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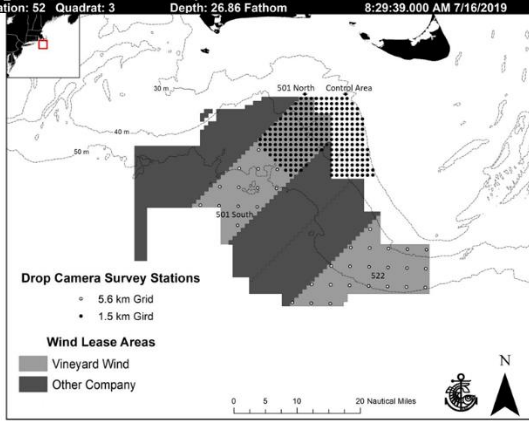
Final Report

2020 Drop Camera Survey of Benthic Communities and Substrate in the 501N Study Area and an adjacent Control Area



Submitted to:
Vineyard Wind LLC
700 Pleasant Street
New Bedford, MA 02740

September 2022 **SMAST-CE-REP-2021-075**

FINAL REPORT

2020 Drop Camera Survey of Benthic Communities and Substrate in the 501N Study Area and a Control Area

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SMAST-CE-REP-2021-075

Project Summary: The University of Massachusetts Dartmouth School for Marine Science and Technology (SMAST) conducted drop camera surveys to examine the benthic community and substrate in the northern portion of Vineyard Wind's Outer Continental Shelf (OCS) Lease Area OCS-A 0501 (501N Study Area) and a Control Area located east and adjacent to the lease area. The primary goal of this project was to collect baseline data for future environmental assessment of wind development impacts. Our objectives were to provide:

1) distribution and density estimates of dominant benthic megafauna,
2) classify substrate types at drop camera stations across the survey domain,
3) compare benthic communities and substrate types between the 501N Study Area, Control Area, and broader regions of the U.S. OCS, and
4) classify substrate within aliquots sampled by the American Lobster (*Homarus americanus*), Black Sea Bass (*Centropristis striata*), and Larval Lobster Abundance Survey, and Lobster Tagging Study (an associated SMAST trap survey also conducted for Vineyard Wind). These aliquots coincided with a subset of the drop camera stations.

We used a centric systematic design to sample survey stations in the 501N Study Area and the Control Area. Stations in the two areas were placed 1.5 kilometers (km) apart following a grid design. At each station, a pyramid mounted with a high-resolution camera was deployed to take four quadrat (2.3 square meter [m^2] image) samples. Both areas were surveyed in July/August and October 2020 using a commercial scallop vessel to deploy the sampling pyramid.

The dominant benthic community of the 501N Study Area and the Control Area were mostly benthic invertebrates such as sand dollars, hermit crabs, waved whelks (*Buccinum undatum*, --not the commercially harvested channeled whelk, *Busycotypus canaliculatus*), anemones, crabs (cancer spp.), and burrowing species. The vertebrates included in the dominant benthic community were skates, silver hake, and red hake. The density of the dominant benthic animals found in the 501N Study Area and Control Area were similar except for waved whelks which had a higher density in the Control Area during August. By contrast, most of the taxa tracked as present or absent in a quadrat were observed in significantly more quadrats per station in the 501N Study Area. This may be related to the differing water depths of the areas. There was significantly less of most animal groups in October compared to July/August, but future investigations will be needed to confirm this seasonal pattern. The confidence intervals associated with the estimates of dominant benthic megafauna prevalence and the ability to detect significant differences show this sampling intensity is adequate for statistical comparison of variance between impact and control sites over time.

The drop camera survey results indicated the substrates in the 501N Study Area and Control Area were dominated by sand with no gravel, cobble, or boulders observed. The benthic community of the 501N Study Area and Control Area were most similar to each other, compared to the selected broader regions of the U.S. OCS. As the broader regions increased in distance from 10's to 100's of kilometers from the 501N Study Area, the similarity decreased. The substrate within trap survey aliquots was entirely comprised of sand.

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Introduction

In 2015, Vineyard Wind LLC (Vineyard Wind) leased a 675 square kilometer (km^2) area for renewable energy development on the Atlantic outer continental shelf (OCS) named Lease Area OCS-A 0501, which is located approximately 14 miles south of Martha's Vineyard in Massachusetts. Vineyard Wind is developing the northern portion of Lease Area OCS-A 0501, and fisheries surveys are being conducted in a 250 km^2 area referred to as the "501N Study Area", which is the focus of this report. Vineyard Wind is also conducting fisheries surveys in the southern portion of Lease Area OCS-A 0501[1] (501S Study Area) and within Lease Area OCS-A 0522 (522 Study Area); these studies are reported separately.

SMAST has developed an image-based drop camera survey that allows for practical data collection of the epibenthic community while minimizing disturbance to the seafloor. The SMAST drop camera survey can be used to better understand benthic macrofaunal community characteristics, substrate habitats, and the spatial and temporal scales of potential impacts on these communities and habitats. The survey techniques were developed collaboratively with scallop (*Placopecten magellanicus*) fishermen and apply quadrat sampling methods based on diving studies (Stokesbury and Himmelman 1993, 1995). Initial surveys in the early 2000s focused on estimating the density of scallops within closed portions of the U.S. Georges Bank fishery and the survey approach has since expanded to cover most of the scallop resource in U.S. and Canadian waters (≈100,000 km^2, Figure 1). Information from the survey has been incorporated into the scallop stock assessment through the Stock Assessment Workshop process and reliably provided to the New England Fisheries Management Council (NEFMC) to aid in annual scallop harvest allocation (NEFSC 2010, 2018).

[1] The Bureau of Ocean Energy Management segregated Lease Area OCS-A 0501 into two lease areas – OCS-A 0501 and OCS-A 0534 – in June 2021. The 501S Study Area is now located in the area designated as Lease Area OCS-A 0534 ad is referred to as the 501S Study Area in SMAST fisheries survey reports published prior to January 2022.

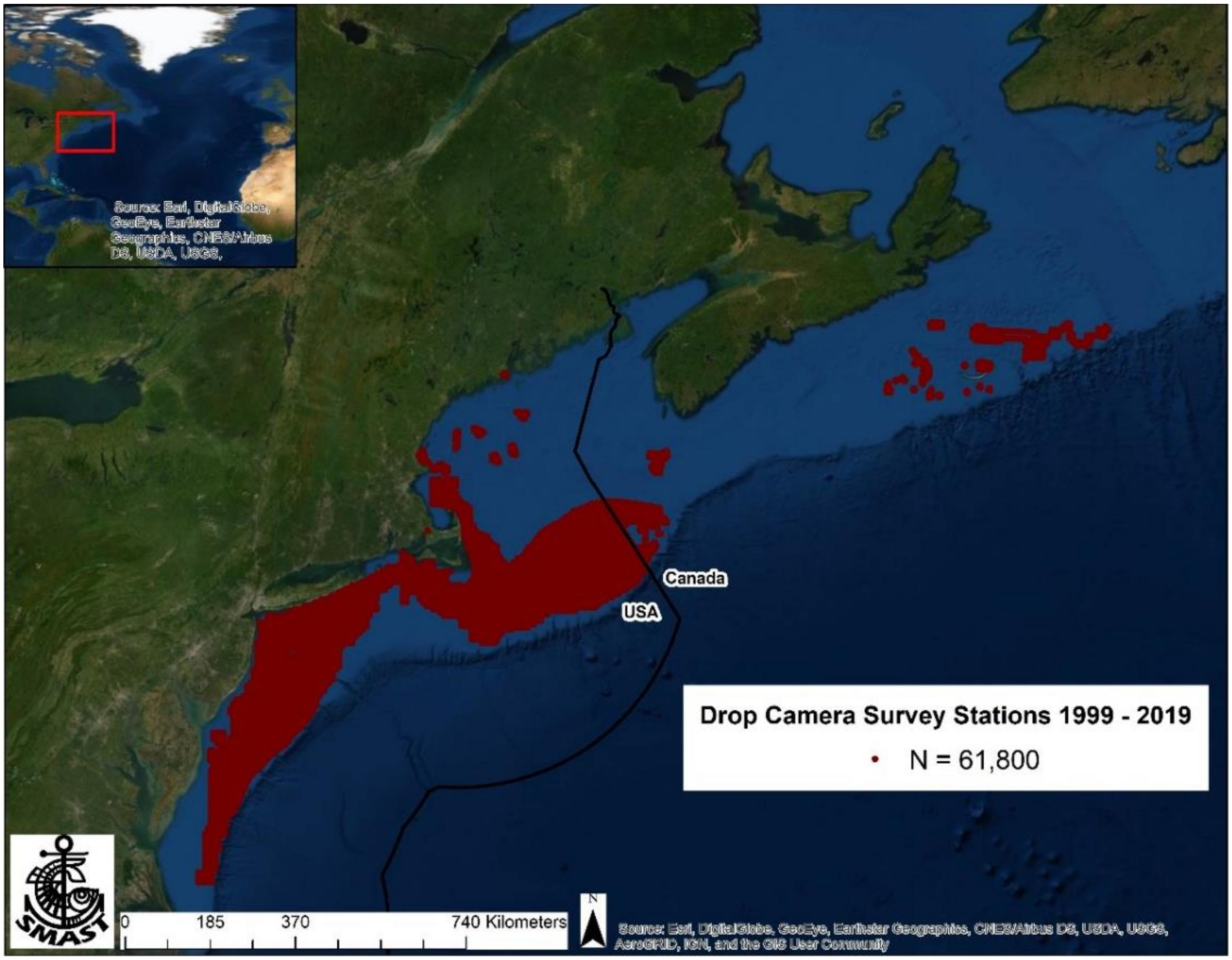

Figure 1. The spatial extent of SMAST drop camera surveys in northwest Atlantic. All stations surveyed since 1999 are displayed.

Data from the drop camera survey has contributed in numerous ways to understanding the ecology of non-scallop species (Marino et al. 2009, MacDonald et al. 2010, Bethoney et al 2017, Asci et al. 2018, Rosellon-Druker and Stokesbury 2020) and the characterization of benthic habitat (Stokesbury and Harris 2006; Harris and Stokesbury 2010; NEFMC 2011; Harris et al. 2012). This work contributed to several ecosystem-based management activities such as the NEFMC Area Seabed Impact model (NEFMC 2011). Drop camera surveys have also been used to define habitat characteristics and spatial distribution of benthic marine invertebrates in potential wind energy areas off the coasts of Maryland and southern New England (Guida et al 2017). Ecologically and economically important species that would be difficult to sample with a net or dredge, such as longfin squid (*Doryteuthis pealeii*) egg clusters or habitat-forming filamentous fauna (bryozoans or hydrozoans), can be counted using the drop camera survey (Figure 2).

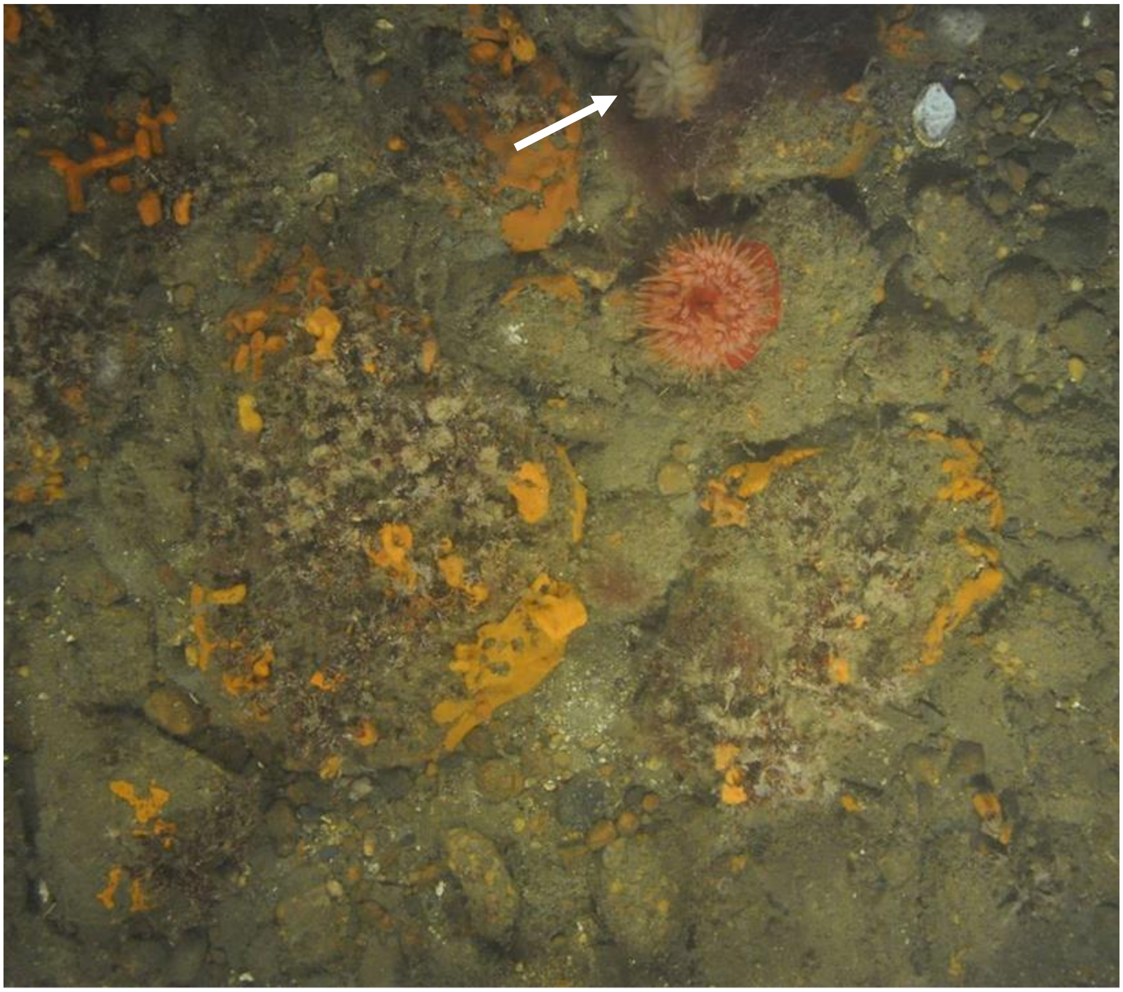

Figure 2. Example of a digital still image taken by the SMAST drop camera survey in complex habitat of the Rhode Island Wind Energy Lease Area on Cox's Ledge during a survey in 2013. A longfin squid *(Doryteuthis pealeii*) egg cluster is present (top, middle).

The data collected by the drop camera survey can be used in an impact assessment to determine whether a change to the environment occurred due to a specific stressor, such as wind development, and to what extent the components are affected (Smith 2006). The Before-After Control-Impact (BACI) study is an experiment designed for assessing anthropogenic impacts on natural habitats and is particularly useful in large-scale anthropogenic disturbances or environmental management (Green 1979; Underwood 1991; Kerr et al. 2020). To account for naturally fluctuating characteristics, a designated area outside of the 501N Study Area, but containing similar environments and communities, is chosen to be the control site (Eberhardt 1976). The approach is strengthened with an asymmetrical design that uses multiple control sites at different distances from the impact site, incorporating the concepts of Beyond BACI (Underwood 1993) and Before After Gradient (Ellis and Scheider 1997). The standardized, systematic approach of the drop camera survey allows each survey the potential to become a dataset integrated into this design with the goal of comparing epibenthic faunal densities between impact and control sites over time. Drop camera surveys within and near areas slated for offshore wind energy development will aid in building a regional, standardized baseline dataset needed to address development impacts on epibenthic communities and habitats.

Goal and Objectives

The primary goal of this project was to provide baseline epibenthic faunal and substrate habitat data for future environmental assessment of wind development in the 501N Study Area (Figure 3). To do this we used information from drop camera surveys of the 501N Study Area and a nearby Control Area during two different time periods to:

1) map the distribution and estimate the density of dominant benthic megafauna, and
2) classify substrate types.

These two objectives documented the primary epibenthic animals and habitats within the 501N Study Area and Control Area to help identify which animals and habitats are detected at high enough rates for future statistical analyses. They also document seasonal changes in distribution and density. Further objectives involve work to:

3) Compare benthic communities and substrate types between the 501N Study Area, Control Area, and broader regions of the U.S. OCS.

This objective is related to identifying multiple control areas at differing distances from the 501N Study Area.

4) Classify substrate within aliquots sampled by SMAST's associated American Lobster, Black Sea Bass, Larval Lobster Abundance Survey, and Lobster Tagging Study of the 501N Study Area and Control Area.

Objectives 3 and 4 leverage drop camera data to provide habitat information for the trap survey.

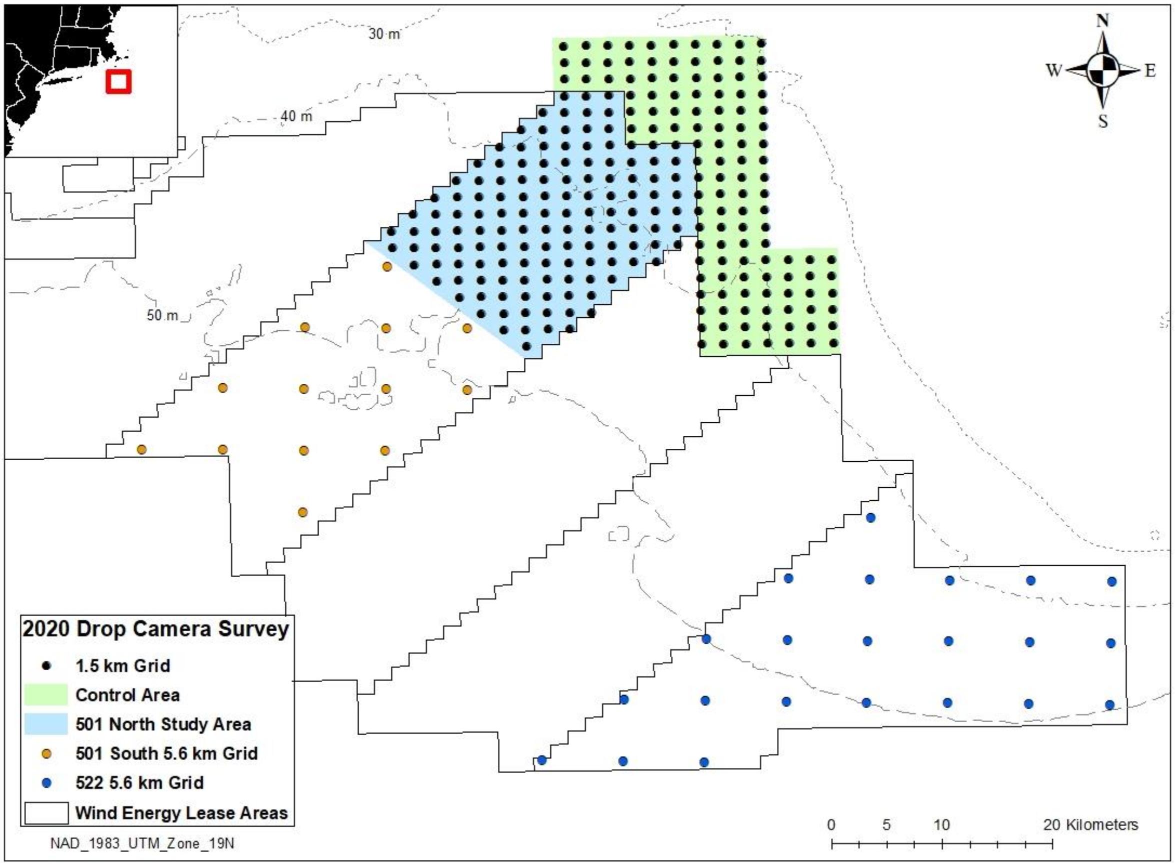

Figure 3. Drop camera survey station grids and MA Wind Energy Lease Areas.

Methods

We utilized a centric stratified, systematic design to sample survey stations in the 501N Study Area and Control Area. Stations in the two areas were placed 1.5 km apart following a grid design. At each station, a sampling pyramid, mounted with a high-resolution camera, was used to take four quadrat samples (Figure 4). Both areas were surveyed from July 28 to August 1 and from October 23 to 27 2020 using a commercial scallop vessel to deploy the sampling pyramid. The Control Area was defined by an adjacent area with the same latitude boundaries (40.93 to 41.14 decimal degrees) as the 501N Study Area in waters deeper than 30 meters (m) that did not overlap with wind lease areas (Figure 3). This resulted in water depths in the 501N Study Area potentially being deeper than the Control Area but offered the best continuous location for a control site near the 501N Study Area. The Control Area could have been moved further away to achieve similar depths but results from the 2012 and 2013 drop camera surveys of MA Wind Energy Areas that provided preliminary data of this area indicated that a control area needed to be near the development site to ensure a similar assemblage of animals. The grid resolution was based on analysis of the variability of the dominant benthic invertebrates observed in the 2012 and 2013 surveys that suggested at least 60 sites, but ideally close to 200, were needed to provide an adequate sample size for meaningful analysis of variance (Krebs 1989). This survey also sampled stations in the 501S Study Area and 522 Study Area with a 5.6 km grid resolution to match previous surveys and provide preliminary information for future statistical power analysis.

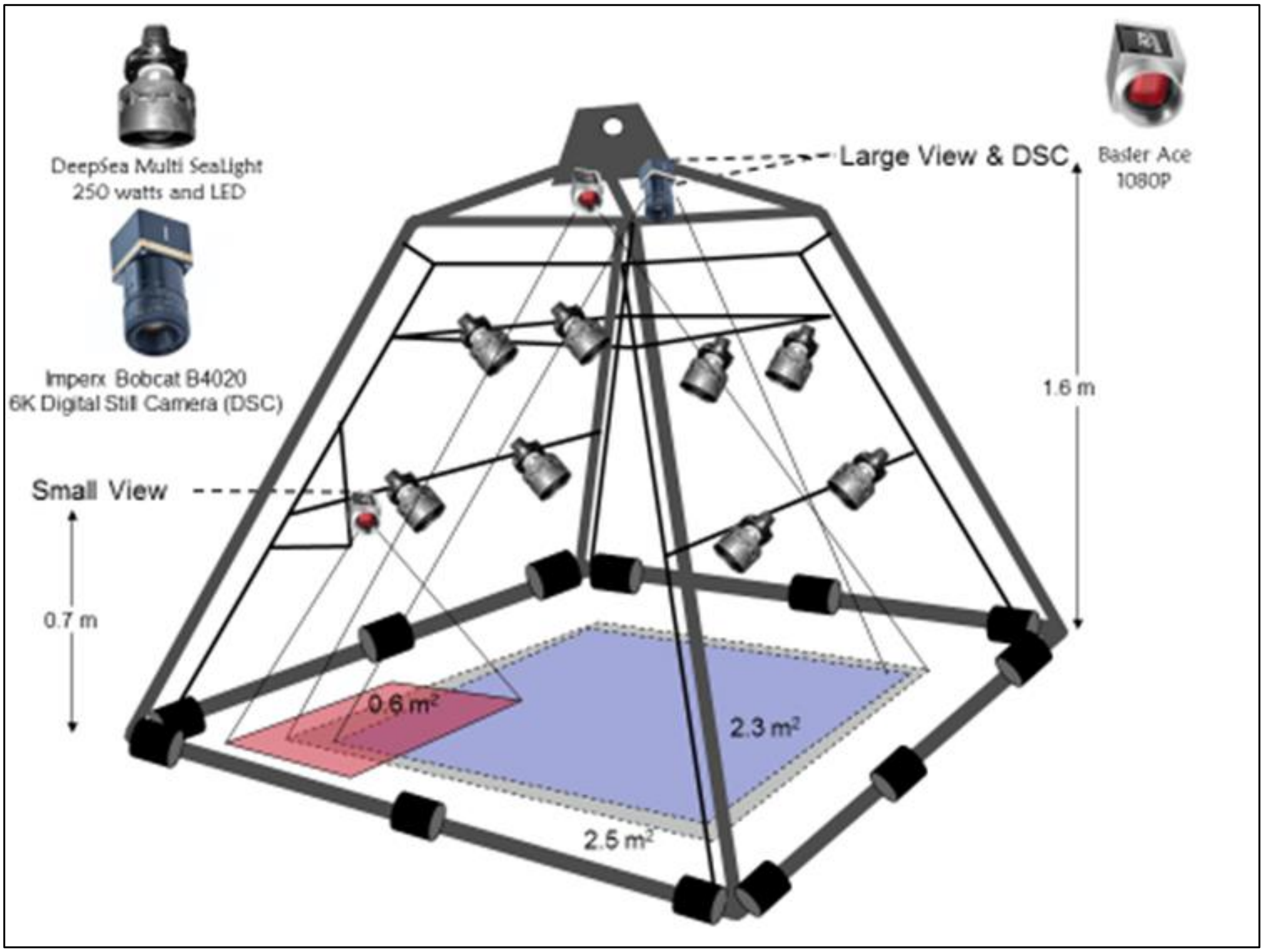

Figure 4. SMAST drop camera survey pyramid with cameras and lights used for data collection. The camera used for the small view was turned to the side to provide a view parallel to the seafloor for some stations.

At each station, we deployed the drop camera pyramid affixed with cameras and lights to the seafloor from a commercial fishing vessel (Stokesbury 2002, Stokesbury et al. 2004, Bethoney and Stokesbury 2018). A mobile studio including monitors, computers for image capturing and data entry, and survey navigation (software integrated with differential global positioning system) was assembled in the vessel's wheelhouse. The two downward-facing cameras mounted on the sampling pyramid provided 2.3 m^2 and 2.5 m^2 quadrat images of the seafloor for all stations. Additionally, a third camera providing a 0.6 m^2 view or view parallel to the seafloor was also deployed. Images from all cameras and video footage from the 2.5 m^2 camera were saved and then the pyramid was raised, so the seafloor could no longer be seen. The vessel drifted approximately 50 m, and then the pyramid was lowered to the seafloor again to obtain a second quadrat; this was repeated a further two times so that each station had four images from each camera. Onboard the survey vessel, scallop counts, station location, and depth were recorded and saved through a specialized field application for entry into an SQL Server Relational Database Management System.

After the survey, the high-resolution digital still images were used as the primary data source (Figure 2). Other images and video collected were used as aids. Within each quadrat, macrobenthos were counted or noted as present, and the substrate was identified on the Wentworth scale (Stokesbury 2002, Stokesbury et al. 2004, Bethoney and Stokesbury 2018). Fifty taxa of macrobenthos are counted or noted as present or absent (see Appendix II). For animals noted as present, the percent of a quadrat they were present within was calculated by portioning the quadrat into equal-sized cells and recording presence or absence for each cell. In addition, longfin squid egg clusters *(Doryteuthis pealeii*), which are not typically enumerated, were counted. Sediments were visually identified following the Wentworth particle grade scale from images, where the sediment particle size categories (in grain diameters) are based on a doubling or halving of the fixed reference point of 1 millimeter (mm); sand = 0.0625 to 2.0 mm, gravel = 2.0 to 256.0 mm and boulders > 256.0 mm (Lincoln et al. 1992). Gravel was divided into two categories, granule/pebble = 2.0 to 64.0 mm and cobble = 64.0 to 256.0 mm (Lincoln et al. 1992). The presence of each sediment category was noted for each image. Maps and analysis focused on classifying stations by the largest sediment particle size observed in a digital still image from that station (Harris and Stokesbury 2010). Shell debris was also identified. After the images were digitized, a quality assurance check was performed on each image to ensure accuracy of counted and identified species and sediments.

Mean densities and standard errors of animals counted were calculated using equations for a two-stage sampling design where the mean of the total sample is (Cochran 1977):

$$\bar{\bar{x}} = \sum_{i=1}^{n} \left(\frac{\bar{x}_i}{n} \right)$$

where *n* is the number of stations and $\bar{x}_i$ is the mean of the four quadrats at station *i*. The SE of this two-stage mean was calculated as:

$$S.E.(\bar{x}) = \sqrt{\frac{1}{n}(s^2)}$$

where:

$$s^2 = \sum^{n} (\bar{x}_i - \bar{\bar{x}})^2 / (n-1)$$

According to Cochran (1977) and Krebs (1989), this simplified version of the two-stage variance is appropriate when the ratio of sample area to survey area (*n*/*N*) is small. In this case, thousands of square meters (*n*) are sampled compared with millions of square meters (*N*) in the study area. A similar multi-stage approach was used to calculate mean presence values. Mean density or quadrats present per station were mapped and statistically compared between the control and development sites. The analysis was limited to the 12 most common benthic animal groups in the 501N Study Area and Control Area, to focus results on the groups detected at high enough rates for statistical analysis (Bethoney et al. 2017). Densities for each taxa were compared by graphing mean estimates with their associated 95% confidence intervals (Sokal and Rohlf 2012).

A percent similarity index (Renkonen 1938) was used to measure similarity between benthic community and substrate types between the 501N Study Area, Control Area, and broader regions of the U.S. continental shelf. This index compares relative proportions of taxonomic categories present in each area standardized as a percentage of the total categories observed. The approach uses species occurrence to assess the spatial dominance of species categories as opposed to the number of individuals observed as abundance comparisons will do. This allows for a more comprehensive model of the benthic communities, as rarer species will not be excluded due to the extraordinarily high abundance of the few dominant species. This comparison will include only species from Asci et al. (2018). These animals were sessile or exhibit locally mobile behavior and were identified in previous drop camera surveys for this comparison. Drop camera data from four areas similar in size and depth to the 501N Study Area, but at increasing distances away from the 501N Study Area were used as the broader areas (Figure 5). These surveys were conducted for sea scallop assessment in 2020 but followed the same design and protocols as described above (Bethoney and Stokesbury 2018). Comparisons were only made to August survey results of the 501N Study Area and Control Areas as the areas in the Mid-Atlantic were surveyed in May, while the areas on Georges Bank were surveyed in August (Figure 5). These four areas are not located in areas slated for wind energy development and could be used as broader control areas based on similarity index results.

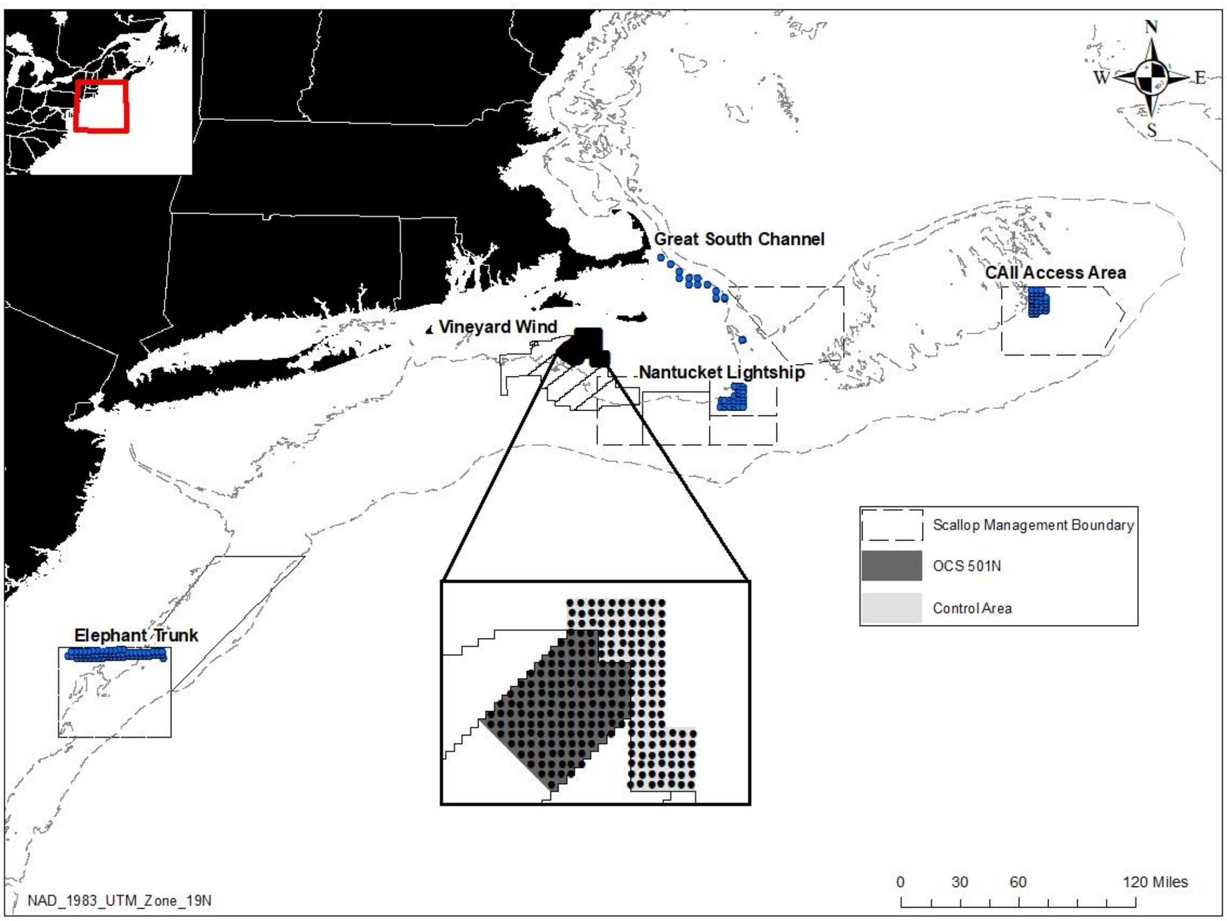

Figure 5. Location of four areas (blue) that were compared to the 501N Study Area and Control Area (black) to assess benthic community and substrate similarity.

Results and Discussion

The two drop camera surveys of the 501N Study Area and Control Area were conducted from July 28 to August 1 and from October 23 to 27 2020. In July/August, 122 stations were sampled in the Control Area and 134 stations in the 501N Study Area. In October, 121 stations were sampled in the Control Area and 133 in the 501N Study Area. Due to high turbidity and silt in the water column, many stations within the Control Area and the 501N Study Area were not visible. This resulted in 56 visible stations in the Control Area and 33 visible stations in the 501N Study Area in October and the exclusion of 26 quadrat samples in the August survey.

All images and video collected were shared with Vineyard Wind. The results related to the most observed benthic animals, as well as scallops and flat fishes, due to their regional commercial importance, as well as the substrate types. For general information on all categories tracked refer to Appendix II (Table 1).

Table 1. The most frequently observed benthic animal groups, in order of most to least quadrats present, during the 2020 SMAST drop camera survey of the 501N Study Area and an adjacent Control Area. Groups left blank in the "Counts" column are tracked as present or absent.

Animal Group	Quadrats Present	Counts
Sand Dollars	682	
Holes (Burrowing Animals)	436	
Anemones	102	
Crabs	86	95
Skates	82	85
Sponges	79	
Red hake	70	78
Silver hake	59	62
Hermit Crabs	25	25
Skate Egg Case	24	27
Bryozoans/Hydrozoans	12	
Flat Fishes	9	11
Moonsnail	8	8
Scallops	8	8
Total Quadrats Sampled	1297	

The lack of visibility in October at certain stations increased the uncertainty around density estimates. However, a clear decline in the abundance or presence of most animal groups occurred between July/August and October (Figures 6-7). It is possible the lack of visibility during the October survey impeded our ability to quantify the organisms in images, but small animals such as hermit crabs and sand dollars were observed. The same patterns were found in deeper areas where visibility was not an issue (see the "2020 Drop Camera Survey of Benthic Communities and Substrate in the 522 Study Area" report**)**. The SMAST trawl survey detected a similar pattern in fish abundance as with our findings (C. Rillahan person comm.). Future investigations, and fewer visibility issues, are necessary to confirm the differences in seasonal patterns detailed in this report.

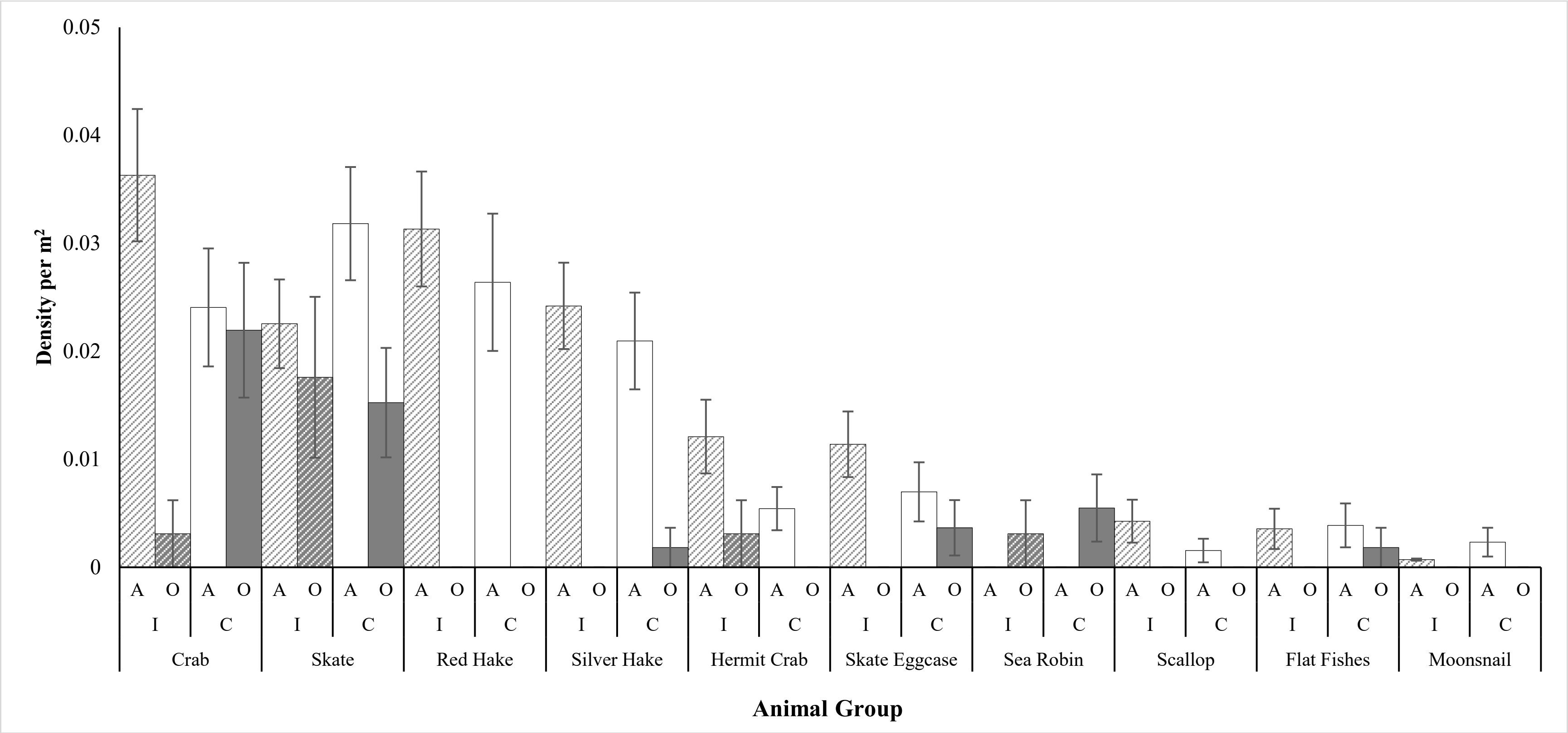

Figure 6. The density of common or commercially important benthic animals in the July/August (A) and October (O) 2020 drop camera survey of the 501N Study Area (I) and the adjacent Control Area (C). Error bars are 95% confidence intervals.

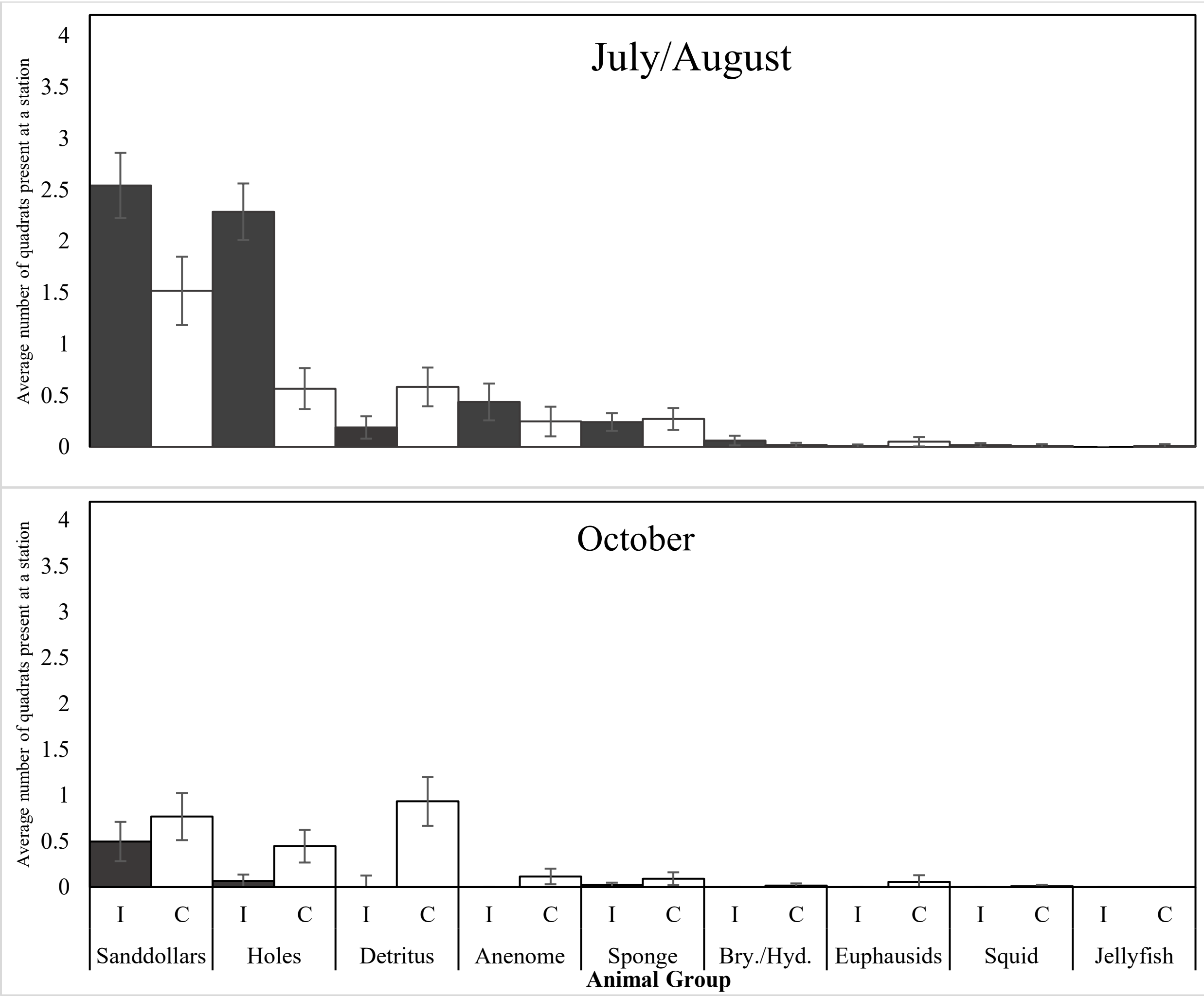

Figure 7. The average number of quadrats of common benthic animals that were present at each station during the July/August (A) and October (O) 2020 drop camera surveys of the 501N Study Area (I) and adjacent Control Area (C). Four quadrats (2.64 m^2 images in August, 2.44 m^2 images in October) were observed at each station. Holes represent burrowing animals and Bry./Hyd. indicates bryozoans and hydrozoans. Error bars are 95% confidence intervals.

The density of the dominant benthic animals found in the 501N Study Area and Control Area were similar (Figure 6). The one exception was skates (*Leucoraja* spp. or *Dipturus laevis*), which had a significantly higher density in the Control Area compared to the 501N Study Area (Figure 6). The species with the highest abundance in both areas during the August survey were crabs (Cancer spp.), skate (*Leucoraja* spp. or *Dipturus laevis*), red hake (*Urophycis chuss*), silver hake (*Merluccius bilinearis*), and hermit crabs (Figure 6). The species with the highest abundance in both areas during the October survey were crabs, skate, and sea robins (*Prionotus carolinus*) (Figure 6).

The distribution of all animals counted (estimated as individuals per m^2) changed between July/August and October (Figures 8-24). In July and August, crabs were distributed throughout the survey areas (Figures 8-9). The other animals were also found throughout the surveyed areas, but densities at or above the 50th percentile appeared to be concentrated at depths greater than 40 m (Figures 11, 13, 15, 17, 19, & 21). In October, all these animals had significantly lower densities or were absent in the 501N Study Area and Control Area, except for skates (Figures 15-16).

Monkfish (*Lophius americanus*) were present in the Control Area, but not the 501N Study Area in August (Appendix I). The visibility issues impacted more stations in the Control Area, limiting the value of this comparison. Overall, the results suggest similar abundance and seasonal trends in the dominant benthic fauna in the 501N Study Area and Control Area. Few squid and no squid eggs were observed. Haddock (*Melanogrammus aeglefinus*), eel (*Anguilliformes*), and sea robin (*Prionotus carolinus*) were only found during the October survey (Appendix I). Several other key organisms, including the American lobster (*Homarus americanus*), were not observed (Appendix I).

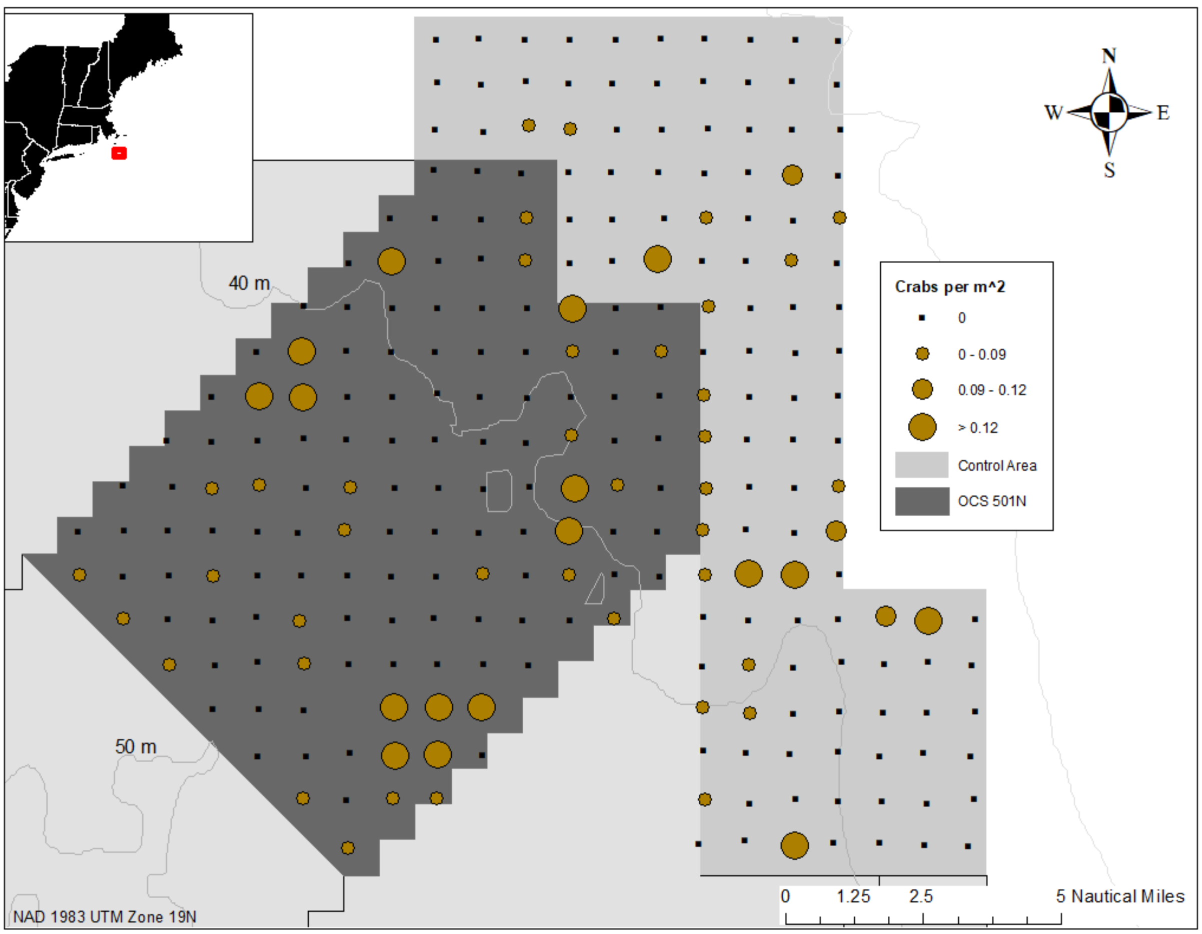

Figure 8. The distribution of crabs in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July/August and October.

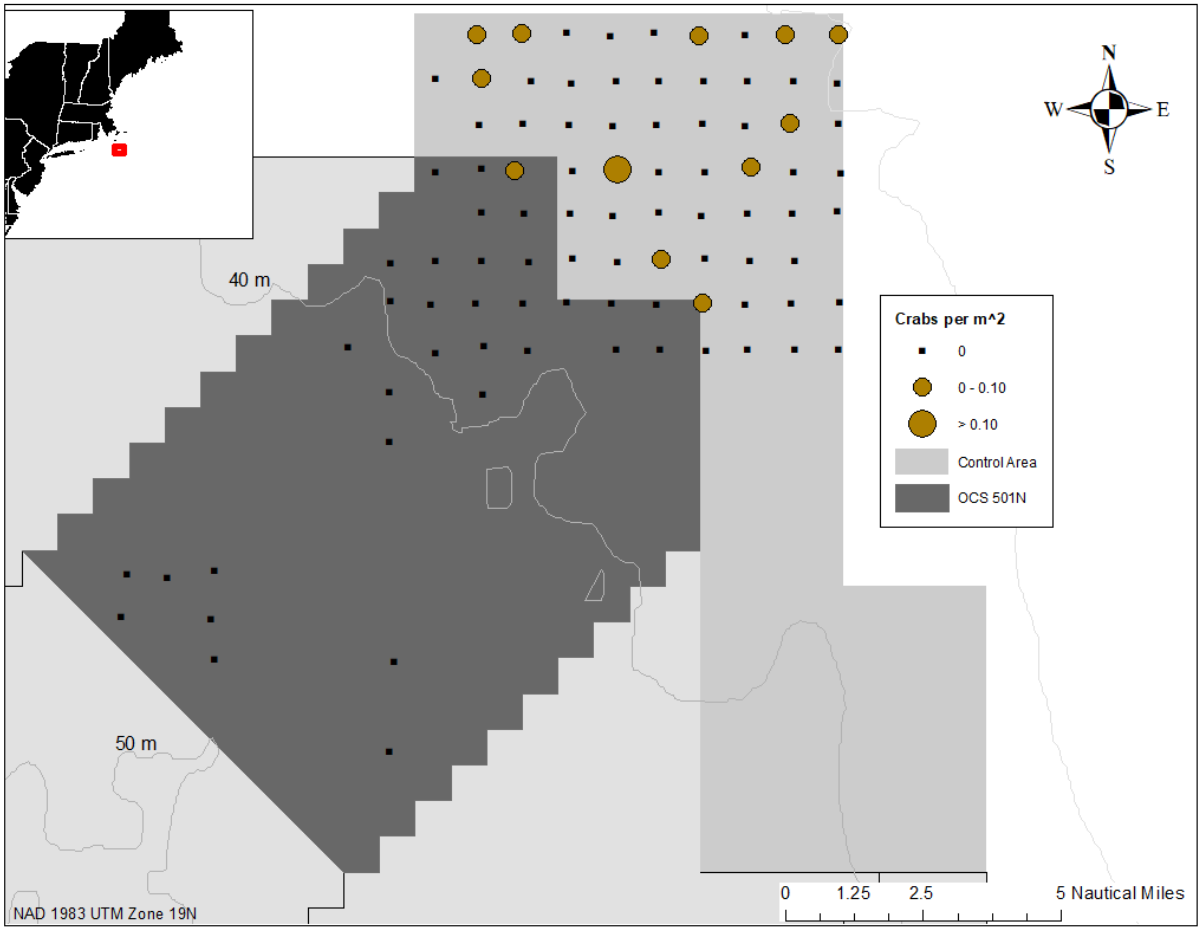

Figure 9. The distribution of crabs in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July/August and October.

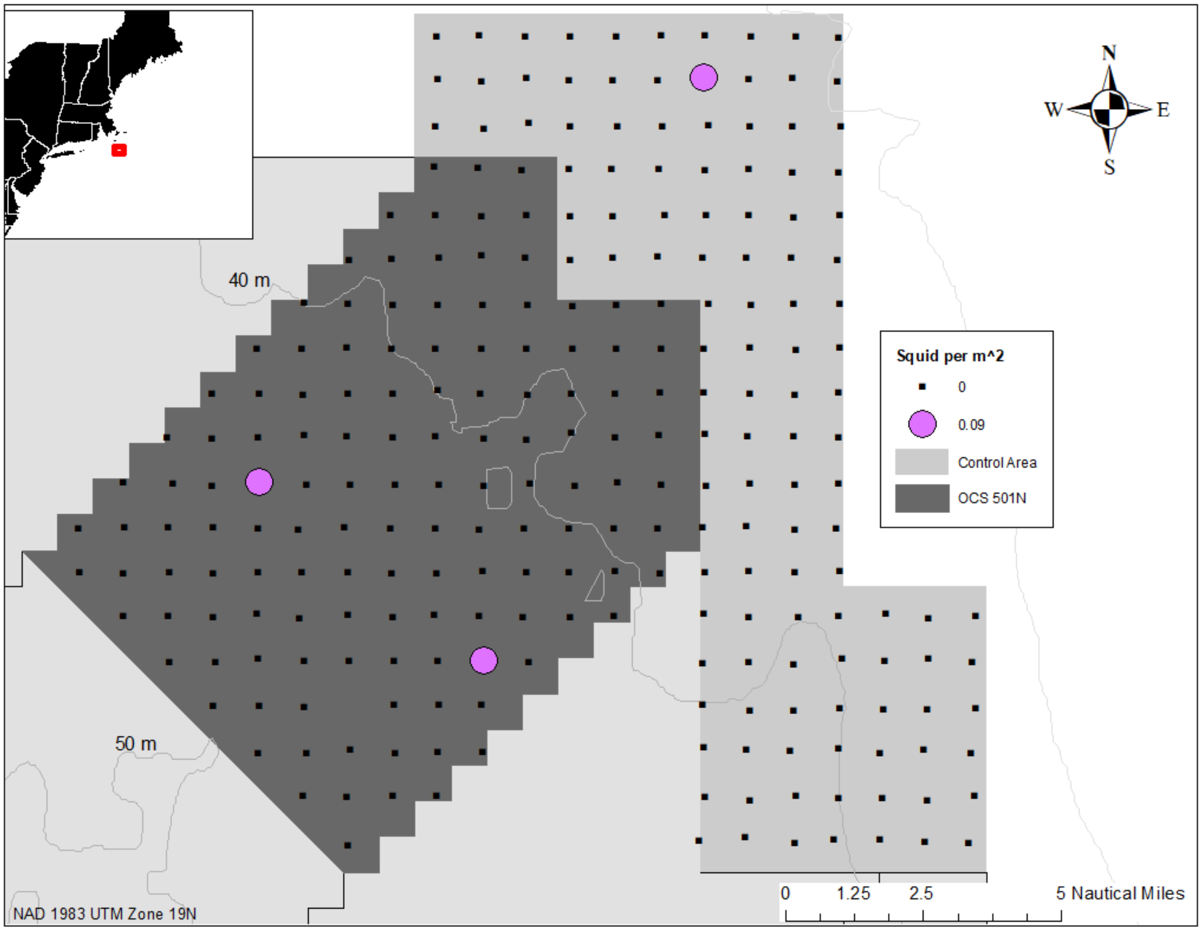

Figure 10. The distribution of squid in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories represent zero or one squid observed at a station.

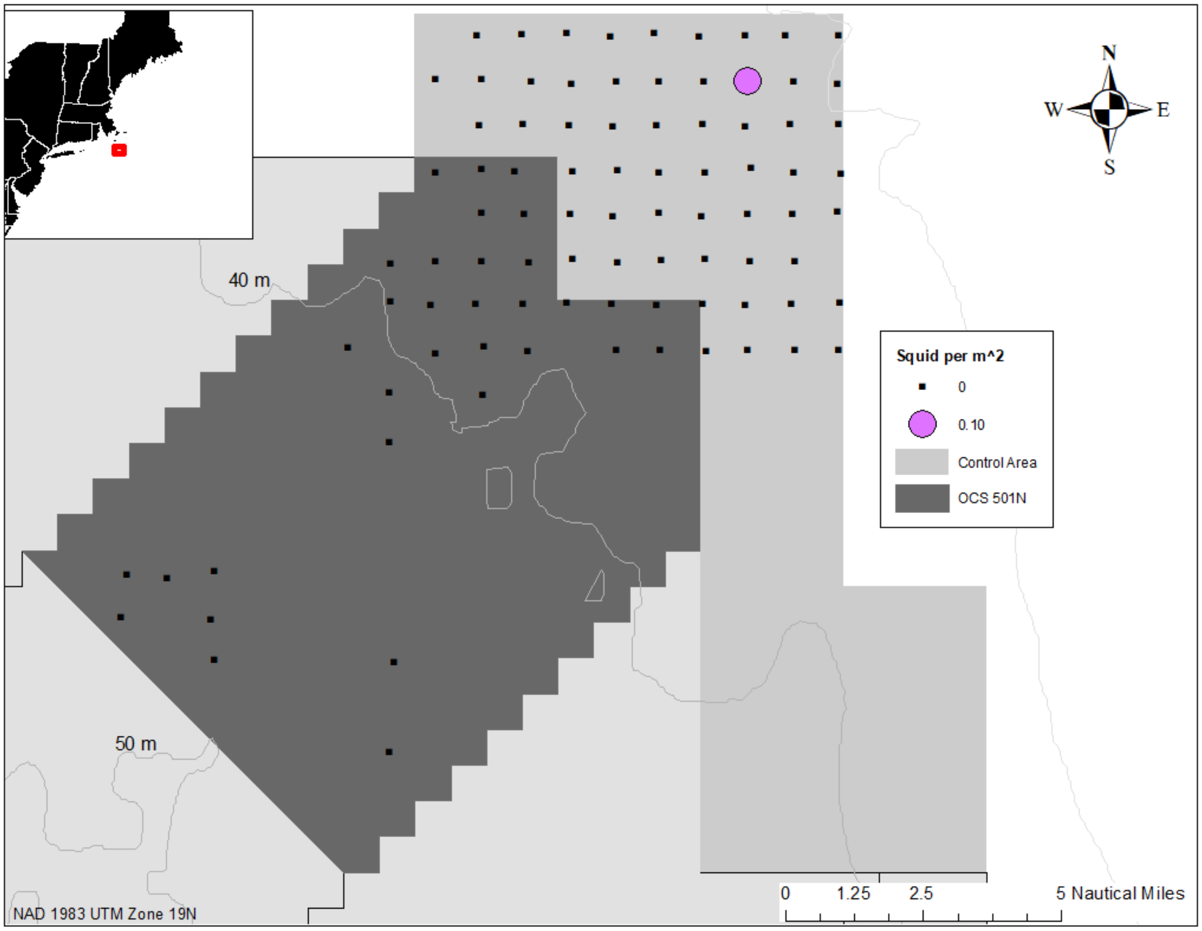

Figure 11. The distribution of squid in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories represent zero or one squid observed at a station.

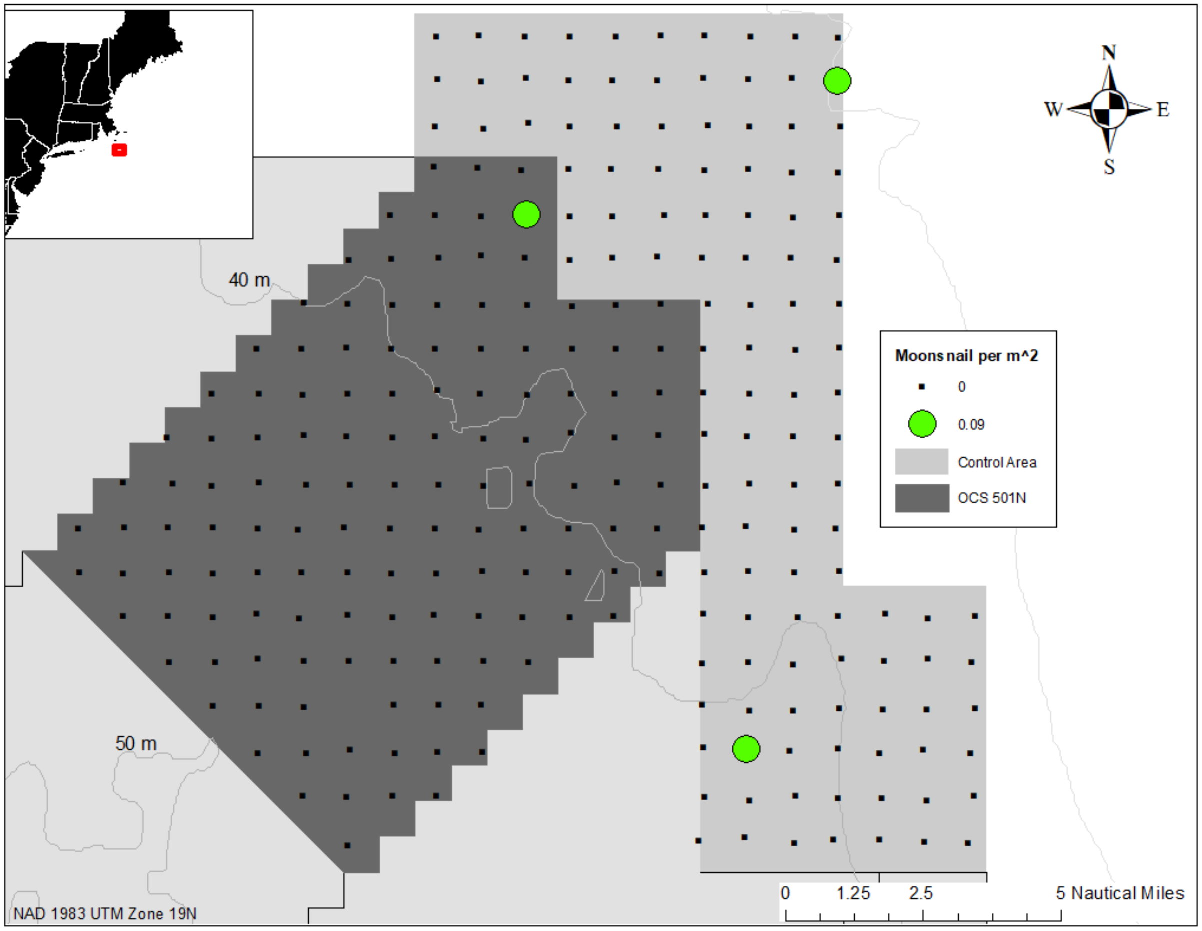

Figure 12. The distribution of moon snails in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. No moon snails were observed in the October 2020 survey of the same areas. Density categories represent zero or one moon snail observed at a station.

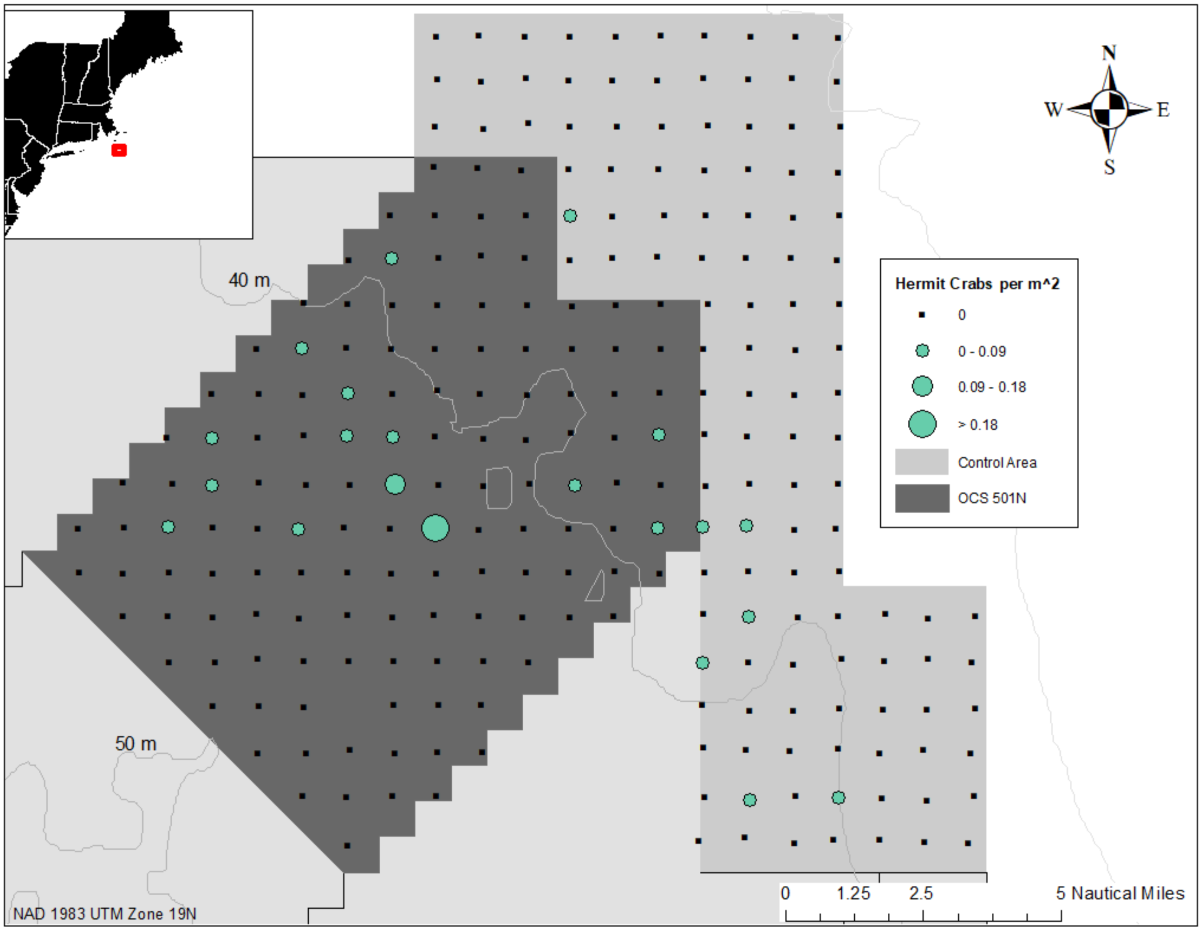

Figure 13. The distribution of hermit crabs in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July/August.

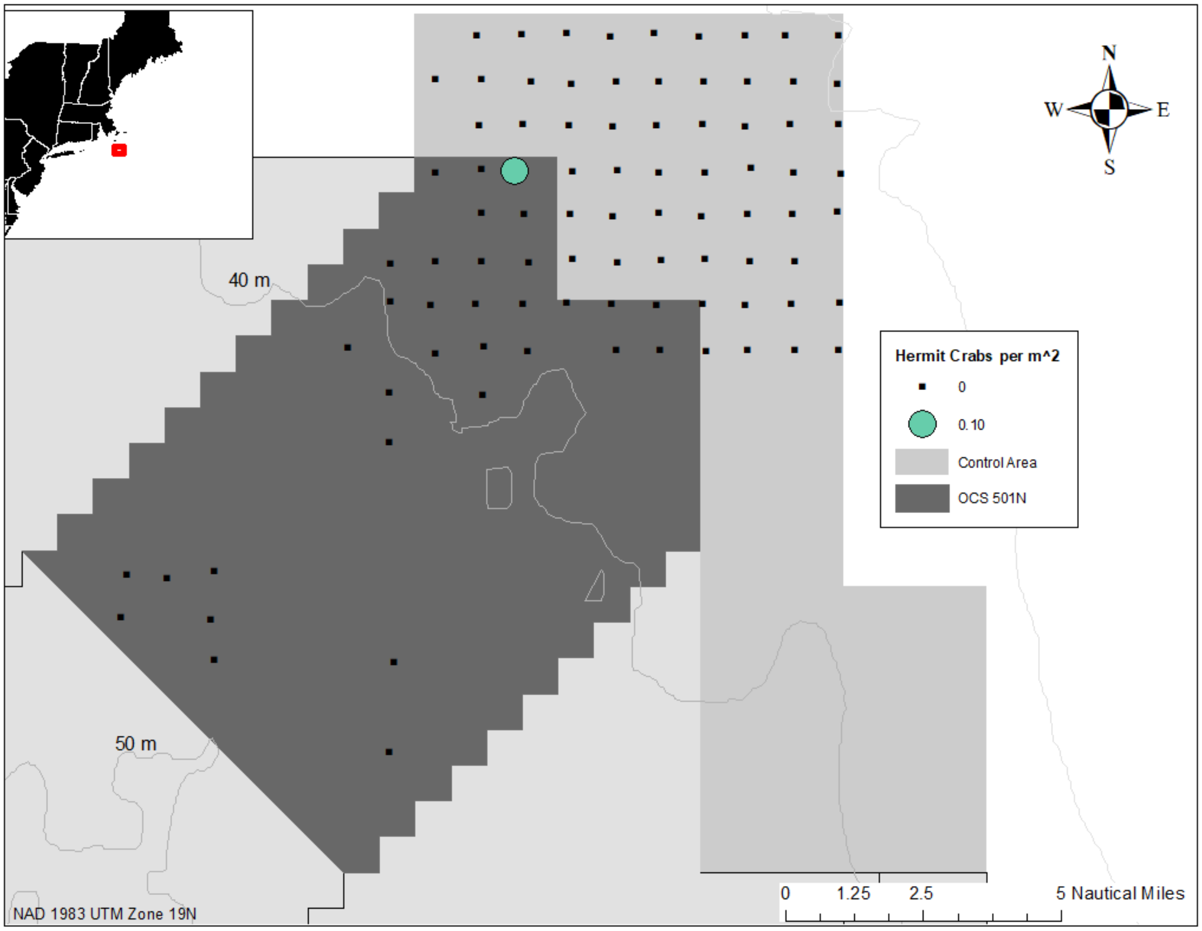

Figure 14. The distribution of hermit crabs in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories represent zero or one hermit crab observed at a station.

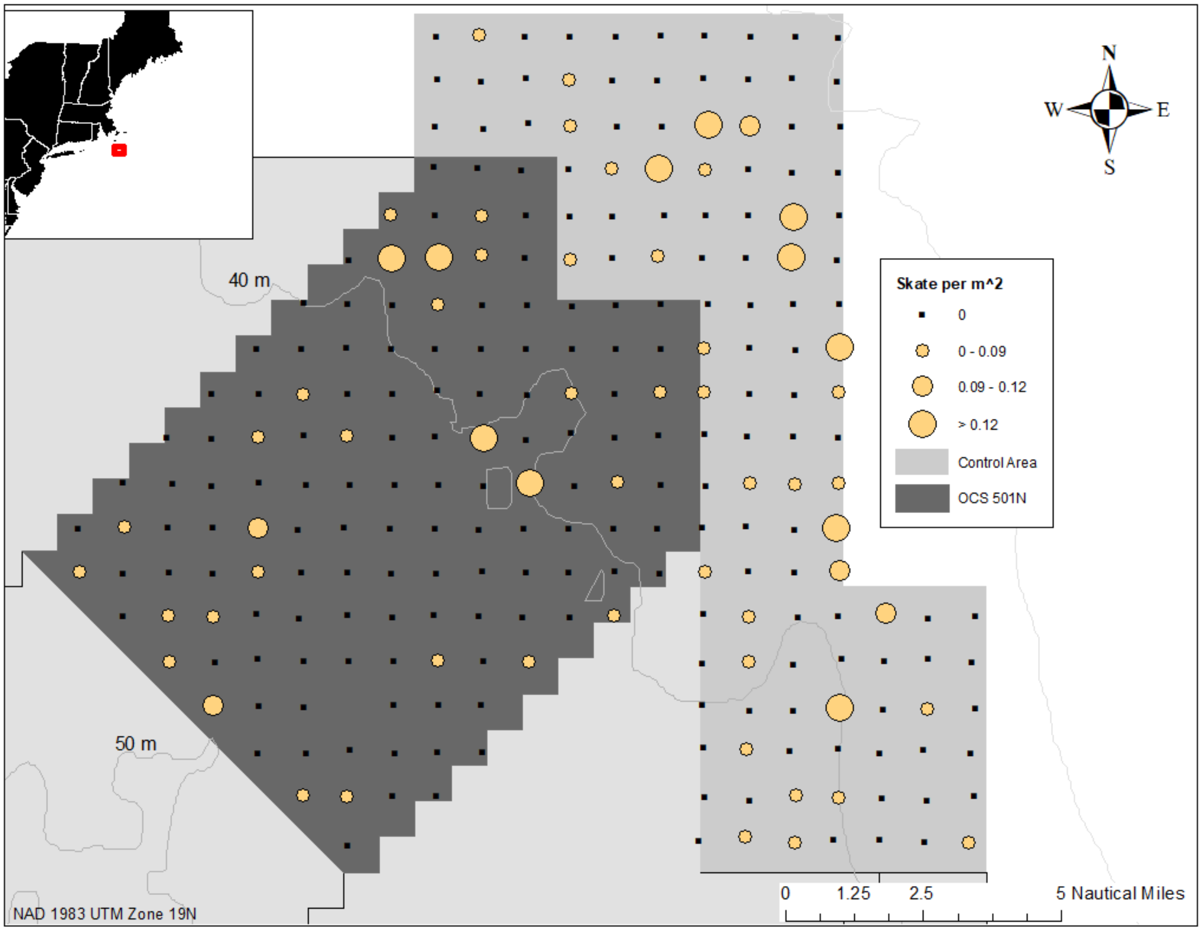

Figure 15. The distribution of skates in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July/August and October.

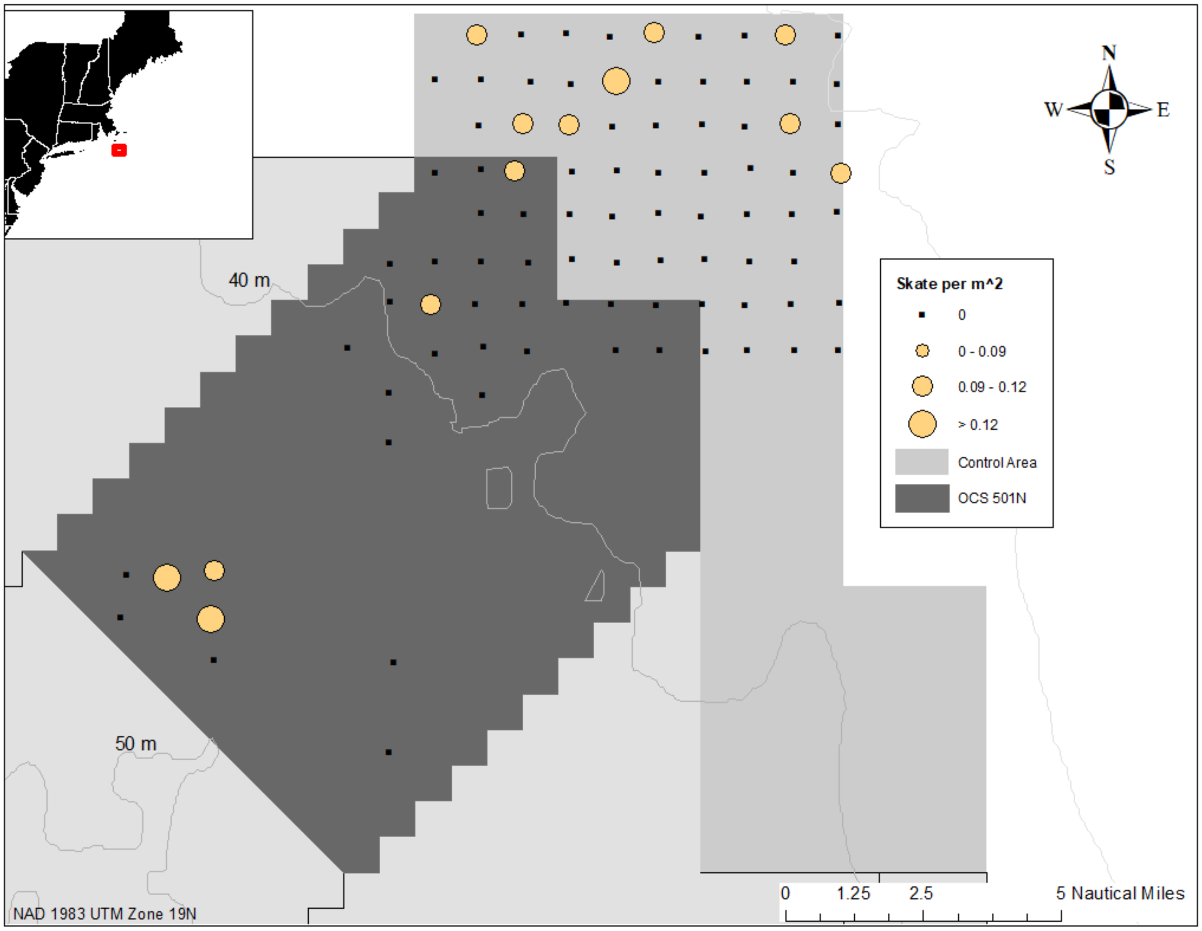

Figure 16. The distribution of skates in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July/August and October.

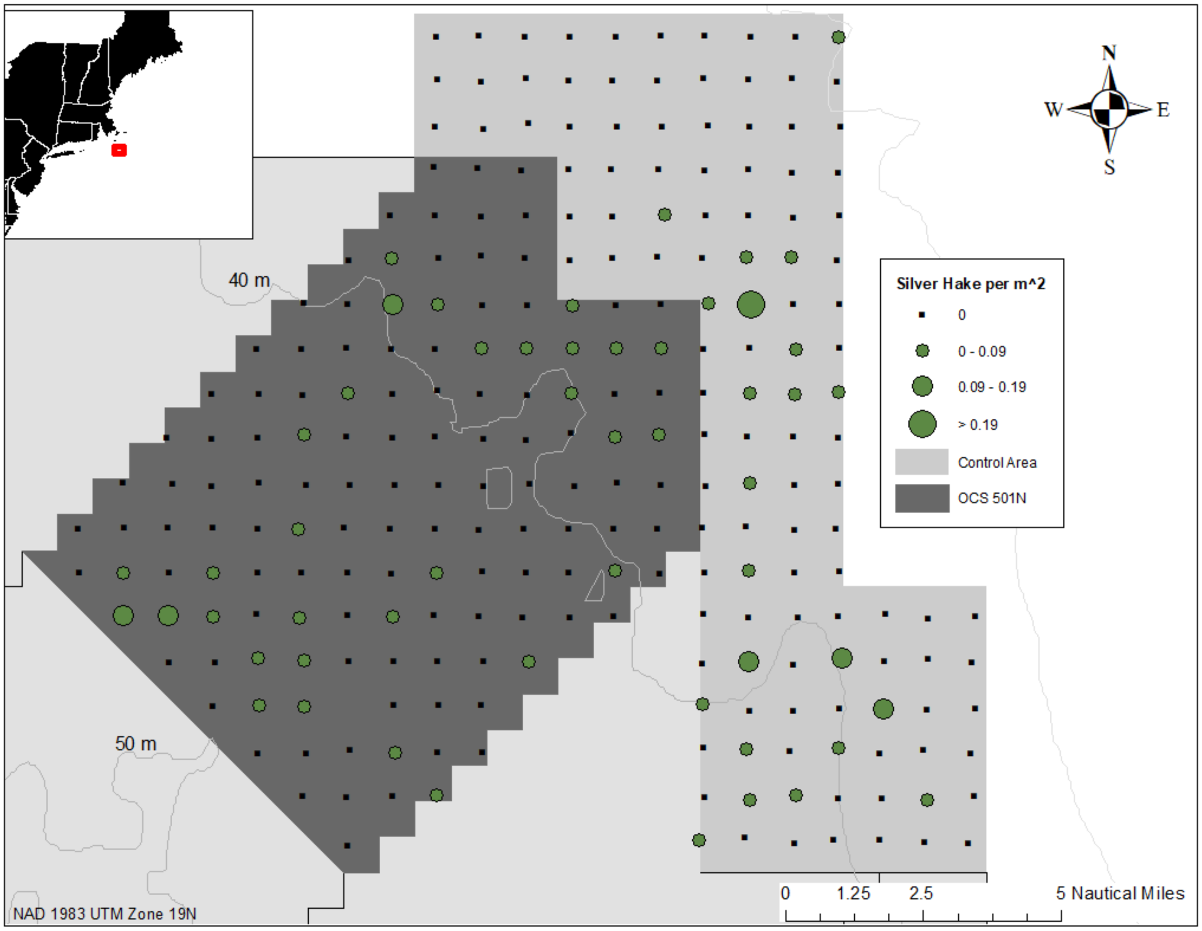

Figure 17. The distribution of silver hake in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July/August.

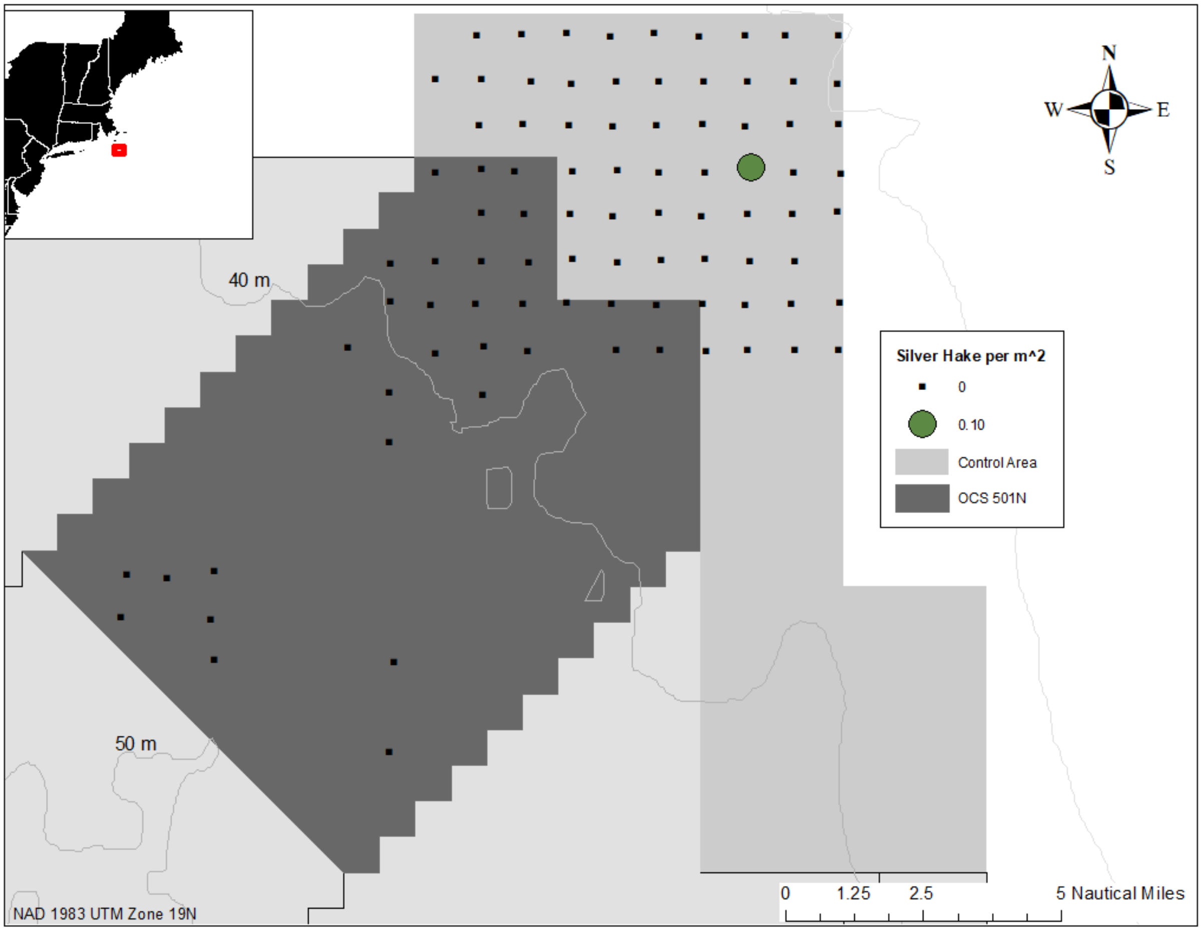

Figure 18. The distribution of silver hake in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories represent zero or one silver hake observed at a station.

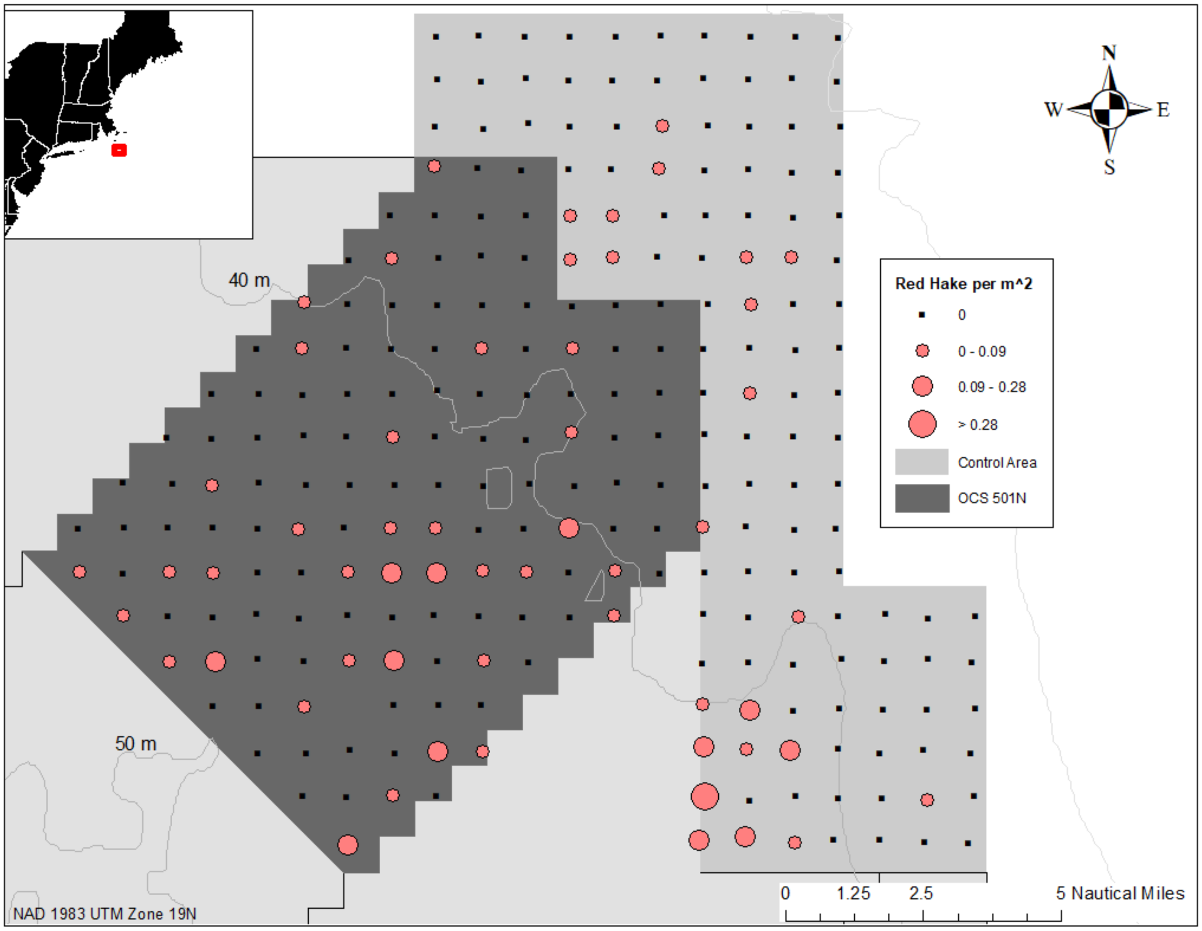

Figure 19. The distribution of red hake in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. No red hakes were observed in an October survey of the same areas. Density categories equally divide the data above zero based on observations in July/August.

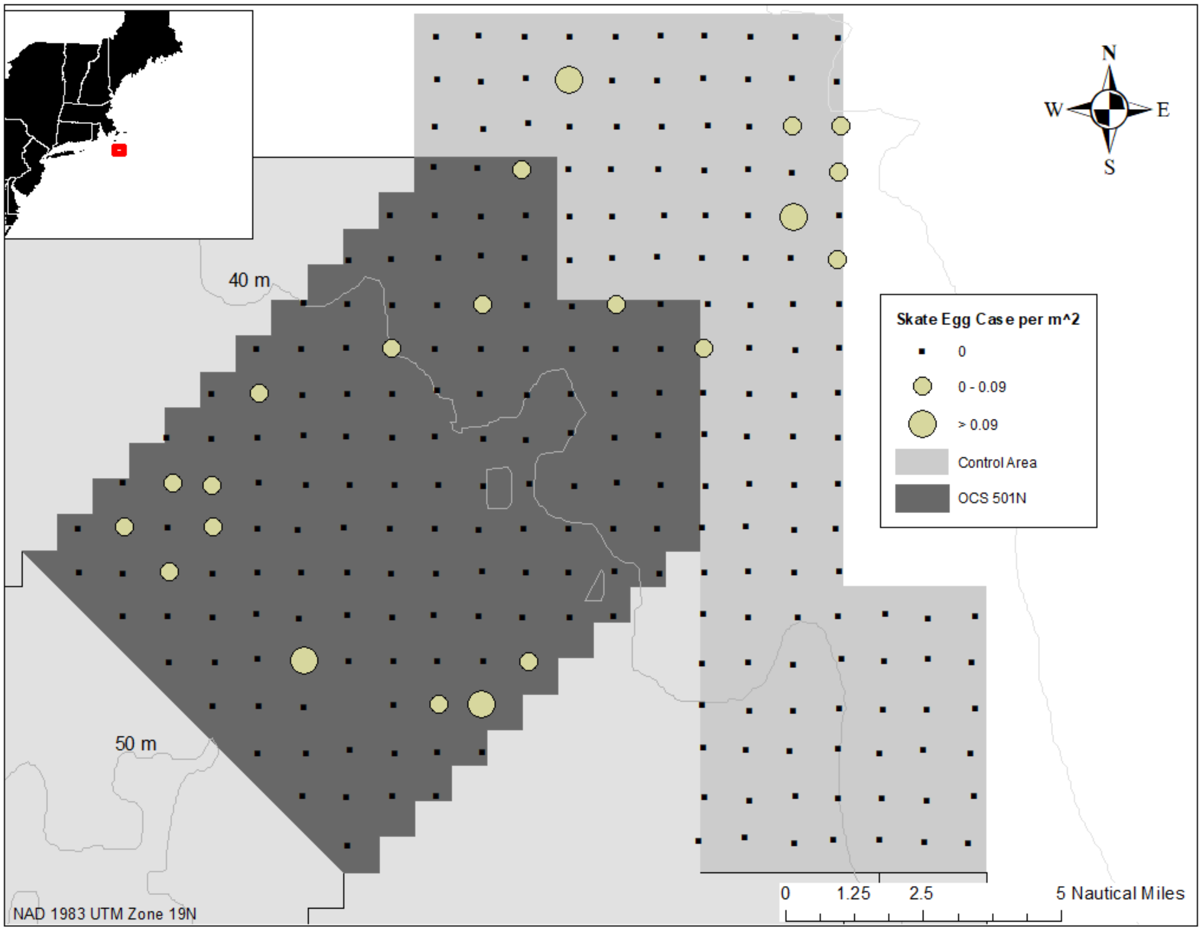

Figure 20. The distribution of skate egg cases in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July/August.

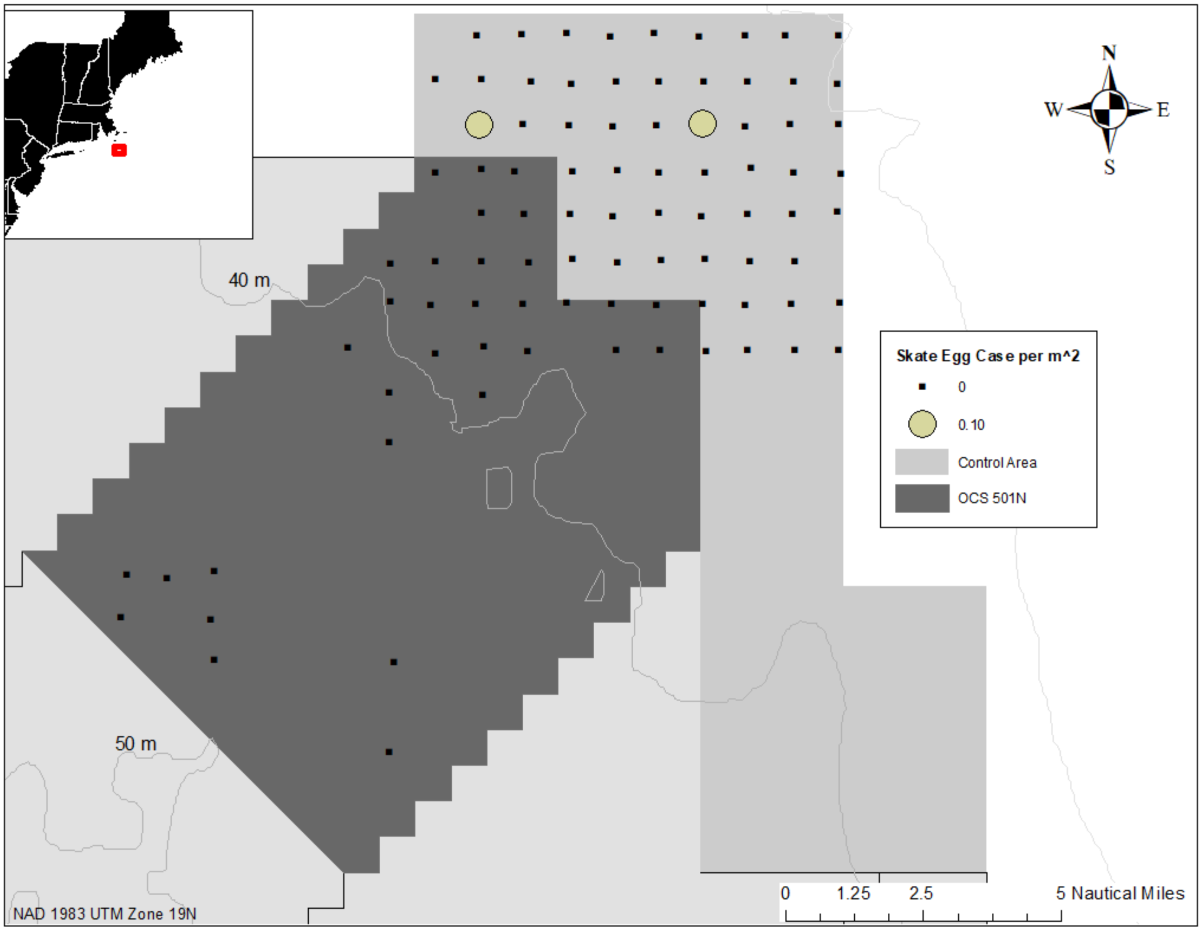

Figure 21. The distribution of skate egg cases in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories represent zero or one skate egg case observed at a station.

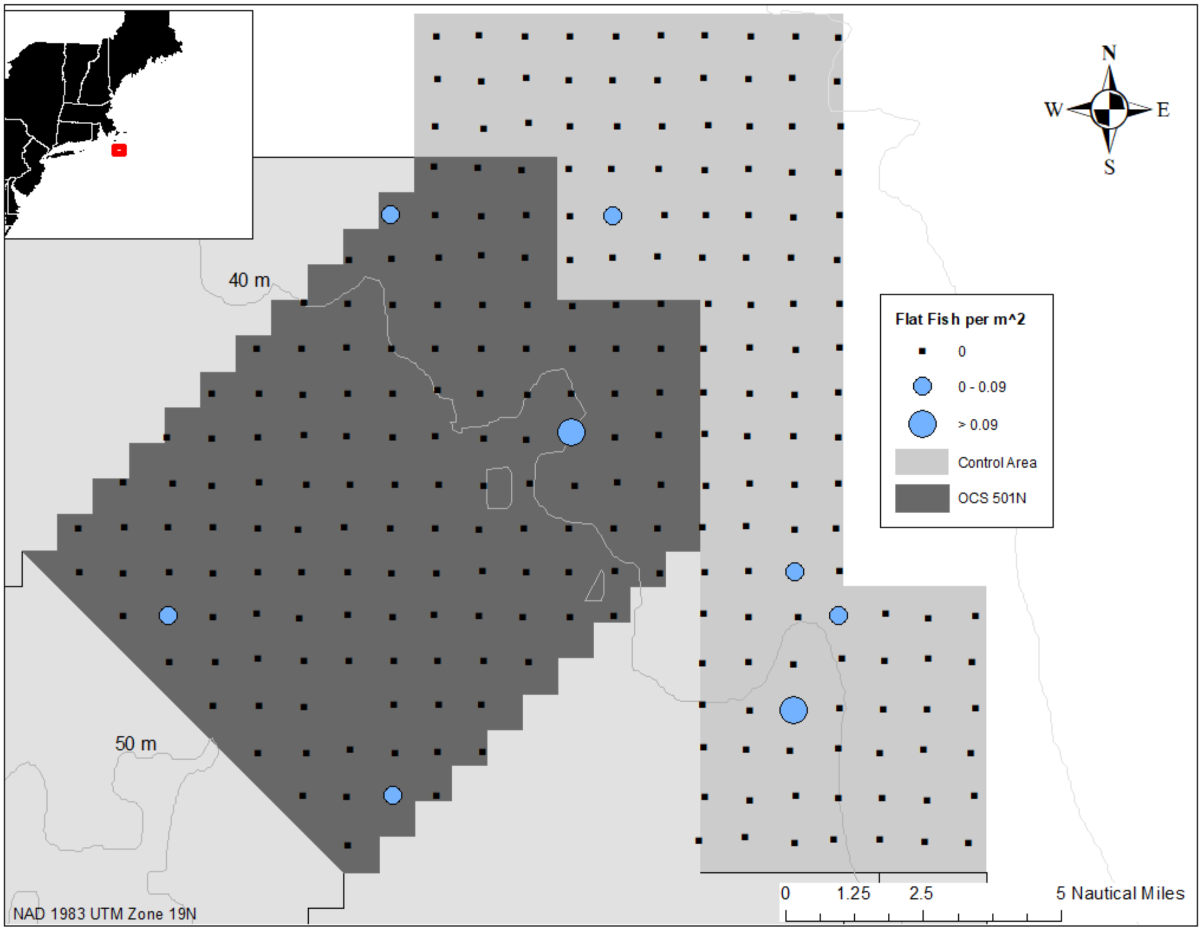

Figure 22. The distribution of flat fishes in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July/August.

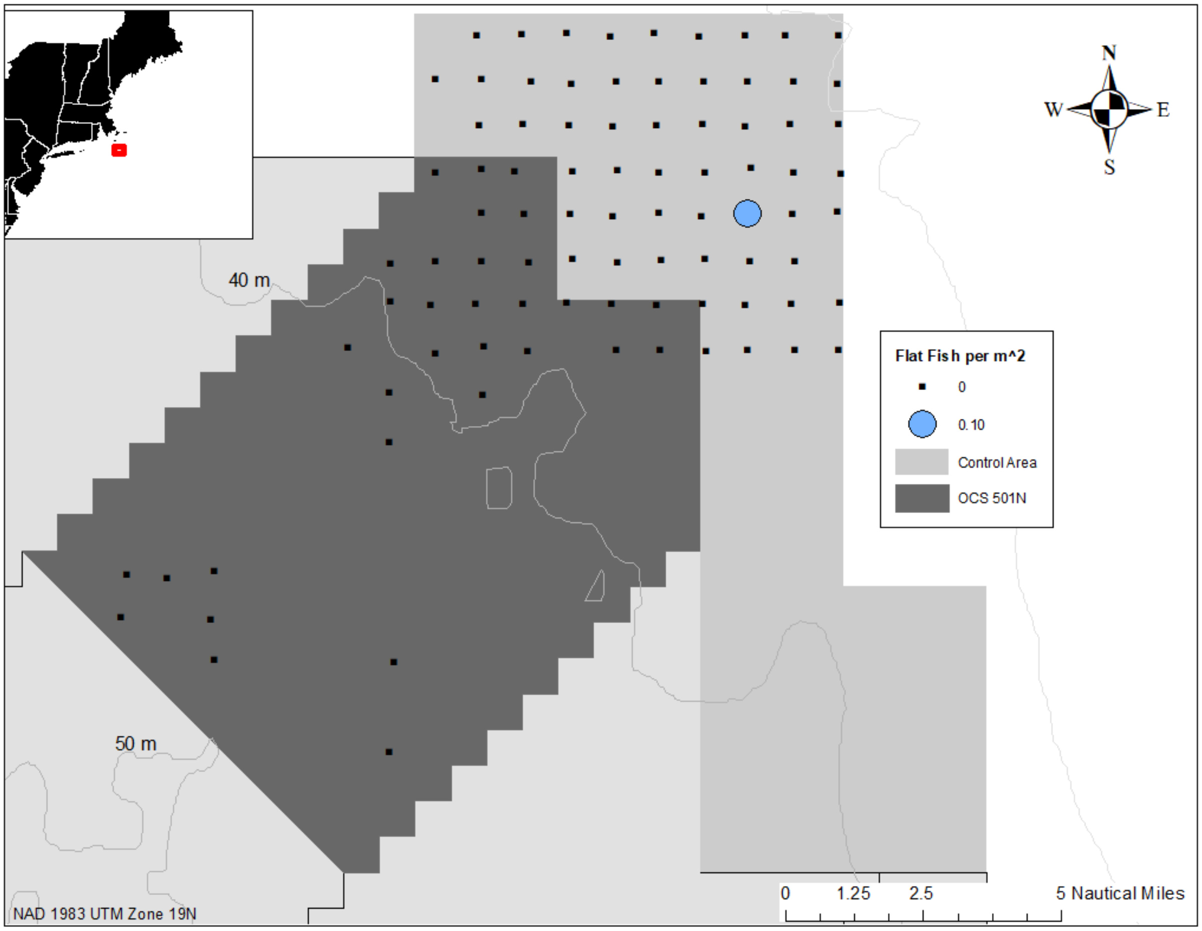

Figure 23. The distribution of flat fishes in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Density categories represent zero or one flat fish observed at a station.

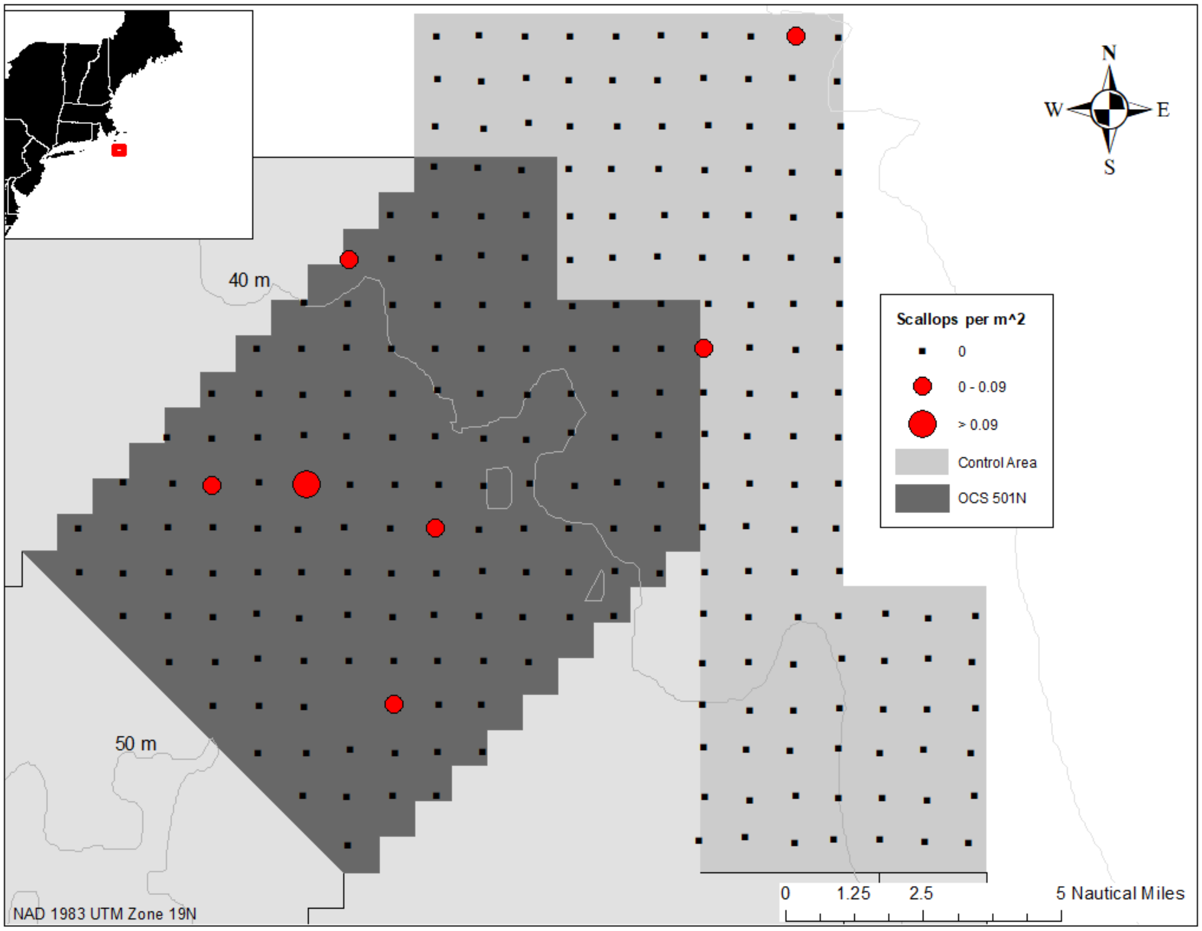

Figure 24. The distribution of scallops in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. No scallops were observed in an October survey of the same areas.

The dominant benthic taxa noted as present or absent included holes (burrowing animals), sand dollars, anemones, bryozoans/hydrozoans, and sponges. All these groups, except sponges, were observed in significantly more quadrats per station in the 501N Study Area compared to the Control Area (Figure 7). This may be related to the water depths in the areas, as the animals were present in three or four quadrats per station more often at depths greater than 40 m (Figures 25-34). The average depth of stations in the 501N Study Area was 42.1 m (95% confidence interval +/- 0.6 m), while the average depth of stations in the Control Area was 36.5 m (+/- 0.6 m) during July/August when all stations in each area were sampled. These animals generally occupied a quarter or less of each quadrat with similar occupation rates in the control and 501N Study Area (Table 2). However, sand dollars occupied closer to 40% of the space within a quadrat when they were observed in the 501N Study Area. The October survey results showed a significant decrease in all groups compared to the July/August survey, with only sand dollars and sponges observed (Figure 7).

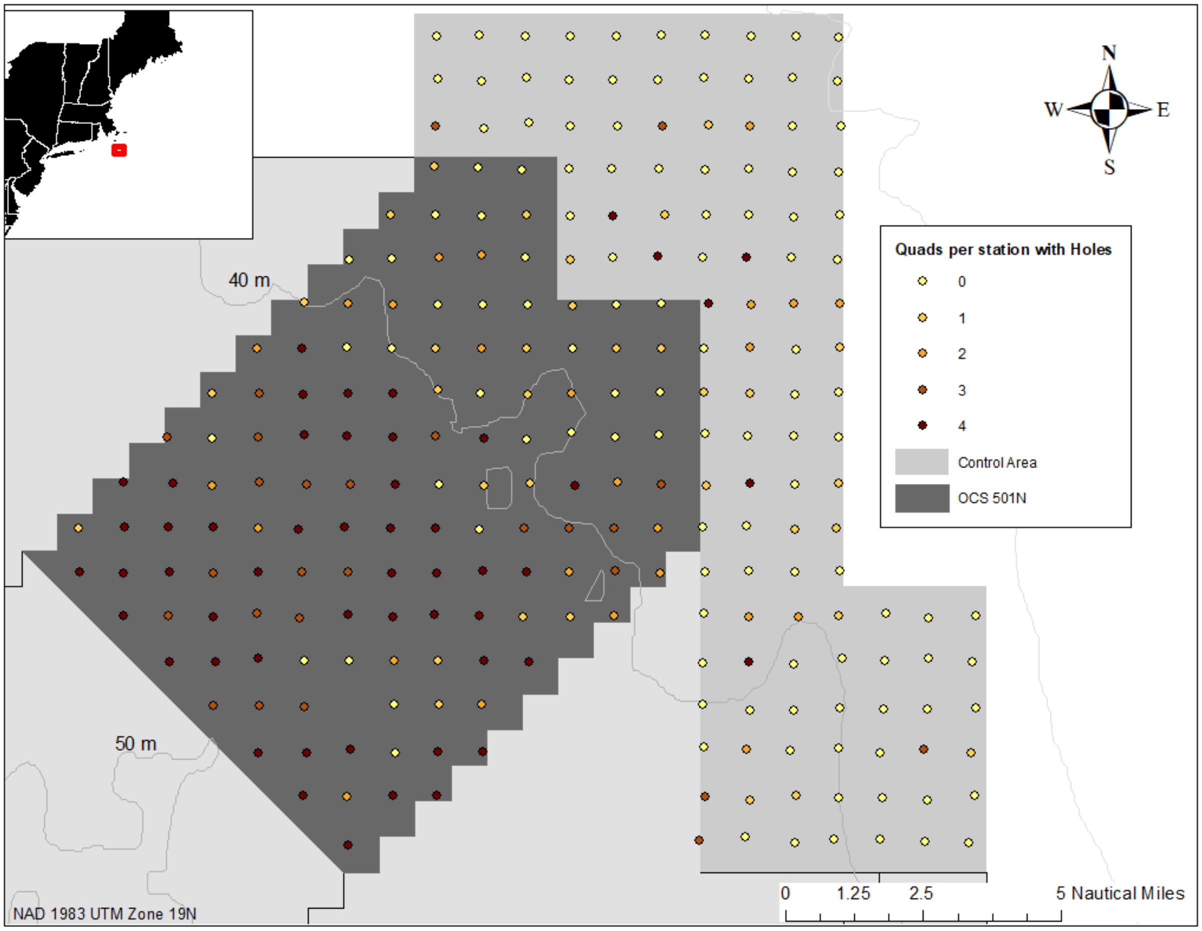

Figure 25. The distribution of holes (burrowing animals) in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.64 m^2 images) were observed at each station.

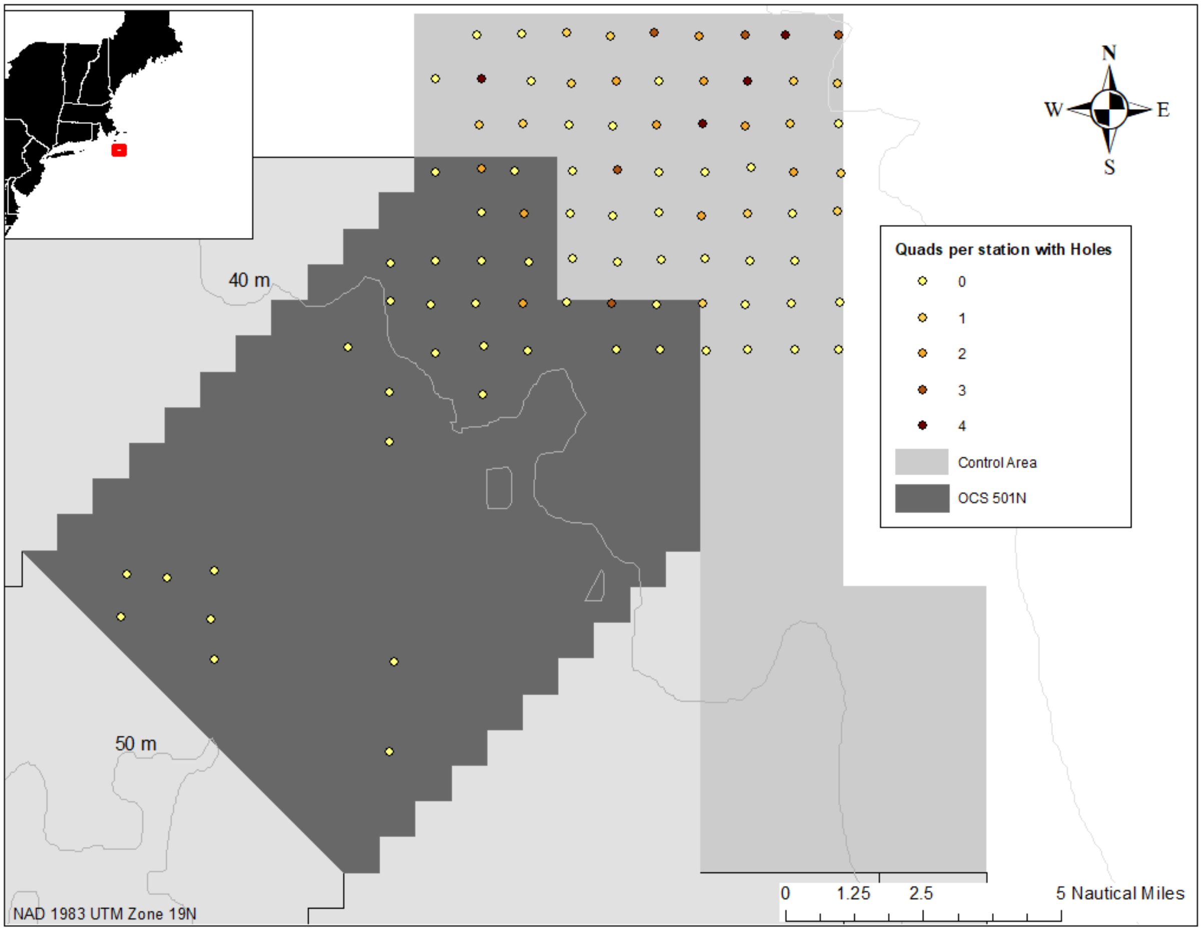

Figure 26. The distribution of holes (burrowing animals) in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.44 m^2 images) were observed at each station.

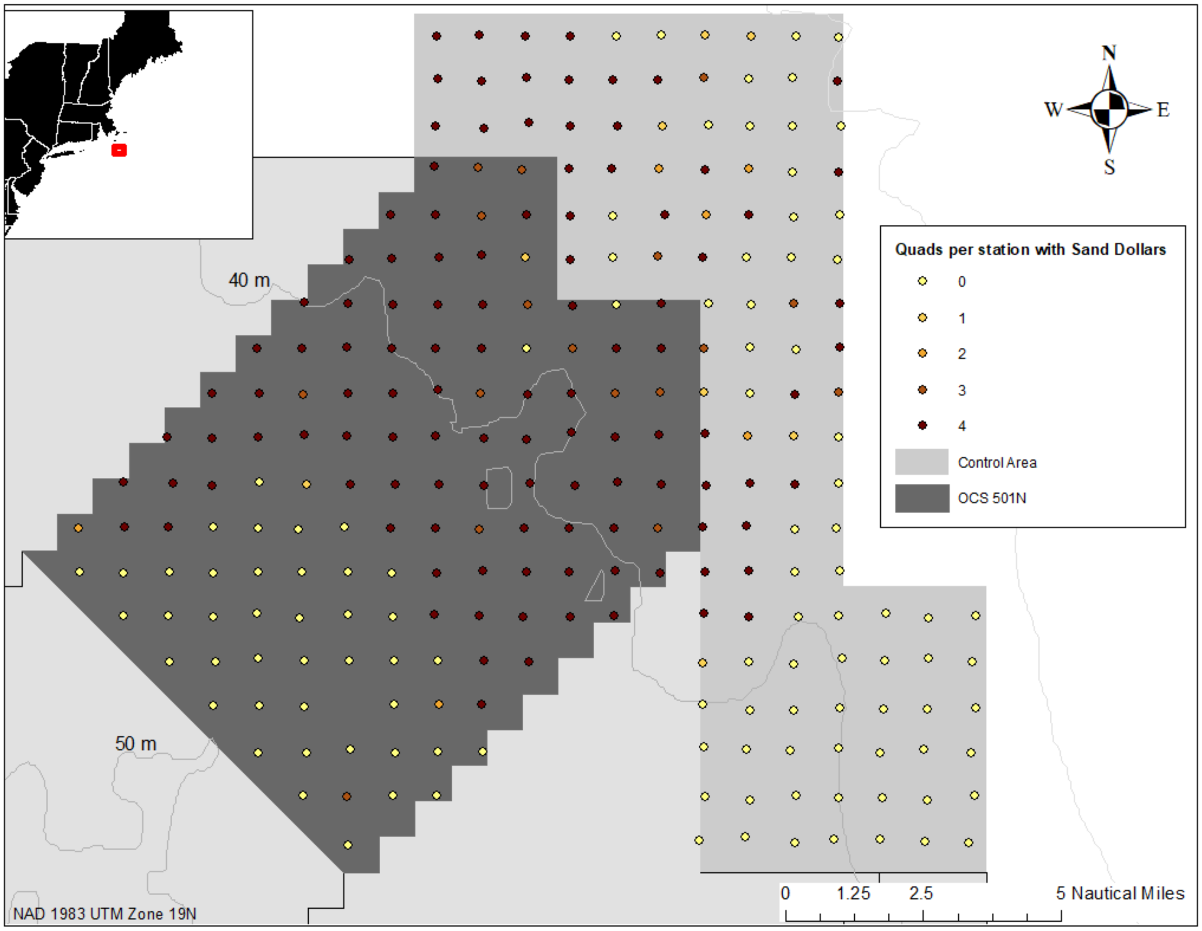

Figure 27. The distribution of sand dollars in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.64 m^2 images) were observed at each station.

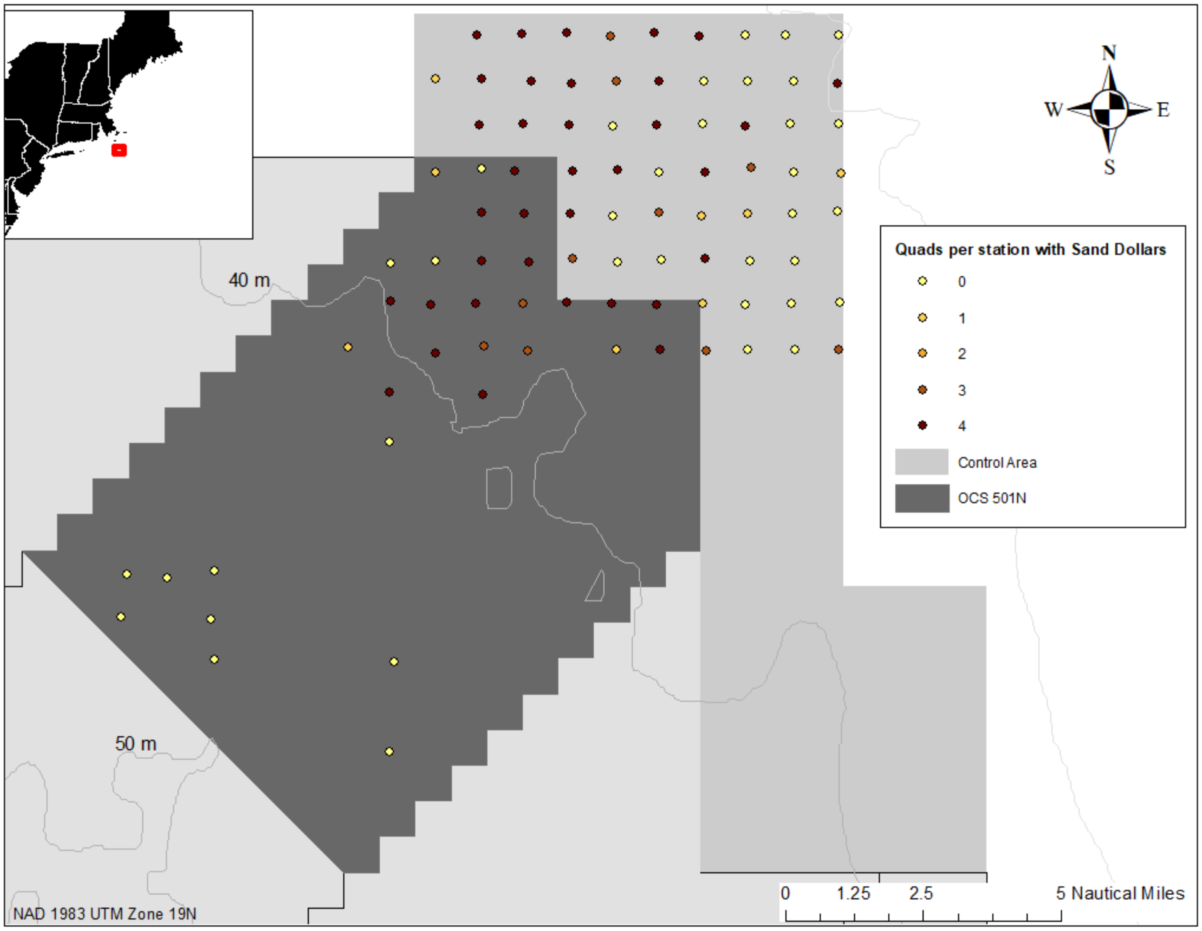

Figure 28. The distribution of sand dollars in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.44 m^2 images) were observed at each station.

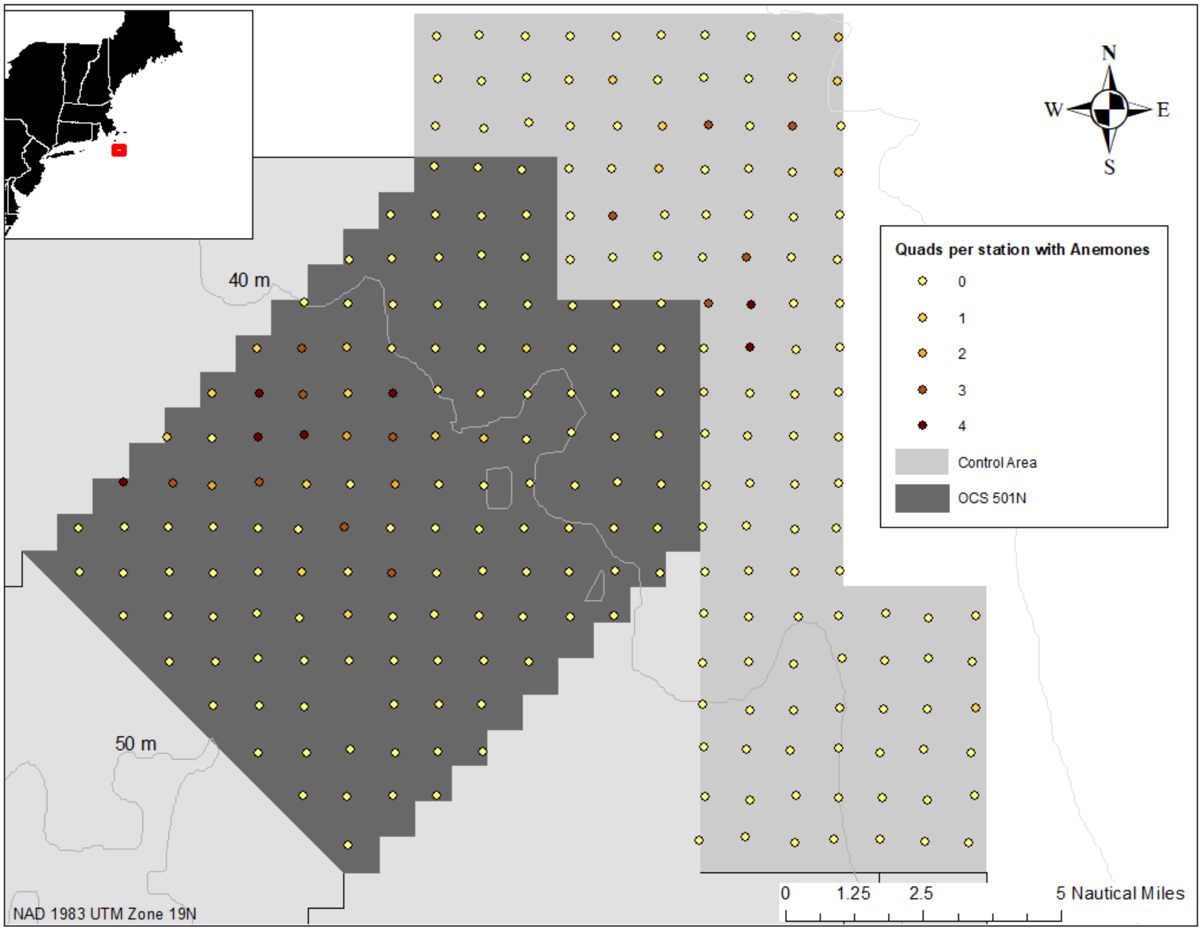

Figure 29. The distribution of anemones in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.64 m^2 images) were observed at each station.

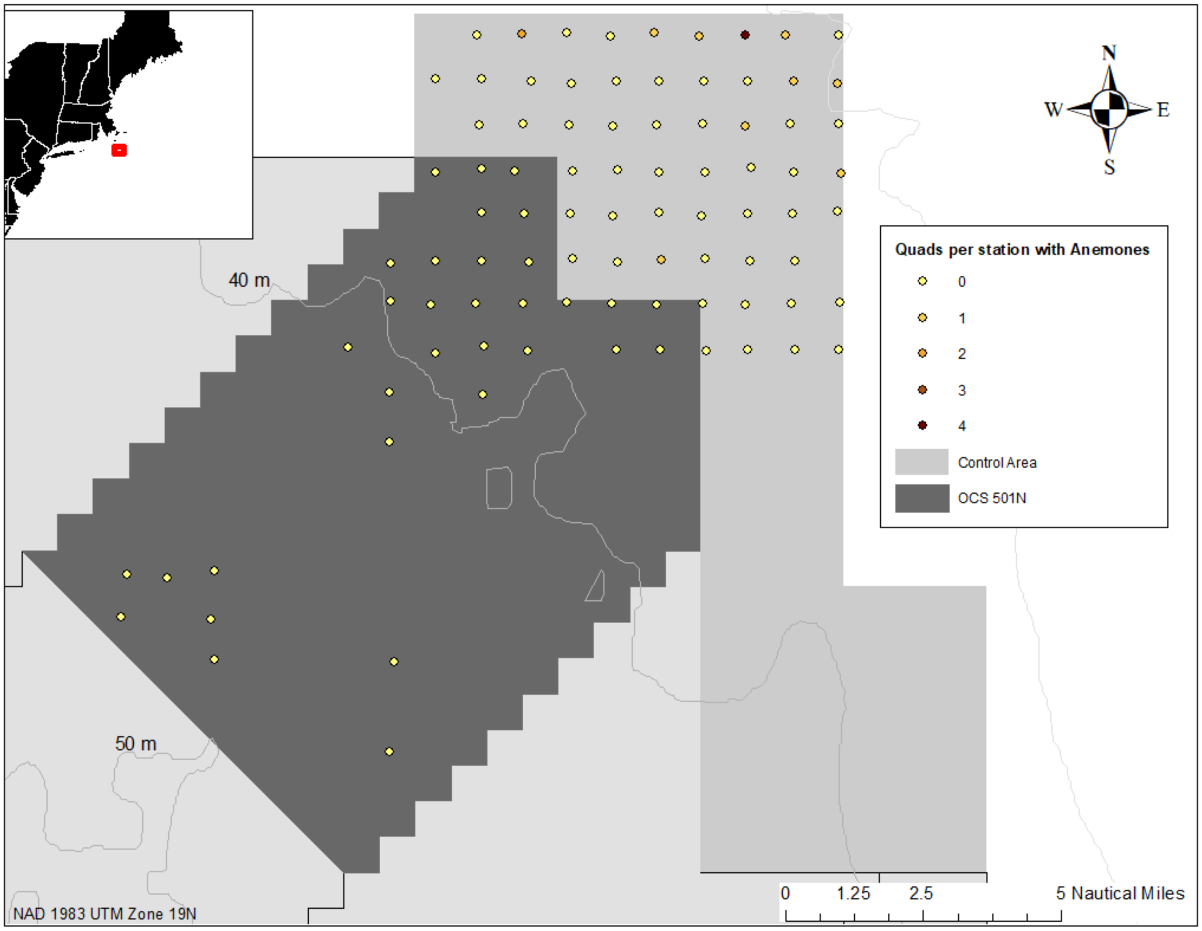

Figure 30. The distribution of anemones in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.44 m^2 images) were observed at each station.

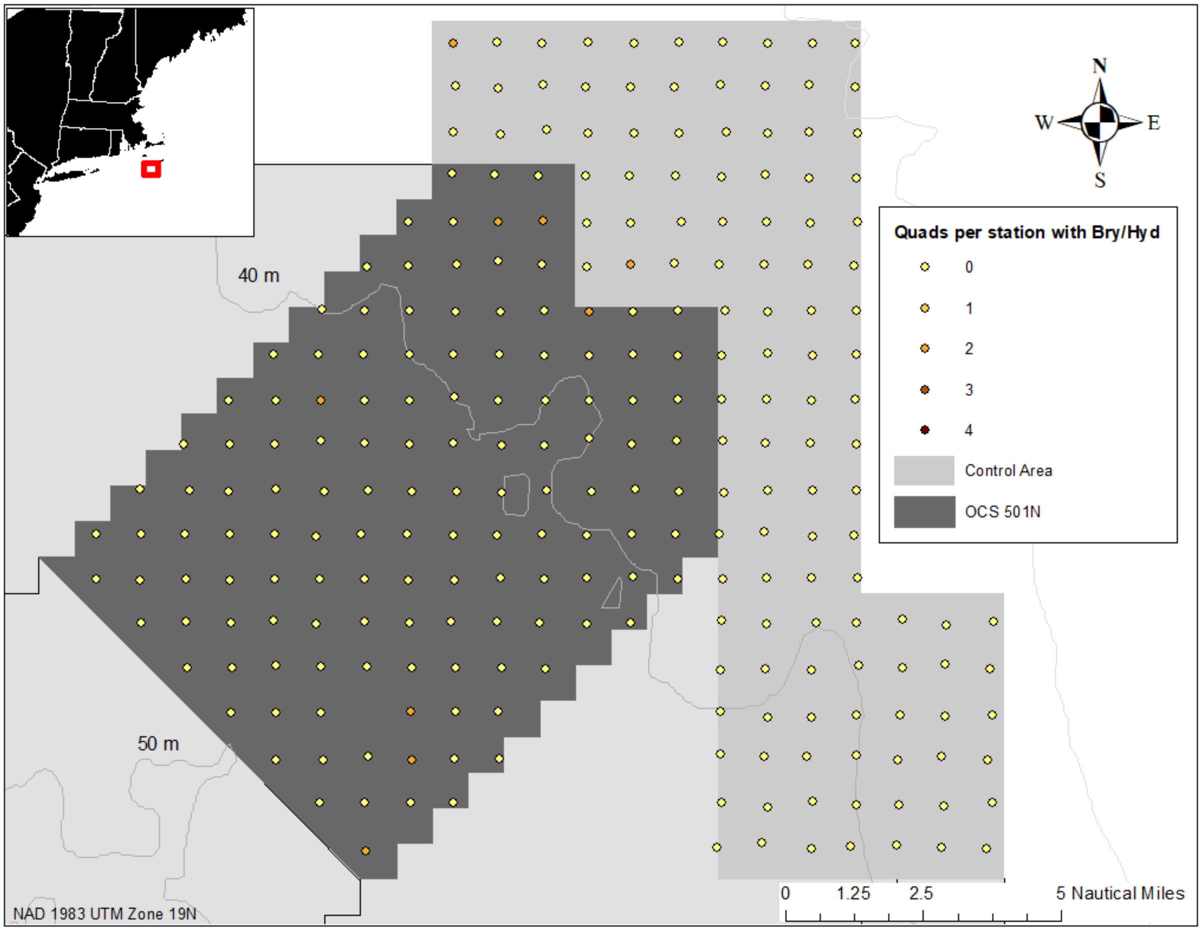

Figure 31. The distribution of bryozoans and hydrozoans in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.64 m^2 images) were observed at each station.

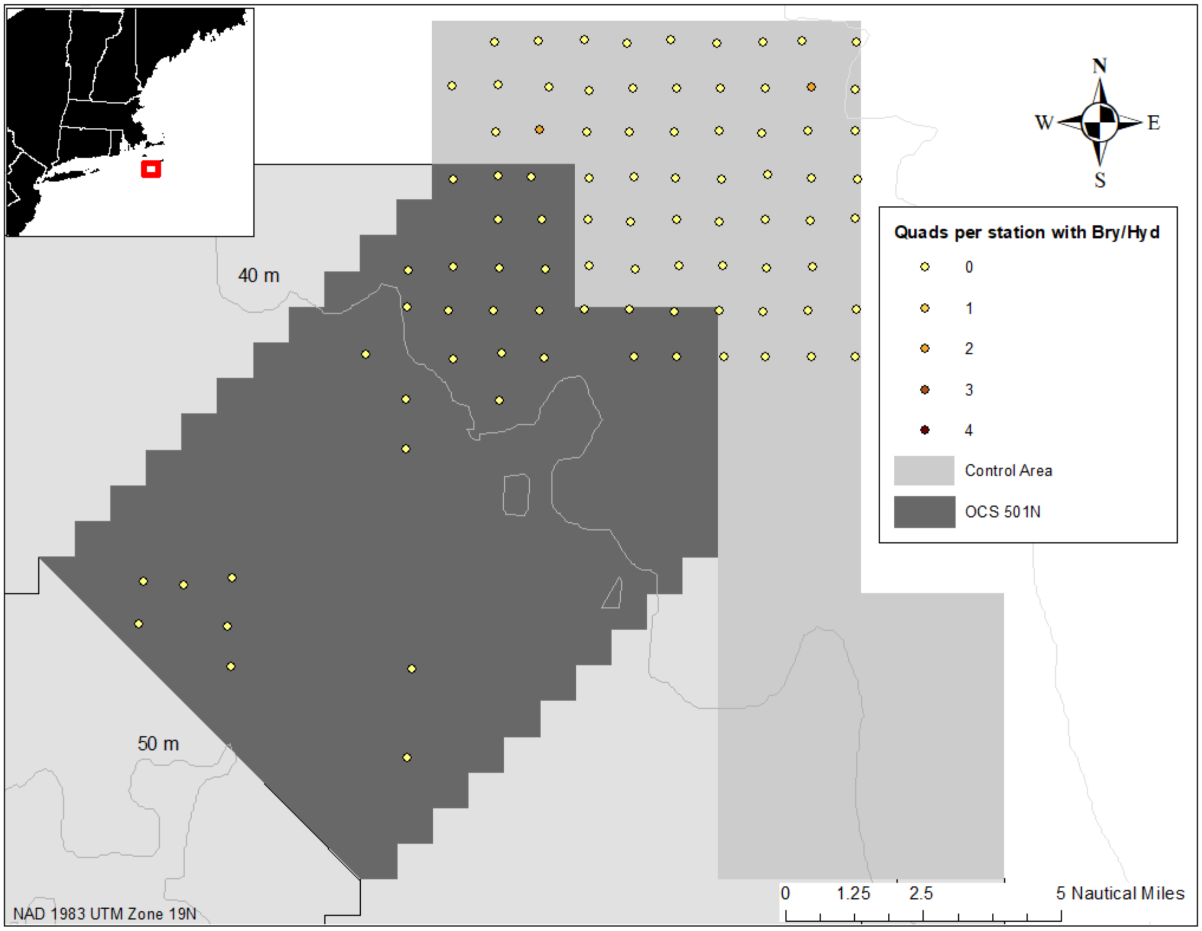

Figure 32. The distribution of bryozoans and hydrozoans in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.44 m^2 images) were observed at each station.

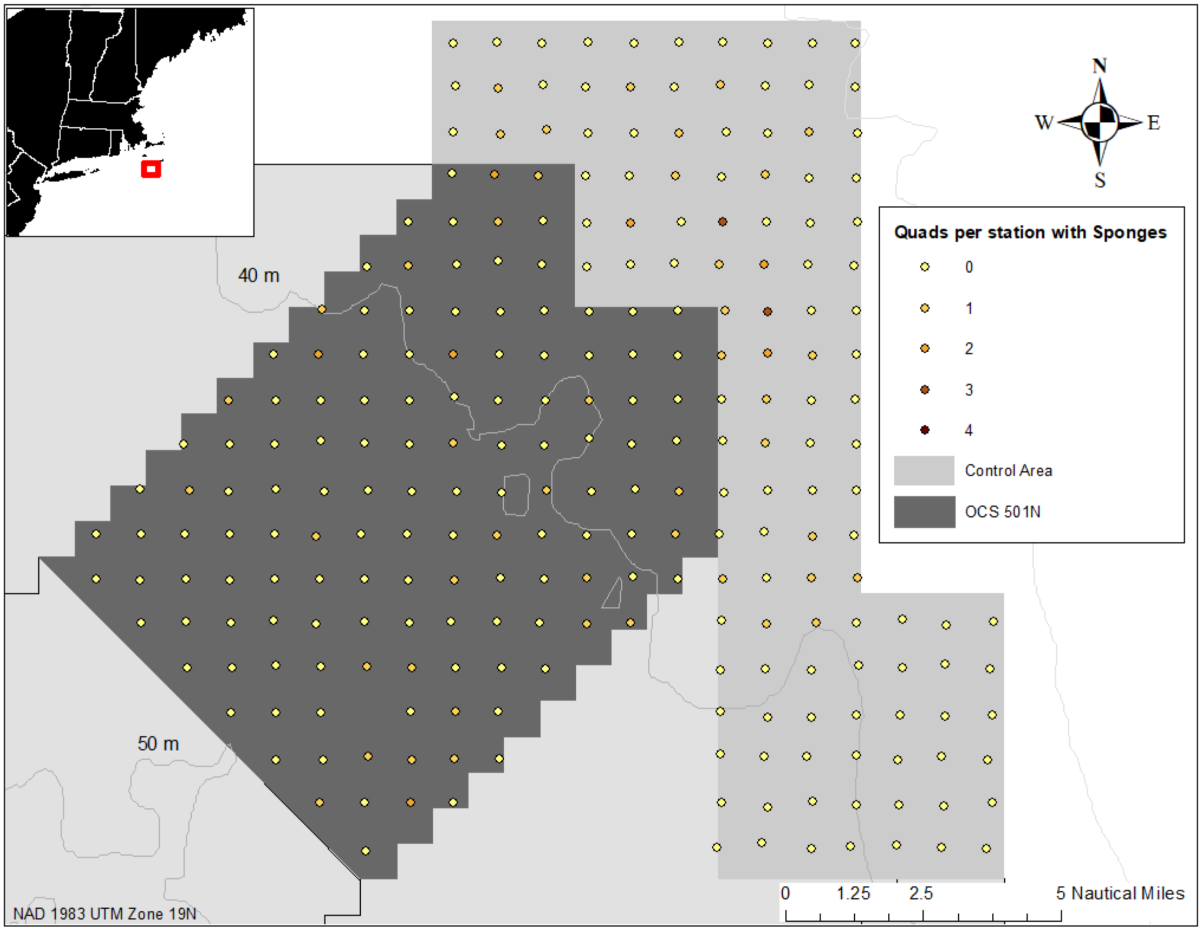

Figure 33. The distribution of sponges in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.64 m^2 images) were observed at each station.

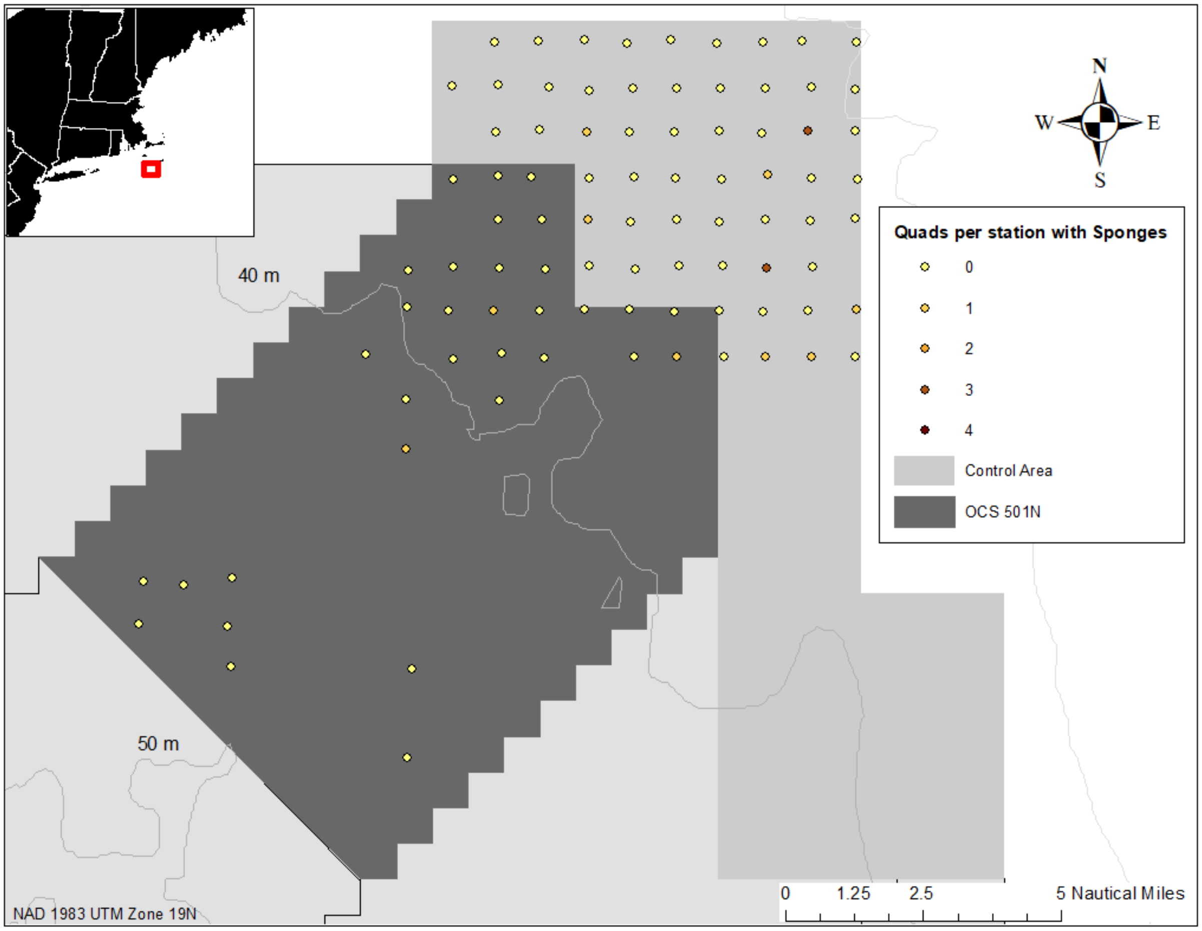

Figure 34. The distribution of sponges in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.44 m^2 images) were observed at each station.

Sand comprised the surficial substrate in the stations surveyed, and it was the largest particle size present in the 501N Study Area and Control Area during the July/August and October surveys; no cobble, rock, or boulders were observed in either survey (Figures 35-37). Silt was present at every station except for two stations in the 501N Study Area (<1% of all stations). A slight change in the distribution of silt and sand appears to have occurred between seasons, where more sand was present in the October survey in both areas (Figure 35). The substrate within aliquots sampled by the American Lobster, Black Sea Bass, Larval Lobster Abundance Survey, and Lobster Tagging Study of this area is predominately comprised of sand (Figures 36-37).

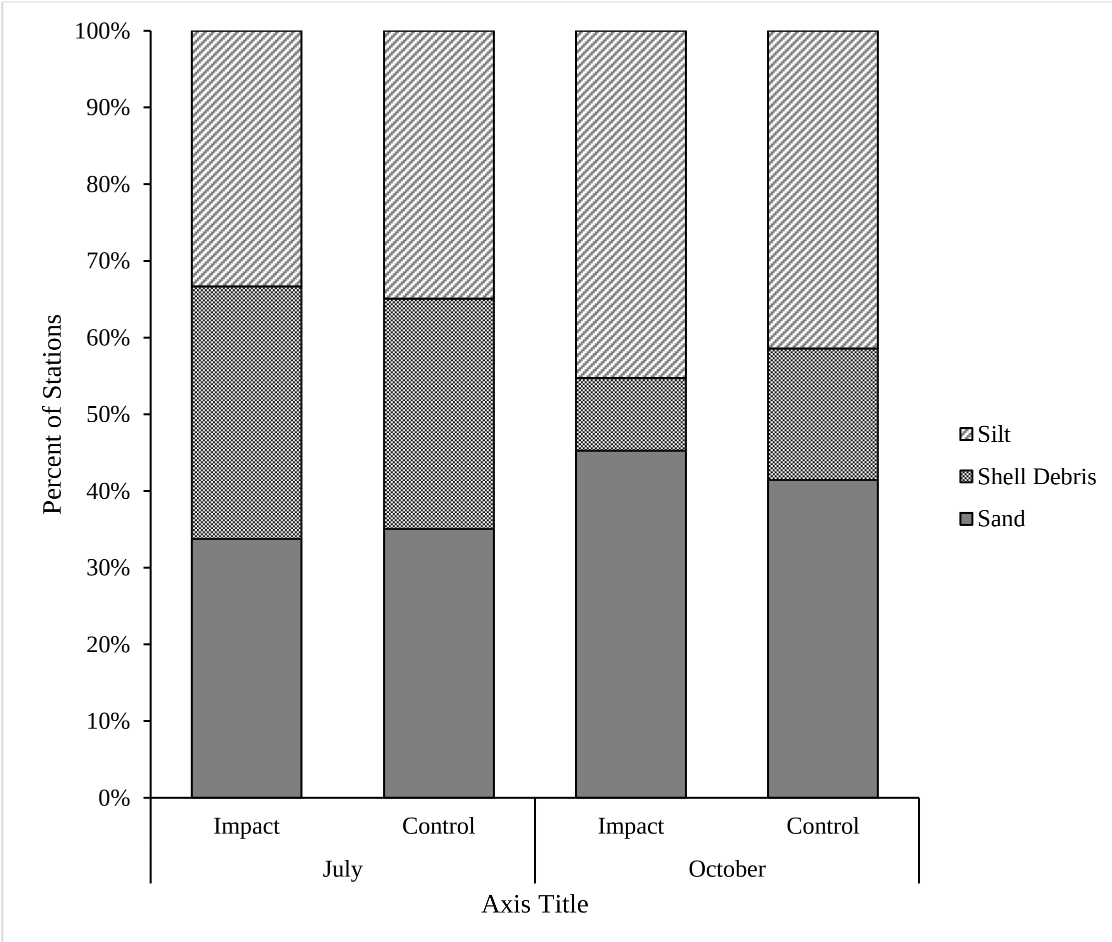

Figure 35. Substrate composition, defined by the most common substrate type observed at a station, during the July/August and October 2020 drop camera surveys of the 501N Study Area and an adjacent Control Area. Gravel, cobble, and rock were not observed at any station. Four quadrats were observed at each station.

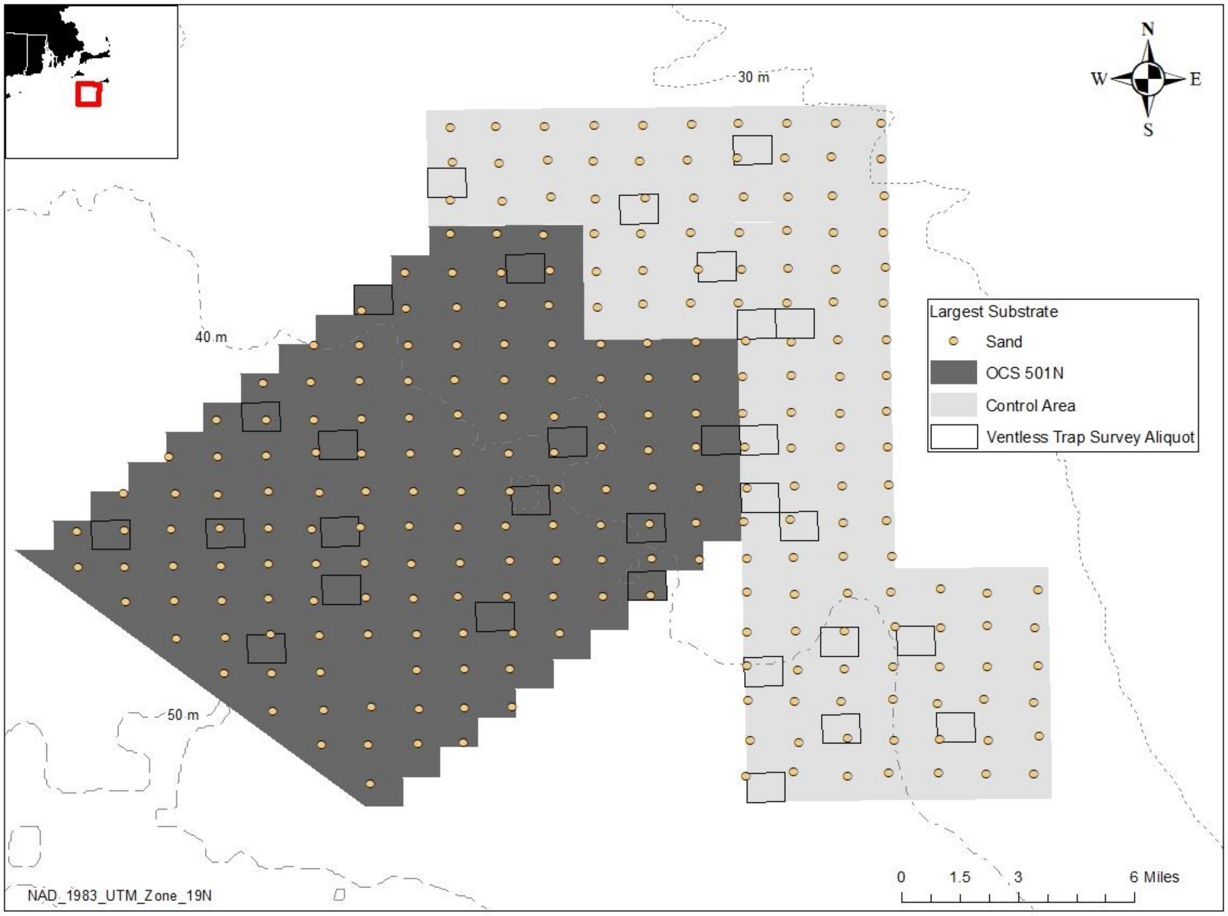

Figure 36. The distribution of substrate types in the July/August 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.3 m^2 images) were observed at each station.

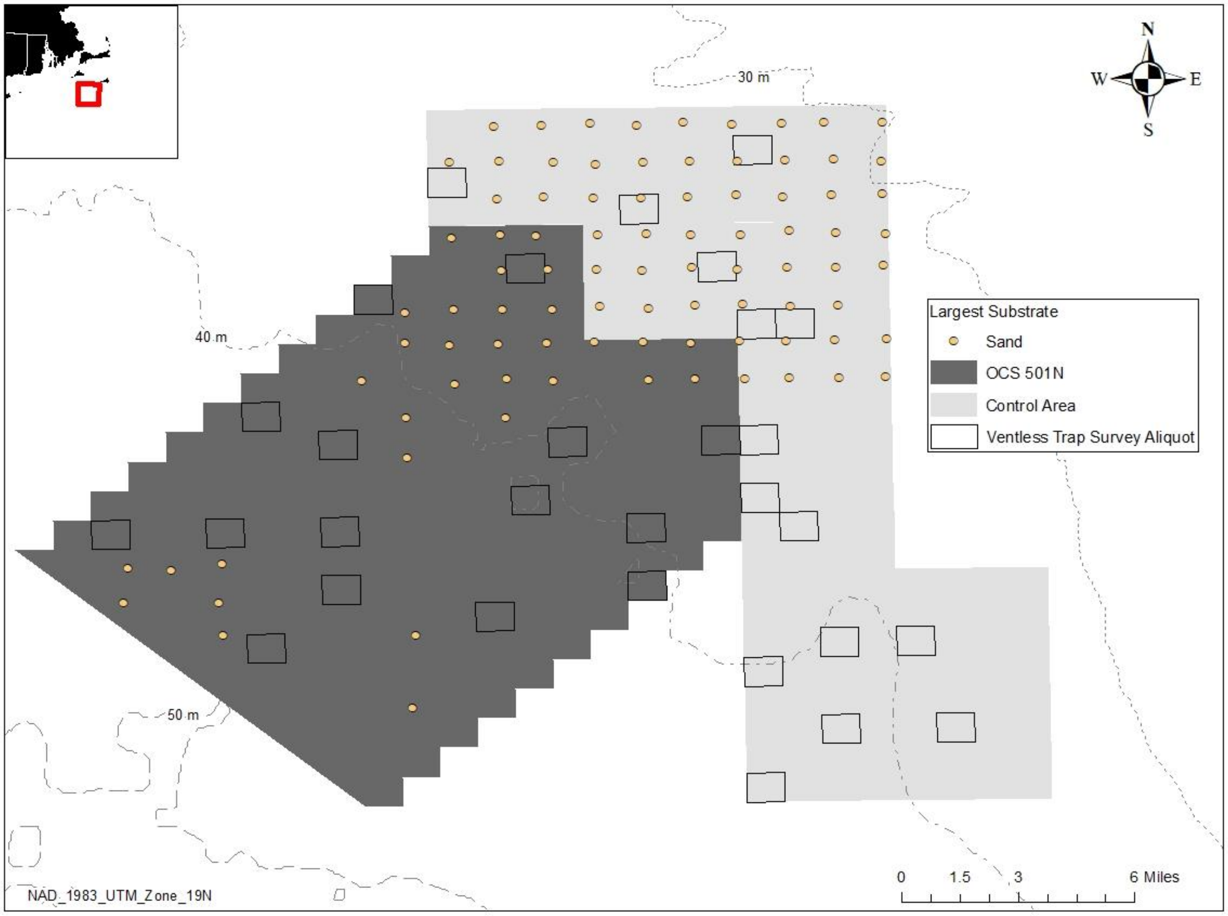

Figure 37. The distribution of substrate types in the October 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Four quadrats (2.3 m^2 images) were observed at each station.

The composition of the benthic community in the 501N Study Area and Control Area was most similar to each other when compared to broader regions of the U.S. continental shelf (Table 2). The two areas were 87% similar. When compared to broader regions of the U.S. continental shelf (Figure 5), the 501N Study Area was most similar to the Nantucket Lightship area with 52% similarity (Table 2), which may correlate with the proximity to the 501N Study Area. As the areas increased in distance from the 501N Study Area, the similarity decreased, with Elephant Trunk having 35% similarity and Northern Edge having 30% similarity index scores. The 501N Study Area is least similar to Great South Channel, with only 23% similarity.

When comparing substrate types, the adjacent Control Area has the highest similarity, with Elephant Trunk following (Table 3). Northern Edge and Nantucket Lightship were 75% similar, which was a shift from 2019. Northern Edge increased in similarity and Nantucket Lightship decreased, suggesting the environments to be highly dynamic with sediment shifts.

Table 2. The percent similarity index between benthic communities in the 501N Study Area, adjacent Control Area, Northern Edge (NE), Nantucket Lightship (NL), Elephant Trunk (ET), and Great South Channel (GSC) areas surveyed in August 2020.

Animal Group	**Study Area**	**Control**	**NE**	**NL**	**ET**	**GSC**
Bryozoans/Hydrozoans	1.41	0.54	9.98	5.07	8.05	19.05
Crabs (cancer spp.)	8.96	8.38	0.07	0.92	2.16	3.25
Flat Fish	0.88	1.35	0.66	0.00	0.86	0.22
Hermit Crabs	2.99	1.89	60.31	37.33	22.70	6.49
Moonsnail	0.18	0.81	0.66	1.84	3.88	0.65
Red Hake	7.73	9.19	2.13	7.37	15.09	1.95
Sand Dollars	59.40	50.00	20.32	33.18	17.24	5.19
Scallops	1.05	0.54	1.25	3.23	9.34	7.58
Sea Stars	0.35	0.00	1.98	2.30	6.61	43.29
Silver Hake	5.98	7.30	0.37	1.38	0.00	1.95
Skate	5.45	11.08	1.76	4.61	0.29	0.65
Sponge	5.62	8.92	0.15	0.00	2.16	8.87
Waved Whelk	0.00	0.00	0.37	2.76	11.64	0.87
Percent Similarity Index						
	86.65					
	30.03					
	52.03					
	35.00					
	23.40					

Table 3. The percent similarity index between substrate types in the 501N Study Area, adjacent Control Area, Closed Area II (CAII), Nantucket Lightship (NL), Elephant Trunk (ET), and Great South Channel (GSC) areas surveyed in August 2020.

Substrate	Study Area	Control	CAII	NL	ET	GSC
Sand	33.7	35.1	41.7	32.7	32.9	30.6
Sand Ripple	0.0	0.0	7.7	2.0	0.0	3.9
Shell Debris	33.0	30.0	37.6	32.5	32.3	30.0
Silt	33.3	34.9	9.0	10.2	16.9	3.1
Gravel	0.0	0.0	3.9	22.2	17.7	21.5
Cobble	0.0	0.0	0.1	0.3	0.0	8.3
Boulder	0.0	0.0	0.0	0.0	0.1	2.5
Percent Similarity Index						
	97.08					
	75.66					
	75.44					
	82.13					
	63.77					

The results of this survey provide a second year of baseline information on the benthic community and substrate of the 501N Study Area and an adjacent Control Area. Continuing this standard systematic sampling approach will allow for the data from different surveys to be leveraged and combined for a comprehensive analysis. Each drop camera survey can be viewed as a potential dataset that can be integrated to conduct statistical analyses to evaluate impacts (Underwood 1993). With this analytical approach, the continuation of the SMAST drop camera survey within and near areas leased to Vineyard Wind will aid in building a regional, standardized baseline dataset to address the management objectives and research priorities for fisheries in the area. This could also be key to conducting a cumulative analysis of wind energy impacts along the U.S. east coast.

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<u>Appendix I:</u> Information on all categories tracked by the 2020 Drop Camera Survey of Benthic Communities and Substrate in the 501N Study Area and an adjacent Control Area

The main body of the report focused on the most common benthic megafauna and two commercially important animal groups observed in the 501N Study Area and the adjacent Control Area. This appendix provides additional information about all animals tracked, including the number of quadrats all animals were observed (Table I-1), the density of all animals counted (Figure I-1), and the average number of quadrats for all categories tracked as present or absent (Figure I-2).

Table I-1. All animal groups, in order of most to least quadrats present, observed during the 2020 drop camera survey of the 501N Study Area and an adjacent Control Area. Groups left blank in the “Counts” column are tracked as present or absent. Note waved whelk listed as Buccinum in this table.

	July				October			
	Control		Impact		Control		Impact	
Animal Group	Present	Counts	Present	Counts	Present	Counts	Present	Counts
Sand Dollar	338		185		93		66	
Holes	304		69		54		9	
Detritus	25		71		113		26	
Anenome	58		30		14		0	
Crabs	45	51	28	31	12	12	1	1
Skate	30	31	39	41	8	8	5	5
Sponges	32		33		11		3	
Hake	41	44	29	34	0	0	0	0
Silver Hake	34	34	24	27	1	1	0	0
Unidentified Fish	19	22	20	21	4	4	2	2
Skate Egg Case	14	16	8	9	2	2	0	0
Hermit Crabs	17	17	7	7	0	0	1	1
Euphausiids	1		6		7		0	
Bry./Hydr.	8		2		2		0	
Flounder	4	5	4	5	1	1	0	0
Moonsnail Egg Case	3	3	6	7	0	0	0	0
Moonsnail	5	5	3	3	0	0	0	0
Scallops	6	6	2	2	0	0	0	0
Clappers	4	4	0	0	0	0	0	0
Sea Robin	0	0	0	0	3	3	1	1
Seaweed	1		3		0		0	
Squid	2		1		1		0	
Sea Stars	2	2	0	0	0	0	1	1
Sculpin	0	0	0	0	2	2	0	0
Eel	0	0	0	0	0	0	1	1
Haddock	0	0	0	0	0	0	1	1
Hagfish	0	0	1	1	0	0	0	0
Jellyfish	0		1		0		0	
Monkfish	0	0	1	1	0	0	0	0
Other Mollucs	1	1	0	0	0	0	0	0
Sandlance	0		0		1		0	
Seed	1	0	0	0	0	0	0	0
Brittlestar	0		0		0		0	
Buccinum	0	0	0	0	0	0	0	0
Clams	0		0		0		0	
Coral	0		0		0		0	
Cod	0	0	0	0	0	0	0	0
Ctenophore	0		0		0		0	
Dogfish	0	0	0	0	0	0	0	0
Echinoderm	0		0		0		0	
Filo	0		0		0		0	
Herring	0	0	0	0	0	0	0	0
Lobster	0	0	0	0	0	0	0	0
Mackerel	0	0	0	0	0	0	0	0
Mouse	0		0		0		0	
Mussels	0		0		0		0	
Oceanpout	0	0	0	0	0	0	0	0
Other Crustaceans	0	0	0	0	0	0	0	0
Other Fish	0	0	0	0	0	0	0	0
Sea Raven	0	0	0	0	0	0	0	0
Tunicates	0		0		0		0	
Urchin	0		0		0		0	
Number of Quadrats Sampled	473		525		202		97	

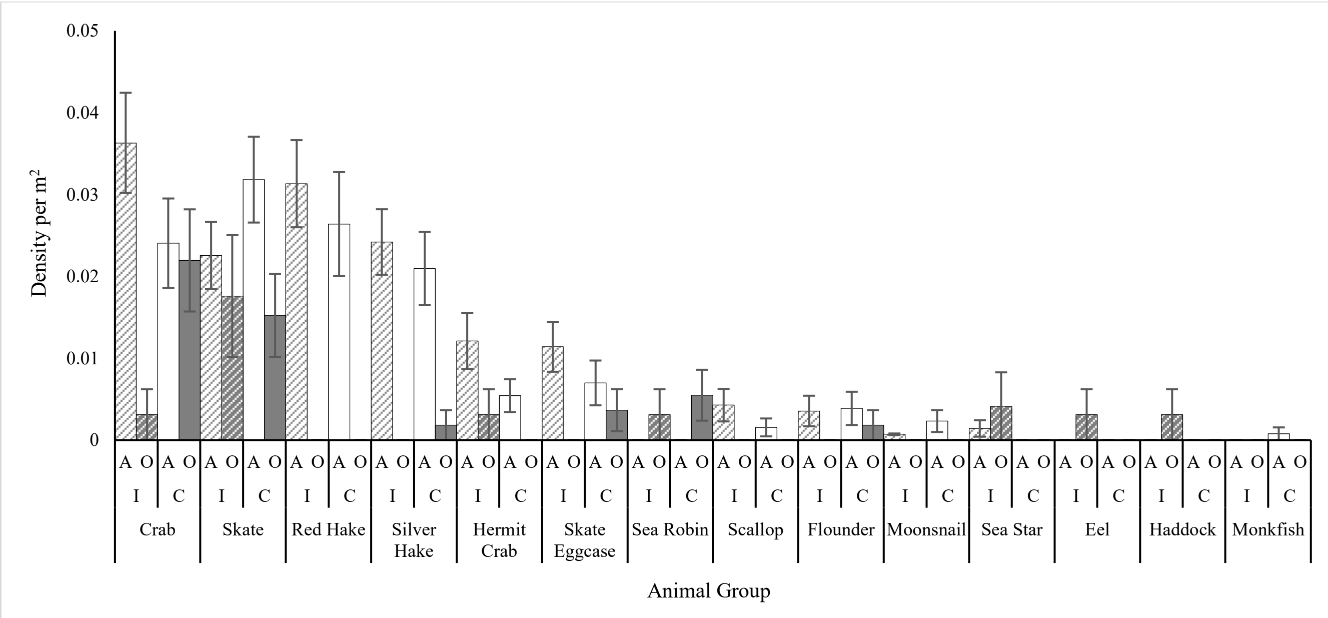

Figure I-1. The density of animals in the July/August (A) and October (O) 2020 drop camera surveys of the 501N Study Area (I) and an adjacent Control Area (C).

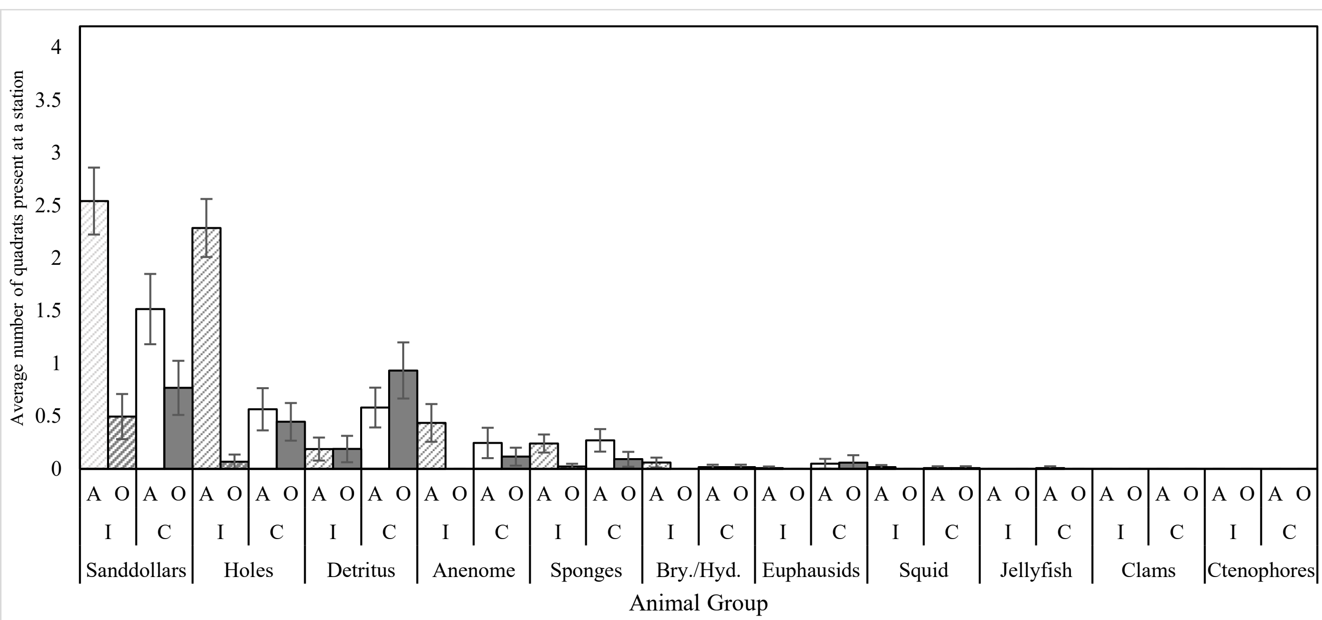

Figure I-2. The average number of quadrats animals present at each station in the July/August (A) and October (O) 2020 drop camera surveys of the 501N Study Area (I) and an adjacent Control Area (C). Four quadrats (2.64 m^2 images in August, 2.44 m^2 images in October) were observed at each station.

<u>Appendix II:</u> Species groups

Table II-1. Georges Bank species are grouped into taxonomic categories (Stokesbury and Harris, 2006).

Category	**Scientific name**	**Common name**
Scallop	*Placopecten magellanicus*	Sea scallop
Starfishes	*Solaster endeca*	Purple sunstar
	Crossaster papposus	Spiny sunstar
	Leptasterias Polaris	Polar sea star
	Asterias spp.	Sea stars
	Henricia spp	Blood star
Sand dollars	*Echinarachnius parma*	Sand dollar
Bryozoans/hydrozoans	*Flustra foliacea*	Bryozoans
	Callopora aurita	Bryozoans
	Electra monostachys	Bryozoans
	Cribrilina punctate	Bryozoans
	Eucratea loricate	Bryozoans
	Tricellaria ternate	Bryozoans
	Eudendrium capillare	Hydrozoans
	Sertularia cupressina	Sea cypress hydroid
	Sertularia argentea	Squirrel's tail hydroid
	Diphasia fallax	Hydrozoans
	Filograna implexa	Lacy tube worm
Sponges	*Suberites ficus*	Fig sponge
	Haliclona oculata	Finger sponge
	Halichondria panacea	Crumb of bread sponge
	Cliona celata Grant	Boring sponge
	Polymastia robusta	Encrusting sponge
	Isodictya palmate	Palmate sponge
	Microciona prolifera	Red beard sponge
Lobster	*Homarus americanus*	American lobster
Crabs	*Cancer irroratus Say*	Atlantic rock crab
	Cancer borealis Stimpson	Jonah crab
Hermit crabs	*Diogenidae*	Left-handed hermit crabs
	Paguridae	Right-handed hermit crabs
	Parapaguridae	Deep water hermit crabs
Eel pout	*Zoarces americanus*	Ocean pout
Flounder	*Paralichthys dentatus*	Summer flounder
	Paralichthys oblongus	Fourspot flounder
	Scophthalmus aquosus	Windowpane flounder
	Pseudopleuronectes americanus	Winter flounder
	Limanda ferruginea	Yellowtail flounder
	Glyptocephalus cynoglossus	Witch flounder
	Trinectes maculatus	Hogchoaker
Haddock	*Melanogrammus aeglefinus*	Haddock
Hake	*Merluccius bilinearis*	Silver hake
	Urophycis spp.	Red and white hake
Sculpins	*Myoxocephalus octodecemspinosus*	Longhorn sculpin
	Prionotus carolinus	Northern sea robin
Skates	*Leucoraja erinacea*	Little skate
	Leucoraja ocellata	Winter skate
	Dipturus laevis	Barndoor skate
Other fish	*Myxine glutinosa*	Atlantic hagfish
	Scyliorhinus rotifer	Chain dogfish
	Squalus acanthias	Spiny dogfish
	Anguilla rostrate	American eel
	Conger oceanicus	Conger eel
	Clupea harengus	Atlantic herring
	Brosme brosme	Cusk
	Gadus morhua	Atlantic cod
	Lophius americanus	Goosefish
	Ammodytes dubius	Northern sand lance
	Scomber scombrus	Atlantic mackerel
	Sebastes fasciatus	Acadian refish
	Anarhichas lupus	Atlantic wolfish
Shell debris	*Buccinum undatum*	Waved whelk
	Euspira heros	Northern moonsnail
	Mercenaria mercenaria	Northern quahog
	Modiolus modiolus	Northern horse mussel
	Ensis directus	Atlantic jackknife
	Placopecten magellanicus	Sea scallops

<u>Appendix III:</u> Visibility information

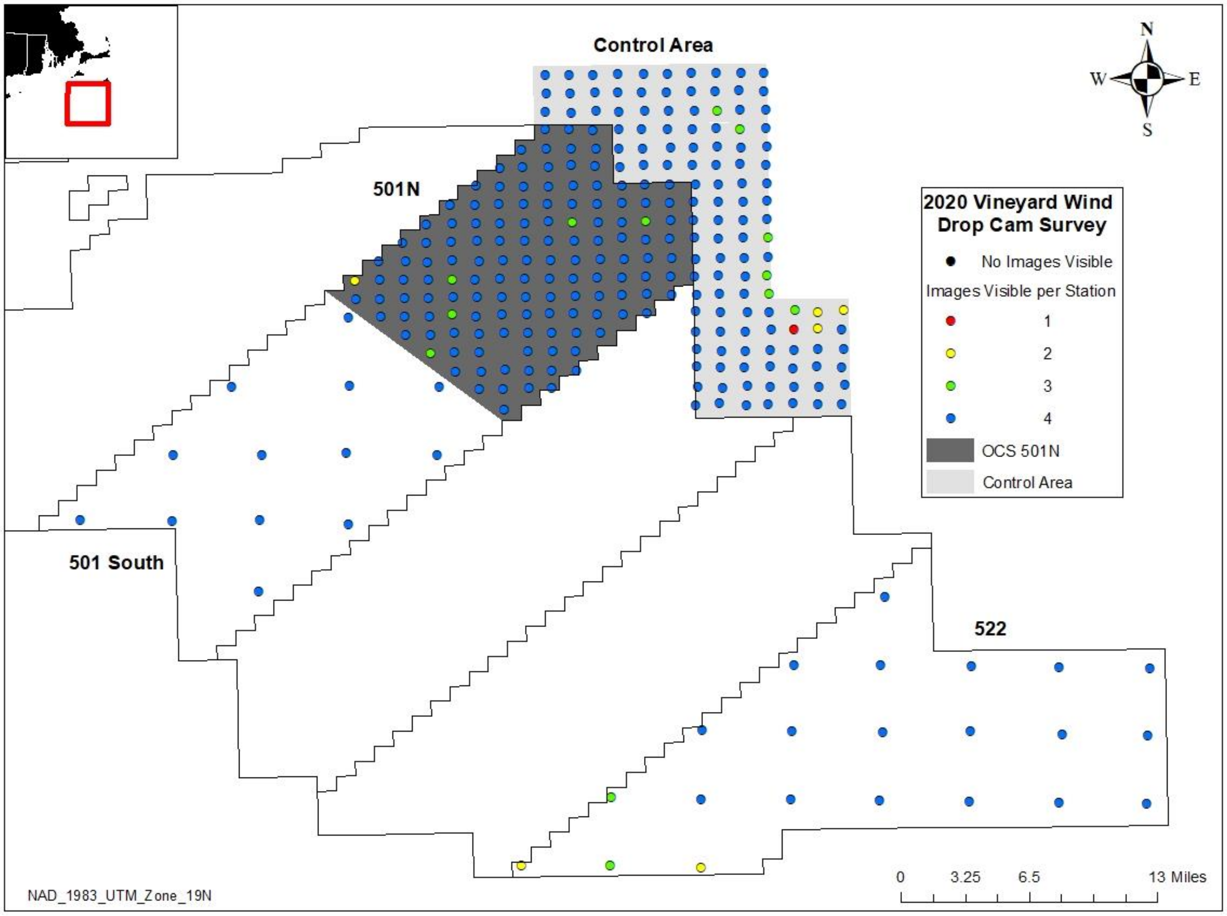

Figure III-1. The distribution of image visibility per station for the July/August 2020 drop camera survey.

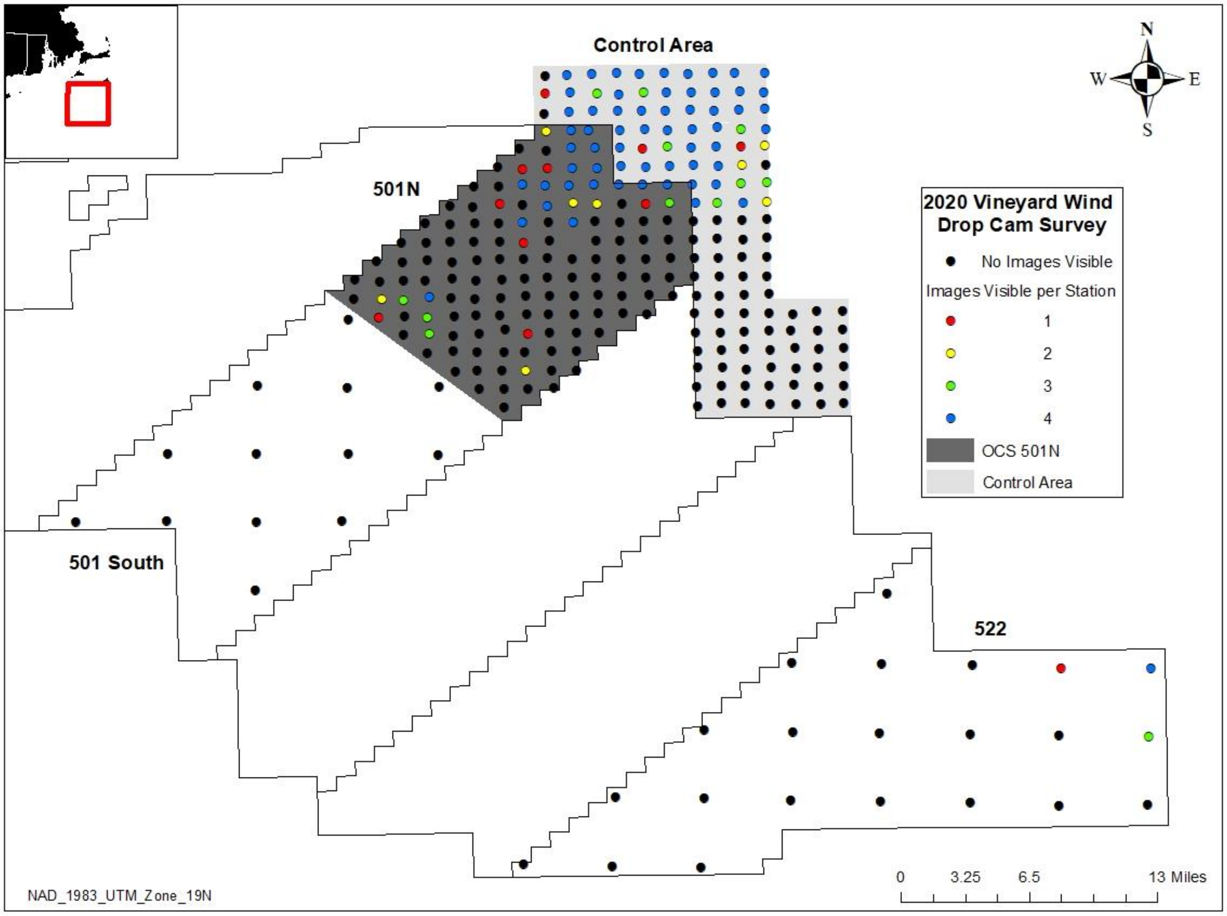

Figure III-2. The distribution of image visibility per station for the October 2020 drop camera survey.