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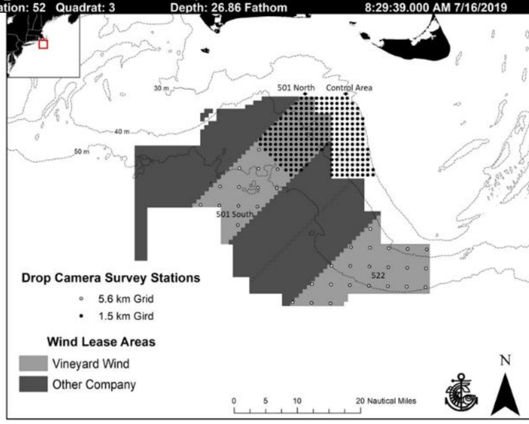
Final Report

2019 Drop Camera Survey of Benthic Communities and Substrate in Vineyard Wind Lease Area OCS-A 0501 North and a Control Area



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

January 2020 **SMAST-CE-REP-2020-075**

FINAL REPORT

2019 Drop Camera Survey of Benthic Communities and Substrate in Vineyard Wind Lease Area OCS-A 0501 North and a Control Area

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SMAST-CE-REP-2020-075

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 and a Control Area 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 development area, Control Area, and broader regions of the U.S.OCS and
4) classify substrate within aliquots sampled by the American Lobster, Black Sea Bass, 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 utilized a centric systematic sampling design to sample survey stations in the northern portion of Lease Area OCS-A 0501 (termed the 501N Impact Area) and the Control Area. Stations in the two areas were placed 1.5 km apart following a grid design. At each station a sampling pyramid was deployed, and a high-resolution camera was used take four quadrat (2.3 m^2 images) samples. Both areas were surveyed in July and October 2019 using a commercial scallop vessel to deploy the sampling pyramid.

The dominant benthic community of Impact and the Control Areas 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 Impact and Control Areas were similar with the exception of waved whelks which had a higher density in the Control Area during July. 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 Impact Area. This may be related to the differing water depths of the areas. A significant decline in the abundance and presence of most animal groups occurred between July and October, but future investigations will be needed to confirm seasonal patterns. The confidence intervals associated with the estimates of dominant benthic megafauna prevalence and the ability to detect significant differences shows 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 Impact Area and Control Areas were dominated by sand with gravel observed at few stations; no cobble or boulders were observed. The benthic community of the 501N Impact 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 Impact Area, the similarity decreased. The substrate within trap survey aliquots was predominately sand, but the aliquots in the northwest part of the 501N Impact Area contained gravel.

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Introduction

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

The University of Massachusetts Dartmouth School for Marine Science and Technology (SMAST has developed a minimally invasive, image-based drop camera survey that allows for practical data collection of the epibenthic community without causing a 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 to aid in annual scallop harvest allocation (NEFSC 2010, 2018).

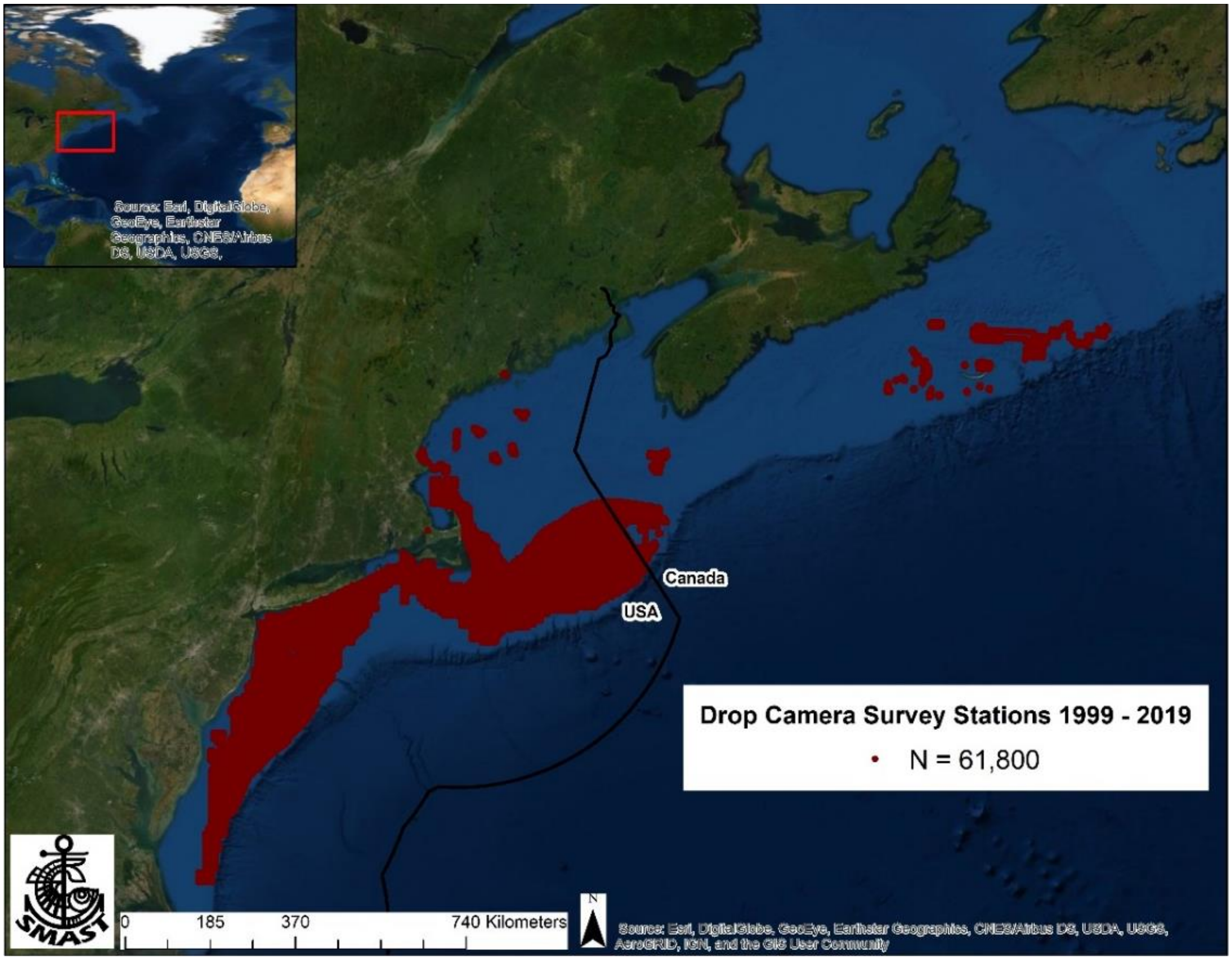

Figure 1. Spatial extent of SMAST drop camera surveys in the northern hemisphere. All stations surveyed since 1999 are displayed.

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 2019) 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 New England Fisheries Management Council Swept 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).

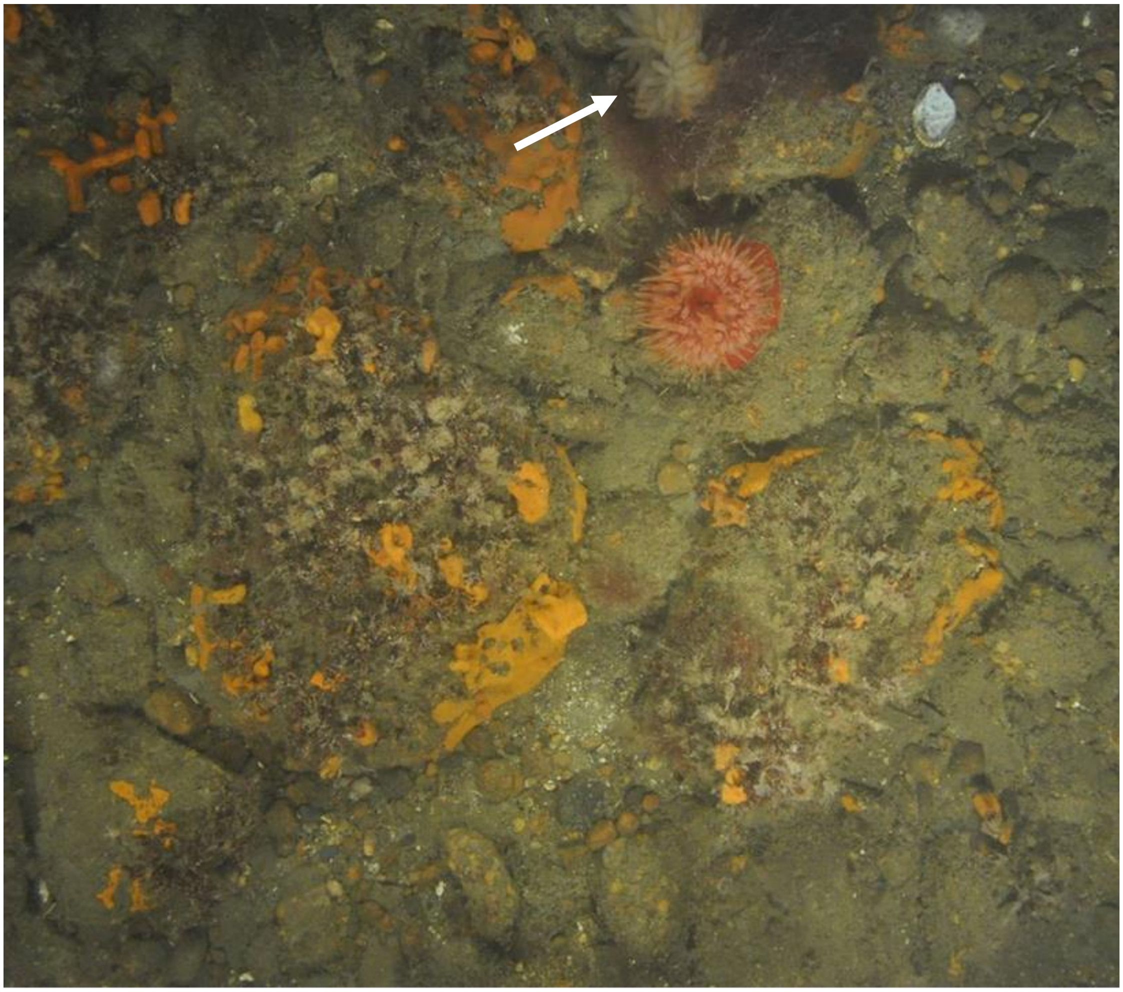

Figure 2. Example of a digital still image taken by the SMAST drop camera survey in complex habitat of the Rhode Island Wind Energy Lease Area on Cox's Ledge during a survey in 2013. A longfin squid *(Doryteuthis pealeii*) egg cluster is present (top, middle).

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 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. 2019). To account for naturally fluctuating characteristics, a designated area outside of the 501N Impact Area, but containing similar environments and communities, is chosen to be the control site (Eberhardt 1976). The approached 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 ultimate goal of comparing epibenthic faunal variance between impact and control sites over time. Based on the drop camera survey's history and this analytical approach, 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 is to provide baseline epibenthic faunal and substrate habitat data for future environmental assessment of wind development in the northern portion of Lease Area OCS-A 0501 (501N Impact Area) (Figure 3). To do this we used information from drop camera surveys of the 501N Impact Area (development area) and a nearby Control Area during two different time periods to:

1) Map the distribution and estimate the density of dominant benthic megafauna

2) Classify substrate types

These two objectives documented the primary epibenthic animals and habitats within the development and Control Area to help identify which animals and habitats are detected at high enough rates for future analysis of variance. They also document seasonal changes in distribution and density.

3) Compare benthic communities and substrate types between the development 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 development 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 Impact and the Control Areas.

This objective leverages drop camera data to provide habitat information for the trap survey.

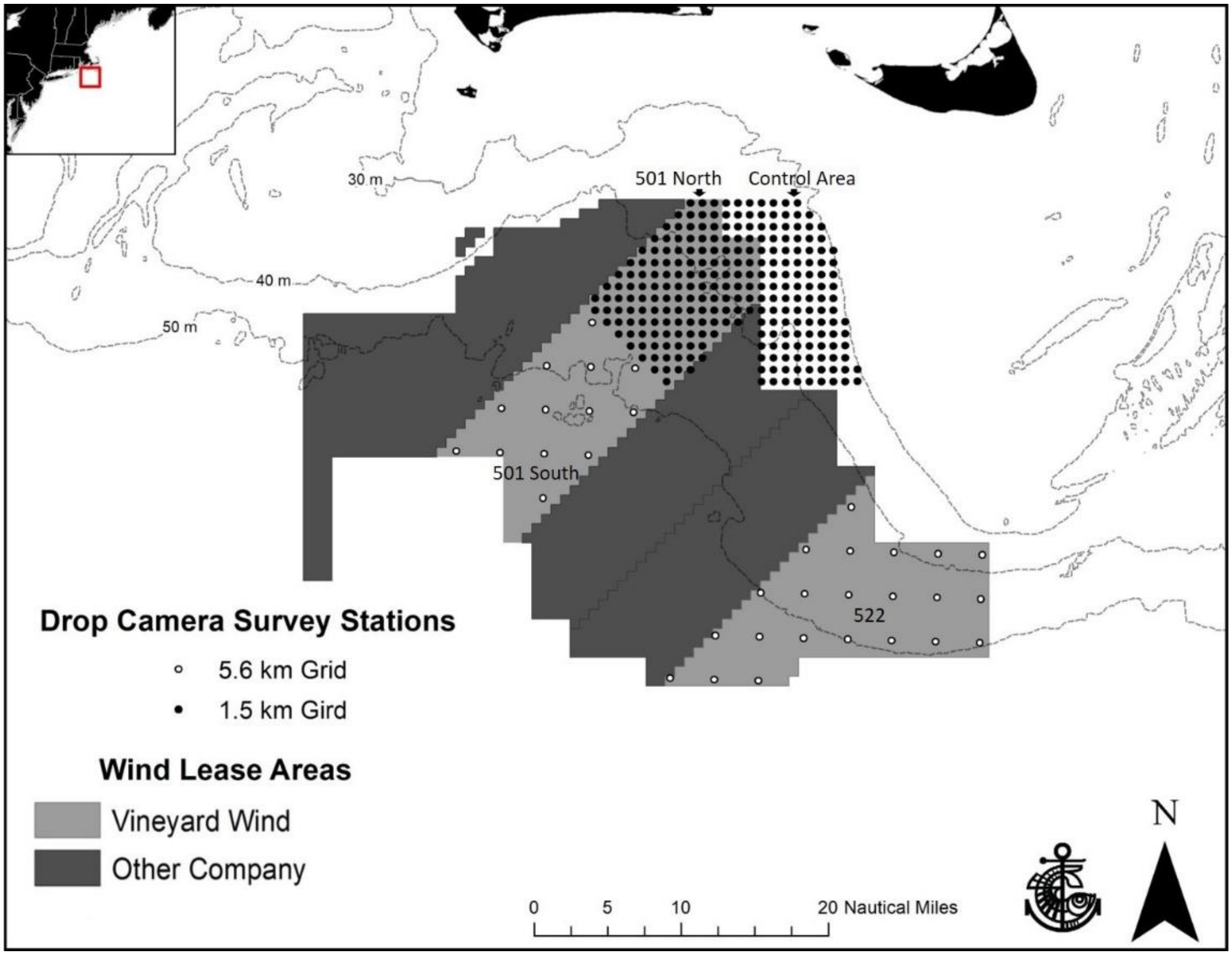

Figure 3. Drop camera survey station grids and Wind Energy Lease Areas.

Methods

We utilized a centric stratified, systematic sampling design to sample survey stations in the 501N Impact Area and Control Areas. Stations in the two areas were placed 1.5 km apart following a grid design. At each station a sampling pyramid was deployed, and a high-resolution camera was used take four quadrats (2.3 m^2 images) samples (Figure 4). Both areas were surveyed in July and October 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 Impact Area in waters deeper than 30 m that did not overlap with wind lease areas (Figure 3). This resulted in water depths in the 501N Impact Area potentially being deeper than the Control Area but offered the best continuous location for a control site near the development 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 OCS Lease 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 off 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 and 522 Study Areas with a 5.6 km grid resolution to match previous surveys and provide preliminary information for future statistical power analysis.

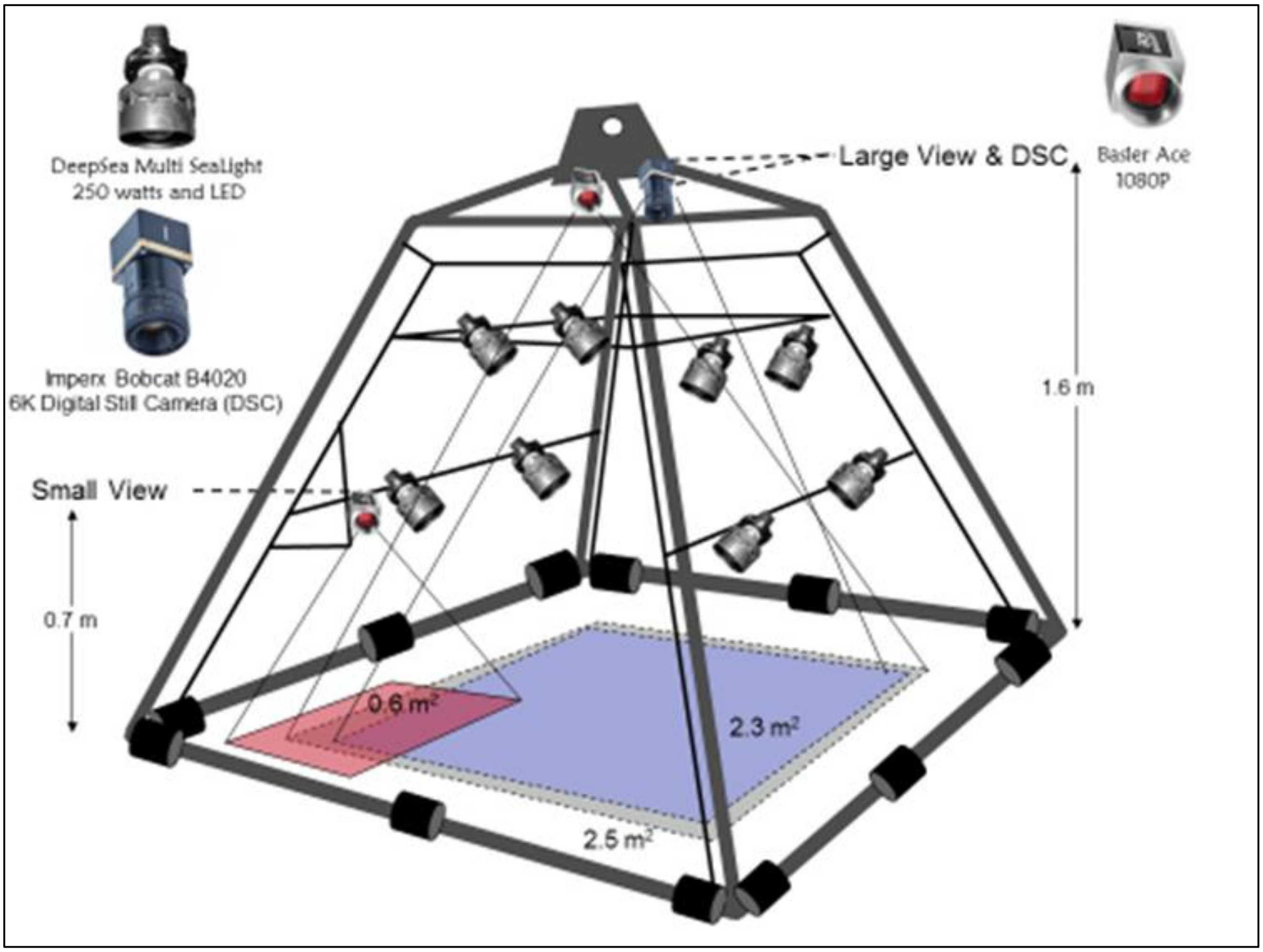

Figure 4. SMAST drop camera survey pyramid with cameras and lights used for data collection. The camera used for the small view was turned to the side to provide a view parallel to the seafloor for some stations.

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 the 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 sea floor 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 quadrat view of the first quadrat was saved and then the pyramid was raised, so the seafloor could no longer be seen. The vessel was allowed to drift approximately 50 m and the pyramid was lowered to the seafloor again to obtain a second quadrat; this was repeated four 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 a 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 (Stokesbury 2002, Stokesbury et al. 2004, Bethoney and Stokesbury 2018). Fifty taxa of macrobenthos are counted or noted as present or absent (see Appendix). 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 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 4 quadrats at station *i*. The SE of this 2-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 2-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 Impact Area and Control Area, to focus results on the groups detected at high enough rates for future analysis of variance (Bethoney et al. 2017). Densities for animal group 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 Impact 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 Impact Area, but at increasing distances away were used as the broader areas (Figure 5). These surveys were conducted for sea scallop assessment in 2019 but followed the same design and protocols as described above (Bethoney and Stokesbury 2018). Comparisons were only made to July survey results of the 501N Impact Area and Control Areas as the areas in the Mid-Atlantic were surveyed in May, while the areas on Georges Bank were surveyed in July (Figure 5). They are not in areas slated for wind energy development and could be used as broader control areas based on similarity index results.

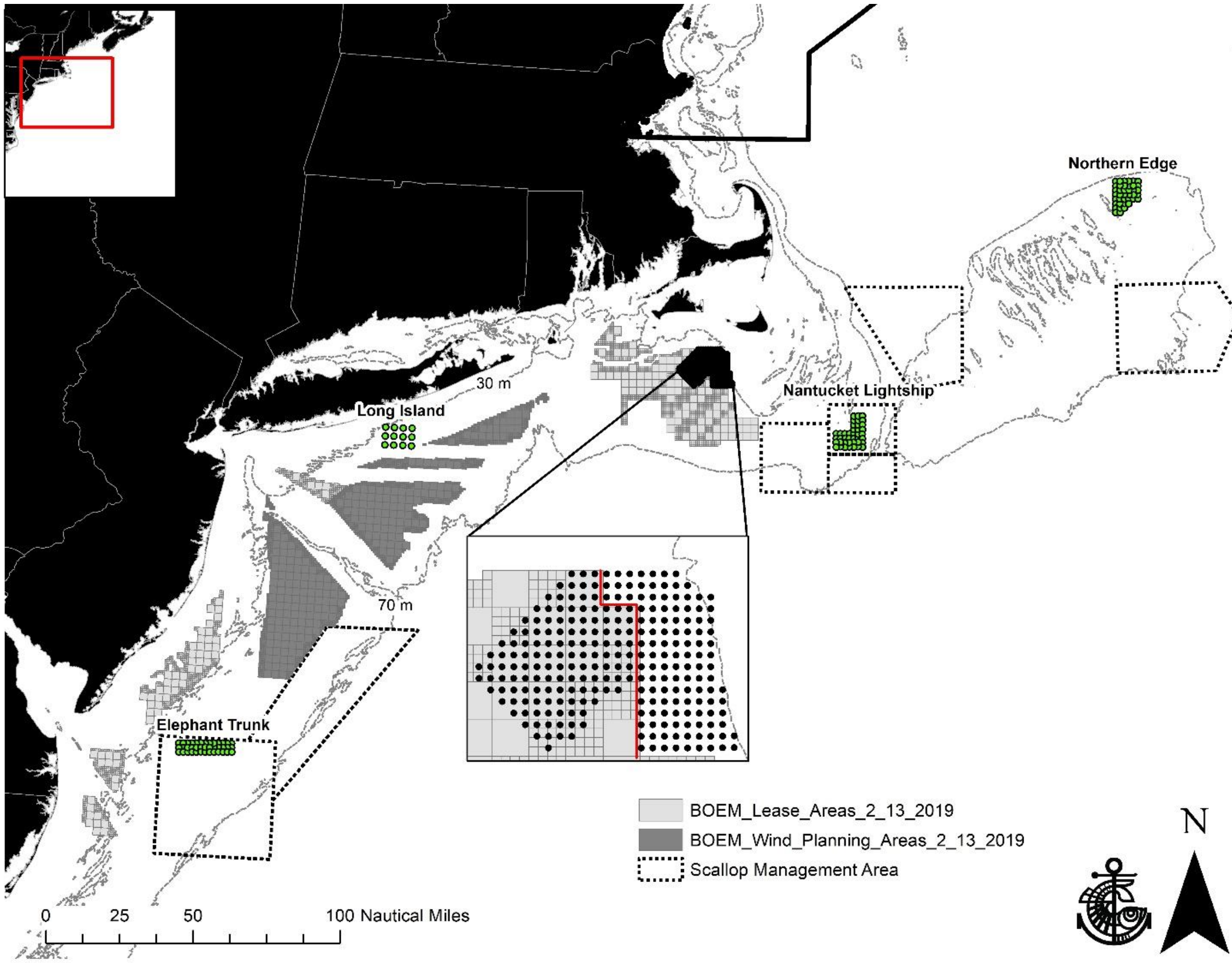

Figure 5. Location of four areas (green) that were compared to the 501N Impact Area and Control Areas (black) to assess benthic community and substrate similarity.

<u>Results and Discussion</u>

The two drop camera surveys of the 501N Impact Area and Control Area were conducted from 16 July to 18 July and from 19 October to 22 October 2019. In July, 124 stations were sampled in the Control Area, and 134 stations in the Impact Area (of these 27 were in the South East corner, which is not being developed immediately). In October, 65 station were collected in the Control Area, 119 in the impact area (again, 27 were in the South East corner, which is not being developed immediately). In October, stations in the northern part of the Control Area and some of the 501N Impact Area were not sampled due to high turbidity caused by an unexpected, rapid weather change that resulted in a surface storm arriving earlier than predicted (detailed in October Drop Camera Post Survey Report).

All images and video collected were shared with Vineyard Wind. The results related to the most commonly observed benthic animals, as well as scallops and flat fishes, due to their regional commercial importance, as well as the substrate types are detailed in this report. For general information on all categories tracked refer to the Appendix.

Table 1. The most frequently observed benthic animal groups, in order of most to least quadrats present, during the 2019 SMAST drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Groups left blank in the "Counts" column are tracked as present or absent.

Animal Group	Quadrats Present	Counts
Holes (burrowing animals)	599	
Sand Dollars	564	
Hermit Crabs	429	732
Anemones	224	
Waved Whelk	181	391
Skates	123	131
Bryozoans/Hydrozoans	101	
Silver hake	86	95
Red hake	82	84
Sponges	65	
Crabs (cancer spp.)	58	69
Skate Egg Case	49	51

The loss of stations in the Control Area in October increased the uncertainty around density estimates. However, a clear decline in the abundance or presence of most animal groups occurred between July 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 2019 Drop Camera reports for OCS 501S and 522). The SMAST trawl survey detected a similar pattern in fish abundance as with our findings (C. Rillahan person comm.). Future investigations, and less visibility issues, are necessary to confirm the differences of seasonal patterns detailed in this report.

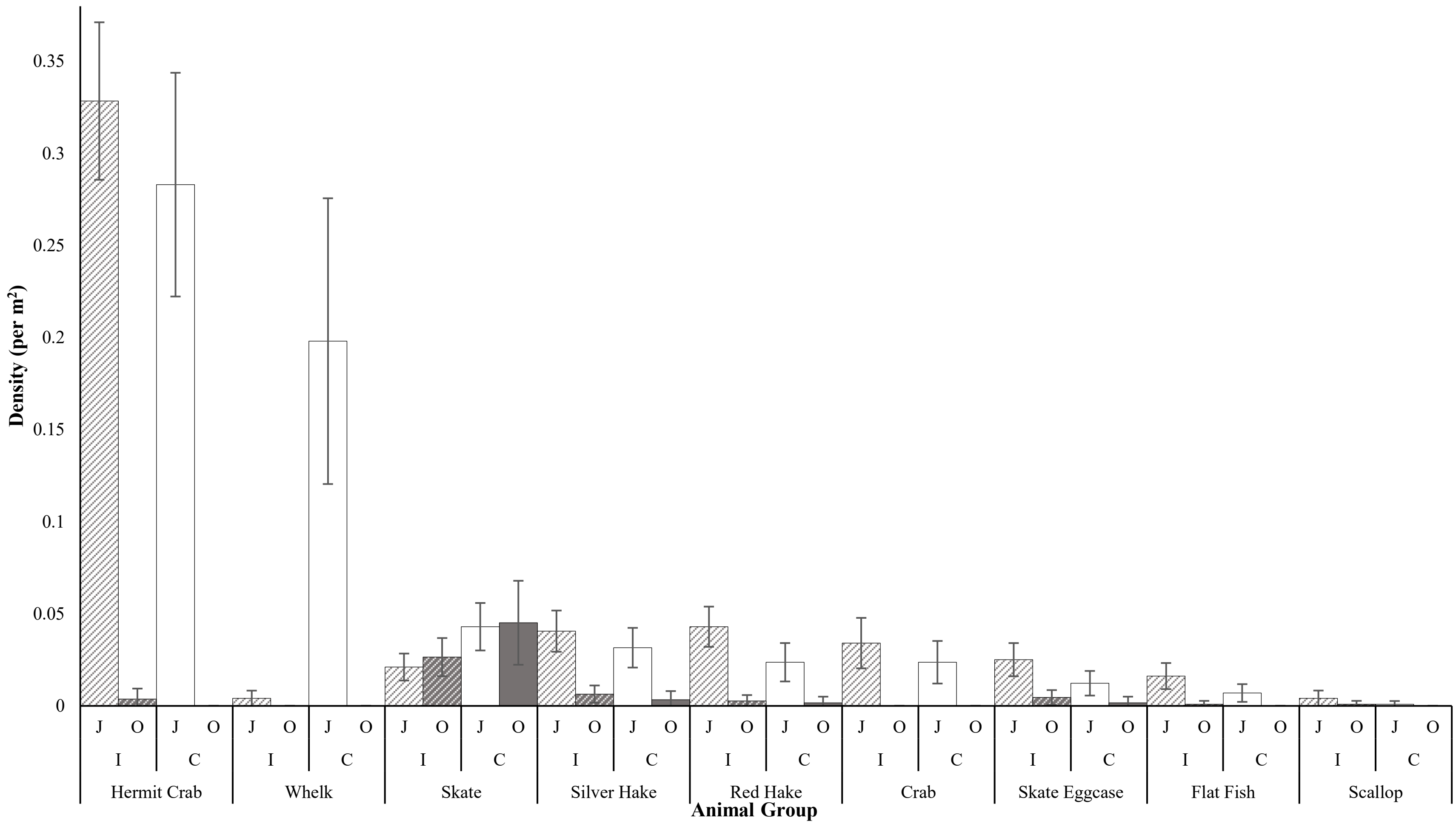

Figure 6. Density of common or commercially important benthic animals in the July (J) and October (O) drop camera survey of the 501N Impact Area (I) and the adjacent Control Area (C). Error bars are 95% confidence intervals.

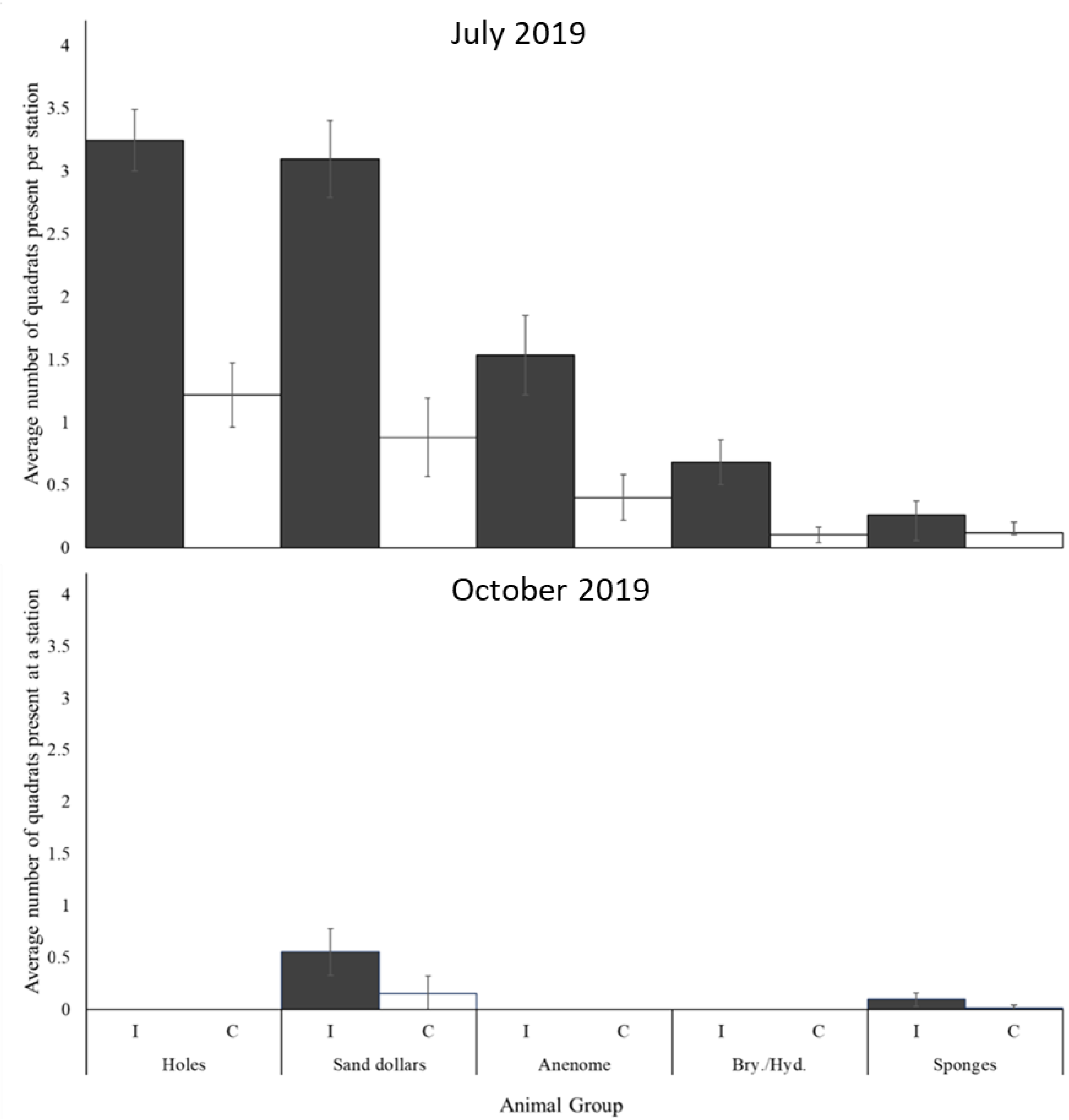

Figure 7. The average number of quadrats common benthic animals were present in at each station during the July (J) and October (O) drop camera surveys of the OCS 501N Impact Area (I) and adjacent Control Area (C). Four quadrats (2.3m^2 images) were observed at each station. Holes represent burrowing 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 Impact Area and Control Areas were similar (Figure 6). The one exception was waved whelks (*Buccinum undatum*, not the commercially harvested channeled whelk, *Busycotypus canaliculatus*), which had a significantly higher density in the Control Area compared to the 501N Impact Area (Figure 6).

The species with the highest abundance were hermit crabs, waved whelks, skate (*Leucoraja* spp. or *Dipturus laevis*), red hake (*Urophycis chuss*), silver hake (*Merluccius bilinearis*), and crabs (Cancer spp.) in both areas in the July survey. Within that group, hermit crabs had significantly higher densities than all other animals except whelks in the Control Area (Figure 6). The distribution of all animals counted (estimated as individuals per m^2) changed between July and October (Figures 8-22). In July, hermit crabs and whelks were distributed throughout the survey area (Figures 8 & 9). The other animals were also found throughout the surveyed area, but densities at or above the 50^{th} percentile appeared to be concentrated at depths greater than 40 meters (Figures 11, 13, 15, 17, 19 & 21) 11-22. In October all these animals had significantly lower densities or were absent in the 501N Impact Area and Control Area, except for skates (Figures 6 & 12).

Some groups were present in the Control Area, but not the 501N Impact Area in October. In general, this represented only one or two observations in the 501N Impact Area. 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 Impact Area and Control Areas. Scallops and flat fishes displayed similar trends as the dominate benthic fauna, but at lower densities that would be difficult to compare statistically (Figure 6). Few squid and no squid eggs were observed. Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), and eel (*Anguilliformes*) were found only in the July survey (Appendix I). Dogfish (*Squalus acanthias*) and sea robin (*Prionotus carolinus*) were only found during the October survey (Appendix). Several other organisms tracked, including the American lobster (*Homarus americanus*), were not observed (Appendix).

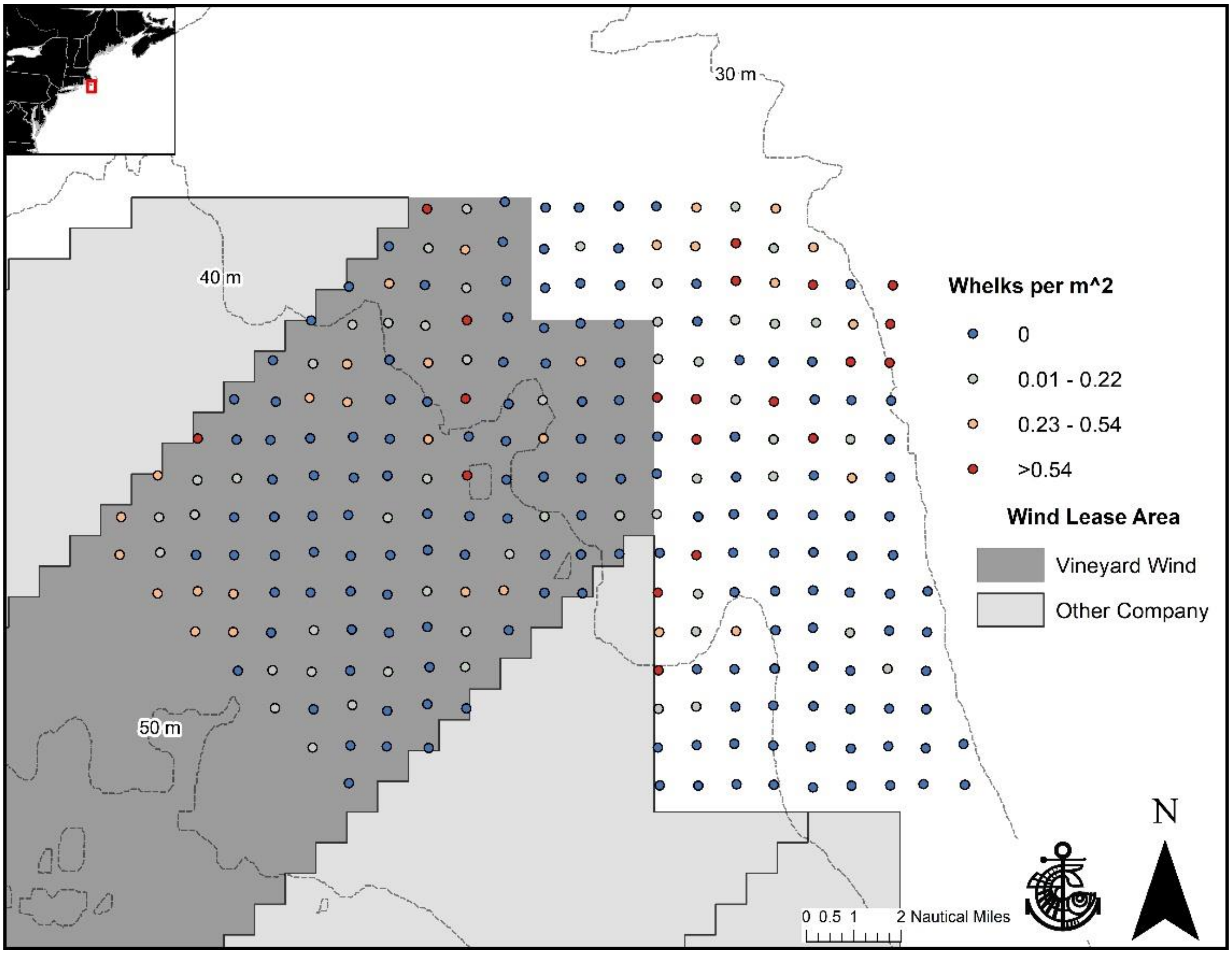

Figure 8. The distribution of waved whelks in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. No waved whelks were observed in an October survey of the same areas. Density categories equally divide the data above zero.

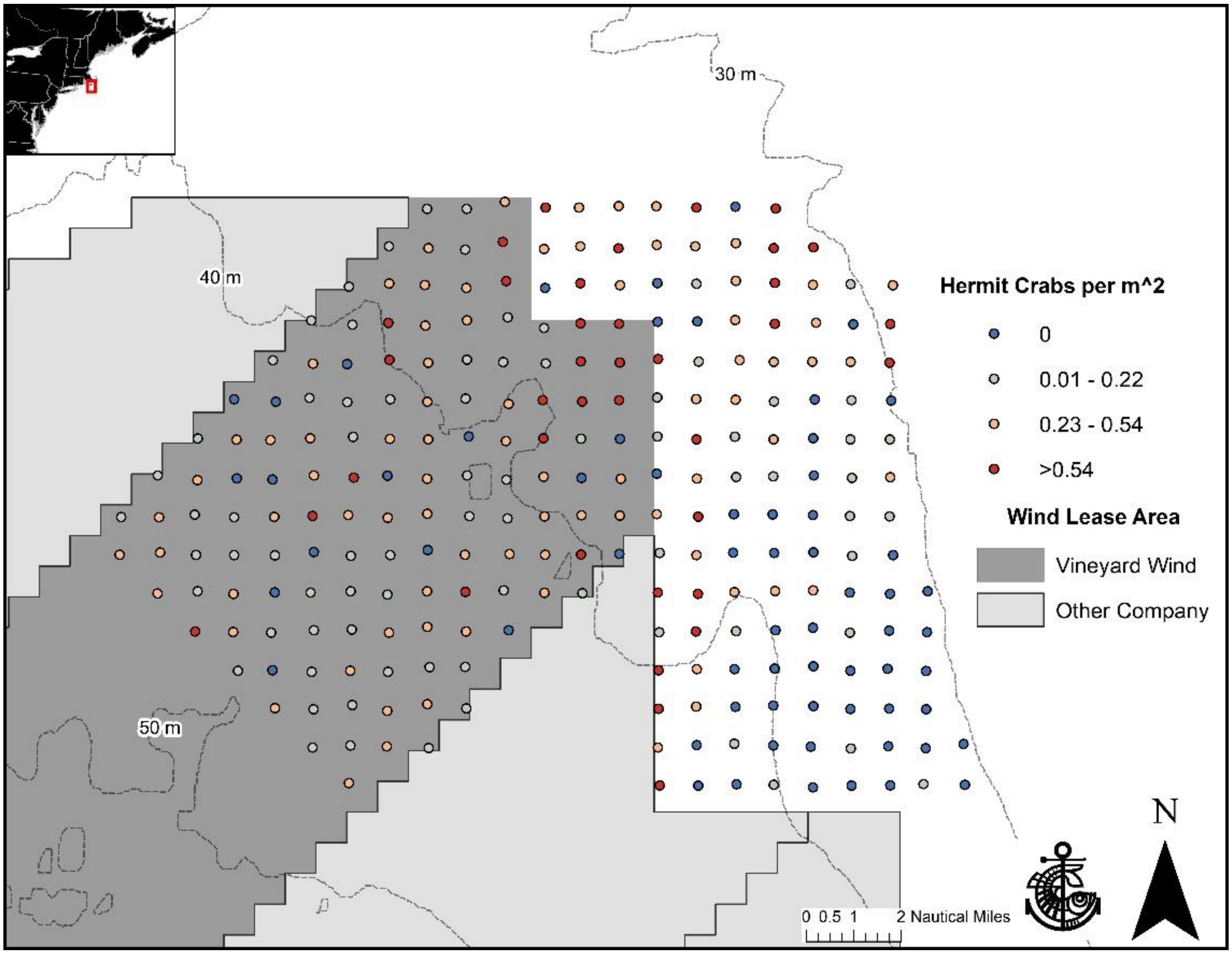

Figure 9. The distribution of hermit crabs in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July and October.

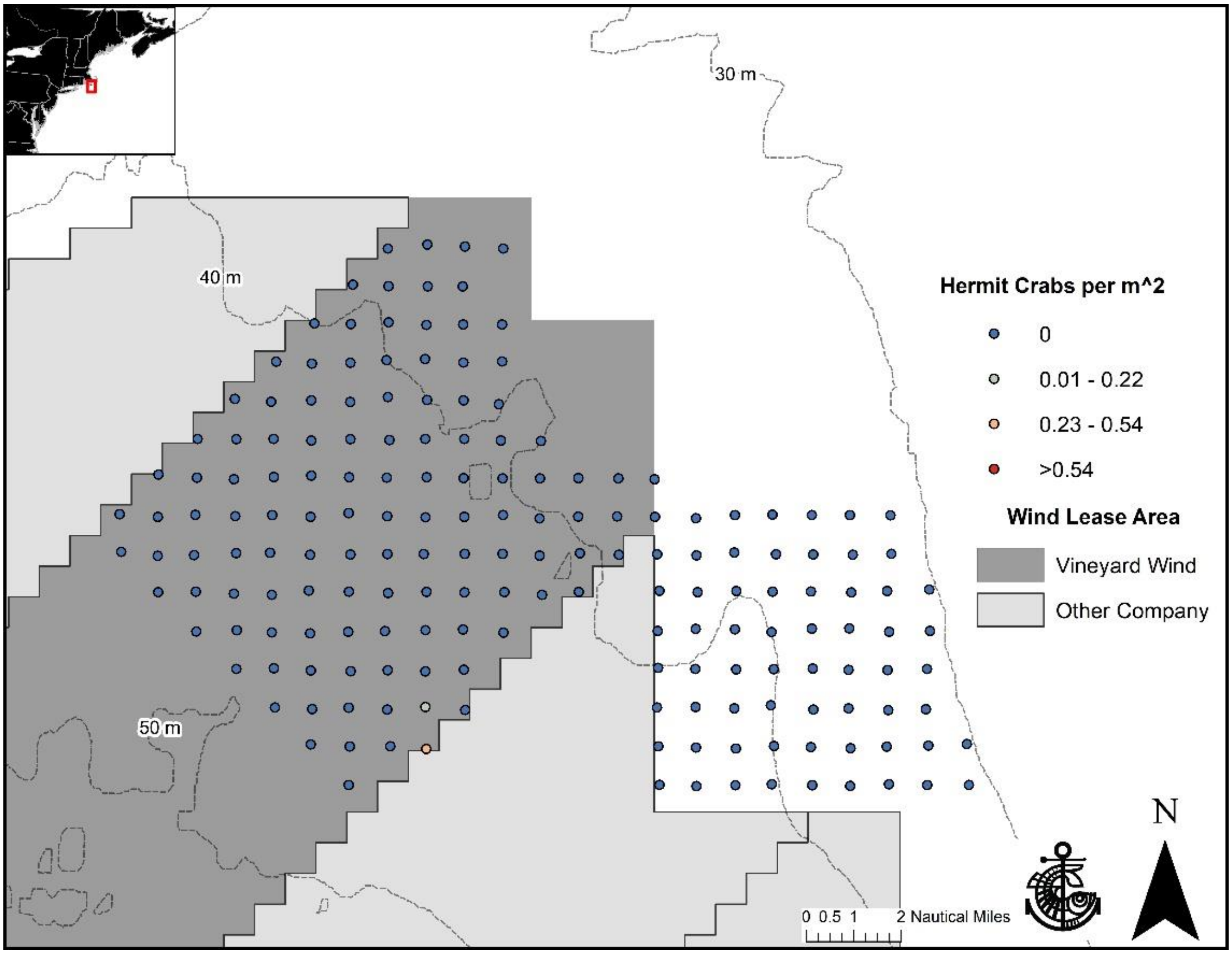

Figure 10. The distribution of hermit crabs in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July and October.

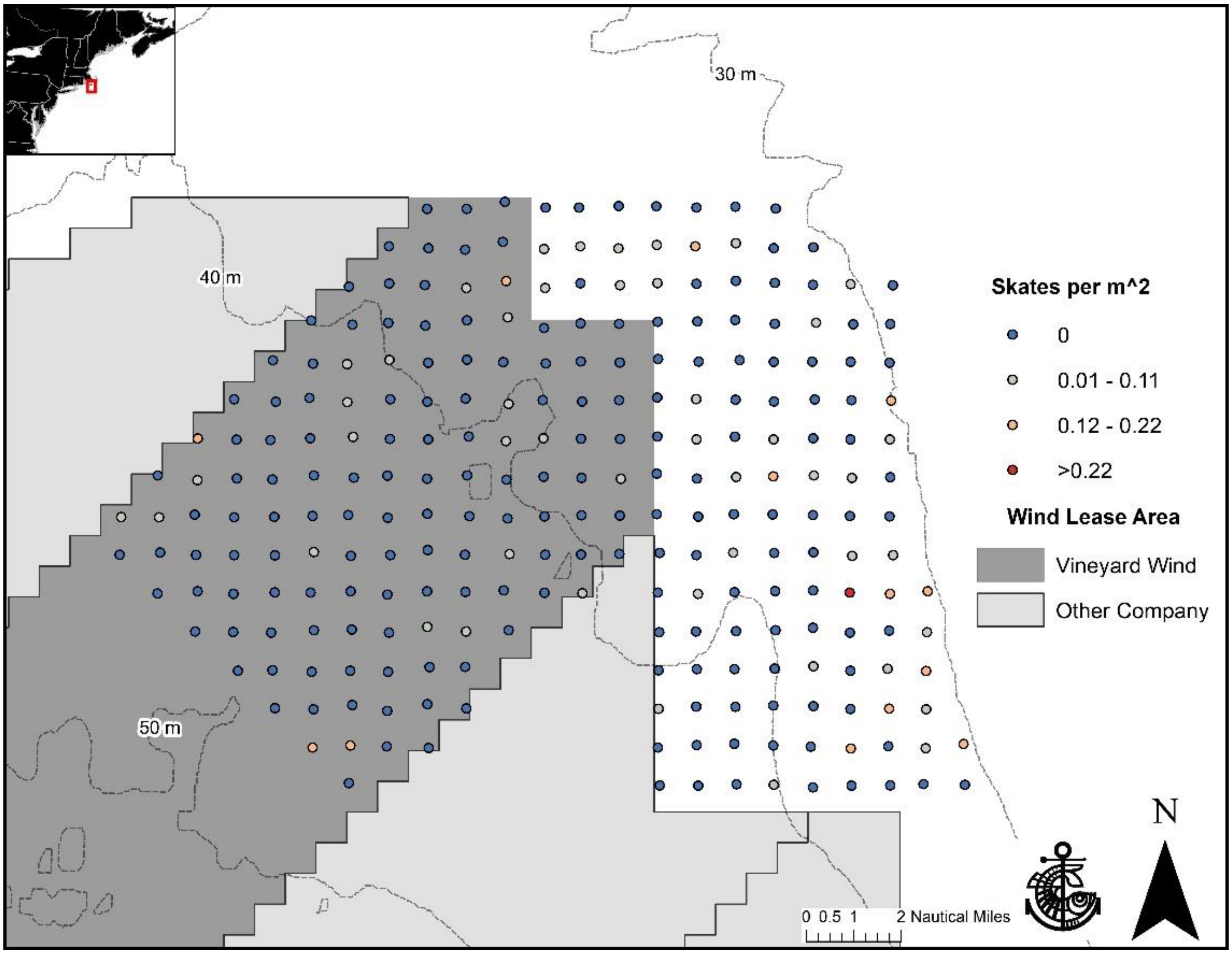

Figure 11. The distribution of skates in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July and October.

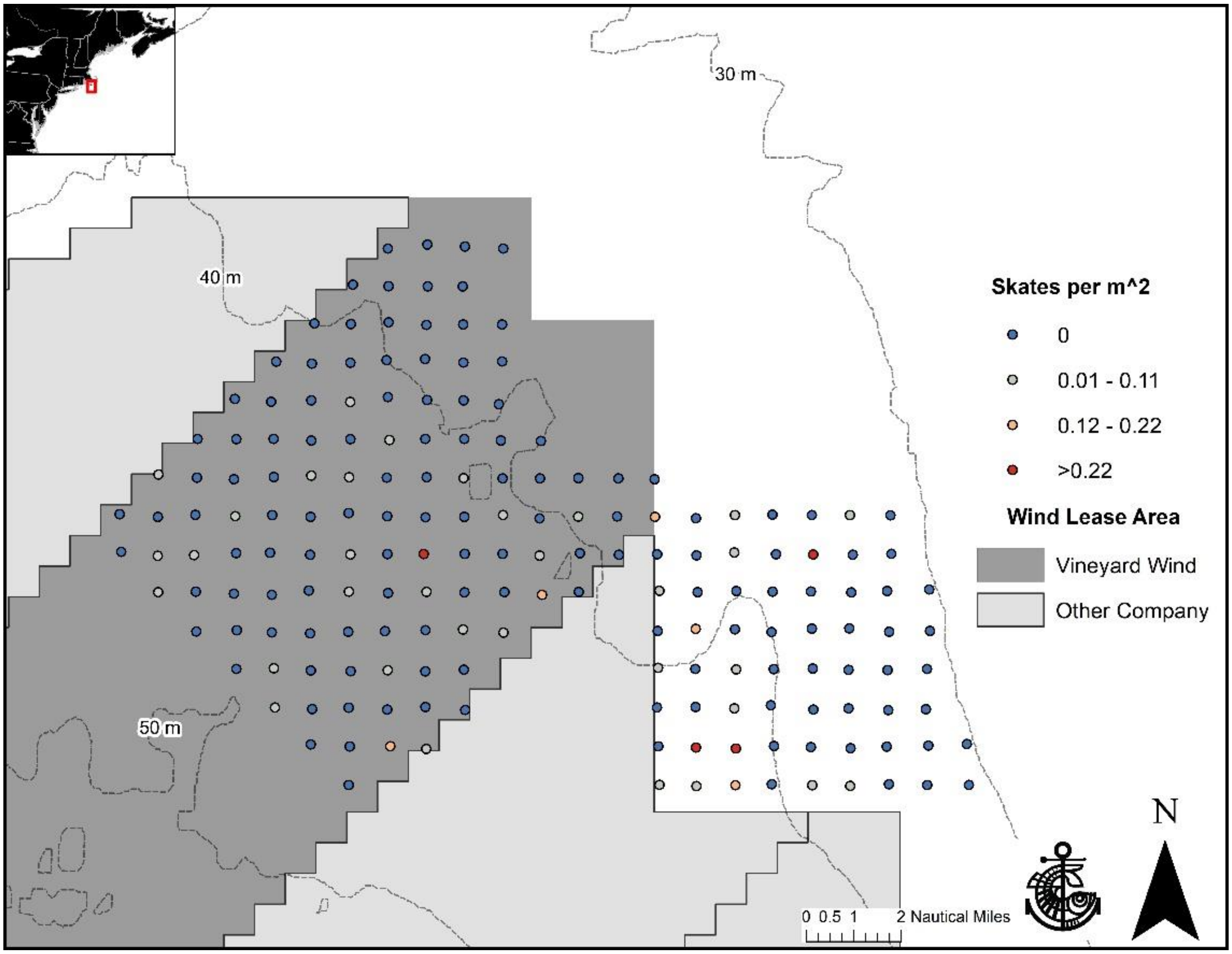

Figure 12. The distribution of skates in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July and October.

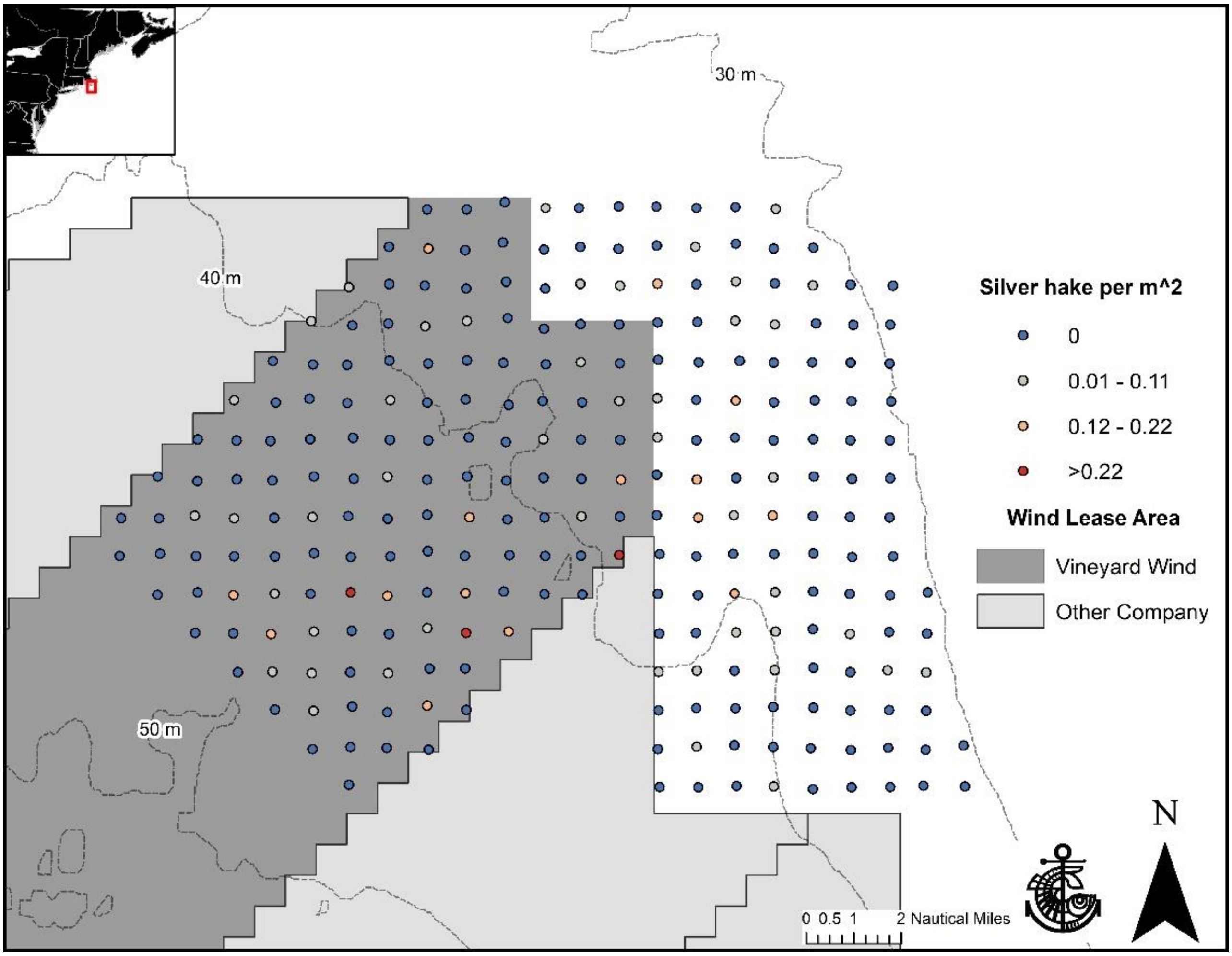

Figure 13. The distribution of silver hake in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July and October.

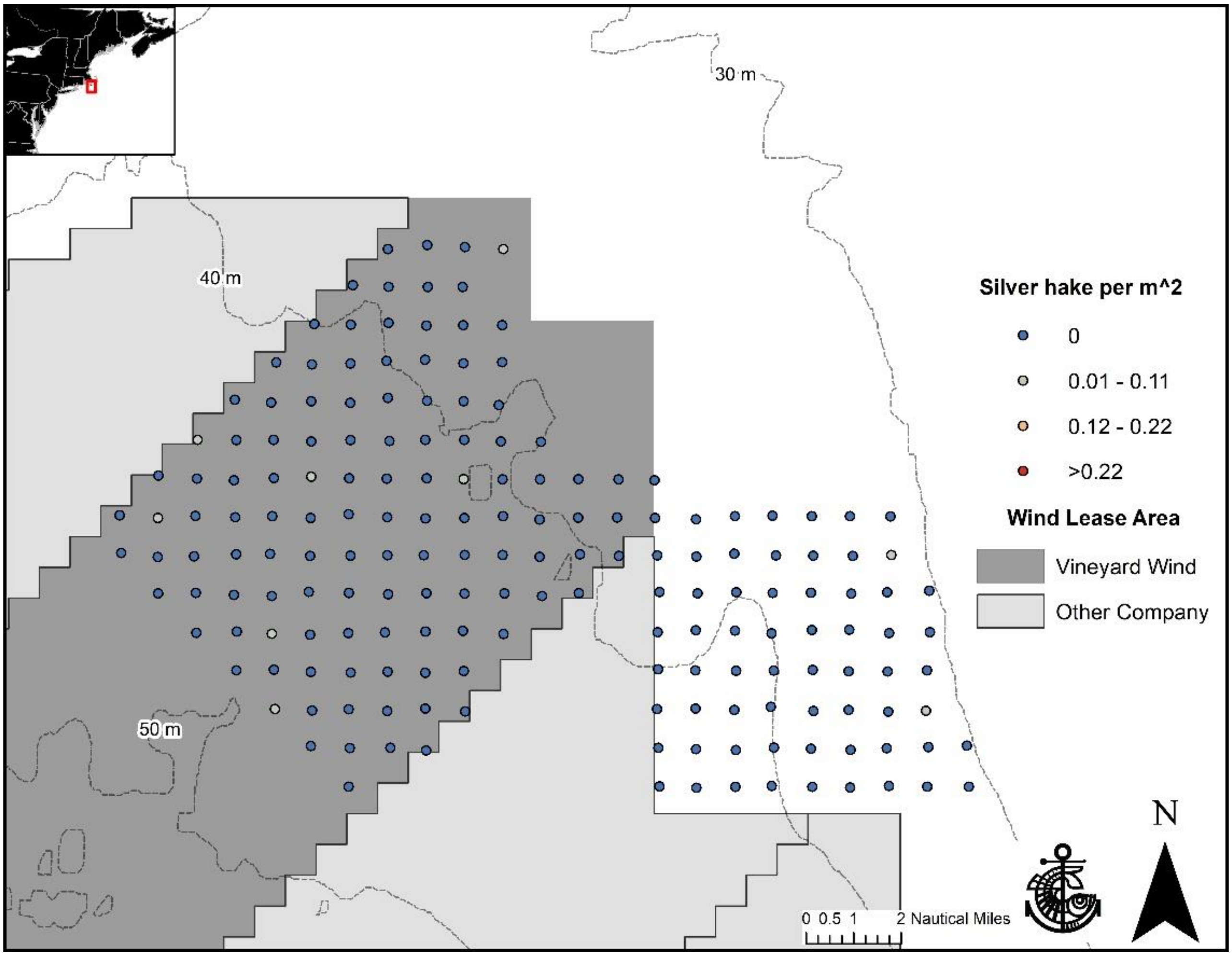

Figure 14. The distribution of silver hake in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July and October.

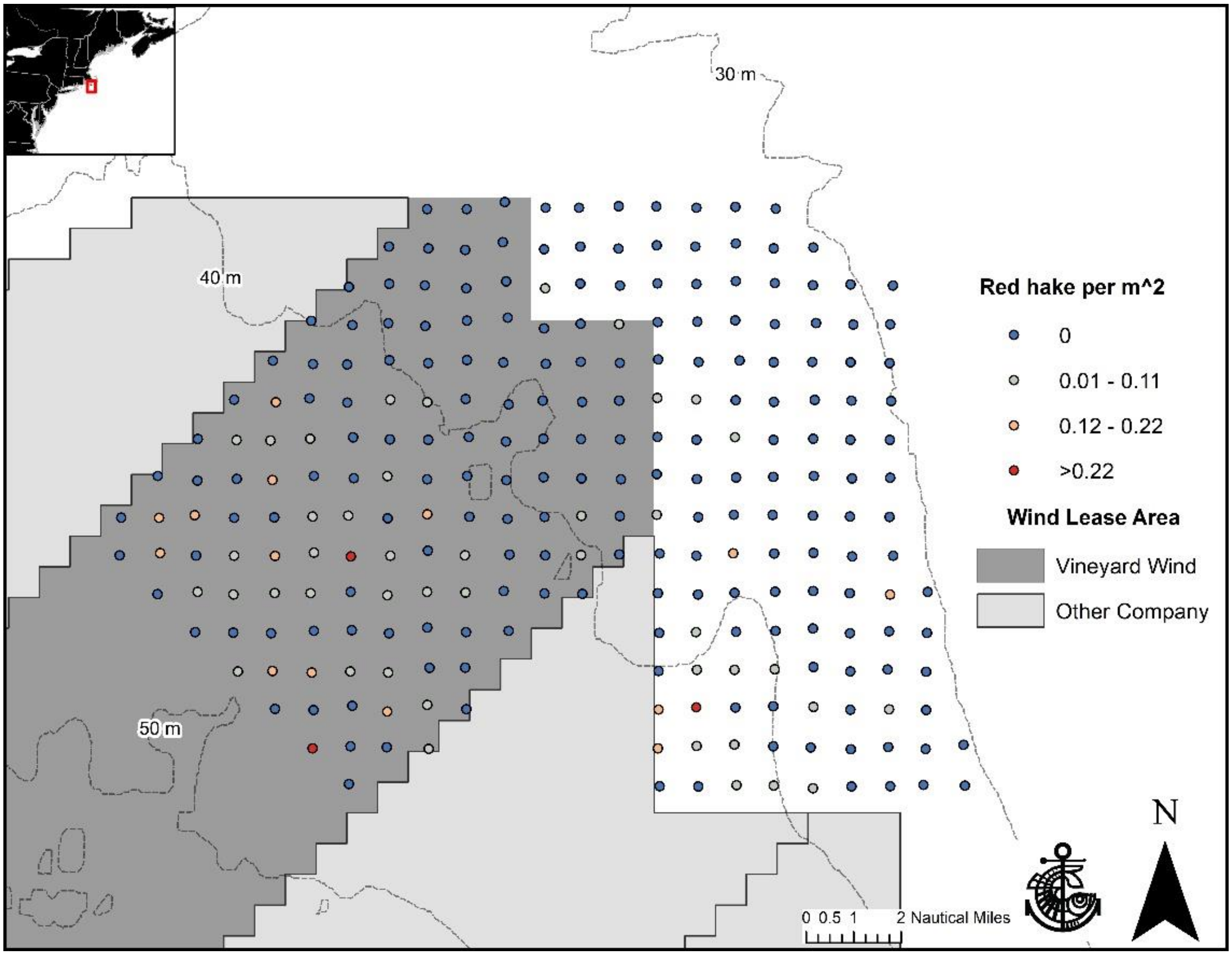

Figure 15. The distribution of red hake in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July and October.

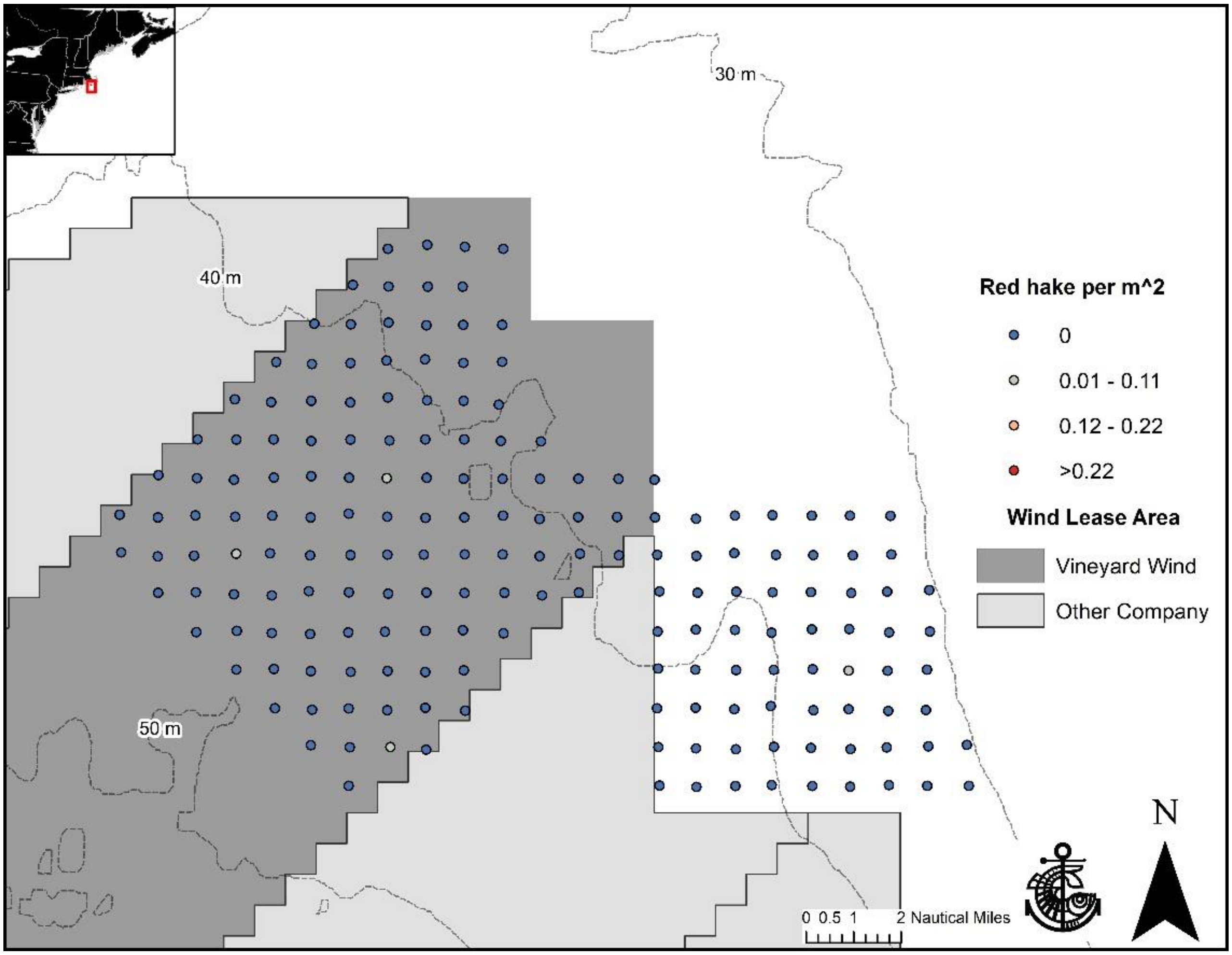

Figure 16. The distribution of red hake in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July and October.

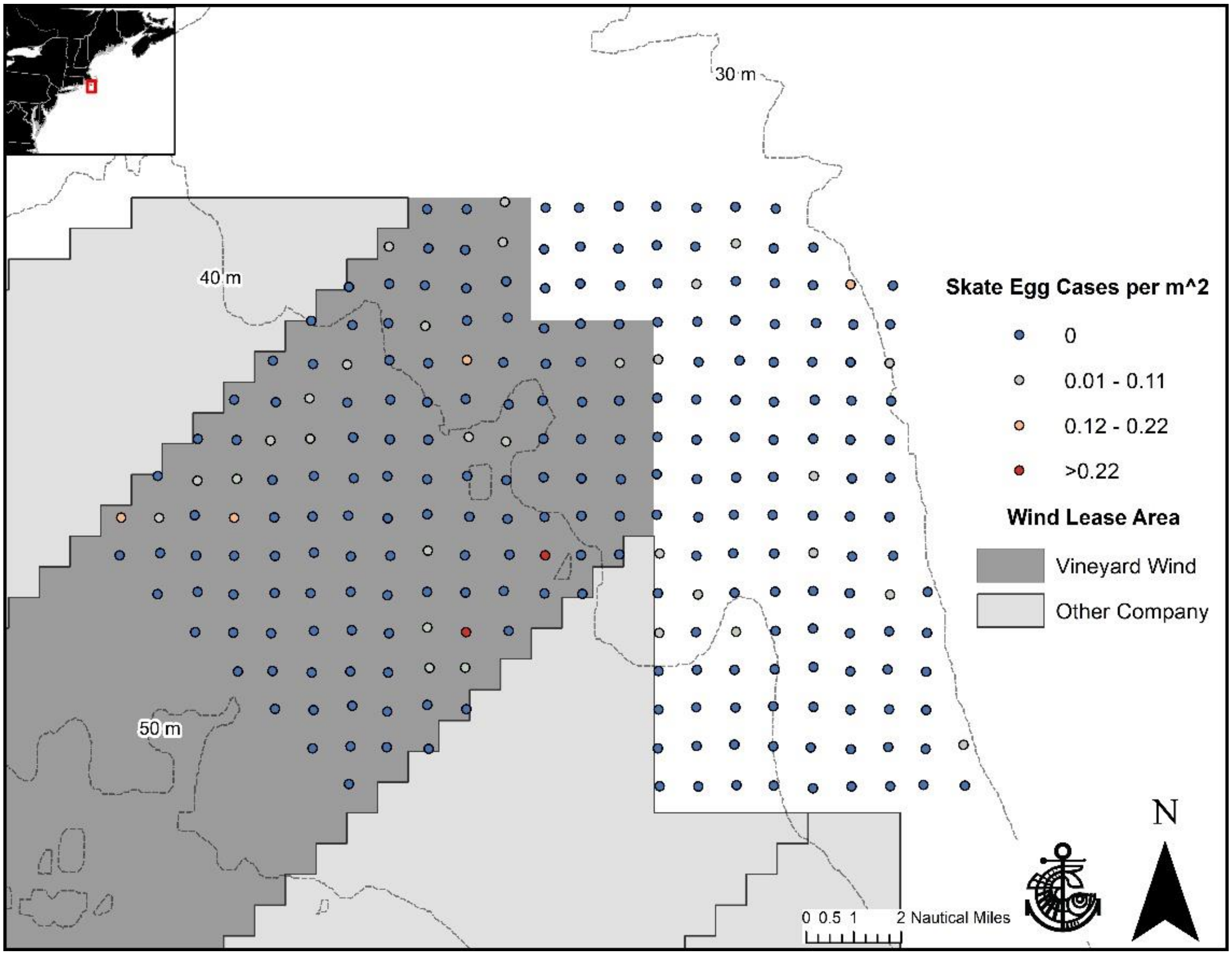

Figure 17. The distribution of skate eggs in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July and October.

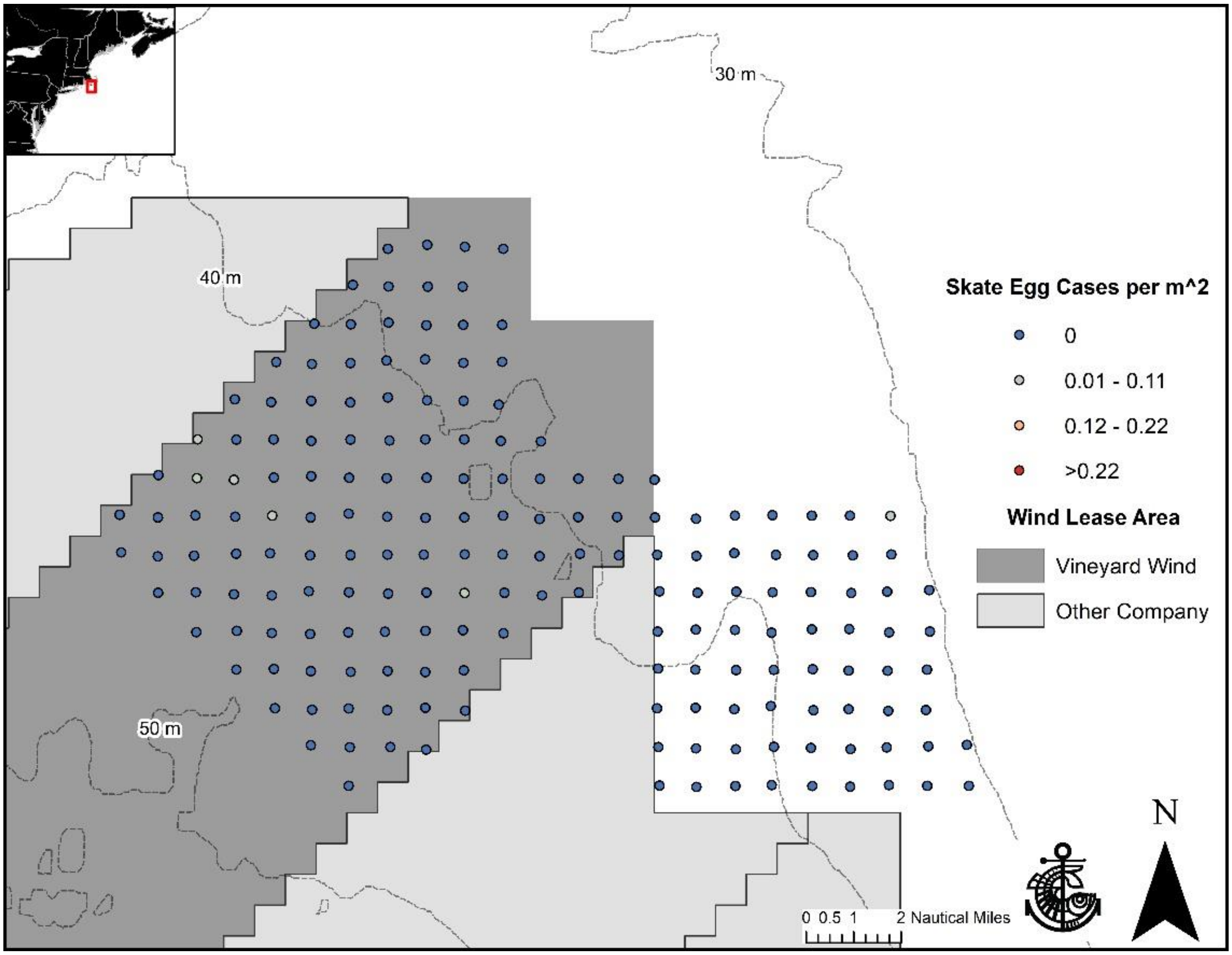

Figure 18. The distribution of skate eggs in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories equally divide the data above zero based on observations in July and October.

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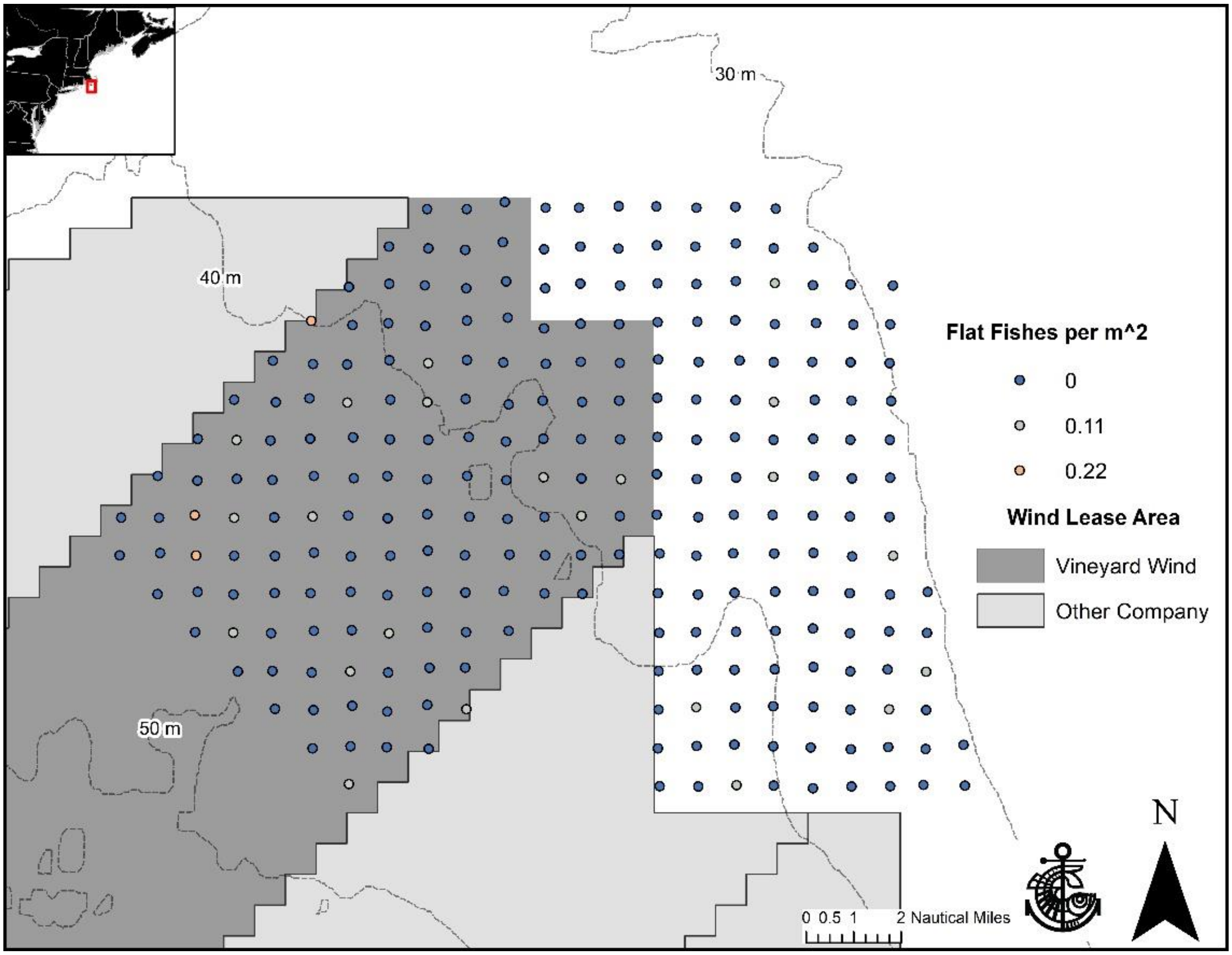

Figure 19. The distribution of flat fishes in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories represent zero, one, or two fishes observed at a station.

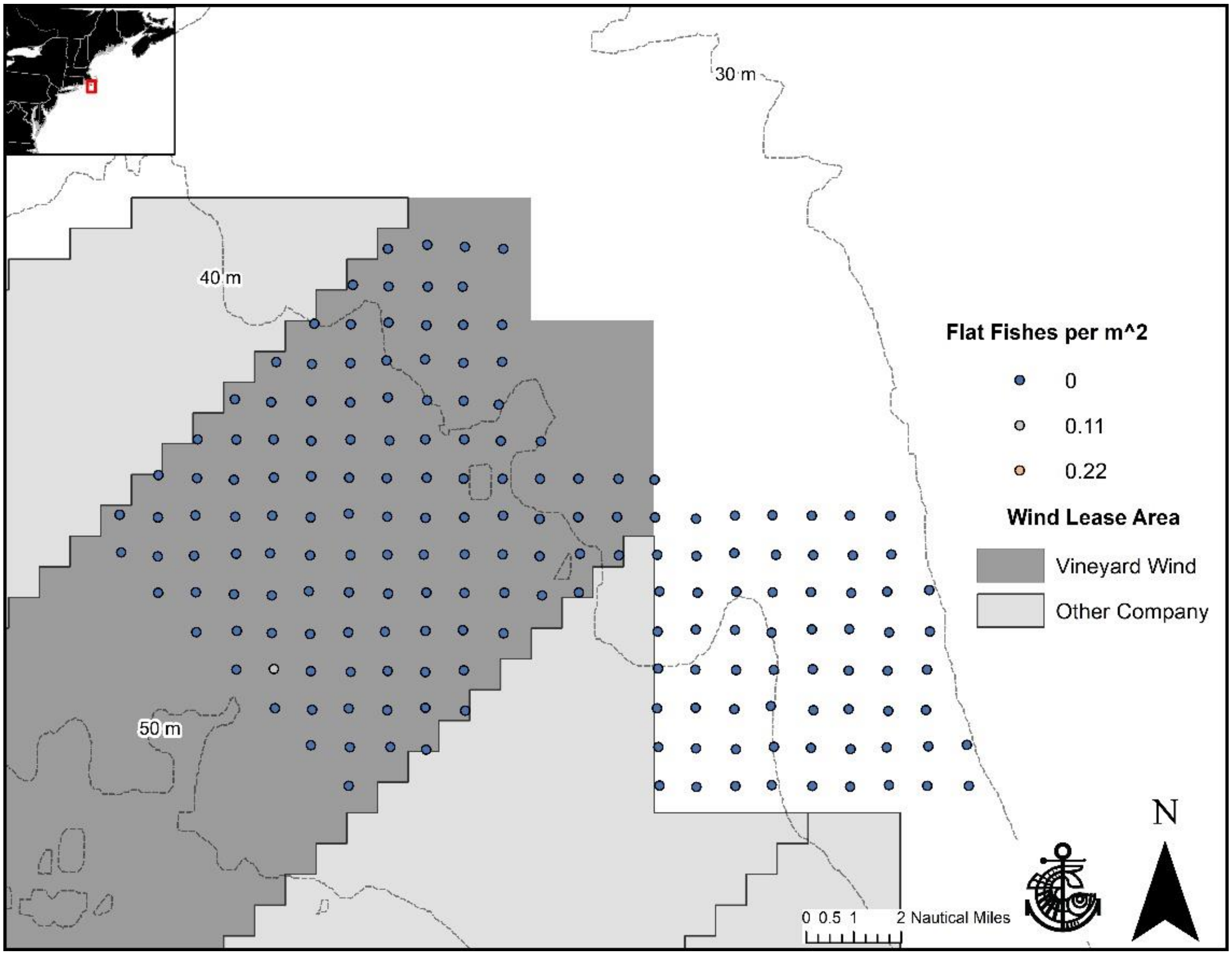

Figure 20. The distribution of flat fishes in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories represent zero, one, or two fishes observed at a station.

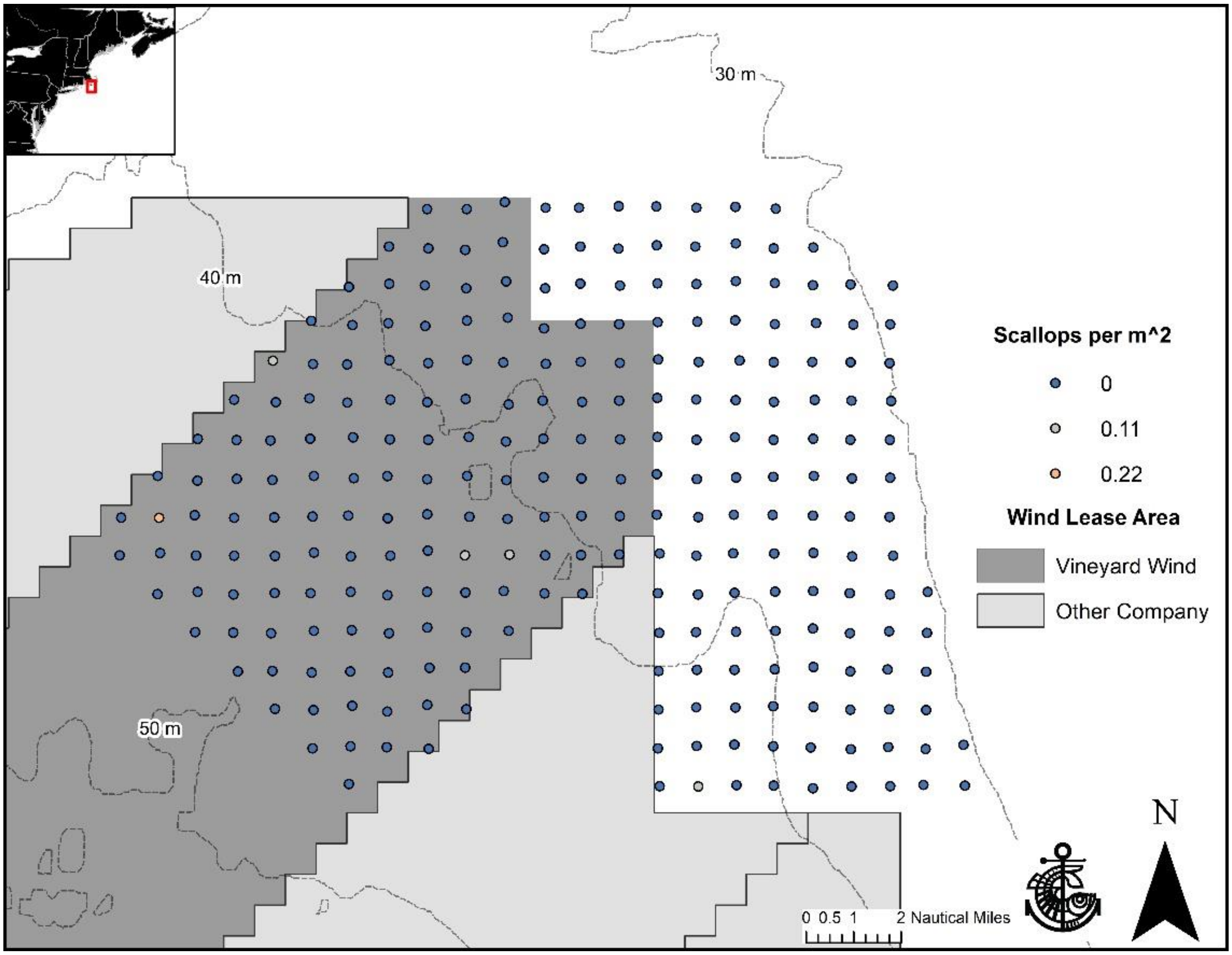

Figure 21. The distribution of scallops in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories represent zero, one, or two scallops observed at a station.

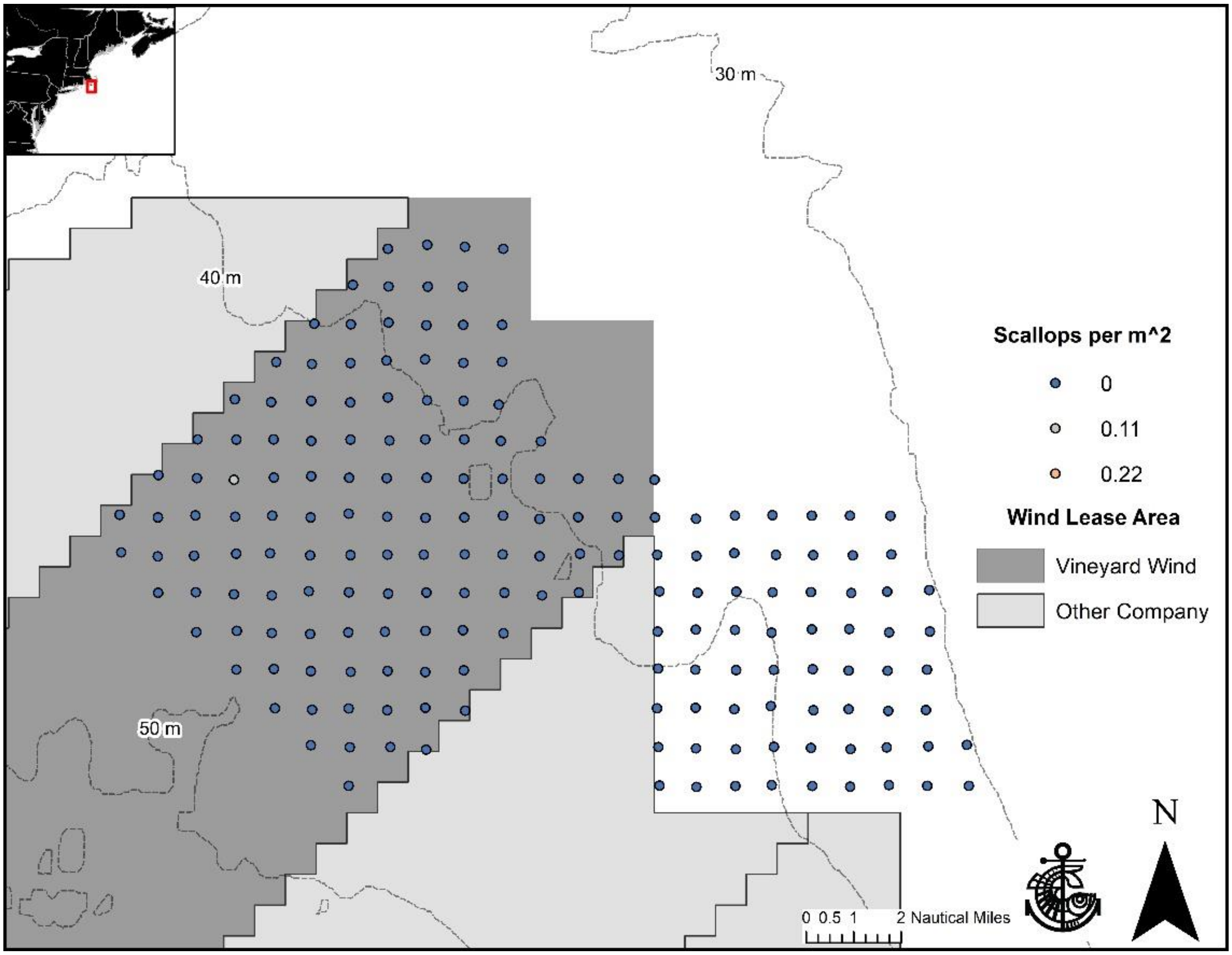

Figure 22. The distribution of scallops in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Density categories represent zero, one, or two scallops observed at a station.

The dominate benthic taxa noted as present or absent included holes (burrowing animals), sand dollars, anemones, bryozoans/hydrozoans, and sponges. All of these groups, except sponges, were observed in significantly more quadrats per station in the 501N Impact 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 a station more often at depths greater than 40 meters (Figures 23-29). The average depth of stations in the 501N Impact 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 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 Impact Area (Table 2). However, sand dollars occupied closer to 40% of the space within a quadrat when they were observed in the 501N Impact Area. The October survey results showed a significant decrease in all groups compared to the July survey, with only sand dollars and sponges observed (Figure 7).

Table 2. The average percent of a quadrat occupied by different animal groups were present. Holes represent burrowing animals, Bry./Hyd. indicates bryozoans and hydrozoans, and dashes indicate the group was not observed. The standard error is shown in parentheses.

Area	Holes		Sand Dollars		Anemone		Bry./Hyd.		Sponges	
	July	Oct.	July	Oct.	July	Oct.	July	Oct.	July	Oct.
Impact	27 (2)	--	39 (1)	16 (2)	13 (2)	--	5 (2)	--	6 (1)	7 (2)
Control	28 (1)	--	25 (2)	19 (4)	12 (1)	--	3 (1)	--	6 (1)	4 (N/A)

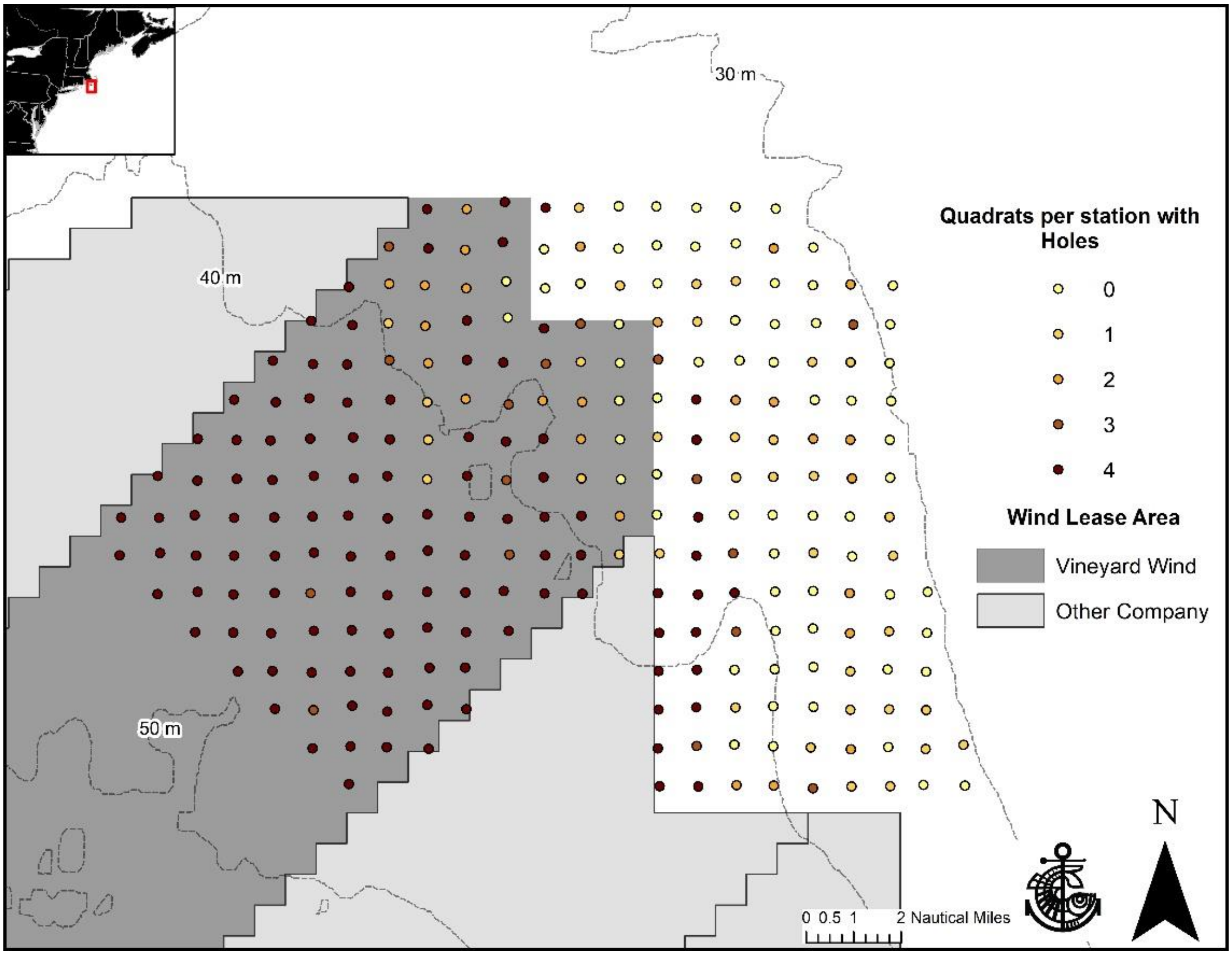

Figure 23. The distribution of holes (burrowing animals) in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Four quadrats (2.3m^2 images) were observed at each station. No holes were observed in an October survey of the same areas.

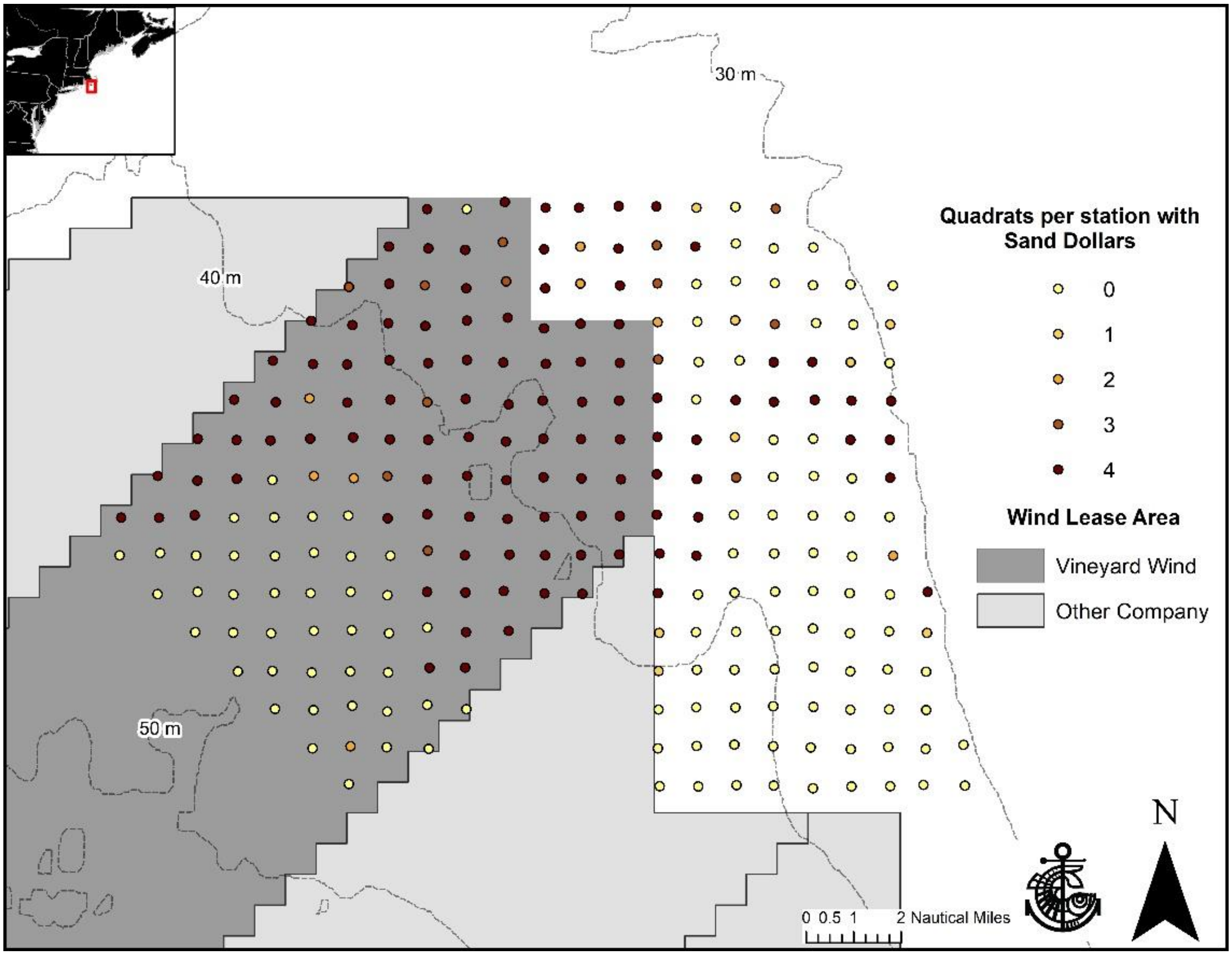

Figure 24. The distribution of sand dollars in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Four quadrats (2.3m^2 images) were observed at each station.

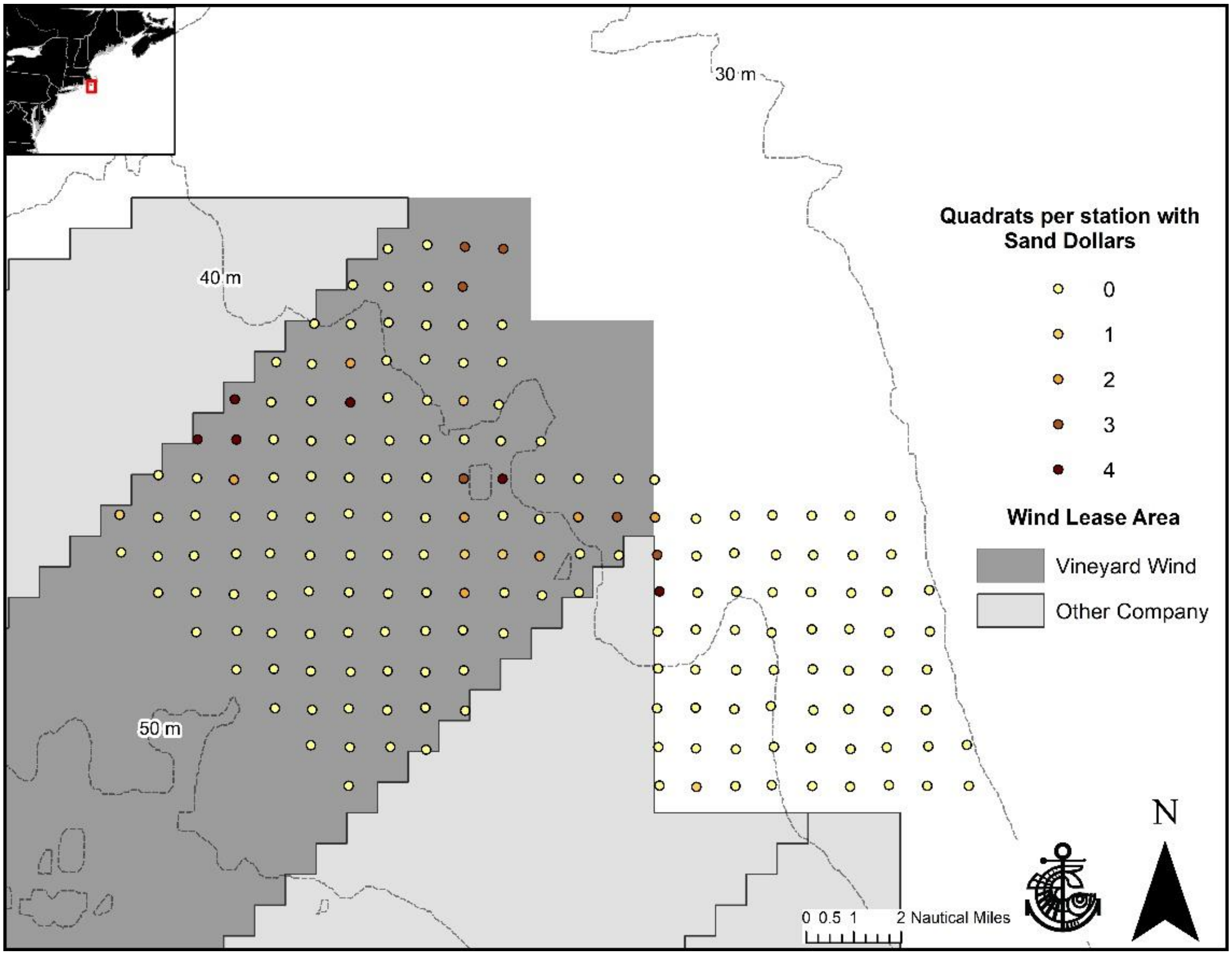

Figure 25. The distribution of sand dollars in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Four quadrats (2.3m^2 images) were observed at each station.

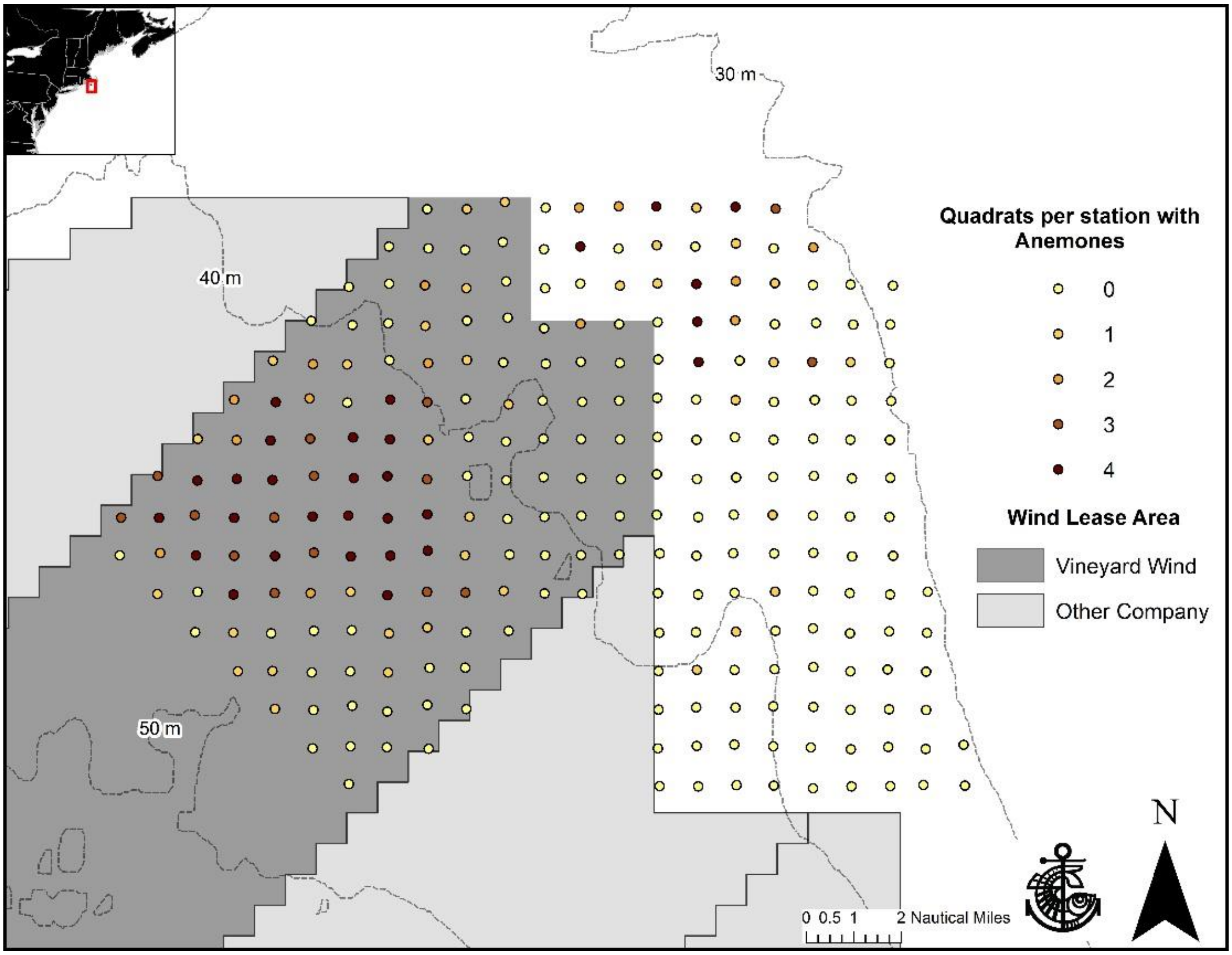

Figure 26. The distribution of anemones in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Four quadrats (2.3m^2 images) were observed at each station. No anemones were observed in an October survey of the same areas.

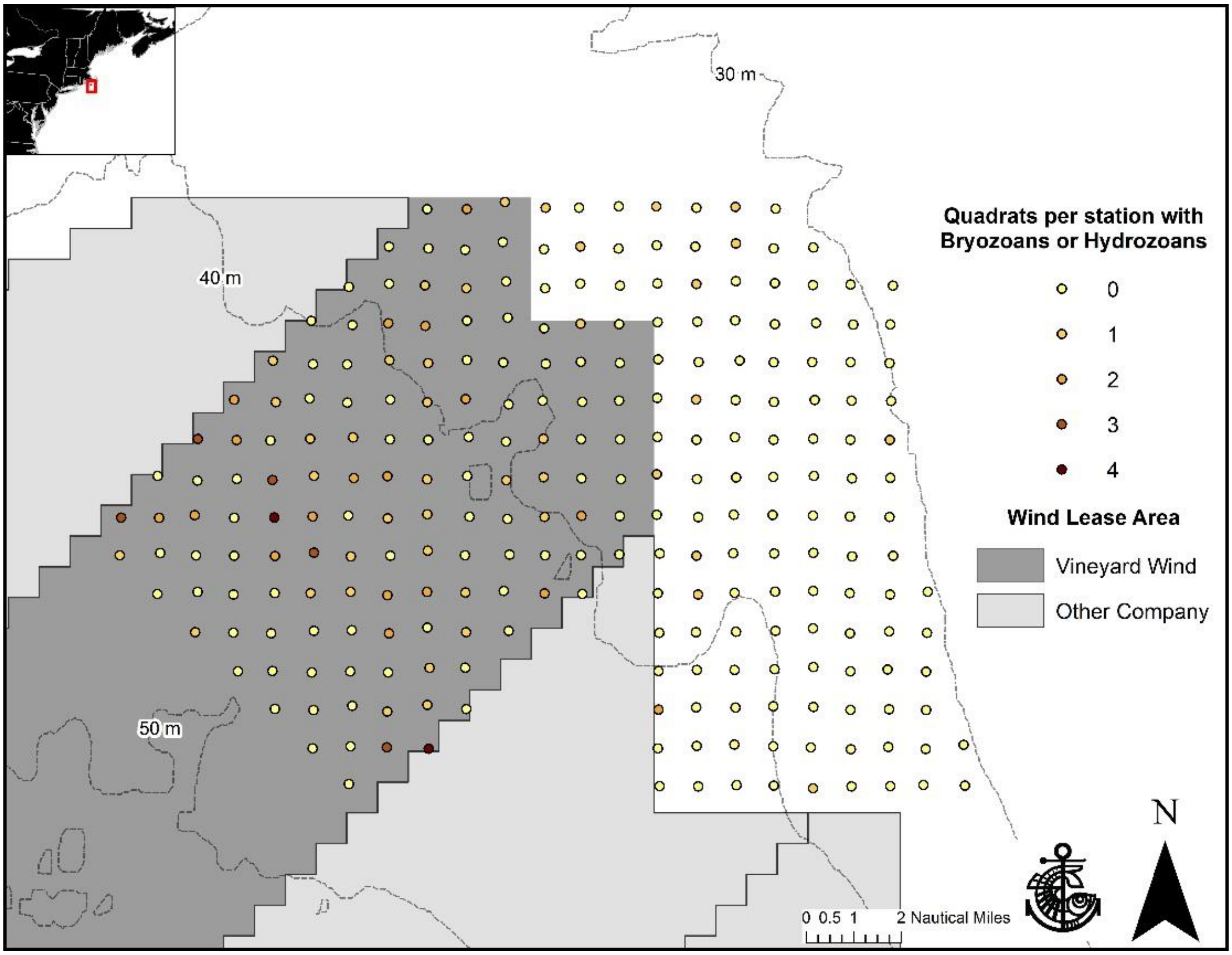

Figure 27. The distribution of bryozoans and hydrozoans in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Four quadrats (2.3m^2 images) were observed at each station. No bryozoans and hydrozoans were observed in an October survey of the same areas.

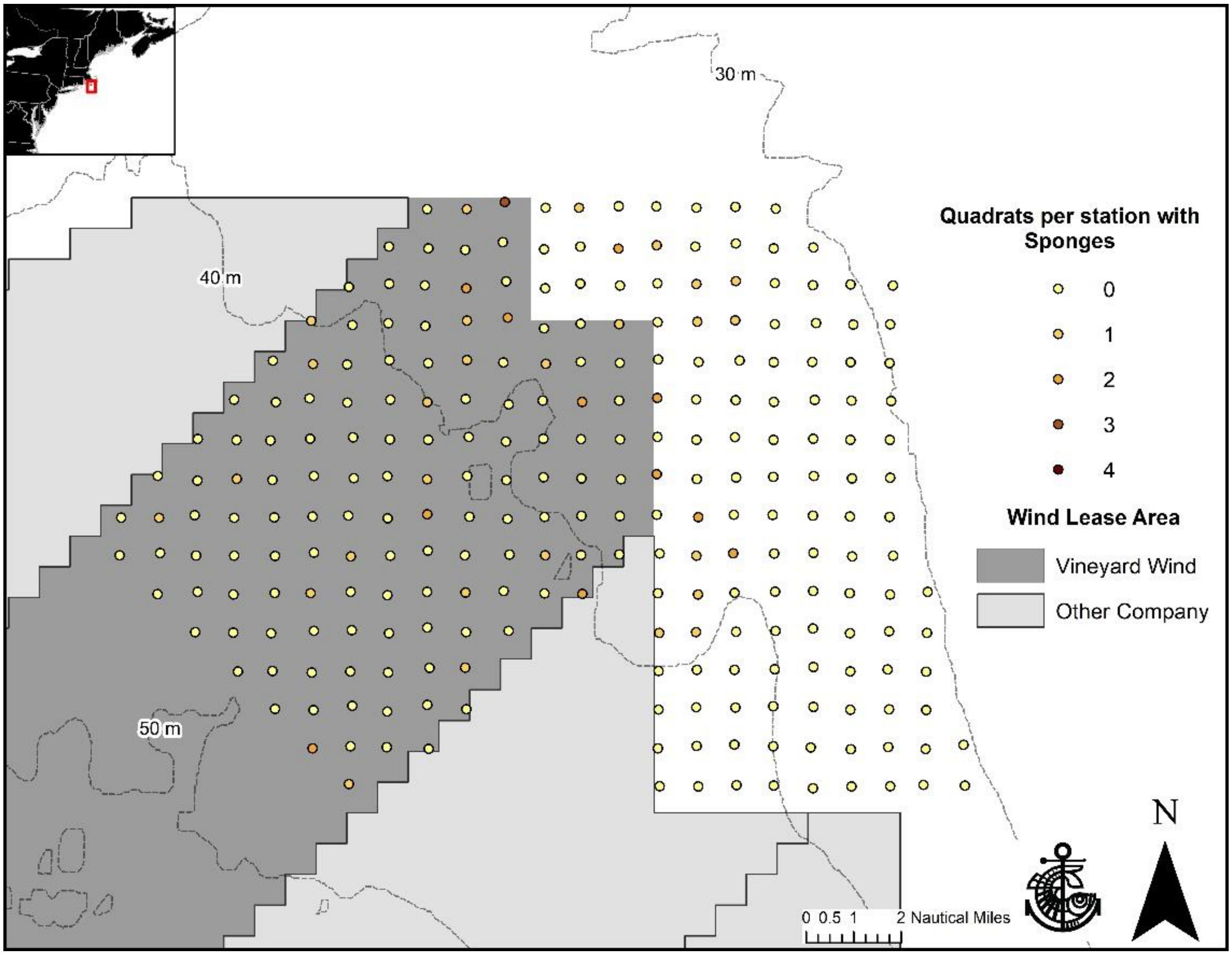

Figure 28. The distribution of sponges in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Four quadrats ($2.3m^2$ images) were observed at each station.

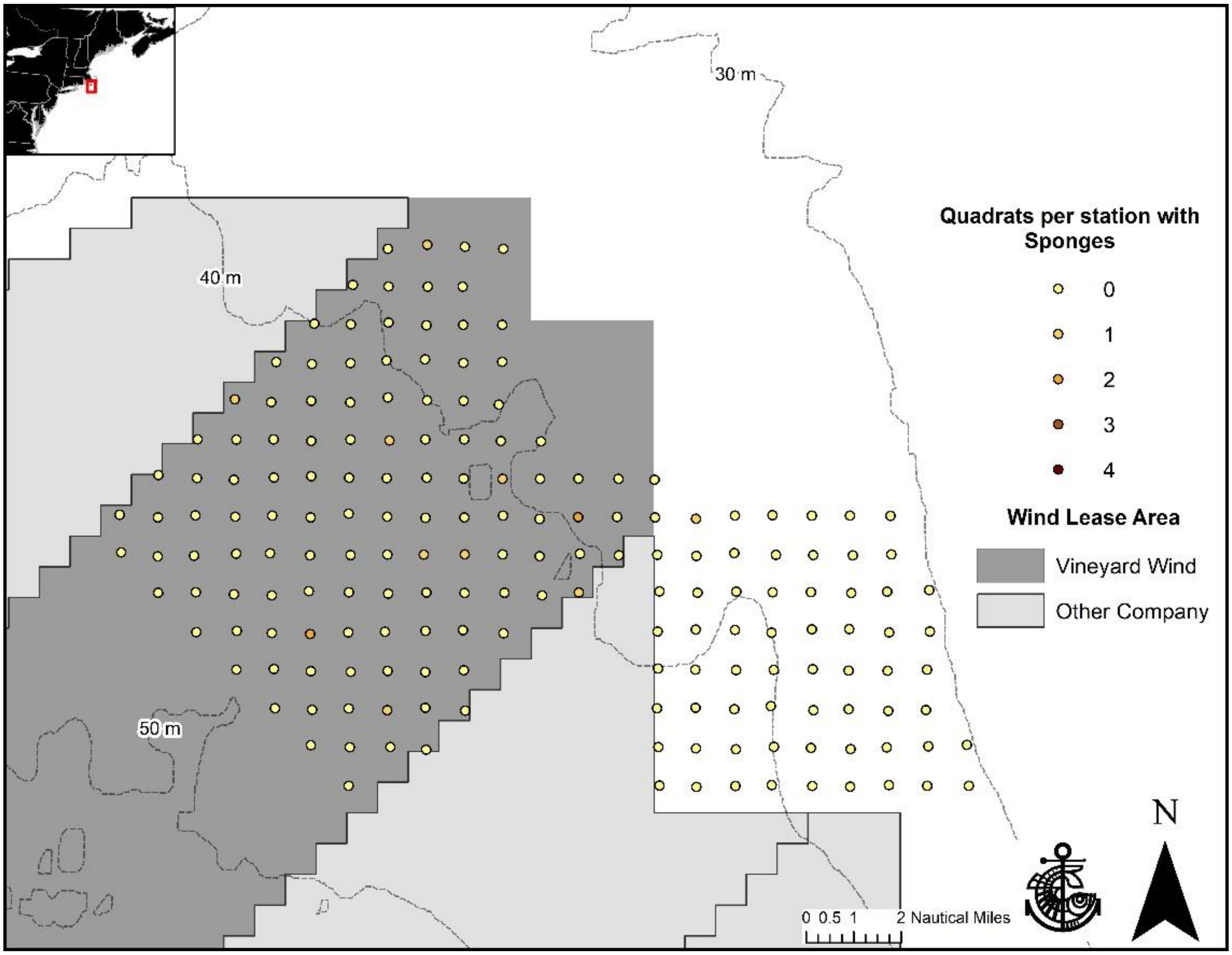

Figure 29. The distribution of sponges in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Four quadrats ($2.3m^2$ images) were observed at each station.

Sand comprised the majority of surficial substrate in the stations surveyed. Gravel or sand were the largest particle sizes present in the 501N Impact Area and Control Areas during the July and October surveys; no cobble or boulders were observed in either survey (Figures 30-32). Silt was present at every station except for two stations in the 501N Impact Area (<1% of all stations). A slight change in the distribution of gravel and sand appears to have occurred between seasons, where more sand was present in the October survey in both areas (Figure 30). 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 sand, but the aliquots in the northwest part of the lease area contain gravel (Figure 31).

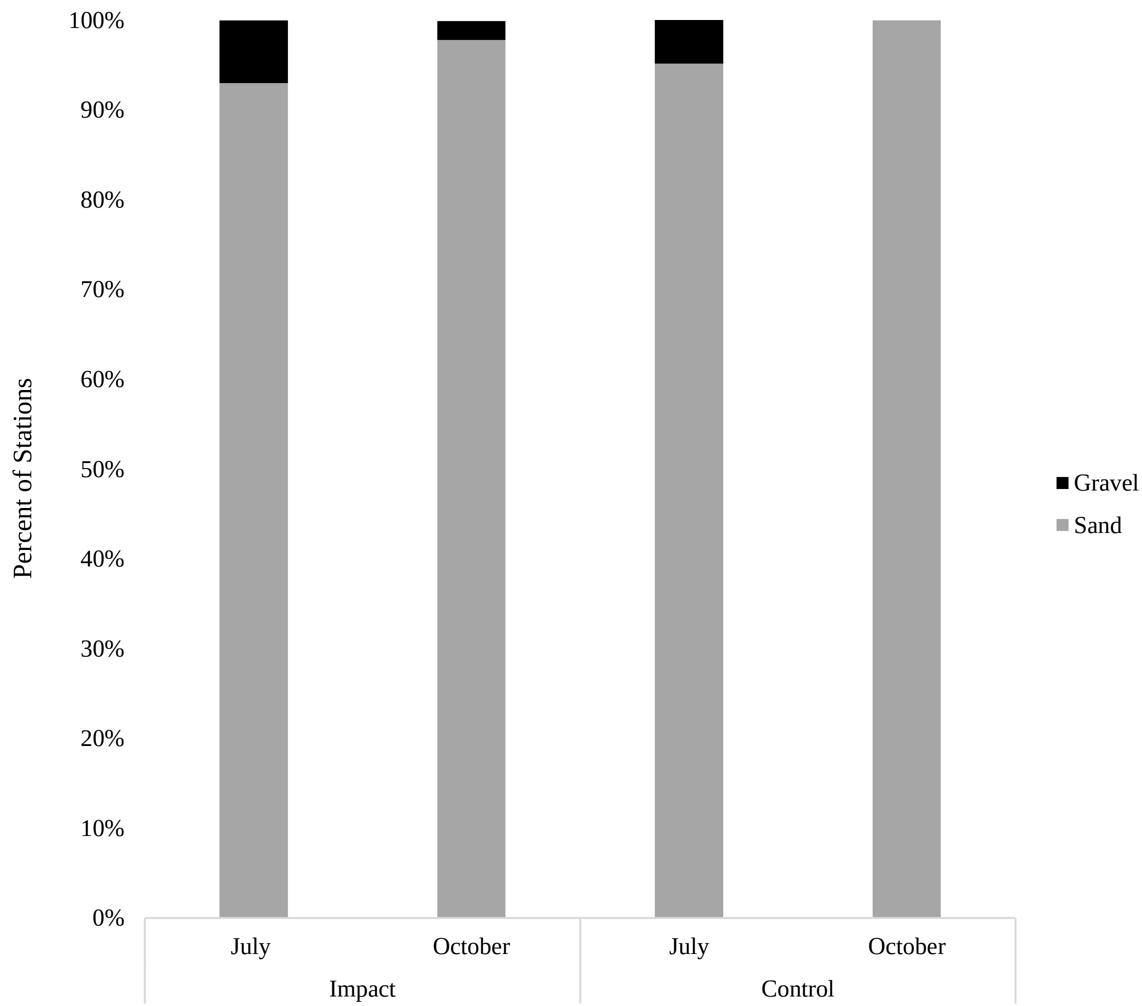

Figure 30. Substrate composition, defined by the largest substrate type observed at a station, during the 2019 July and October drop camera surveys of OCS 501N Impact Area and an adjacent Control Area. Four quadrats (2.3m^2 images) were observed at each station.

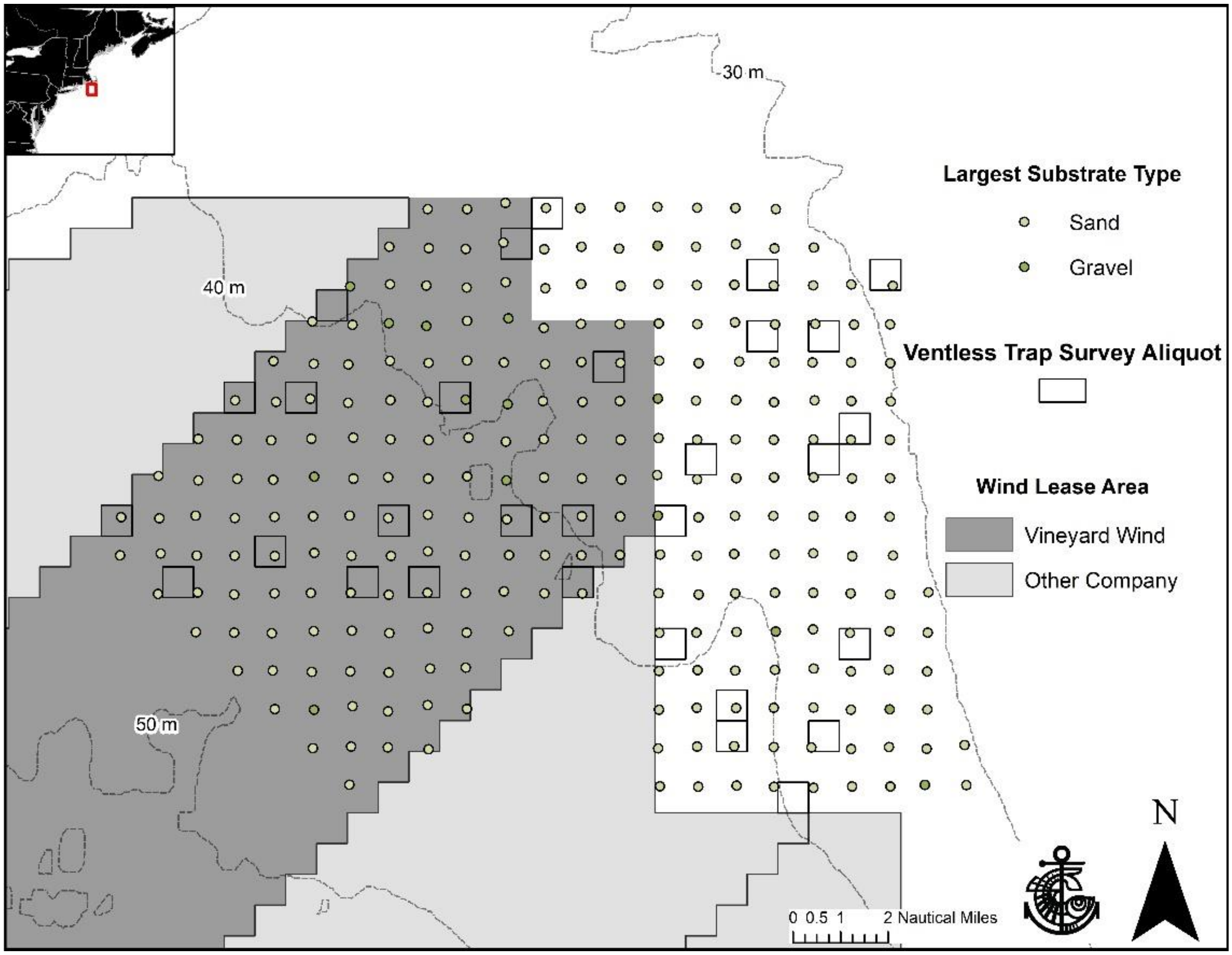

Figure 31. The distribution of substrate types in the July 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Four quadrats (2.3m^2 images) were observed at each station.

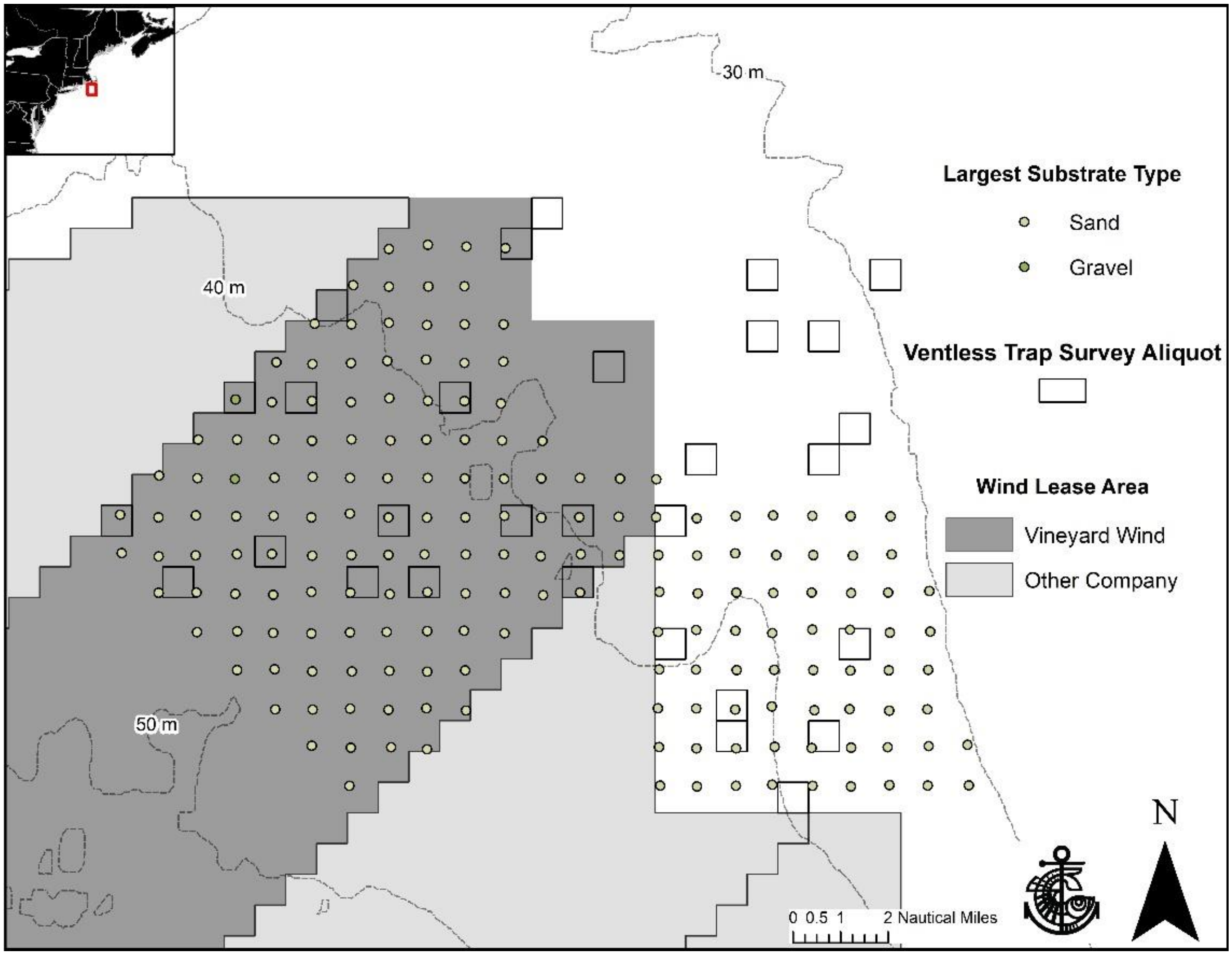

Figure 32. The distribution of substrate types in the October 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Four quadrats (2.3m^2 images) were observed at each station.

The composition of the benthic community in the 501N Impact Area and Control Area were most similar to each other when compared to broader regions of the U.S. continental shelf (Table 3). The two areas were 85% similar. When compared to broader regions of the U.S. continental shelf (see Figure 5), the 501N Impact Area was most similar to the Nantucket Lightship area with 78% similarity (Table 3). The Nantucket Lightship, Long Island, and Elephant Trunk areas are approximately 90 km, 170 km, and 360 km from the 501N Impact Area, respectively. As the areas increased in distance from the 501N Impact Area, the similarity decreased with Long Island having 71% similarity and Elephant Trunk having 64% similarity index scores. The 501N Impact Area is least similar to the Northern Edge, with only 53% similarity. The dominant animals in the Northern Edge benthic community were hermit crabs, bryozoan/hydrozoan, sea stars and scallops. In contrast, the other areas were less diverse with hermit crabs and sand dollars dominating community composition (Table 3). When applied to substrate types, the same similarity patterns were observed with higher percent similarity between all areas (Table 4). This higher similarity can be expected when comparing fewer categories. The differences in habitat between the Northern Edge and the other areas is likely linked to the differences in animals observed; the Northern Edge contains mostly gravel and cobble supporting species that prefer a more complex habitat (Tables 3 & 4).

Table 3. The percent similarity index between benthic communities in the OCS 501N Impact Area, an adjacent Control Area, the Northern Edge (NE), the Nantucket Lightship (NL), Long Island (LI), and Elephant Trunk (ET) areas surveyed in July 2019.

Animal Group	Impact	Control	NE	NL	LI	ET
Bryozoans/Hydrozoans	10.63	3.95	24.68	8.77	8.00	5.06
Waved Whelk	10.43	14.29	0.65	8.77	16.00	6.18
Crabs (cancer spp.)	5.71	6.69	4.55	1.75	0.00	11.24
Flat Fishes	3.35	2.43	2.60	1.75	0.00	2.81
Red Hake	7.68	6.38	0.00	0.00	0.00	7.87
Hermit Crabs	23.43	22.80	20.78	25.44	20.00	18.54
Moon snails	3.54	3.34	7.14	7.02	12.00	4.49
Sand Dollars	17.91	14.59	0.65	25.44	28.00	7.30
Scallops	0.79	0.00	11.04	7.02	4.00	15.17
Sea Stars	1.18	0.91	18.18	0.00	0.00	13.48
Silver Hake	6.50	9.12	0.65	7.02	8.00	1.12
Skates	4.33	11.55	2.60	6.14	0.00	0.00
Sponges	4.53	3.95	6.49	0.88	4.00	6.74
Percent Similarity Index						
	85.33					
	53.14					
	78.43					
	71.17					
	64.44					

Table 4. The percent similarity index between substrates in the OCS 501N Impact Area, an adjacent Control Area, the Northern Edge (NE), the Nantucket Lightship (NL), Long Island (LI), and Elephant Trunk (ET) areas surveyed in July 2019.

Substrate	Impact	Control	NE	NL	LI	ET
Sand	100.0	100.0	98.7	97.5	100.0	100.0
Shell debris	92.5	97.2	100.0	98.8	100.0	99.4
Silt	99.5	100.0	36.5	56.9	83.3	61.5
Gravel	2.1	1.2	96.8	56.9	27.1	21.8
Cobble	0.0	0.0	16.7	0.0	0.0	0.0
Boulder	0.0	0.0	0.0	0.0	0.0	0.0
Percent Similarity Index						
	98.89					
	68.18					
	91.23					
	91.23					
	87.93					

The results of this survey provide baseline information on the benthic community and substrate of the OCS 501N Impact 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 an asymmetrical analysis of variance to evaluate impacts (Underwood 1993). With this analytical approach, 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 area. This could also be key to conducting a cumulative analysis of wind energy impacts along the U.S. coast.

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<u>Appendix I:</u> Information on all categories tracked by the 2019 Drop Camera Survey of Benthic Communities and Substrate in Vineyard Wind Lease Area OCS-A 0501 North and a 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 Impact 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 1), the density of all animals counted (Figure 1), and the average number of quadrats for all categories tracked as present or absent (Figure 2).

Table 1. All animal groups, in order of most to least quadrats present, observed during the 2019 drop camera survey of OCS 501N Impact Area and an adjacent Control Area. Groups left blank in the "Counts" column are tracked as present or absent.

	July				October			
	Control		Impact		Control		Impact	
Animal Group	Quadrats Present	Counts	Quadrats Present	Counts	Quadrats Present	Counts	Quadrats Present	Counts
Euphausids	256		369		256		238	
Hermit Crab	177	323	250	405	0	0	2	4
Sanddollar	154		349		10		51	
Holes (Burrowing Animals)	145		454		0		0	
Whelk	91	226	90	165	0	0	0	0
Detritus	208		45		3		16	
Anenome	53		171		0		0	
Ctenophore	1		49		47		47	
Skate	46	49	25	26	23	27	29	29
Bryozoans/Hydrozoans	14		87		0		0	
Silver hake	35	36	42	50	2	2	7	7
Other crustaceans	16	16	66	66	0	0	0	0
Red hake	27	27	51	53	1	1	3	3
Sponge	20		32		1		12	
Crab	23	27	35	42	0	0	0	0
Other molluscs	8	8	60	60	0	0	0	0
Skate eggcase	14	14	29	31	1	1	5	5
Moonsnail	11	11	20	22	0	0	0	0
Flounder	8	8	18	20	0	0	1	1
Moonsnail eggcase	10	10	11	11	0	0	0	0
Jellyfish	0		0		10		16	
Squid	4		1		0		11	
Sea robin	0	0	0	0	1	1	10	10
Sea star	3	3	6	6	0	0	1	1
Other fish	1	4	2	2	1	1	2	2
Dogfish	0	0	0	0	0	0	8	8
Scallop	1	1	5	5	0	0	1	1
Haddock	2	3	3	3	0	0	0	0
Eel	0	0	1	1	0	0	1	1
Clams	0		1		0		0	
Cod	0	0	1	1	0	0	0	0
Clapper	1	1	0	0	0	0	0	0
Monkfish	0	0	1	1	0	0	0	0
Other echinoderm	0		1		0		0	
Sea mouse	0		0		0		1	
Tunicate	0		0		0		1	
Filograna	0		0		0		0	
Hagfish	0	0	0	0	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
Mussels	0		0		0		0	
Oceanpout	0	0	0	0	0	0	0	0
Sandlance	0		0		0		0	
Sculpin	0	0	0	0	0	0	0	0
Sea raven	0	0	0	0	0	0	0	0
Seaweed	0		0		0		0	
Seed	0		0		0		0	
Squid eggcase	0	0	0	0	0	0	0	0
Urchin	0		0		0		0	
Number of Quadrats Sampled	496		536		260		476	

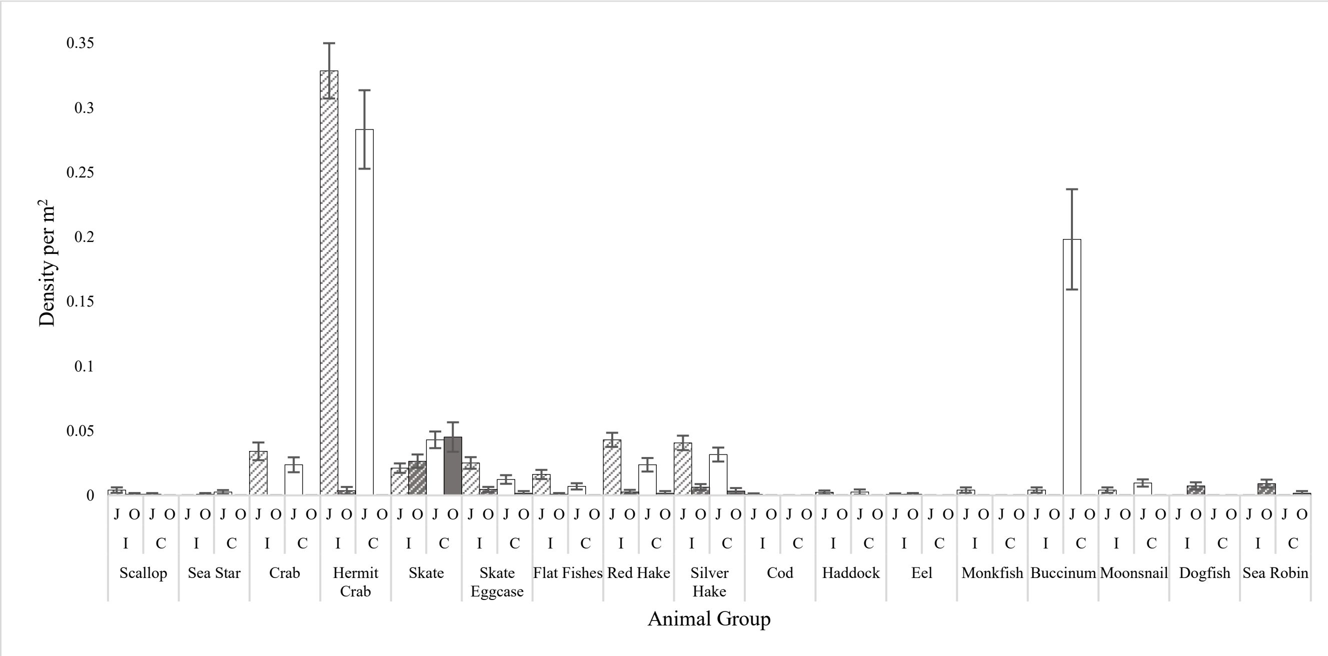

Figure 1. Density of animals in the 2019 July (J) and October (O) drop camera surveys of OCS 501N Impact Area (I) and an adjacent Control Area (C).

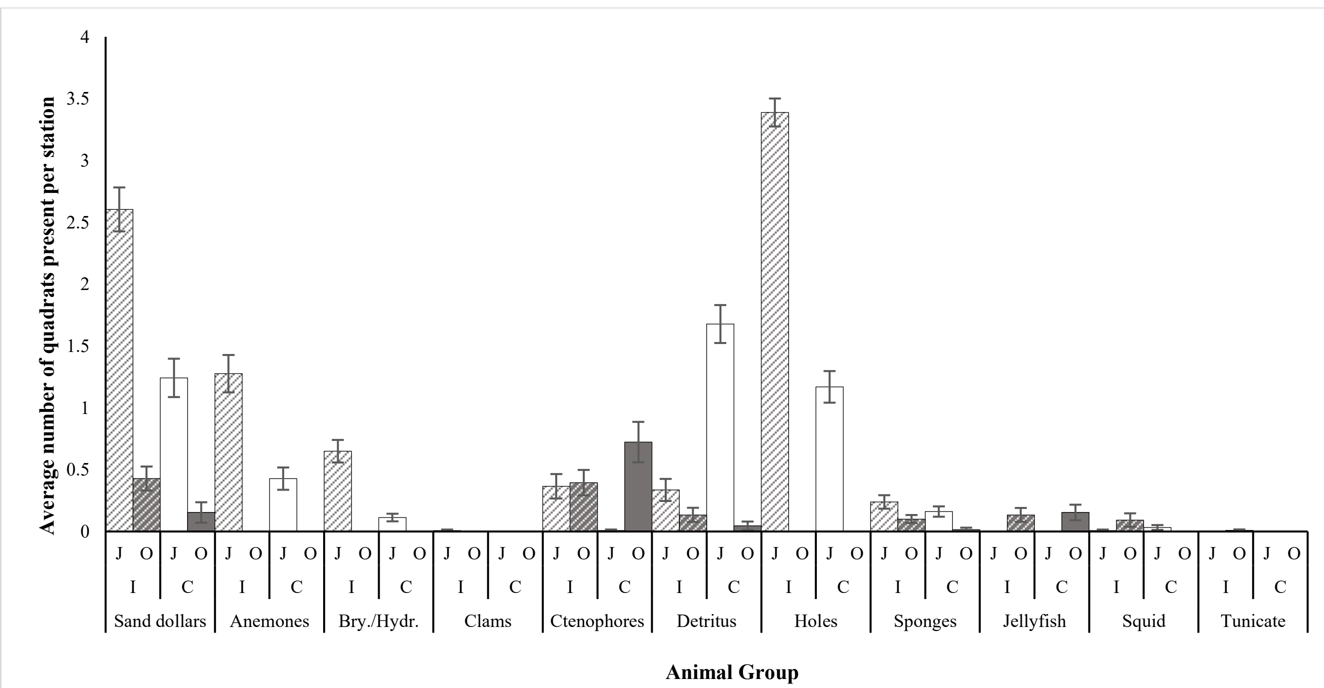

Figure 2. Average number of quadrats animals were present in at each station in the 2019 July (J) and October (O) drop camera surveys of OCS 501N Impact Area (I) and an adjacent Control Area (C). Four quadrats (2.3m^2 images) were observed at each station.