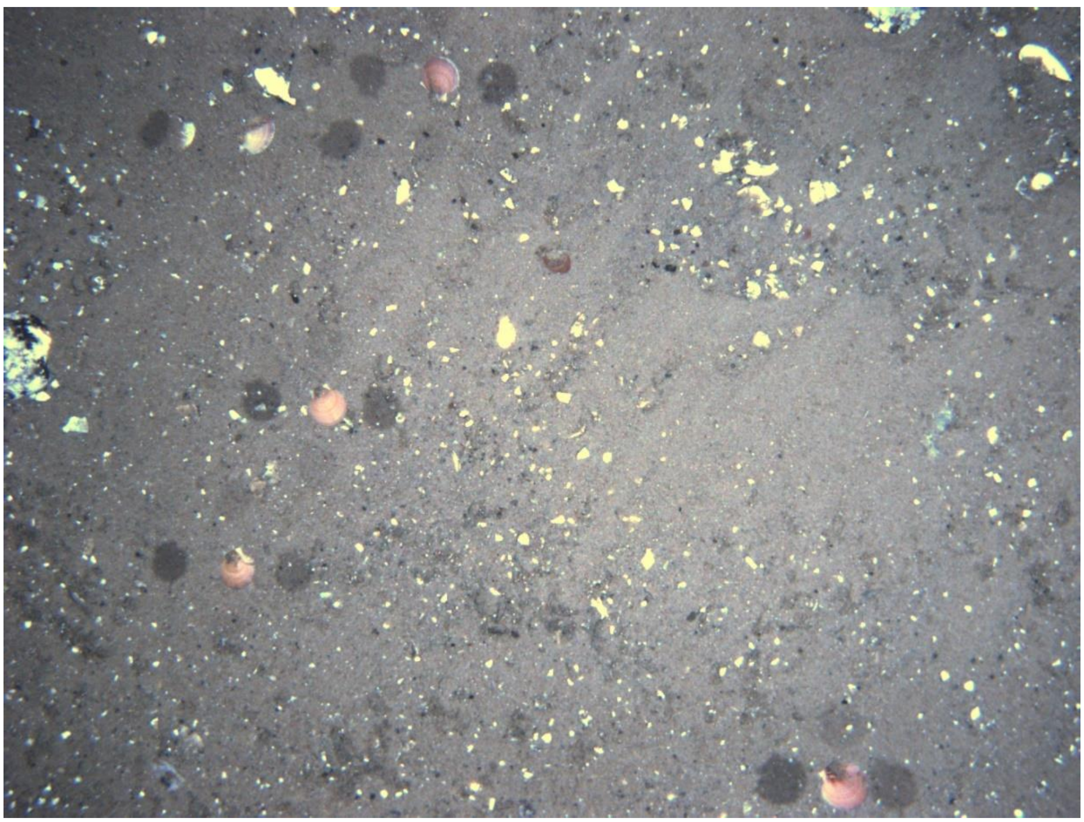
# Annual Monitoring Survey of the Sunrise Wind Farm Lease Area

## 2022 Annual Report

**Prepared for Orsted**

[redacted]

**December 31, 2022**



Submitted By

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**Project Information**

Report Title: Annual Benthic Survey of Sunrise Wind Farm

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Organization: Coonamessett Farm Foundation

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Date: December 31, 2022

## Executive Summary

The HabCam v3 survey of the Sunrise Wind Farm (SRWF) area was designed to provide critical survey-based information to supplement monitoring efforts of the SRWF lease area. This survey will provide critical information regarding benthic habitat and species before, during, and after turbine construction. A reference control area was established adjacent to the SRWF area through discussions between Coonamessett Farm Foundation (CFF) and Orsted. The primary objectives of this project were to:

- Provide photographic imagery from proposed transects in the control and SRWF areas
- Create GIS-based plots of various predetermined annotated habitat types and species
- Produce length-frequency distributions of scallops within the surveyed areas
- Derive biomass estimates within each area surveyed using stratified mean estimation by depth and ordinary kriging

On July 29th, 2022, CFF departed from New Bedford at 10:00 aboard the F/V *Kathy Marie* to complete the final portions of the proposed track within SRWF and the control area. The planned track was ~165 nm, which was modified slightly to avoid obstacles and hazards in the area (**Figure 1**). Some tracks extended slightly beyond the surveyed areas.

Both the reference control area and SRWF areas were comprised mainly of sandy substrate. Sea scallops were found throughout the tracks in both areas, though the control area contained more scallops overall. Scallops were predominantly pre-recruit (< 35 mm) or large adult scallops (> 75 mm), with few recruit scallops (35 -75 mm) noted in either area. The control area is a polygon adjacent to the SRWF, which was determined based on its proximity, similar benthic sediment, depth profiles, and fishing traffic.

Scallop biomass (both exploitable and total) was nearly double in the control area compared to the SRWF area (**Table 1**). The mean scallop height and weight were similar between areas, with the control area having only slightly higher mean shell height and weight than the SRWF. Biomass was derived using two methods (**Table 1**).

*Table 1: Estimated Sea scallop biomass and abundance by site. Both stratified mean and ordinary kriging estimates are included.*

| | | | | | Stratified Mean | | | | | | Ordinary Kriging | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Area/Km$^2$ | Average Size | Mean Weight | Density | BmsMT | BmsSE | NumMil | ExpBms MT | ExpBms SE | NumMil Exp | BmsMT | NumMil | ExpBms MT | NumMil Exp |
| Control | 599.7 | 110.9 | 26.8 | 0.042 | 648.2 | 130.5 | 25.2 | 525.1 | 107.2 | 18.0 | 657.3 | 25.9 | 529.7 | 18.3 |
| Sunrise | 445.0 | 109.4 | 26.6 | 0.027 | 313.4 | 94.0 | 11.2 | 259.3 | 80.4 | 8.4 | 296.2 | 10.8 | 243.8 | 8.0 |

Fish and invertebrate species abundance and density were mapped and counts by area can be found in the Results section. Only scallops were measured by annotators; all other species were counted. Nearly all species annotated were more abundant in the control area than in the SRWF, except for red hake and sand lance.

## Background

### *1.1 Description of Problem*

Ecosystem monitoring is key for understanding and tracking long-term shifts in environments, including changes in assemblages of species. Offshore wind farms are a new and emerging sector in the northwest Atlantic. Wind lease areas have been established throughout the east coast of the US, and thousands of turbines are planned for construction in the offshore and nearshore communities in the coming years. It is known that offshore development will bring about changes in marine communities, though how these communities will change, and the extent or such changes, are still unknown.

Atlantic sea scallops (*Placopecten magellanicus*) are a high value fishery in in the northeast region with an ex-vessel revenue between $400-$600 million (Smolowitz, 2016); these species have been previously recognized as an indicator species that should be prioritized for monitoring the impacts of offshore wind development (Malek, 2015; Petruny-Parker *et al*., 2015). Following a review of a draft Benthic Research Monitoring Plan for SRWF, Orsted received feedback from NOAA Fisheries, the Rhode Island Coastal Resources Management Council, and the Fishermen's Advisory Board suggesting the addition of targeted monitoring to investigate changes in the abundance and biomass of sea scallops. In response to this feedback, Orsted partnered with Coonamessett Farm Foundation (CFF) to include an optical survey utilizing the HabCam v3 within the lease site and a nearby control area.

Optical surveys are important components to an overall survey strategy and hold several key advantages over traditional dredge surveys. Optical surveys overcome the issue of decreased dredge efficiency, which can lead to underestimation of biomass in dense aggregations (NEFSC, 2018). Additionally, optical surveys can characterize the spatial scale of areas containing seed and very small scallops, which may be missed or only qualitatively noted by dredge surveys due to size selectivity (Rudders, 2015). Optical surveys can also cover large swept areas in a relatively short time frame, allowing for detection of fine-scale distribution changes.

The HabCam v3 is a fully vetted stock assessment monitoring tool that has undergone peer review and directly informs scallop management decisions. HabCam survey data collected from 2011-2017 was included in the most recent scallop assessment (NEFSC, 2018). Utilization of the HabCam survey equipment and protocols ensures 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 images and metadata collected during surveys hold ancillary information such as species interactions, distribution of additional flora and fauna, temperature, salinity, and substrate type. Thus, each image captured during a HabCam v3 optical survey is essentially a complete holistic snapshot of the environmental at a specific space in time. 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.

### *1.2 Long-Term Project Goals*

- Evaluate changes in the relative abundance of scallops between SRWF and the reference control area pre-construction, during construction, and post-construction.
- Assess changes in the size structure of scallops between SRWF and the control areas pre-construction, during construction, and post-construction.
- 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.
- Determine habitat types and analyze changes between SRWF and the control area pre-construction, during construction, and post-construction.

### *1.3 Annual Project Objectives*

- Provide photographic imagery from proposed transects in the control and SRWF areas
- Create GIS-based plots of various predetermined annotated habitat types and species, including:
    - i. scallop distribution and density by size
    - ii. sediment type
    - iii. fish and invertebrate density and distribution
    - iv. benthic temperature and salinity
- Produce length-frequency distributions of scallops within the surveyed areas
- Derive biomass estimates within each area surveyed using stratified mean estimation by depth and ordinary kriging

## 2 Methods

The SRWF monitoring survey took place from July 29th to 31st, 2022. The vehicle was deployed off the stern of the vessel around 16:45 on July 29th and began logging data on the seafloor by 16:57. All data was collected and recorded in Universal Time Coordinates (UTC) to ensure consistency with other HabCam surveys. In all, over 3 TB of data and over 725,000 paired images were captured as raw TIFF files. Every 10th image was processed to allow for annotations within the CFF-modified graphic user interface, and every 10th processed image was annotated to provide a “station” every ~40 m of track. The proposed 165 nm track was only modified to allow for obstacle avoidance and safety (**Figure 1**). The survey concluded at 01:36 on July 31st, 2022, and the vessel docked in New Bedford around 09:00 that morning.

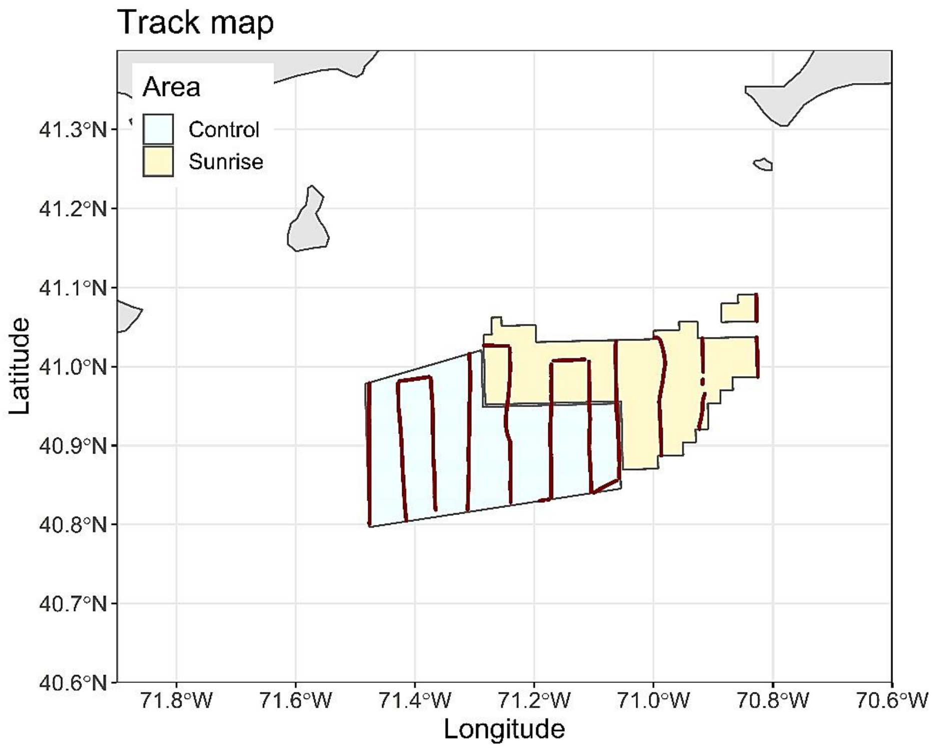



***Figure 1****: Map of track lines for the 2022 HabCam v3 survey within the Sunrise Wind (yellow) and control area (blue). The track can be seen in red. The actual tracks deviated only slightly from the original proposed track to account for obstacle avoidance and safety.*

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 on a fiber optic tether. 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 habitat. 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 and double counting individual animals. For annotations, CFF uses a version of open-source software developed by the Visual Geometry Group (VGG) at Oxford University (Dutta and Zisserman, 2019), 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 conducted by CFF. The new image annotation GUI has been optimized from VIA Version 3 (available at http://www.robots.ox.ac.uk/~vgg/software/via/) for current data acquisition methods and needs with the addition of sliders for adjusting image contrast and brightness, new zoom features to aid in identification of small objects, and improvements to GUI layout.

Scallops were counted and measured, while fish, sea stars, and other organisms of interest were counted (bound by box). Scallop shell heights were measured when the hinge was visible; if this was not possible, scallop shell width was used in lieu of height and widths were converted to shell heights using the following equation:

$$\mathrm{SH} = (-0.0003502 \times \mathrm{Width}^2) + (1.034 \times \mathrm{Width}) + 3.538$$

where SH is shell height in millimeters. This is the same equation used by the NEFSC for their 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 and juvenile fish, which can be difficult to identify to species at smaller sizes. All annotated images were reviewed for quality control prior to analysis. Quality assurance and control was performed on all annotated images.

### *2.1 Biomass Estimates*

Scallop lengths were initially recorded in pixels and were subsequently converted into shell heights in millimeters based on the image FOV. Each SH measured from the HabCam images was converted to a meat weight (MW) in grams using the following location-specific SH-MW equation:

$$W = \exp\Big(-9.48 + (2.51\ x \log(SH)) + (-0.1743) + (-0.000134\ x\ mday^2) + (-0.0033\ x\ Depth) + \left(0.021\ x\ Lat_{decdeg}\right) + (-0.031\ x\ Clop) + \left(0.00525\ x\ (\log(SH)\ x\ mday)\right) + \left(-0.000065\ \ x\ (mday\ x\ Depth)\right)\Big)$$

W is the meat weight in grams and SH is the shell height in millimeters, Clop is the management strategy (open vs closed), Lat is the latitude in decimal degrees, mday is the days since April 30th and is set to 21 for all surveys, and D is depth. Biomass areas were considered “open” using the Mid-Atlantic equation (Hennen and Hart, 2012; NEFSC, 2018). Biomass estimates were derived using two methods: 1) 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 estimates using the variogram function in the R package gstat (Pebesma, 2004).

### *2.2 Reference Control Area*

The proposed control polygon was located just southwest of the current SRWF lease area. The area was chosen as it appeared to have relatively similar levels of vessel traffic and fishing effort for many groundfish and invertebrate species, based on VMS and/or VTR (vessel trip report) data. However, CFF noted differences in abundances between the areas, as the control area had a greater abundance and density of nearly every vertebrate and invertebrate species annotated. The sediment types (primarily sand and cobble with small boulders) were also similar between the two areas. The control area has a similar depth profile as the adjacent SRWF, with depths ranging from 30 – 60 m. The proposed cable route is planned to run through a proportionally small section of the control area.

## 3 Results

### *3.1 Sea Scallop Density and Distribution*

Sea scallops were found throughout the track, with greater total numbers noted in the control area than in the SRWF. Small pre-recruit scallops under 35 mm and large exploitable scallops over 75 mm were abundant in both sites, though notably both were more prevalent in the control area (**Figures 2A, 2C**). Interestingly, recruit scallops 35 mm -75 mm were very sparsely scattered in both sites, but overall, very few scallops were measured in this size range (Figure 2B).

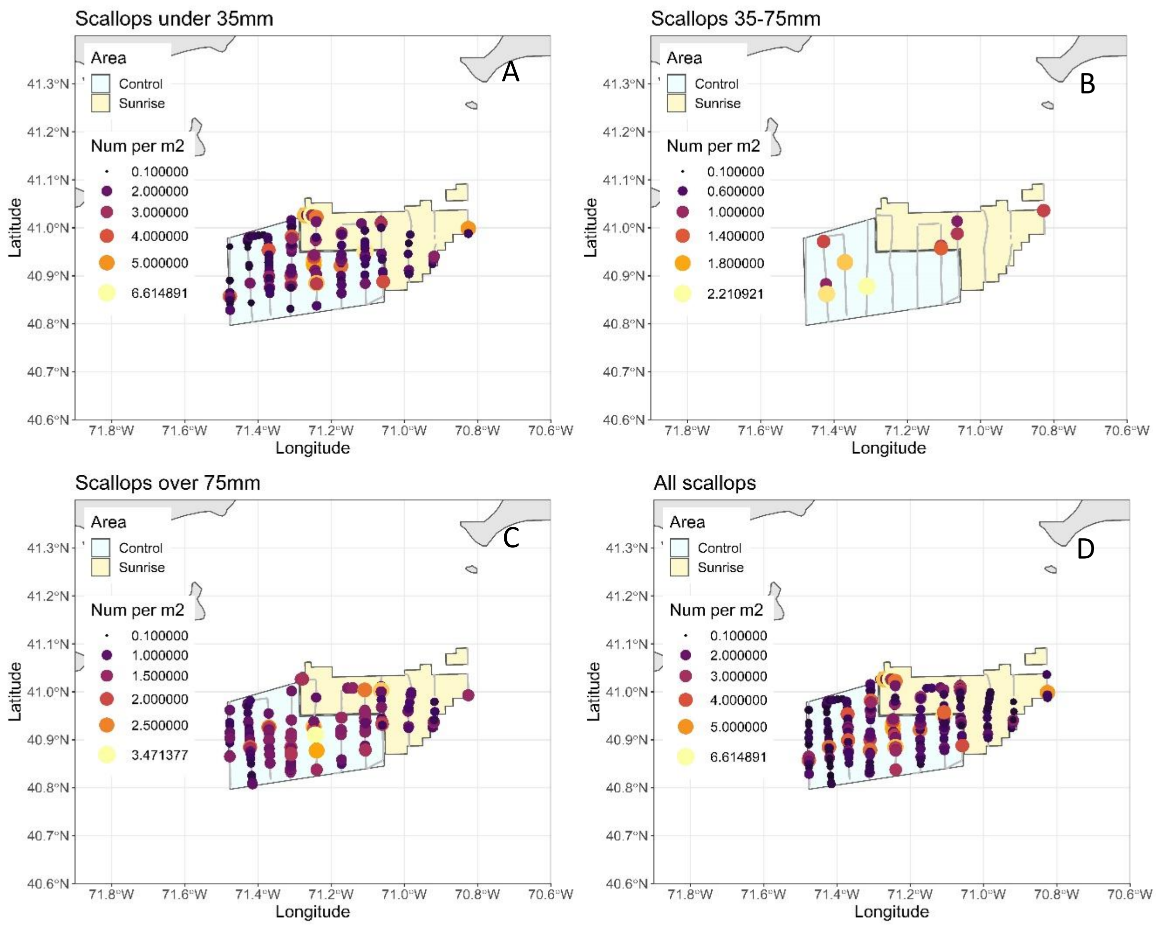



*Figure 2: Maps of sea scallop density within the SRWF and control areas. Sea scallops are separated by pre-recruit < 35 mm (A), recruit 35 mm - 75 mm (B), exploitable adult scallops > 75 mm (C), and all scallops in all size classes (D).*

## *3.2 Sea Scallop Size and Biomass Estimates*

The mean scallop length was similar between the control and SRWF areas, with a mean difference of 1.5 mm. The size distributions between the areas varied, and the control area had nearly three times the number of scallops greater than 40 mm in the area (**Figure 3**). Only scallops 40 mm and greater were used in length calculations for consistency with annual scallop stock assessment parameters. Exploitable scallop biomass in the control area was nearly double that found in the SRWF area (**Figure 4**). Total biomass in the control area was also nearly double that found in the SRWF (see **Table 1** listed in the **Executive Summary**)

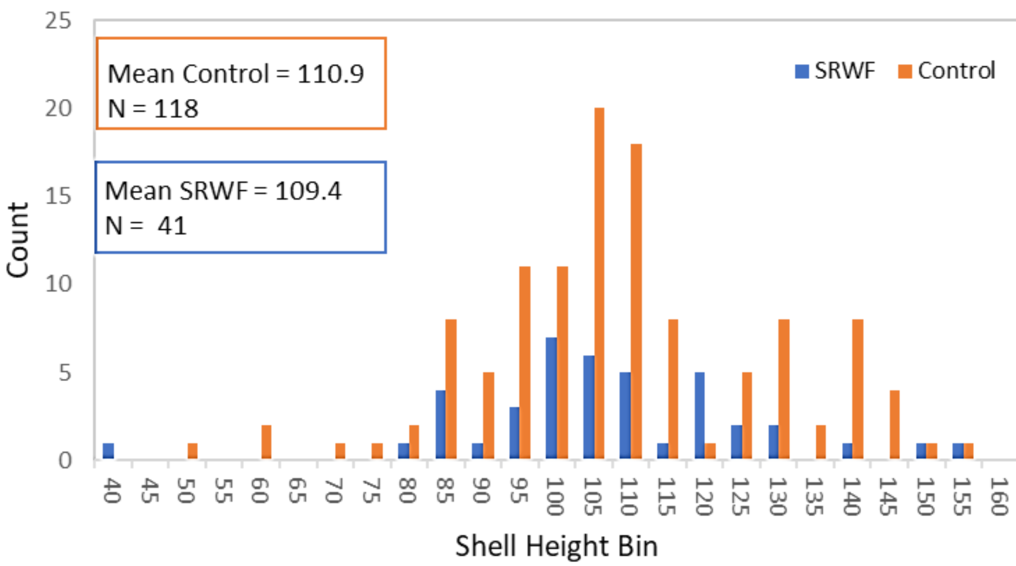
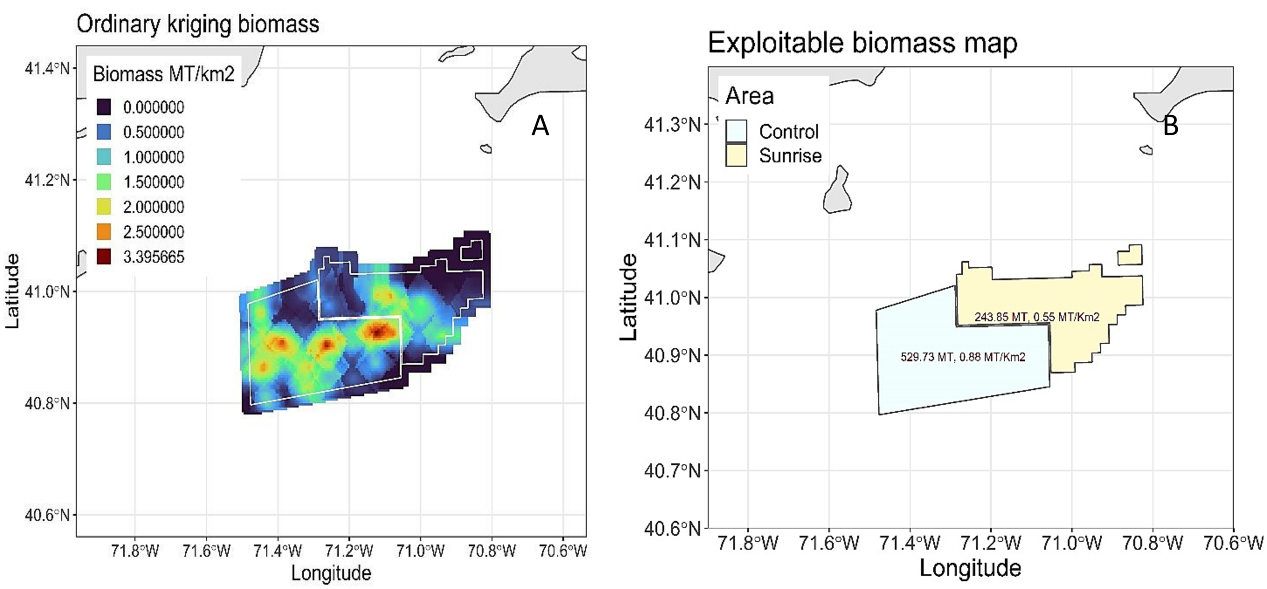



*Figure 3: Scallop lengths by site. Only scallops 40 mm and over are used for length frequency calculations, as scallops less than 40 mm are not used in scallop biomass estimates.*



### *3.3 Fish and Invertebrates*

Flounders in both the control area and the SRWF sites were mainly comprised of gulfstream flounder, though at very small sizes, it can be difficult to positively determine juvenile flounder species. Most species were found in greater numbers in the control area than the SRWF, with the exception of sand lance and red hake. Sand lance was notably found in only a few dense patches near the middle of the track lines (**Figure 5C**). Sand lance are not typically noted in scallop stock assessment, but they are a critical forage species for many commercially important species in New England and changes in their abundance and distribution could be useful for understanding shifts in commercial species. Eel-like fish were mainly comprised of snake eels, fawn-cusk eels, and hagfish.

All invertebrate species annotated were found in greater numbers in the control area than in SRWF (**Figure 5C** and **Figure 6 A-E**.). Whelks, moon snails, and *Astropecten* spp. and *Asterias* spp. sea stars are key predators of sea scallops and other invertebrates, and their density and distribution within areas is important in understanding scallop settlement and survival.

*Figure 4: Exploitable biomass maps and estimates using ordinary kriging.*

*Astropecten* spp., which mainly predate on juvenile scallops, were abundant in the control area

(**F** ... ab ... egory

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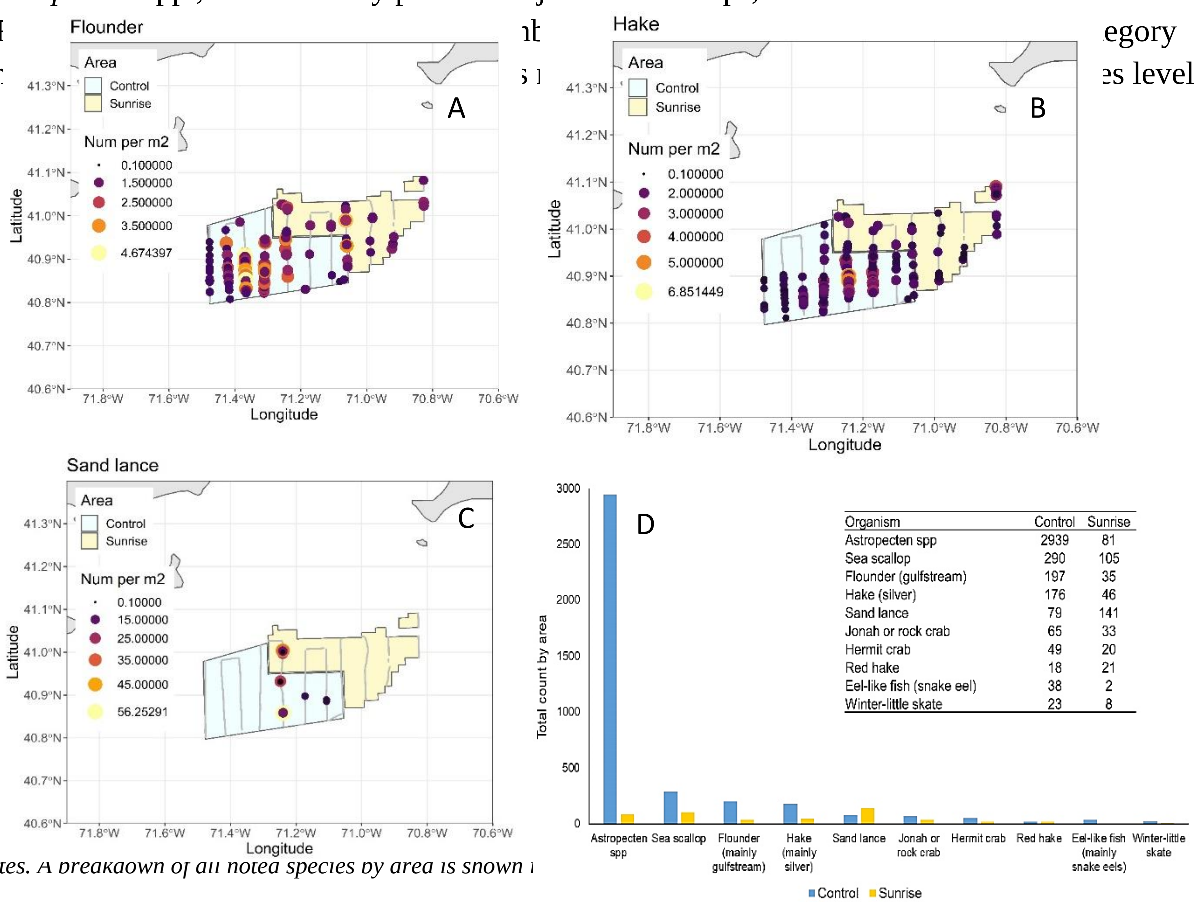



*F*

*sites. A breakdown of all noted species by area is shown i* by annotators. These often include *Henricia* spp. and *Leptasterias* spp. sea stars but may include others as well.

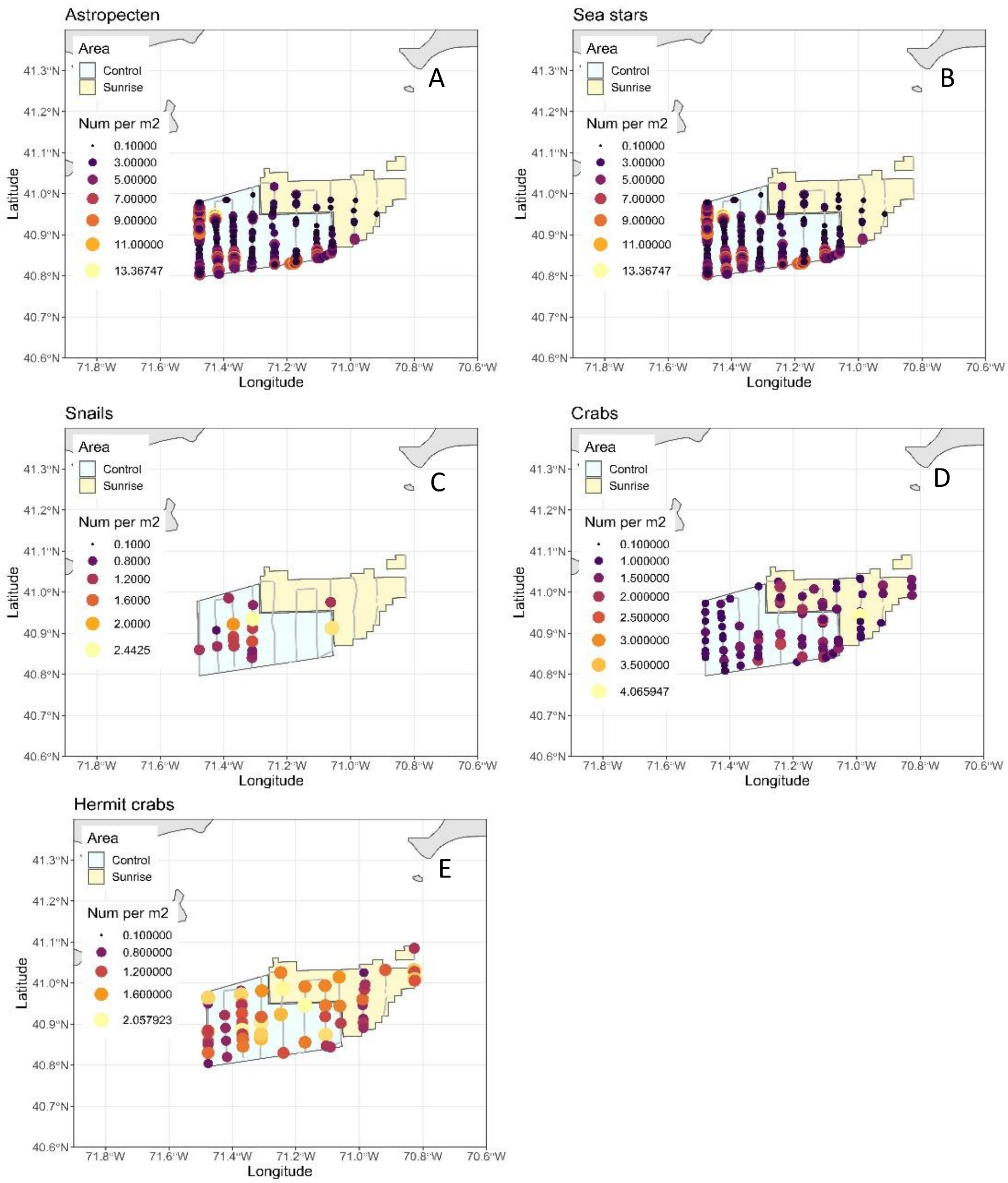



*Figure 6: Density and distribution of important invertebrate species along the tracks within SRWF and the control site. Note that density legends vary between maps.*

### *3.4 Benthic Habitat/Sediment Composition*

Benthic temperatures ranged from 9.94 °C to 13.8 °C with the warmest temperatures located in the northeast corers of the track (**Figure 7A**). These warmer areas had notably less sea scallops and sea stars compared to most other species.

A SeaBird CTD was attached to the HabCam which continuously collects conductivity, temperature, and depth readings. Salinity was calculated using international standard equations for calculating practical salinity using conductivity and temperature (Pritchard, 1982). Salinity, as measured in parts per thousand, or ppt, ranged from 32.9 ppt to 33.9 ppt (**Figure 7B**).

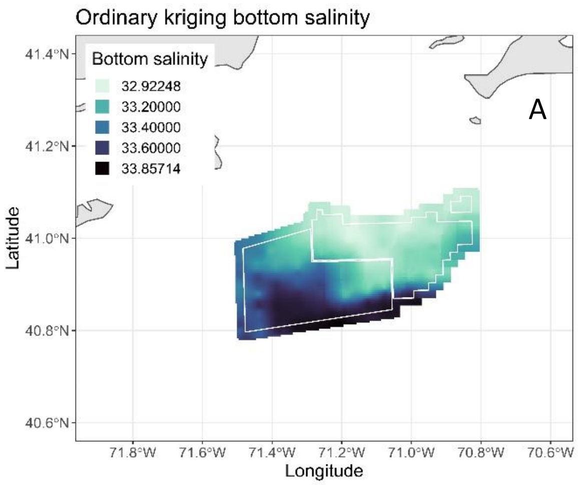
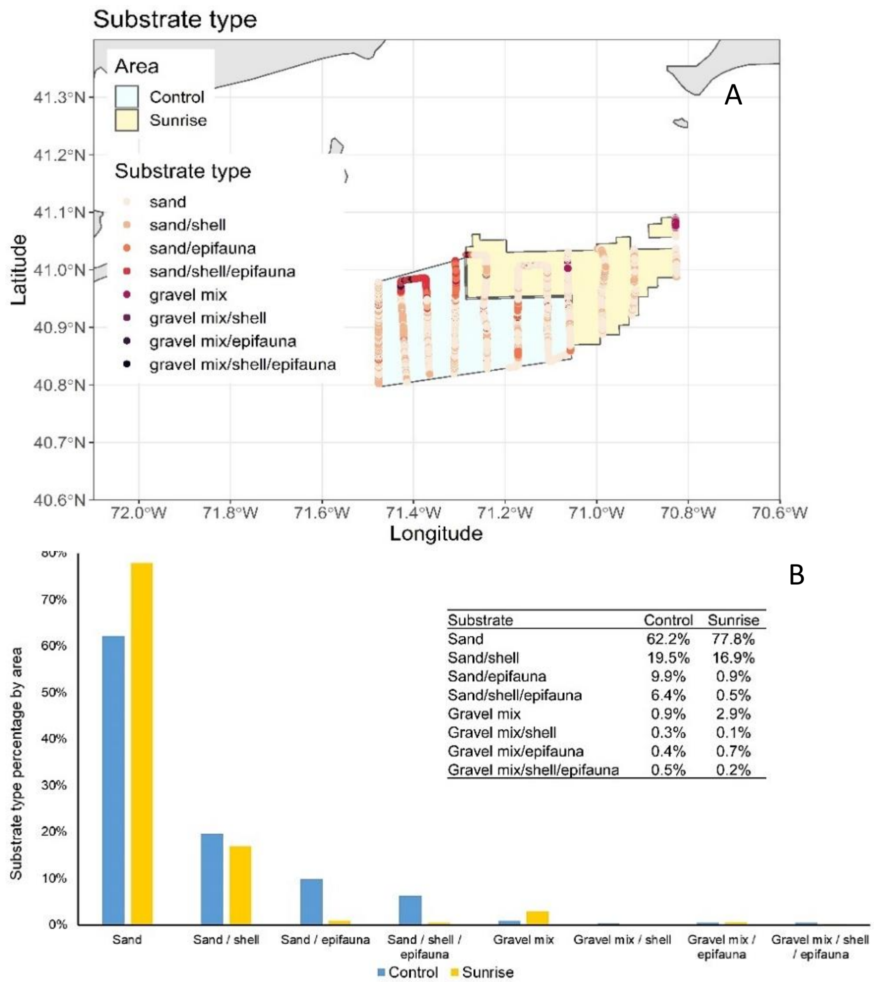



*Figure 7: Benthic salinity and temperature. Salinity is measured in parts per thousand (ppt) and temperature is recorded in degrees Celsius.*

The sediment in both the control and SRWF areas was primary characterized as sandy with some mix of shell hash, epifauna, and gravel (**Figure 8 A-B**). Some larger rocks were seen but not noted in the annotations. No large boulders were found in imagery along the tracks.




| Substrate | Control | Sunrise |
|---|---|---|
| Sand | 62.2% | 77.8% |
| Sand/shell | 19.5% | 16.9% |
| Sand/epifauna | 9.9% | 0.9% |
| Sand/shell/epifauna | 6.4% | 0.5% |
| Gravel mix | 0.9% | 2.9% |
| Gravel mix/shell | 0.3% | 0.1% |
| Gravel mix/epifauna | 0.4% | 0.7% |
| Gravel mix/shell/epifauna | 0.5% | 0.2% |

*Figure 8: Substrate composition for the 2022 control and SRWF areas. The specific breakdowns can be seen by area in both A and B, with a proportional breakdown in B.*

## 4 Issues

The survey did experience technical issues that arose early on, but did not cause any data loss. The SRWF annual monitoring was originally planned to begin on July 13th, 2022, just days after the end of RSA-funded stock assessment surveys completed. However, the system experienced internal issues that necessitated ordering new internal components and troubleshooting. This pushed the SRWF survey back ~2 weeks, and the survey successfully deployed on July 29th, 2022, completing all survey tracks. A brief summary is included below:

On July 13th, 2022, CFF departed from New Bedford at 08:00 aboard the F/V *Kathy Marie* to complete the proposed track within SRWF and the control area. Due to the presence of another survey ship in the SRWF area, CFF started at the most westerly waypoint along the track in the control area moving eastward. The system was deployed around 14:30 on July 13th and over 40 nm of track was covered, until the vehicle experienced issues around 05:18 on July 14th.

Onboard scientists troubleshooted the system until 12:12 on July 14th, when the decision was made to return to land and schedule support services with a technician to allow for more involved system diagnostics. On July 20th, 2022, CFF attempted to depart from New Bedford at 04:00 aboard the F/V *Kathy Marie*. However, continued issues with the HabCam v3 system forced the vessel to return to the harbor. The main bottle of the vehicle was removed for further diagnosis. A technician was assisted in identifying and repairing issues within the system. On July 29th, 2022, CFF successfully departed from New Bedford to complete the final portions of the proposed track within SRWF and the control area.

# 5 Evaluation

## *5.1 Annual Project Objectives included:*

- Provide photographic imagery from proposed transects in the control and SRWF areas
- Create GIS-based plots of various predetermined annotated habitat types and species
- Produce length-frequency distributions of scallops within the surveyed areas
- Derive biomass estimates within each area surveyed using stratified mean estimation by depth and ordinary kriging

All project objectives were completed for the 2022 survey season. Photographic imagery from the proposed transects in the control and SRWF areas were collected as raw TIFF files and processed at a rate of 1:10 into JPEG files. All imagery files were copied and will be provided to Orsted, along with associated metadata. Data will be collected annually each summer until 2026. Collection of annual data and successful objective completion will allow CFF to successfully address long-term project goals by analyzing the cumulative multi-year data set at the conclusion of the contract.

## *5.2 Dissemination of Results*

A small subset of the sea scallop data density, size, count and distribution within the overlap of the control area and the Block Island SAMS area was shared at the annual Scallop PDT meeting on August 31st-Sept 1st, 2022, as agreed upon between CFF and Orsted. No imagery nor data from outside this previously agreed upon subset was shared during this meeting. Additionally, a field report was provided to Orsted on August 11th, 2022. Following this annual report, CFF and Orsted will meet to discuss the survey, data, and further dissemination of results, as applicable. All raw TIFs, processed JPEGS, and associated data will be shared with Orsted.

# 6 Literature Cited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