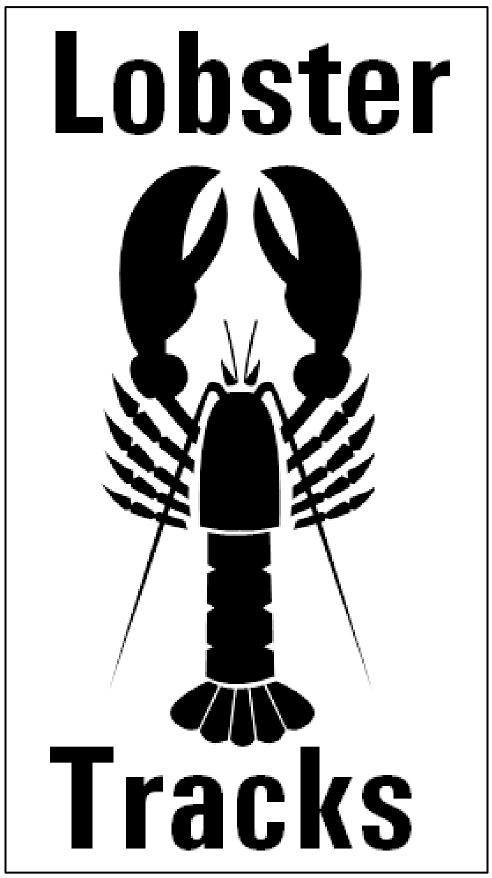
OCS Study
BOEM 2021-010

Spatial and Temporal Distributions of Lobsters and Crabs in the Rhode Island/Massachusetts Wind Energy Area

2018 Update



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Spatial and Temporal Distributions of Lobsters and Crabs in the Rhode Island/Massachusetts Wind Energy Area

2018 Update

July 2019

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DISCLAIMER

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Cover graphic by Anna Malek Mercer.

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Abbreviations and Acronyms

ASMFC	Atlantic States Marine Fisheries Commission
BOEM	Bureau of Ocean Energy Management
CMECS	Coastal and Marine Ecological Classification Standard
MADMF	Massachusetts Division of Marine Fisheries
OCS	Outer Continental Shelf
RAFOS	Sound Fixing and Ranging (inverted)
RIDEM	Rhode Island Department of Environmental Management
RIMA WEA	Rhode Island/Massachusetts Wind Energy Area
RIS	Rhode Island Sound
SNECVTS	Southern New England Cooperative Ventless Trap Survey
WEA	Wind Energy Area

1. Introduction

A goal of marine spatial planning is to aid in siting activities in areas that will minimize, to the extent possible, the cumulative impacts on resident species while maintaining the ecological and economic services derived from marine regions (Crowder & Norse 2008). A core challenge of developing a spatial management plan is the acquisition of knowledge concerning the distributions, population structures, interactions and trends of key species and communities (Foley et al. 2010). Research to address these knowledge gaps has been undertaken in the vicinity of the study area for this project, the Rhode Island/Massachusetts Wind Energy Area (RI/MA Lease Area) in Southern New England. Rhode Island's Ocean Special Area Management Plan compiled the available knowledge of finfish, shellfish and fisheries in the offshore waters of RI (Olsen et al. 2014). Trawl surveys throughout Rhode Island Sound and Block Island Sound have begun to characterize fish populations (Malek et al. 2014), but spatial coverage is limited by the presence of fixed fishing gear, such as gillnets and lobster trawls, and the inaccessibility of rocky bottom. Prior to this study, the distribution and dynamics of the American lobster (*Homarus americanus*), one of the most valuable species in New England, was poorly understood, especially on the inner continental shelf, beyond state waters (ASMFC 2009). With the leasing of areas for offshore wind-energy development, it became essential to evaluate the baseline status of the lobster population in the Rhode Island/Massachusetts Wind Energy Area (RIMA WEA), to inform the impact assessment of wind turbines within the lease area and to monitor the potential impacts of wind turbine construction.

The American lobster fishery remains one of the most valuable fisheries in Southern New England, with 2013 landings of 3.3 million pounds worth $15 million in revenue (ASMFC 2015). Massachusetts and Rhode Island are the primary contributors to the Southern New England lobster fishery, supporting fleets of 1,500 and 250 vessels, respectively (MADMF 2010, Hasbrouck et al. 2011). In addition to nearly 2,000 commercial fishing jobs, the southern New England lobster fishery also sustains a variety of support businesses, such as trap-builders, gear suppliers, bait and ice dealers, shipyards, fuel companies, engine sales and repair businesses, and marine electronic retailers. Since peaking in the late 1990s, the Southern New England lobster stock has become severely depleted, especially the inshore component of the stock, where environmental conditions have remained unfavorable for lobsters (ASMFC 2015). Since 2008, a higher percentage of landings has come from the offshore stock component of the Southern New England fishery.

Jonah crab (*Cancer borealis*) has long been considered a bycatch species in the commercial American lobster fishery. However, an increase in market demand coupled with declining lobster abundance in southern New England have resulted in significant Jonah crab landings over the last decade, resulting in a mixed-crustacean fishery. During the three-year period 2012-2014, MA and RI accounted for 93% of the Jonah crab landings, most of which came from southern New England. The 2018 ex-vessel value of the Jonah crab fishery in southern New England exceeded $10 million. As the Jonah crab fishery began developing, the Atlantic States Marine Fisheries Commission (ASMFC) initiated the first Jonah Crab Interstate Fisheries Management Plan (FMP) to sustain the resource while optimizing yield (ASMFC 2015). Under the FMP, several Jonah crab management regulations were adopted, including a minimum size of 4.75 inches and prohibition of egg-bearing females. While the FMP recognizes both the growing industry and need for proper scientifically-based management, few data are available describing the species. As will be seen below, Jonah crab was the most numerous species in this ventless trap survey.

This document provides the final report of a one-year continuation of the Southern New England Cooperative Ventless Trap Survey (SNECVTS), which was originally conducted from 2014-2015. SNECVTS was developed to provide a baseline assessment of the lobster and crab populations in the RIMA WEA prior to offshore wind energy development in southern New England. In addition, the survey was designed to contribute to the assessment of the Southern New England lobster stock, which is currently at a low level of abundance (ASMFC 2015). The study was necessary to establish the pre-construction status of the lobster population, without which potential effects post construction would not be discernable from the effects of fishing and other population stressors (Schmitt & Osenberg 1998). To the extent possible, this project followed ASMFC survey protocols and adhered to the Atlantic Coastal Cooperative Statistics Program data requirements.

Throughout this report, the original two-year SNECVTS survey from 2014-2015 will be referred to as Phase I, and the single year continuation of the survey (May 2018 – November 2018) will be referred to as Phase II. Small changes to the survey design and protocols were made during Phase II, which will be discussed in detail throughout this report.

1.1 Project Objectives

The objectives of the one-year continuation of SNECVTS through Phase II were as follows:

1) Assess the seasonal movement, local distribution, and habitat use of the American lobster (*Homarus americanus*) in areas of wind energy development in Southern New England (i.e. the RI/MA Lease Area and Massachusetts Wind Energy Area).

2) Assess the local distribution and habitat use of Jonah crab (*Cancer borealis*), a species of emerging economic importance, in areas of wind energy development in Southern New England (i.e. the RI/MA Lease Area and Massachusetts Wind Energy Area).

Both of these objectives are identified as priorities in BOEM's Environmental Studies Program Studies Development Plan for FYs 2017-2019 (BOEM 2016).

2. Survey Design and Description

The survey was a cooperative project that included representatives of the Rhode Island lobster industry, the University of Rhode Island, and Commercial Fisheries Research Foundation. The participating vessel captains and fishing vessels were:

- Wayne Fredette, F/V Three Sons, Point Judith, RI
- Greg Lisi, F/V Amelia Anne, Point Judith, RI
- Eric Marcus (Rich Lodge, alternate), F/V Persistence, Point Judith, RI

The same twenty-four lease blocks from SNECVTS Phase I in the RI/MA Lease Area were included in SNECVTS Phase II (Figures 1 and 2). These blocks were selected based on their potential development for wind energy, and the practicality of conducting a monitoring survey with lobster boats. In consultation with the lobstermen, five aliquots (1/16 of a BOEM lease block or 1,200 m^2) that would be suitable for the survey were selected from each lease block, given known fishing grounds and gear conflicts. Each year, one of these five aliquots from each lease block was randomly chosen for sampling, along with another aliquot as an alternate. This sampling design provided a broad coverage over the selected lease blocks with randomized placement within each lease block. This stratified random design allows the results from the selected stations to be generalized over the study area. The sampling density translates to one station per 9 square nautical miles. The coordinates of the selected aliquots are listed in Appendix 2.

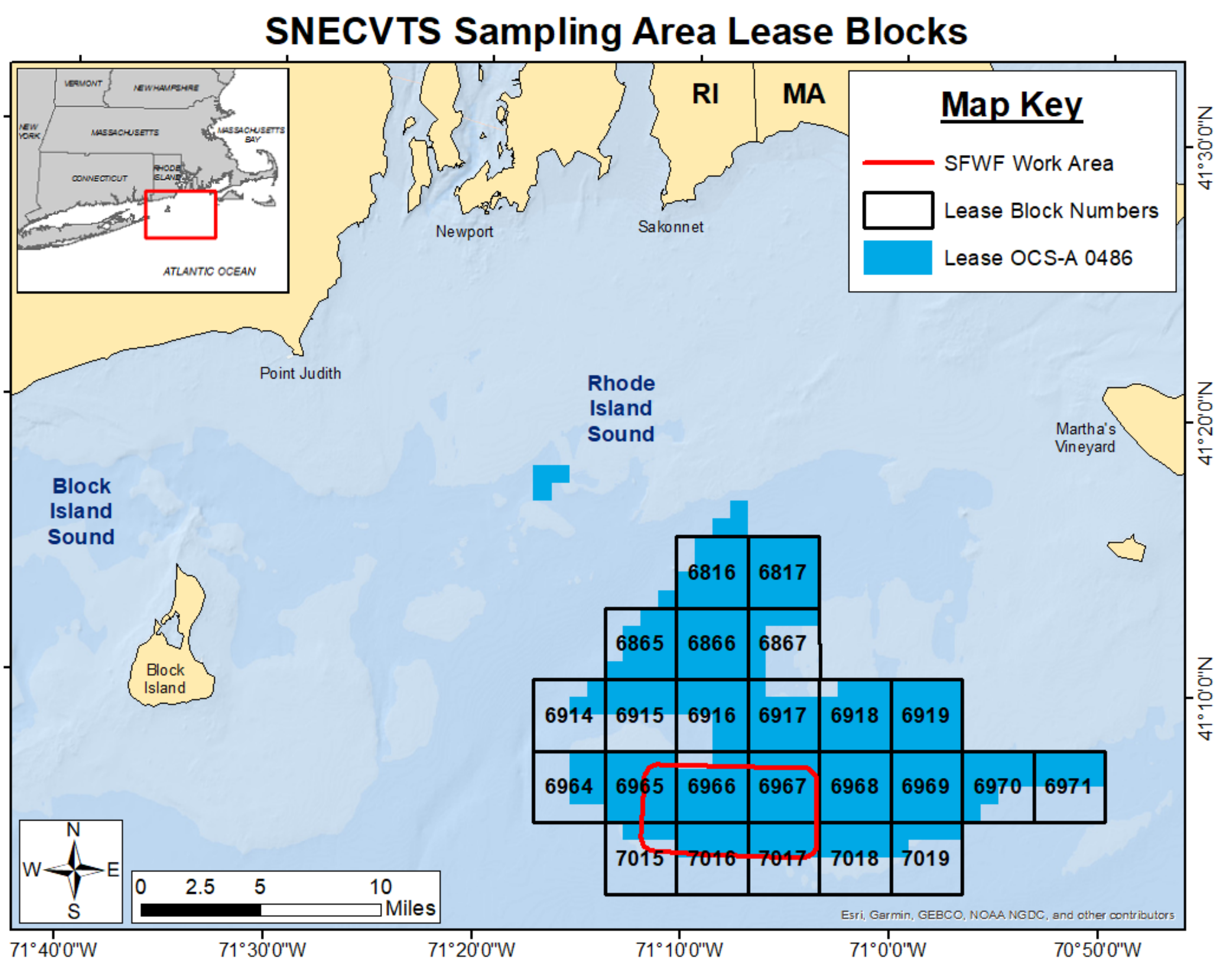

Figure 1. Study site of the Rhode Island/Massachusetts Wind Energy Area encompassing BOEM Lease OCS-A 0486 and associated lease blocks. SFWF is the South Fork Wind Farm.

The sampling design employed in this project is consistent with Atlantic States Marine Fisheries Commission (ASMFC 2010) ventless trap survey, in which stations are selected randomly at the start of the season and are then retained for the duration of the year. New stations are then randomly selected each year of the survey. Maintaining fixed locations approximates the operations of commercial lobstermen, keeps the locations occupied within the sampling season, and reduces the time spent moving gear. Exceptions of moving sampling gear within a year were only made in the event of repeated occurrences of lost gear due to gear conflict with other fishing activities in the area.

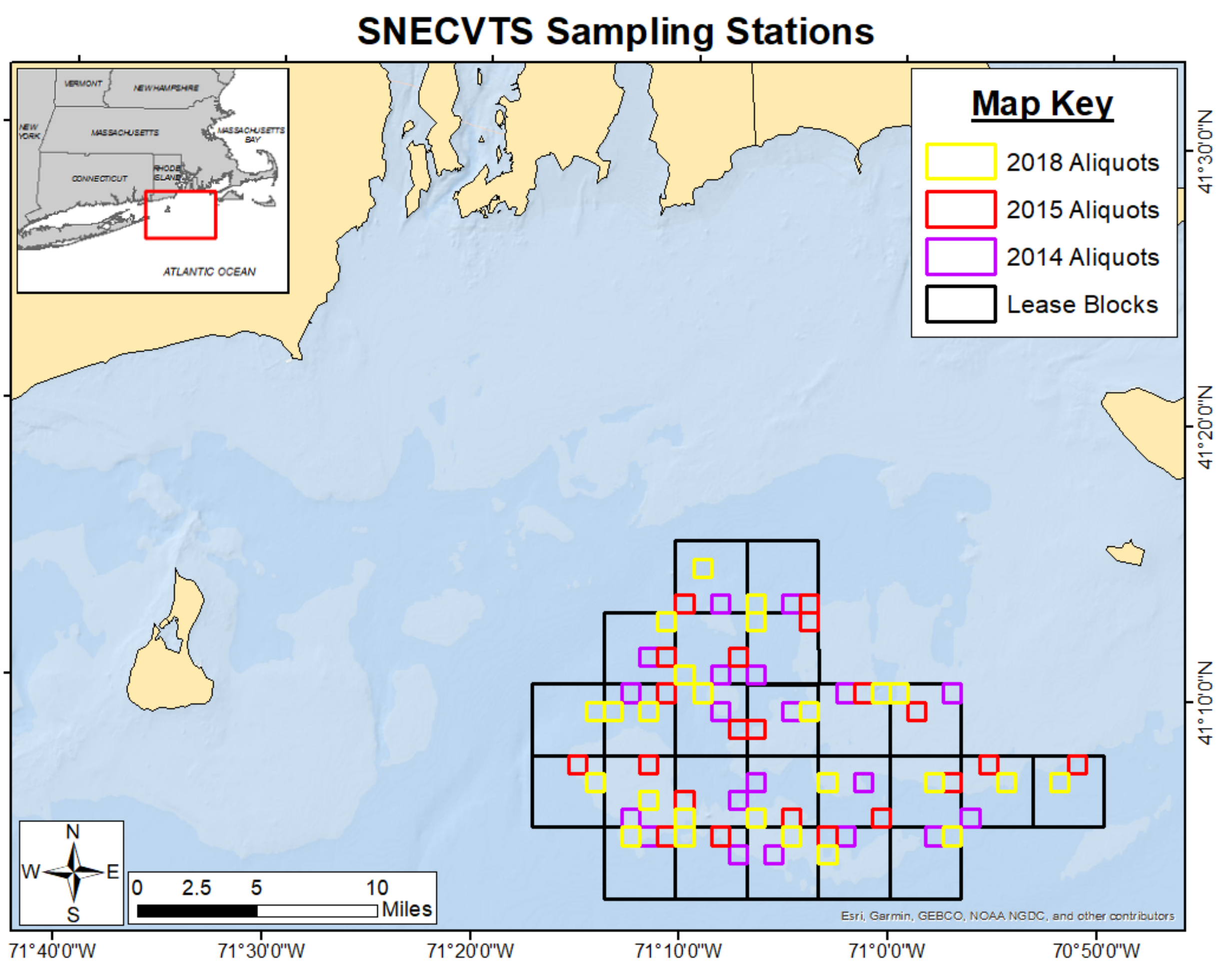

Figure 2. Study site and sampled aliquots in the Rhode Island/Massachusetts Lease Area. Coordinates and depths of the sampling locations are given in Appendix 2.

2.1 Description of the Sampling Gear

Trap design:

- 40” length x 21” width x 16” height
- Single parlor
- 5” entrance hoops
- 1” square rubber coated 12-gauge wire
- Standard shrimp mesh netting
- Wood runners with three “ergo” blocks
- 4” x 6” disabling door
- One rectangular vent with dimensions 5-3/4” length x 1-15/16” height

This trap design is consistent with ASMFC coastwide, ventless trap surveys (ASMFC 2010). Traps were deployed on ten-trap trawls with 100-ft separation between traps. Six ventless traps (V) were alternated with four standard traps (S) so that the data can be compared with commercial catch rates, resulting in a trap pattern of (V-S-V-S-V-V-S-V-S-V). Longer trawls are required offshore to provide more weight and ease of recovery in the event that buoys are lost.

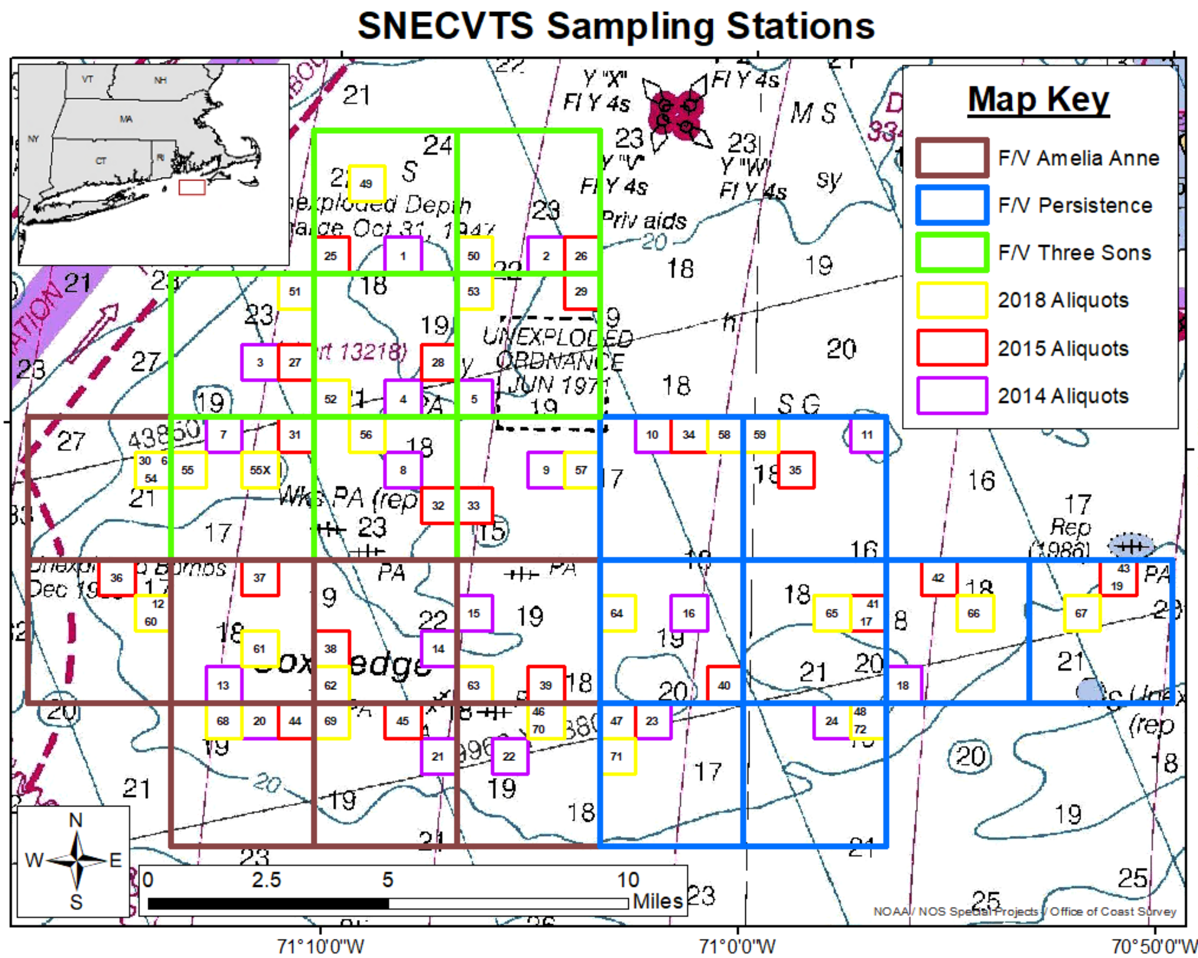

Figure 3. Detail of the study area showing the 24 lease blocks, the 2014 aliquots (purple boxes), the 2015 aliquots (red boxes), and the 2018 aliquots (yellow boxes). Note that aliquots 6, 30, and 54, 12 and 60, 17 and 41, 19 and 43, 46 and 70, and 48 and 72 were repeated between years; all other aliquots are distinct. In Phase II, aliquot 55 was relocated after multiple events of gear loss, the new sampling station is indicated as aliquot 55X.

3. Summary of Biological Sampling

Given the spatial extent of the study area, three commercial lobster boats were needed to conduct the survey. An additional vessel was on standby in case of mechanical problems with the primary vessels. Each boat was responsible for eight trawls (80 traps) in a particular segment of the overall study area (Figure 3). In Phase I, each boat sampled eight stations over four days each month from May through October. However, in Phase II, each boat sampled eight stations three days per month from May through November to better capture the tail end of the lobster and crab fisheries in the area. The first day per month was allocated to baiting the traps with skate and the remaining days per month to sampling catch. The target soak time (number of days between baiting and sampling) was five days (Table 1), which differs from the three-day soak time used in state ventless trap surveys. A longer soak time was used because lower densities of lobsters were expected offshore compared with inshore areas of Maine and Massachusetts, and because of the logistics of sampling offshore. The majority of soak times were 5 days; deviations from the target were due to adverse weather conditions. In 2018, a full ten-trap trawl was lost on one sampling trip due to unknown causes. After the final sampling day per month, the traps were disabled for the remainder of the month. On-board data sampling was conducted by two qualified biologists. Data were collected on audio recorders and transcribed onto computer tablets. Over the course of three years, a total of 11,990 trap hauls were sampled.

Table 1. Frequency and percentage of soak times by year.

Year	4 Days	5 Days	6 Days	7 Days	8 Days	Totals
2014	1	343	56	8	24	432
2015	48	272	104	8	0	432
2018	48	191	48	24	24	335
2014	0%	79%	13%	2%	6%	100%
2015	11%	63%	24%	2%	0%	100%
2018	14%	57%	14%	7%	7%	100%

3.1 Data Parameters Collected for Lobster, Jonah Crab and Bycatch

Lobster Parameters:

- Carapace length (mm) measured with digital calipers
- Sex (determined by examining the first pair of swimmerets)
- Egg status (presence or absence)
- V-notch status (presence or absence)
- Shell hardness (hard or soft)
- Cull status (claws missing, buds, or regenerated)
- Incidence of shell disease (none – 0% coverage, moderate – 1%-50% coverage, or severe – 50%-100% coverage)
- Mortality (alive or dead)

Jonah Crab Parameters:

- Carapace width (mm) measured with digital calipers
- Sex (determined by examining abdomen)
- Egg status (presence or absence)
- Shell hardness (hard or soft)
- Cull status (claws missing, buds, or regenerated)
- Mortality (alive or dead)

Bycatch Parameters:

- Species
- Size (total length in cm for fish species, carapace or shell width in mm for crab and shellfish)
- Sex (if possible depending on species)

Legal sized lobsters were not retained for sale and all lobsters were returned to the water in the area where they were caught. The target species were lobster and Jonah crab, but other crabs and fish species were also speciated, enumerated, and measured as bycatch. In Phase I, up to 10 Jonah crabs per trap were measured and their sex recorded; if more than 10 Jonah crabs were caught, a subsample of 10 was measured. In Phase II, the number of Jonah crabs subsampled was increased to 20 per trap. In Phase I, rock crab (*Cancer irroratus*) were enumerated for each trap; however, in Phase II a subsample of 10 rock crab were measured per trap. These changes were instituted because of increased interest in the crab fishery. The physical variables collected at each station included latitude, longitude, depth, temperature, sea state, and wind direction and velocity. Bottom temperature was measured with data loggers, one of which was attached to each trawl. Wind direction and velocity were measured with a hand-held weather meter.

4. Habitat Studies and Classification

In Phase I, sedimentary composition of each sampling site was characterized with sidescan sonar, followed by ground-truth data of three grab samples taken along the transect where traps were set. In addition, a video camera on the grab sampler provided visual confirmation of habitat type. In Phase II, sedimentary composition of each site was characterized with a camera system.

4.1 Habitat Camera

For each aliquot included in Phase II, a video and still imaging habitat camera sled system was used to collect imagery of the seafloor in each aliquot. The camera sled system consisted of an Applied Microvideo 310 camera which provided video imaging and live video streams during deployment, and a GoPro Hero 3+ which provided still images of the seafloor at 2 second intervals. Depending on ocean conditions and drift direction and speed, imaging was conducted for a single ten-minute drift along the ten-trap trawl or two five minute drifts along the ends of the ten-trap trawl at each aliquot. The camera sled was deployed one meter off the seafloor, and two 510 lumen LED lights (Ikelite Pro-V8 LED Video Light) illuminated the seafloor.

4.2 Data Integration and Aliquot Bottom Type Classification

In Phase I, habitat categories were chosen that are relevant to this study and also consistent with the substrate component of the Coastal and Marine Ecological Classification Standard (CMECS) classification framework. The substrate component was the only component that could be applied to the datasets collected for this study (Table 2 and 3). Based on those four CMECS habitat classifications from Phase I, habitat imagery was used to classify all aliquots from Phase II into the same four CMECS habitat categories independently by two individuals; each individual reviewed ten randomly selected five-second segments of video from each aliquot and classified the aliquot based on the dominant habitat type. If video quality was insufficient to determine habitat type for any segment of video, GoPro still images were used. Discrepancies between the two independent classifications were reexamined and reclassified by both individuals together for consistency. For Phase II aliquots which overlapped Phase I aliquots with sidescan sonar and grab samples, habitat classifications were validated for consistency. Habitat camera imaging was completed for all 24 original aliquots in Phase II. Aliquot 55X, which was moved from aliquot 55 in October due to gear loss, was not sampled with the habitat camera sled system. Sidescan sonar data and consultation from Dr. John King of URI were used to classify the habitat type in aliquot 55X.

The number of bottom-type categories was not pre-defined in Phase I; instead, aliquots with similar characteristics were grouped together as appropriate. The bottom-type categories were given names believed to be meaningful to the end user. Four habitat categories were generated: soft sediments (comprising clay, silt, very fine sand, and fine sand), medium to coarse sand (comprising medium, coarse, and very coarse sands), boulders on sand (boulders on medium to coarse sand), and transition zone (where a change in bottom type was evident within an aliquot). These categories and their corresponding CMECS classifications are given in Tables 2 and 3. The habitat classification of each aliquot is listed in Appendix 2 and mapped in Figure 4. Bottom types are patchily distributed throughout the lease area. Medium to coarse sand occurs throughout the study area. Soft sediments are confined to the northern, deeper aliquots. Boulders on sand occurred in the southwest and central aliquots. Finally, the transition zone habitat occurred in central and eastern aliquots. Figures 5-8 show examples of each habitat type.

Table 2. CMECS Substrate Component Classification for bottom type categories.

Component Code	Unit Code	Origin	Class	Subclass	Group	Subgroup
S	1.2.2	Geologic Substrate	Unconsolidated Mineral Substrate	Fine Unconsolidated Substrate	See Below	See Below

Table 3. CMECS Substrate Component 'Group' and 'Subgroup' Classifications.

Bottom Type Category	Unit Code	Group	Subgroup	CMECS Modifier
Soft Sediment	1.2.2.2.4 1.2.2.2.5 1.2.2.3.1-3 1.2.2.4.1-3 1.2.2.5.1-3	Sand Sand Muddy Sand Muddy Mud Mud	Fine Sand Very Fine Sand Silty Sand, Silty-Clayey Sand Sandy Silt, Sandy Silt-Clay, Sandy Clay Silt, Silt-Clay, Clay	
Medium to Coarse Sand	1.2.2.2.1 1.2.2.2.2 1.2.2.2.3	Sand Sand Sand	Very Coarse Sand Coarse Sand Medium Sand	
Boulders on Sand	1.2.2.2.2 1.2.2.2.3	Sand Sand	Very Coarse Sand Coarse Sand	Boulders Boulders
Transition Zone	Combination of more than one of the other habitat categories.			

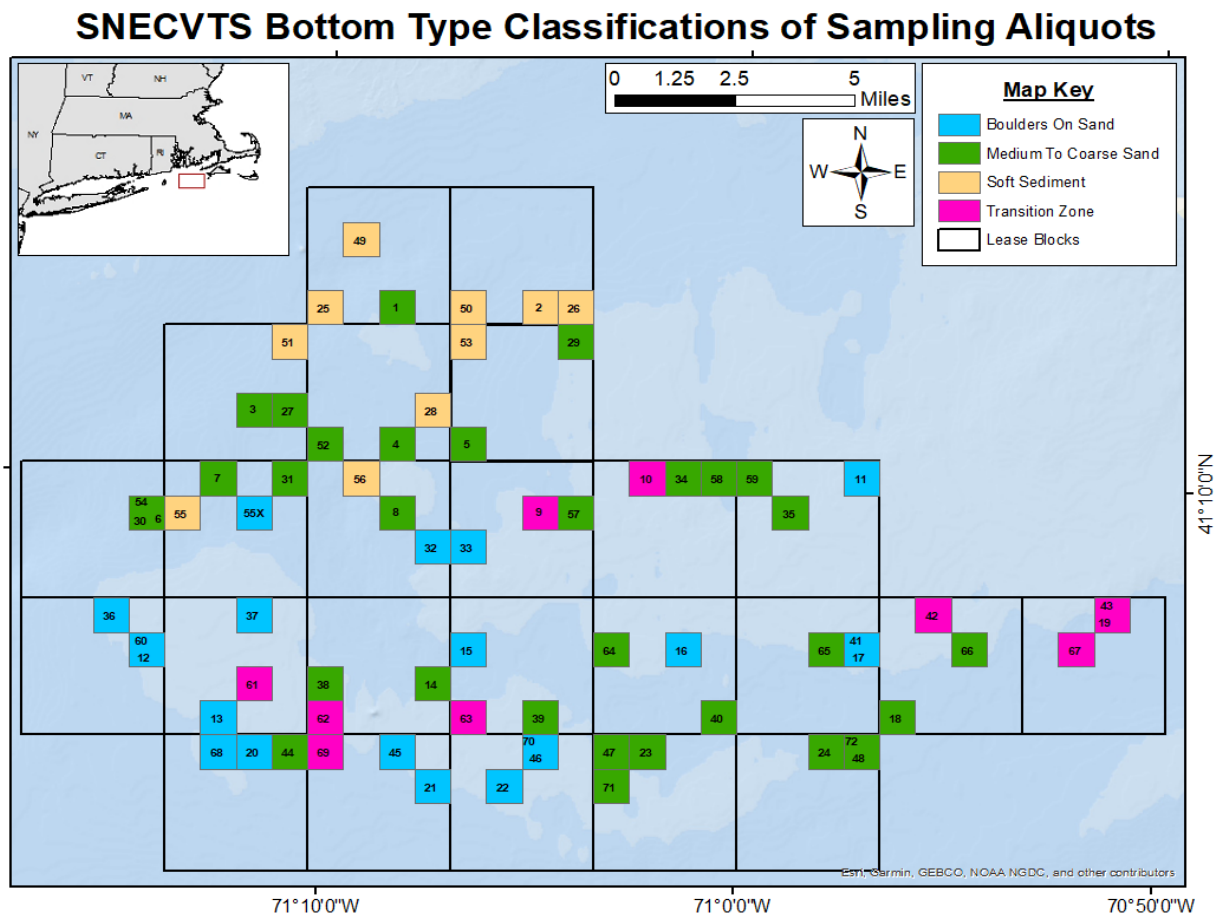

Figure 4. Bottom type classifications of aliquots sampled by SNECVTS.

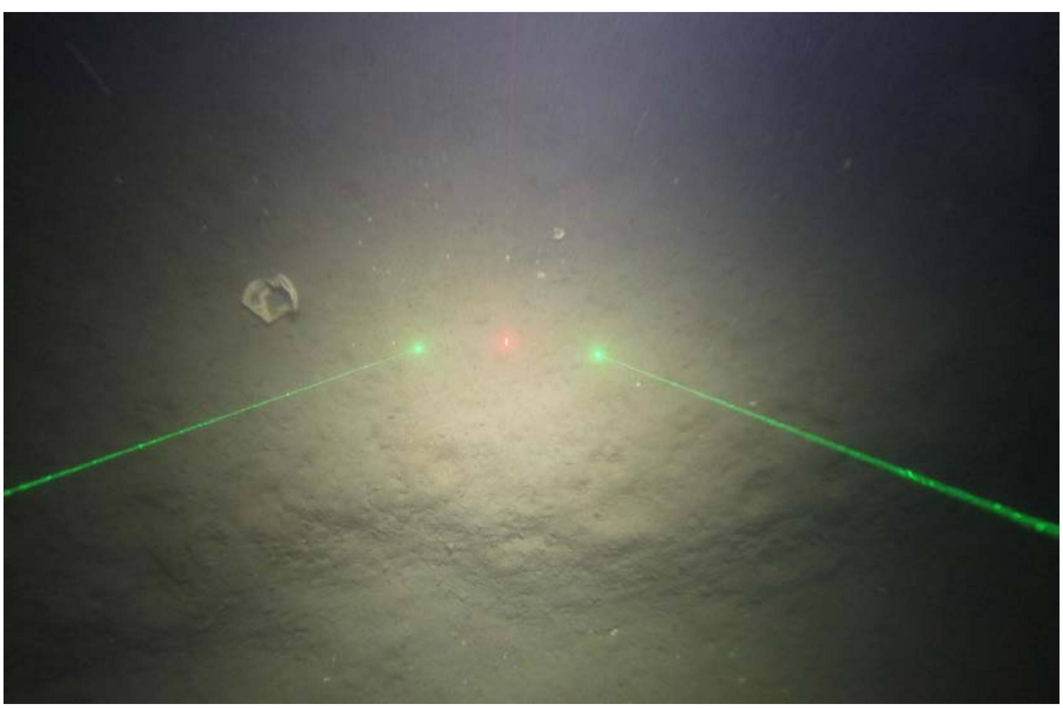

Figure 5. Bottom photograph representing "soft sediment" habitat taken at aliquot 50.

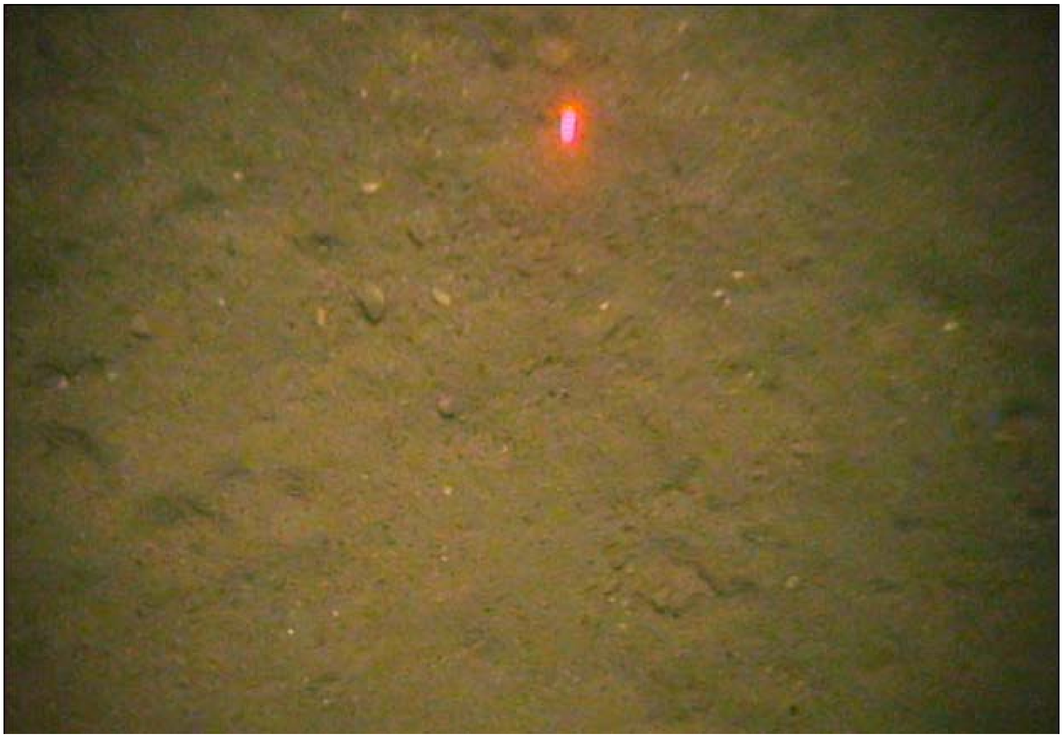

Figure 6. Bottom photograph representing "medium to coarse sand" habitat taken at aliquot 64.

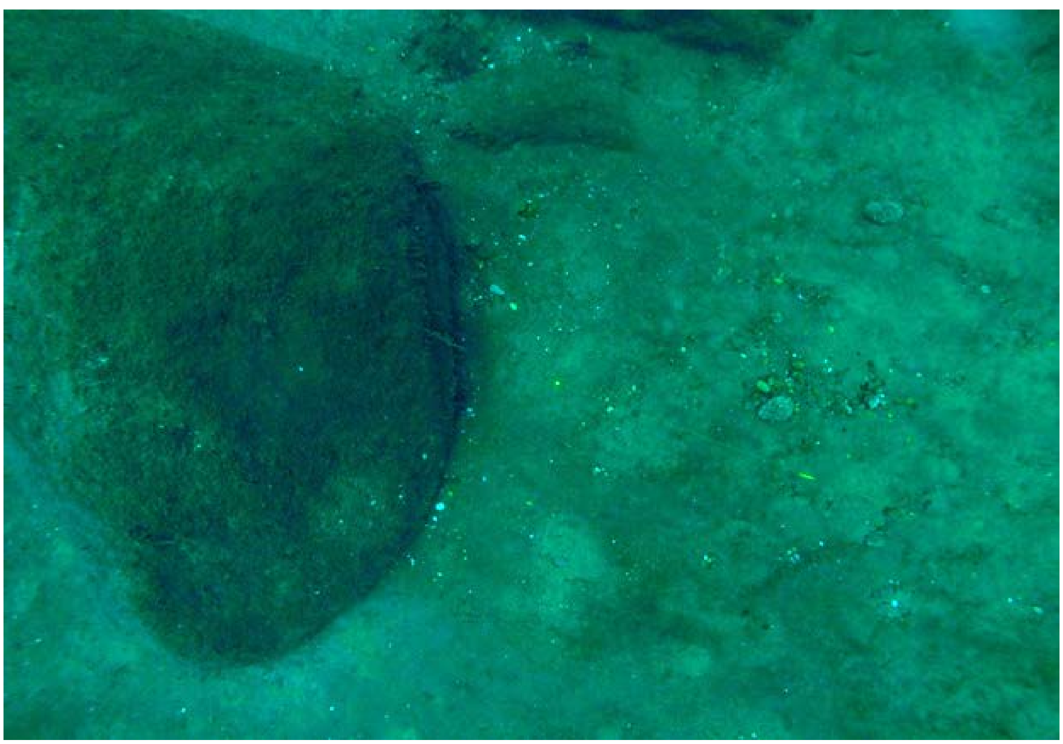

Figure 7. Bottom photograph representing "boulders on sand" habitat taken at aliquot 60.

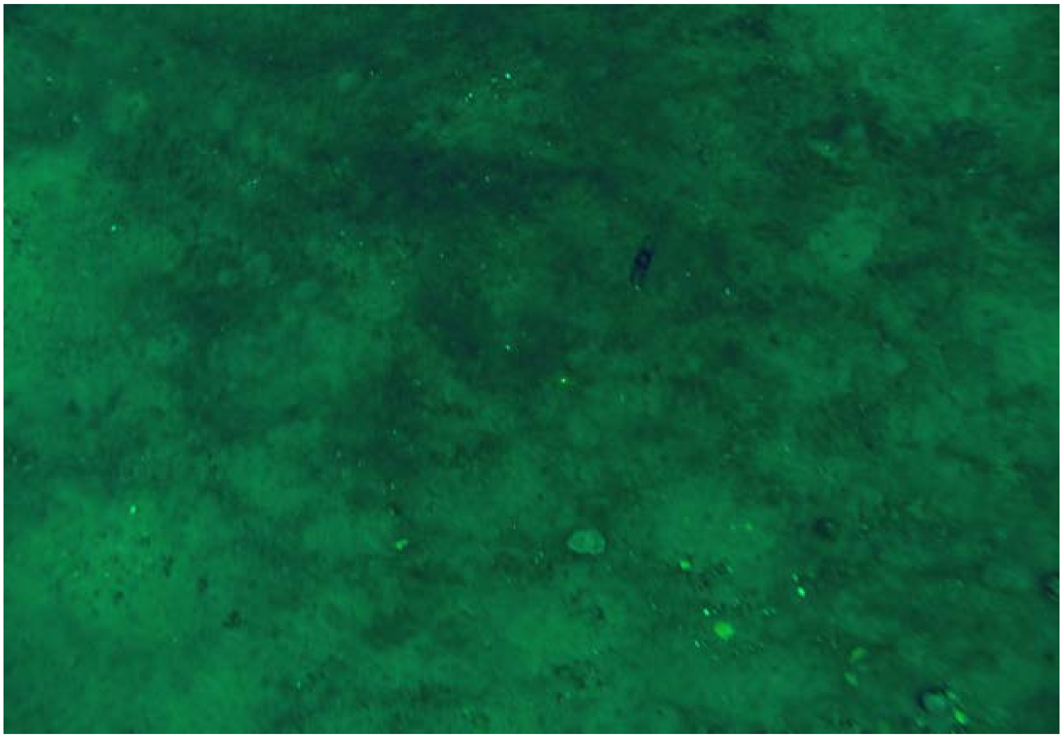

Figure 8. Bottom photograph representing “transitional zone” habitat taken at aliquot 61. Transitional zone habitat captures any aliquot that did not fall into one of the other three main habitat categories.

5. Bottom Temperatures

Continuous records of bottom temperature were made from May to November (May to October in Phase I) in each aliquot. The raw data were collected at 30-minute intervals. They have been averaged over daily intervals (Figures 9 and 10) for comparison with the lobster catches and over monthly intervals for presentation. Monthly temperatures were interpolated across the study area using inverse-distance weighting with a cubic function of distance (Figure 11). Beginning in May, the shallower, eastern aliquots warm more quickly than the western, deeper aliquots. This temperature gradient is maintained throughout the summer, until the bottom water begins to cool. This transition occurs in October, when the shallower, eastern aliquots begin to cool more rapidly than the deeper, western aliquots. In November the warmest water was in the deeper areas to the east and southwest corner of the study area.

Following the cold winter of 2015, bottom-water temperatures were several degrees cooler in May 2015 than in May 2014 or 2018 (Figure 9). The temperature pattern in 2018 was similar to 2014, except that maximum temperatures were lower. The maximum temperature reached in 2018 was 19° C in aliquots 66 and 67 at the beginning of October (day 279). Bottom temperatures dropped rapidly after this peak and continued to cool through the end of the sampling season.

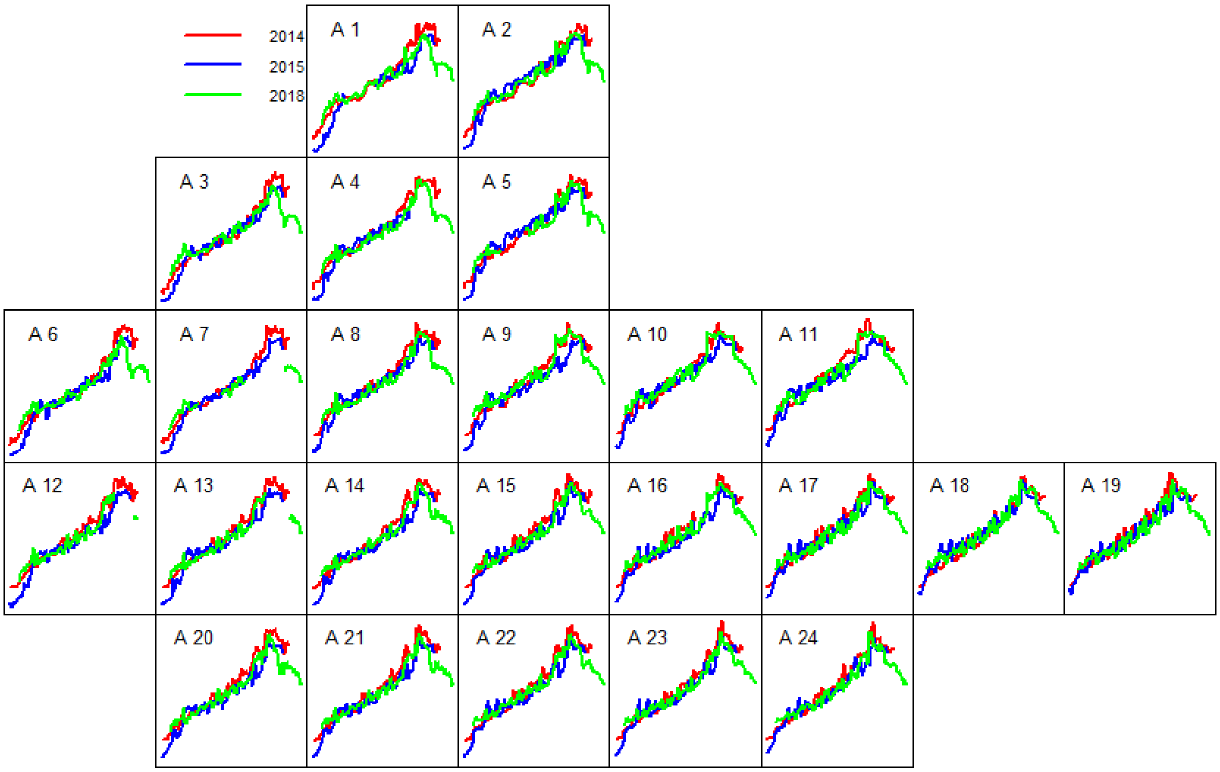

Figure 9. Daily bottom temperatures at each lease block. The boxes correspond with the lease blocks shown in Figures 1-3.

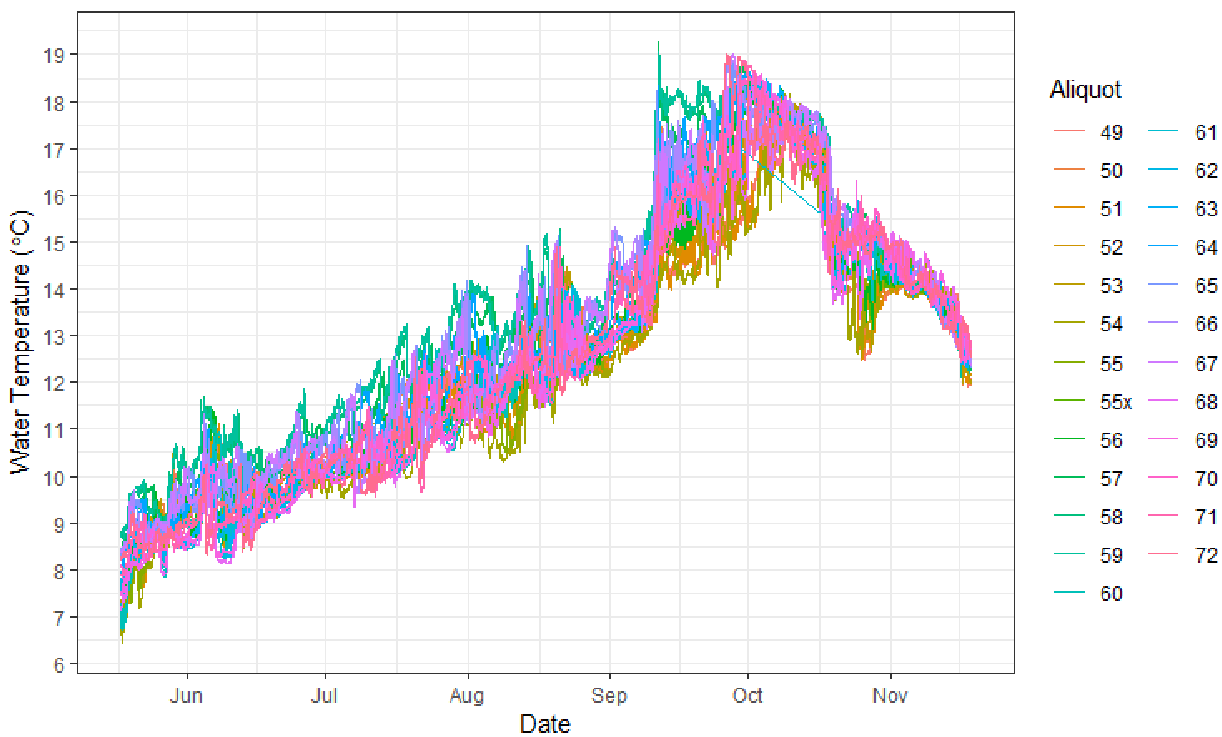

Figure 10. Bottom temperature (°C) by day in 2018.

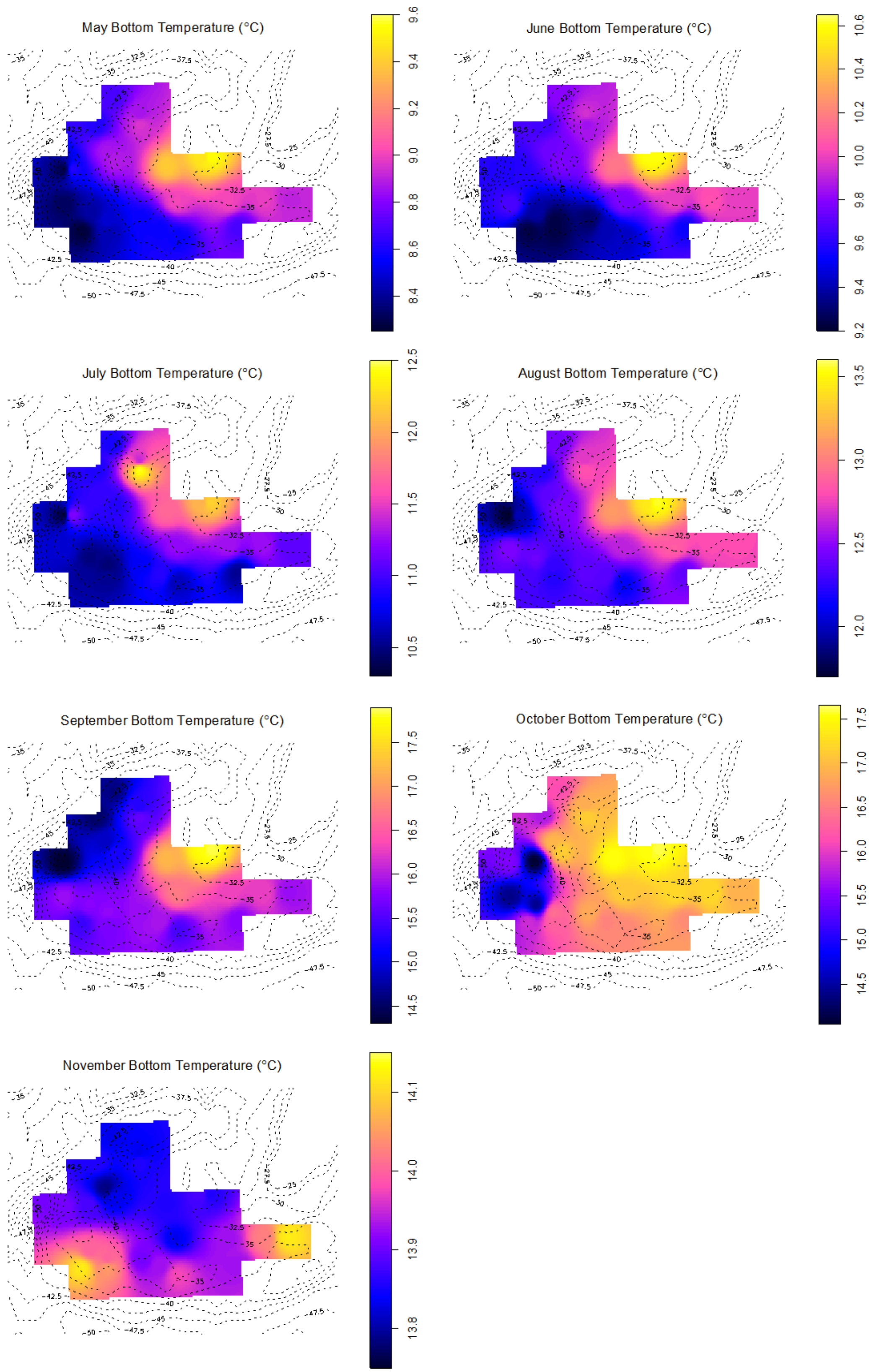

Figure 11. Bottom temperature (°C) by month in 2018, each subplot corresponds with the study area shown in Figures 1-3, dashed lines are depth contours in meters.

6. Lobster Statistics

In general from Phase I, lobster catches were higher on the eastern side of the study area (Figure 12). In 2014, the highest lobster catches were from aliquots 10 and 11 (Table 4), which are located in the northeast of the lease block area (Figure 3). High catches were also obtained from aliquots 2, 9, and 17, which are also on the northeast side of the lease block area. In 2015, the total lobster catch was slightly lower and the catches were distributed more evenly across aliquots. The highest catches were obtained in aliquots 41 and 42, which are on the east side of the study area. High catches were also obtained from aliquots 26, 30, 35, 40, and 43. Aliquots 6, 30, and 54, 12 and 60, 17 and 41, 19 and 43, 46 and 70, and 48 and 72 were repeated between years; all other aliquots were distinct.

Table 4. Total catches of lobster, average catch per trawl, average catch per ventless trap, and average catch per standard trap by year and aliquot.

Year	Aliquot	Total Lobsters	Lobster Per Trawl	Lobster Per Ventless Trap	Lobster Per Standard Trap
2014	1	495	27.5	3.7	1.4
2014	2	663	36.8	4.5	2.4
2014	3	444	24.7	3.1	1.5
2014	4	304	16.9	2.2	0.9
2014	5	529	29.4	3.8	1.7
2014	6	424	23.6	2.9	1.5
2014	7	241	13.4	1.7	0.8
2014	8	245	13.6	1.9	0.5
2014	9	627	34.8	4.9	1.4
2014	10	1,235	68.6	9.6	2.7
2014	11	1,140	63.3	8.4	3.2
2014	12	340	18.9	2.7	0.6
2014	13	221	12.3	1.7	0.5
2014	14	309	17.2	2.2	0.9
2014	15	434	24.1	3.4	1.0
2014	16	685	38.1	5.3	1.6
2014	17	801	44.5	6.1	2.0
2014	18	374	20.8	2.8	1.0
2014	19	197	10.9	1.5	0.6
2014	20	207	11.5	1.5	0.7
2014	21	173	9.6	1.3	0.4
2014	22	180	10.0	1.4	0.3
2014	23	235	13.1	1.9	0.5
2014	24	253	14.1	2.0	0.5
2014	Total	10,756	24.9	3.4	1.2
2015	25	376	20.9	2.6	1.3
2015	26	449	24.9	3.2	1.4

Year	Aliquot	Total Lobsters	Lobster Per Trawl	Lobster Per Ventless Trap	Lobster Per Standard Trap
2015	27	333	18.5	2.3	1.2
2015	28	469	26.1	3.3	1.5
2015	29	428	23.8	2.9	1.6
2015	30	464	25.8	3.3	1.5
2015	31	273	15.2	2.0	0.8
2015	32	337	18.7	2.6	0.8
2015	33	299	16.6	2.2	0.9
2015	34	287	15.9	2.1	0.8
2015	35	437	24.3	3.3	1.1
2015	36	354	19.7	2.5	1.1
2015	37	158	8.8	1.2	0.4
2015	38	252	14.0	1.8	0.8
2015	39	409	22.7	3.1	1.0
2015	40	430	23.9	3.3	1.0
2015	41	594	33.0	4.4	1.6
2015	42	889	49.4	6.4	2.8
2015	43	449	24.9	3.3	1.3
2015	44	182	10.1	1.5	0.2
2015	45	385	21.4	2.9	1.0
2015	46	326	18.1	2.5	0.7
2015	47	206	11.4	1.5	0.7
2015	48	288	16.0	2.1	0.8
2015	Total	9,074	21.0	2.8	1.1
2018	49	273	19.5	2.7	0.9
2018	50	313	22.4	3.1	0.9
2018	51	337	24.1	3.4	0.9
2018	52	232	16.6	2.4	0.6
2018	53	297	21.2	3.0	0.9
2018	54	264	18.9	2.5	1.0
2018	55	133	14.8	2.1	0.6
2018	56	179	12.8	1.9	0.4
2018	57	178	12.7	1.8	0.5
2018	58	309	22.1	3.0	1.1
2018	59	463	33.1	4.3	1.9
2018	60	236	16.9	2.4	0.7
2018	61	199	14.2	2.0	0.6
2018	62	261	18.6	2.2	1.4
2018	63	150	10.7	1.5	0.5
2018	64	115	8.2	1.2	0.3
2018	65	404	28.9	4.0	1.3
2018	66	666	47.6	6.4	2.3

Year	Aliquot	Total Lobsters	Lobster Per Trawl	Lobster Per Ventless Trap	Lobster Per Standard Trap
2018	67	494	35.3	4.5	2.0
2018	68	97	6.9	0.8	0.5
2018	69	108	7.7	0.9	0.6
2018	70	171	12.2	1.7	0.6
2018	71	289	20.6	2.9	0.8
2018	72	330	23.6	3.1	1.2
2018	55X	121	30.3	3.6	2.1
2018	Total	6,619	19.8	2.7	0.9

In Phase II, lobster catches were lower than both 2014 and 2015, resulting in a decline of lobster abundance through the three years of the survey (Table 4). In 2018, lobster catches remained highest on the eastern side of the study area (Figure 12), with the highest lobster catches in aliquots 66, 67, and 59 (Table 4). Aliquot 55X also had a high lobster catch rate; however, that is likely a result of the limited sampling duration in that location of only October and November.

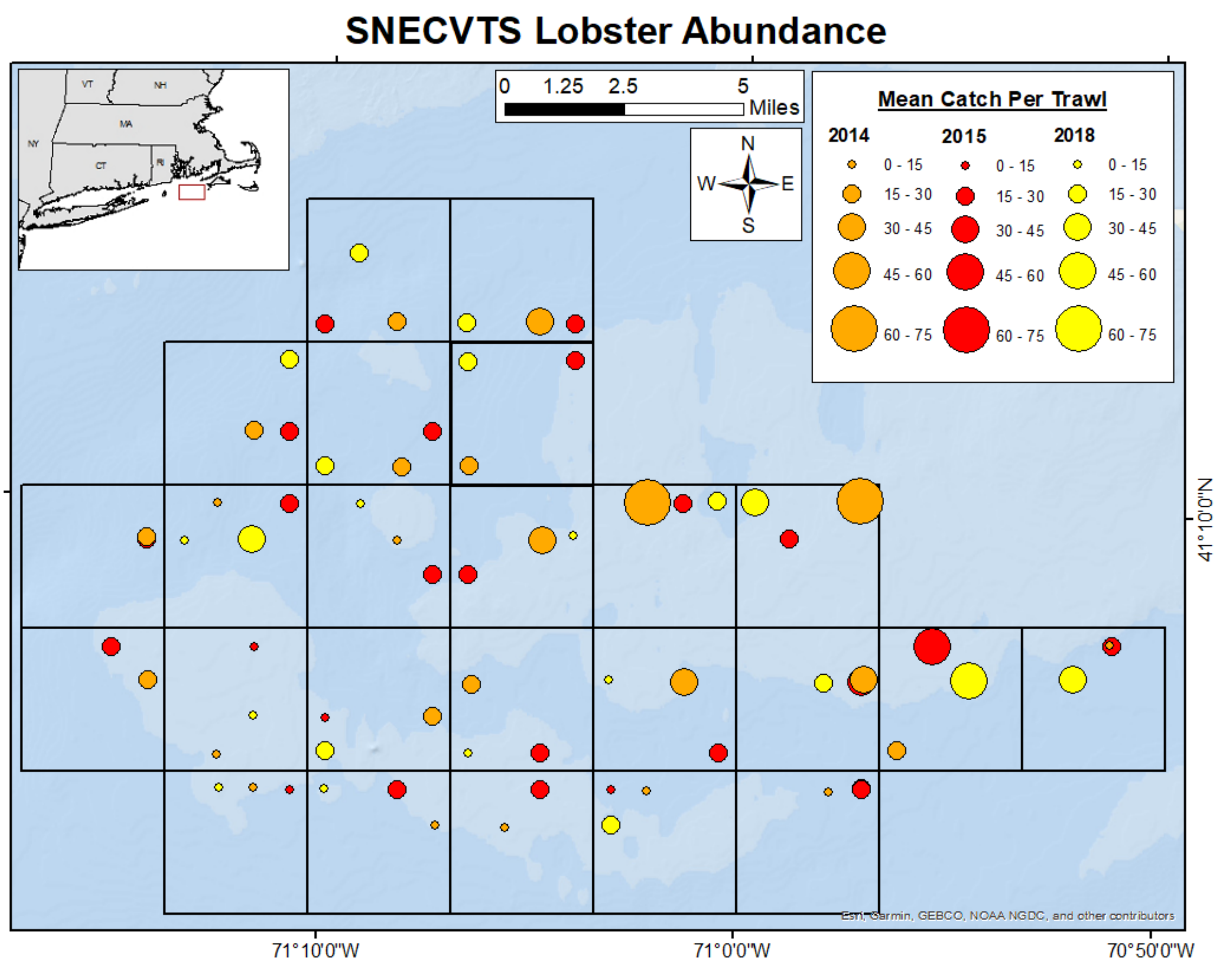

Figure 12. Lobster abundance by year and by aliquot.

Table 5. Total catch of lobster, average catch per trawl, average catch per ventless trap, and average catch per standard trap by year and month.

Year	Month	Total Lobsters	Lobster Per Trawl	Lobster Per Ventless Trap	Lobster Per Standard Trap
2014	May	417	5.8	0.7	0.4
	June	788	10.9	1.3	0.8
	July	2272	31.6	4.3	1.5
	August	3223	44.8	6.3	1.8
	September	2563	35.6	4.9	1.5
	October	1493	20.7	2.7	1.1
	Total	10756	24.9	3.4	1.2
2015	May	235	3.3	0.4	0.3
	June	407	5.7	0.6	0.5
	July	1089	15.1	1.9	0.9
	August	2870	39.9	5.4	1.9
	September	2809	39.0	5.3	1.8
	October	1664	23.1	3.1	1.2
	Total	9074	21.0	2.8	1.1
2018	May	144	3.0	0.3	0.3
	June	161	3.4	0.3	0.3
	July	1817	38.7	5.1	1.8
	August	1810	37.7	5.3	1.5
	September	1935	40.3	5.4	2.0
	October	445	9.3	1.2	0.5
	November	307	6.4	0.9	0.3
	Total	6619	19.8	2.7	0.9

Table 6. Lobster catch summary statistics by year and month.

Year	Month	Mean Size (mm)	Male	Female	% Female	Eggers	% Females With Eggs	% Cull	% V-Notch
2014	May	85.8	60	357	86%	231	55%	6%	2%
2014	June	82.8	120	668	85%	231	29%	10%	3%
2014	July	78.4	936	1,336	59%	93	4%	8%	3%
2014	August	76.3	1,451	1,772	55%	56	2%	12%	2%
2014	September	77.7	1,177	1,386	54%	176	7%	11%	3%
2014	October	80.2	527	966	65%	253	17%	14%	5%
2014	Total	78.5	4,271	6,485	60%	1,040	10%	11%	3%
2015	May	90.2	36	199	85%	132	56%	7%	4%
2015	June	86.3	128	279	69%	148	36%	7%	10%
2015	July	82.0	554	535	49%	44	4%	8%	2%
2015	August	78.9	1,540	1,329	46%	37	1%	9%	2%

Year	Month	Mean Size (mm)	Male	Female	% Female	Eggers	% Females With Eggs	% Cull	% V-Notch
2015	September	78.7	1,515	1,293	46%	112	4%	11%	1%
2015	October	79.7	778	886	53%	237	14%	16%	2%
2015	Total	80.0	4,551	4,521	50%	710	8%	11%	2%
2018	May	92.5	27	117	81%	92	64%	10%	3%
2018	June	89.6	26	135	84%	86	53%	4%	13%
2018	July	78.9	973	840	46%	31	2%	12%	2%
2018	August	78.0	960	850	47%	22	1%	11%	0%
2018	September	80.3	861	1,074	56%	239	12%	14%	0%
2018	October	79.6	195	250	56%	93	21%	16%	2%
2018	November	78.4	131	176	57%	70	23%	16%	2%
2018	Total	79.6	3,173	3,442	52%	633	10%	13%	1%

Lobster catches in the SNECVTS survey were dominated by females in spring and early summer (Table 5 and 6). In all years the percentage of females started at over 80% in May and decreased toward an equal sex ratio in July, then began to increase just above 50% into the fall. In 2014, the percentage of females never decreased below 50%, whereas in 2015 and 2018 it decreased to 46%. The percentage of females with eggs was highest in May when females dominated the catches. Females incubate their eggs until the larvae hatch from mid-May to mid-June (ASMFC 2015). The percent of females with eggs declined to a minimum in August and then increased to over 25% in October of both years, as the next generation was incubated. The dominance of females in May and June can therefore largely be explained by the presence of egg-bearing females, which are protected from capture. Given the high exploitation rates of legal-sized lobsters, which can be seen in the decreasing monthly average size each year, these females rapidly disappear from the population once they shed their eggs. The percent of lobsters with missing claws (culls) varied between 4 and 16%. The percent of culls tended to be lower in May, June, and July, and higher in the remaining months. The percent of v-notched lobsters was highest in June 2015 and 2018 and declined throughout the remaining months. This decline suggests that the v-notch was not retained during the molt. The percent mortality was 0 in all years and months.

The incidence of shell disease was generally low in the SNECVTS survey. In 2014, shell disease incidence was lower in the offshore aliquots (Figure 13). In 2015 and 2018, shell disease incidence was lower overall (Table 7), especially on the eastern side of the lease block area (Figures 14 and 15). The incidence of severe shell disease was higher in the near-shore lease blocks. Shell disease incidence was highest in May to June, and then decreased below 10% in August and September as more of the lobsters had recently molted (Table 7). Following the molting period, shell disease incidence increased moderately in October and November. The incidence of shell disease therefore follows the annual molt cycle of lobsters (Castro and Angell 2000).

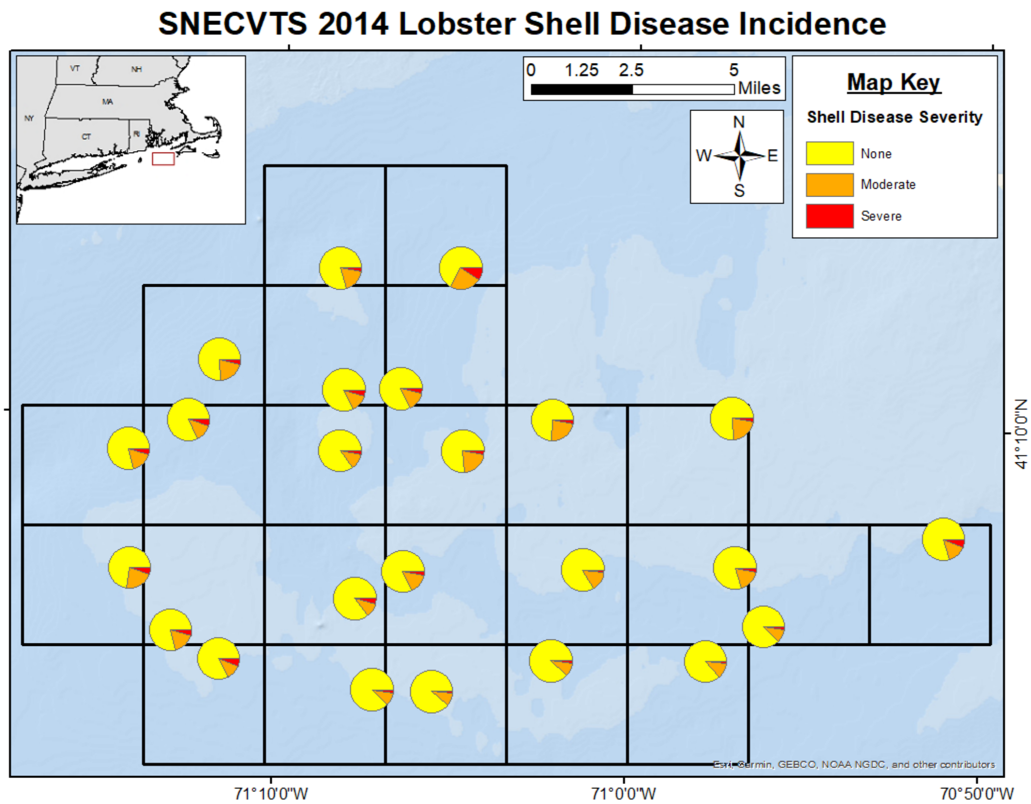

Figure 13. Incidence of shell disease by aliquot in 2014.

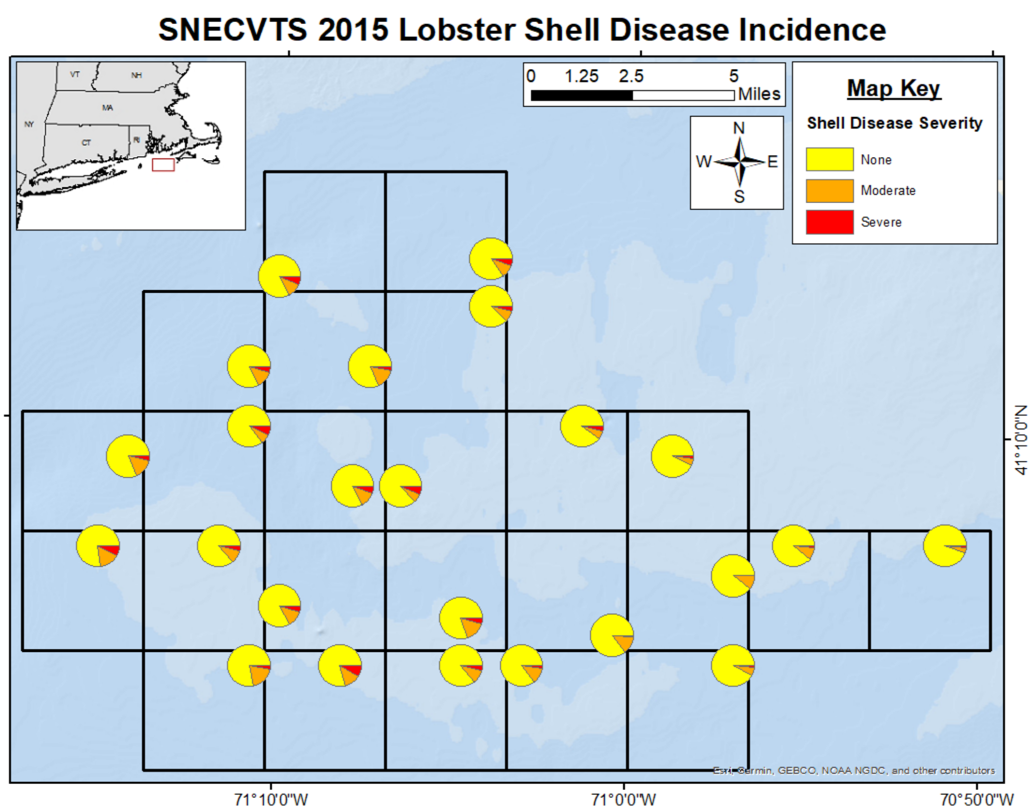

Figure 14. Incidence of shell disease by aliquot in 2015.

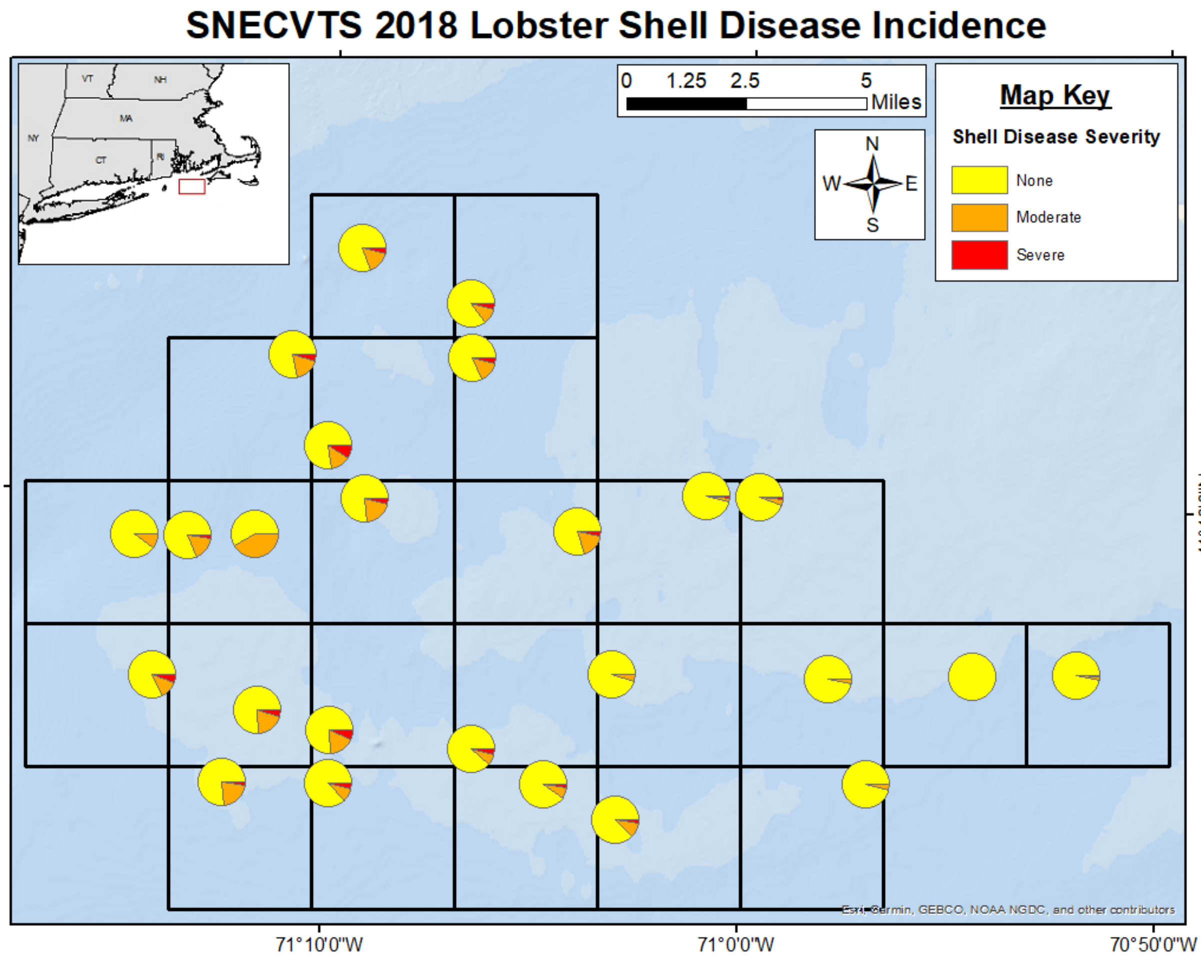

Figure 15. Incidence of shell disease by aliquot in 2018.

Lobsters ranged from 20 to 196 mm carapace length in 2014 and 2015, and in 2018 ranged from 29 to 133 mm carapace length. However, the majority of lobsters were between 40 and 120 mm (Figures 16 and 17). May and June catches contained large females, a high proportion of which carried eggs (Table 6) and were therefore protected from exploitation. Once the eggs are released these females are no longer protected from exploitation (unless v-notched) and the size distributions became more truncated beyond the legal LMA 2 size of 85.7 mm. Smaller lobsters were more numerous in the summer months, with a high proportion of males. These smaller lobsters may have just molted into the 60 to 80 mm length class and become vulnerable to capture. As expected, the standard traps predominantly caught few lobsters smaller than 80 mm (Figure 17).

In 2014, lobster catches were consistently higher in aliquots 10 and 11 (Table 4, Figure 18). These high catches are partially explained by the warmer water temperatures in the northeast of the lease block area; this temperature gradient persisted through September 2014, after which catch rates decreased. In 2015, lobster catches were low in May and June in most aliquots (Table 4 and 5), owing to low bottom temperatures (Figure 19). With warming temperatures, the highest catches were obtained in July, August, and September. In 2018, lobster catches were again low in May and June (Figure 20). Catches increased in July, especially on the eastern side of the study area (Aliquots 59, 65-67). Lobster catches fell off quite abruptly in October and November.

Table 7. Incidence of shell disease by year and month.

		Frequency			Percentage		
Year	Month	None	Moderate	Severe	None	Moderate	Severe
2014	May	158	220	39	38%	53%	9%
2014	June	277	396	115	35%	50%	15%
2014	July	1,673	469	130	74%	21%	6%
2014	August	2,952	236	35	92%	7%	1%
2014	September	2,374	153	36	93%	6%	1%
2014	October	1,068	391	34	72%	26%	2%
2014	Total	8,502	1,865	389	79%	17%	4%
2015	May	106	89	40	45%	38%	17%
2015	June	193	135	79	47%	33%	19%
2015	July	811	186	92	74%	17%	8%
2015	August	2,689	125	56	94%	4%	2%
2015	September	2,584	180	45	92%	6%	2%
2015	October	1,394	231	39	84%	14%	2%
2015	Total	7,777	946	351	86%	10%	4%
2018	May	60	69	15	42%	48%	10%
2018	June	76	44	41	47%	27%	25%
2018	July	1,591	164	62	88%	9%	3%
2018	August	1,713	78	19	95%	4%	1%
2018	September	1,772	136	27	92%	7%	1%
2018	October	344	92	9	77%	21%	2%
2018	November	245	56	6	80%	18%	2%
2018	Total	5,801	639	179	88%	10%	3%

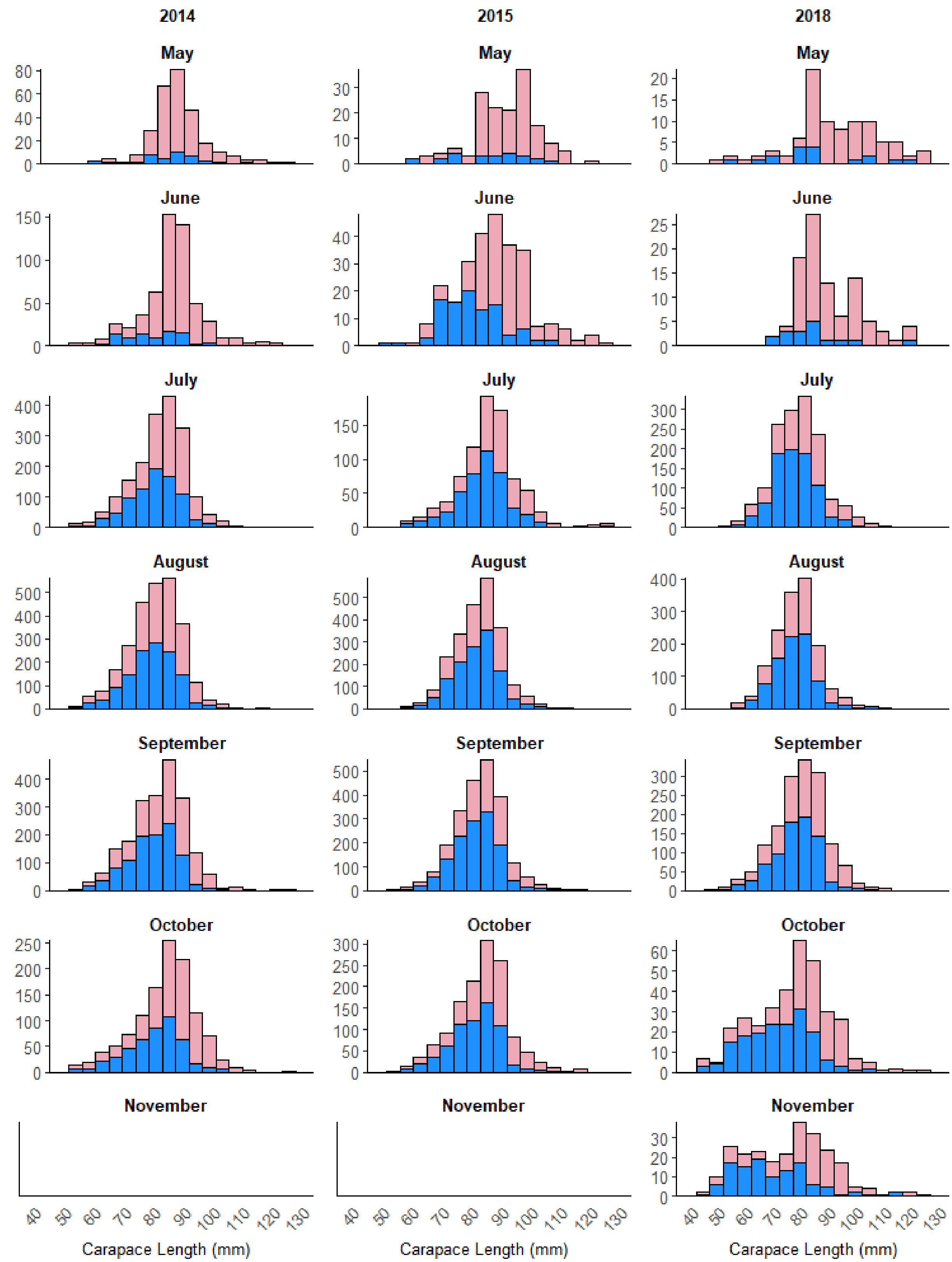

Figure 16. Length-frequency distributions of lobsters in ventless traps, by year and month. Red bars are females and blue bars are males.

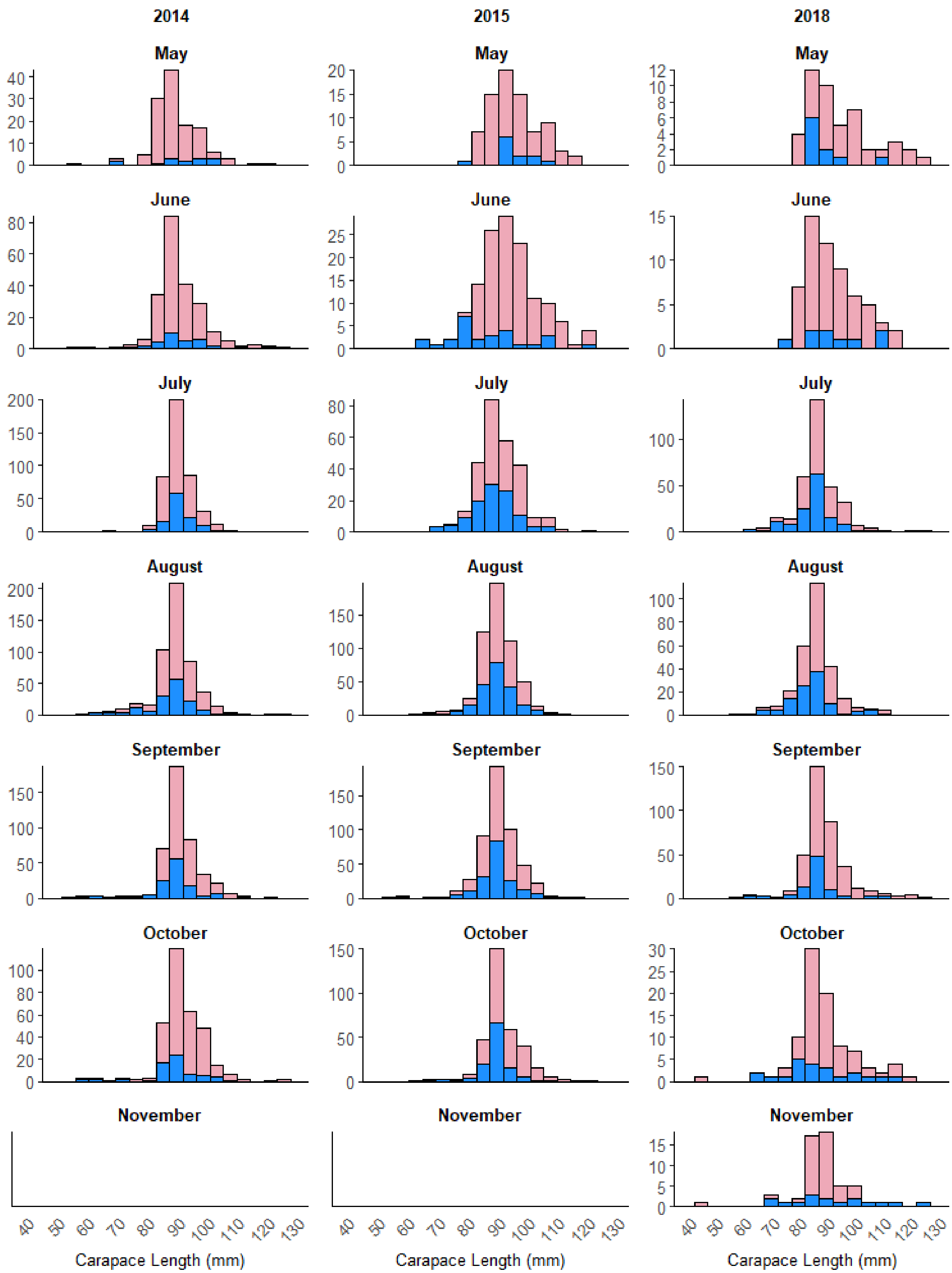

Figure 17. Length-frequency distributions of lobsters in standard traps, by year and month. Red bars are females and blue bars are males.

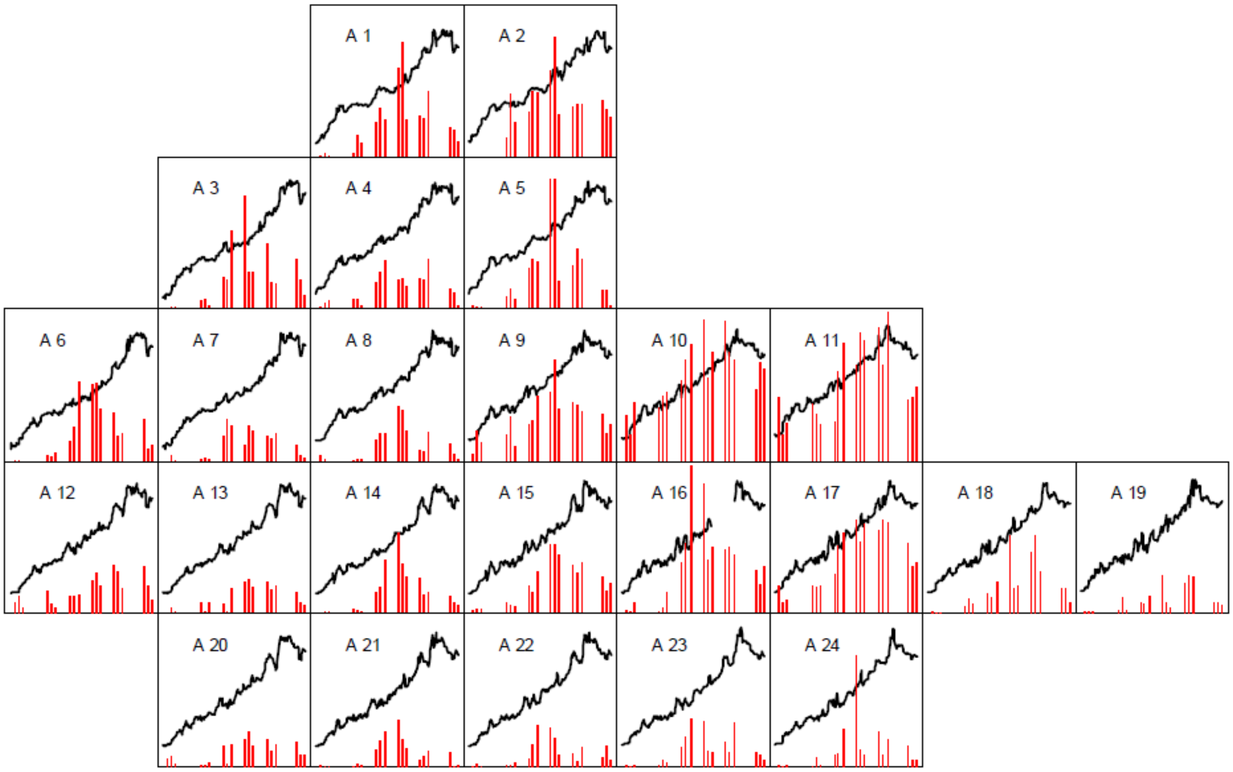

Figure 18. Distribution of lobster catches (red bars) in relation to bottom temperature (black lines) in 2014. The boxes correspond with the lease blocks shown in Figures 1-3.

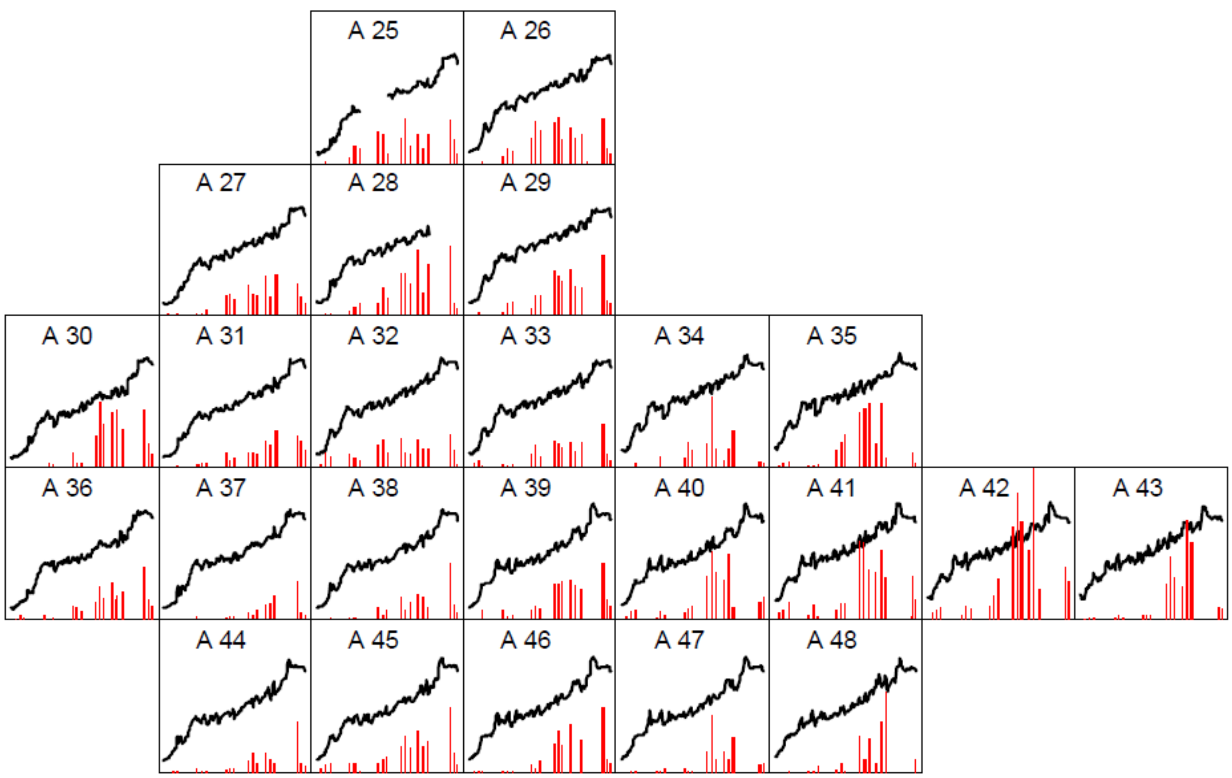

Figure 19. Distribution of lobster catches (red bars) in relation to bottom temperature (black lines) in 2015. The boxes correspond with the lease blocks shown in Figures 1-3.

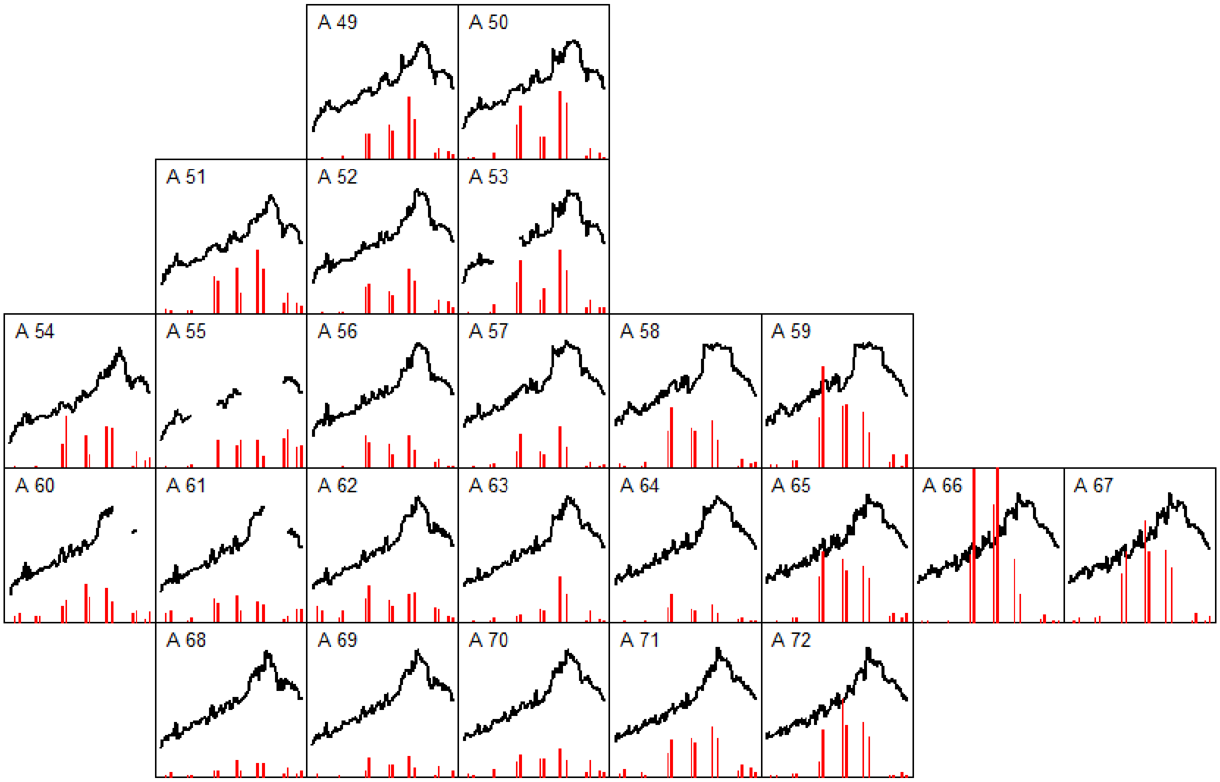

Figure 20. Distribution of lobster catches (red bars) in relation to bottom temperature (black lines) in 2018. The boxes correspond with the lease blocks shown in Figures 1-3.

The seasonal onshore-offshore migrations of American lobster are understood as a strategy to maintain high local ambient temperatures to maximize the degree days needed for molting, growth, gonad development, egg extrusion (Cooper and Uzman 1986) and egg development (Campbell 1986). As bottom temperature warms in the spring, lobsters migrate onshore to shallower depth. As temperatures approach their peak in late summer, lobsters return to cooler and deeper offshore water. This strategy can explain the increasing catches in the SNECVTS survey from May through August, followed by declines in October and November. It therefore appears that lobster abundance in the study area is constrained by water temperatures below their lower and above their upper thermal preference.

A generalized additive model (GAM) was fit to explain the spatiotemporal variability of lobster abundance, measured as the total number of lobsters caught in an aliquot on each sampling date, as a function of a suite of covariates including temperature, depth, latitude and longitude, day of the year, year, and habitat type. Year and habitat type were considered as factors. Due to high concurvity between water temperature and day of the year, a GAM with a Gaussian error distribution was fit to temperature as a function of the day of the year. The residuals of this model were considered the temperature anomalies, representing the deviation of a measured temperature at an aliquot from the average temperature across the study area on a given day of the year during Phases I and II combined. The temperature anomalies, along with the depth, day of the year, and an interaction term between latitude and longitude, were considered in the model as spline functions. The interaction between latitude and longitude was included to explain any residual geographic variation not explained by the other predictors and was constrained to k=12 knots in order to avoid overfitting the data. Finally, the high variability of lobster abundance necessitated the use of a quasi-Poisson error distribution. Model variants were compared using likelihood ratio tests.

Table 8. Generalized Additive Model fit to lobster abundance in 2014, 2015, and 2018. Habitat coefficients are expressed relative to Boulders; Year effects are expressed relative to 2014.

Parametric Coefficients			
Covariate	Estimate	Standard Error	P-value
Intercept	2.809	0.055	< 0.001
Habitat: Medium to Coarse Sand	-0.193	0.063	0.002
Habitat: Soft Sediment	-0.147	0.121	0.225
Habitat: Transition Zone	0.317	0.076	< 0.001
Year: 2015	-0.163	0.050	0.001
Year: 2018	0.030	0.059	0.608
Spline Functions			
Covariate	Estimated DF	Reference DF	P-value
Temperature Anomalies	7.748	8.589	0.002
Day of the Year	7.323	8.253	< 0.001
Latitude x Longitude	9.723	10.717	< 0.001

Of the tested covariates, only depth was excluded from the selected GAM (63.8% deviance explained, Table 8). This may be because there is little depth variation across the study area. Lobster abundance was statistically insignificantly ($p > 0.05$) different in 2014 and 2018, but was significantly lower in 2015 ($p = 0.001$). The coefficients fit to the tested habitat types suggest that lobster abundance was lowest in areas of medium to coarse sand ($p = 0.002$) and highest in transition zones ($p < 0.001$). Abundance was statistically insignificantly different in areas of boulders on sand and soft sediment and was in between that of transition zones and areas of medium to coarse sand.

The spline fit to the temperature anomalies (Figure 21) suggests that lobsters are slightly more abundant in warmer areas, on a given day of year. Observed temperature anomalies are shown as a rug on the x-axis. Over the interval of frequently observed values (-1 °C, 1 °C), the spline suggests lobsters are more abundant at higher temperatures. The shape of the fitted day of the year spline indicates that the lobster abundance trend is dome-shaped between spring and fall, peaking in August and September (Figure 22). Finally, the spline surface fit to latitude and longitude identifies the northeast portion of the study area as having the highest lobster abundance (Figure 23).

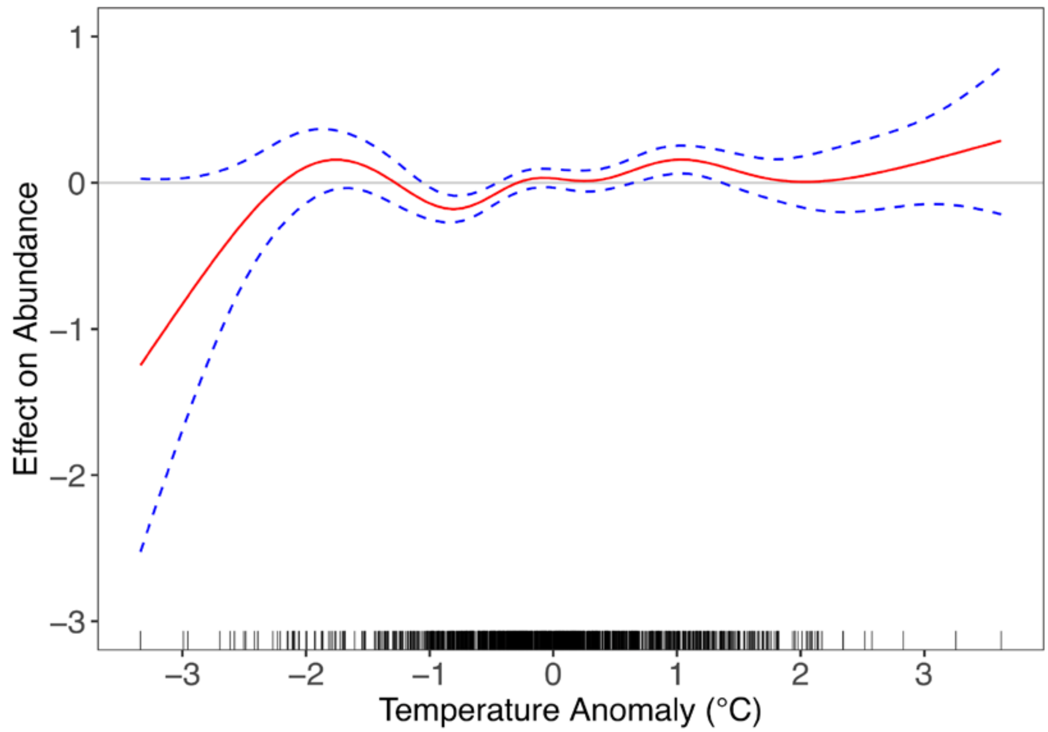

Figure 21. The fitted spline (red) with a 95% confidence interval (blue) of the effect of the observed temperature anomalies on lobster abundance.

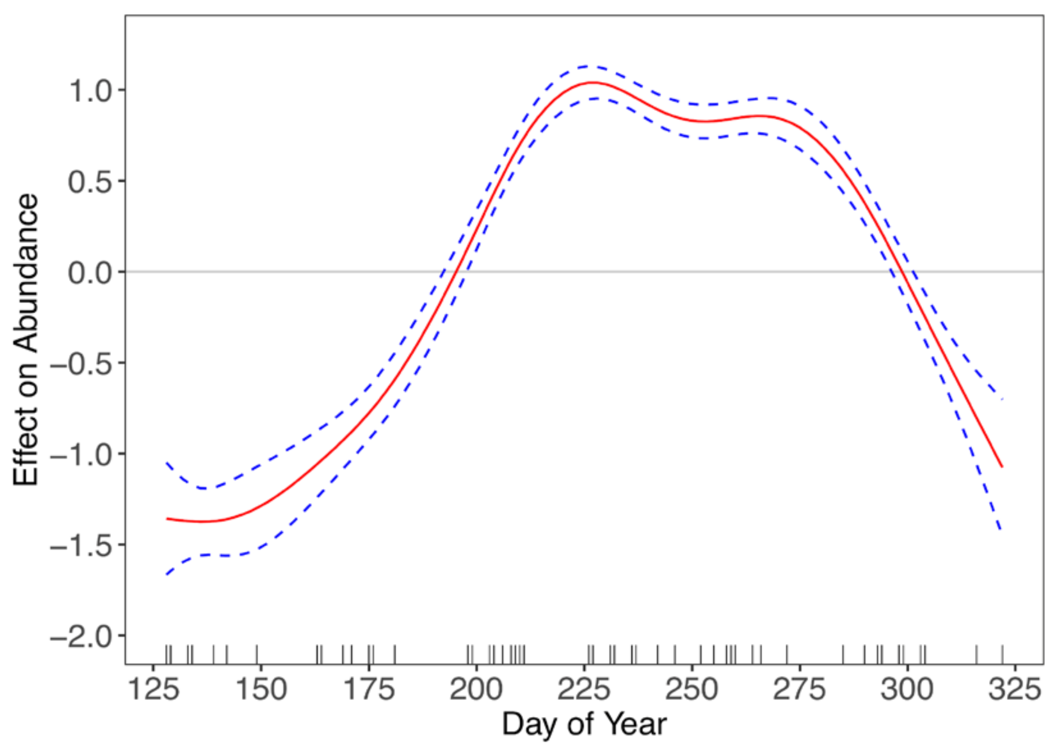

Figure 22. The fitted spline (red) with a 95% confidence interval (blue) of the effect of the day of the year on lobster abundance. Sampling days are shown as a rug on the x-axis.

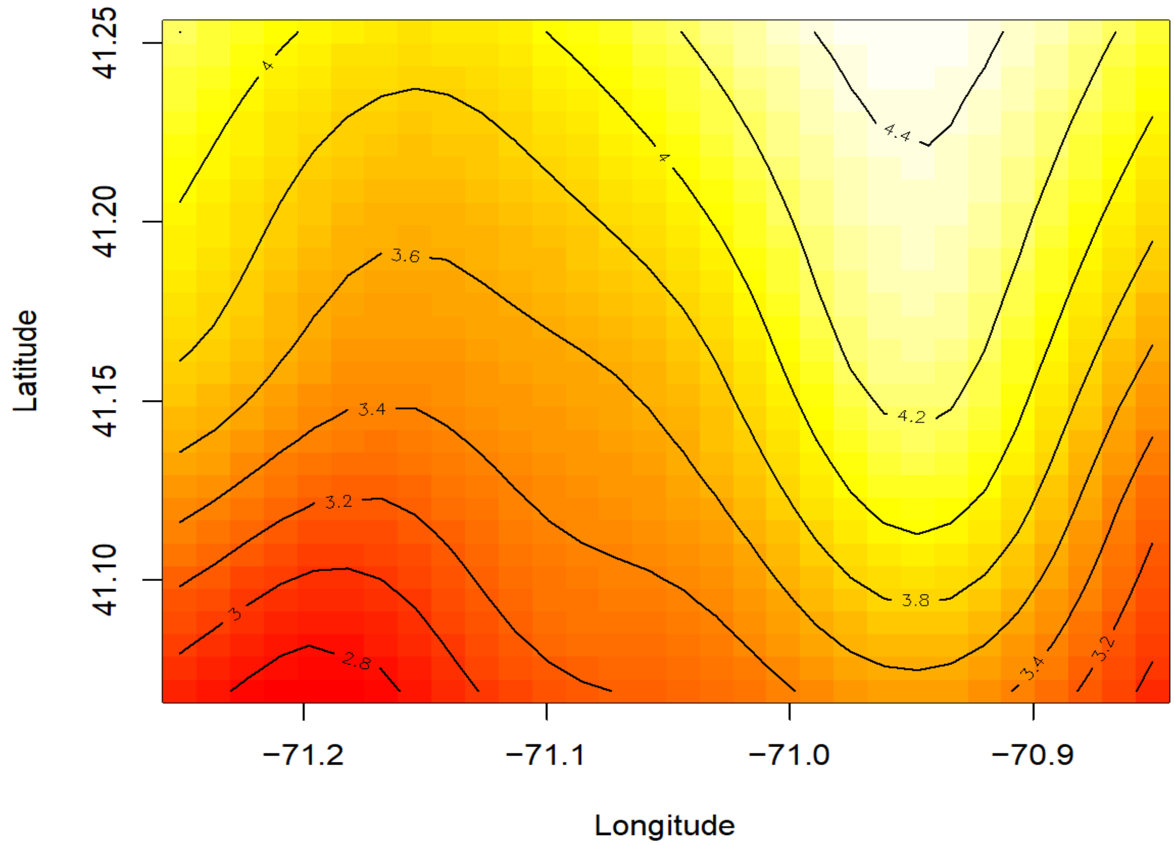

Figure 23. The fitted surface of the effect of latitude and longitude on lobster abundance in the selected GAM variant. Abundance is highest in the northeast portion of the study area.

7. Jonah Crab Statistics

Jonah crab catches were generally higher in the central, northern, and western areas of the study area (Table 9 and Figure 24). In 2014 the highest catches came from aliquots 6 and 14, which are located in the western and south-central regions of the lease block area, respectively (Table 9). High catches for 2014 also came from aliquots 2, 21 and 22. In 2015, the highest Jonah crab catches were in aliquots 25, 29 and 33. Aliquots 25 and 29 are located in the north-central region of the lease block area, and aliquot 33 is located centrally. High catches for 2015 also came from aliquots 26, 28, 30 and 34. The highest overall annual abundance of Jonah crab was in 2018, with the highest catches in aliquots 56 and 57, which are in the center of the lease area. Other aliquots with high Jonah crab catch rates in 2018 were 50, 52, and 53. Note that aliquots in the same row are in the same lease blocks. Aliquots 6, 30, and 54, 12 and 60, 17 and 41, 19 and 43, 46 and 70, and 48 and 72 were repeated between years; all other aliquots were distinct.

Jonah crab catches were highest in the month of September in both 2014 and 2015; however, in August, October, and November 2018, catch rates of Jonah crab exceeded the peak catch rates from 2014 and 2015 (Table 9 and 10). Overall, Jonah crab catches were low in the months of May, June, and July through all three years.

Table 9. Total catches of Jonah crab, average catch per trawl, average catch per ventless trap, and average catch per standard trap by year and aliquot.

Year	Aliquot	Total Jonah Crab	Jonah Crab Per Trawl	Jonah Crab Per Ventless Trap	Jonah Crab Per Standard Trap
2014	1	1,478	82.1	11.5	3.3
2014	2	1,593	88.5	13.2	2.3
2014	3	1,604	89.1	13.1	2.6
2014	4	1,196	66.4	9.9	1.8
2014	5	1,224	68.0	9.7	2.5
2014	6	2,163	120.2	18.1	2.9
2014	7	1,541	85.6	12.7	2.3
2014	8	1,401	77.8	11.6	2.1
2014	9	1,282	71.2	10.5	2.0
2014	10	1,195	66.4	9.2	2.7
2014	11	1,046	58.1	8.0	2.6
2014	12	519	28.8	4.2	0.9
2014	13	719	39.9	5.8	1.2
2014	14	3,198	177.7	26.9	4.1
2014	15	892	49.6	7.4	1.3
2014	16	1,384	76.9	10.6	3.3
2014	17	873	48.5	6.8	1.9
2014	18	588	32.7	4.5	1.4
2014	19	1,400	77.8	11.3	2.5
2014	20	783	43.5	6.3	1.4
2014	21	1,635	90.8	14.0	1.7
2014	22	1,995	110.8	16.3	3.3
2014	23	1,068	59.3	8.5	2.1
2014	24	579	32.2	4.5	1.2
2014	Total	31,356	72.6	10.6	2.2
2015	25	1,347	74.8	11.0	2.3
2015	26	1,177	65.4	8.8	3.1
2015	27	1,080	60.0	7.0	4.6
2015	28	1,150	63.9	8.9	2.6
2015	29	1,255	69.7	9.8	2.7
2015	30	1,133	62.9	8.8	2.5
2015	31	1,107	61.5	7.8	3.7
2015	32	828	46.0	6.8	1.3
2015	33	930	51.7	7.6	1.5
2015	34	1,540	85.6	11.9	3.6
2015	35	1,083	60.2	8.3	2.6
2015	36	385	21.4	2.9	1.0
2015	37	651	36.2	5.3	1.1

Year	Aliquot	Total Jonah Crab	Jonah Crab Per Trawl	Jonah Crab Per Ventless Trap	Jonah Crab Per Standard Trap
2015	38	821	45.6	6.8	1.2
2015	39	913	50.7	7.5	1.5
2015	40	490	27.2	3.7	1.3
2015	41	416	23.1	3.4	0.6
2015	42	384	21.3	3.0	0.9
2015	43	633	35.2	5.2	1.0
2015	44	971	53.9	7.5	2.3
2015	45	920	51.1	7.1	2.1
2015	46	702	39.0	5.8	1.1
2015	47	947	52.6	7.5	1.9
2015	48	328	18.2	2.4	0.9
2015	Total	21,191	49.1	6.9	2.0
2018	49	2,203	157.4	21.1	7.8
2018	50	2,589	184.9	24.8	9.0
2018	51	2,460	175.7	24.5	7.1
2018	52	2,771	197.9	28.2	7.1
2018	53	2,716	194.0	27.2	7.7
2018	54	1,419	101.4	14.5	3.5
2018	55	1,301	144.6	20.7	5.1
2018	56	3,037	216.9	31.1	7.6
2018	57	3,477	248.4	36.8	6.9
2018	58	2,459	175.6	22.8	9.6
2018	59	1,147	81.9	11.4	3.4
2018	60	784	56.0	8.3	1.5
2018	61	1,391	99.4	15.6	1.4
2018	62	1,461	104.4	15.9	2.2
2018	63	1,635	116.8	17.2	3.4
2018	64	2,232	159.4	21.5	7.6
2018	65	1,109	79.2	11.5	2.6
2018	66	1,162	83.0	11.4	3.7
2018	67	617	44.1	6.4	1.4
2018	68	1,042	74.4	10.7	2.6
2018	69	1,567	111.9	17.0	2.4
2018	70	1,471	105.1	15.2	3.5
2018	71	1,661	118.6	17.9	2.9
2018	72	987	70.5	9.9	2.7
2018	55X	614	153.5	22.5	4.6
2018	Total	43,312	129.3	18.4	4.7

Male Jonah crabs ranged in size from 40 mm to 191 mm, and females were between 49 mm and 189 mm in Phase I; in Phase II males ranged from 10 mm to 159 mm, and females ranged from

32 mm to 151 mm. In Phase I, the mean carapace width of females (104 mm) was lower than for males (117 mm), which is consistent with the biology of the species. Similarly, in Phase II, the mean carapace width of females (104 mm) was lower (t-test, $p < 0.001$) than for males (118 mm). There were also differences in catch rates between ventless and standard traps for Jonah crab (Figures 25 and 26); however, it was not as strong of an effect on Jonah crab as it was for lobster.

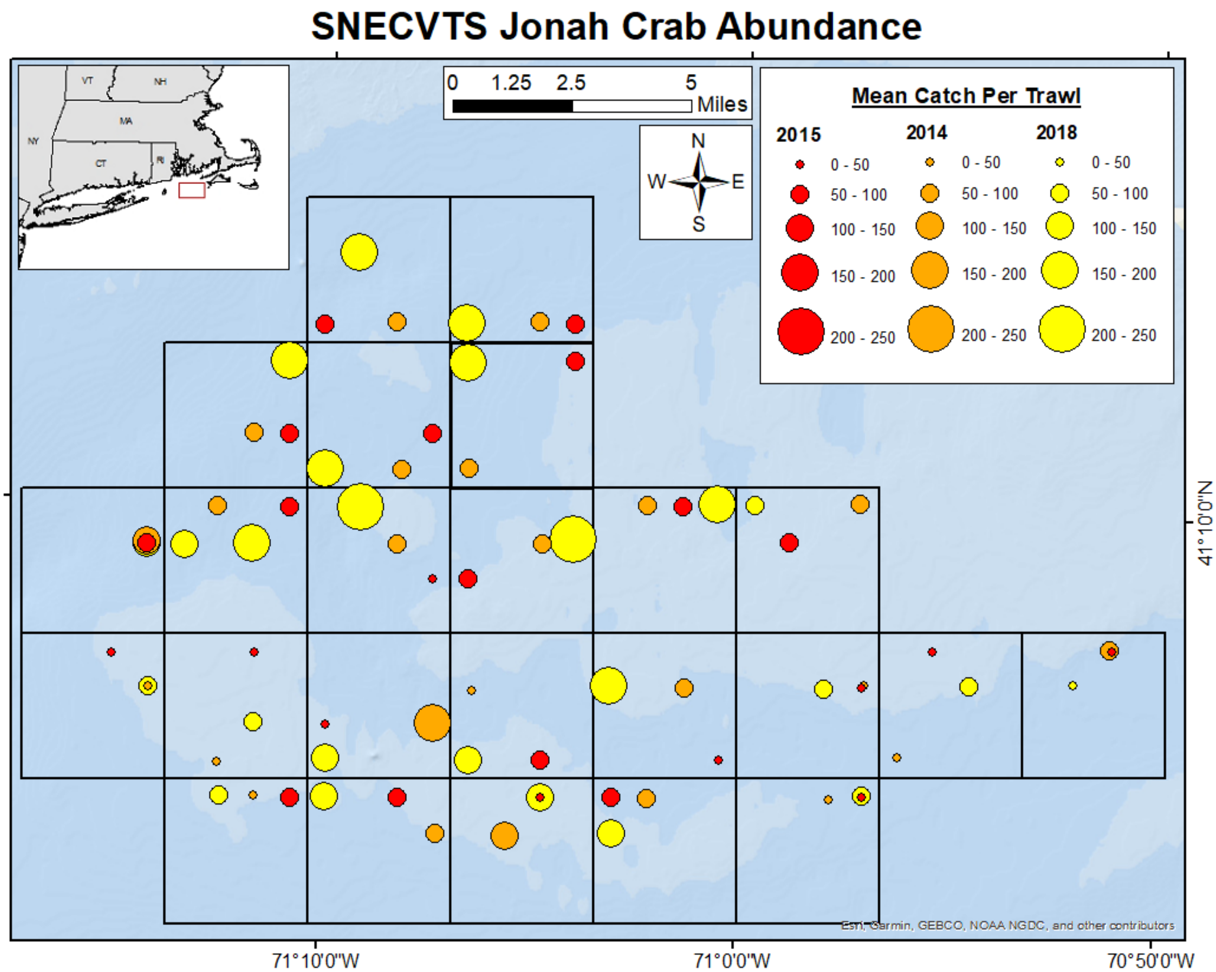

Figure 24. Jonah crab abundance by year and by aliquot. Abundance was highest in the northern and central lease blocks. This abundance pattern was consistent between 2014, 2015, and 2018.

The proportion of females was highest in catches in September and October in 2014 and 2015 (Table 11), then highest in August and September in 2018. Lowest female catch rates were observed in July in 2014 and 2015, then in June in 2018. Number of eggers and percent eggers is not available from Phase I in 2014 and 2015 because Jonah crab were sampled as bycatch and egg status was not collected as part of the bycatch biological sampling. Note that only a subset (10 per trap in Phase I and 20 per trap in Phase II) of the total Jonah crab catch was sampled for size, sex, egg presence, and cull status.

Table 10. Total catch of Jonah crab, mean catch per trawl, sex ratio, and percent of female Jonah crabs with eggs by year and month.

Year	Month	Total Jonah Crab	Jonah Crab Per Trawl	Jonah Crab Per Ventless Trap	Jonah Crab Per Standard Trap
2014	May	1,109	15.4	2.2	0.5
2014	June	3,814	53.0	7.1	2.7
2014	July	4,387	60.9	8.7	2.1
2014	August	5,255	73.0	10.7	2.1
2014	September	11,107	154.3	23.5	3.3
2014	October	5,684	78.9	11.4	2.6
2014	Total	31,356	72.6	10.6	2.2
2015	May	400	5.6	0.8	0.2
2015	June	1,845	25.6	3.3	1.4
2015	July	2,863	39.8	5.5	1.7
2015	August	2,849	39.6	5.6	1.4
2015	September	8,541	118.6	17.3	3.8
2015	October	4,693	65.2	8.7	3.3
2015	Total	21,191	49.1	6.9	2.0
2018	May	1,390	29.0	3.9	1.4
2018	June	2,215	46.1	6.3	2.1
2018	July	2,166	46.1	7.0	1.1
2018	August	10,062	209.6	30.0	7.5
2018	September	5,460	113.8	16.6	3.6
2018	October	11,613	241.9	34.0	9.5
2018	November	10,406	216.8	31.0	7.6
2018	Total	43,312	129.3	18.4	4.7

Table 11. Jonah crab catch summary statistics by year and month.

Year	Month	Mean Size (mm)	Sampled Male	Sampled Female	Sampled Unknown Sex	% Female	% Female With Eggs	% Cull
2014	May	112.1	654	262	118	25%	NA	NA
2014	June	110.3	2,877	316	101	10%	NA	NA
2014	July	122.7	3,179	261	7	8%	NA	NA
2014	August	115.4	1,963	1,556	0	44%	NA	NA
2014	September	113.5	1,886	2,433	3	56%	NA	NA
2014	October	113.3	1,670	1,931	0	54%	NA	NA
2014	Total	114.6	12,229	6,759	229	35%	NA	NA
2015	May	109.5	250	136	14	34%	NA	NA
2015	June	103.4	1,505	297	14	16%	NA	NA
2015	July	110.3	2,475	219	7	8%	NA	NA
2015	August	106.9	1,330	879	4	40%	NA	NA

Year	Month	Mean Size (mm)	Sampled Male	Sampled Female	Sampled Unknown Sex	% Female	% Female With Eggs	% Cull
2015	September	108.9	1,371	3,000	4	69%	NA	NA
2015	October	108.3	1,108	1,981	15	64%	NA	NA
2015	Total	108.1	8,039	6,512	58	45%	NA	NA
2018	May	109.3	1,185	202	3	15%	2%	17%
2018	June	111.0	2,068	147	0	7%	2%	24%
2018	July	118.4	1,727	343	0	17%	1%	16%
2018	August	108.0	1,132	4,468	0	80%	0%	11%
2018	September	108.0	887	3,525	1	80%	0%	8%
2018	October	108.5	1,724	4,460	0	72%	0%	13%
2018	November	109.1	2,058	3,851	0	65%	0%	15%
2018	Total	109.4	10,781	16,996	4	61%	0%	14%

Observations of ovigerous females in this study found the highest proportion of females with eggs in May and June, with no ovigerous females caught after July. This may be a cause for the reduced catches of females in spring and early summer months; sex-specific migration and behavioral changes associated with the reproductive cycle have been postulated as causes for differential catches of male and female Jonah crabs (Wenner et al. 1992). Aggregating and burying behavior by ovigerous females has been observed in a related *Cancer* crab species (Rasmuson 2013), and low catchability of ovigerous females has been well documented in *Cancer borealis* and other congeneric crabs (Krouse 1980, Ungfors 2007). The percent of dead Jonah crabs was measured in 2018 only. The percent mortality was 1% in May and June and 0% in the other months.

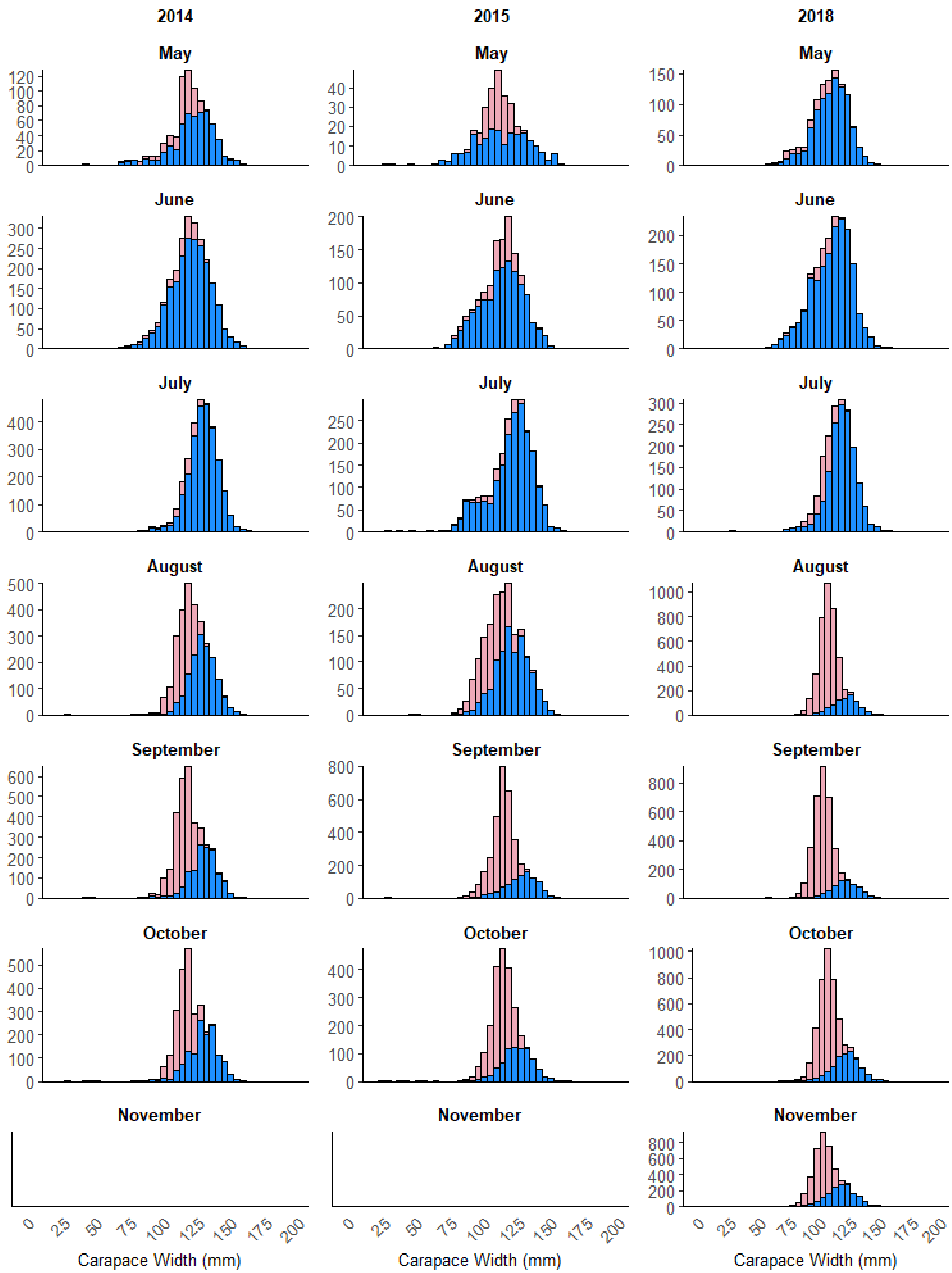

Figure 25. Width-frequency distributions of Jonah crabs in ventless traps, by year and month. Red bars are females and blue bars are males.

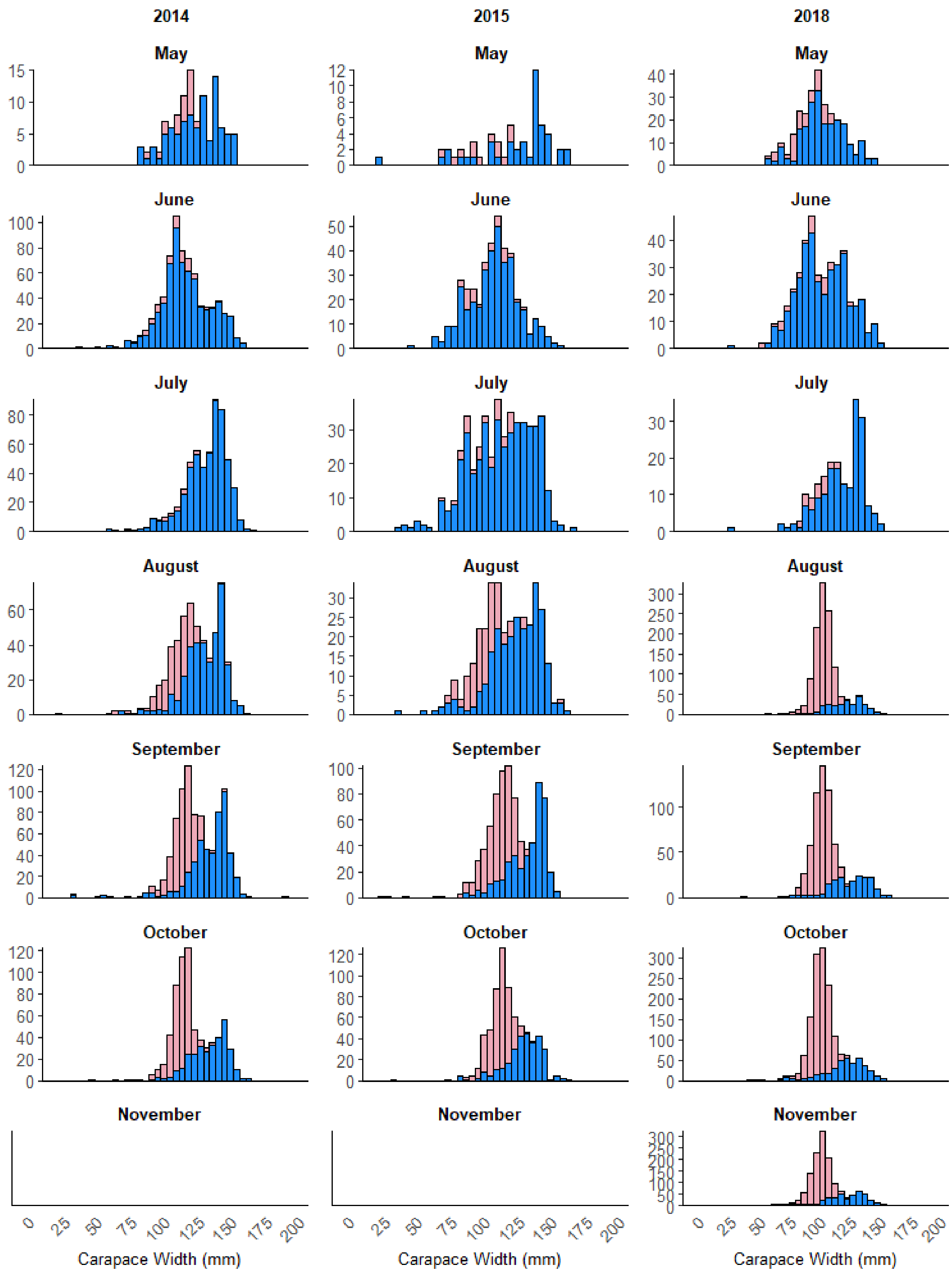

Figure 26. Width-frequency distributions of Jonah crabs in standard traps, by year and month. Red bars are females and blue bars are males.

A GAM was fitted to Jonah crab abundance using the same procedure and error distribution as described above for lobster abundance. The only difference in the Jonah crab case was the inclusion of lobster abundance, as a spline function, as a covariate due to evidence of behavioral interaction between the species (Richards 1983). Depth was the only covariate excluded from the final GAM model (70.2% of deviance explained, Table 12). Additionally, the spline fit to lobster abundance was statistically insignificantly different from a linear relationship (Likelihood Ratio Test, $p > 0.05$) and was therefore removed in favor of a parametric fit of this covariate. The selected GAM suggested that Jonah crabs were least abundant in 2015 and the most abundant in 2018, with all differences among years being statistically significant ($p < 0.001$). The lowest abundance of Jonah crabs was observed in habitats characterized as transition zones and boulders on sand, with no detectable difference between these ($p > 0.05$). Jonah crabs were more abundant in areas of medium to coarse sand ($p = 0.019$) and even more so in areas of soft sediment ($p = 0.006$). Jonah crab abundance decreased with increased lobster abundance ($p < 0.001$), perhaps explaining why they were less ubiquitous in the habitats identified in the lobster GAM model as most favorable. Also, in contrast to lobsters, Jonah crab abundance was found to decrease with increasing temperature anomalies (Figure 27). Whereas lobster abundance exhibited a dome-shaped relationship throughout the summer, Jonah crab abundance increased throughout the study window with local maxima detected in July and September (Figure 28). Finally, the surface fit to latitude and longitude suggests that Jonah crabs were most abundant in the northern part of the study area (Figure 29).

Table 12. Generalized Additive Model fit to Jonah crab abundance in 2014, 2015, and 2018. Habitat coefficients are expressed relative to Boulders; Year effects are expressed relative to 2014.

Parametric Coefficients			
Covariate	Estimate	Standard Error	P-value
Intercept	3.759	0.042	< 0.001
Habitat: Medium to Coarse Sand	0.100	0.042	0.019
Habitat: Soft Sediment	0.190	0.070	0.006
Habitat: Transition Zone	-0.060	0.054	0.272
Year: 2015	-0.399	0.036	< 0.001
Year: 2018	0.370	0.037	< 0.001
Lobster Abundance	-0.004	0.001	< 0.001
Spline Functions			
Covariate	Estimated DF	Reference DF	P-value
Temperature Anomalies	4.529	5.667	< 0.001
Day of the Year	8.863	8.993	< 0.001
Latitude x Longitude	9.533	10.635	< 0.001

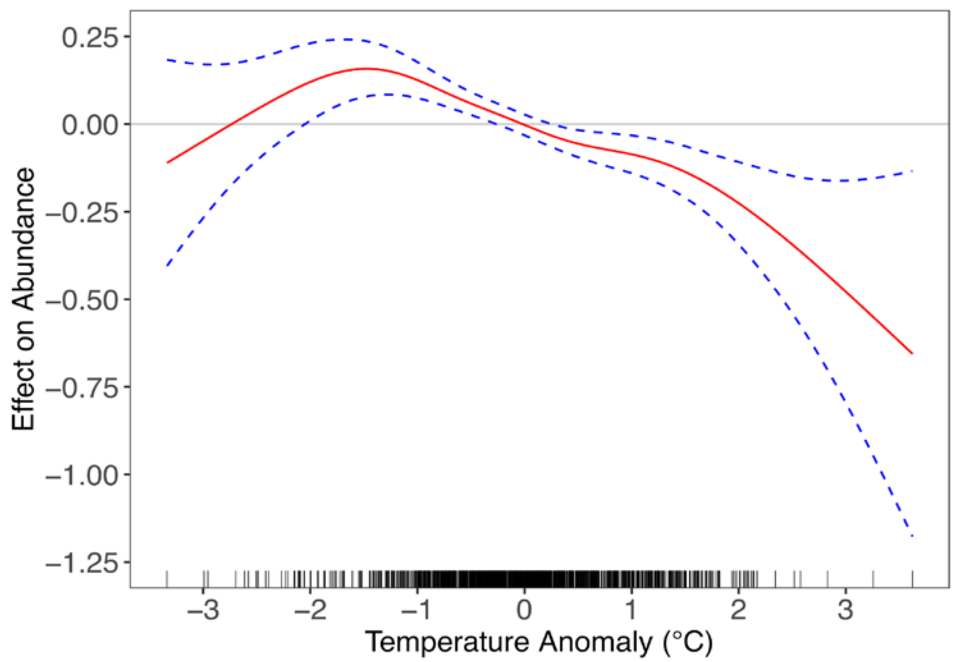

Figure 27. The fitted spline (red) with a 95% confidence interval (blue) of the effect of the temperature anomalies on Jonah crab abundance. Observed temperature anomalies are shown as a rug on the x-axis. The effect suggests Jonah crabs may seek out cooler temperatures within their habitat.

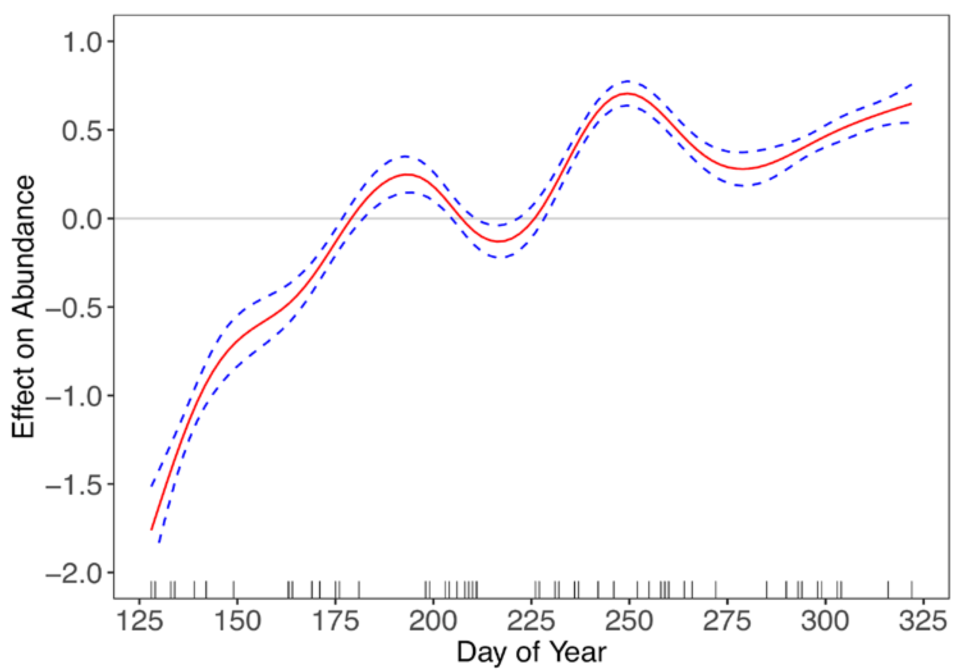

Figure 28. The fitted spline (red) with a 95% confidence interval (blue) of the effect of the day of the year on Jonah crab abundance. Sampling days are shown on the x-axis. The effect increases throughout the study window, with peaks detected in July and September.

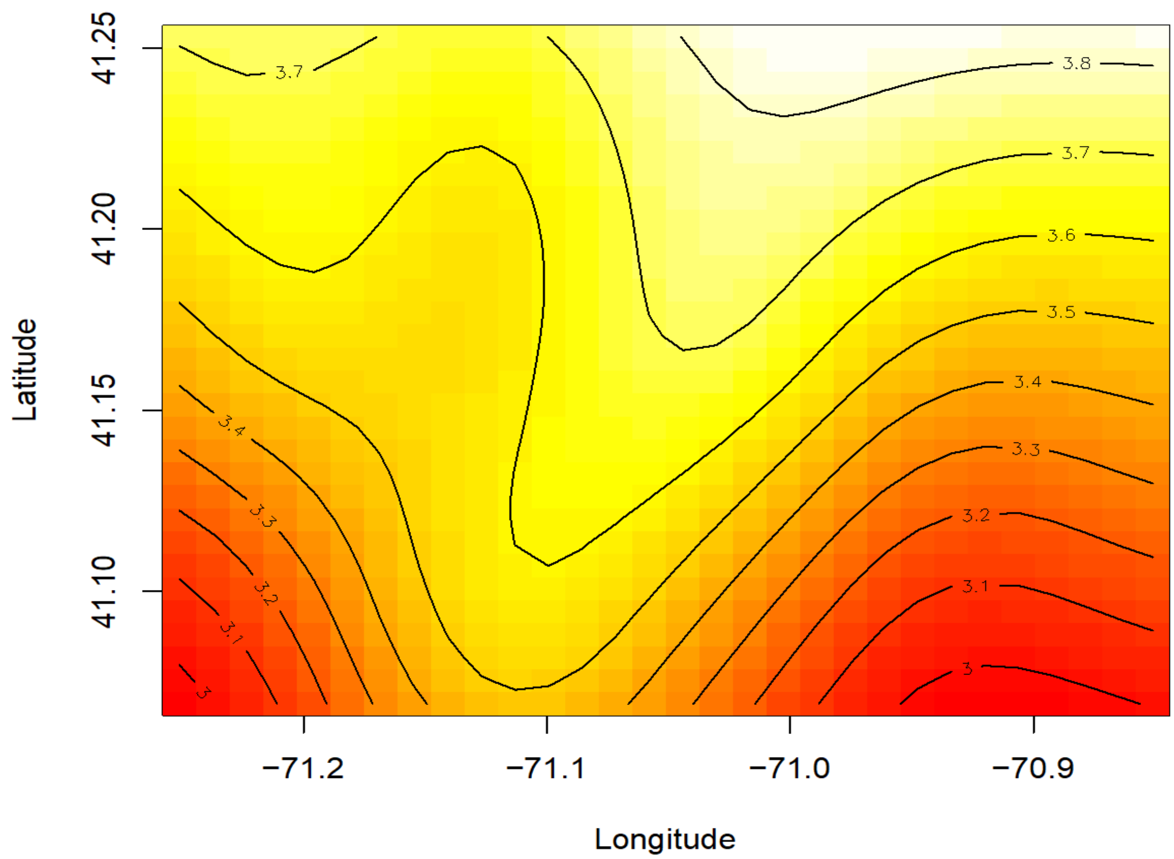

Figure 29. The fitted surface of the effect of latitude and longitude on Jonah crab abundance. The surface suggests Jonah crab abundance was highest in the northern part of the study region.

8. Bycatch Species

A total of 43 different species were caught in the SNECVTS survey (Table 13). Besides the target species, lobster and Jonah crab, the most numerous bycatch species were rock crab, red hake, and black sea bass. Rock crab were generally abundant throughout the lease-block area, with no clear spatial pattern or differences in abundance between 2014, 2015, and 2018. The only exception was the lease block furthest east which included aliquots 19 and 43, where there was much higher abundance of rock crab. Red hake was more abundant in the southern blocks of the lease area (aliquots 12-24), and their overall abundance was highest in 2014. Black sea bass was highest in the most northern and most southern aliquots, with lower abundance in the central region of the study area; their overall abundance was highest in 2014. The spatial distributions of these species are plotted in Figures 30-32.

Table 13. Total abundance and average catch per trawl of species caught in the SNECVTS survey by year.

		Total Abundance			Average Per Trawl		
Common Name	Scientific Name	2014	2015	2018	2014	2015	2018
Jonah crab	*Cancer borealis*	31,356	21,191	43,312	72.58	49.05	129.29
Rock crab	*Cancer irroratus*	15,435	18,767	10,187	35.73	43.44	30.41
Lobster	*Homarus americanus*	10,756	9,074	6,619	24.90	21.00	19.76
Red hake	*Urophycis chuss*	3,133	1,795	1,773	7.25	4.16	5.29
Black sea bass	*Centropristis striata*	1,914	1,109	1,243	4.43	2.57	3.71
Cunner	*Tautogolabrus adspersus*	779	359	366	1.80	0.83	1.09
Ocean pout	*Macrozoarces americanus*	288	376	489	0.67	0.87	1.46
Conger eel	*Conger oceanicus*	294	289	384	0.68	0.67	1.15
Scup	*Stenotomus chrysops*	264	115	258	0.61	0.27	0.77
Sea raven	*Hemitripterus americanus*	48	165	71	0.11	0.38	0.21
Longhorn sculpin	*Myoxocephalus octodecemspinosus*	60	63	30	0.14	0.15	0.09
Moon snail	*Polinices heros*	57	12	39	0.13	0.03	0.12
Hermit crab	*Pagurus spp.*	71	23	8	0.16	0.05	0.02
Speckled barrelfish	*Hyperoglyphe perciformis*	1	0	87	0.00	0.00	0.26
Atlantic cod	*Gadus morhua*	20	23	1	0.05	0.05	0.00
Spotted hake	*Urophycis regia*	6	2	14	0.01	0.00	0.04
Spider crab	*Libinia emarginata*	5	2	3	0.01	0.00	0.01
Sea scallop	*Placopecten magellanicus*	2	4	3	0.00	0.01	0.01
Waved whelk	*Buccinum undatum*	4	4	0	0.01	0.01	0.00
Smooth dogfish	*Mustelus canis*	1	2	4	0.00	0.00	0.01
Starfish	*Asterias spp.*	5	0	1	0.01	0.00	0.00
Mahogany clam	*Arctica islandica*	0	1	4	0.00	0.00	0.01
Skate (egg case)	*Leucoraja spp.*	3	1	0	0.01	0.00	0.00
Spiny dogfish	*Squalus acanthias*	2	2	0	0.00	0.00	0.00
American eel	*Anguilla rostrata*	1	1	2	0.00	0.00	0.01
Haddock	*Melanogrammus aeglefinus*	3	0	0	0.01	0.00	0.00
Filefish	*Monacanthidae*	2	1	0	0.00	0.00	0.00
Lions mane jellyfish	*Cyanea capillata*	1	2	0	0.00	0.00	0.00

		Total Abundance			Average Per Trawl		
Common Name	Scientific Name	2014	2015	2018	2014	2015	2018
Sea robin	*Prionotus spp.*	2	0	1	0.00	0.00	0.00
Winter flounder	*Pseudopleuronectes americanus*	1	0	2	0.00	0.00	0.01
Triggerfish	*Balistes capriscus*	0	1	2	0.00	0.00	0.01
Little skate	*Leucoraja erinacea*	0	0	3	0.00	0.00	0.01
Butterfish	*Peprilus triacanthus*	2	0	0	0.00	0.00	0.00
Yellowtail flounder	*Pleuronectes ferruginea*	2	0	0	0.00	0.00	0.00
Pollock	*Pollachius virens*	1	0	0	0.00	0.00	0.00
Snowy grouper	*Epinephelus niveatus*	1	0	0	0.00	0.00	0.00
Surfclam	*Spisula solidissima*	1	0	0	0.00	0.00	0.00
Tilefish	*Lopholatililus chamaeleonticeps*	1	0	0	0.00	0.00	0.00
American shad	*Alosa sapidissima*	0	1	0	0.00	0.00	0.00
Toadfish	*Opsanus tau*	0	1	0	0.00	0.00	0.00
Anemone	*Actiniaria spp.*	0	0	1	0.00	0.00	0.00
Rock gunnel	*Pholis gunnellus*	0	0	1	0.00	0.00	0.00
Tautog	*Tautoga onitis*	0	0	1	0.00	0.00	0.00

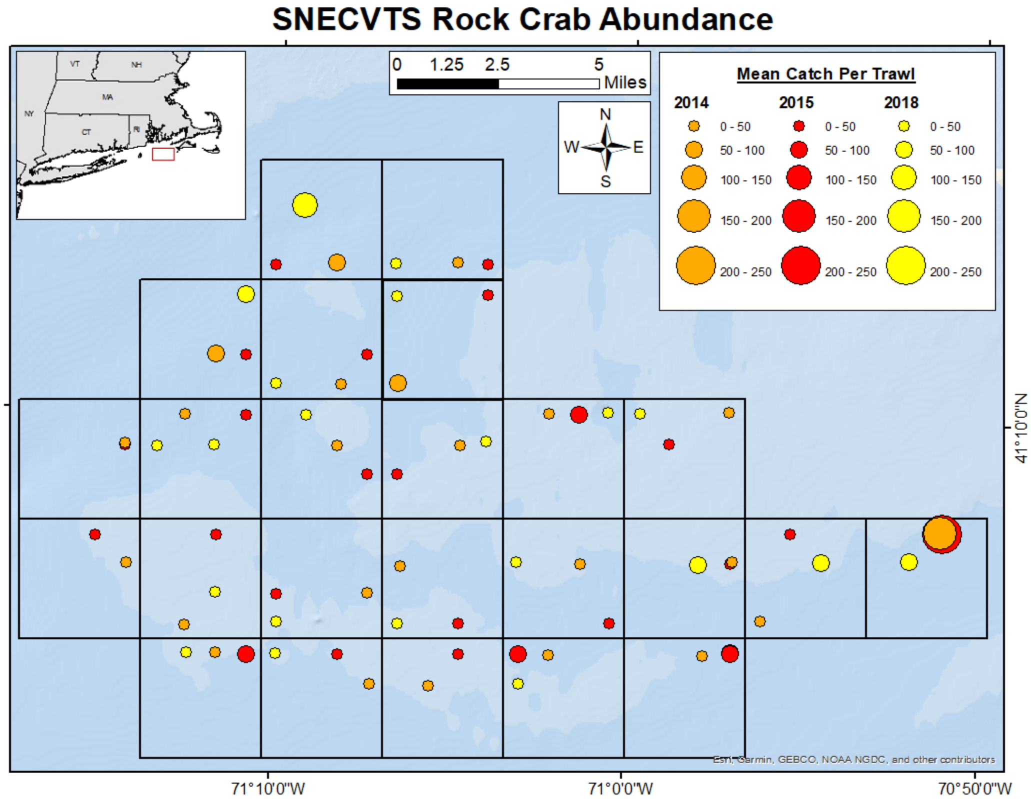

Figure 30. Rock crab, *Cancer irroratus*, abundance by year and by aliquot.

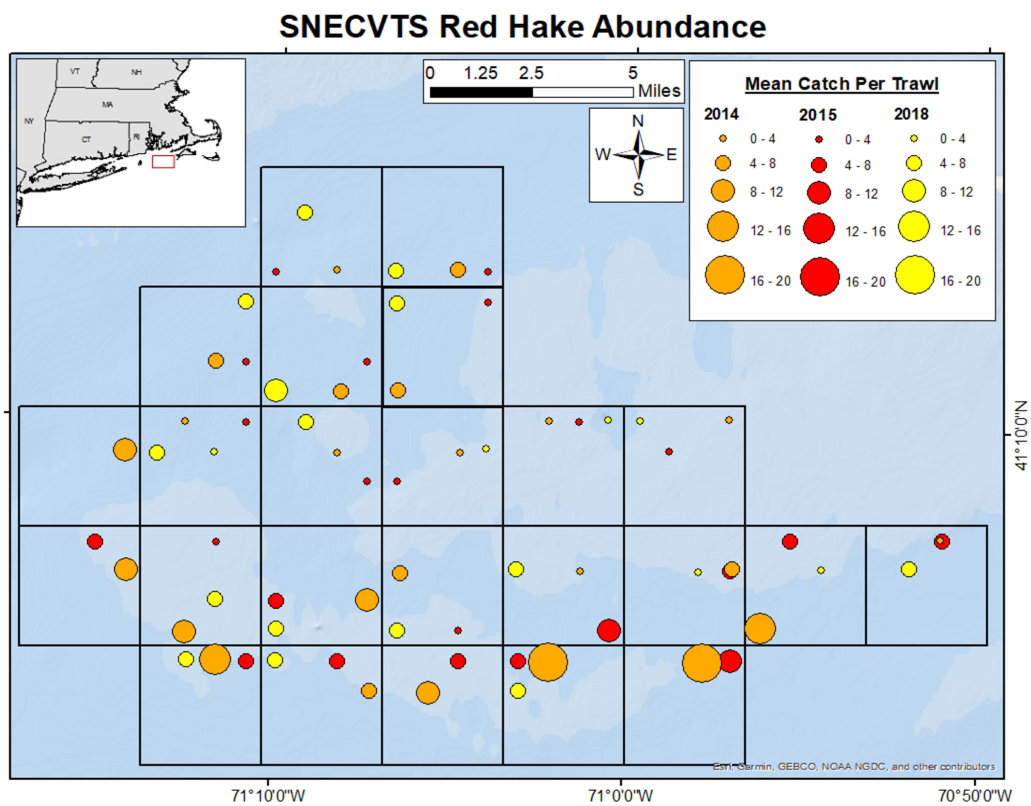

Figure 31. Red hake, *Urophysis chuss*, abundance by year and by aliquot.

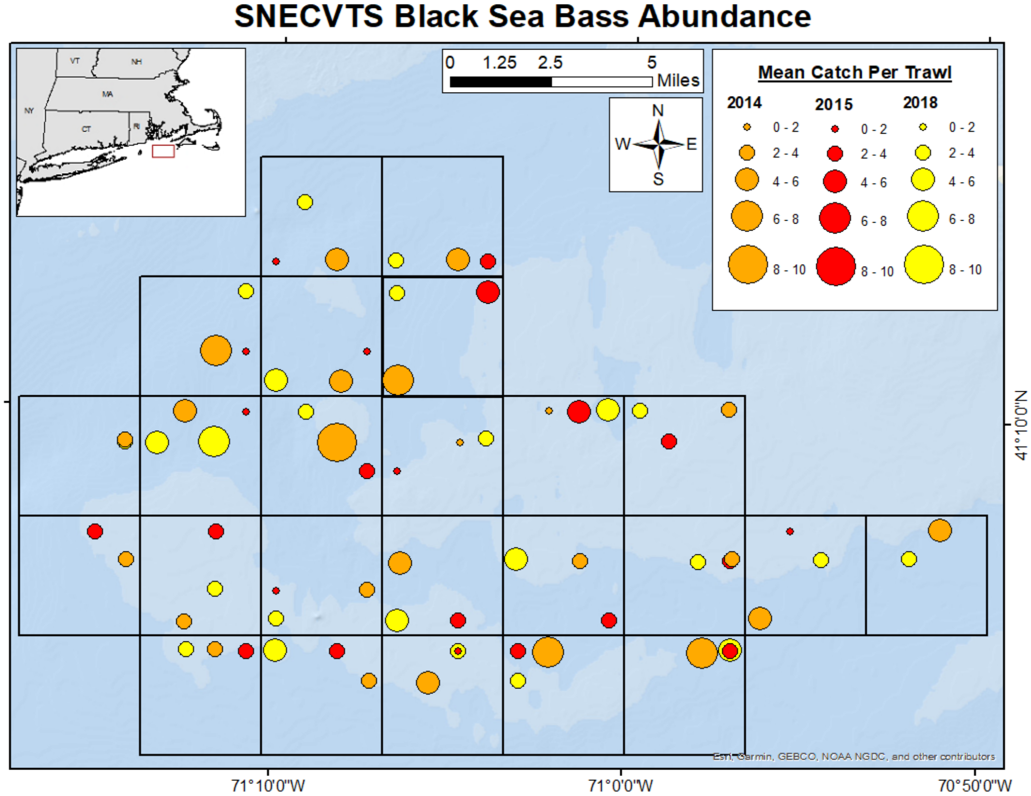

Figure 32. Black sea bass, *Centropristis striata*, abundance by year and by aliquot.

9. Lobster Tagging

A pilot tagging study was initiated in 2015, to begin to evaluate the movement of lobsters in and around the RI/MA lease area and the probability that the same lobsters are captured multiple times. Lobsters were tagged with individually numbered cable ties, attached around the "elbow" of the claw. These tags were expected to remain on the lobster until it molts. A total of 300 lobsters were tagged in August 2015 as that time of year is just after many lobsters should have just molted. A total of 300 lobsters were tagged – 100 on each vessel, distributed more-or-less evenly among aliquots (e.g. 12 per aliquot, depending on numbers caught). All sizes of lobsters were tagged. Lobsters with shell disease were not tagged, as these old-shell lobsters are more likely to molt and shed the tag. These pilot tagging efforts resulted in 39 recaptures, for an overall return rate of 13%.

Tagging efforts were increased in 2018, with t-bar sphyrion anchor tags (Floy Tag & Mfg. Inc., Seattle, Washington) replacing the coded cable ties. The sphyrion tags were expected to remain in the lobsters through one molt, as the tags are anchored under the membrane and new developing shell behind the carapace (Figure 33). These sphyrion tags were marked with unique ID numbers and the CFRF phone number to call in recapture reports from the commercial lobster fleet. A tag notification was posted throughout southern New England ports and distributed electronically to encourage recapture reporting from commercial lobstermen (Figure 34). A monetary reward system was also put in place to encourage reports form commercial lobstermen, with a lottery drawing taking place in February 2019 to randomly select winners.

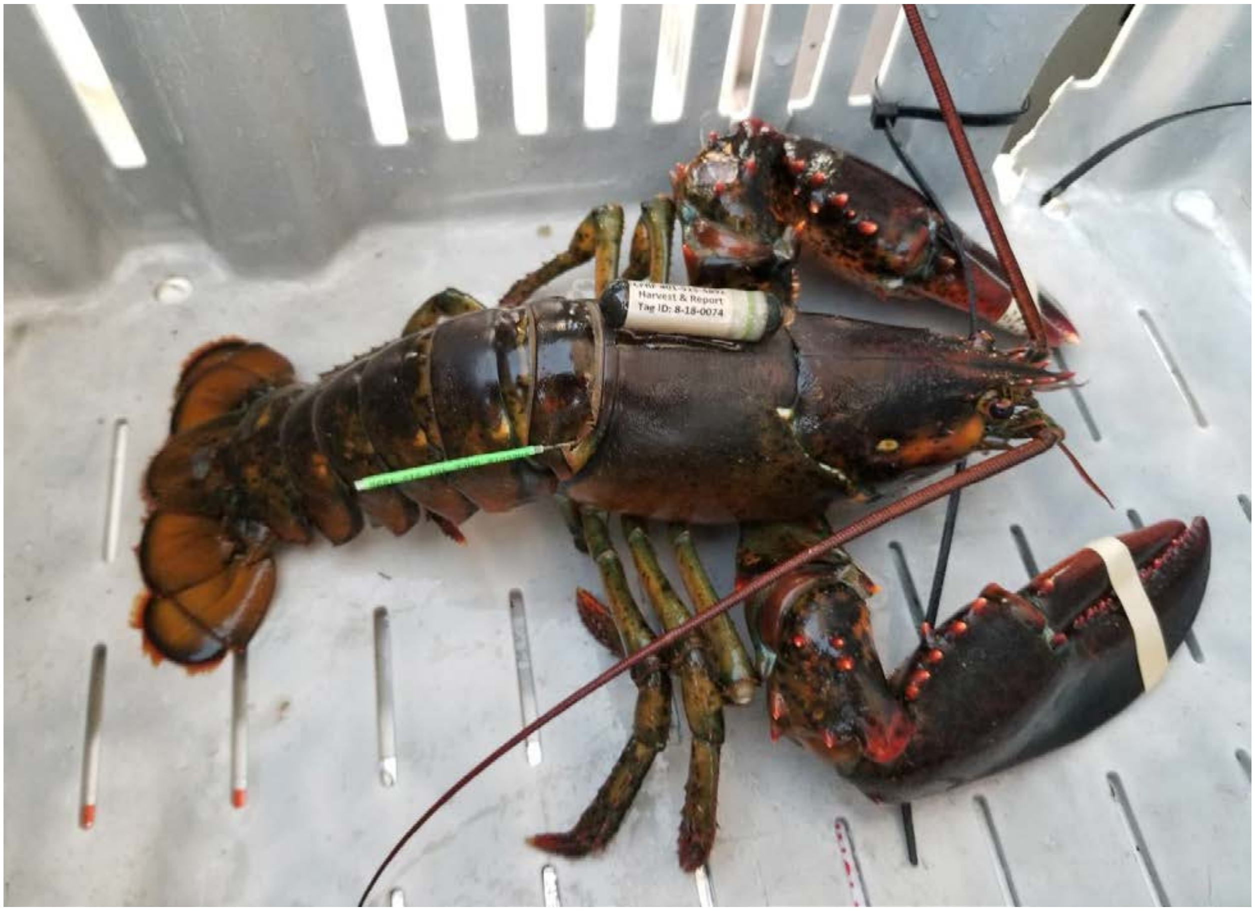

Figure 33. Lobster tagged in 2018 with a green sphyrion t-bar tag behind carapace and acoustic tag on top of carapace.

A total of 2,735 lobsters were tagged with sphyrion tags from May through November of 2018, predominantly in the SNECVTS study area. A cohort of 501 of those tags were released in state waters of Rhode Island Sound through the Rhode Island Department of Environmental Management ventless trap survey in August 2018 in an attempt to capture offshore movements of lobsters from state waters out into or through the SNECVTS study area. As in 2015, all sizes of lobsters were tagged, and lobsters with severe shell disease were not tagged.

A total of 195 recapture events occurred through April 2019, for an overall recapture rate of 7%. Of the 195 recaptures, 105 were from SNECVTS sampling and 90 were from commercial lobstermen. Of the 195 recaptures, 148 were around the SNECVTS study area and Rhode Island Sound waters, and 47 moved south from the study area. Although these recaptures are not corrected for sampling effort, they do indicate a residence time of months within the study area.

Most of the recaptures occurred within three months of tagging (Figure 35). These results are consistent with previous tagging studies, in which most recaptures occurred in the first few months near where the lobsters were tagged (Campbell & Stasko 1985). However, for the SNECVTS tag recaptures, the end of project sampling in November 2018 resulted in less effort contributed to tag recapture efforts after that time. The inshore lobster and crab fisheries are also slow in the winter and early spring, which further resulted in less effort dedicated to potential tag recaptures over time for the end of the tagging study.

Most recaptures were in the vicinity of the lease block area (Figures 35-37). The majority of lobsters traveled less than 5 km; and the majority of those travelled less than 1 km. There was no obvious direction of travel, except that few lobsters moved in a northerly direction. A total of 38 lobsters traveled over 120 km to the edge of the continental shelf where they were caught by offshore lobstermen (Figure 37). These lobsters travelled at speeds upwards of 5 km/day, and one lobster traveled 135 km in 9 days, resulting in an average velocity of 15 km/day (Figure 35).

Previous tagging studies indicate that mature lobsters travel considerably farther than juveniles (Campbell & Stasko 1985, Campbell 1986). Long-distance migration (>100km) has been reported, including lobsters that make excursions of 10-400 km, returning to the area of initial tagging after 10 to 14 months (Pezzack & Duggan 1986). These long excursions are thought to be part of the temperature-mediated, seasonal migration of American lobster.

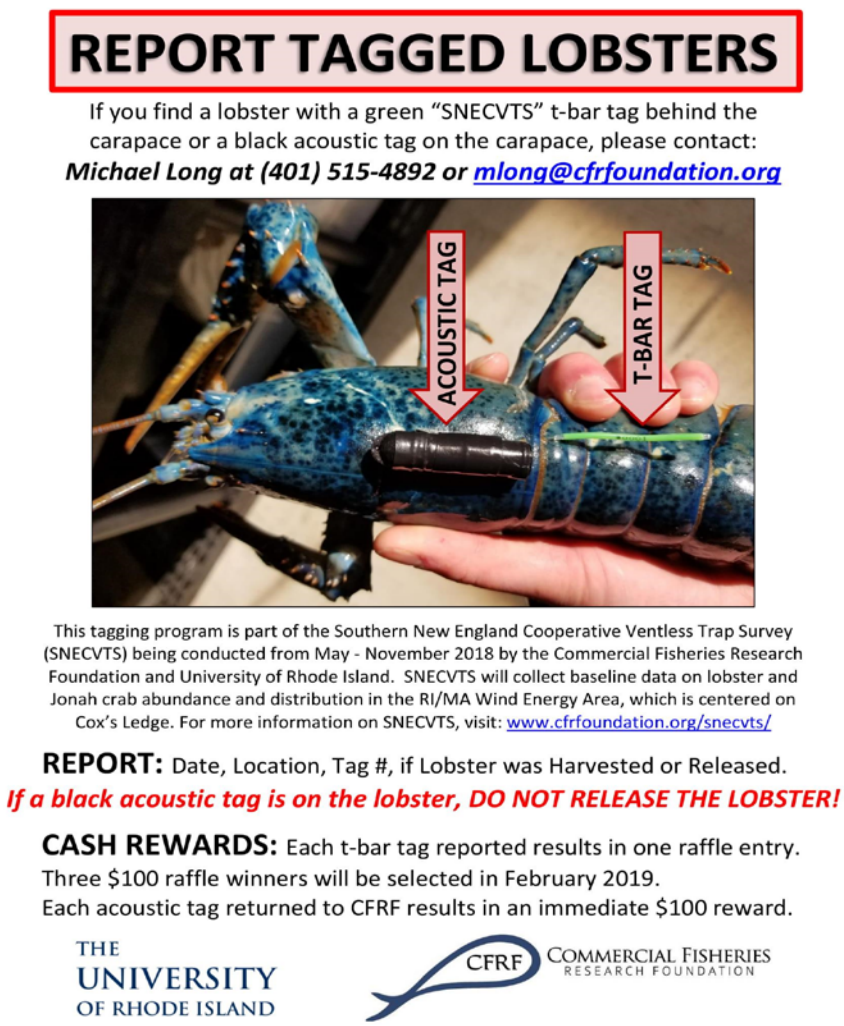

Figure 34. SNECVTS tag notification posted throughout southern New England ports and distributed electronically to encourage recapture reporting from commercial lobstermen.

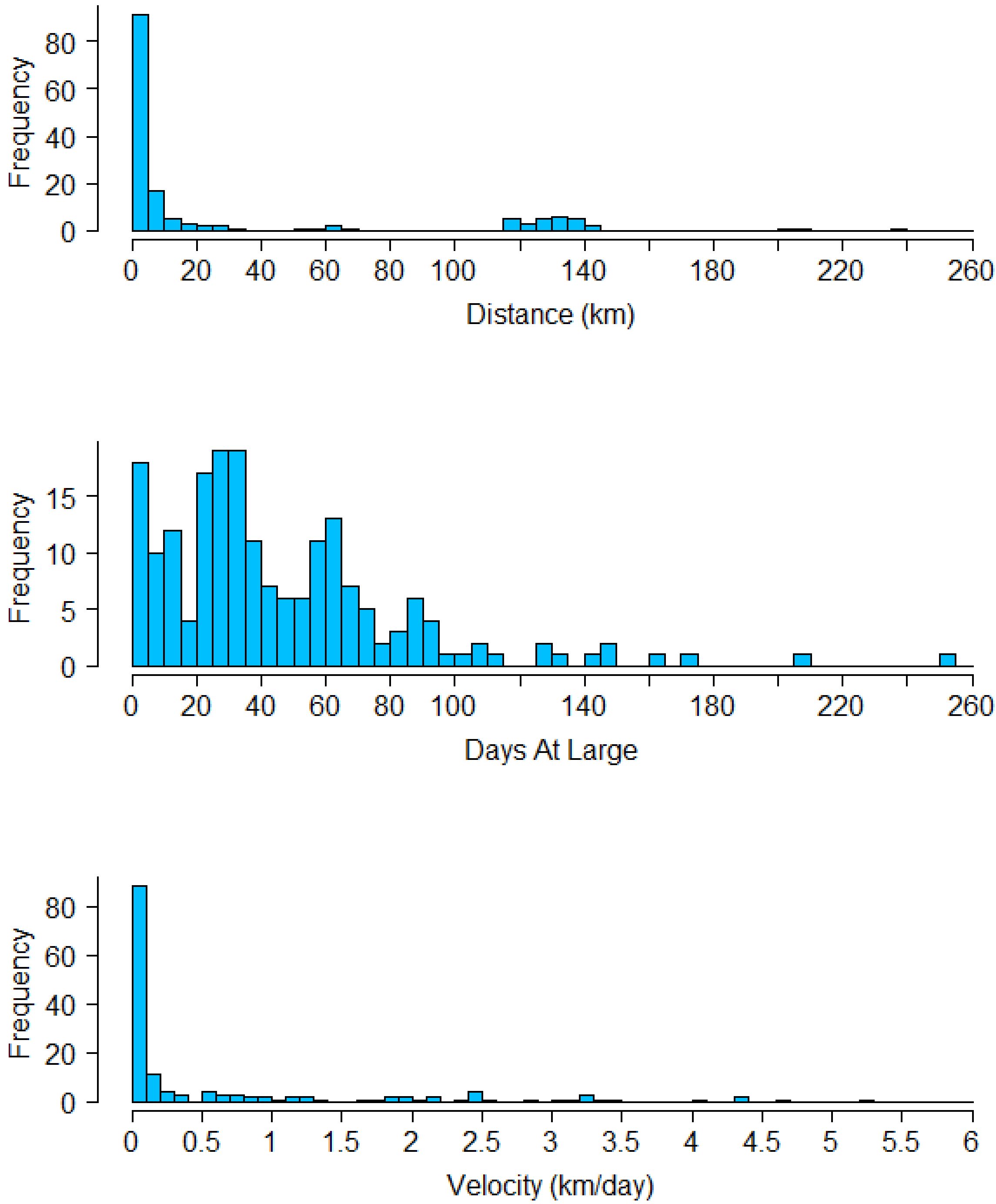

Figure 35. Distance traveled by lobsters from the point of tagging to the point of recapture, days between tagging and recapture, and estimated velocity. One lobster with an estimated velocity of 15 km/day is not included in the third plot to allow better visualization of the majority of the data.

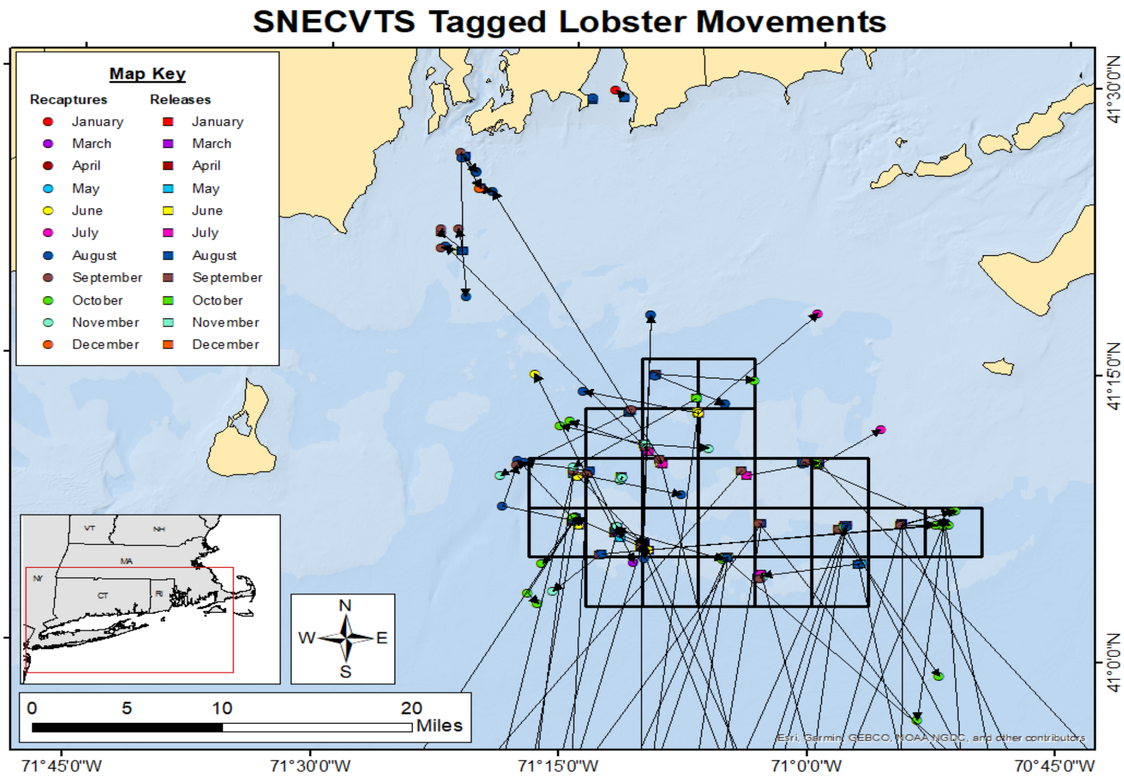

Figure 36. Tagging and recapture locations of lobsters tagged in 2018 and recaptured around the study area, arrows indicate direction of travel (see Figure 37 for offshore recaptures).

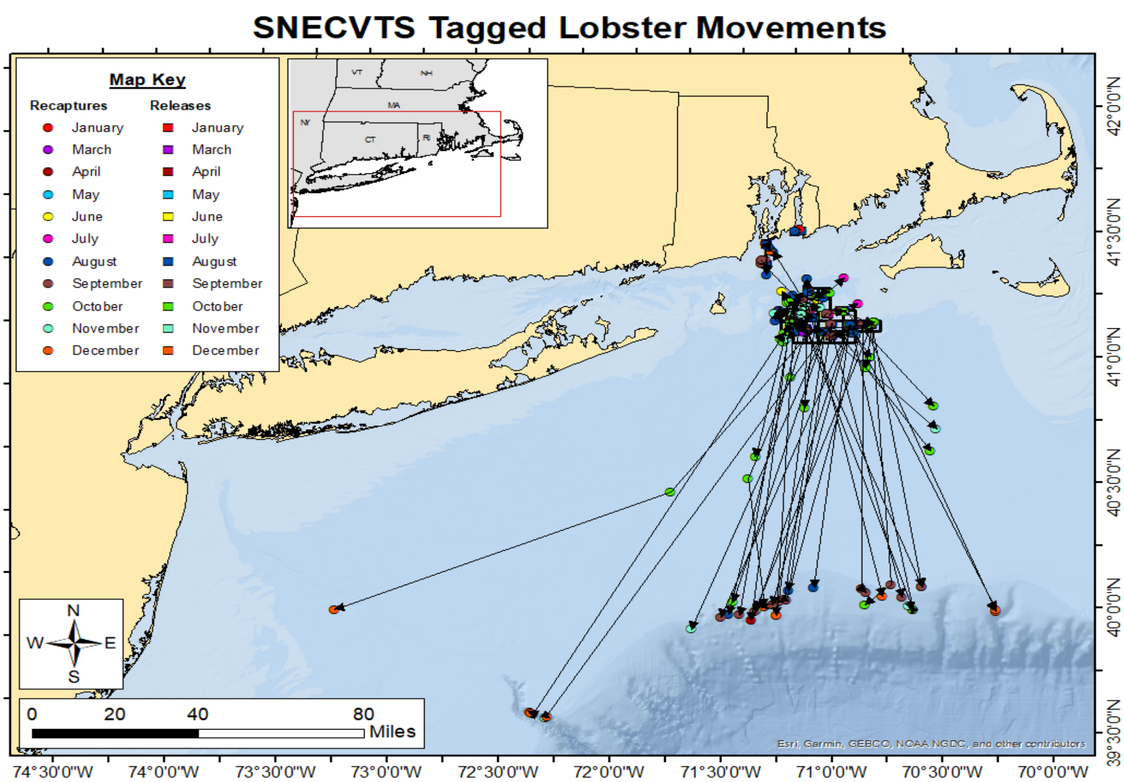

Figure 37. Tagging and recapture locations of all lobsters tagged in 2018, arrows indicate direction of travel (see Figure 36 for recaptures in the vicinity of the study area).

In addition to the sphyrion tagging study, a pilot acoustic telemetry study was conducted in 2018 using a new URI Fish Chip technology and RAFOS sound sources. Thirty-two tags were glued to the carapace of mature male lobsters (Figure 33). Three sounds sources were deployed south of the RI/MA wind-energy area and the tagged lobsters were released within the wind-energy area. This pilot study was mostly successful. Six of the 32 tags were recovered after intervals of 10 to 64 days. One of the tagged lobsters was recaptured twice. These numbers confirm that the adhesives work and that satisfactory recovery rates of tagged individuals can be expected. Unfortunately, the sound sources were not turned on to full power and no location data were recorded. The sources were recovered later in the fall and were found to be fully functional. Otherwise, the tags operated as designed. The internal clocks kept time to within 7-11 seconds over the 2-3 month time span (an error of 1-2 parts per million) and the temperature was recorded every 40 minutes. Acoustic tag #38 was released in the study area on September 29, 2018 and recovered on December 1, 2018 at the edge of the continental shelf. Figure 38 shows the temperature record collected by this tag during the 64 days it was submerged. We conclude from this pilot study that this tagging methodology is mature and ready for a full-scale field study.

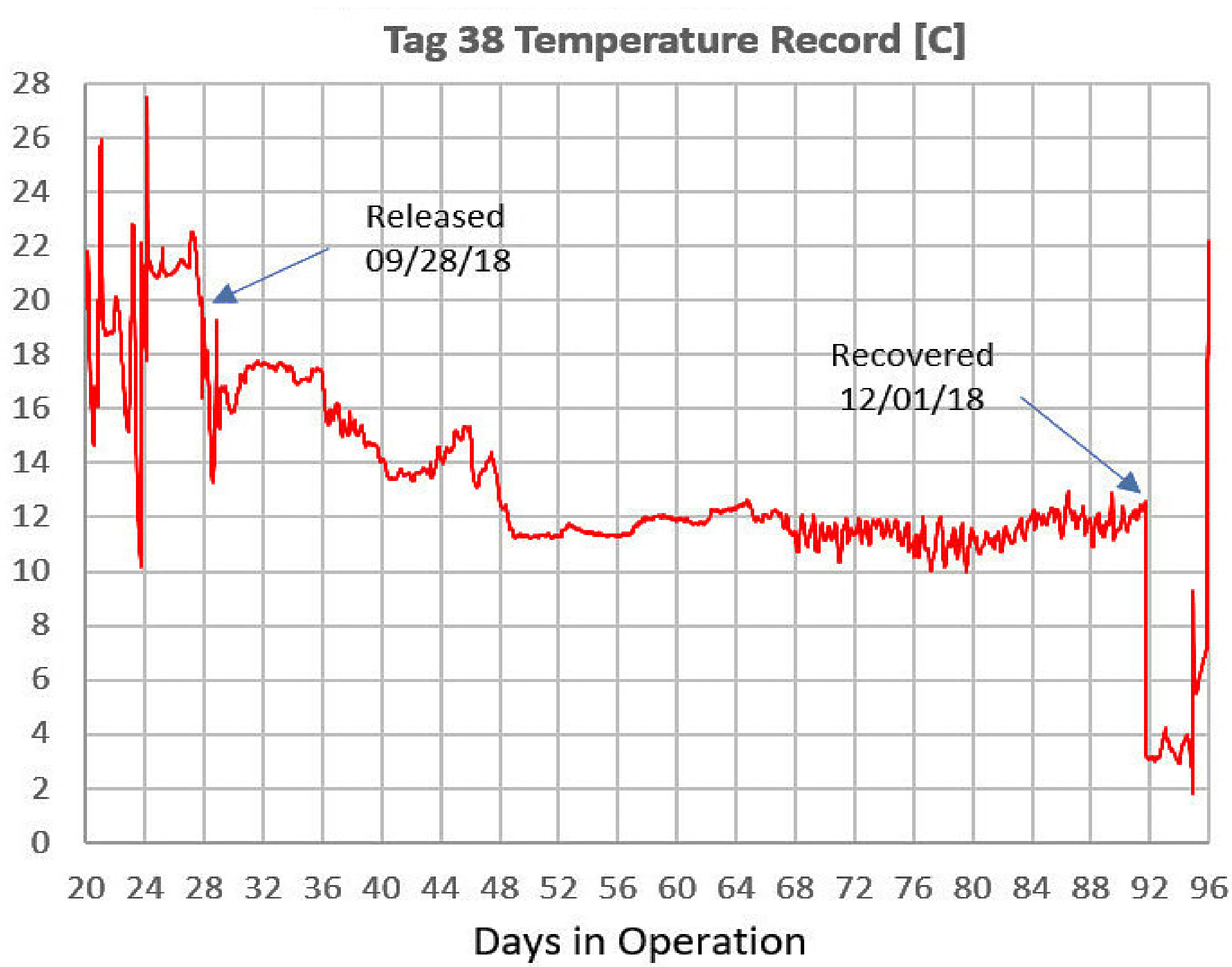

Figure 38. Temperature record from Acoustic Tag 38. This trajectory is consistent with past evidence that lobsters move toward their preferred temperature range when temperatures exceed 16°C (Jury & Watson 2013).

10. Conclusions

The Southern New England Cooperative Ventless Trap Survey has provided a three-year baseline against which to assess the potential effects of offshore wind energy development in the RIMA wind energy area. Habitat types are patchy in the study area, but there is generally more soft sediment in the deeper northern lease blocks and more boulder habitat to the south (Figure 4).

Though separated by two years, the 2018 data are largely consistent with 2014 and 2015, with no strong temporal trends in lobster abundance. The Generalized Additive Models (GAMs) provide our best estimate of lobster abundance because they account for covariates that significantly affect lobster catch rates (day of year, habitat type, and temperature anomalies). Though catch per trawl was lowest in 2018, the estimated year effects in the GAM were not significantly different between 2014 and 2018; lobster abundance was significantly lower in 2015 (Table 4 and 5).

Likewise, the spatial distribution of lobsters was consistent among years. Lobster abundance was consistently high on the eastern side of the study area (Figure 12) in lease blocks 6918, 6919 and 6970 (Figure 1). High abundance in these lease blocks is partially explained by the occurrence of boulder and transition habitat (Figure 4). Lobster catch rates were significantly higher in transition zones between boulders and sand (Table 4 and Appendix 2). These spatial patterns are important for siting assessments and for choosing appropriate control sites for post-construction monitoring. For example, the South Fork Work Area in the southwest corner of the study area (lease blocks 6965-6967 and 7015-7017) had consistently lower lobster catches over the three years (Figure 12). Suitable control sites would be those with similar habitat types and lobster catch rates.

Results of lobster tagging in 2015 and 2018 are consistent with the hypothesis of bimodal movement patterns. Most lobsters were recaptured in the lease area, while a subset migrated to the edge of the continental shelf during the late summer to early fall (Figure 36). These movements can likely be explained as a pursuit of bottom temperatures within their thermal preferences, which past studies have suggested spans 12-18 °C (Jury & Watson 2013). Seasonal temperature cycles (Figure 10) exceeded 20 °C only briefly in 2014. This offshore habitat may provide a refuge from warm temperatures (>20 °C) that occur regularly in inshore areas in southern New England. The lower temperatures experienced offshore may also contribute to the low incidence of shell disease. However, seasonal patterns of catch and the results of 2018 tagging efforts suggest that lobsters left the study area prior to peak bottom temperatures. These observations indicate that the bottom temperatures of the inner continental shelf in southern New England may exceed lobster thermal preferences in the late summer to early fall. This thermal challenge is likely to become more severe in the future as climate change continues.

Jonah crab abundance increased significantly in 2018 (Tables 9 and 10). Across all years, Jonah crabs were consistently abundant in the northern lease blocks 6816-6817, 6865-6867, and 6915-6917. Jonah crab abundance was higher on soft sediments and was negatively associated with lobster abundance. Although Jonah crab catch peaked in late summer to early fall (Table 11) when bottom temperatures were near their peak, this species appeared to be most abundant at the coldest temperatures available within the study area (Figure 27).

Consistent spatial patterns were found for other numerous bycatch species, except for black sea bass, which had a more homogeneous distribution (Figure 32). Rock crab abundance was highest in the eastern-most lease block (Figure 30). Red hake was more abundant in the southern lease blocks (Figure 31). Taken together, the distribution of lobsters, Jonah crabs, and bycatch species suggest that the study area represented a heterogenous habitat that supported a variety of commercially-important species with unique fine-scale distribution patterns that may be partially explained by temperature and substrate preferences. The data collected and analyzed as part of this effort may provide insights into the varying distributions of these species and inform siting assignments and monitoring efforts in the future.

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Appendix 1. List of Project Personnel

Name	Affiliation	Role
Alyssa Lopez	URI	Assistant Sea Sampler
Andrew White	F/V Amelia Anne	Captain, Crew
Anna Malek Mercer	CFRF	Co-Principal Investigator
Aubrey Ellertson	CFRF	Assistant Sea Sampler
Brian Hooker	BOEM	Project Liason
Brian Jenkins	URI	Lead Sea Sampler
Brian Thibeault	F/V Ashley Ann	Captain
Christopher Glass	CFRF	Co-Principal Investigator
Coral Fredette	F/V Three Sons	Crew
Corinne Truesdale	URI GSO	Assistant Sea Sampler
Dawn Parry	URI	Assistant Sea Sampler
Elizabeth Molnar	URI	Assistant Sea Sampler
Eric Marcus	F/V Persistence	Captain
Godi Fischer	URI	Acoustic Telemetry Developer
Greg Lisi	F/V Amelia Anne	Captain
Greg Mataronas	F/V Cailyn Gregory	Captain
Jeremy Collie	URI GSO	Principal Investigator
Jon Laiuppa	URI	Assistant Sea Sampler
Joseph Langan	URI GSO	Lead Sea Sampler
Josh Miller	F/V Persistence	Crew
Kim Hindle	URI GSO	Grant Management Support
Lanny Dellinger	F/V Megan & Kelsey	Captain
Luis Pomales	URI GSO	Assistant Sea Sampler
Matt Griffin	RWU	Lead Sea Sampler

Name	Affiliation	Role
Michael Long	CFRF	Field Coordinator, Lead Sea Sampler
Mike Marchetti	F/V Mister G	Captain
Miriam Ameworwor	URI	Assistant Sea Sampler
Rich Lodge	F/V Persistence (F/V Select)	Captain
Ryan Soucy	North Kingstown High School	Tagging Trial Technician
Saroj Mohanty	URI	Lobster Tracks App Developer
Skylar Nelson	URI	Assistant Sea Sampler
Teresa Winneg	CFRF	Business Manager
Thomas Heimann	CFRF	Lead Sea Sampler
Tom Rossby	URI GSO	Acoustic Telemetry Developer
Wayne Fredette	F/V Three Sons	Captain

Appendix 2. Coordinates of Sampling Locations, Depth and Habitat Classification

* Aliquot 55X habitat classification was determined anecdotally from independent data outside of the 2018 habitat classification protocols, see Section 4. Habitat Studies and Classification.

Year	Aliquot	Latitude	Longitude	Depth (m)	Habitat Classification
2014	1	41.221	-71.140	37.5	Medium to coarse sand
2014	2	41.222	-71.083	40.8	Soft sediment
2014	3	41.187	-71.196	40.8	Medium to coarse sand
2014	4	41.177	-71.137	37.2	Medium to coarse sand
2014	5	41.178	-71.110	37.2	Medium to coarse sand
2014	6	41.154	-71.238	42.4	Medium to coarse sand
2014	7	41.165	-71.210	36.3	Medium to coarse sand
2014	8	41.155	-71.138	35.1	Medium to coarse sand
2014	9	41.156	-71.080	34.1	Transition zone
2014	10	41.168	-71.038	34.1	Transition zone
2014	11	41.170	-70.953	27.4	Boulders on sand
2014	12	41.111	-71.236	33.2	Boulders on sand
2014	13	41.089	-71.208	33.2	Boulders on sand
2014	14	41.102	-71.122	38.7	Medium to coarse sand
2014	15	41.112	-71.107	34.7	Boulders on sand
2014	16	41.114	-71.022	34.7	Boulders on sand
2014	17	41.116	-70.950	32.6	Boulders on sand
2014	18	41.095	-70.936	36.0	Medium to coarse sand
2014	19	41.128	-70.852	37.5	Transition zone
2014	20	41.079	-71.193	33.5	Boulders on sand
2014	21	41.069	-71.120	34.7	Boulders on sand
2014	22	41.069	-71.092	33.5	Boulders on sand
2014	23	41.081	-71.036	36.0	Medium to coarse sand

Year	Aliquot	Latitude	Longitude	Depth (m)	Habitat Classification
2014	24	41.082	-70.963	35.4	Medium to coarse sand
2015	25	41.220	-71.169	43.0	Soft sediment
2015	26	41.221	-71.069	37.2	Soft sediment
2015	27	41.187	-71.182	39.9	Medium to coarse sand
2015	28	41.188	-71.125	38.7	Soft sediment
2015	29	41.211	-71.068	35.7	Medium to coarse sand
2015	30	41.153	-71.238	42.4	Medium to coarse sand
2015	31	41.165	-71.181	39.3	Medium to coarse sand
2015	32	41.145	-71.124	35.7	Boulders on sand
2015	33	41.145	-71.109	34.4	Boulders on sand
2015	34	41.168	-70.024	32.9	Medium to coarse sand
2015	35	41.158	-70.981	34.1	Medium to coarse sand
2015	36	41.121	-71.251	33.8	Boulders on sand
2015	37	41.122	-71.194	31.4	Boulders on sand
2015	38	41.101	-71.165	35.1	Medium to coarse sand
2015	39	41.092	-71.079	33.8	Medium to coarse sand
2015	40	41.093	-71.008	36.0	Medium to coarse sand
2015	41	41.115	-70.951	32.6	Boulders on sand
2015	42	41.127	-70.923	32.9	Transition zone
2015	43	41.128	-70.851	37.5	Medium to coarse sand
2015	44	41.079	-71.179	34.1	Medium to coarse sand
2015	45	41.080	-71.136	34.7	Boulders on sand
2015	46	41.081	-71.079	33.8	Boulders on sand
2015	47	41.081	-71.050	35.7	Medium to coarse sand
2015	48	41.083	-70.950	36.6	Medium to coarse sand

Year	Aliquot	Latitude	Longitude	Depth (m)	Habitat Classification
2018	49	41.241	-71.156	44	Soft sediment
2018	50	41.221	-71.112	41	Soft sediment
2018	51	41.209	-71.183	42	Soft sediment
2018	52	41.177	-71.168	40	Medium to coarse sand
2018	53	41.209	-71.111	40	Soft sediment
2018	54	41.153	-71.238	40	Medium to coarse sand
2018	55	41.153	-71.223	38	Soft sediment
2018	55X	41.154	-71.195	38	Boulders on sand*
2018	56	41.166	-71.153	39	Soft sediment
2018	57	41.158	-71.068	34	Medium to coarse sand
2018	58	41.169	-71.010	39	Medium to coarse sand
2018	59	41.169	-70.995	35	Medium to coarse sand
2018	60	41.111	-71.236	34	Boulders on sand
2018	61	41.101	-71.194	34	Transition zone
2018	62	41.091	-71.165	34	Transition zone
2018	63	41.091	-71.108	34	Transition zone
2018	64	41.114	-71.052	35	Medium to coarse sand
2018	65	41.115	-70.966	34	Medium to coarse sand
2018	66	41.116	-70.908	34	Medium to coarse sand
2018	67	41.117	-70.867	37	Transition zone
2018	68	41.079	-71.207	34	Boulders on sand
2018	69	41.080	-71.165	35	Transition zone
2018	70	41.081	-71.079	34	Boulders on sand
2018	71	41.070	-71.050	35	Medium to coarse sand
2018	72	41.083	-70.950	36	Medium to coarse sand

Appendix 3. Data from Tagged and Recaptured Lobsters.

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
13	5/22/2018	41.0906	-71.1646	5/29/2018	41.0906	-71.1646	0	0	7	0.00
16	5/22/2018	41.0906	-71.1646	5/29/2018	41.0906	-71.1646	0	0	7	0.00
17	5/22/2018	41.0936	-71.1693	6/20/2018	41.0906	-71.1646	1	123	29	0.03
21	5/22/2018	41.0936	-71.1693	7/25/2018	41.0956	-71.1706	0	326	64	0.00
22	5/22/2018	41.0906	-71.1646	7/30/2018	41.0933	-71.1715	1	292	69	0.01
36	5/22/2018	41.1048	-71.1991	7/25/2018	41.1082	-71.1976	0	24	64	0.00
38	5/22/2018	41.1011	-71.1939	5/29/2018	41.1011	-71.1939	0	0	7	0.00
40	5/22/2018	41.1048	-71.1991	6/24/2018	41.2422	-71.2847	17	328	33	0.52
44	5/29/2018	41.1110	-71.2361	8/24/2018	41.1667	-71.3000	8	311	87	0.09
44	5/22/2018	41.1110	-71.2361	5/29/2018	41.1110	-71.2361	0	0	7	0.00
46	7/25/2018	41.1159	-71.2403	10/4/2018	41.0511	-71.2855	8	215	71	0.11
46	10/4/2018	41.0511	-71.2855	10/10/2018	41.0416	-71.2748	1	132	6	0.17
46	5/22/2018	41.1149	-71.2421	7/25/2018	41.1159	-71.2403	0	60	64	0.00
49	5/22/2018	41.1562	-71.2433	8/15/2018	41.1399	-71.1331	9	98	85	0.11
54	7/25/2018	41.0956	-71.1706	7/30/2018	41.0933	-71.1715	0	200	5	0.00
54	6/20/2018	41.0906	-71.1646	7/25/2018	41.0956	-71.1706	1	310	35	0.03

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
54	7/30/2018	41.0933	-71.1715	8/25/2018	41.0976	-71.1703	0	16	26	0.00
54	5/29/2018	41.0963	-71.1695	6/20/2018	41.0906	-71.1646	1	139	22	0.05
56	5/29/2018	41.0963	-71.1695	7/30/2018	41.0933	-71.1715	0	214	62	0.00
57	7/25/2018	41.0956	-71.1706	7/30/2018	41.0933	-71.1715	0	200	5	0.00
57	5/29/2018	41.0963	-71.1695	7/25/2018	41.0956	-71.1706	0	240	57	0.00
61	5/29/2018	41.0963	-71.1695	8/25/2018	41.0836	-71.1693	1	179	88	0.01
62	5/29/2018	41.0963	-71.1695	9/17/2018	40.0783	-70.6100	123	151	111	1.11
64	5/29/2018	41.0963	-71.1695	7/25/2018	41.0956	-71.1706	0	240	57	0.00
68	5/29/2018	41.1083	-71.1977	8/25/2018	41.1083	-71.1991	0	268	88	0.00
68	8/25/2018	41.1083	-71.1991	8/30/2018	41.1102	-71.1975	0	38	5	0.00
69	5/29/2018	41.1083	-71.1977	7/25/2018	41.1082	-71.1976	0	145	57	0.00
71	5/29/2018	41.1083	-71.1977	7/25/2018	41.1082	-71.1976	0	145	57	0.00
75	5/29/2018	41.1083	-71.1977	7/25/2018	41.1082	-71.1976	0	145	57	0.00
75	7/25/2018	41.1082	-71.1976	10/26/2018	41.0842	-71.0891	9	102	93	0.10
81	5/29/2018	41.1179	-71.2399	6/20/2018	41.1110	-71.2361	1	151	22	0.05
82	5/29/2018	41.1179	-71.2399	7/25/2018	41.1159	-71.2403	0	190	57	0.00

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
83	5/29/2018	41.1179	-71.2399	10/4/2018	41.0766	-71.2717	5	218	128	0.04
84	5/29/2018	41.1179	-71.2399	9/4/2018	39.9500	-71.4333	131	189	98	1.34
95	6/20/2018	41.1110	-71.2361	7/25/2018	41.1159	-71.2403	1	319	35	0.03
98	6/20/2018	41.1534	-71.2381	9/21/2018	41.0957	-71.1700	9	130	93	0.10
99	6/25/2018	41.0861	-71.0842	10/31/2018	41.0855	-71.0880	0	261	128	0.00
106	6/25/2018	41.0953	-71.1698	7/25/2018	41.0956	-71.1706	0	290	30	0.00
107	6/25/2018	41.0953	-71.1698	7/30/2018	41.0933	-71.1715	0	221	35	0.00
107	7/30/2018	41.0933	-71.1715	8/30/2018	41.2961	-71.1696	23	1	31	0.74
110	6/25/2018	41.1061	-71.1991	7/25/2018	41.1082	-71.1976	0	36	30	0.00
111	6/25/2018	41.1144	-71.2421	7/25/2018	41.1159	-71.2403	0	50	30	0.00
116	7/25/2018	41.1159	-71.2403	7/30/2018	41.0854	-71.0855	13	101	5	2.60
116	7/30/2018	41.0854	-71.0855	8/30/2018	41.0859	-71.0851	0	36	31	0.00
117	9/14/2018	40.0167	-71.2333	9/20/2018	40.0050	-71.2583	2	245	6	0.33
117	7/25/2018	41.0859	-71.0852	9/14/2018	40.0167	-71.2333	119	188	51	2.33
135	7/25/2018	41.0956	-71.1706	7/30/2018	41.1063	-71.1990	3	291	5	0.60
136	7/25/2018	41.0956	-71.1706	7/30/2018	41.0933	-71.1715	0	200	5	0.00

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
145	7/25/2018	41.0956	-71.1706	8/25/2018	41.0976	-71.1703	0	11	31	0.00
150	7/25/2018	41.0956	-71.1706	7/30/2018	41.0933	-71.1715	0	200	5	0.00
163	7/25/2018	41.1082	-71.1976	10/26/2018	41.1073	-71.1989	0	237	93	0.00
170	7/25/2018	41.1082	-71.1976	8/26/2018	39.9524	-71.4839	131	194	32	4.09
194	8/25/2018	41.0976	-71.1703	9/29/2018	41.0936	-71.1722	0	206	35	0.00
194	7/30/2018	41.0933	-71.1715	8/25/2018	41.0976	-71.1703	0	16	26	0.00
206	5/22/2018	41.1697	-71.0103	6/20/2018	41.1698	-71.0105	0	303	29	0.00
211	5/22/2018	41.1185	-70.8669	6/15/2018	41.1164	-70.8674	0	194	24	0.00
211	6/15/2018	41.1164	-70.8674	6/25/2018	41.1180	-70.8674	0	1	10	0.00
211	6/25/2018	41.1180	-70.8674	7/30/2018	41.1188	-70.8671	0	23	35	0.00
212	6/25/2018	41.1180	-70.8674	7/25/2018	41.1187	-70.8675	0	349	30	0.00
212	5/22/2018	41.1185	-70.8669	6/25/2018	41.1180	-70.8674	0	225	34	0.00
212	7/25/2018	41.1187	-70.8675	7/30/2018	41.1188	-70.8671	0	79	5	0.00
215	5/22/2018	41.0830	-70.9500	5/29/2018	41.0704	-71.0496	8	263	7	1.14
246	6/20/2018	41.1681	-70.9956	7/16/2018	41.2000	-70.9333	6	63	26	0.23
264	6/20/2018	41.0688	-71.0519	7/25/2018	41.0712	-71.0505	0	29	35	0.00

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
265	8/25/2018	41.1702	-71.0111	8/30/2018	41.1684	-71.0115	0	191	5	0.00
265	6/25/2018	41.1697	-71.0106	8/25/2018	41.1702	-71.0111	0	312	61	0.00
276	8/25/2018	41.1704	-70.9954	8/30/2018	41.1691	-70.9957	0	191	5	0.00
276	6/25/2018	41.1696	-70.9947	8/25/2018	41.1704	-70.9954	0	320	61	0.00
295	7/30/2018	41.1699	-71.0105	8/25/2018	41.1702	-71.0111	0	299	26	0.00
304	8/30/2018	41.0721	-71.0491	9/21/2018	41.0677	-71.0514	1	208	22	0.05
304	7/25/2018	41.0712	-71.0505	8/30/2018	41.0721	-71.0491	0	61	36	0.00
307	7/25/2018	41.0712	-71.0505	9/21/2018	41.0677	-71.0514	0	194	58	0.00
313	7/25/2018	41.0712	-71.0505	9/29/2018	40.0333	-70.7000	119	161	66	1.80
400	7/25/2018	41.0712	-71.0505	7/30/2018	41.0720	-71.0501	0	27	5	0.00
420	6/20/2018	41.2125	-71.1185	12/12/2018	39.9500	-71.2667	141	187	175	0.81
445	6/25/2018	41.2113	-71.1176	7/2/2018	41.3000	-71.0000	14	53	7	2.00
447	6/25/2018	41.2113	-71.1176	8/5/2018	41.2279	-71.2350	10	278	41	0.24
459	6/25/2018	41.1668	-71.1555	8/3/2018	41.3516	-71.3793	28	310	39	0.72
484	8/17/2018	41.2193	-71.0918	8/27/2018	41.2193	-71.0918	0	270	10	0.00
484	7/25/2018	41.2431	-71.1625	8/17/2018	41.2193	-71.0918	6	109	23	0.26

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
537	7/25/2018	41.1575	-71.0675	8/25/2018	41.1704	-70.9954	6	80	31	0.19
552	7/25/2018	41.1657	-71.1530	9/12/2018	41.4002	-71.3335	30	322	49	0.61
568	7/30/2018	41.1831	-71.1720	10/23/2018	41.1977	-71.2580	7	280	85	0.08
568	7/25/2018	41.1768	-71.1676	7/30/2018	41.1831	-71.1720	1	325	5	0.20
623	7/30/2018	41.1063	-71.1990	8/25/2018	41.1083	-71.1991	0	357	26	0.00
630	7/30/2018	41.1147	-71.2422	10/26/2018	41.1146	-71.2405	0	92	88	0.00
632	7/30/2018	41.1147	-71.2422	8/25/2018	41.1154	-71.2415	0	46	26	0.00
638	7/30/2018	41.1147	-71.2422	8/30/2018	41.1184	-71.2399	0	31	31	0.00
639	7/30/2018	41.1147	-71.2422	8/25/2018	41.1154	-71.2415	0	46	26	0.00
648	7/30/2018	41.1576	-71.2428	4/10/2019	39.9303	-71.3811	137	186	254	0.54
661	8/25/2018	41.0687	-71.0520	11/12/2018	41.0695	-71.0480	0	78	79	0.00
685	8/25/2018	41.0976	-71.1703	8/30/2018	41.2961	-71.1696	22	0	5	4.40
716	8/25/2018	41.0976	-71.1703	9/21/2018	41.1100	-71.1982	3	294	27	0.11
726	8/25/2018	41.1154	-71.2415	9/21/2018	41.1173	-71.2405	0	29	27	0.00
729	8/25/2018	41.1154	-71.2415	8/27/2018	41.1261	-71.3135	6	278	2	3.00
729	8/27/2018	41.1261	-71.3135	9/6/2018	41.1622	-71.3005	4	20	10	0.40

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
771	8/30/2018	41.0906	-71.1646	9/21/2018	41.1173	-71.2405	7	289	22	0.32
776	9/21/2018	41.0957	-71.1700	9/29/2018	41.0936	-71.1722	0	225	8	0.00
776	8/30/2018	41.0906	-71.1646	9/21/2018	41.0957	-71.1700	1	313	22	0.05
799	8/30/2018	41.1102	-71.1975	11/12/2018	41.1107	-71.1968	0	61	74	0.00
835	9/21/2018	41.0861	-71.0857	11/1/2018	39.8880	-71.6532	141	205	41	3.44
841	9/21/2018	41.0861	-71.0857	10/15/2018	40.0000	-71.4667	125	199	24	5.21
863	9/21/2018	41.0957	-71.1700	10/31/2018	41.0946	-71.1723	0	243	40	0.00
866	9/21/2018	41.0957	-71.1700	9/29/2018	41.0936	-71.1722	0	225	8	0.00
903	7/30/2018	41.0720	-71.0501	9/21/2018	41.0677	-71.0514	0	196	53	0.00
933	7/30/2018	41.1697	-70.9949	8/30/2018	41.1691	-70.9957	0	229	31	0.00
938	7/30/2018	41.1697	-70.9949	8/25/2018	41.1704	-70.9954	0	327	26	0.00
945	7/30/2018	41.1163	-70.9652	9/19/2018	39.9933	-71.2900	128	196	51	2.51
969	7/30/2018	41.1189	-70.9093	9/13/2018	40.0667	-70.8833	117	179	45	2.60
969	9/13/2018	40.0667	-70.8833	9/19/2018	40.0517	-70.8617	2	125	6	0.33
982	9/12/2018	40.0133	-71.2267	9/24/2018	39.9833	-71.3500	11	256	12	0.92
982	7/30/2018	41.1189	-70.9093	9/12/2018	40.0133	-71.2267	126	196	44	2.86

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
1015	7/25/2018	41.1162	-70.9665	11/3/2018	39.9731	-71.3548	131	199	101	1.30
1018	7/25/2018	41.1162	-70.9665	8/31/2018	40.0667	-71.1000	117	187	37	3.16
1022	7/25/2018	41.1162	-70.9665	9/11/2018	39.9403	-71.5198	139	205	48	2.90
1025	7/30/2018	41.1188	-70.8671	9/17/2018	40.0783	-70.6100	118	166	49	2.41
1036	7/25/2018	41.1159	-71.0522	8/31/2018	40.0500	-71.2167	119	189	37	3.22
1194	7/30/2018	41.1588	-71.2263	8/8/2018	41.1650	-71.2928	6	275	9	0.67
1218	8/6/2018	41.4842	-71.2024	1/15/2019	41.4910	-71.2110	1	308	162	0.01
1259	8/6/2018	41.4299	-71.3626	8/9/2018	41.4304	-71.3621	0	52	3	0.00
1260	8/6/2018	41.4299	-71.3626	8/21/2018	41.4169	-71.3502	2	136	15	0.13
1260	8/21/2018	41.4169	-71.3502	9/12/2018	41.4169	-71.3502	0	106	22	0.00
1268	8/6/2018	41.4299	-71.3626	8/9/2018	41.4304	-71.3621	0	52	3	0.00
1271	8/6/2018	41.4299	-71.3626	9/21/2018	41.4169	-71.3502	2	136	46	0.04
1298	8/6/2018	41.4029	-71.3454	8/28/2018	41.4001	-71.3336	1	103	22	0.05
1300	8/6/2018	41.4029	-71.3454	8/9/2018	41.4020	-71.3440	0	120	3	0.00
1343	8/6/2018	41.3480	-71.3619	9/14/2018	41.4335	-71.3669	10	357	39	0.26
1343	9/14/2018	41.4335	-71.3669	12/31/2018	41.4023	-71.3462	4	146	108	0.04

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
1347	8/6/2018	41.3480	-71.3619	8/18/2018	41.3083	-71.3569	4	173	12	0.33
1349	8/6/2018	41.3480	-71.3619	9/16/2018	41.3667	-71.3669	2	345	41	0.05
1357	8/6/2018	41.3480	-71.3619	9/23/2018	41.3500	-71.3834	2	275	48	0.04
1505	8/9/2018	41.4821	-71.2337	8/30/2018	41.4838	-71.2343	0	340	21	0.00
1596	8/9/2018	41.3478	-71.3618	9/17/2018	41.3635	-71.3841	3	305	39	0.08
1596	9/17/2018	41.3635	-71.3841	9/23/2018	41.3668	-71.3835	0	10	6	0.00
1678	8/9/2018	41.4304	-71.3621	8/14/2018	41.4285	-71.3647	0	235	5	0.00
1678	8/14/2018	41.4285	-71.3647	8/21/2018	41.4169	-71.3502	2	129	7	0.29
1695	8/9/2018	41.4304	-71.3621	8/14/2018	41.4285	-71.3647	0	235	5	0.00
1698	8/9/2018	41.4304	-71.3621	8/21/2018	41.4169	-71.3502	2	139	12	0.17
1702	8/25/2018	41.2103	-71.1890	11/18/2018	41.1532	-71.3172	12	246	85	0.14
1749	8/25/2018	41.2437	-71.1629	8/30/2018	41.2429	-71.1626	0	163	5	0.00
1793	8/25/2018	41.1587	-71.2268	3/20/2019	41.0800	-71.1800	10	149	207	0.05
1801	8/30/2018	41.2124	-71.1866	9/21/2018	41.2126	-71.1863	0	53	22	0.00
1923	9/21/2018	41.2445	-71.1616	10/1/2018	41.2406	-71.0623	8	92	10	0.80
1963	10/26/2018	40.4333	-71.7667	12/4/2018	39.9192	-73.2692	140	251	39	3.59

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
1963	9/21/2018	41.1613	-71.0737	10/26/2018	40.4333	-71.7667	100	224	35	2.86
2007	9/29/2018	41.1811	-71.1713	10/11/2018	41.2015	-71.2483	7	285	12	0.58
2013	9/29/2018	41.1563	-71.2288	12/12/2018	39.9500	-71.2667	134	182	74	1.81
2014	9/29/2018	41.1697	-71.1559	12/1/2018	40.0367	-70.7900	130	162	63	2.06
2047	10/31/2018	41.2238	-71.1206	11/12/2018	41.1614	-71.2432	12	243	12	1.00
2059	10/31/2018	41.1828	-71.1722	11/12/2018	41.1830	-71.1707	0	81	12	0.00
2061	10/31/2018	41.1828	-71.1722	11/18/2018	41.1804	-71.1068	5	92	18	0.28
2080	10/31/2018	41.1542	-71.1946	11/18/2018	41.1512	-71.1952	0	190	18	0.00
2082	10/31/2018	41.1542	-71.1946	11/18/2018	41.1512	-71.1952	0	190	18	0.00
2088	11/12/2018	41.1539	-71.1934	11/18/2018	41.1512	-71.1952	0	214	6	0.00
2088	10/31/2018	41.1542	-71.1946	11/12/2018	41.1539	-71.1934	0	105	12	0.00
2092	10/31/2018	41.1542	-71.1946	11/12/2018	41.1539	-71.1934	0	105	12	0.00
2248	9/29/2018	41.0936	-71.1722	11/7/2018	39.9833	-70.6500	131	155	39	3.36
2249	9/29/2018	41.0936	-71.1722	10/31/2018	40.7822	-71.1622	35	178	32	1.09
2259	10/10/2018	40.9000	-71.2333	10/30/2018	40.4953	-71.4125	47	204	20	2.35
2259	10/30/2018	40.4953	-71.4125	12/15/2018	39.9850	-71.3233	57	170	46	1.24

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
2259	9/29/2018	41.0936	-71.1722	10/10/2018	40.9000	-71.2333	22	198	11	2.00
2268	9/29/2018	41.0853	-71.2136	11/30/2018	41.0532	-71.2607	5	236	62	0.08
2293	11/19/2018	39.5322	-72.3498	12/10/2018	39.5388	-72.3673	2	291	21	0.10
2293	12/10/2018	39.5388	-72.3673	12/20/2018	39.5355	-72.3586	1	111	10	0.10
2293	9/29/2018	41.1148	-71.2418	11/19/2018	39.5322	-72.3498	199	215	51	3.90
2298	9/29/2018	41.1148	-71.2418	10/31/2018	41.1173	-71.2413	0	11	32	0.00
2301	9/29/2018	41.1585	-71.2427	10/26/2018	40.5801	-71.3854	65	194	27	2.41
2345	10/31/2018	41.0855	-71.0880	11/13/2018	40.7054	-70.5585	61	126	13	4.69
2607	8/25/2018	41.1161	-71.0519	11/19/2018	39.5203	-72.2982	206	218	86	2.40
2607	11/19/2018	39.5203	-72.2982	12/9/2018	39.5228	-72.2872	1	77	20	0.05
2614	8/25/2018	41.0687	-71.0520	9/21/2018	41.0677	-71.0514	0	147	27	0.00
2629	10/9/2018	39.9833	-70.6500	11/7/2018	40.0000	-70.6667	2	315	29	0.07
2629	8/25/2018	41.0817	-70.9523	10/9/2018	39.9833	-70.6500	125	165	45	2.78
2637	8/25/2018	41.1163	-70.9656	8/30/2018	41.1146	-70.9663	0	203	5	0.00
2652	8/25/2018	41.1186	-70.9098	12/13/2018	39.9824	-70.2722	137	151	110	1.25
2663	8/25/2018	41.1189	-70.8673	8/30/2018	41.1177	-70.8676	0	191	5	0.00

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
2669	8/25/2018	41.1704	-70.9954	8/30/2018	41.1691	-70.9957	0	191	5	0.00
2673	8/25/2018	41.1704	-70.9954	9/21/2018	41.1708	-70.9947	0	61	27	0.00
2677	8/25/2018	41.1704	-70.9954	8/30/2018	41.1691	-70.9957	0	191	5	0.00
2685	8/25/2018	41.1702	-71.0111	10/16/2018	41.1175	-70.8618	14	109	52	0.27
2692	8/25/2018	41.1702	-71.0111	9/21/2018	41.1705	-71.0085	0	84	27	0.00
2729	8/30/2018	41.1177	-70.8676	9/21/2018	41.1184	-70.8683	0	315	22	0.00
2729	9/21/2018	41.1184	-70.8683	10/31/2018	41.1168	-70.8679	0	167	40	0.00
2738	9/30/2018	40.0833	-70.7500	10/9/2018	40.0000	-70.8667	14	234	9	1.56
2738	8/30/2018	41.1177	-70.8676	9/30/2018	40.0833	-70.7500	115	174	31	3.71
2750	8/30/2018	41.1176	-70.9101	10/16/2018	41.1307	-70.8556	5	76	47	0.11
2848	9/21/2018	41.1708	-70.9947	10/26/2018	41.1695	-70.9972	0	243	35	0.00
2849	9/21/2018	41.1708	-70.9947	10/16/2018	40.7973	-70.5745	54	132	25	2.16
2860	9/21/2018	41.1184	-70.8683	9/30/2018	39.9632	-71.3676	135	203	9	15.00
2868	9/21/2018	41.1184	-70.8683	10/16/2018	40.9471	-70.8894	19	187	25	0.76
2885	9/21/2018	41.1169	-70.9105	10/16/2018	41.1297	-70.8607	4	76	25	0.16
2887	9/21/2018	41.1169	-70.9105	10/16/2018	41.1173	-70.8758	3	89	25	0.12

Tag #	Previous Capture Date	Previous Capture Latitude	Previous Capture Longitude	Recap Date	Recap Latitude	Recap Longitude	Distance Traveled (km)	Bearing (deg)	Days At Large	Travel Rate (km/day)
2897	9/21/2018	41.1123	-70.9734	10/16/2018	40.9858	-70.8690	17	140	25	0.68
2903	10/31/2018	41.1147	-70.9680	12/2/2018	39.9885	-70.2722	138	148	32	4.31
2927	9/29/2018	41.1164	-71.0540	10/21/2018	40.6167	-70.5833	68	137	22	3.09

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under US administration.

The Bureau of Ocean Energy Management

As a bureau of the Department of the Interior, the Bureau of Ocean Energy (BOEM) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS) in an environmentally sound and safe manner.