Annual Monitoring Survey of the Sunrise Wind Farm Lease Area

2023 Annual Report

Prepared for Orsted

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Submitted By

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Project Information

Report Title: Annual Benthic Survey of Sunrise Wind Farm

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Executive Summary

The Coonamessett Farm Foundation (CFF) survey of the Sunrise Wind Farm (SRWF) area using the HabCam v3 was designed to provide critical survey-based information to supplement monitoring efforts of the SRWF lease area. This survey will collect 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 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, and
- Derive biomass estimates using stratified mean estimation by depth and ordinary kriging.

On July 6th, 2023, CFF departed from New Bedford aboard the F/V *Kathy Marie* to complete the proposed track within SRWF and the control area. The planned track was ~160 nm, which was modified slightly to avoid obstacles and hazards in the area (**Figure 1**). Some tracks extended slightly beyond the surveyed areas. The vessel returned on July, 8th, 2023 and reported no significant issues or delays.

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 activity.

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 biomass (total and exploitable) and abundance for sea scallops by site. Both stratified mean and ordinary kriging estimates are included.

		Total Biomass (MT)	Abundance (millions)	Exp Biomass	Exp Abundance (millions)	Density	Mean Wt (g)
Ordinary Kriging	Control	487.01	20.27	415.14	12.44		
	Sunrise	193.19	9.48	142.90	5.22		
Stratified Mean	Control	467.00	19.12	393.63	11.81	0.03	28.06
	Sunrise	181.66	7.98	141.77	5.00	0.02	22.95

Fish and invertebrate species abundance and density were mapped and counts by area can be found in the Results section. Only scallops were measured; counts were supplied for all other species. With few exceptions, species surveyed were more abundant in the control area than in the SRWF.

Background

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 waters off the East Coast of the US, and thousands of turbines are planned for construction in offshore and nearshore waters 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 of such changes, are still unknown. Further studies on the effects of this nascent industry on marine environments is necessary to ensure the sustainability of marine ecosystems and to better understand how to mitigate any negative impacts, should they arise.

Atlantic sea scallops (*Placopecten magellanicus*) are a high-value fishery in in the northeast region with an ex-vessel revenue between $400-$600 million (NMFS, 2022); 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 submitted draft Benthic Research Monitoring Plan for SRWF, Orsted received feedback from the National Oceanic and Atmospheric Administration (NOAA), 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 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 (NMFS, 2018; Miller et al., 2019). 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 the size selectivity of dredge bags (Hart, 2015; Rudders 2015). Optical surveys can also cover large swept areas in a relatively short time frame, allowing for detection of fine-scale changes in species distributions.

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 comprehensive scallop stock assessment (NMFS, 2018). Utilization of the HabCam survey equipment and protocols ensures that the data collected as part of this fisheries monitoring plan will be standardized and comparable to 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 environment 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 therefore poses negligible risks to protected species.

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.

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

Methods

The SRWF monitoring survey took place from July 6th to 8th, 2023. The vehicle was deployed off the stern of the vessel around 20:49 on July 6th and began logging data on the seafloor by 20:52. 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 (GUI), 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 01:57 on July 8th, 2023, and the vessel docked in New Bedford around 10:00 that morning.

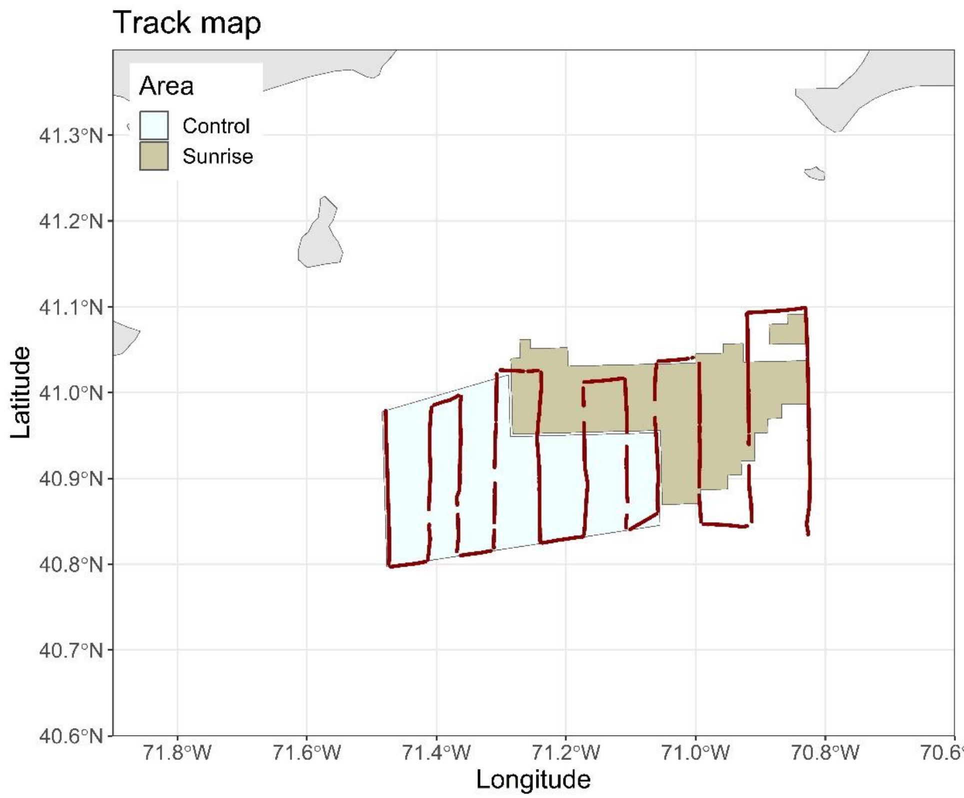

Figure 1*: Map of track lines for the 2023 HabCam v3 survey within the Sunrise Wind (tan) and control area (light blue). The track can be seen in dark red. The actual tracks deviated only slightly from the original proposed track to account for obstacle avoidance and safety.*

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 and conductivity 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 collected images 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 (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 (SH) were measured when the hinge was visible (from hinge to the end of the shell); 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:

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

which is the same equation used by the New England Fisheries Science Center (NEFSC) in 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 to ensure quality assurance and quality control prior to analysis.

Biomass Estimates

Scallop lengths were initially recorded in pixels and were subsequently converted into SH 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 published location-specific Mid-Atlantic SH-MW equation that includes depth and latitude as covariates (NEFSC, 2018). An additional covariate based on the status of an area for scallop rotational management is also part of the Mid-Atlantic equation (Hennen and Hart, 2012; NEFSC, 2018), and the SRWF and control area were considered “open” for deriving MW estimates. Before deriving biomass estimates, the mean biomass per m^2 was derived over 1000m segments to minimize spatial autocorrelation along tracks. Biomass estimates were derived from the aggregated dataset using two methods: 1) stratified mean estimation by depth and 2) ordinary kriging using the variogram function in the R package “gstat” (Pebesma, 2004).

Reference Control Area

The proposed control area is a polygon 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 Vessel Monitoring System and Vessel Trip Report data. The sediment types (primarily sand and cobble with small boulders) were also similar between the two areas, and the control area has a similar depth profile as the adjacent SRWF, with depths ranging from 30 – 60 m. However, CFF noted differences in abundances between the areas in both 2022 and 2023, as the control area had a greater abundance and density of nearly every vertebrate and invertebrate species annotated. In addition, the proposed cable route runs through a proportionally small section of the control area.

Results

Sea Scallop Density and Distribution

Sea scallops of all sizes were found throughout the track, with greater total numbers noted in the control area than in the SRWF (**Figure 2A**). 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 2B, 2D**). 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 2C**). There was a notable change in overall scallop density and distributioin in the surveyed areas between the 2022 and 2023 surveys (**Figure 3A, 3B**). Overall, fewer scallops were found during the 2023 survey, though a small aggregation of juvenile scallops were found with a slightly higher density than seen in 2022.

Sea Scallop Size and Biomass Estimates

The size distributions between the areas varied, and the control area had nearly three times the total number of scallops than in the SRWF area (139 scallops versus 51 scallops, respectively) (**Figure 4A**). Although the length frequency distribution curve was similar between 2022 and 2023, the total number of scallops was significantly greater in 2022 than 2023 for both areas (**Figures 4A, 4B**). Only scallops 40 mm and greater were used in length frequency and biomass calculations for consistency with annual scallop stock assessment parameters. The scallops in the control area had a slightly higher mean SH (using scallops 40 mm and over) than the scallops in the SRWF (111.30 mm and 102.39 mm, respectively) in 2023, which was a similar trend as in 2022. The mean SH for scallops both areas combined (using scallops 40 mm and greater) was similar between 2022 (110.54) and 2023 (108.88) as well.

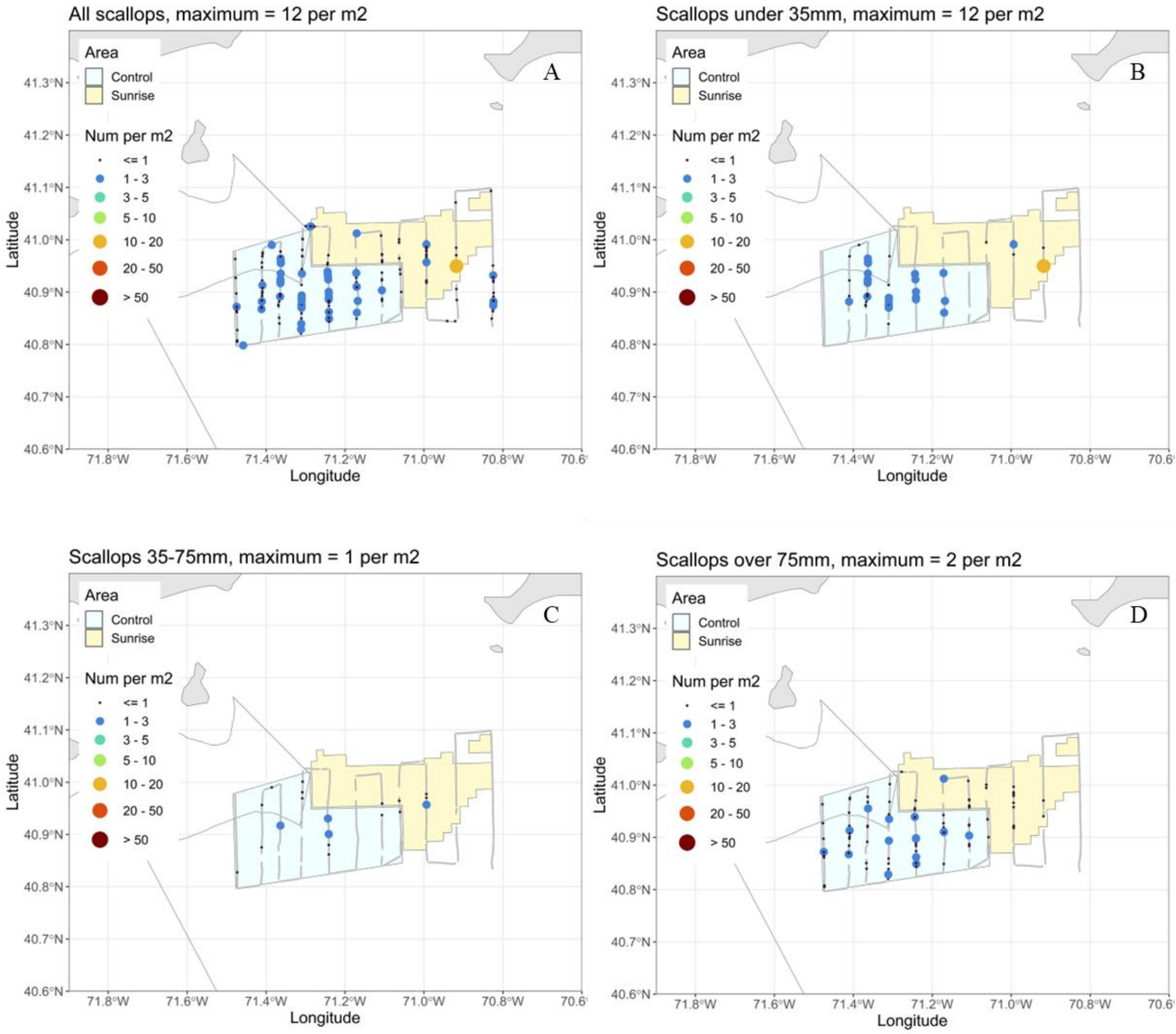

Figure 2: Maps of density and distribution of scallops. Scallops are shown in all size classes (A), as pre-recruits < 35 mm (B), recruit scallops 35 -75 mm (C), and large, adult scallops > 75 mm (D). Maximum density per square meter (m2) is labeled on the top each map.

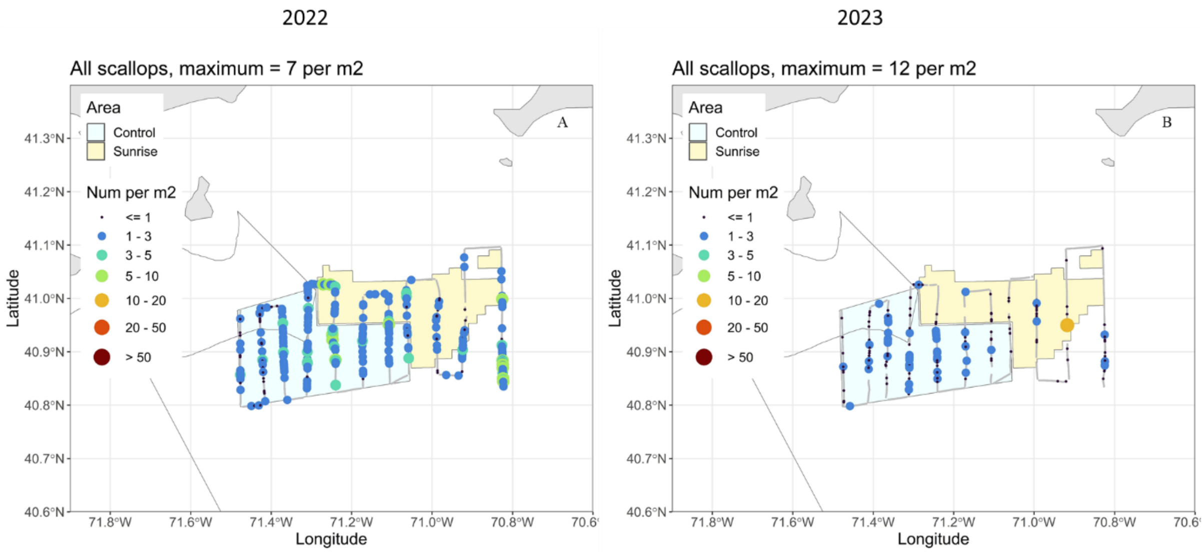

Figure 3: Density and distribution map for all scallops annotated in 2022 and 2023 in both areas surveyed.

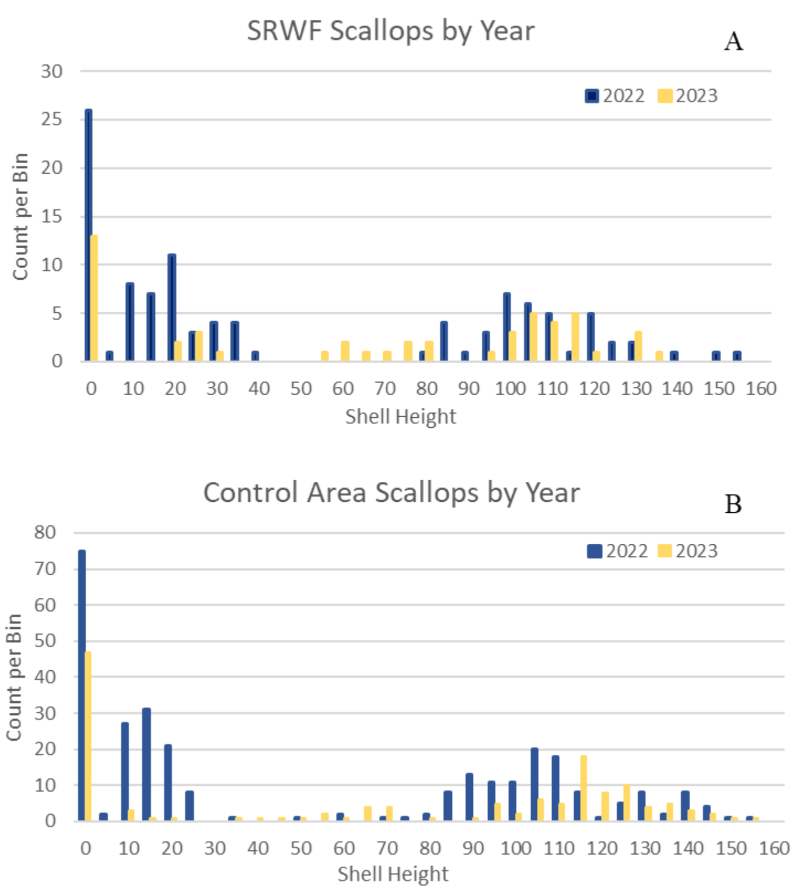

Figure 4: Scallop lengths and counts per size bin at each surveyed site in both 2022 and 2023.

Exploitable biomass estimates for sea scallops in the control area were significantly higher that found in the SRWF area (**Figure 5, Table 2**). Total biomass in the control area was also more than double that found in the SRWF (**Table 1, 2**). Both total and exploitable biomass decreased significantly between 2022 and 2023 in both areas. Total biomass decreased over 40% in the SRWF and approximately 28% in the control area between 2022 and 2023, while exploitable biomass decreased by approximately 45% in the SRWF area and by approximately 25% in the control area between years. While construction has begun at other offshore wind sites nearby, no construction has begun in the SRWF or adjoining sites as of the 2023 survey. It is highly possible that the decrease in biomass of scallops and the decrease in fish and other invertebrate species could be due to fishing pressure in the area.

Table 2: Table of total and exploitable biomass estimates in 2023 versus 2022.

		2023				2022			
		Total Biomass (MT)	Num (millions)	Exp Biomass (MT)	Exp Num (millions)	Total Biomass (MT)	Num (millions)	Exp Biomass (MT)	Exp Num (millions)
Ordinary Kriging	Control	487.01	20.27	415.14	12.44	679.62	26.61	549.72	18.92
	Sunrise	193.19	9.48	142.90	5.22	330.60	12.54	271.19	8.92
Stratified Mean	Control	467.00	19.12	393.63	11.81	649.56	25.22	526.18	18.06
	Sunrise	181.66	7.98	141.77	5.00	310.84	12.02	254.79	8.35

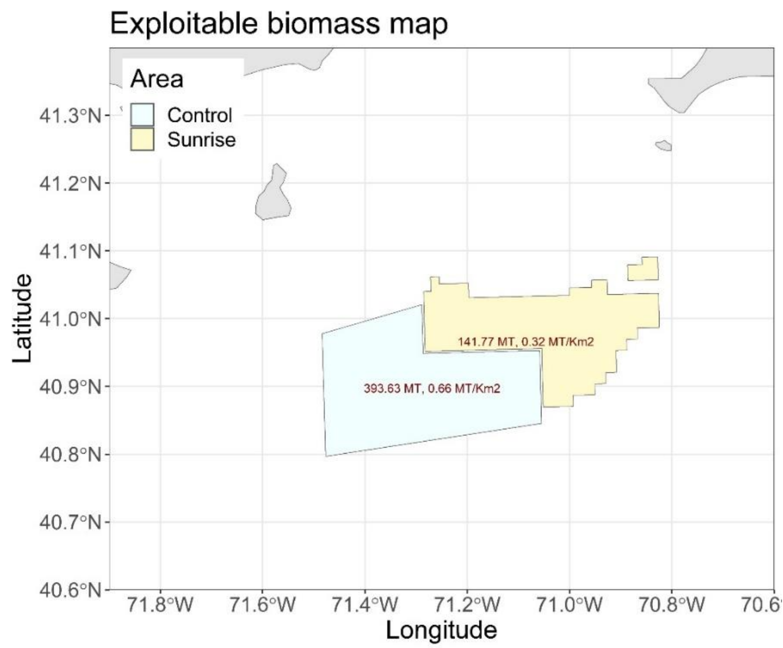

Figure 5: Exploitable biomass of sea scallop in the Control and SRWF areas.

Fish and Invertebrates

Many fish species were flounders in both the control area and the SRWF sites (**Figure 6A**). These were mainly gulfstream flounder, though at very small sizes, it can be difficult to positively determine juvenile flounder species. Other commonly observed species were hake, mainly red and silver hake (**Figure 6B**). Most species were found in greater numbers in the control area than the SRWF, except for sand lance. Sand lance was notably found in only a few dense patches near the middle of the track lines (**Figure 6C**). 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.

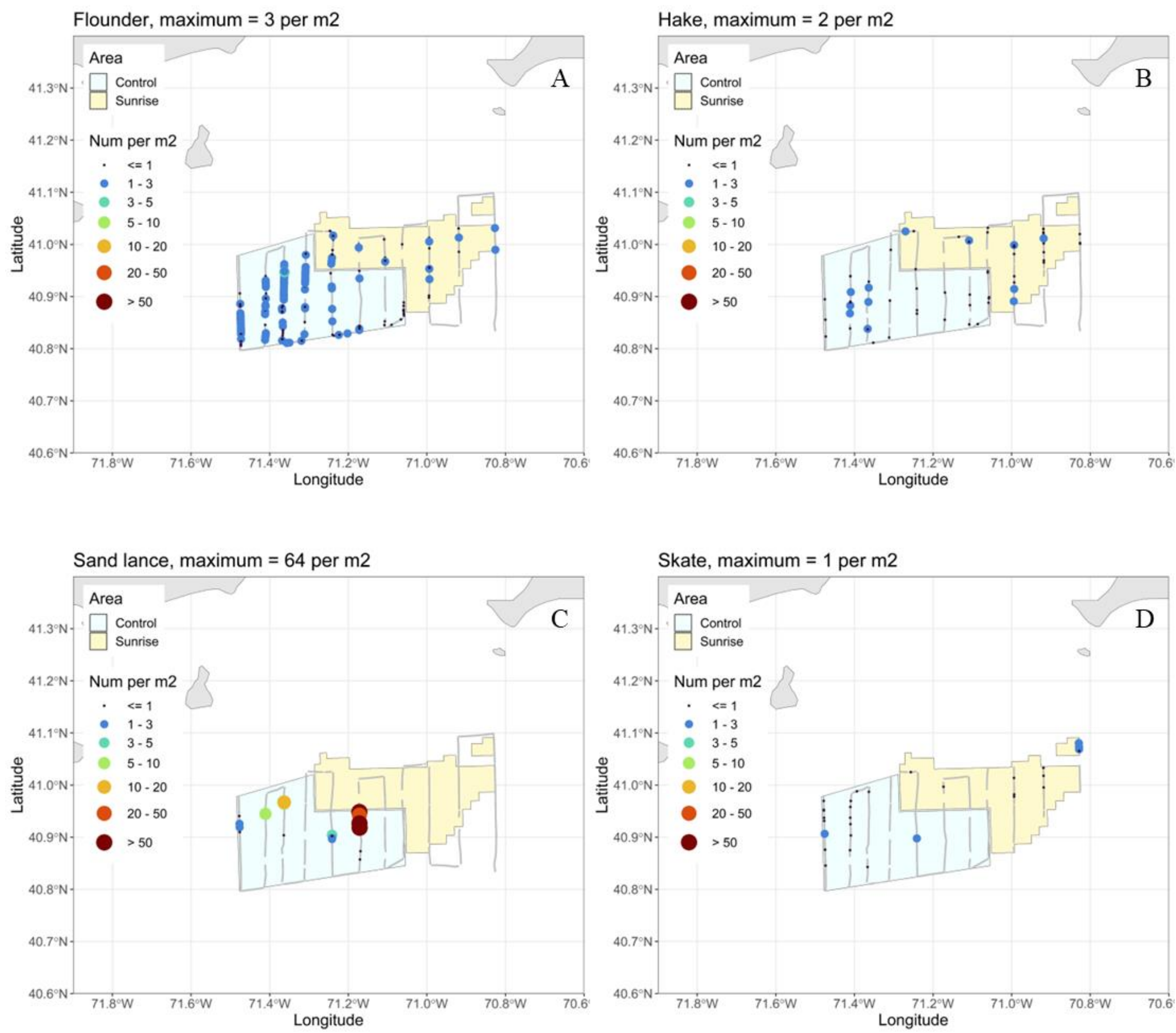

Figure 6: Maps of density and distribution of notable species found along the tracks within the SRWF and controls sites.

Similar to other species, notable invertebrate predators were found in greater numbers in the control area than in SRWF (**Figure 7**). Whelks, moon snails, crabs and sea stars (typically *Astropecten* spp. and *Asterias* spp.) are key predators (as well as scavengers) of sea scallops, and their density and distribution within surveyed areas is important in understanding scallop settlement and survival. In 2023, the largest sea star species noted was by far *Astropecten* spp, which is known to predate on juvenile scallops. Dense aggregations of *Astropecten* spp were found along the southern and western borders of the control area (**Figure 7A**).

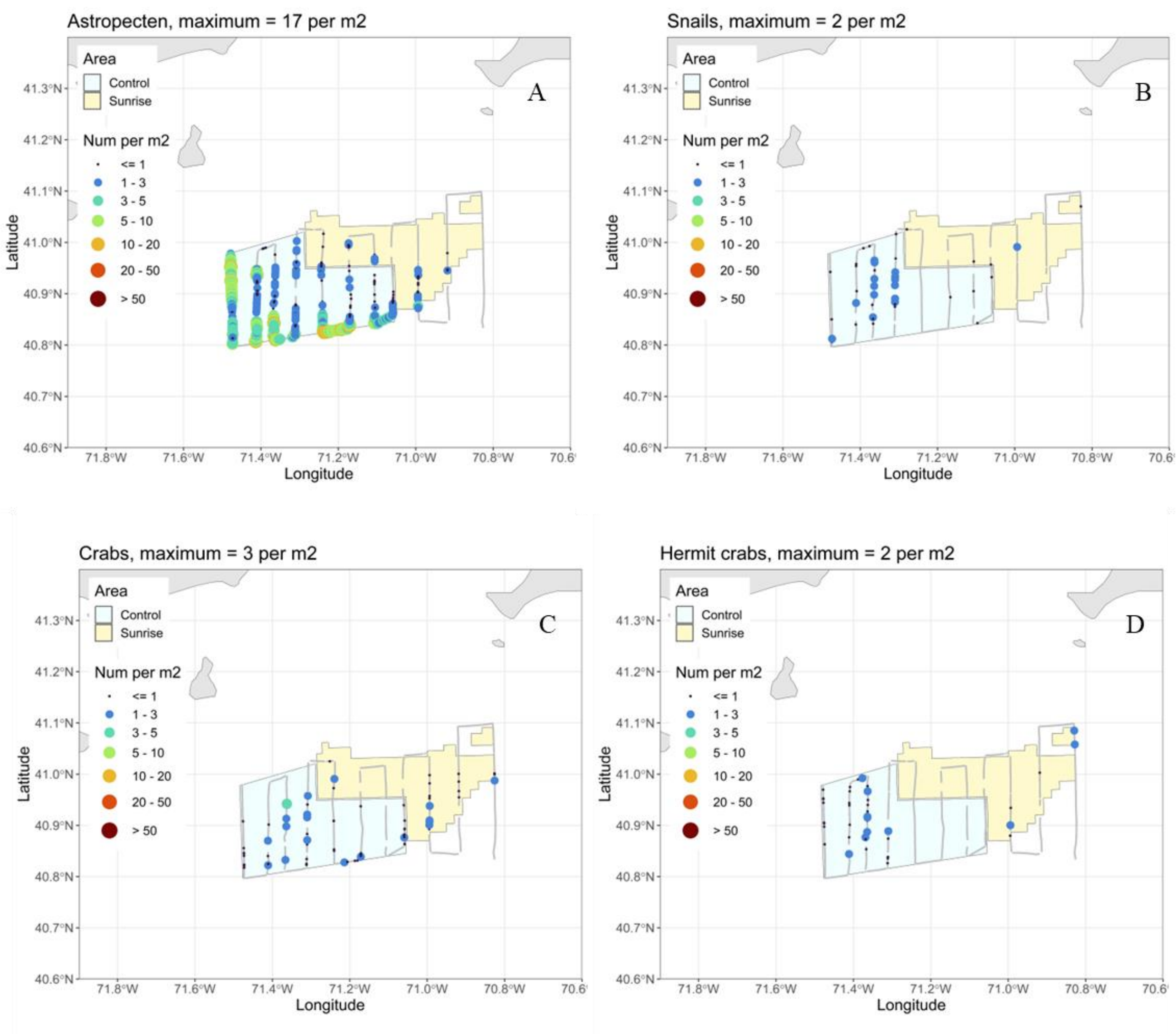

Figure 7: Density and distribution of important invertebrate species that are known scallop predators and/or scavengers along the tracks within SRWF and the control site.

Benthic Habitat/Sediment Composition

Benthic temperatures ranged from 9.41°C to 11.64°C (versus 9.94 °C to 13.8 °C in 2022) with the warmest temperatures located in the northeast corners of the track (**Figure 8**). As in 2022, these warmer areas had notably fewer species, particularly less sea scallops and sea stars compared to other areas. The temperature minimum remained similar as that in 2022, though the nearly 2 °C difference in the maximum temperature could be due to the 3-week difference in timing between the two surveys. Despite the differences in temperature range, the temperature gradient remained similar to 2022 (**Figures 8A, 8B**).

A SeaBird CTD was attached to the HabCam which continuously collects conductivity, temperature, and depth readings. This CTD data was integrated into image data, so each unique image contained this environmental metadata. 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 32.22 ppt to 32.98 ppt (versus 32.9 ppt to 33.9 ppt in 2022) (**Figure 8**). The salinity upper range varied by approximately 1 ppt between 2022 to 2023. Though the range was more condensed in 2023, the salinity range distribution was slightly different between 2022 to 2023 (**Figure 8 C, 8D**).

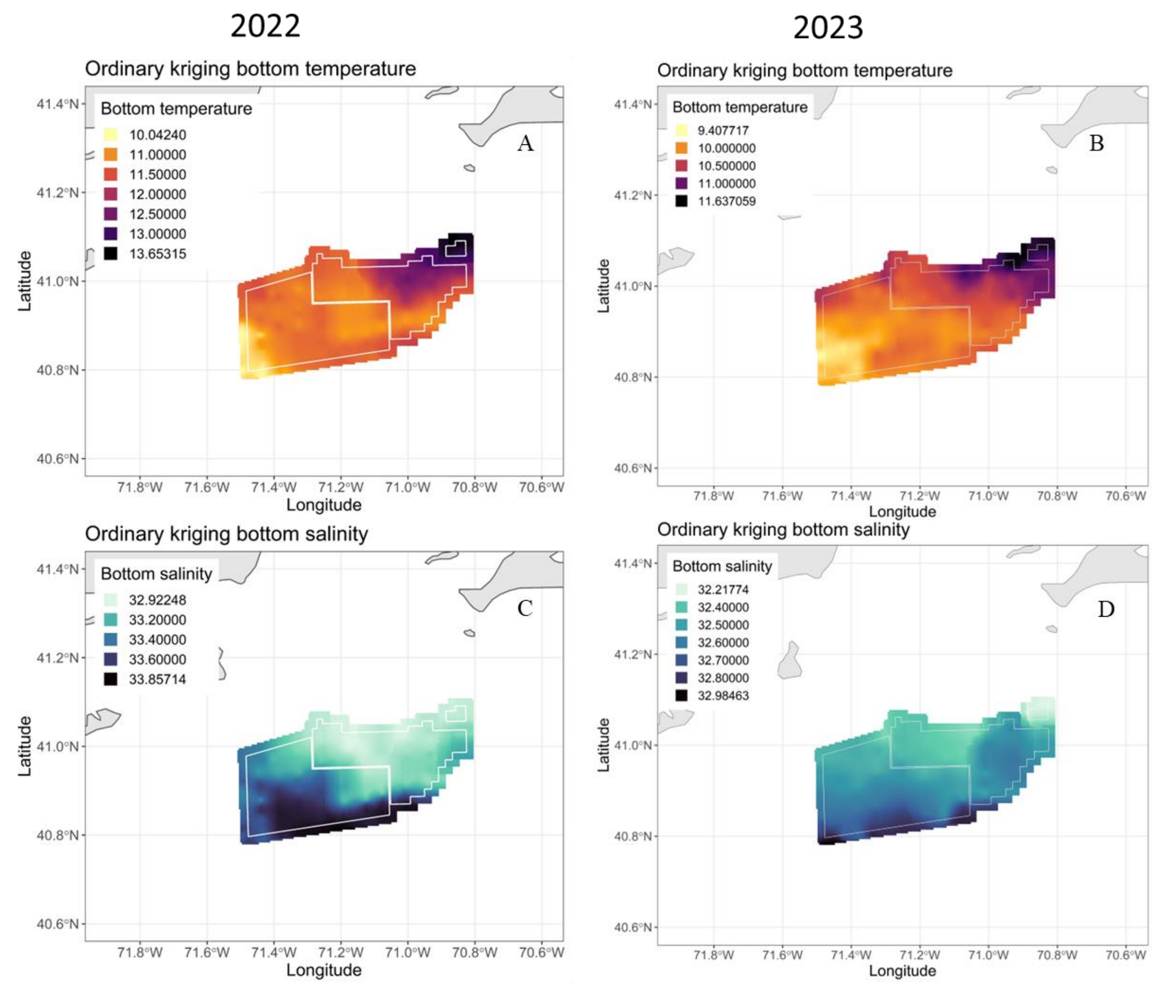

Figure 8: Benthic salinity and temperature in 2022 and 2023. Salinity is measured in parts per thousand (ppt) and temperature is recorded in degrees Celsius.

The sediment in both the control and SRWF areas was primary characterized as sandy with a variable mix of shell hash and epifauna (**Figure 9**). No large boulders were found in imagery along the tracks.

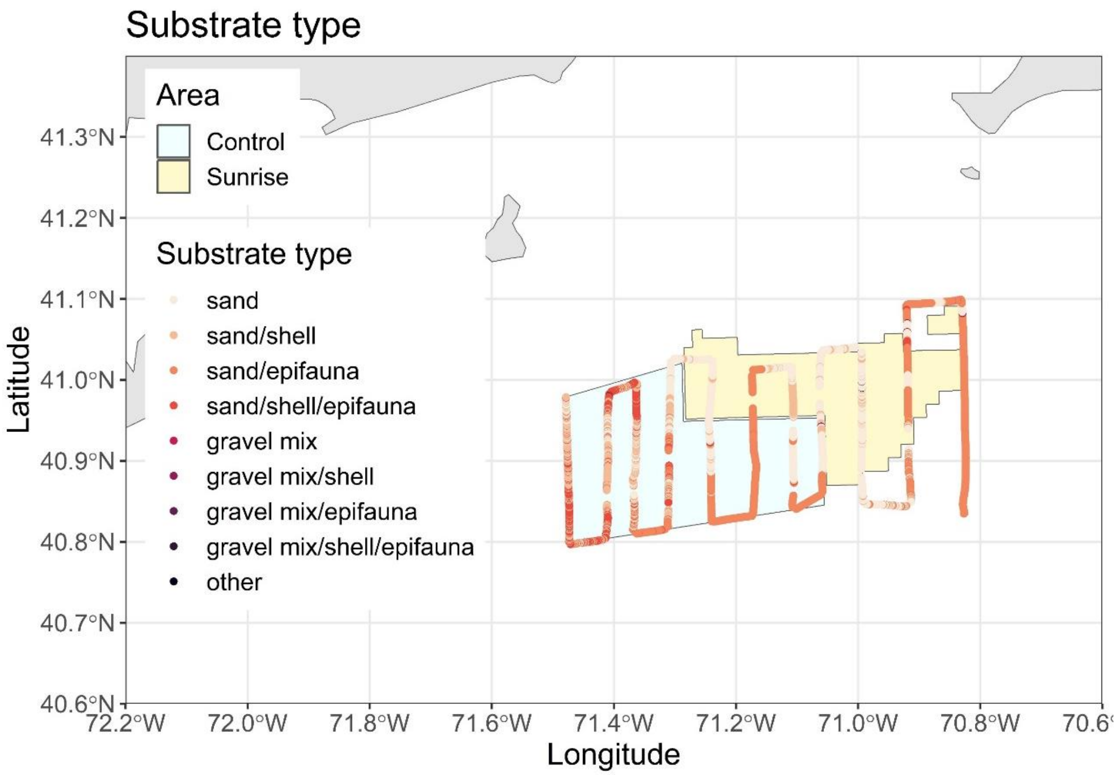

Figure 9: Substrate annotation map with legend for the 2023 survey.

Issues

No major issues were encountered during the survey. Gaps in coverage and shifts in the survey track were largely due to obstacle avoidance. The HabCam was lifted several meters each time scientists or crew sighted highfliers in order to avoid fixed gear within the survey areas. This was also done to avoid boulders/large rocky areas and shipwrecks when it was not possible to shift the track.

Evaluation

Annual Project Objectives

All project objectives listed below were completed for the 2023 survey season.

- 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

Photographic imagery from the proposed transects in the SRWF and control 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 at a date decided upon by both parties. 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.

Dissemination of Results

A field report was provided to Orsted on July 24th, 2023. Following this annual report, CFF and Orsted will meet to discuss the survey, data, and further dissemination of results, as applicable. CFF will plan to present the survey findings at a meeting of Orsted survey teams, as was done following the 2022 season. All raw TIFFs, processed JPEGS, and associated data will be shared with Orsted. Additionally, CFF researchers will be presenting at the World Fisheries Congress in Seattle in March 2024.

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