a5g0khmptt4m/h?dl=0). The instructor, Ben Church, was a Northeast Fisheries Observer Program Observer, a Northeast Fisheries Observer Program Data Debriefer and taught shark and sturgeon identification/biological sampling as part the Individual Animal Log documentation to at-sea monitors, NEFOP and Industry Funded Scallop observers as part of their initial training.

Additionally, all vessel and survey crew are required to take a Permitting and Environmental Compliance Plan (PECP) training prior to the start of each fisheries monitoring survey component. This is a virtual training conducted by the Sunrise Permitting team. The training will provide a survey overview, the survey plans, permits and environmental compliance including marine debris training, communications and vessel best practices, marine species identification and protection including vessel separation distances, strike avoidance, record keeping and reporting procedures including protected species reporting (slide deck attached). All training participants are required to sign a sign in sheet after completion of training.

**Table 1:** The Bureau of Ocean Energy Management proposed mitigation, monitoring and reporting measures for Endangered Species Act listed species in the Action Area relevant to Sunrise fisheries monitoring surveys, as listed in Appendix A of the Sunrise Wind Biological Opinion (Measure), the relevant training component (Training Component) and a brief description of how the training satisfies the Measure (Description).

| Measure | Training Component | Description |
|---|---|---|
| **Sea turtle/ Atlantic sturgeon identification and data collection** | AIS<br><br>Lynker<br><br>Instructional Video<br><br>NOAA | Turtles: The AIS, Lynker and NOAA courses provided instruction in the morphology, identification, safe handling and release of captured sea turtles. They also provided instruction in determining animal condition and photographing captured sea turtles as well as correctly filling out the required take report forms including required measurements.<br><br>Sturgeon: The AIS and Lynker courses provided instruction in the morphology, identification safe handling and release of captured sturgeon. They also provided instruction in measuring, weighing, and photographing sturgeon as well as scanning the fish for PIT tags and genetic sampling. Finally, these courses provided instruction in correctly filling out required take report forms, including required measurements.<br><br>Video training provided instruction in species identification, photography, genetic sampling extraction, preservation and labelling and PIT tag scanning of Atlantic and shortnose sturgeon.<br><br>Finally, the vessel will carry a PIT tag reader capable of identifying tagged animals. |
| **Sea turtle/Atlantic sturgeon handling and resuscitation guidelines** | AIS<br><br>Lynker<br><br>NOAA | Turtles: These courses provided instruction in the safe handling, resuscitation, and release of the different species of sea turtles that might be encountered during fisheries surveys. |

| | | |
|---|---|---|
| | | Sturgeon: These courses provided instruction in the safe handling, resuscitation and release of sturgeon that might be encountered during fisheries surveys. |
| **Take notification** | AIS<br><br>Lynker<br><br>PECP | These courses provided instruction on reporting requirements and how to properly fill out take report forms for marine mammals, sea turtles and sturgeon.<br><br>The PECP also addressed take notifications and reporting requirements. |
| **Gear identification forms (sea turtles/Atlantic Sturgeon)** | N/A | N/A as pot/trap surveys are not part of the Sunrise Wind Fisheries Monitoring Plan |
| **Sea Turtle disentanglement** | N/A | N/A as pot/trap surveys are not part of the Sunrise Wind Fisheries Monitoring Plan |
| **Marine Debris awareness and elimination** | PECP | Vessel and survey crew undergo Marine Debris Awareness Training as part of the PECP training. This training included slides that define marine debris, outlined best practices and incorporated a ~ 10-minute video from BSEE on marine debris and prevention (BSEE Marine Trash and Debris Update - YouTube). |
| **Survey training** | AIS<br><br>Lynker<br><br>Instructional Video<br><br>NOAA | A combination of these courses were used to meet the requirements of the SRW BiOp Term and Condition 10 the ensure that at least one of the survey staff have been trained in protected species identification and safe handling. |

| | | |
|---|---|---|
| **Vessel Crew and Visual Observer Training Requirements** | PECP | Vessel and survey crew were provided instruction in marine mammal and sea turtle identification, vessel strike avoidance and reporting requirements as part of the PECP training. All vessel and survey crew are also required to fill out a sign in sheet after completion of the PECP training. |
| **Vessel Observer Requirements** | PECP | Vessel and survey crew are required to have a designated watch during fisheries surveys. Crew members are provided species identification training and instruction on vessel avoidance, separation distances, NARW SMAs and DMAs and reporting as part of the PECP training. The training slides are on the vessel during fisheries surveys. |

| | | |
|---|---|---|
| **Vessel Strike Avoidance of Small Cetaceans and Seals** | PECP | Vessel and survey crew are provided instruction on separation distances and corrective actions (including speed reduction) for marine mammals and sea turtles as part of the PECP training. |
| **Vessel Strike Avoidance of Sea Turtles** | PECP | Vessel and survey crew are provided instruction on separation distances and corrective actions (including speed reduction) for marine mammals and sea turtles as part of the PECP training. |
| **Reporting of All NARW Sightings** | PECP | All vessel and survey crew are provided instruction on NARW reporting requirements during the PECP training. |
| **Detected or Impacted Protected Species Reporting** | PECP | All vessel and survey crew are provided instruction on protected species reporting requirements during the PECP training. |

**Table 2.** The Reasonably Prudent Measure (RPM) and Terms and Conditions (T&C) related to the SRW trawl survey (Measure), the relevant training component (Training Component) and a brief description of how the training satisfies the Measure (Description).

| Measure | Training Component | Description |
|---|---|---|
| **RPM 4**<br><br>**T&C 7 a-**<br><br>**Sea Turtle or sturgeon observations or interactions reporting** | AIS<br><br>Lynker<br><br>NOAA PECP | Turtles: The AIS, Lynker and NOAA courses provided instruction in correctly filling out the required take report forms including required measurements.<br><br>Sturgeon: The AIS and Lynker courses provided instruction in correctly filling out required take report forms, including required measurements.<br><br>The PECP training provided instruction on the reporting requirements for sea turtles and sturgeon including the timelines for report submittal. |
| **RPM 4**<br>**T&C 7b**<br>**North Atlantic Right Whale Reporting** | PECP | The PECP training provides instruction on the procedures for reporting North Atlantic Right Whale sightings including regional contacts, required information and reporting timelines. |
| **RPM 4**<br>**T&C 7c**<br>**Vessel strike reporting** | PECP | The PECP training provides instruction on the procedures for reporting a suspected or confirmed vessel strike of ESA listed species including agency contact information, required report information and reporting timelines. |
| **RPM 4**<br>**T&C 7d**<br>**Injured or dead animal reporting** | PECP | The PECP training provides instruction on the procedures for reporting dead or injured ESA listed species including agency contact information and reporting timelines. |

Required forms mentioned in Biological Opinion that need to on board the survey vessel:

- Northeast Atlantic Coast STDN Disentanglement Guidelines
    - https://www.reginfo.gov/public/do/DownloadDocument?objectID=102486501 and the procedures described in "Careful Release Protocols for Sea Turtle Release with Minimal Injury" (NOAA Technical Memorandum 580; https://repository.library.noaa.gov/view/noaa/3773 ).
- Sturgeon and Sea Turtle Take Standard Operating Procedures
    - https://media.fisheries.noaa.gov/dam-migration/sturgeon_&_sea_turtle_take_sops_external.pdf
- Procedures for Obtaining Sturgeon Fin Clips
    - https://media.fisheries.noaa.gov/dam-migration/sturgeon_genetics_sampling_revised_june_2019.pdf
- Sturgeon Genetic Sample Submission Form
    - https://www.fisheries.noaa.gov/new-england-mid-atlantic/consultations/section-7-take-reporting-programmatics-greater-atlantic
- NMFS Take Report Form (must be filled out for each individual sturgeon and sea turtle)
    - https://media.fisheries.noaa.gov/2021-07/Take%20Report%20Form%2007162021.pdf?null
- Handling and resuscitation procedures for sea turtles
    - https://media.fisheries.noaa.gov/dam-migration/sea_turtle_handling_and_resuscitation_measures.pdf
- Sturgeon Resuscitation Guidelines: https://media.fisheries.noaa.gov/dam-migration-miss/Resuscitation-Cards-120513.pdf
- GARFO PRD must be notified within 24 hours of any interaction with a sea turtle or sturgeon (nmfs.gar.incidental-take@noaa.gov). The form:(download at: https://media.fisheries.noaa.gov/2021-07/Take%20Report%20Form%2007162021.pdf?null )
- 

Additional information on the Marine Mammal Authorization Program, including reporting requirements, can be found at: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-authorization-program

https://media.fisheries.noaa.gov/dam-migration/mmap_reporting_form_dec2019_fillable_508.pdf

# APPENDIX D – OUTREACH MATERIALS FOR THE HMS RECEIVER ARRAY

012.345.6789

## Acoustic Telemetry Study for Highly Migratory Species

**Who is doing this study?**

- Orsted is funding researchers from the New England Aquarium and Inspire Environmental to carry out a multi-year acoustic telemetry study for Highly Migratory Species.

**What species are being studied?**

- Acoustic transmitters are being used to track Highly Migratory Species including blue sharks, shortfin mako sharks, and bluefin tuna. The movements of tagged animals will be tracked using a network of acoustic receivers (blue dots on chart).

**Why is this study being done?**

- This study will investigate the behavior, residence time, and movements of Highly Migratory Species in Orsted's South Fork Wind, Revolution Wind, and Sunrise Wind development areas to understand if offshore wind development leads to changes in the behavior and distribution of tagged fish.

**How does this tracking technology work?**

- Transmitters emit a coded ping every couple of minutes that can be heard when a tagged fish is within about 3,000 feet of an acoustic receiver. The receivers record the date and time when they hear the pings from each tag. Information about fish presence and movements within and throughout the study area can later be determined when data are downloaded from all of the receivers.

**When will the receivers be put out, and how long will they be left out for?**

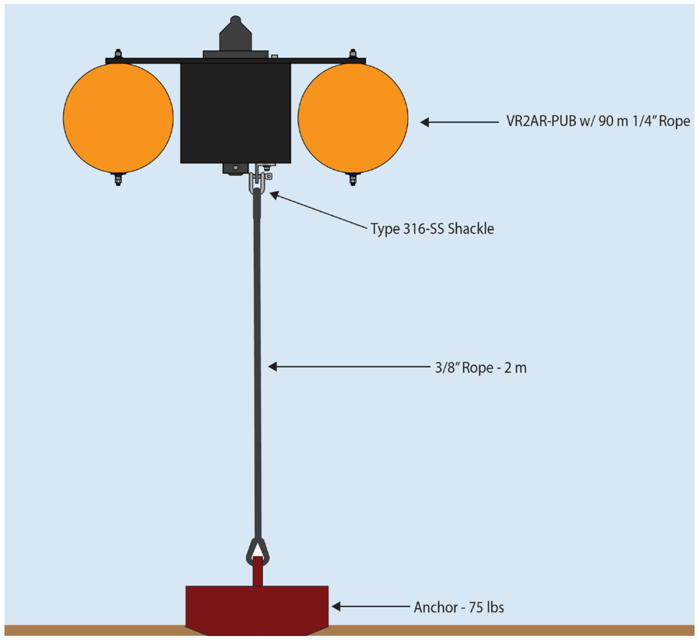
- The acoustic receivers will be deployed in May or June of 2022. The receivers will remain in the water, year-round, through at least the end of 2026. This long duration study is meant to collect data before, during, and after the construction of the offshore wind farms. The project team will retrieve and redeploy the receivers two or three times a year so the data can be downloaded and the batteries on the acoustic receivers can be changed.

**How are the receivers moored to the bottom?**

- The Innovasea receivers will be deployed using ropeless technology (acoustic release receivers) to minimize risks to marine mammals and other protected species. The receivers will be rigged in a pop-up canister that suspends about 6 feet off the bottom. The canister will be anchored in place with a 75-pound pyramid anchor (see picture below). At the end of the study, all gear (acoustic receivers and anchors) will be removed from the water completely.

**Where will the receivers be located?**

- The research team intends to place the receivers strategically to avoid interaction with commercial fishing gear, particularly mobile gear fishing effort. For example, receivers will be located in hard bottom habitats or out of popular mobile gear fishing locations.

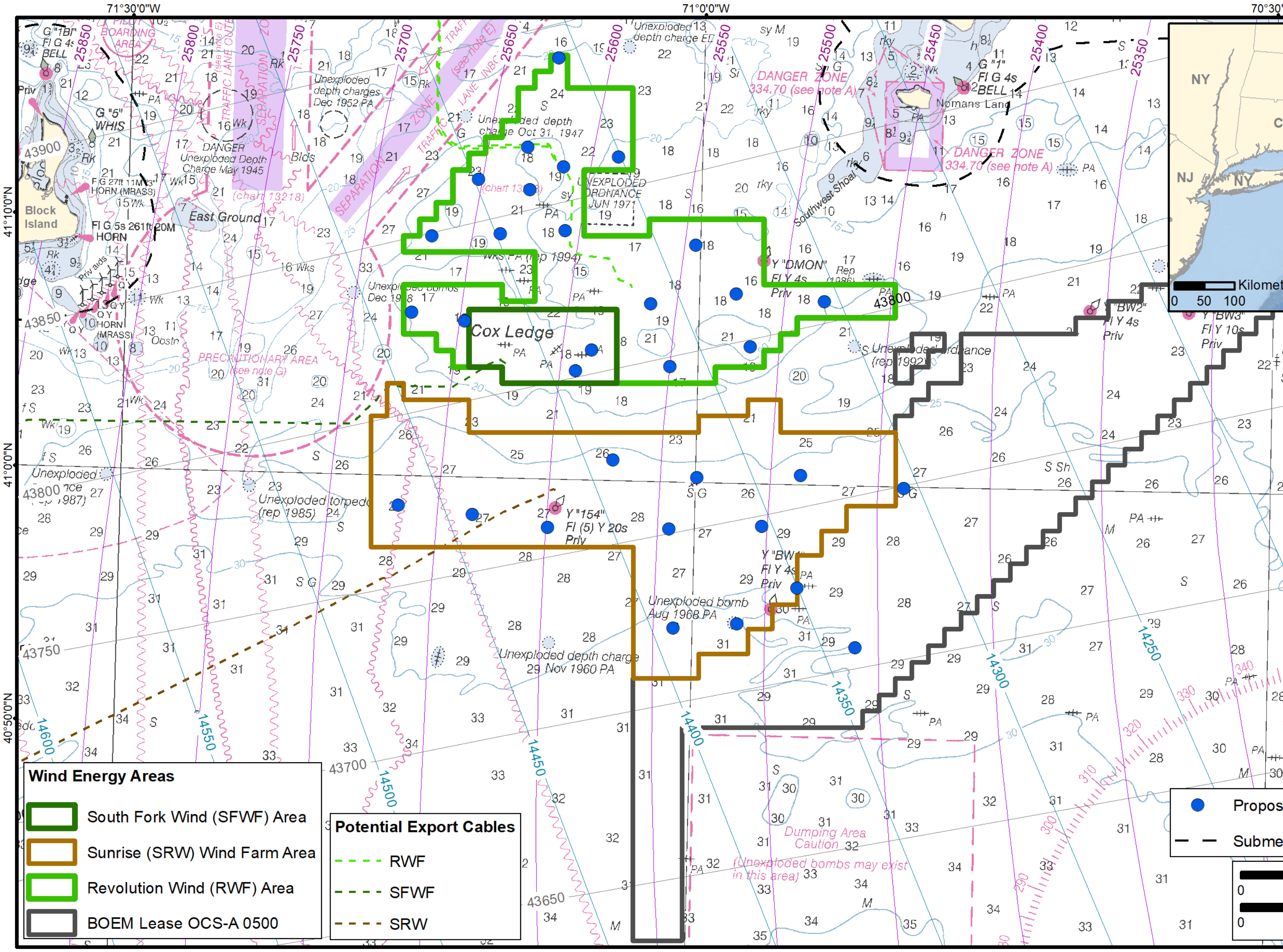



**Who can I Contact for more information?**

- Jeff Kneebone, New England Aquarium, jkneebone@neaq.org, 617-226-2424 (office), 603-969-2138 (cell)
- Brian Gervelis, Inspire Environmental, brian@inspireenvironmental.com, 401-608-2735
- Greg DeCelles, Orsted, grede@orsted.com, 857-408-4497

Sunrise Wind | Powered by Ørsted & Eversource

012.345.6789




Data: NOAA NOS Chart 12300

Document Name: Orsted_proposed_receiver_locations_20220211

# APPENDIX E – OUTREACH MATERIALS FOR THE SUNRISE WIND EXPORT CABLE RECEIVER ARRAYS

## Sunrise Wind Export Cable Acoustic Telemetry Study

**Who is doing this study?**

- Orsted is funding researchers from the Stony Brook University and Cornell Cooperative Extension to carry out a multi-year acoustic telemetry study for several species along the south coast of Long Island.

**What species are being studied?**

- Acoustic transmitters are being used to track several species including sandbar sharks, dusky sharks, sand tiger sharks, winter skates, smooth dogfish, lobsters, and horseshoe crabs. The movements of tagged animals will be tracked using a network of acoustic receivers.

**Why is this study being done?**

- This study will investigate the behavior, residence time, and movements tagged animals along the Sunrise Wind Export Cable route to understand if the installation and operation of the cable leads to changes in the behavior and distribution of marine organisms.

**How does this tracking technology work?**

- Transmitters emit a coded ping every couple of minutes that can be heard when a tagged animal is within about 3,000 feet of an acoustic receiver. The receivers record the date and time when they hear the pings from each tag. Information about fish presence and movements within study area can later be determined when data are downloaded from all of the receivers.

**When will the receivers be put out, and how long will they be left out for?**

- The acoustic receivers will be deployed in June or July of 2022. The receivers will remain in the water, year-round, until 2027. This long duration study is meant to collect data before, during, and after the installation of the Sunrise Wind Export Cable. The project team will retrieve and redeploy the receivers two or three times a year so the data can be downloaded and the batteries on the acoustic receivers can be changed.

**How are the receivers moored to the bottom?**

- The Innovasea receivers will be deployed using ropeless technology (acoustic release receivers) to minimize risks to marine mammals and other protected species. The receivers will be rigged in a pop-up canister that suspends about 6 feet off the bottom. The canister will be anchored in place with a 75-pound pyramid anchor (see picture on third page). At the end of the study, all gear (acoustic receivers and anchors) will be removed from the water completely.

**Where will the receivers be located?**

- The receivers will be located at two locations along the route of the Sunrise Wind Export Cable (see the following charts). The research team intends to place the receivers strategically to avoid interaction with commercial fishing gear, particularly mobile gear fishing effort.

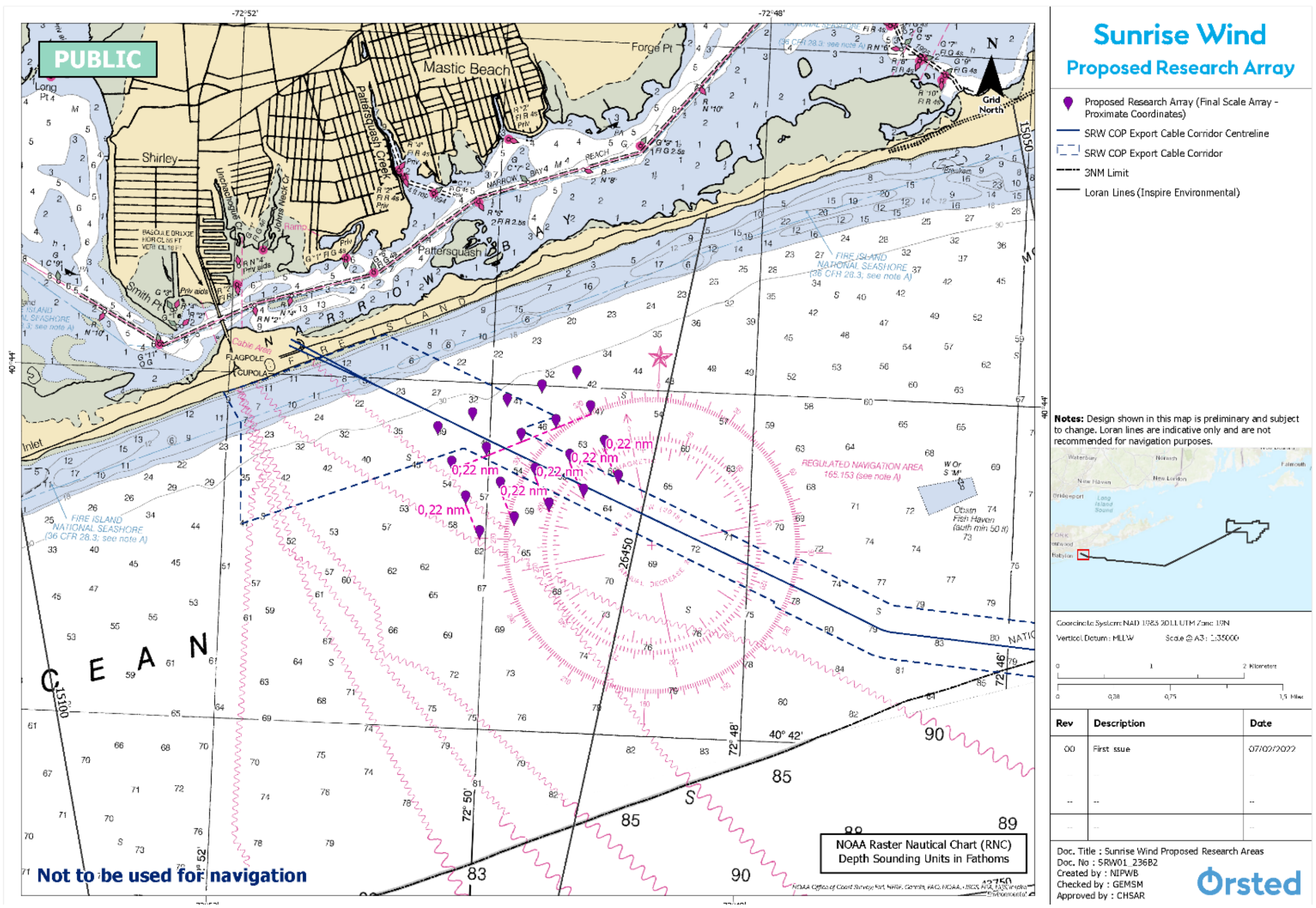
**What outreach has been done for this project?**

- Starting last summer, Orsted has met with several state and federal resource agencies to discuss the scope and duration of this monitoring study.
- Fisheries Liaisons from the Orsted Marine Affairs team have been meeting with members of the commercial fishing industry that fish in this area to gather feedback on the proposed locations of these receiver arrays. That outreach will continue in the coming months in order to minimize the potential for interactions between mobile gear fishing effort and the scientific monitoring equipment.

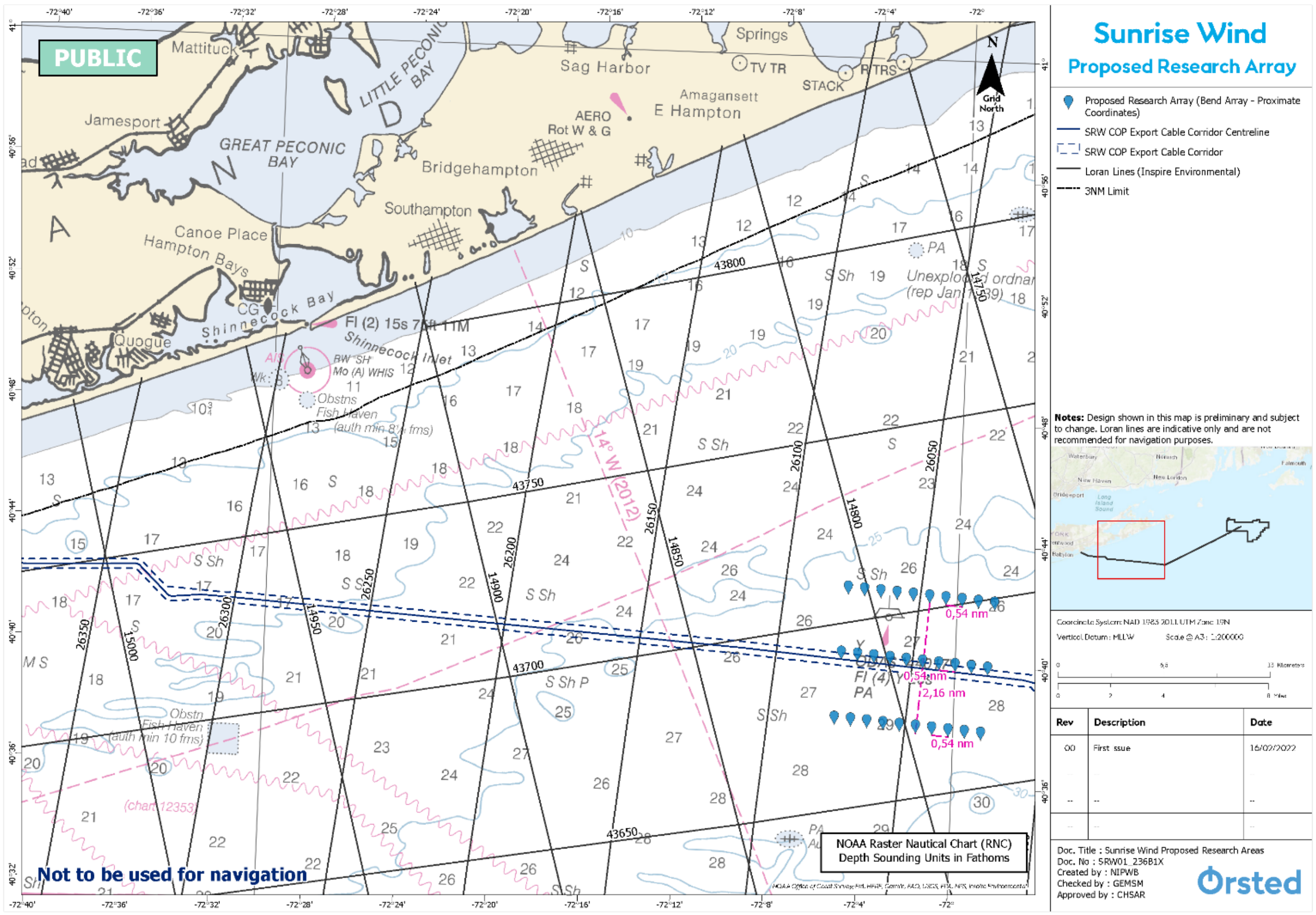
**Who can I Contact for more information?**

- Bradley Peterson, Stony Brook University, bradley.peterson@stonybrook.edu, 631-632-5044
- Matthew Sclafani, Cornell University Cooperative Extension, ms332@cornell.edu
- Greg DeCelles, Orsted Fisheries Science Specialist, grede@orsted.com, 857-408-4497
- Julia Prince, Orsted Fisheries Liaison for New York, julpr@orsted.com, 857-348-3263

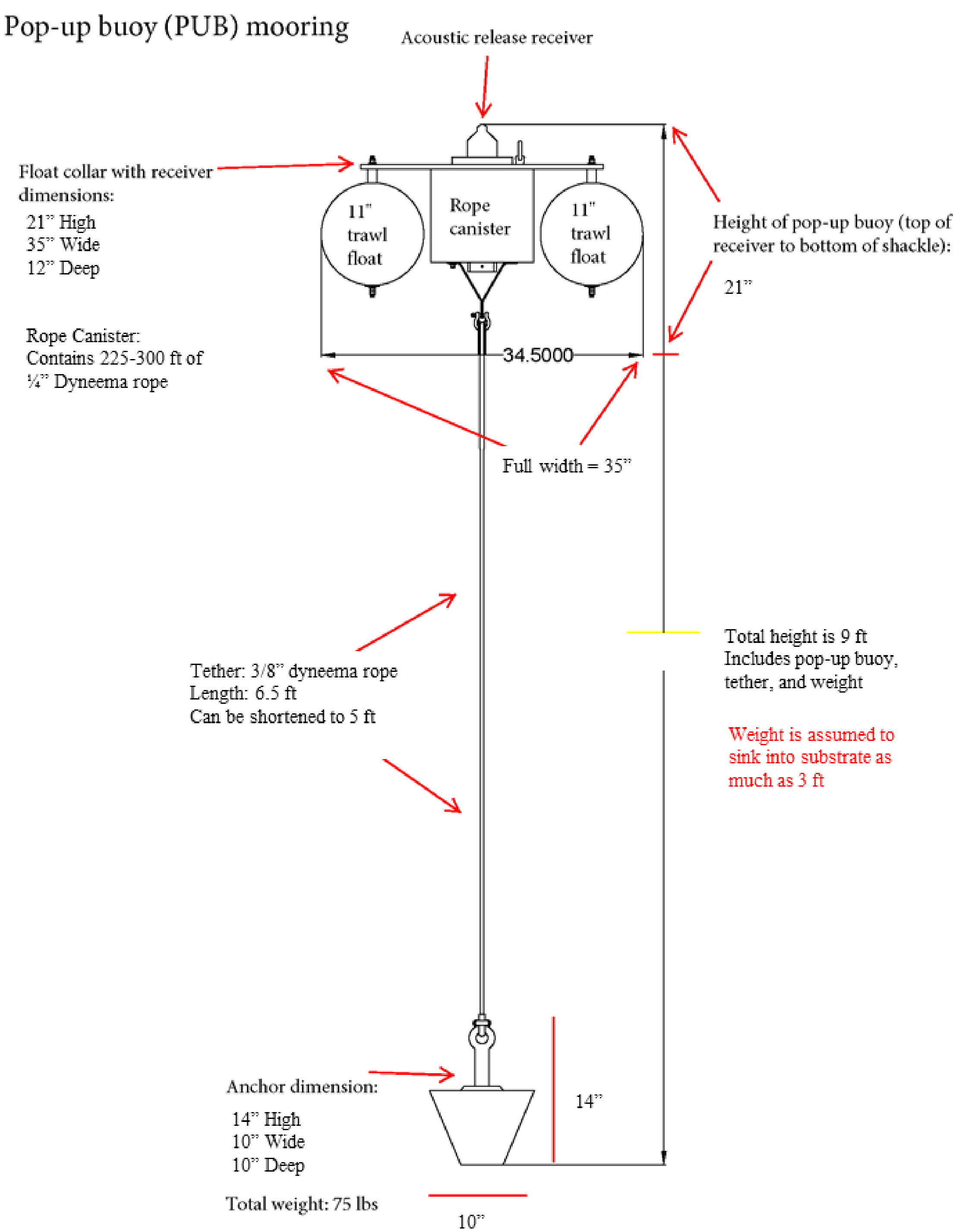
## Proposed locations for the ‘near-shore’ receiver array



## Proposed locations for the 'offshore' receiver array



## Diagram of an acoustic receiver with the pop-up buoy mooring



# APPENDIX F – OVERLAP BETWEEN HIGH-RESOLUTION GEOPHYSICAL SURVEYS AND FISHERIES MONITORING SURVEYS

# Appendix F: Overlap Between High-Resolution Geophysical Surveys and Fisheries Monitoring Surveys

High-Resolution Geophysical (HRG) surveys are conducted by wind energy developers for site investigation to inform engineering and design, as well as for archaeological assessments and benthic habitat mapping. These surveys are also required by the Bureau of Ocean Energy Management (BOEM) for offshore wind development activities. Some stakeholders have raised the question about whether any spatial and temporal overlap of HRG surveys with fisheries monitoring surveys could bias the results of the pre-construction fisheries monitoring.

Seismic air guns, which studies have shown can influence the distribution and catch rates of commercially important marine fish (e.g., Lokkeborg and Soldal, 1993; Engas et al., 1996), are not used during HRG surveys for offshore wind development. Instead, offshore wind HRG surveys employ a variety of equipment types, other than seismic air guns, as summarized in Table E-1. Offshore wind HRG equipment operate at a range of frequencies. The acoustic characteristics of HRG survey equipment used during offshore wind development are well known. Table E-1 includes all equipment authorized for use under the approved 2019 Ørsted IHA application and incorporates data from a recent study funded by BOEM to independently measure and verify the noise levels and frequencies of HRG equipment (Crocker and Fratantonio, 2016). Additional field studies have been conducted and are in review. Well established audiograms have been used to understand the hearing sensitivities for a number of species of fish (Table E-2). Fish have been classified into four groupings based on their physiology and their presumed hearing sensitivity (Hawkins et al., 2020). Of the HRG equipment that is commonly employed in offshore wind HRG surveys, non-airgun sub bottom profilers known as ‘sparkers’ and ‘boomers’ operate at the lowest frequency range, and thus are most relevant to assess further for any potential to impact the distribution and behavior of fish in the region, based on their hearing sensitivity. For this reason, HRG equipment commonly used in offshore wind surveys have been studied by BOEM.

In the BOEM Final Programmatic Environmental Impact Statement (EIS) for Geological and Geophysical Surveys in the Gulf of Mexico, several alternatives were considered, which included >180,000 km of non-airgun HRG surveys using equipment such as boomers, sparkers, CHIRP sub-bottom profilers, side-scan sonars and multibeam echosounders. For all alternatives, the EIS concluded that non-airgun HRG equipment would have little to no measurable impacts on fisheries resources, Essential Fish Habitat, on commercial and recreational fisheries, and on benthic communities (BOEM, 2017). The Vineyard Wind Supplemental EIS concluded that impacts of HRG survey noise to finfish, invertebrates and Essential Fish Habitat were negligible (BOEM, 2020).

Ørsted does not plan to use seismic airguns and/or ‘boomers’ in the Sunrise Wind lease area in 2022. However, ’sparkers’ may be used for a brief period (e.g., one month) at the Sunrise Wind site in 2022 to map subsurface features. While the HRG equipment is likely to change over time, Ørsted commits that seismic air guns will never be used for site investigations surveys on the Sunrise Wind farm.

Given the lack of temporal overlap and minimal spatial overlap that are anticipated to occur between the low frequency HRG surveys (e.g., boomers and sparkers) and the SRW fisheries monitoring surveys, we do not anticipate there to be any impacts on the results of the fisheries monitoring surveys. In addition, the reference areas for the SRW fisheries monitoring studies will be located well outside of the Sunrise Wind lease areas, in areas that have not been directly surveyed using HRG equipment. The Ørsted site investigations team records the time, date, and location that each piece of HRG equipment is deployed during site investigations surveys, and this information can be considered in the context of the fisheries monitoring results, as appropriate.

**Table E-1. Summary of the operating frequencies and source levels of HRG equipment from the 2019 Ørsted IHA application and issued authorization.**

| Representative HRG Survey Equipment | Range of Operating Frequencies (kHz) | Baseline Source Level a/ | Representative $RMS_{90}$ Pulse Duration (millisec) | Pulse Repetition Rate (Hz) | Primary Operating Frequency (kHz) |
|---|---|---|---|---|---|
| **USBL & Global Acoustic Positioning System (GAPS) Transceiver** | | | | | |
| Sonardyne Ranger 2 transponder b/ | 19-34 | 200 $dB_{RMS}$ | 300 | 1 | 26 |
| Sonardyne Ranger 2 USBL HPT 5/7000 transceiver b/ | 19 to 34 | 200 $dB_{RMS}$ | 300 | 1 | 26 |
| Sonardyne Ranger 2 USBL HPT 3000 transceiver b/ | 19 to 34 | 194 $dB_{RMS}$ | 300 | 3 | 26.5 |
| Sonardyne Scout Pro transponder b/ | 35 to 50 | 188 $dB_{RMS}$ | 300 | 1 | 42.5 |
| Easytrak Nexus 2 USBL transceiver b/ | 18 to 32 | 192 $dB_{RMS}$ | 300 | 1 | 26 |
| IxSea GAPS transponder b/ | 20 to 32 | 188 $dB_{RMS}$ | 20 | 10 | 26 |
| Kongsberg HiPAP 501/502 USBL transceiver b/ | 21 to 31 | 190 $dB_{RMS}$ | 300 | 1 | 26 |
| Edgetech BATS II transponder b/ | 17 to30 | 204 $dB_{RMS}$ | 300 | 3 | 23.5 |
| **Shallow Sub-Bottom Profiler (Chirp)** | | | | | |
| Edgetech 3200 c/ | 2 to 16 | 212 $dB_{RMS}$ | 150 | 5 | 9 |
| EdgeTech 216 b/ | 2 to 16 | 174 $dB_{RMS}$ | 22 | 2 | 6 |
| EdgeTech 424 b/ | 4 to 24 | 176 $dB_{RMS}$ | 3.4 | 2 | 12 |
| EdgeTech 512 b/ | 0.5 to 12 | 177 $dB_{RMS}$ | 2.2 | 2 | 3 |
| Teledyne Benthos Chirp III - TTV 170 b/ | 2 to 7 | 197 $dB_{RMS}$ | 5 to 60 | 4 | 3.5 |
| GeoPulse 5430 A Sub-bottom Profiler b/, e/ | 1.5 to 18 | 214 $dB_{RMS}$ | 25 | 10 | 4.5 |
| PanGeo LF Chirp b/ | 2 to 6.5 | 195 $dB_{RMS}$ | 481.5 | 0.06 | 3 |
| PanGeo HF Chirp b/ | 4.5 to 12.5 | 190 $dB_{RMS}$ | 481.5 | 0.06 | 5 |
| **Parametric Sub-Bottom Profiler** | | | | | |
| Innomar SES-2000 Medium 100 c/ | 85 to 115 | 247 $dB_{RMS}$ | 0.07 to 2 | 40 | 85 |
| Innomar SES-2000 Standard & Plus b/ | 85 to 115 | 236 $dB_{RMS}$ | 0.07 to 2 | 60 | 85 |
| Innomar SES-2000 Medium 70 b/ | 60 to 80 | 241 $dB_{RMS}$ | 0.1 to 2.5 | 40 | 70 |
| Innomar SES-2000 Quattro b/ | 85 to 115 | 245 $dB_{RMS}$ | 0.07 to 1 | 60 | 85 |
| PanGeo 2i Parametric b/ | 90-115 | 239 $dB_{RMS}$ | 0.33 | 40 | 102 |
| **Medium Penetration Sub-Bottom Profiler (Sparker)** | | | | | |
| GeoMarine Geo-Source 400J d/ | 0.2 to 5 | 212 $dB_{Peak}$<br>201 $dB_{RMS}$ | 55 | 2 | 2 |
| GeoMarine Geo-Source 600J d/ | 0.2 to 5 | 215 $dB_{Peak}$<br>205 $dB_{RMS}$ | 55 | 2 | 2 |
| GeoMarine Geo-Source 800J d/ | 0.2 to 5 | 215 $dB_{Peak}$<br>206 $dB_{RMS}$ | 55 | 2 | 2 |
| Applied Acoustics Dura-Spark 400 System d/ | 0.3 to 1.2 | 225 $dB_{Peak}$<br>214 $dB_{RMS}$ | 1.1 | 0.4 | 1 |
| GeoResources Sparker 800 System d/ | 0.05 to 5 | 215 $dB_{Peak}$<br>206 $dB_{RMS}$ | 55 | 2.5 | 1.9 |

**Table E-1 continued.**

| Representative HRG Survey Equipment | Range of Operating Frequencies (kHz) | Baseline Source Level a/ | Representative $RMS_{90}$ Pulse Duration (millisec) | Pulse Repetition Rate (Hz) | Primary Operating Frequency (kHz) |
|---|---|---|---|---|---|
| **Medium Penetration Sub-Bottom Profiler (Boomer)** | | | | | |
| Applied Acoustics S-Boom 1000J b/ | 0.250 to 8 | 228 $dB_{Peak}$ 208 $dB_{RMS}$ | 0.6 | 3 | 0.6 |
| Applied Acoustics S-Boom 700J b/ | 0.1 to 5 | 211 $dB_{Peak}$ 205 $dB_{RMS}$ | 5 | 3 | 0.6 |

Notes:

a/ Baseline source levels were derived from manufacturer-reported source levels (SL) when available either in the manufacturer specification sheet or from the SSV report. When manufacturer specifications were unavailable or unclear, Crocker and Fratantonio (2016) SLs were utilized as the baseline:

b/ source level obtained from manufacturer specifications

c/ source level obtained from SSV-reported manufacturer SL

d/ source level obtained from Crocker and Fratantonio (2016)

e/ unclear from manufacturer specifications and SSV whether SL is reported in peak or rms; however, based on SLpk source level reported in SSV, assumption is SLrms is reported in specifications.

The transmit frequencies of sidescan and multibeam sonars for the 2019 marine site characterization surveys operate outside of marine mammal functional hearing frequency range.

It is important to note that neither Crocker and Farantino (2016), nor HRG manufacturer technical specifications report source levels in terms of the $RMS_{90}$, which is the metric required in assessment to the distance of NOAA Fisheries Level B harassment thresholds. Therefore, careful consideration should be made when attempting to make such direct comparisons. As shown in Crocker and Farantino, the pulse duration may also be a function of HRG operator settings.

**Table E-2. Summary of available information regarding the hearing sensitivities for fish species that are commonly encountered in the northwest Atlantic.**

| Species/Species Group | Family | Order | Sound Detection | Sensitivity |
|---|---|---|---|---|
| American eel | Anguillidae | Anguilliformes | Swim bladder close but not connecting to ear; Hearing by particle motion and pressure | Hawkins et al. 2020<br>Group 3<br>Up to 1-2 kHz |
| Alewife/herring/menhaden | Clupeidae | Clupeiformes (includes anchovies) | Weberian ossicles connecting swim bladder to ear; Hearing by particle motion and pressure | Hawkins et al. 2020<br>Group 4<br>Up to 3-4 kHz<br>Alosinae detect to over 100 kHz |
| Cod/Pollock/Haddock/Hake | Gadidae | Gadiformes | Swim bladder close but not connecting to ear; Hearing by particle motion and pressure | Hawkins et al. 2020<br>Group 3<br>Up to 1-2 kHz |
| Mako sharks/mackerel sharks | Lamnidae | Lamniformes | No air bubble; Particle motion only | Hawkins et al. 2020<br>Group 1<br>Well below 1 kHz |
| Monkfish/goosefish | Lophiidae | Lophiiformes | | unknown |
| Bluefish | Pomatomidae | Perciformes | | unknown |
| Sea bass/groupers | Serranidae | | | unknown |
| Striped bass | Moronidae | | | unknown |
| Sand lance | Ammodytidae | | | unknown |
| Tautog | Labridae | | | unknown |
| Tunas/mackerels/albacores | Scombrinae | | Swim bladder far from ear; Particle motion only | Hawkins et al. 2020<br>Group 2<br>Up to 1 kHz |
| Billfish/swordfish | Xiphiidae | | | unknown |
| Flounders/flatfish/sole/halibut | Pleuronectidae | Pleuronectiformes | No air bubble; Particle motion only | Hawkins et al. 2020<br>Group 1<br>Well below 1 kHz |
| Skates/rays | Rajidae | Rajiformes | No air bubble; Particle motion only | Hawkins et al. 2020<br>Group 1<br>Well below 1 kHz |
| Spiny dogfish | Squalidae | Squaliformes | No air bubble; Particle motion only | Hawkins et al. 2020<br>Group 1<br>Well below 1 kHz |

# References

Bureau of Ocean Energy Management (BOEM). 2017. Gulf of Mexico OCS Proposed Geological and Geophysical Activities. Western, Central and Eastern Planning Areas. Final Programmatic Environmental Impact Statement. Volume 1: Chapters 1-9. OCS EIS/EA BOEM 2017-051.

Bureau of Ocean Energy Management (BOEM). 2020. Vineyard Wind 1 Offshore Wind Energy Project. Supplement to the Draft Environmental Impact Statement. June 2020. OCS EIS/EA BOEM 2020-025.

Crocker, S.E., and Fratantonio, F.D. 2016. Characteristics of sounds emitted during high-resolution marine geophysical surveys. Naval Undersea Warfare Center Division Technical Report.

Engas, A., Lokkeborg, S., Ona, E., and Soldal, A.V. 1996. Effects of seismic shooting on local abundance and catch rates of cod (Gadus morhua) and haddock (Melogrammus aeglefinus). Canadian Journal of Fisheries and Aquatic Sciences, 53(10): 2238-2249.

Hawkins, A.D., Johnson, C., and Popper, A.N. 2020. How to set sound exposure criteria for fishes. The Journal of the Acoustical Society of America, 147: 1762. doi: 10.1121/10.0000907.

Kikuchi, R. 2010. Risk formulation for the sonic effects of offshore wind farms on fish in the EU region. Marine Pollution Bulletin, 60: 172-177.

Lokkerborg, S., and Soldal, A.V. 1993. The influence of seismic exploration with airguns on cod (Gadus morhua) behavior and catch rates. ICES Marine Science Symposium, 196: 62-67.

Ørsted Wind Power North America (Ørsted). 2019. Request for the taking of marine mammals incidental to the site characterization of lease areas OCS-A 0486, OCS-A 0487, and OCS-A 0500. Submitted to National Oceanic and Atmospheric Administration. June 10, 2019.

Popper, A.N., Hawkins, A.D., Fay, R.R. and 12 others. 2014. ASA S3/SC1.4TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Spring Briefs in Oceanography. Springer Science + Business Media. 87 pp.