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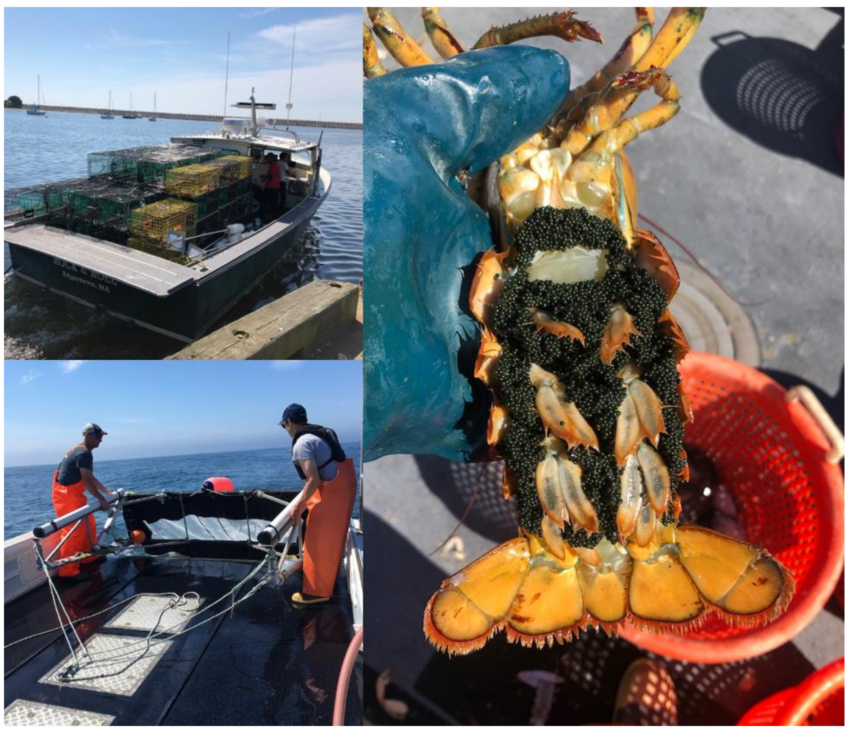
2020 Survey Season Annual Report
June Through October 2020

American Lobster, Black Sea Bass, Larval Lobster Abundance Survey, And Lobster Tagging Study of the 501N Study Area



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

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Project Title:	American Lobster, Black Sea Bass, Larval Lobster Abundance Survey, And Lobster Tagging Study of the 501N Study Area
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PROJECT SUMMARY

The University of Massachusetts Dartmouth School for Marine Science and Technology (SMAST) and Massachusetts Lobstermen's Association conducted a standardized ventless lobster trap survey and tagging study in Vineyard Wind's Lease Area OCS-A 0501 (Lease Area), on the Outer Continental Shelf (OCS). In the northern portion of the Lease Area, termed the 501N Study Area, populations of adult American lobster (*Homarus americanus*), larval lobster, and black sea bass (*Centropritis* striata) were sampled and compared to those in the easterly adjacent Control Area (Figure 1).[1]

The primary goal of this project was to identify baseline conditions in the 501N Study Area and adjacent Control Area, to then compare potential impacts on several marine species of proposed wind development activities in the 501N Study Area and the Control Area between years. To establish a baseline, a Before-After-Control-Impact (BACI) design was employed to detect eventual patterns of sustained difference. Our primary objectives for this project were to:

1) estimate the size and distribution of lobster and black sea bass populations in the 501N Study Area and adjacent Control Area;
2) classify population dynamics of these two species such as length, sex, reproductivity success, age, diet, and disease;
3) estimate the relative abundance and distribution of planktonic species such as larval lobster in the neustonic layer of each area, using a towed ichthyoplankton net at each survey location; and
4) obtain movement patterns of adult lobsters through a tagging study.

For the lobster, black sea bass, and planktonic sampling locations, we employed a random sampling design by stratifying the area of interest using existing lease blocks. Lease blocks within the two study areas (the 501N Study Area and adjacent Control Area) were identified and divided into smaller sub-areas called aliquots. An aliquot (within each lease block) was randomly selected and served as a sampling location that held constant throughout the survey season. There were 15 sampling sites selected in the 501N Study Area and 15 in the Control Area, for a total of 30 stations. Each location was sampled two times per month from June to October 2020 using a string of 7 traps. Ventless traps (3) were alternated with standard vented traps (3) to compare differences in catch rates and size selectivity of both trap types. A single, unbaited sea bass pot was also attached to one end of a string. Surface plankton tows were conducted twice per month from June to October.

A total of 921 lobsters were sampled between both study areas and trap types: 662 in the 501N Study Area, with an average size of 87.24±0.73 millimeter (mm), and 259 in the Control Area, with an average size of 93.65±1.19 mm. The 501N Study Area yielded an overall male: female ratio of 2.4:1, and the Control Area ratio was 4.2:1. A total of 456 black sea bass were sampled from commercial-sized sea bass pots at each location; 149 in the 501N Study Area and 307 in the Control Area. Larval lobster samples were collected at each location with a neuston net; for the season we collected 91 total lobster larvae ranging from stages one to four. The average larval lobster density was 0.29 larvae per 1,000 cubed meters (m^3) in the development area and 0.09 larvae per 1,000 m^3 in the Control Area.

Jonah crab was reported independently of other bycatch due to their existence as commercially important target species. The overall catch during the survey was 3,828 crabs, with 2,578 sampled in the

[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.

501N Study Area and 1,250 in the Control Area. Jonah crab data are presented in Appendix I, while counts of additional bycaught species are presented in Appendix II.

The substrate and habitat classification were determined from data collected by a separate SMAST Drop Camera Survey of Benthic Communities and Substrate in the Vineyard Wind Lease Area OCS-A 0501 and Control Area. The dominant substrate was shown to be sand in both the 501N Study Area and Control Areas (Appendix III, Figure 1)

INTRODUCTION

The Vineyard Wind Lease Area OCS-A 0501 is located approximately 14 miles from the southeast corner of Martha's Vineyard. The Lease Area is within the Massachusetts Wind Energy Area (MA WEA), which was established on the OCS for offshore wind energy development, and ranges from approximately 37 to 49.5 meters (m) in depth (Vineyard Wind, 2018). As part of extensive pre- and post-construction research initiatives, SMAST surveyed populations of commercially targeted species of concern in the northern portion of Vineyard Wind's Lease Area (501N Study Area) and an easterly adjacent Control Area. The surveys used traps (for bottom-dwelling species) and towed planktonic nets (for larval species) to begin assessing potential impacts of offshore wind development activities in the 501N Study Area using BACI protocol. The design of this experiment assumes that the 501N Study Area and Control Area have similar environments and over time would change at the same levels in the absence of planned development activities (Underwood, 1991) in the Lease Area.

The Vineyard Wind monitoring plan developed by SMAST after considerable stakeholder and agency input, called for research on adult and larval lobster populations in the 501N Study Area as well as reef-structure associated finfish; this study satisfied all components. Black sea bass monitoring was conducted also at the request of the Massachusetts Division of Marine Fisheries (MA DMF) as part of their recommendation for an environmental assessment in the 501N Study Area (MA DMF, 2018; Cadrin et al., 2019). Year two of the study provided a baseline comparison to year one on American lobster and black sea bass abundance through a trap survey, as well as temporal abundance and distribution of lobster larvae in the upper layer of the water column.

Ventless trap surveys are a widely accepted method for assessing populations relatively (Courchene and Stokesbury, 2011). This methodology is used widely by the MA DMF and Rhode Island Department of Environmental Management (RI DEM) to assess the status of the American lobster in southern New England (ASMFC, 2015). This survey design was also implemented in several graduate student projects at SMAST (Courchene and Stokesbury, 2011; Cassidy, 2018). Ventless trap surveys were previously used with success in the pre-construction monitoring of the Rhode Island/Massachusetts wind energy area (RI/MA WEA), located on Cox's Ledge (Collie and King, 2016), in the United Kingdom (Roach et al., 2018), and to assess the impact of the Block Island Wind Farm on American lobster abundance from 2013 through 2018 (Griffin et al., 2019).

PROJECT GOALS AND OBJECTIVES

The goal of this project is to provide baseline relative abundance data for several species of concern to help inform the environmental impact assessment of wind energy development in the 501N Study Area and the adjacent Control Area (Figure 1). Our primary objectives are to:

1) estimate the size and distribution of lobster and black sea bass populations in the 501N Study Area and adjacent Control Area;
2) classify population dynamics of these two species such as length, sex, reproductivity success, age, diet, and disease;
3) estimate the relative abundance and distribution of planktonic species such as larval lobster in the neustonic layer of each area, using a towed ichthyoplankton net at each survey location; and
4) obtain movement patterns of adult lobsters through a tagging study.

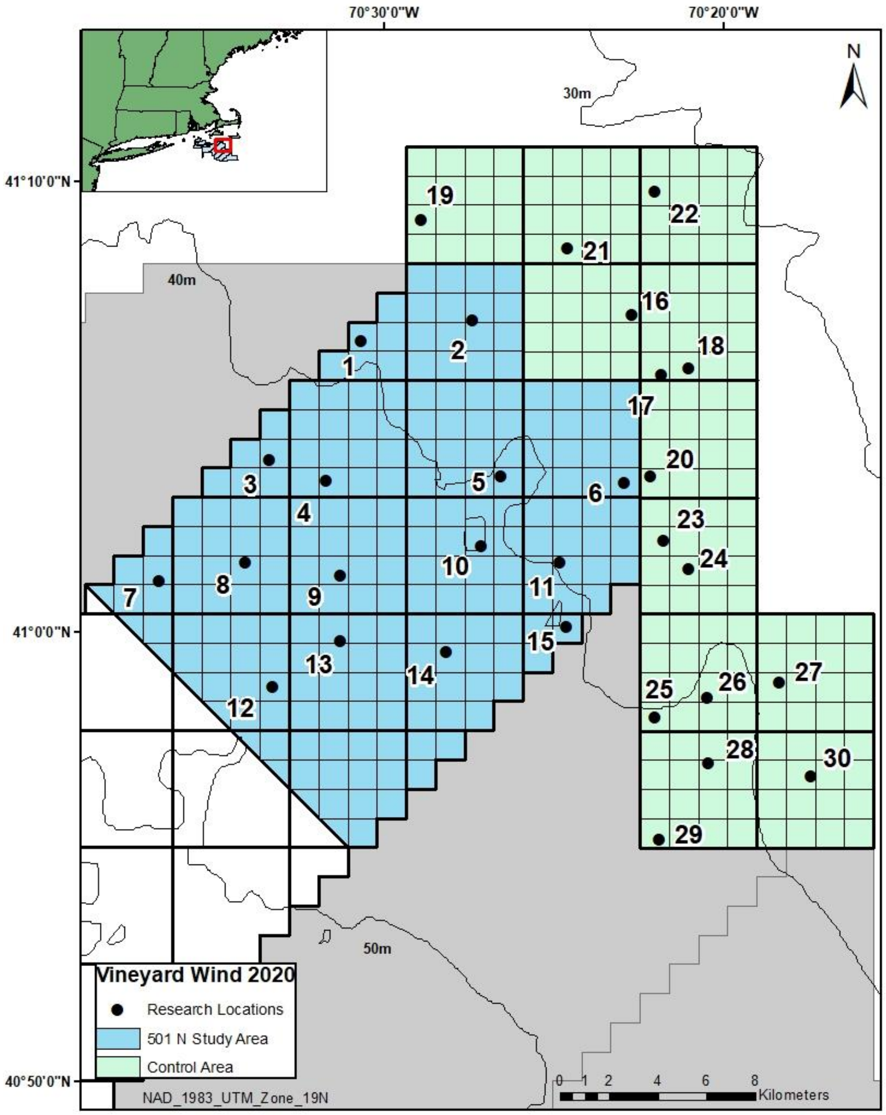

Figure 1. 501N Study Area (blue) and Control Area (green) with randomly selected sampling sites (research locations).

METHODS

Ventless Trap Survey

Fisheries-dependent trap sampling data historically has been used selectively to aid in relative abundance indices for American lobster because of substantial spatial biases associated with the way these data are collected (ASMFC, 2015). The non-random fashion in which commercial traps are fished introduces a potential source of bias to catch per unit effort (CPUE) estimates, as the fishery actively targets lobster. Instead, trawl survey relative abundance indices have been used for lobster stock assessment purposes, because of the randomized sampling design and non-selective nature of trawl gear. However, trawl surveys have potential biases associated with their inability to fish in all productive lobster habitats, such as rock and ledge bottom, and in areas where static fishing gear is deployed (traps, gillnets, and bottom longlines) due to gear conflict (ASMFC, 2015).

To minimize the potential biases associated with standard abundance indices we modified Collie and King's (2016) cooperative, random stratified ventless trap survey of the RI/MA WEA. Just as it did in Collie and King (2016), this survey design will generate robust estimates of lobster relative abundance and juvenile lobster population estimates in the 501N Study Area and Control Area. Sampling sites were determined by dividing our area into lease blocks (larger grid cells in Figure 1) that were 23 square kilometers (km^2) each. Each block was divided into 16 "aliquots" and one randomly selected aliquot (1.4 km^2) within each block served as a sampling site for the duration of the survey season. This survey design combines the best aspects of both fishery-dependent and independent surveys; random stratified sampling design and static fishing gear that can be deployed on any substrate type.

SMAST worked in cooperation with Capt. Jarett Drake and Capt. Mohawk Bolin on the project, who allowed the scientists on board and deployed and maintained the gear used in the surveys. Also, given the onset of the COVID-19 pandemic, industry partners and the university worked to develop Coronavirus research activity plans, which allowed to survey with no significant delays. A total of 30 strings of traps were deployed from their vessels at the sampling sites between June 13 and 14, 2020, and split equally between the 501N Study Area and Control Area. The strings in each area are designed using the standard protocols demonstrated in previous SMAST, MA DMF, and coastwide ventless trap studies (Courchene and Stokesbury, 2011; ASFMC, 2015). Each string contained six lobster pots, alternating between vented and ventless traps to obtain information on catch rates of lobsters both above and below the minimum landing size (MLS). A single, unbaited commercial-sized sea bass pot was attached at one end of each string (Figure 2) to collect information on this hard-structure associated finfish species. The dimensions for all lobster traps were standardized (40" x 21" x 16") throughout all survey areas and contained a single kitchen, parlor, and rectangular vent in the parlor of vented traps (size 1 $^{15}/_{16}$" x 5 ¾"). All traps were spaced 150 feet apart and the gear followed federal rigging regulations; the downlines of each string utilized new weak link technology to deter whale entanglements. A Tidbit v2™ Temperature Logger was placed on the middle traps of each string to compare CPUE and bottom water temperature (Cassidy, 2018). Additionally, in 2020, select trap strings at stations stratified by depth were equipped with pH, dissolved oxygen, and conductivity sensors to track changes in environmental conditions and correlate catch metrics with those data.

Trap deployment, maintenance, and hauling were contracted to commercial lobstermen, but sampling was always conducted by a SMAST researcher onboard each fishing vessel. To the degree possible, survey gear was hauled on a three-day soak time, in an attempt to standardize catchability among trips. All strings were reset in the same assigned location after each haul. SMAST researchers accompanied fishermen on each sampling trip to record CPUE and biological data using the standard MA DMF and RI DEM lobster trap sampling protocol, which enumerate lobsters per trap, number of trap hauls, soak time, trap and bait type, carapace length (to the nearest millimeter [mm]), sex, shell hardness, number of claws or shell damage, presence of shell disease, and egg stages on ovigerous females (ASMFC, 2015). American lobster and Jonah crab CPUE refer to the number of animals collected per each string hauled. A subset of these data (carapace width [mm] and sex) was collected from the majority of Jonah crabs sampled. In addition, other bycaught species were recorded and are described in Appendix I and II. String locations were confirmed with the station's original coordinates after each haul via GPS, and some within aliquot modifications to the sampling sites were made at the instruction of commercial fisherman to avoid user conflicts with other fishing gear types. Depth at mean low water for each trawl location was recorded from National Oceanic and Atmospheric Administration navigational charts as a survey standard to avoid variability from tidal fluctuations.

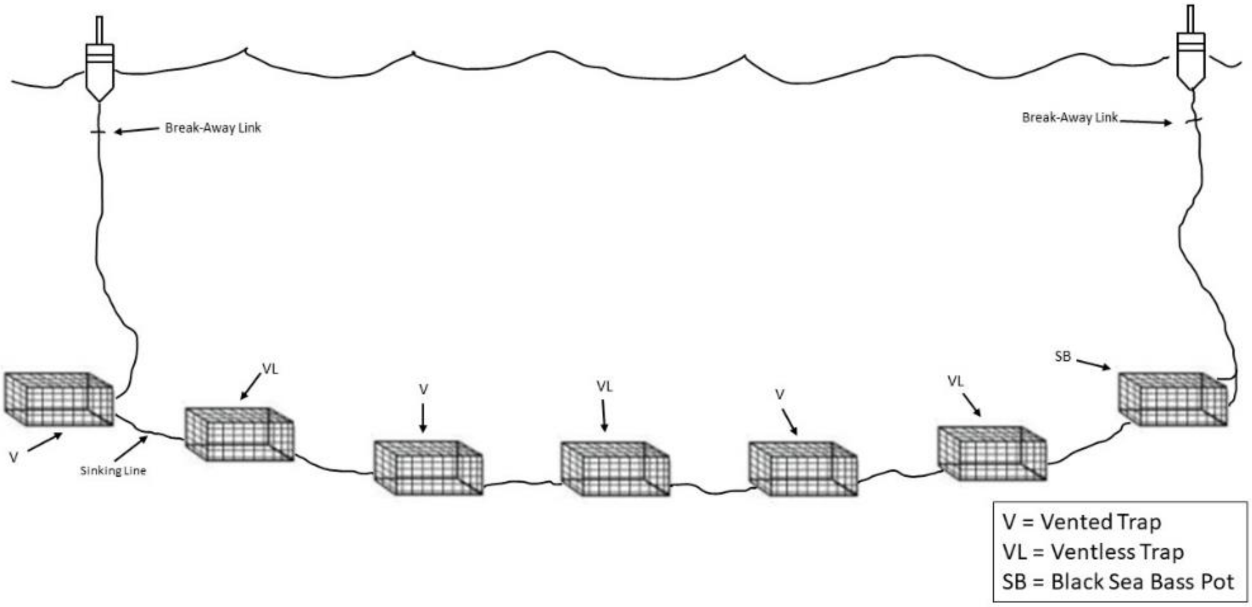

Figure 2. Diagram of a string of traps (three vented, three ventless, and one sea bass pot) placed at each sampling site.

Lobster Tagging Study

A lobster tagging study was also conducted using the methods described in Courchene and Stokesbury (2011). Lobsters with a carapace length greater than 80 mm were tagged using Floy™ anchor tags inserted with a hypodermic needle. The tags were inserted into the arthral muscle of the animal, so it is retained during molting. Each tag displayed an individual identification number and included a phone number for reporting of recaptures by fishermen (Cassidy, 2018). Each tagged lobster was released at the aliquot of capture, allowing for the spatial assessment of lobster within and outside the development area. Tagging data have also been useful for recapture information by commercial fishermen to determine the average velocity of recaptured individuals (Cooper and Uzmann, 1971; Geraldi et al., 2009).

Black Sea Bass

This survey assessed the black sea bass population at all 30 strings in both the 501N Study Area and Control Area. To achieve this, one un-baited black sea bass pot was set at the far end of each string of lobster traps and was allowed to naturally saturate over the soaking period. The sampling for black sea bass occurred simultaneously with lobster trap hauling and all black sea bass caught in sea bass pots were counted and measured to the total length in centimeters (cm). Black sea bass CPUE refers to the number of black sea bass captured per each sea bass pot haul. A subset of these fish was taken at each hauling period for biological analysis (aging, diet, and fecundity), with a goal of two specimens from each sampling site; or 30 fish from each area for a total of 60 fish per sampling period. Stomach content analyses were conducted on all sea bass collected throughout the study, as this species preys on lobster (Wahle et al., 2013). Otolith samples were taken from those fish collected and were stored for potential future analysis. These analyses were important for collecting general information on this species in a previously undescribed location.

Larval Lobster Study

A towed neuston net collected samples from the same sampling sites as the traps. This occurred on the days set aside for baiting and setting gear from June through October 2020. The sampling net was deployed off the stern of the commercial fishing vessels; the net opens to 2.4 m x 0.6 m x 6 m in size and is made of a 1,300-micrometer mesh. The net, when towed, samples the top 0.5 m of the water column. One 10-minute tow at approximately 4 knots was conducted at each location. The contents from each tow were washed into tubs, sorted, and stored in a mixture of 10% formalin: 90% seawater, as described by Milligan (2010). Once back in the lab, samples were transferred into 70% ethanol for preservation, and lobster larvae were staged according to Herrick (1911).

RESULTS AND DISCUSSION

Lobster Trap Survey

Individual trap hauls in the 501N Study Area totaled 437 vented traps and 439 ventless traps. These numbers were slightly lower in the Control Area, where 414 vented traps and 417 ventless traps were sampled. A total of 141 separate strings were hauled in the 501N Study Area, while 138 strings were hauled in the Control Area. Accounting for strings containing less than six lobster traps, an average of 13.9±0.62 strings were hauled per sampling period in the Control Area. The 501N Study Area averaged 14.6±0.63 lobster string hauls during each sampling period, with no difference in the number of individual lobster trap hauls between areas (Two Sample T-test, 1.93, df= 18, p=0.07). The number of black sea bass pot hauls between both study areas did not vary either (Two Sample T-test, 1.56, df= 18, p=0.14), as 146 and 141 pot hauls occurred in the 501N Study Area and Control Area, respectively. Gear loss throughout the survey explains the discrepancy between total, individual trap hauls per area. This was attributed to transiting vessels and fishing activity that occurs in the area. The black sea bass pots were unbaited while both vented and ventless lobster traps were baited using Atlantic Herring.

A total of 921 American lobsters were collected from both lobster trap types combined: 259 were caught in the Control Area, while 662 were in the 501N Study Area. American lobster counts were the lowest at the beginning of June during the first sampling period (n=6) and reached a high in August during the fifth sampling period (n=167). Lobster catch fluctuated monthly and by area (Figure 3). The aliquots in the 501N Study Area that experienced the highest lobster totals were Aliquots 7, 12, and 9 (n=124, n=88, and n=73). The aliquots in the Control Area that experienced the highest lobster totals were Aliquots 25, 29, and 20 (n=32, n=28, and n=25) (Figure 4). Overall, 557 males and 321 females were observed between both study areas. The Control Area produced 192 males and 60 females, while 365 males and 261 females originated from the 501N Study Area. This resulted in a 4.2:1 ratio in the Control Area, a 2.4:1 ratio in the 501N Study Area, and a 2.7:1 overall ratio. Overall, male:female sex ratios ranged between 0.2 to 1.8 in the 501N Study Area and 0.0 to 21.0 in the Control Area (Table 1).

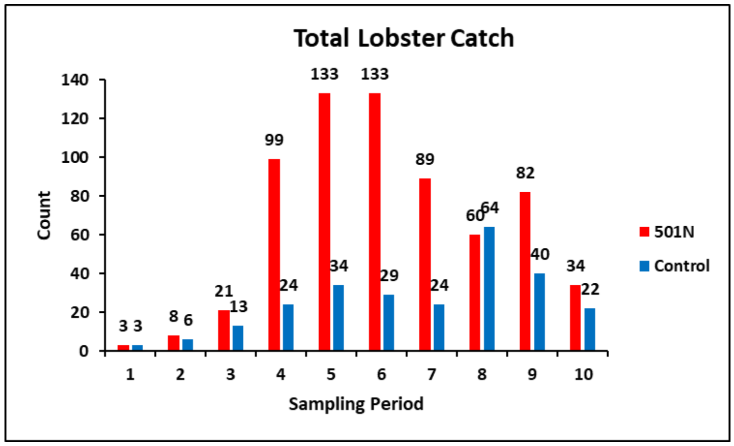

Figure 3. Total lobster catches by sampling period for the 501N Study Area (red) and Control Area (blue).

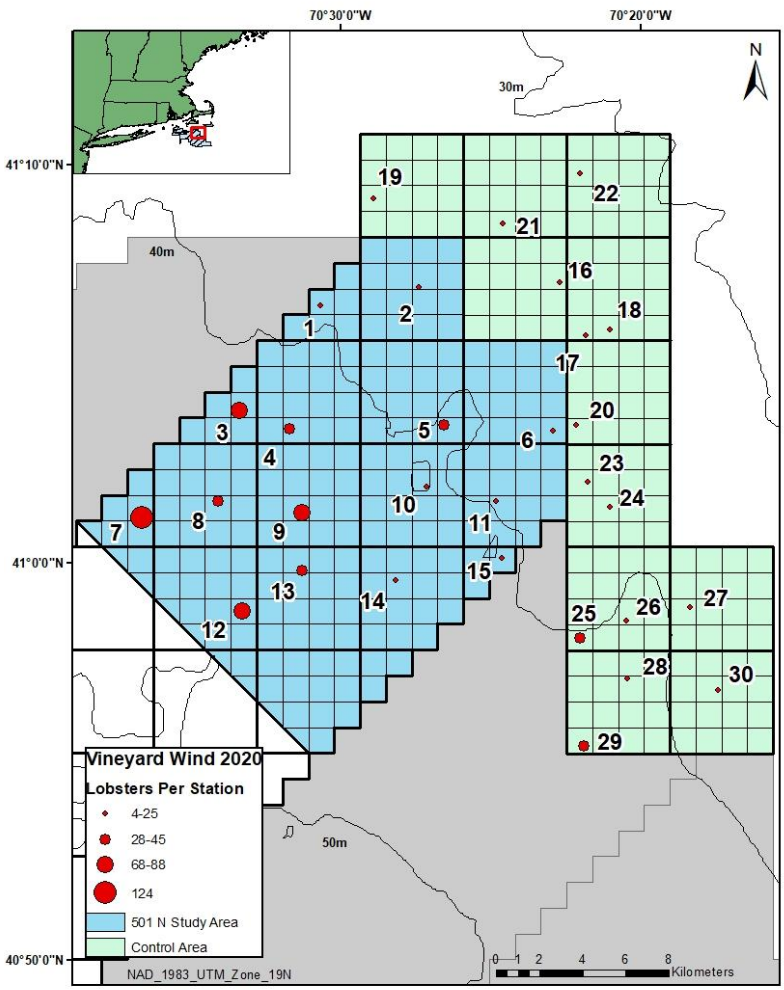

Figure 4. Total lobster catch at each aliquot over the duration of the field season, numbers next to each dot are the station numbers.

CPUE was used to compare catches of American lobster between areas and over time and refers to the average number of organisms caught on a per string basis. The average CPUE recorded throughout the survey was 3.24±0.21 lobsters/string. Average area level comparisons showed lobster CPUE was higher in the 501N Study Area (4.52±0.34 lobsters/string) than in the Control Area (1.95±0.23 lobsters/string) (Table 1). Differences are visualized in Figure 5a, as higher relative abundances were observed in the 501N Study Area. CPUE also varied with respect to area and sampling period. In the Control Area, sampling period 1 in early June produced 0.20±0.23 lobsters/string, the minimum CPUE observed throughout the season. The highest average catches seen in the Control Area occurred during sampling periods 8 and 9 (5.08±1.23 and 3.38±1.00 lobsters/string) at the end of September and the beginning of October. Similar to the Control Area, the lowest average catches recorded in the 501N Study Area was also during sampling period 1 (0.27±0.26 lobsters/string). The highest average catches recorded in the 501N Study Area occurred during sampling periods 5 and 6 (8.87±1.07 lobsters/string) in August. Results suggest that lobster relative abundance was seasonal with greater CPUE estimates observed towards the end of summer in the month of August.

Table 1. Summary of results from the ventless trap survey conducted for each sampling period in the 501N Study Area and Control Area, including the month sampled, the average bottom temperature, the number of lobsters collected, the catch per unit effort (for a six-pot string), the mean carapace length, and the sex ratio.

Sampling Period	Area	Month	Temp (°C)	Number Caught	CPUE	Mean CL (mm)	Sex Ratio (M:F)
1	Control	June	10.38	3	0.20	86.67	-
2	Control	June	10.75	6	0.40	90.50	5.0
3	Control	July	12.05	13	0.87	89.38	0.9
4	Control	July	11.85	24	1.71	100.17	3.0
5	Control	August	11.54	34	2.43	88.97	2.4
6	Control	August	15.85	29	1.93	94.69	4.8
7	Control	September	17.42	24	1.85	88.05	3.4
8	Control	September	16.16	64	5.08	95.25	3.0
9	Control	October	15.86	40	3.38	95.00	2.9
10	Control	October	16.28	22	1.69	95.50	21.0
1	501N	June	9.40	3	0.27	97.00	0.5
2	501N	June	9.71	8	0.53	99.57	0.2
3	501N	July	10.25	21	1.40	92.72	1.6
4	501N	July	10.30	99	6.60	85.36	1.2
5	501N	August	9.99	133	8.87	84.60	1.4
6	501N	August	14.22	133	8.87	86.52	1.8
7	501N	September	17.26	89	6.13	88.47	1.5
8	501N	September	15.67	60	4.29	90.40	1.1
9	501N	October	15.67	82	5.86	87.24	1.7
10	501N	October	15.60	34	2.43	86.79	1.2
Average	Control	All	13.88±0.64	259	1.95±0.23	93.65±1.19	3.2
Average	501N	All	12.76±0.58	662	4.52±0.34	87.24±0.73	1.4
Average	Both	All	13.29±0.43	921	3.24±0.21	89.08±0.62	1.7

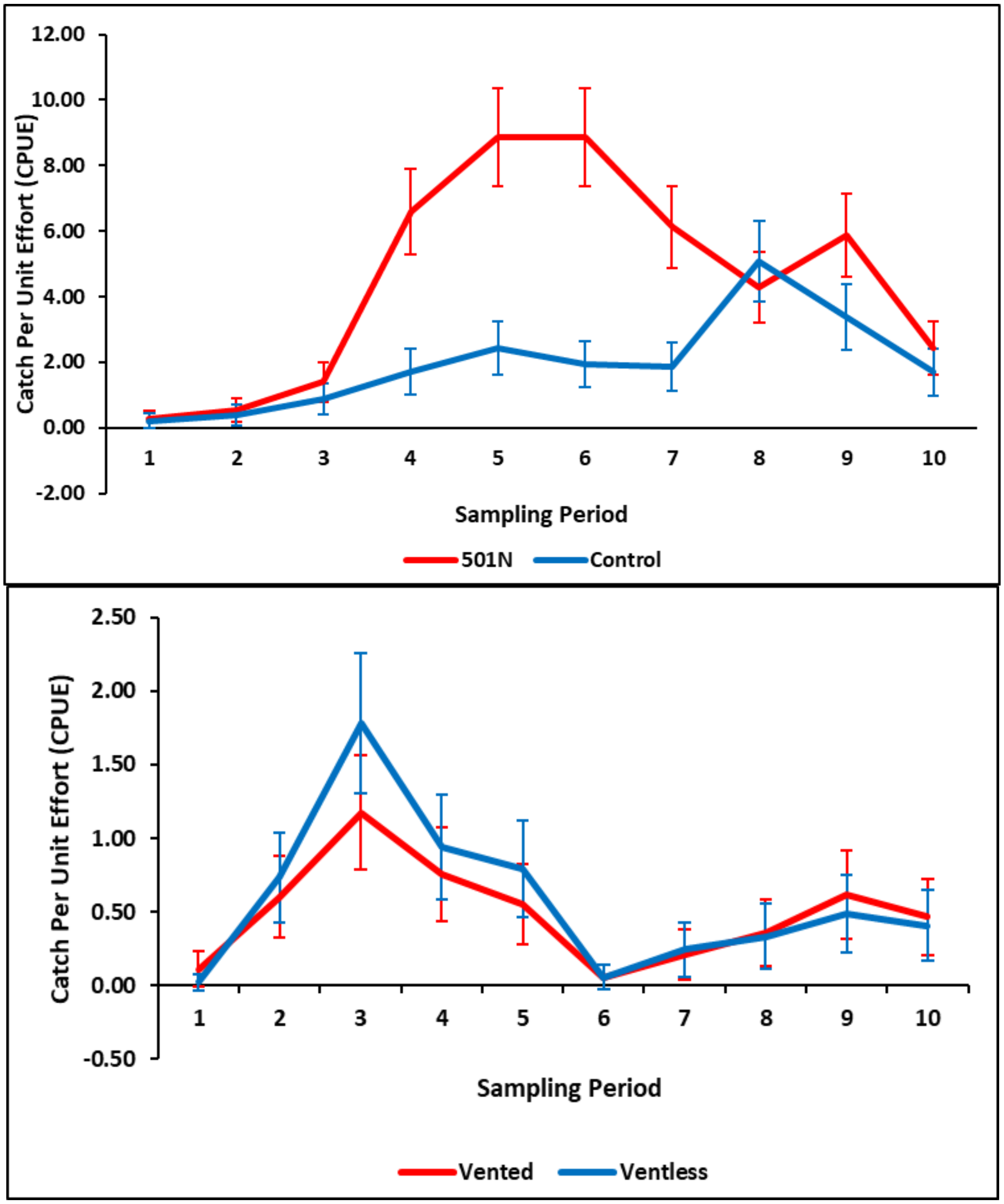

Figure 5a. Average Lobster CPUE (catch per string of six pots) results with standard error bars (95% confidence interval) for the 501N Study Area and Control Area (top). **Figure 5b.** Estimates of trap type performance over the duration of the survey (bottom) with standard error bars (95% confidence interval).

Comparing only differences between the two different trap types showed ventless traps outperformed vented traps, catching 500 lobsters compared to 421. An average of 4.91±0.26 lobsters were caught in vented traps on each string, while 5.80±0.28 lobsters were caught in ventless traps on each string. The average size of lobsters caught in vented traps (94.1±0.97 mm) was greater than that of ventless traps (85.2±0.81 mm) (Two Sample T-test, 9.85, df = 876, p = 8.74e-22). When compared to the MLS of 85.7

mm, ventless traps nearly averaged a commercially legal-sized lobster while vented traps contained lobsters that were well above the MLS.

The average and range of carapace length of lobsters sampled in the 501N Study Area were 87.24±0.73 (46-154 mm) and 93.65±1.19 mm (52-159 mm) in the Control Area. (Table 1). Female lobsters were on average larger than males (94.56±2.81 mm compared to 89.0±1.91 mm). A difference in average size (Two Sample T-test, 3.66, df = 876, p =.65e-04) was observed between male and female lobsters when all survey data were examined as an aggregate.

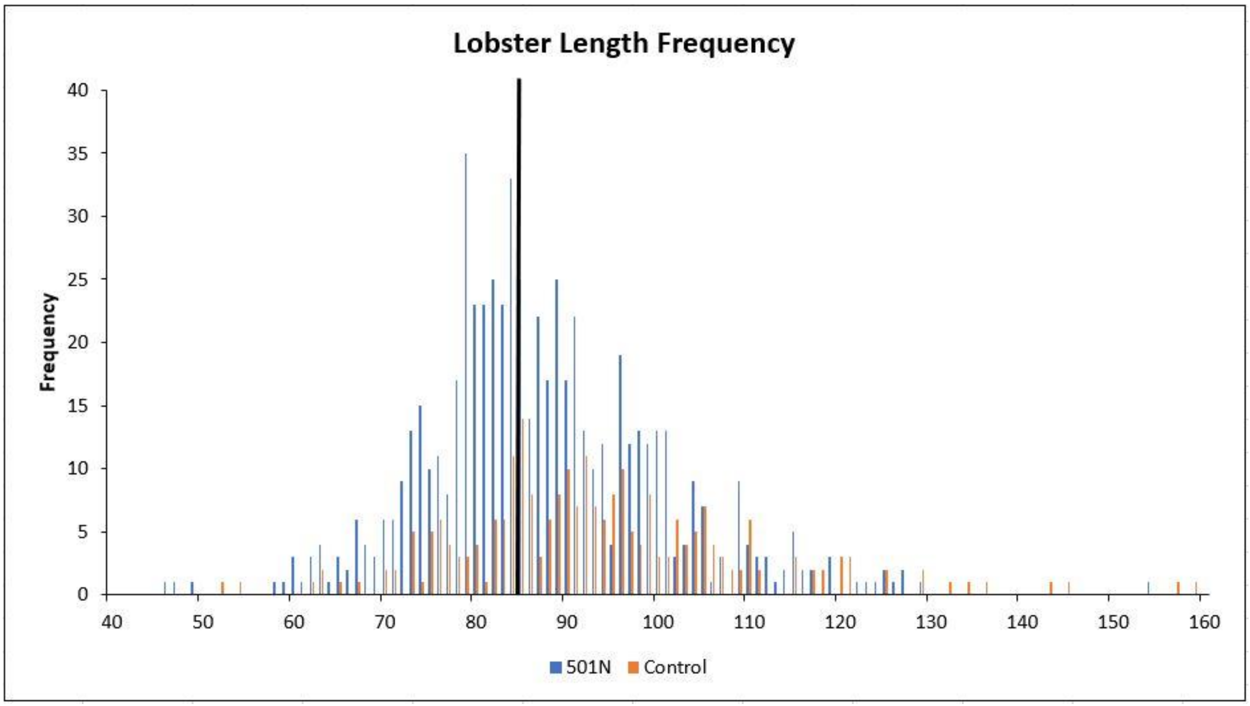

Figure 6. Lobster carapace lengths by study area. Black line indicates the Massachusetts legal size of 85.7 mm.

As shown in Table 2, of the 321 females sampled in both trap types, 28% (n=17) from the Control Area and 23% (n=59) from the 501N Study Area had some level of egg development, with more females sampled overall in the second half of the survey (n=190) than in the first half (n=131). The highest proportion of egg presence occurred during sampling period 10 in the Control Area and sampling period 1 in the 501N Study Area (100% in both the 501N Study Area and Control Area), but sample sizes of female lobsters were low (n=1 and n=2, respectively) during this time (Table 2). The lowest proportions of females with eggs occurred during June and July (sampling periods 1,2, and 4) in the Control Area, and during the end of July and August (sampling periods 4-6) in the 501N Study Area. The majority of egg-bearing females were observed in deeper water between the 40-m and 50-m isobaths (Figure 7).

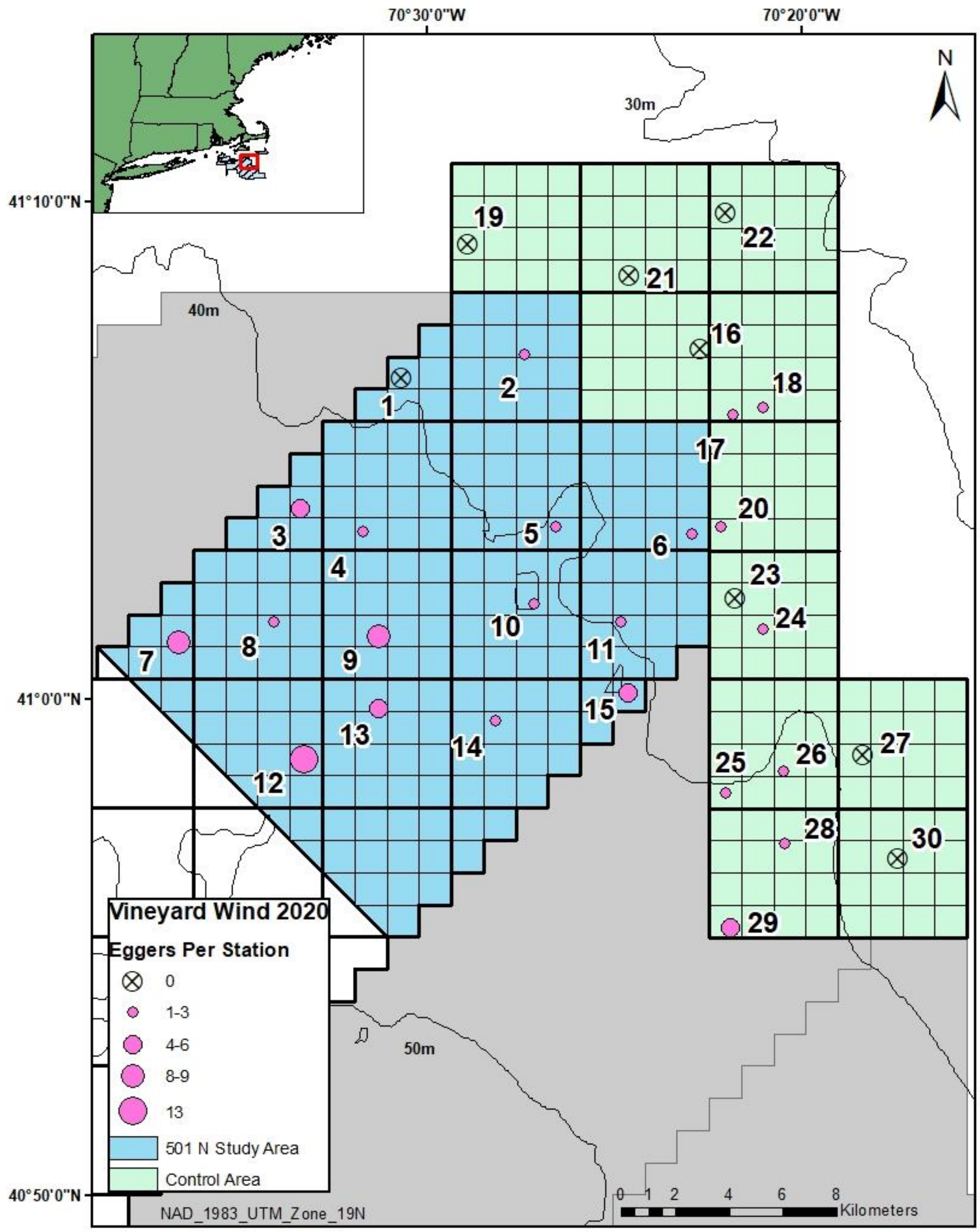

Figure 7. Map depicting the total number of egg-bearing females sampled in the ventless trap survey throughout the 501N Study Area and Control Area.

Table 2. Summary of lobster egg-bearing female samples throughout all sampling periods during the survey in the 501N Study Area and Control Area.

Sampling Period	Area	Month	Number of Females	Number with Eggs	Eggers (%)
1	Control	June	0	0	0%
2	Control	June	1	0	0%
3	Control	July	7	1	14%
4	Control	July	6	0	0%
5	Control	August	10	1	10%
6	Control	August	5	1	20%
7	Control	September	5	1	20%
8	Control	September	16	6	38%
9	Control	October	9	6	67%
10	Control	October	1	1	100%
1	501N	June	2	2	100%
2	501N	June	6	3	50%
3	501N	July	7	4	57%
4	501N	July	40	3	8%
5	501N	August	52	1	2%
6	501N	August	48	1	2%
7	501N	September	36	9	25%
8	501N	September	29	13	45%
9	501N	October	26	16	62%
10	501N	October	15	7	47%
Average	Control	All	60	17	28%
Average	501N	All	261	59	23%
Average	Both	All	321	76	24%

The proportion of lobsters containing any level of epizootic shell disease was low. As shown in Table 3, from the Control Area, the rate of infected individuals ranged from 0% to 33%, with an overall infection rate of 8% (n=21) (Table 3). In the 501N Study Area, infection rates ranged from 0% to 67% with an overall infection rate of 8% (n=53) (Table 3). Combined, an 8% (n=74) infection rate was observed for the duration of the study (Table 3).

Table 3. Summary of lobsters sampled in the ventless trap survey that were infected with epizootic shell disease from both the 501N Study Area and Control Area.

Sampling Period	Area	Month	Number Caught	Number w/Shell Disease	Shell Disease (%)
1	Control	June	3	1	33%
2	Control	June	7	1	17%
3	Control	July	13	1	8%
4	Control	July	24	1	4%
5	Control	August	34	7	21%
6	Control	August	29	2	7%
7	Control	September	22	0	0%
8	Control	September	66	5	8%
9	Control	October	35	1	3%
10	Control	October	24	2	9%
1	501N	June	3	2	67%
2	501N	June	7	1	14%
3	501N	July	18	5	28%
4	501N	July	86	18	21%
5	501N	August	131	9	7%
6	501N	August	140	2	2%
7	501N	September	92	3	3%
8	501N	September	60	3	5%
9	501N	October	70	6	9%
10	501N	October	34	4	12%
Average	Control	All	257	21	8%
Average	501N	All	641	53	8%
Average	Both	All	898	74	8%

Average soak times throughout the sampling season ranged from three to five days, with an average of 3.2 days in the 501N Study Area, and three to seven days, with an average of average 3.7 days, in the Control Area. Minimum and maximum temperatures of 8.82°C and 22.87°C were recorded during the third and eighth sampling periods (in July and September), respectively. The overall average temperature throughout the survey was 13.29±0.43 in both study areas, 12.76±0.58 in the 501N Study Area, and 13.88±0.64 in the Control Area. The average temperatures in the 501N Study Area fluctuated from 9.56°C in June, 10.28°C in July, to 12.11°C in August, 16.46°C in September, and 15.63°C in October. In the Control Area, average temperatures also deviated monthly from 10.56°C in June, 11.95°C in July, to 13.69°C in August, 16.79°C in September, and dropped to 16.07°C during October (Figure 8). Dissolved oxygen (DO, milligrams per liter), Conductivity (micro Siemens/cm), and pH were monitored in each area beginning in July (sample period 3). The overall average DO throughout the survey was 8.33±0.74 in both study areas, 7.80±0.94 in the 501N Study Area, and 9.03±1.18 in the Control Area. The overall average conductivity throughout the survey was 32,606.98±45.69 in both study areas, 32,203.99±61.23 in the 501N Study Area, and 33,099.51±68.63 in the Control Area. The overall average pH throughout the survey was 8.33±0.72 in both study areas, 8.33±0.97 in the 501N Study Area, and 8.33±1.07 in the Control Area. The variability in environmental data between areas is likely attributed to depth and month in which the samples were taken. Sites in the 501N Study Area were on average, 42.9±1.14 m while the Control Area sites were 39.1±1.25 m.

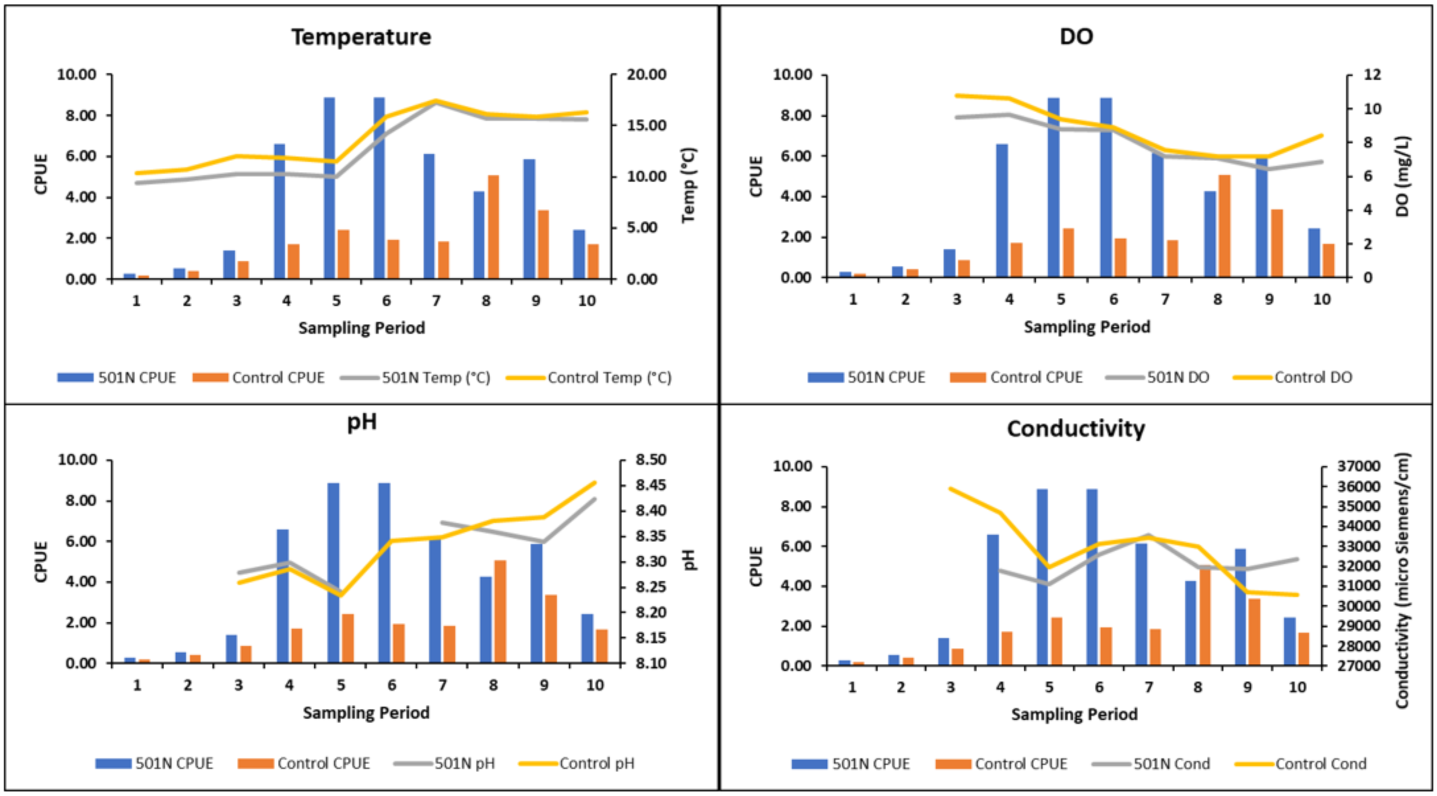

Figure 8. Average environmental data (Temperature, pH, DO, and Conductivity) over lobster CPUE by sampling period for both the 501N Study Area and Control Area of the ventless trap survey.

Lobster Tagging Study

Of the 921 lobsters captured, 703 were tagged and released, while the remaining did not receive a tag. As of January 11, 2021, twelve different recaptures have been reported; ten lobsters were re-released while two were landed. Four recaptures occurred during survey activities, one was reported by Commercial Fisheries Research Foundation, three were reported by Capt. Mohawk Bolin, two were reported by Capt. Jarrett Drake, and two by Capt. Tom Kiewitz during commercial fishing activities. Ten recaptures were male and two were female ranging in carapace length from 86 to 120 mm. Days at large ranged from 10 to 412 and one of the tagged lobsters was recaptured twice within 64 days. The recaptured lobsters moved distances ranging from 4.81 to 128.82 kilometers (km). Movement rates were estimated for these lobsters ranged from 0.06 to 3.58 km/day. Of the reported recaptures from commercial fishermen, six were initially tagged in 501N Study Area and two were from the Control Area (Figure 9).

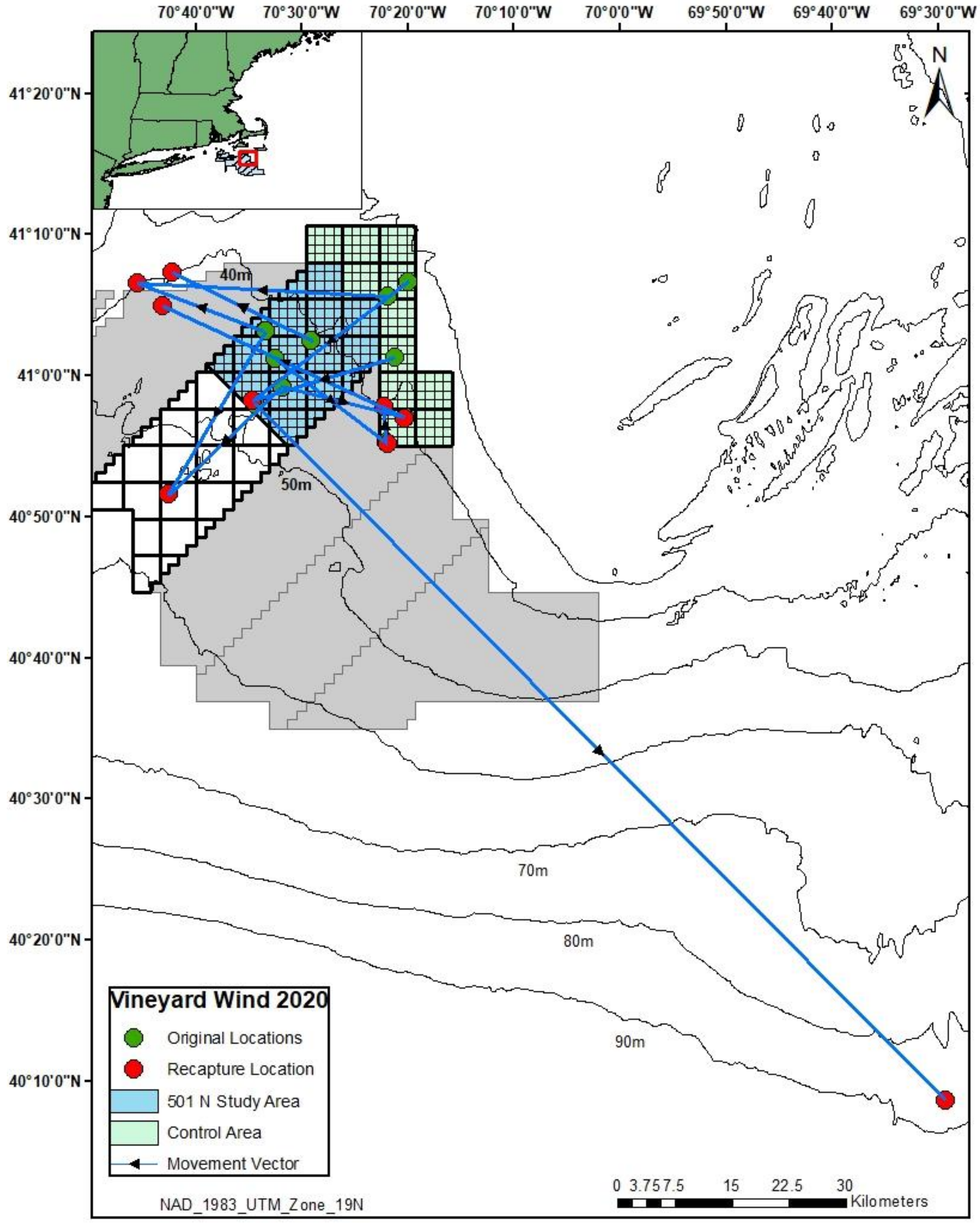

Figure 9. Map depicting tagged recaptured lobsters during 2020 survey season. Original tag location (green dot) and recapture location (red dot) are shown.

Black Sea Bass

In total, n=456 black sea bass were collected from 287 individual black sea bass pots hauled over the duration of the study; n=149 originated from the 501N Study Area, while n=307 black sea bass stemmed from the Control Area (Table 4, Figure 10). Comparatively, more sea bass was captured in sea bass pots (n=456) than in vented or ventless traps (n=940), given there were n=851 vented and n=856 ventless individual trap hauls. CPUE by individual traps were 1.67±0.15 fish/trap for sea bass pots, 8.27±0.33 fish/trap in ventless pots, and 3.29±0.21 fish/trap in vented pots. On average, sea bass pots in the 501N Study Area were 1.03±0.16 fish/trap, while the Control Area yielded 2.31±0.25 fish/trap (Table 4). Sea bass CPUE showed strong seasonality, with 86% (n=392) of sea bass observed during September and October in both study areas. This was reflected in CPUE; the average catch rate for September and October was 7.13±0.70 and 7.45±0.73 fish/trap, respectively (Figure 11). Of the n=456 black sea bass observed throughout the survey, lengths were not taken on n=4 fish. The average total length of sea bass caught in the 501N Study Area was 31.22±0.91 cm and 31.19±0.63 cm in the Control Area (Table 4).

Table 4. Summary of black sea bass collected from sea bass-specific sampling pots.

Sampling Period	Area	Month	Temp (°C)	Number (Caught)	Number (Measured)	CPUE	Mean Length (cm)
1	Control	June	10.38	1	1	0.07	45.00
2	Control	June	10.75	0	0	0.00	0.00
3	Control	July	12.05	0	0	0.00	0.00
4	Control	July	11.85	1	1	0.07	31.00
5	Control	August	11.54	1	1	0.07	34.00
6	Control	August	15.85	30	30	2.00	32.80
7	Control	September	17.42	27	27	1.93	28.89
8	Control	September	16.16	108	107	8.31	31.99
9	Control	October	15.86	88	88	6.77	27.91
10	Control	October	16.28	51	51	3.92	35.14
1	501N	June	9.40	0	0	0.00	0.00
2	501N	June	9.71	1	1	0.07	36.00
3	501N	July	10.25	0	0	0.00	0.00
4	501N	July	10.30	0	0	0.00	0.00
5	501N	August	9.99	0	0	0.00	0.00
6	501N	August	14.22	30	29	2.00	32.59
7	501N	September	17.26	42	40	2.80	32.98
8	501N	September	15.67	17	17	1.21	31.12
9	501N	October	15.67	41	41	2.93	29.88
10	501N	October	15.60	18	17	1.29	27.82
Average	Control	All	13.88±0.64	307	306	2.31±0.25	31.19±0.63
Average	501N	All	12.76±0.58	149	145	1.03±0.16	31.22±0.91
Average	Both	All	13.29±0.43	456	451	1.67±0.15	31.20±0.52

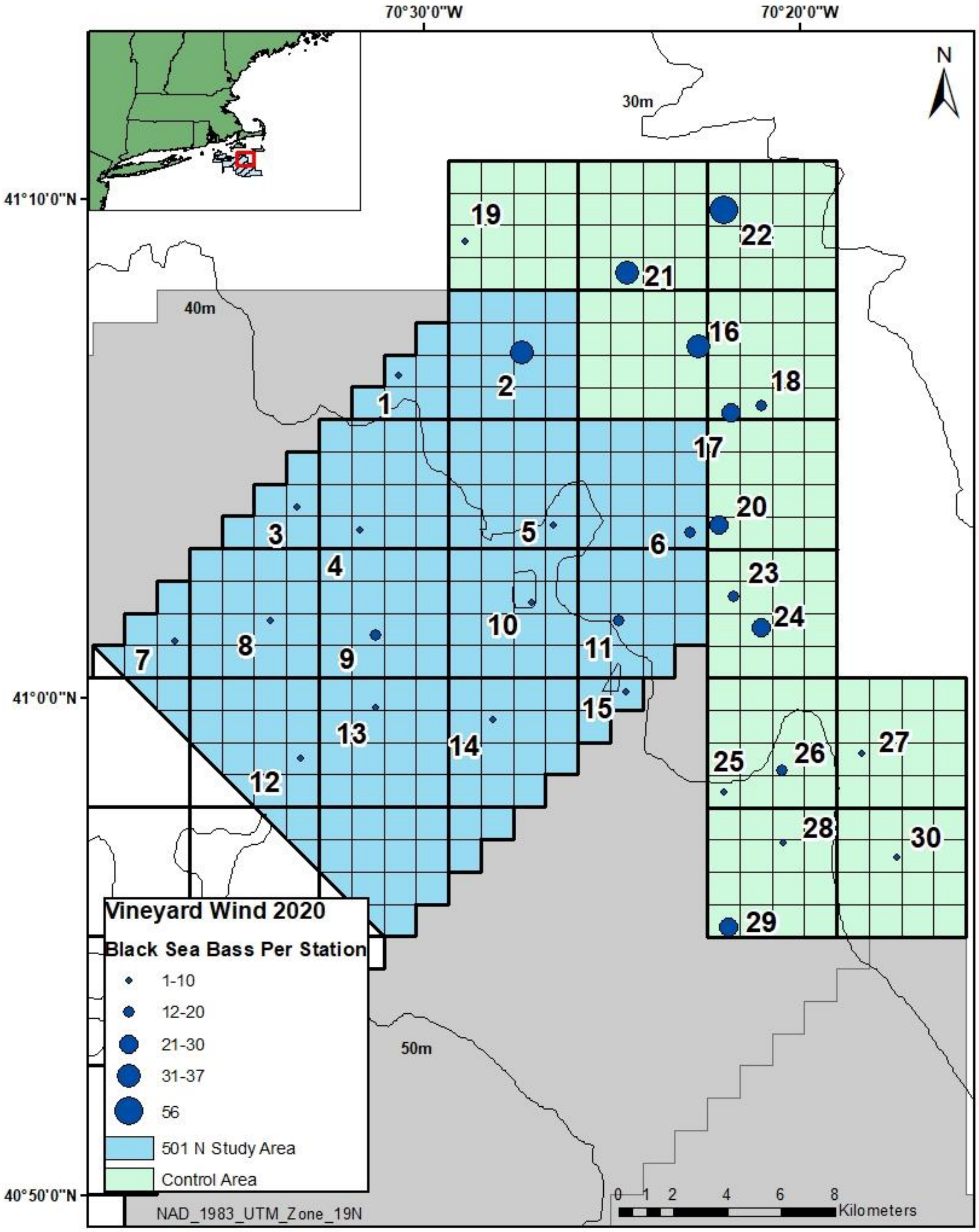

Figure 10. Map depicting the total number of black sea bass sampled in sea bass-specific pots at each location over the duration of the study.

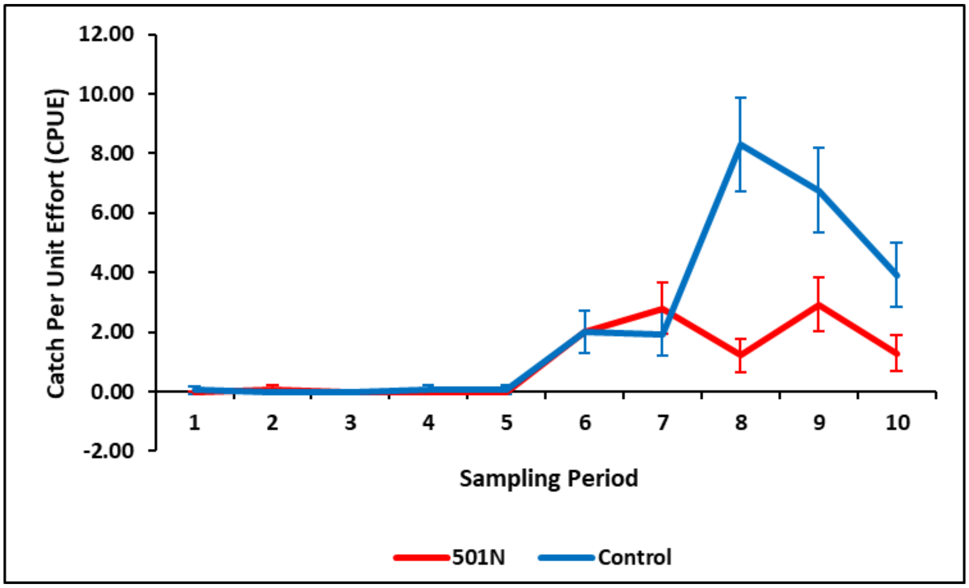

Figure 11. Average black sea bass CPUE (catch per black sea bass pot) results with standard error bars (95% confidence interval) for the 501N Study Area and Control Area.

During the study, n=91 black sea bass were dissected from the Control Area and n=77 in the 501N Study Area (Table 5). Of the fish dissected, 12% (n=9) from the 501N Study Area and 21% (n=19) from the Control Area contained food. Of the 28 fish that contained food, the stomach contents contained crab, fish, clam, hermit crab, and shrimp. Otoliths were extracted from sampled sea bass and saved for future analysis.

Table 5. Summary of results from stomach content analysis of black sea bass sampled.

Sampling Period	Area	Number Sampled	Number With Contents	Contents (%)
1	Control	1	1	100%
6	Control	4	2	50%
7	Control	20	7	35%
8	Control	22	3	14%
9	Control	22	6	27%
10	Control	22	0	0%
2	501N	1	0	0%
6	501N	6	1	17%
7	501N	20	4	20%
8	501N	12	3	25%
9	501N	24	1	4%
10	501N	14	0	0%
Average	Control	91	19	21%
Average	501N	77	9	12%
Average	Both	168	28	17%

Larval Lobster Study

Each vessel utilized standardized tow durations of 10 minutes, a net sampling opening to 1.75 square meters (m^2), and average tow speeds ranging from 2.0 to 5.6 knots depending on the sea state. This translated to an average of 1892.2±4.92 m^3 of water sampled at each tow location. In total, n=91 lobster larvae were captured during the larval study, with n=61 (Table 6, Figure 12) in the 501N Study Area and n=30 in the Control Area. Catches per sampling period ranged from n=0 to n=40 larval lobsters of life stages one, two, three, and four (Table 6). Larval lobster counts per sampling period ranged from 0 to 1.95±0.71 lobster larvae per 1,000 m^3 of seawater sampled. Combined there was an estimated 0.19±0.05 larvae per 1,000 m^3, with a higher density in the 501N Study Area than in the Control Area, 0.29±0.09 and 0.09±0.05 larvae per 1,000 m^3 respectively (Table 7). While other species were also observed and collected during the larval towing periods, such as fish, crabs, shrimp, jellyfish, and various isopods, we did not classify these samples further. However, all samples were stored and preserved for possible future analysis.

Table 6. Summary of the counts of lobster larvae by stage during the survey.

		Total Lobster Larvae Sampled				
Area	**Sampling Period**	**Larval Stage**				
		I	**II**	**III**	**IV**	**Total**
Control	1	4	10	6	0	20
Control	2	3	0	0	0	3
Control	3	6	0	1	0	7
Control	4	0	0	0	0	0
Control	5	0	0	0	0	0
Control	6	0	0	0	0	0
Control	7	0	0	0	0	0
Control	8	0	0	0	0	0
Control	9	0	0	0	0	0
Control	10	0	0	0	0	0
501N	1	17	17	6	0	40
501N	2	7	4	0	0	11
501N	3	0	2	3	2	7
501N	4	0	0	0	0	0
501N	5	0	0	0	0	0
501N	6	0	0	2	1	3
501N	7	0	0	0	0	0
501N	8	0	0	0	0	0
501N	9	0	0	0	0	0
501N	10	0	0	0	0	0
Control	All	13	10	7	0	30
501N	All	24	23	11	3	61
Both	All	37	33	18	3	91

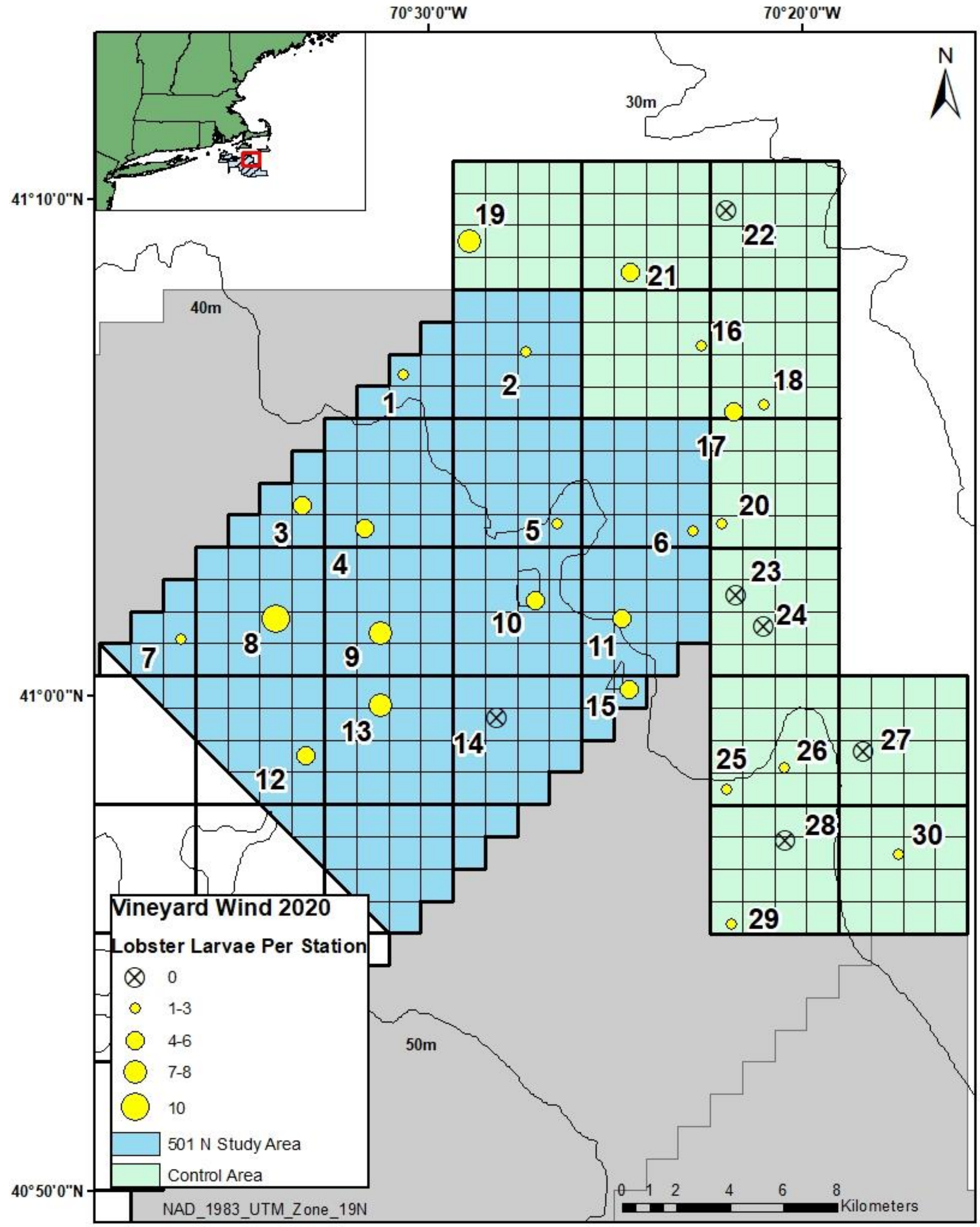

Figure 12. Map depicting the total number of lobster larvae sampled during neuston net tows at each location over the duration of the study.

Table 7. Summary of the mean density of lobster larvae estimated for each study area over the duration of the study.

			Mean Lobster Larvae / 100 m				
			Larval Stage				
Area	Sampling Period	Month	I	II	III	IV	Total
Control	1	June	0.12	0.30	0.17	0	0.59
Control	2	June	0.09	0	0	0	0.12
Control	3	July	0.17	0	0.02	0	0.19
Control	4	July	0	0	0	0	0
Control	5	August	0	0	0	0	0
Control	6	August	0	0	0	0	0
Control	7	September	0	0	0	0	0
Control	8	September	0	0	0	0	0
Control	9	October	0	0	0	0	0
Control	10	October	0	0	0	0	0
501N	1	June	0.80	0.84	0.31	0	1.95
501N	2	June	0.32	0.18	0.00	0	0.50
501N	3	July	0	0.08	0.15	0.07	0.30
501N	4	July	0	0	0	0	0
501N	5	August	0	0	0	0	0
501N	6	August	0	0	0.08	0.04	0.18
501N	7	September	0	0	0	0	0
501N	8	September	0	0	0	0	0
501N	9	October	0	0	0	0	0
501N	10	October	0	0	0	0	0
Control	Average	All	0.04±0.03	0.03	0.02±0.02	0	0.09±0.05
501N	Average	All	0.11±0.05	0.11±0.05	0.05±0.04	0.01±0.02	0.29±0.09
Both	Average	All	0.07±0.03	0.07±0.03	0.04±0.02	0.01±0.01	0.19±0.05

Comparative Analysis 2019 to 2020

The 501N study area and adjacent Control area are similar in size and depth. The ideal method to assess the impact or change on an environment is through a Before-After-Control-Impact (BACI) study. The design of this experiment assumes that the 501N Study Area and Control Area have similar environments over time would change at the same levels. Although there are some differences in the areas, they serve adequate for the study. The strong baseline of data for the pre-construction phase of the 501N study area and Control Area will be utilized in the longer term Before-After-Control-Impact assessment.

501N Study Area:

Two years of data have been collected in 2019 and 2020. A complete comparative analysis was conducted for both the 501N Study Area and Control Area between years. To evaluate CPUE, a value of 1 was added to all raw count data and transformed using the natural log of the raw value. The residuals of the natural log-transformed count data fit a Gaussian error distribution and were, therefore, able to be evaluated using statistical tests assuming a normal distribution. Normality was confirmed through a Shapiro-Wilk Normality Test (W = 0.75, p = 2.2e-16), with 95% confidence intervals for CPUE reported assuming a Poisson distribution.

For the 501N Study Area, there was no difference in the lobster CPUE between 2019 and 2020 (K-S test, D=0.17, p-value=0.06). There was, however, a difference in the average size of all (Two Sample T-test, 2.91, df=308, p=0.004), male (Two Sample T-test, 2.26, df=197, p=0.03) and female (Two Sample T-test, 2.12, df=110, p=0.04) lobsters between years (Figure 13). There was also a difference in distribution of sizes between all (K-S test, D=0.12, p-value=0.02), male (K-S test, D=0.16, p-value=0.01), and female (K-S test, D=0.14, p-value=0.20) lobsters between years. Overall, lobsters were smaller in 2020, 87.24±5.89, than 2019, 90.75±1.14.

There was a difference in the ratio of females between years with a higher ratio in 2020 than 2019 (K-S test, D=0.71, p-value=0.02, figure 13). There was no difference in both shell disease presence (K-S Test, D=0.060, p-value=0.11) or egger ratio (Two Sample T-test, 1.65, df=14, p=0.12) between years.

Regarding black sea bass from black sea bass pots in the 501N study area there was no difference in CPUE (K-S test, D=0.07, p-value=0.96) but there was a difference in length between years (K-S test, D=0.07, p-value=0.96, figure 14). The 2019 mean length was higher in 2019, 33.06±0.57, than in 2020, 31.22±3.12.

There was a difference in temperature between years (K-S test, D=0.30 p-value=1.61e-04) with 2019 being higher than 2020. In the 501 N Study Area average temperature ranged from 9.04°C to 18.35°C in 2019 and 8.89°C to 17.71°C in 2020. There was no difference in stage 1 (K-S test, D=0.07, p-value=0.54), stage 2 (K-S test, D=0.02, p-value=1), stage 3 (K-S test, D=0.02, p-value=1), stage 4 (K-S test, D=0.01, p-value=1), or total larvae lobsters (K-S test, D=0.07, p-value=0.70) in the 501N Study Area between years.

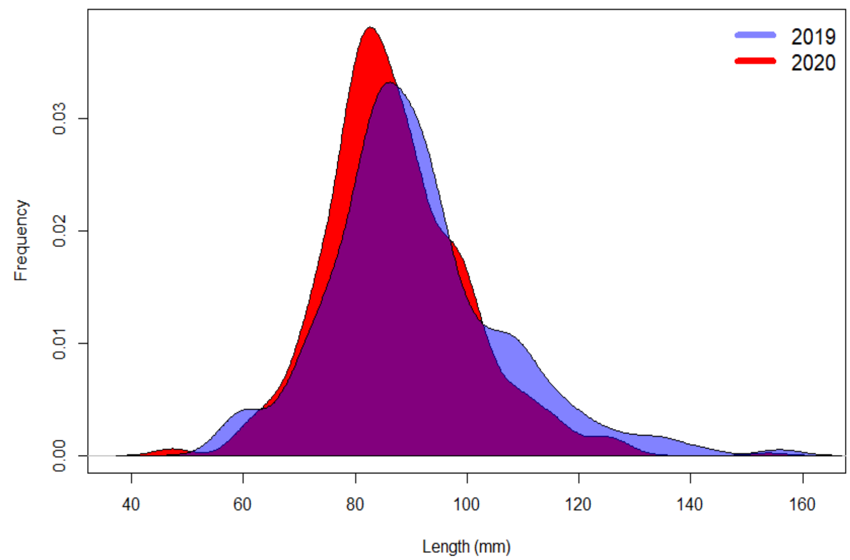

Figure 13. Proportional distribution of lobster carapace length by year in 501N Study Area.

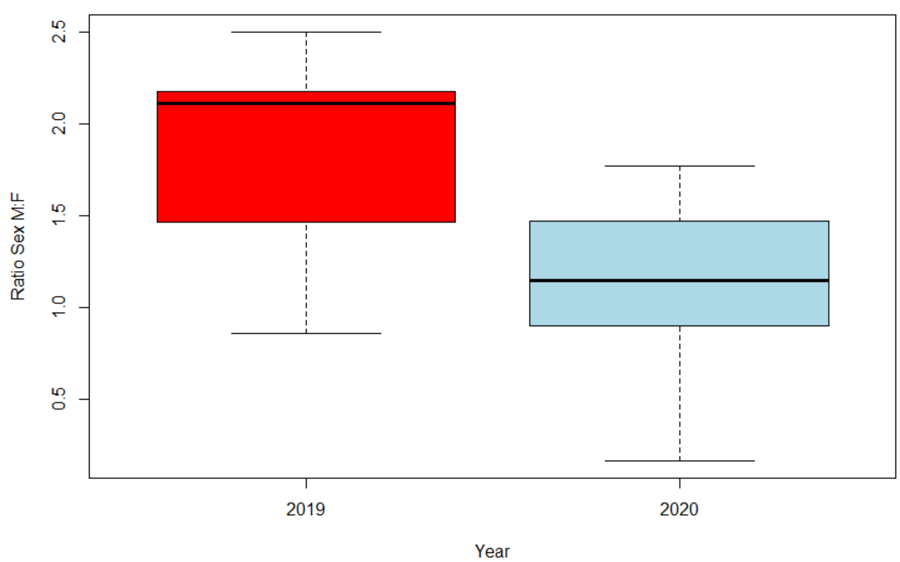

Figure 14. Boxplot of lobster sex ratio by year in the 501N Study Area.

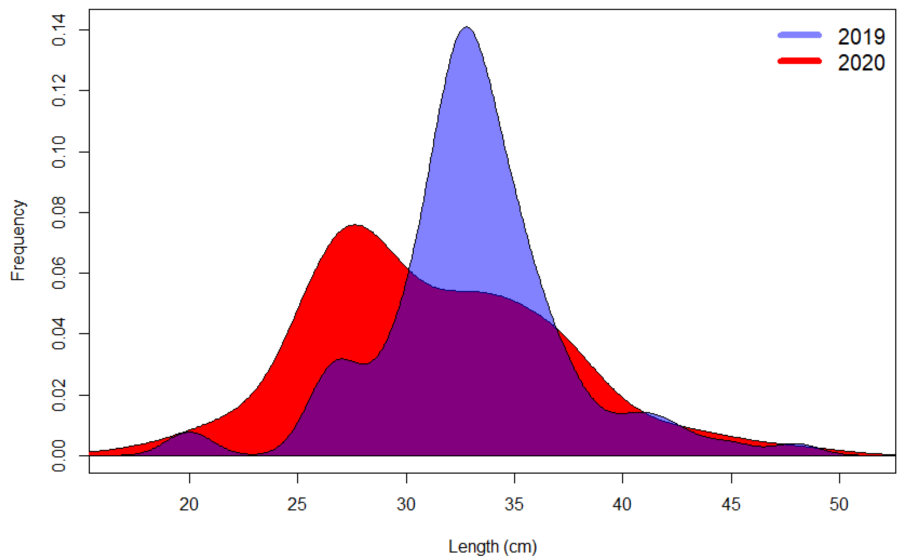

Figure 15. Proportional distribution of black sea bass length by year in 501N Study Area.

Control Study Area:

For the Control Area, there was no difference in the lobster CPUE between 2019 and 2020 (K-S test, D=0.16, p-value=0.13). There was no difference in average size of all (Two Sample T-test, -1.54, df=307, p=0.12), male (Two Sample T-test, -1.50, df=204, p=0.14), and female (Two Sample T-test, -0.87, df=96, p=0.38) lobsters between years. There was also no difference in distribution of sizes between all (K-S test, D=0.10, p-value=0.39), male (K-S test, D=0.10, p-value=0.59), and female (K-S test, D=0.14, p-value=0.72) lobsters between years.

There was a difference in the egger ratio of females between years with a higher ratio in 2019 than 2020 (Two Sample T-test, 2.70, df=11.12, p=0.02, Figure 15). There was no difference in both shell disease presence (Two Sample T-test, -0.42, df=13, p=0.68) or female ratio (K-S test, D=0.5, p-value=0.27) between years.

Regarding black sea bass from black sea bass pots in Control Area there was no difference in CPUE (K-S test, D=0.12, p-value=0.41), but a difference in length between years (K-S test, D=0.36, p-value=2.504e-12, figure 16). The 2019 mean length was higher in 2019, 33.68±1.66, than in 2020, 31.19±3.32.

There was a difference in temperature between years (K-S test, D=0.26 p-value=0.003) with 2020 being higher than 2019. In the control area average temperature ranged from 11.08°C to 18.40°C in 2019 and 9.58°C to 17.74°C in 2020. There was no difference in stage 1 (K-S test, D=0.07, p-value=0.87), stage 2 (K-S test, D=0.02, p-value=1), stage 3 (K-S test, D=0.02, p-value=1), stage 4 (0), or total larvae lobsters (K-S test, D=0.06, p-value=0.96) in the Control Area between years.

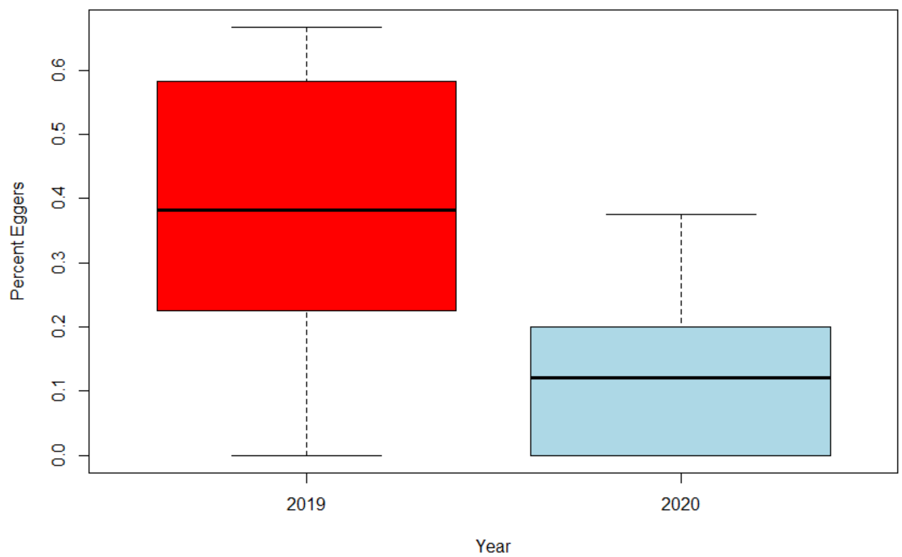

Figure 16. Boxplot of percent frequency of egg-bearing female lobsters by year in the Control Area.

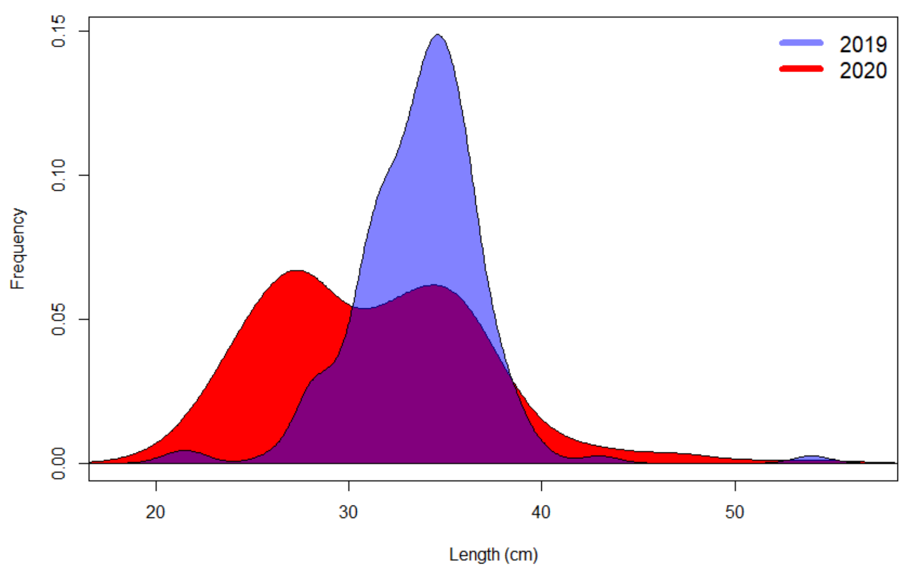

Figure 17. Proportional distribution of black sea bass length by year in the Control Area.

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Appendix I

Jonah Crab

A total of 3,828 Jonah crabs were collected from lobster traps in the 501N Study Area and Control Area: 67.3% (n=2,578) in the 501N Study Area and 32.7% (n=1,250) in the Control Area (Table 1, Figure 1). Total counts of Jonah crab fluctuated throughout the survey and the highest catches occurred in September into October. Average Jonah crab string CPUE in both study areas throughout the survey was 13.49±0.42 crab/string. The average CPUE in the Control Area was 9.19±0.50 crabs/string, and 17.78±0.68 crabs/string in the 501N Study Area (Table 1, Figure 2a).

Of the 3,828 Jonah crab counted throughout the survey duration 3,683 were measured and sexed. Ventless traps outperformed vented traps and caught 72.5% (n=2,776) of Jonah crab compared to 27.5% (n=1,052) caught in vented traps (Table 2, Figure 2b). Vented traps tended to capture larger crabs compared to ventless traps. Jonah crabs captured in ventless and vented traps had an average and range carapace widths of 119.19±0.41 mm (24-179 mm) and 120.41±0.69 mm (35-170 mm), respectively. Jonah crab carapace width varied by area: on average animals caught in the 501N Study Area were larger than in the Control Area. Carapace width average and range of 120.57±0.44 mm (24-163 mm) were recorded in the 501N Study Area, and 117.44±0.60 mm (41-179 mm) in the Control Area (Table 1).

Jonah crab sex ratio remained consistently male-skewed throughout all sampling periods. Of the 3,683 crabs sexed, 93.3% (n=3,438) were males and 6.7% (n=245) were females. The highest occurrence of female Jonah crab in both study areas was in October. Overall, October produced 66.5% of all females recorded for all months: n=67 in the 501N Study Area and n=94 in the Control Area. Average male: female sex ratios over the survey duration were 19.5 and 9.1 from the 501N Study Area and Control Area, respectively. This resulted in a combined sex ratio of 14.2 males for every one female. No females were observed to have any level of external egg development.

Table 1. Summary of area-level Jonah crab data collected throughout the duration of the study.

Sampling Period	Area	Month	Temp (°C)	N (Caught)	N (Measured & Sexed)	CPUE	Mean CW (mm)	Sex Ratio (M:F)
1	Control	June	10.38	74	74	4.93	123.72	-
2	Control	June	10.75	72	72	4.80	117.74	35.0
3	Control	July	12.05	80	80	5.33	123.69	15.0
4	Control	July	11.85	57	54	4.07	128.74	-
5	Control	August	11.54	94	93	6.71	123.78	-
6	Control	August	15.85	104	104	6.93	125.32	103.0
7	Control	September	17.42	97	97	7.46	121.96	11.1
8	Control	September	16.16	314	312	24.15	118.02	23.0
9	Control	October	15.86	181	181	13.92	121.91	24.9
10	Control	October	16.28	177	177	13.62	92.37	1.0
1	501N	June	9.40	185	185	12.33	123.15	184.0
2	501N	June	9.71	309	196	20.60	121.96	48.0
3	501N	July	10.25	139	139	9.27	125.68	-
4	501N	July	10.30	119	119	7.93	124.13	58.5
5	501N	August	9.99	282	282	18.80	122.24	93.0
6	501N	August	14.22	267	264	17.80	121.81	16.6
7	501N	September	17.26	152	145	10.73	120.23	13.5
8	501N	September	15.67	304	290	21.71	117.31	16.1
9	501N	October	15.67	374	374	26.71	119.06	16.8
10	501N	October	15.60	447	445	31.93	118.03	8.7
Average	Control	All	13.88±0.64	1250	1244	9.19±0.50	117.44±0.60	9.1
Average	501N	All	12.76±0.58	2578	2439	17.78±0.68	120.57±0.44	19.5
Average	Both	All	13.29±0.43	3828	3683	13.49±0.42	119.51±0.35	14.2

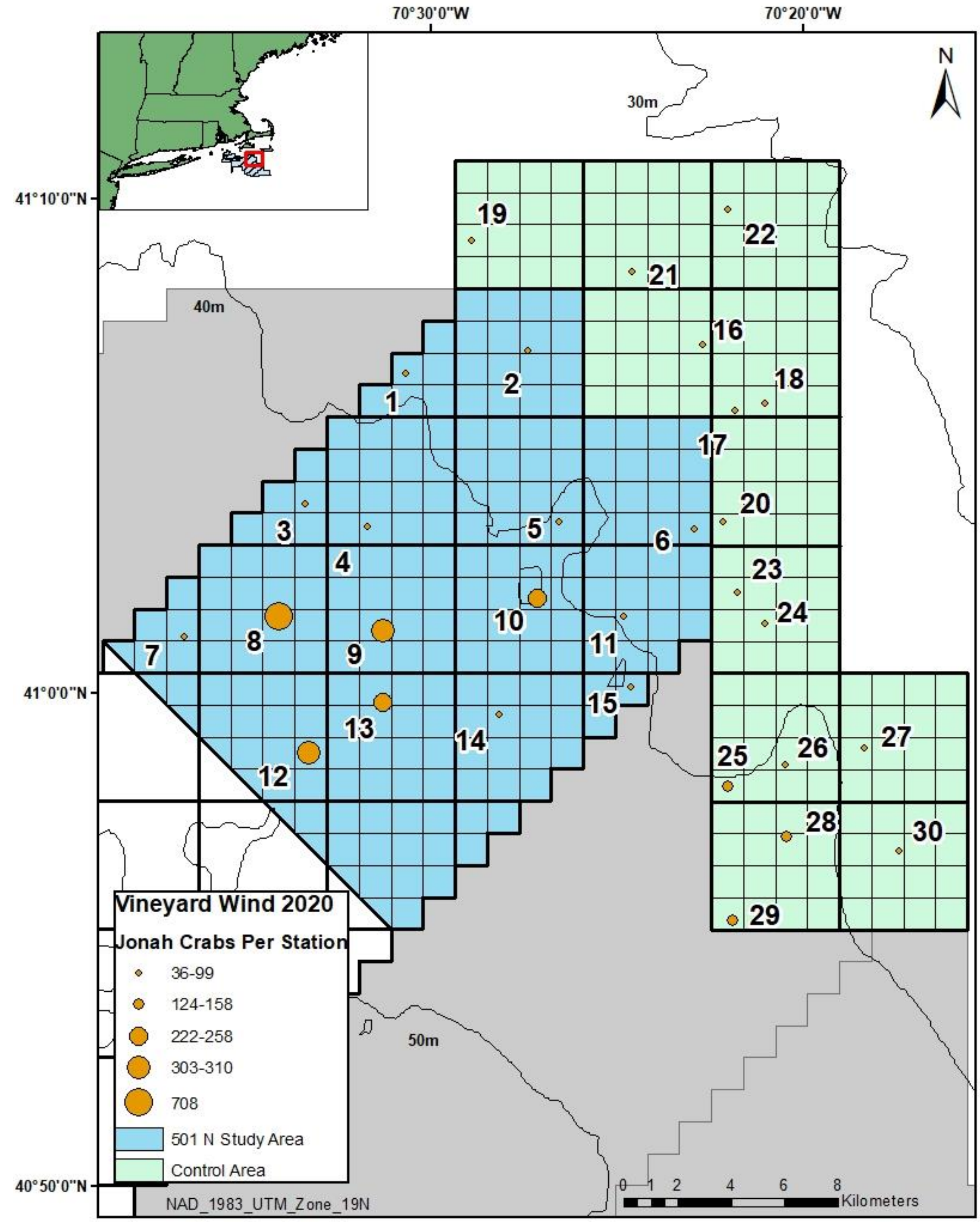

Figure 1. The distribution of Jonah crab sampled at all locations over the course of the study.

Table 2. A summary of Jonah crab data organized by trap type.

Sampling Period	Trap Type	Month	Number (Caught)	% Caught	CPUE	Mean CW (mm)
1	Vented	June	48	19%	0.53	129.92
2	Vented	June	65	17%	0.72	123.46
3	Vented	July	60	27%	0.67	127.85
4	Vented	July	44	25%	0.51	132.51
5	Vented	August	85	23%	0.98	130.35
6	Vented	August	95	26%	1.06	125.68
7	Vented	September	100	40%	1.20	124.78
8	Vented	September	128	21%	1.58	117.41
9	Vented	October	116	21%	1.43	124.16
10	Vented	October	311	50%	3.93	103.91
1	Ventless	June	211	81%	2.34	121.81
2	Ventless	June	316	83%	3.51	119.98
3	Ventless	July	159	73%	1.73	123.89
4	Ventless	July	132	75%	1.52	123.13
5	Ventless	August	291	77%	3.34	120.33
6	Ventless	August	276	74%	3.07	121.57
7	Ventless	September	149	60%	1.87	118.48
8	Ventless	September	490	79%	6.28	117.75
9	Ventless	October	439	79%	5.42	118.86
10	Ventless	October	313	50%	3.86	114.30
Average	Vented	All	1052	27%	12.60±0.41	120.41±0.69
Average	Ventless	All	2776	73%	32.95±0.67	119.19±0.41

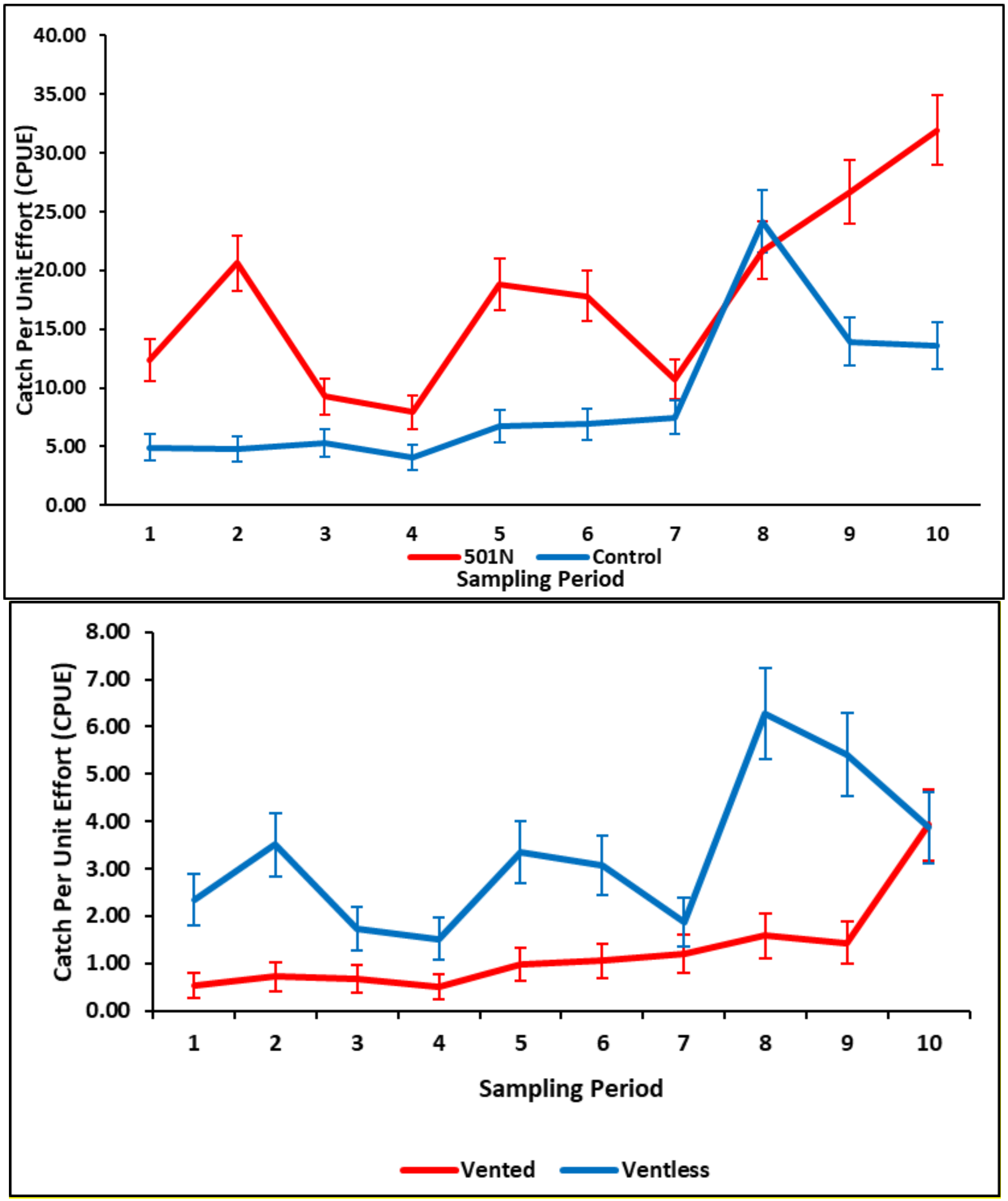

Figure 2a. Average Jonah crab CPUE (catch per string) results with standard error bars (95% confidence interval) for the Study Areas (top). **Figure 2b.** Estimates of trap type performance over the duration of the survey (bottom) with standard error bars (95% confidence interval).

APPENDIX II

Bycaught Species

Rock crabs were the most abundant species observed in both study areas throughout the duration of the survey: n=11,863 and n=11,829 were collected in lobster traps from the 501N Study Area and Control Area, respectively. In the 501N Study Area, red hake (n=1,337), black sea bass (n=289), and hermit crabs (n=200) were observed, while red hake (n=927), black sea bass (n=651), and scup (n=329) produced the next highest counts in the Control Area (Table 1). Commonly observed bycatch from un-baited sea bass pots located in the Control Area was rock crab (n=406), scup (n=303), and Jonah crab (n=145). This differed slightly within the 501N Study Area, as rock crab (n=308), Jonah crab (160), and scup (n=98) were most regularly observed as bycatch in sea bass pots. Overall, rock crab (n=24,406) was the most frequently encountered species across all trap configurations in both study areas.

Table 1. Break down of total counts for bycaught species in each study area.

Species	Lobster Traps (Both Types)		Seabass Pots		Total
	501N	Control Area	501N	Control Area	
RockCrab	11,863	11,829	308	406	**24,406**
JonahCrab	2,578	1,250	160	145	**4,133**
RedHake	1,337	927	44	39	**2,347**
BlackSeaBass	289	651	149	307	**1,396**
Lobster	662	259	12	8	**941**
Scup	162	329	98	303	**892**
Hermit	200	49	1	2	**252**
Pout	125	63	5	2	**195**
SpottedHake	138	25	1	1	**165**
Conger	84	78	1	1	**164**
SeaRaven	33	34	10	1	**78**
SpiderCrab	19	42	0	10	**71**
SpinyDog	21	23	0	0	**44**
Sculplin	12	10	2	0	**24**
Skate	7	10	0	0	**17**
SmoothDogfish	3	9	0	0	**12**
SilverHake	9	0	0	1	**10**
Monkfish	7	2	0	0	**9**
MoonSnail	5	3	1	0	**9**
SeaRobin	2	5	0	0	**7**
TriggerFish	0	6	1	0	**7**
Cod	1	3	1	1	**6**
Butterfish	0	5	0	0	**5**
BarrelFish	1	0	3	0	**4**
FourSpot	1	3	0	0	**4**
Scallop	1	3	0	0	**4**
Tautog	2	2	0	0	**4**
TileFish	0	2	0	1	**3**
Cunner	1	1	0	0	**2**
WhiteHake	0	2	0	0	**2**
Cusk	0	1	0	0	**1**
SummerFlounder	0	1	0	0	**1**
Totals	**17,563**	**15,627**	**797**	**1,228**	**35,215**

APPENDIX III

Substrate Composition

The substrate composition was sand across both study areas in 2019 (Figure 1) and 2020 (Figure 2). These results were gathered from the SMAST Drop Camera Survey of Benthic Communities and Substrate in Vineyard Wind Lease Area OCS-A 0501 and a Control Area that was conducted in July and October 2019 and 2020.

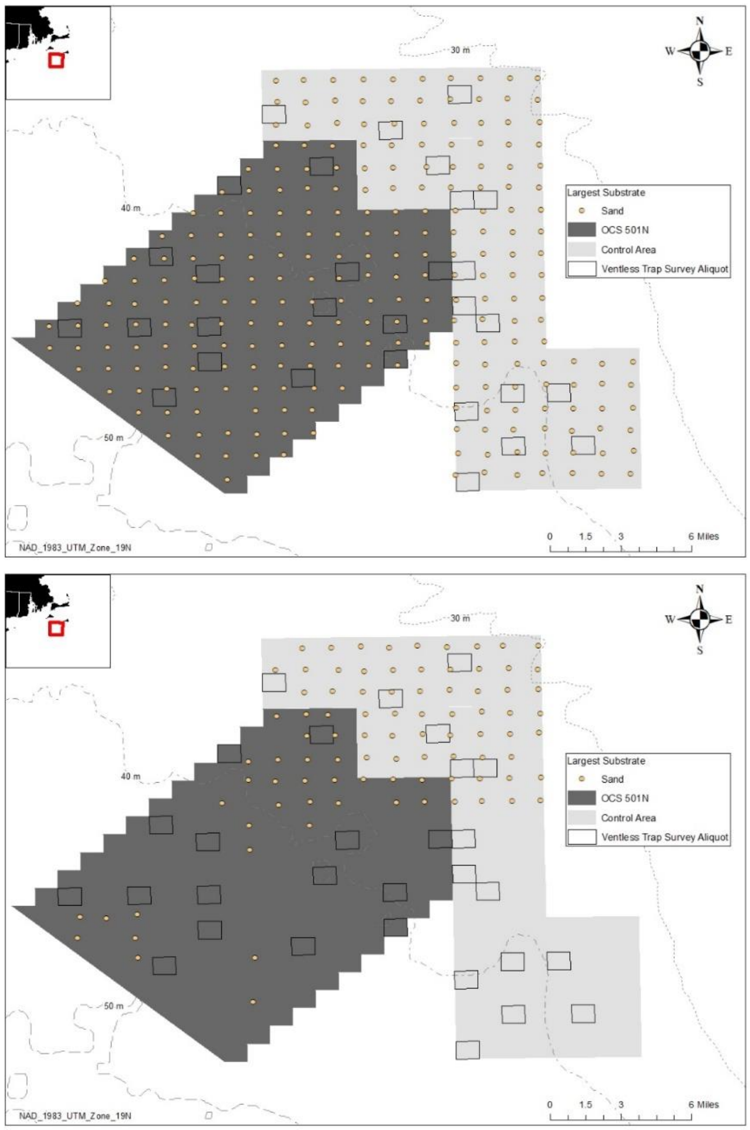

Figure 1. Results from the SMAST Drop Camera Survey of Benthic Communities and Substrate in Vineyard Wind Lease Area OCS-A 0501 and a Control Area showing the largest substrate type present at each sampling aliquot from July (top) and October 2020 surveys (bottom).

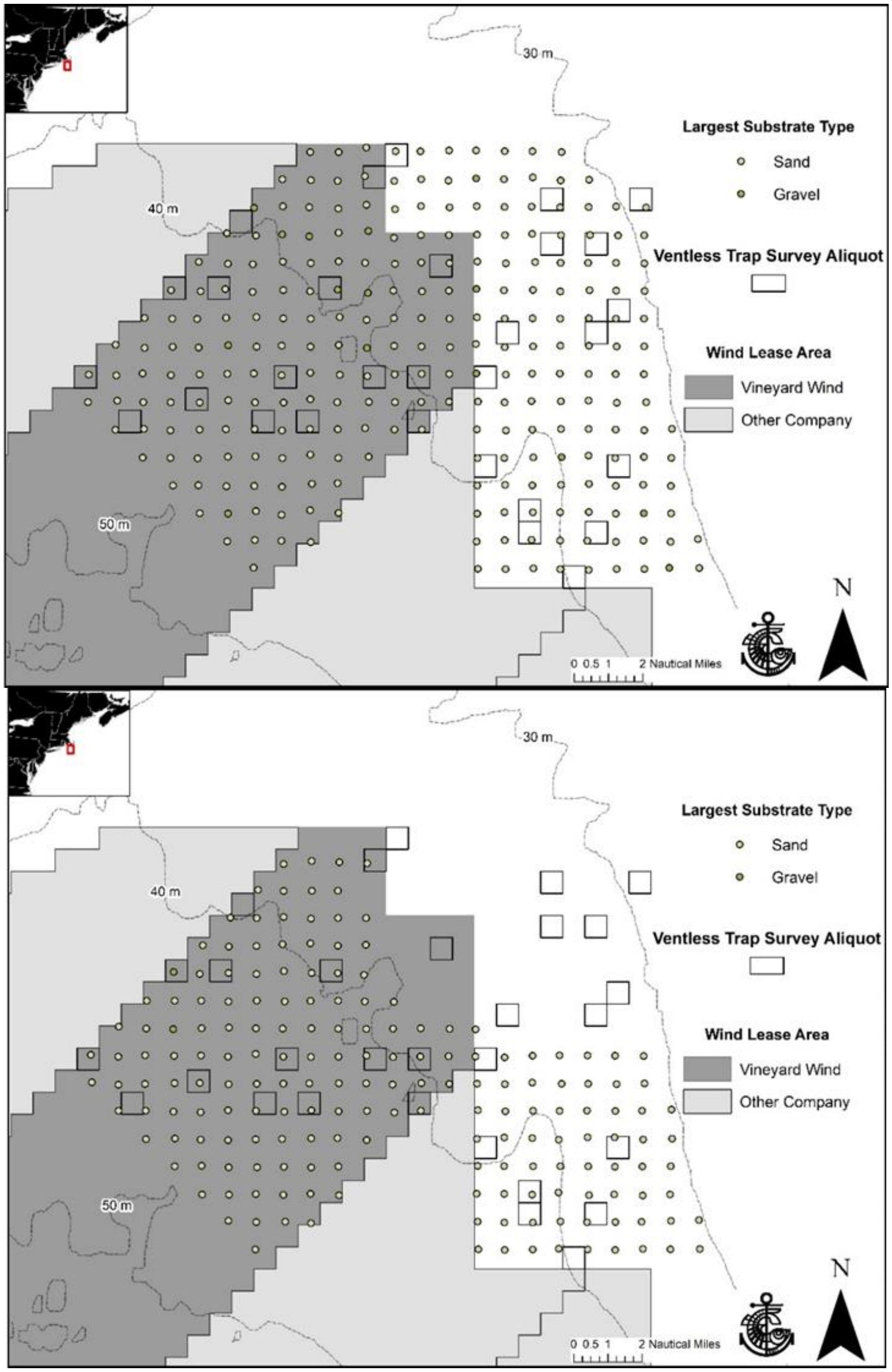

Figure 2. Results from the SMAST Drop Camera Survey of Benthic Communities and Substrate in Vineyard Wind Lease Area OCS-A 0501 and a Control Area showing the largest substrate type present at each sampling aliquot from July (top) and October 2019 surveys (bottom).