Great South Channel Habitat Management Area Survey

Progress Report for

Exempted Fishing Permit #19066

February 9, 2022

Submitted By

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A. Exempted Fishing Permit: 19066

B. Permit Holder: Coonamessett Farm Foundation, Inc.

C. Project Title: Great South Channel Habitat Management Area Survey

D. Project Start Date: 6/03/2020

E. Period Covered by Report: 6/03/2020 – 11/30/2020

F. Objectives: The intent of this project is to improve manager's understanding of the distribution of biotic and abiotic habitat features within the Great South Channel Habitat Management Area (GSC HMA). Specifically, this is achieved by using dredge-mounted cameras to document substrate, habitat features (e.g. sand waves, mussel beds), and fishes and invertebrates within the Rose and Crown area of the GSC HMA. Data from the dredge-mounted cameras provides for an analysis of the spatial-temporal distribution of biotic and abiotic habitat features which can be used to inform future management actions regarding the GSC HMA.

G. Summary of Work to Date: Beginning June 3, 2020, while operating under an Exempted Fishing Permit (EFP), Coonamessett Farm Foundation (CFF) and Nantucket Sound Seafood began collecting video of seafloor features in a 7nm^2 closed area of the Rose and Crown within the GSC HMA. Since starting the projects, dredge-mounted cameras have been deployed on 100 trips, recording video from 3,500 tows. This report presents data from 83 of the tows, to provide examples of how dredge-mounted video can be used to document the changes of biotic and abiotic habitat features between seasons within an area being fished. While the report only presents summer and fall, at the current annotation rate the remainder of the seasons will be completed by the within two months' time. As video continues to be annotated, the resolution and accuracy of maps generated for this report will improve.

1. Catch Data

1.1. Methodology

For each trip to the research area, the F/V Seafox was accompanied by an at-sea technician who managed the dredge-mounted cameras, recorded tow data, and subsampled of the catch when possible. A one-bushel subsample was selected, catch was separated, counted and weighed to the nearest 0.01 kilogram. After the remainder of the catch was sorted by crew members, the at-sea technician recorded the total catch (number of bushels retained for sale). Some tows were not sampled if the technician was busy handling cameras and/or lights. Additionally, the final few tows of every trip did not permit sampling due to space limitations resulting from vessel operations. The catch subsample was pulled from the same portion of catch pile every tow.

For each tow, the following data was collected:

- Tow start and end date/time (DD/MM/YY, HH:MM)
- Tow start and end location (Latitude and Longitude)
- Tow start and end depth (ft)
- Average tow speed (kts)
- Surf clam catch rates (bushels/tow)
- Picture of each catch pile
- Groundfish (gadids, flatfish, elasmobranchs, etc.) catch rate (number/tow and weight (kg)/tow)
- Groundfish length frequency (cm)
- Substrate and epifauna composition
    - Number of cobbles per one-bushel subsample
    - Weight (kg) of cobbles per one-bushel subsample
    - Picture of cobbles from subsample
    - Weight (kg) of shell/trash per one-bushel subsample
    - Weight (kg) of mussels per one-bushel subsample
    - Picture of mussels from subsample
    - Number of bycatch species (Cancer spp. and moonsnails) per one-bushel subsample
    - Weight (kg) of bycatch per one-bushel subsample

1.2. Results

Tow locations, durations and area covered within the study region varied based on season and best fishing practices as determined by the captain of the vessel (**Figures 1a, 1b** and **Table 1**). A total of 16 unique species were caught throughout all sampled tows (**Table 2)** and consistency of catch varied by month (**Table 3**).

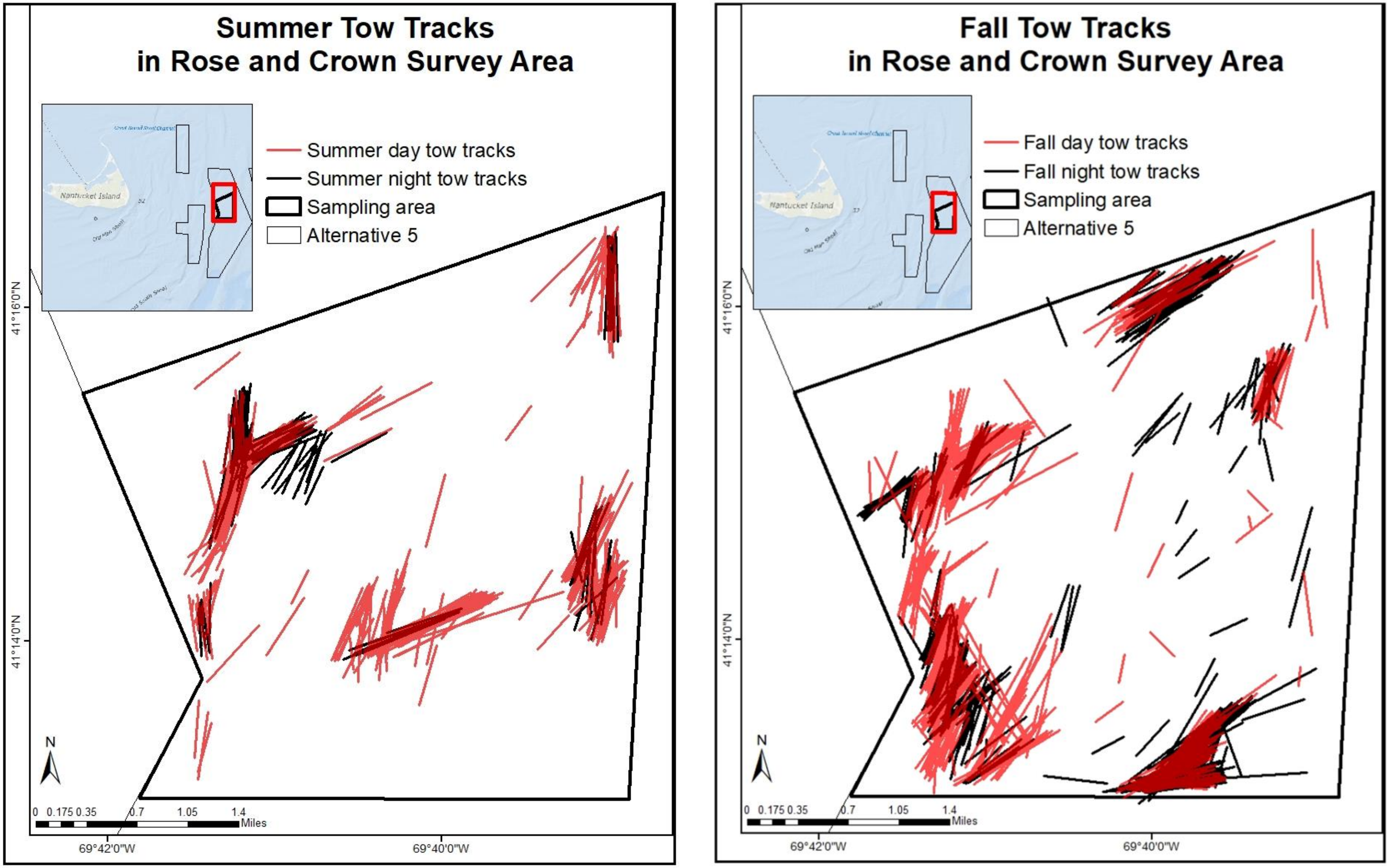


Figure 1. **a)** Summer and **b)** Fall 2020 tow tracks in the Rose and Crown research subarea. Red lines denote daytime tows while black are night tows.

Table 1. Trip, tow numbers, and area swept for summer and fall 2020 survey trips in the GSC HMA.

	Trips	*Tows*	*Area Swept (km^2)*	*Bottom Contact Time (hrs)*
Summer 2020	15	421	0.41	81.7
Fall 2020	26	884	0.83	143.2

Table 2. All species caught in the summer and fall survey trips in the GSC HMA.

Common Name	*Scientific Name*
Atlantic surfclam	*Spisula solidissima*
Blue mussel	*Mytilus edulis*
Horse mussel	*Modiolus modiolus*
Winter skate	*Leucoraja ocellata*
Little skate	*Leucoraja erinacea*
Winter flounder	*Pseudopleuronectes americanus*
Spiny dogfish	*Squalus acanthias*
American lobster	*Homarus americanus*
Jonah crab	*Cancer borealis*
Atlantic rock crab	*Cancer irroratus*
Hermit crab	*Pagurus pollicaris*
Northern moonsnail	*Neverita duplicata*
Common whelk	*Buccinum undatum*
Atlantic slippersnail	*Crepidula fornicata*
Atlantic purple sea urchin	*Arbacia punctulate*
Orange footed sea cucumber	*Cucumaria frondosa*

Table 3. Mean expanded surf clam and substrate/epifauna catch for each of the six months sampled during the reporting period in the GSC HMA.

Month	*n*	*Mean Surf Clam (kg)*	*St. Dev.*	*Mean Mussels (kg)*	*St. Dev.*	*Mean Shells (kg)*	*St. Dev.*	*Mean Cobble (kg)*	*St. Dev.*
June	102	456.33	159.13	33.28	35.00	80.75	103.03	33.06	58.63
July	25	478.04	147.97	82.50	48.68	76.93	53.83	0.27	1.35
August	69	398.84	155.75	35.00	27.94	84.39	55.56	15.05	32.33
September	173	411.28	131.89	36.30	30.49	60.62	54.18	14.27	23.00
October	277	484.61	149.54	25.42	27.52	45.62	35.31	8.69	17.44
November	199	395.34	121.97	40.99	28.46	32.40	24.67	13.45	27.52
All Trips	845	436.21	146.64	34.66	31.55	54.92	53.31	13.49	28.71

2. Video Data

2.1.Methodology

Eighty-three videos from two seasons in 2020 were annotated for this report, 33 from summer and 50 from fall. Summer was specified June 1 to August 31 and fall as September 1 to November 30. This was chosen as a simple way to remain constant interannually through changes in the calendar year. Other seasonal trends could be considered when separating the data set; such as water temperature, seasonal species growth, monthly benthic disturbance, etc. The sampling area was divided into eighteen 1 x 1 nm squares making a numerically organized grid (**Figure 2**). Ideally, fishing effort would have been evenly distributed throughout the grid; however, commercial fishing operations are dependent upon meteorological and oceanographic conditions and therefore squares experienced varying degrees of fishing effort. Where available, three tows with the clearest videos, i.e. low turbidity and well-lit, were chosen from a square. Tows were also chosen to best cover the most area within the squares.

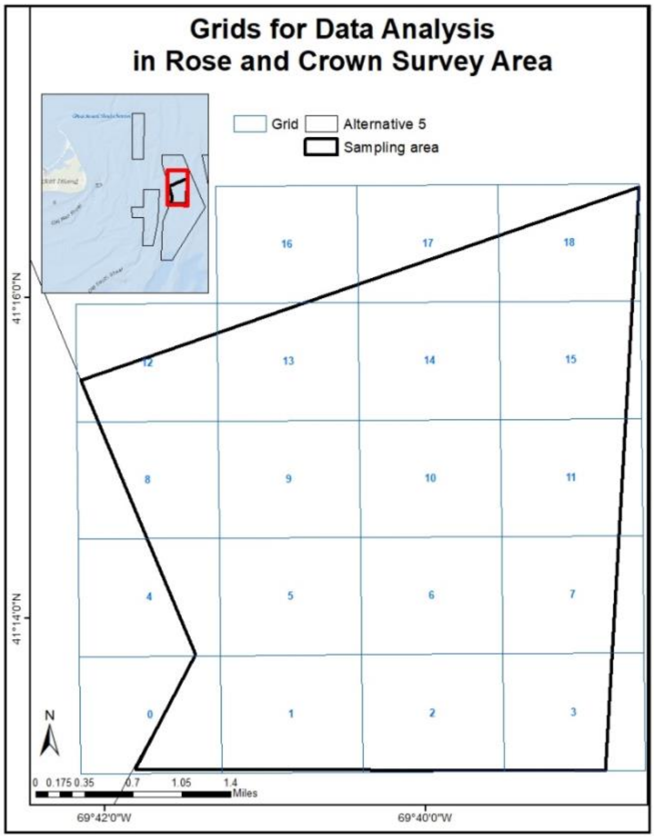


Figure 2. Grid created for data analysis purposes in the Rose and Crown research area.

The 83 videos chosen to represent summer and fall were annotated using Behavioral Observation Research Interactive Software (BORIS). This software utilizes a user designed ethogram to document when and for how long events occur in video observations. In this case, the events are substrate type, topographical features, epifauna, and other species present. Substrate and epifauna were classified as state events with a start and end time and could include modifiers to document macroalgae/bryozoan/hydrozoan coverage and the presence/absence of mussels and shell hash. While rocks/boulders were point events with a single point in time. Rocks were defined as 6-12 inches, while boulders were anything larger than 12 inches (Powell et al. 2019). Observations of fish and invertebrates were also classified as point events. Four staff scientists annotated the same five videos in order to determine inter-rater (or annotator) reliability by using Cohen's Kappa analysis package in BORIS (Friard and Gamba 2016) before the videos for data analysis were examined. The ethogram was altered after the last progress report in order to align the substrates more with the protocol used by the Habitat PDT in their analysis in the surfclam framework (NEFMC 2019). Substrates were classified as "sand" or "pebble and cobble." Pebble and cobble were broken into four categories: < 25%, 25-50%, 51-75% and >75% coverage. Once the videos were annotated, the data was exported as a CSV file and organized for use in ArcGIS.

By pairing the annotated tow's start/end time and location with the behavioral timeline the location of each observation was mapped along the tow path. The annotated tow paths were then transformed into a sequence of points spaced three meters apart and assigned the corresponding substrate category. The three-meter spacing is based on the maximum distance ahead of the dredge that an annotator could reliably categorize substrate. The substrate category for each point was then transformed into a value on a discrete inverse scale representing complexity with sand represented by 100 and the highest coverage of pebble cobble is zero. With this value, the relative complexity of each square within the grid was evaluated using R (R Core Team 2020). Based on this information, habitat distribution maps were created in ArcGIS using the inverse distance weighted (IDW) tool, a point-based interpolation method where the reference points around the interpolation point are used to estimate average values (ESRI 2016, Harman et al. 2016 and Maleika 2020). The number of points per grid square were calculated to determine the appropriate number of points to set as a reference for the IDW (**Table 4**). Interpolation maps for both seasons were generated using the mean number of points and the number of points within one standard deviation (**Figure 3a, b, c**). After evaluation, it was decided to use the mean points by grid (**Figure 3b**).

Table 4. Descriptive statistics of the number of data points by grid square per season.

a) Summer	
Mean	371.4211
Standard Error	71.36576
Median	367
Mode	0
Standard Deviation	311.0761
Sample Variance	96768.37
Kurtosis	-1.1176
Skewness	0.281684
Range	931
Minimum	0
Maximum	931
Sum	7057
Count	19
Confidence Level(95.0%)	149.9339

b) Fall	
Mean	519.4737
Standard Error	53.56902
Median	532
Mode	#N/A
Standard Deviation	233.5019
Sample Variance	54523.15
Kurtosis	0.900821
Skewness	-0.49872
Range	917
Minimum	0
Maximum	917
Sum	9870
Count	19
Confidence Level(95.0%)	112.5443

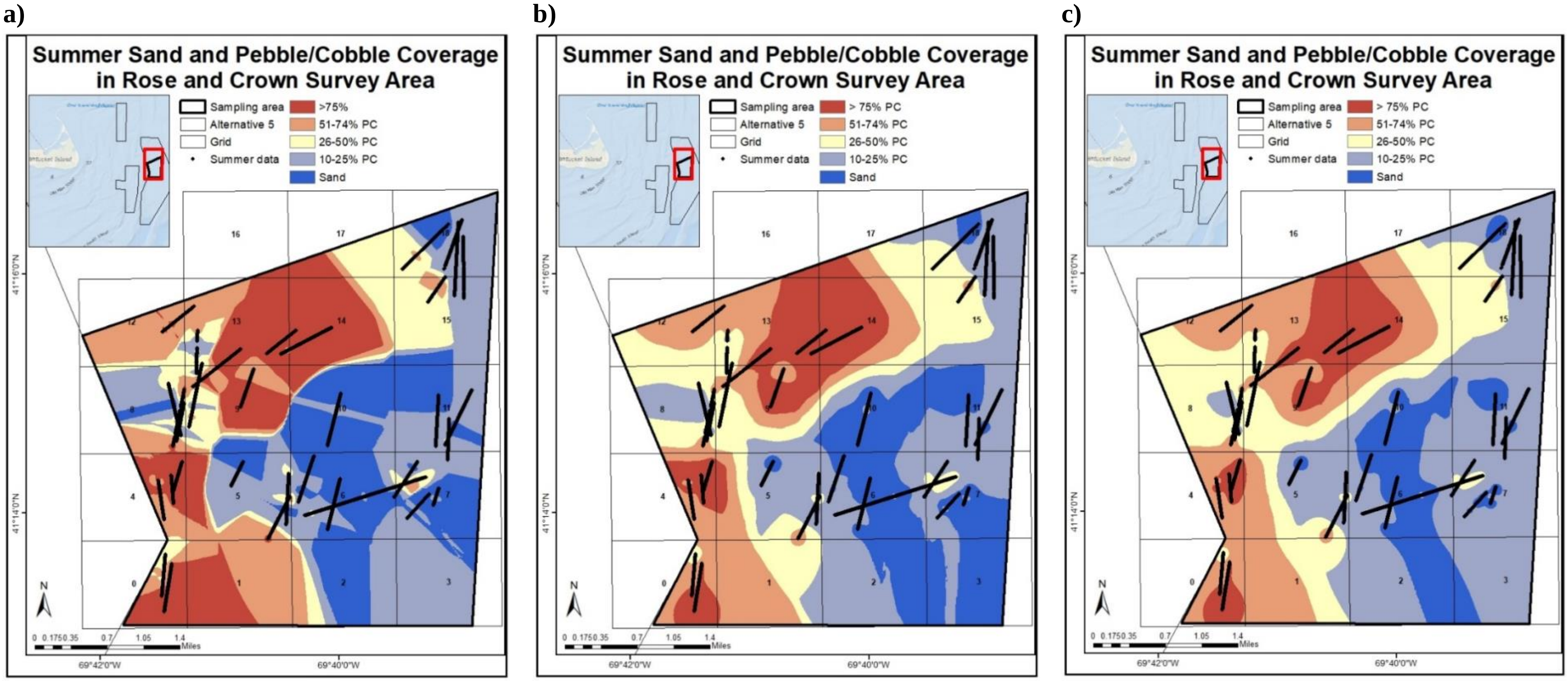


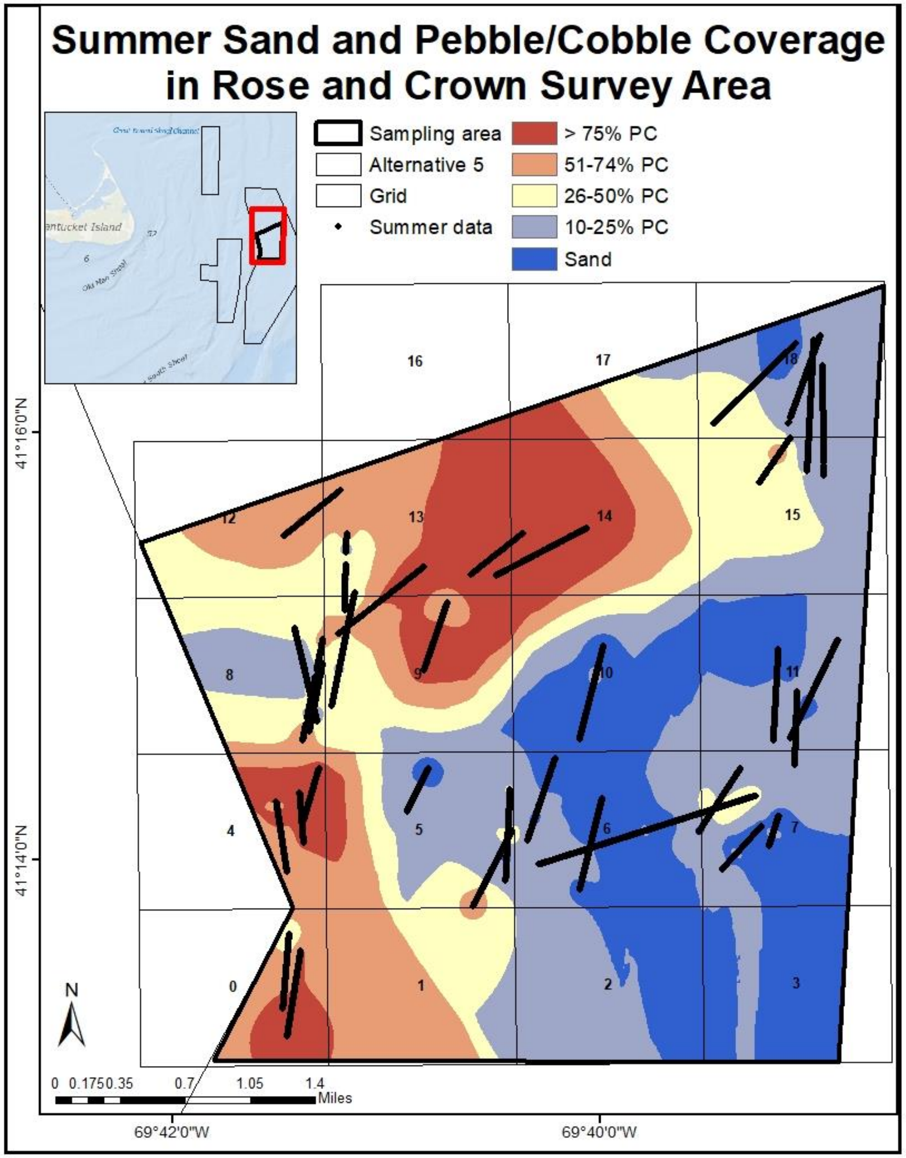
Figure 3. Habitat distribution map of sand, pebble, and cobble coverage from summer with different parameters of interpolation **a)** 60 points, **b)** 371 points, and **c)** 682 points.

2.2.Results

Habitat Maps

Substrates and macroalgae coverage data were interpolated with IDW to the entire sampling area (**Figures 4 through 12**) with a data point search radius of 371 for summer and 519 for fall. An example of using data points and a maximum distance radius (300m) which was generated but not used for analysis in this report is shown in **Figure 13**. Mussel beds, mussel clumps, rock/boulders, sand dunes and clam catch per tow (number of bushels) were plotted using hard data points and are displayed on the interpolated substrates to determine if the substrates and epifauna showed any consistent association. An important note, there are small reference (unfished) areas in the northwest and southeast corners of the research area (**Figure 13**).

a)



b)

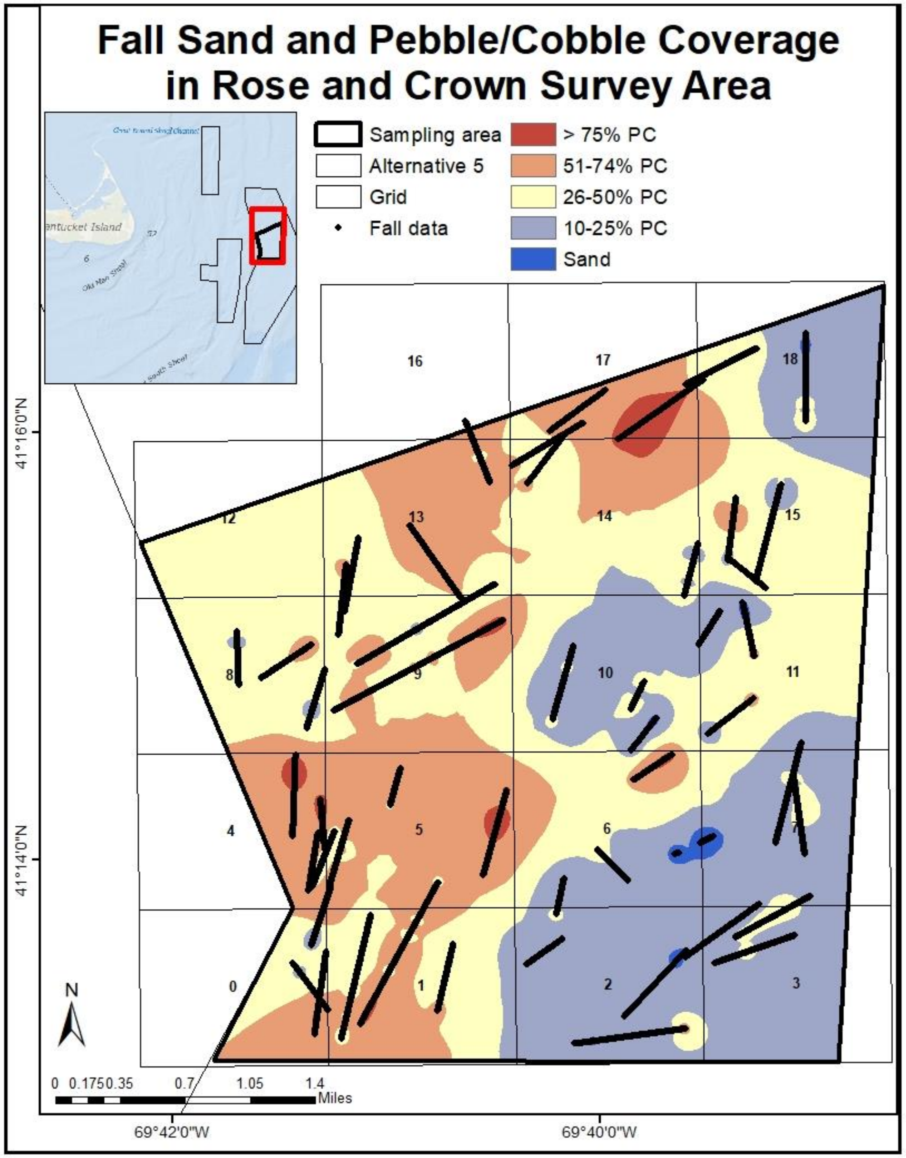
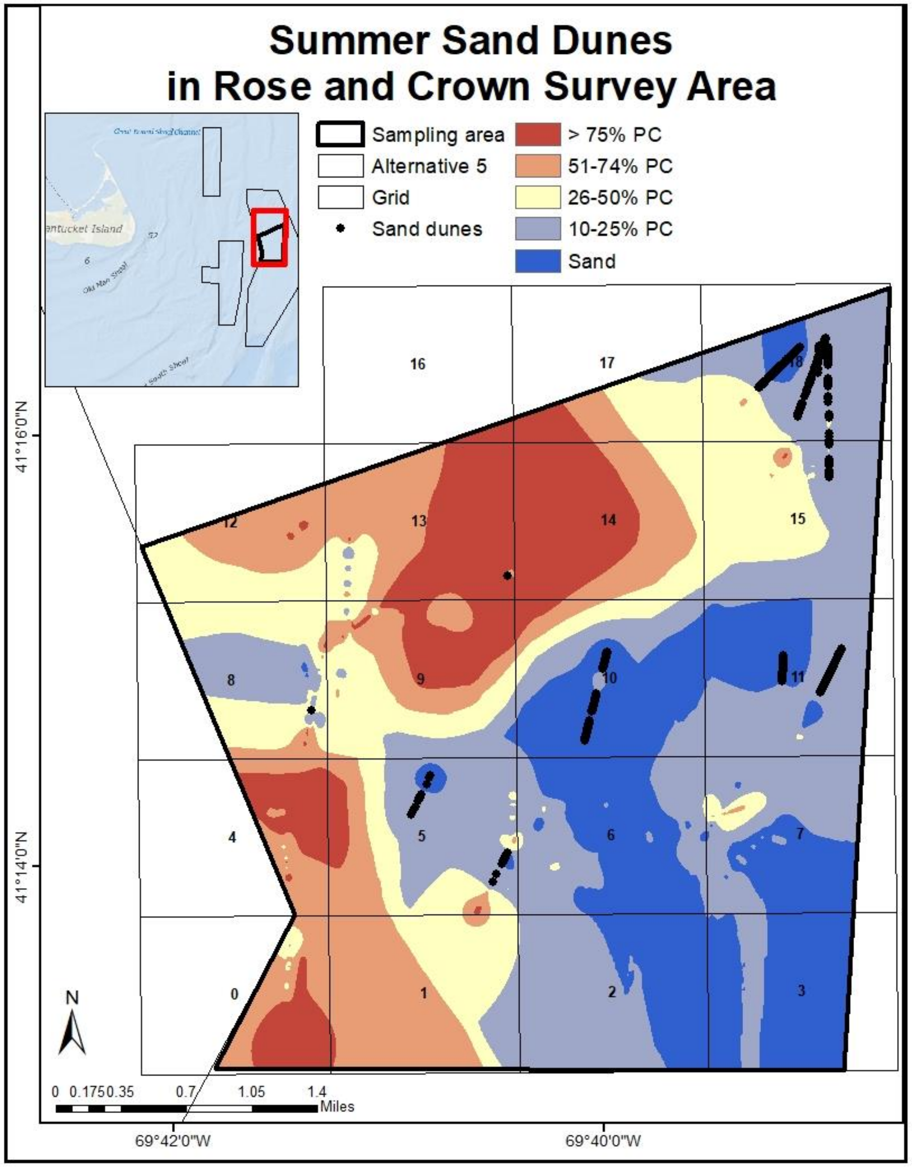


Figure 4. Habitat distribution map of sand, pebble, and cobble coverage from **a)** summer and **b)** fall 2020 in the Rose and Crown research area.

a)



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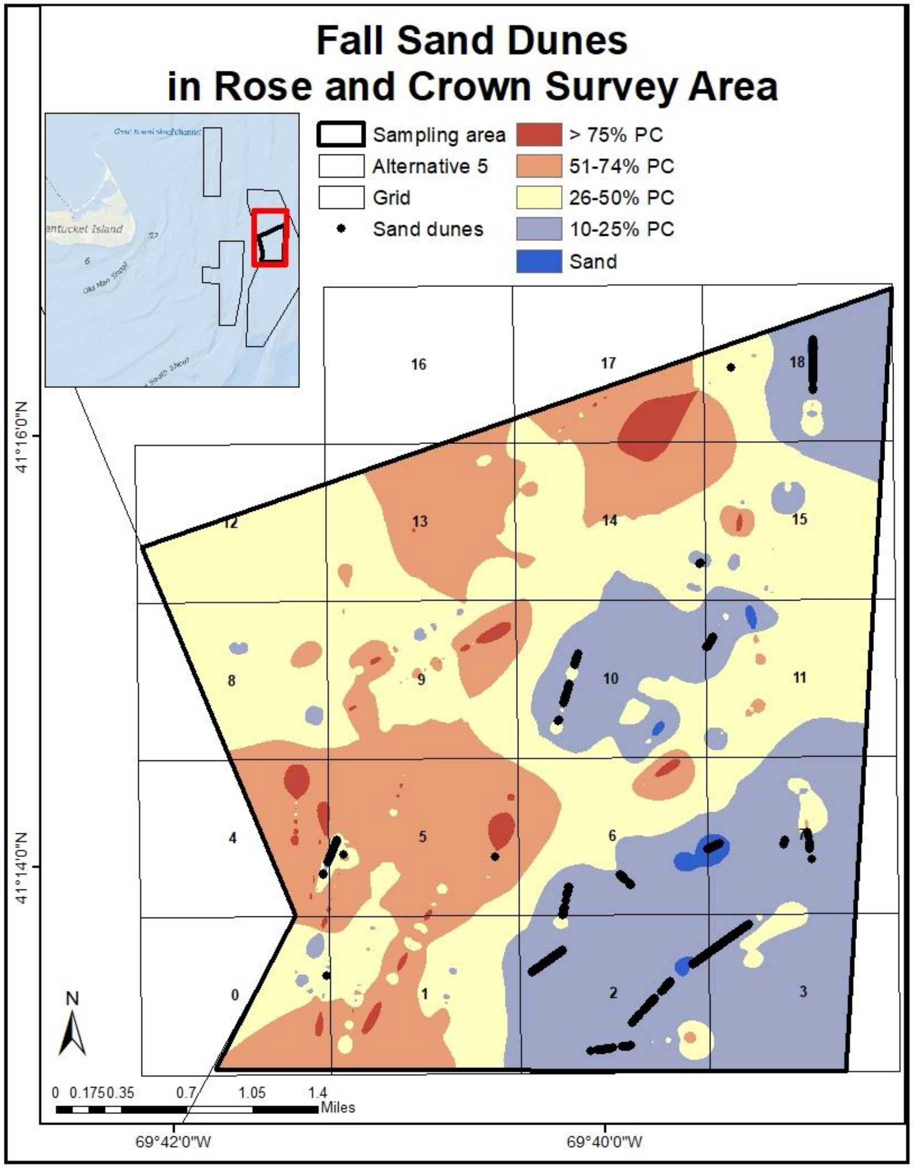


Figure 5. **a)** Summer and **b)** fall 2020 maps showing sand wave/dune events found along the tow tracks overlayed on the sand, pebble and cobble coverage distribution map.

a) b)

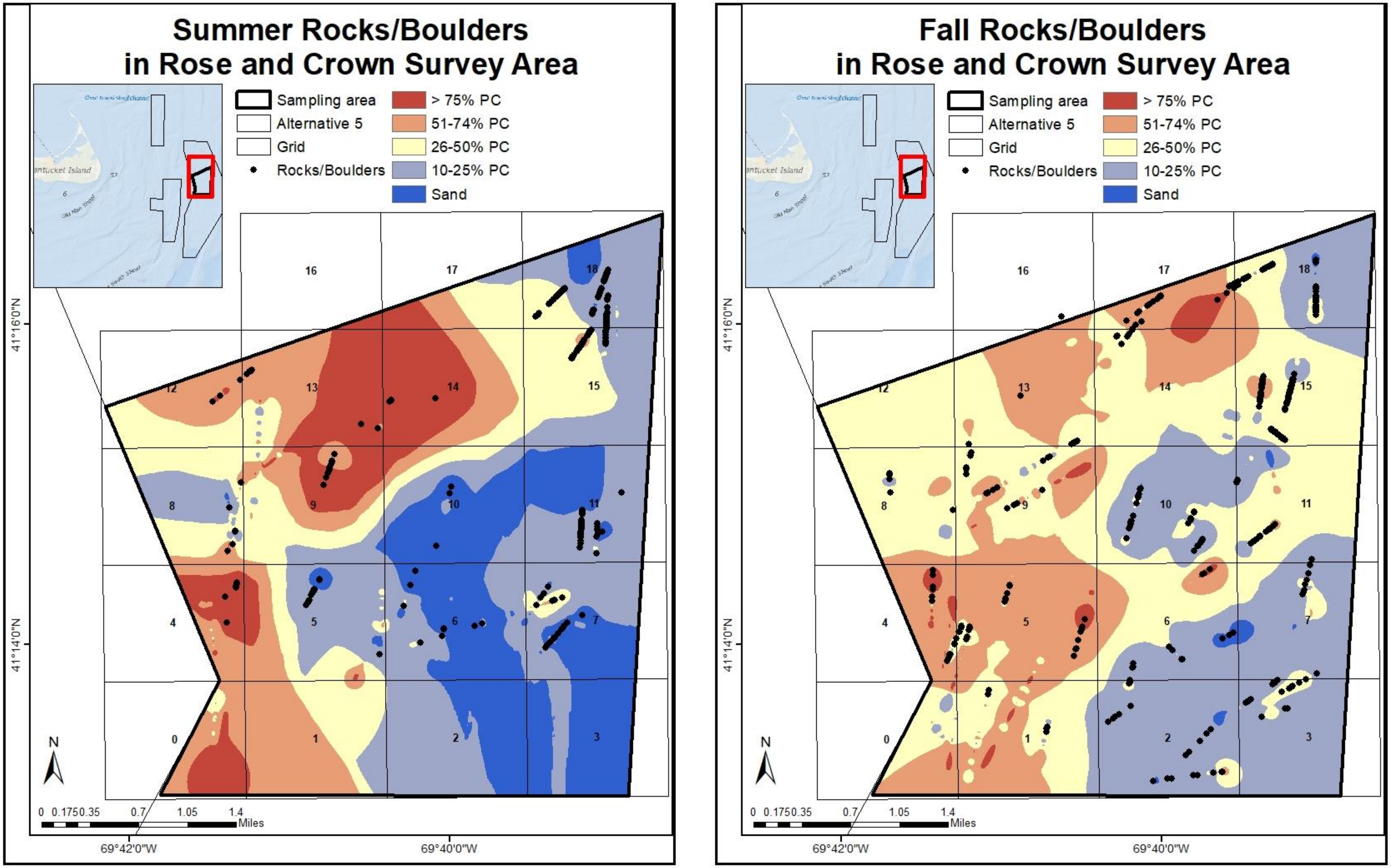


Figure 6. **a)** Summer and **b)** fall 2020 maps showing rocks and boulder events found along the tow tracks overlayed on the sand, pebble and cobble coverage distribution map.

a) b)

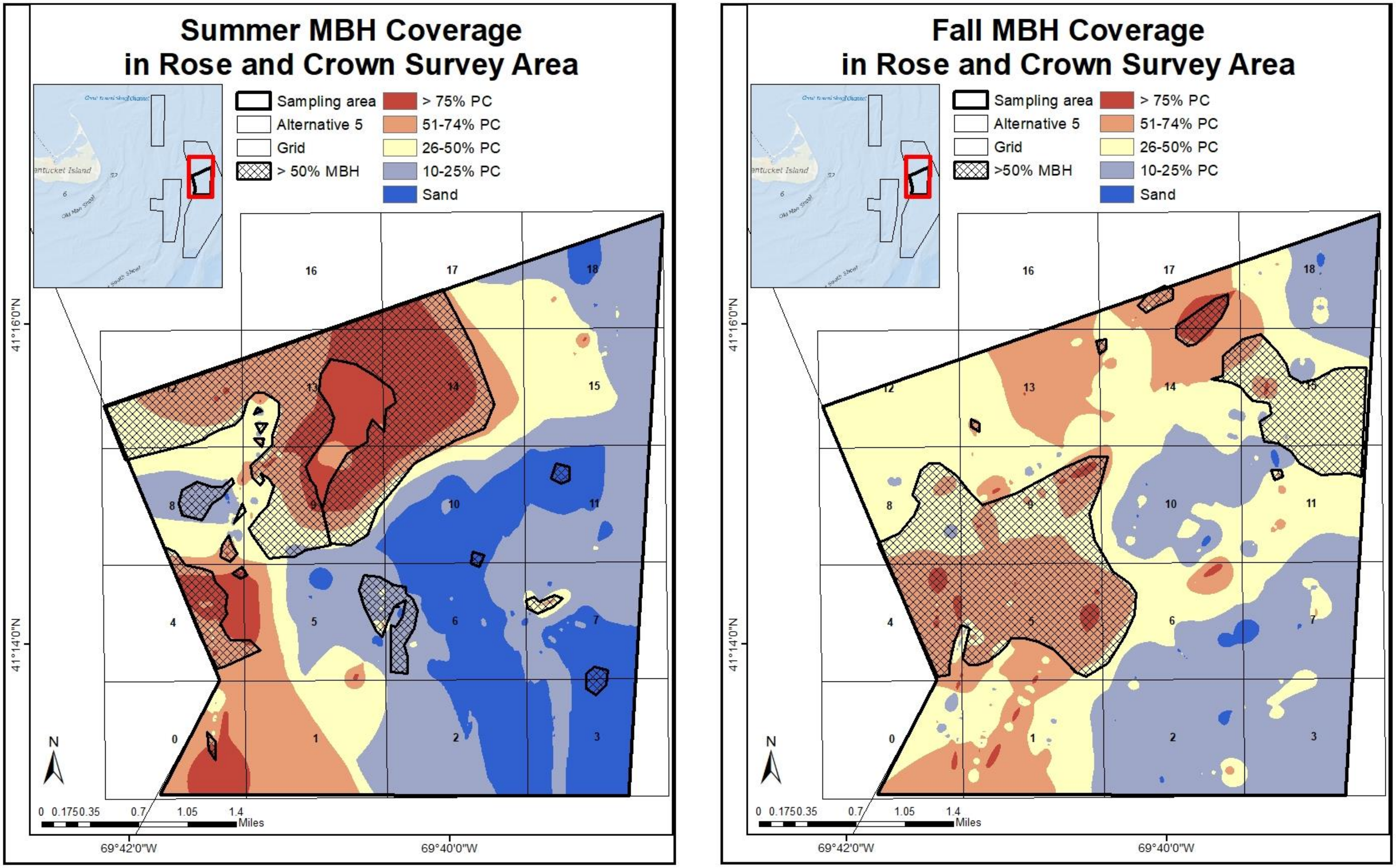


Figure 7. **a)** Summer and **b)** fall 2020 maps showing macroalgae/bryozoan/hydrozoan (MBH) coverage overlayed on the sand, pebble and cobble coverage distribution map.

a) b)

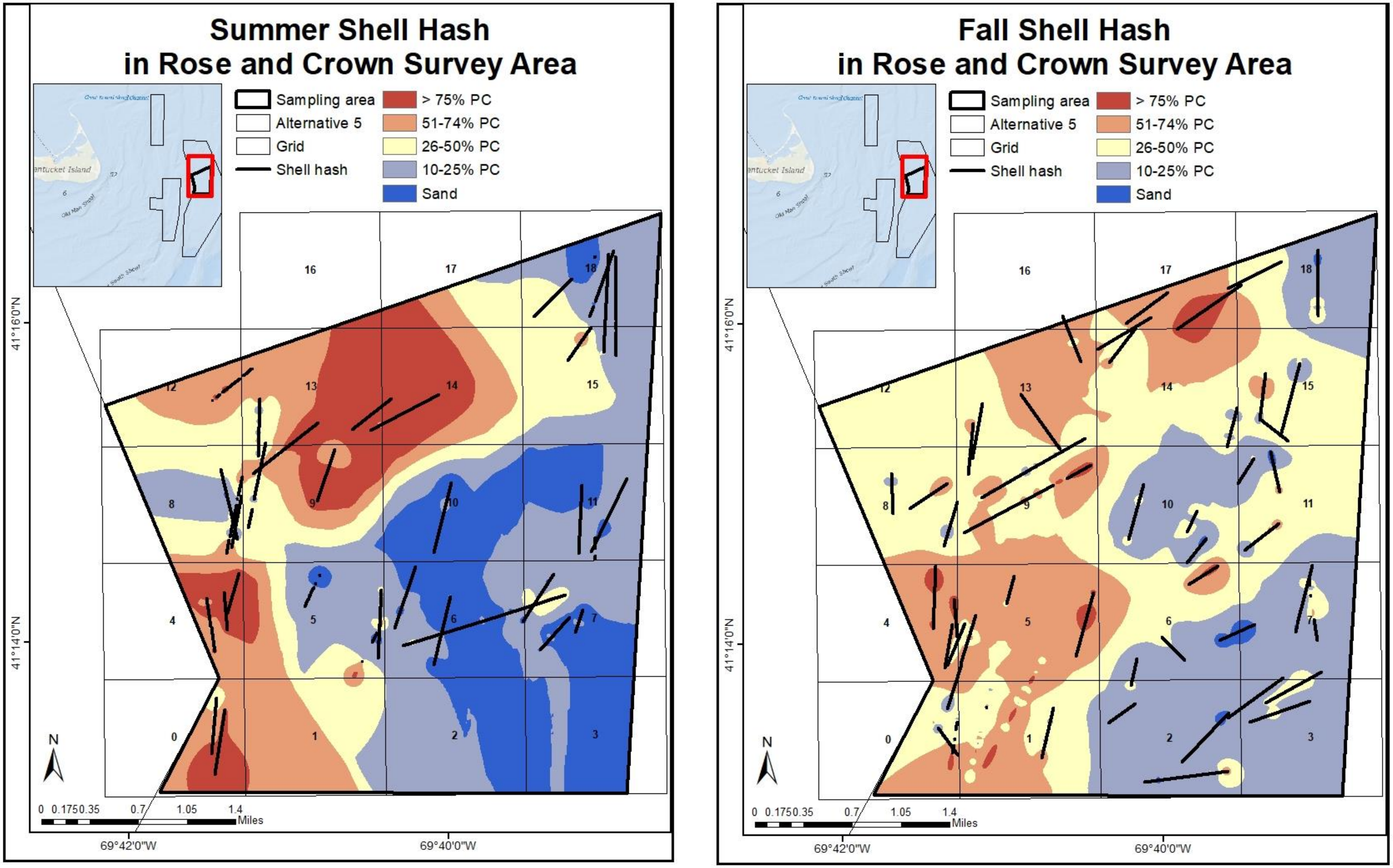
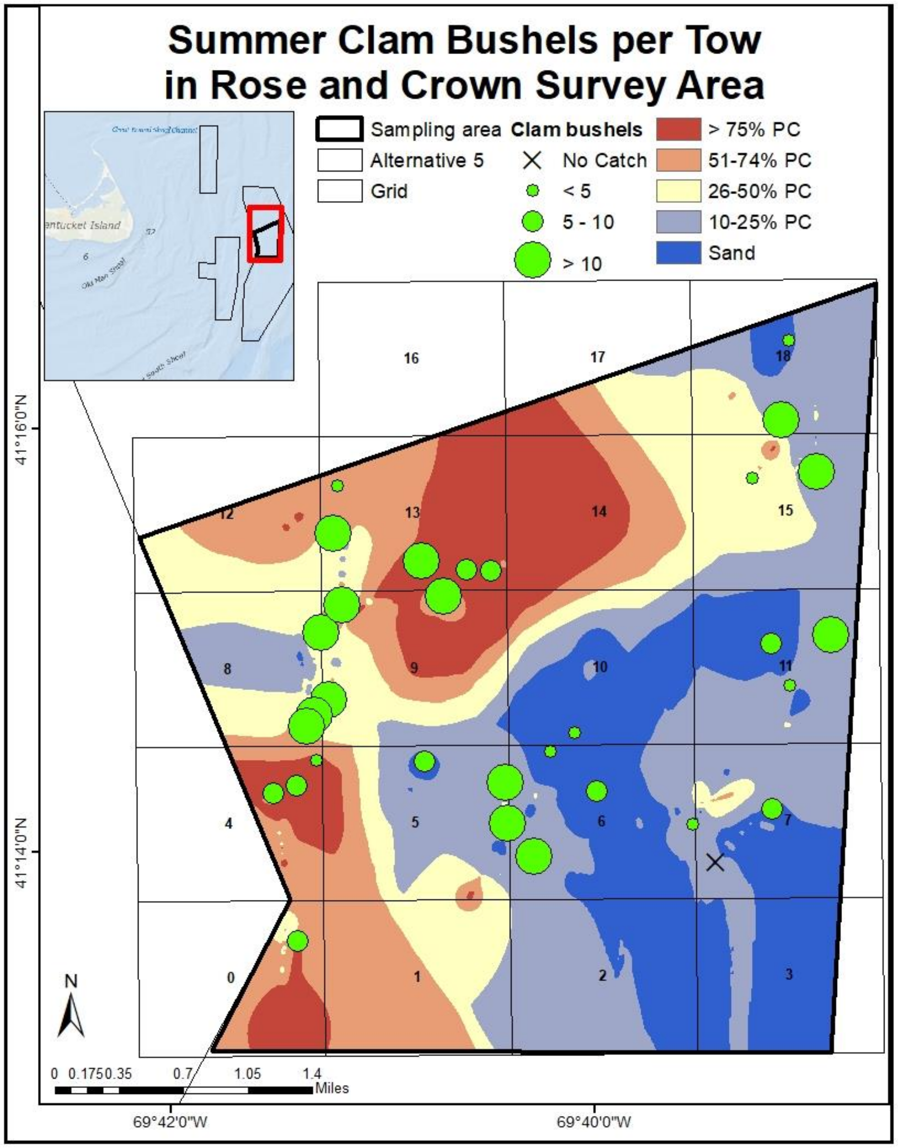


Figure 8. **a)** Summer and **b)** fall 2020 maps showing shell hash found along the tow tracks overlayed on the sand, pebble and cobble coverage distribution map.

a)



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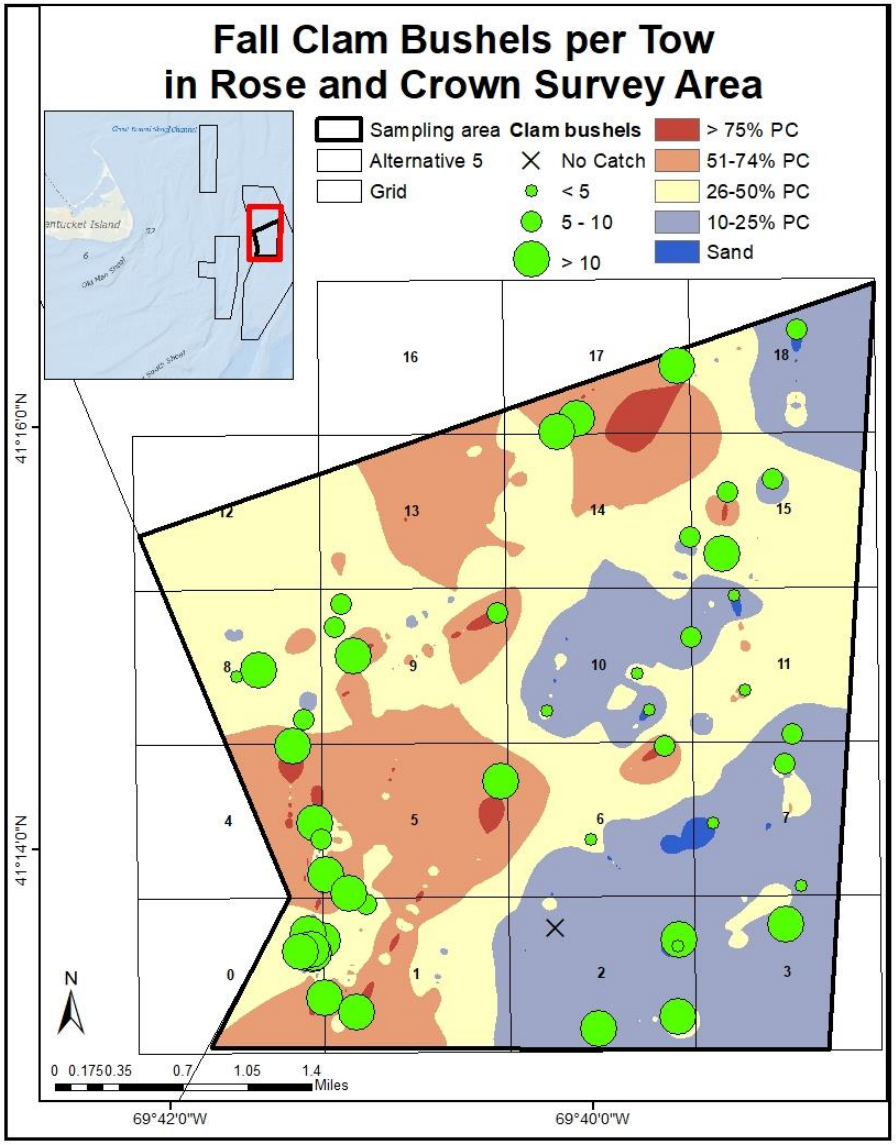


Figure 9. **a)** Summer and **b)** fall 2020 maps showing clam catch by bushels per tow overlayed on the sand, pebble and cobble coverage distribution map.

a) b)

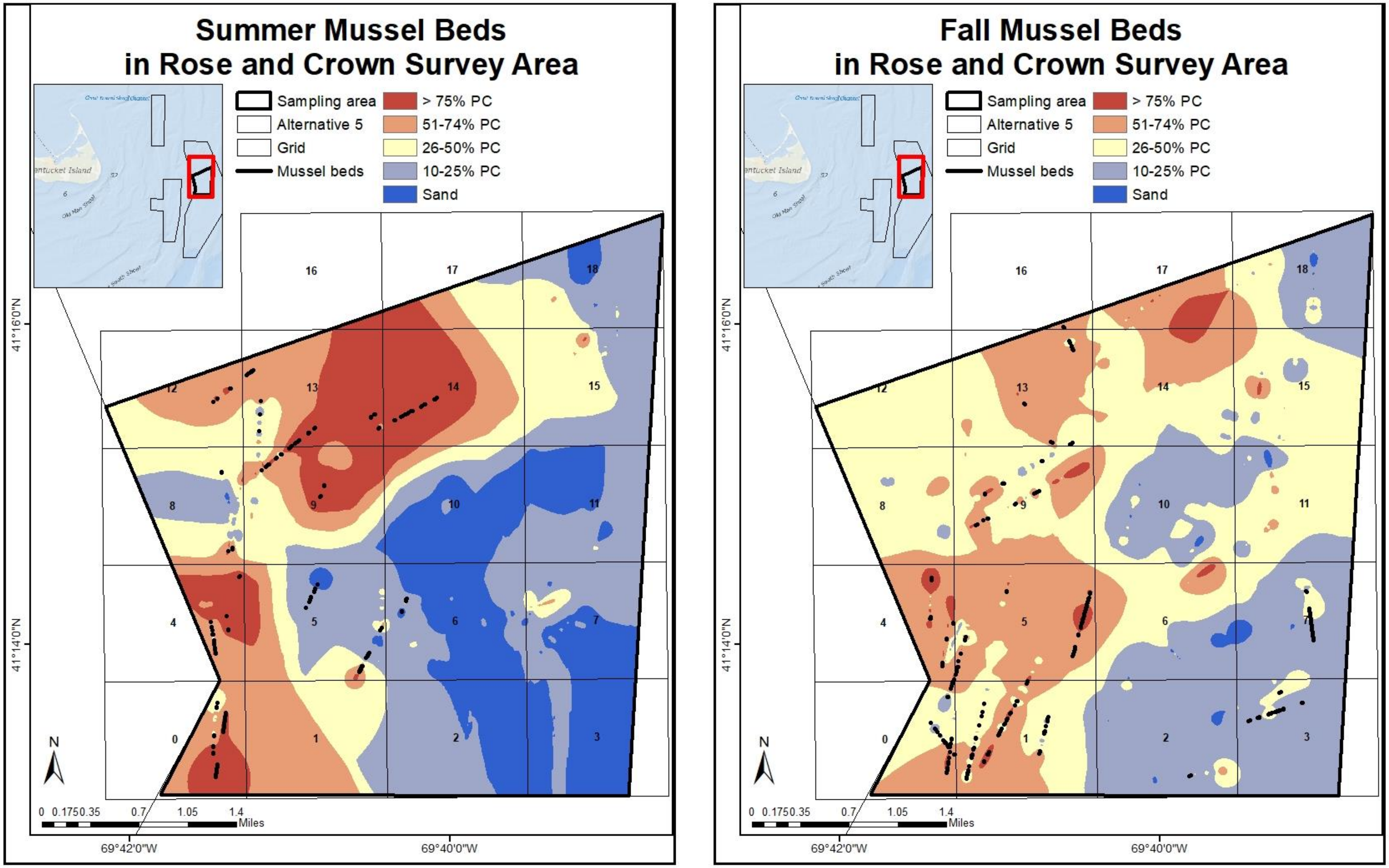
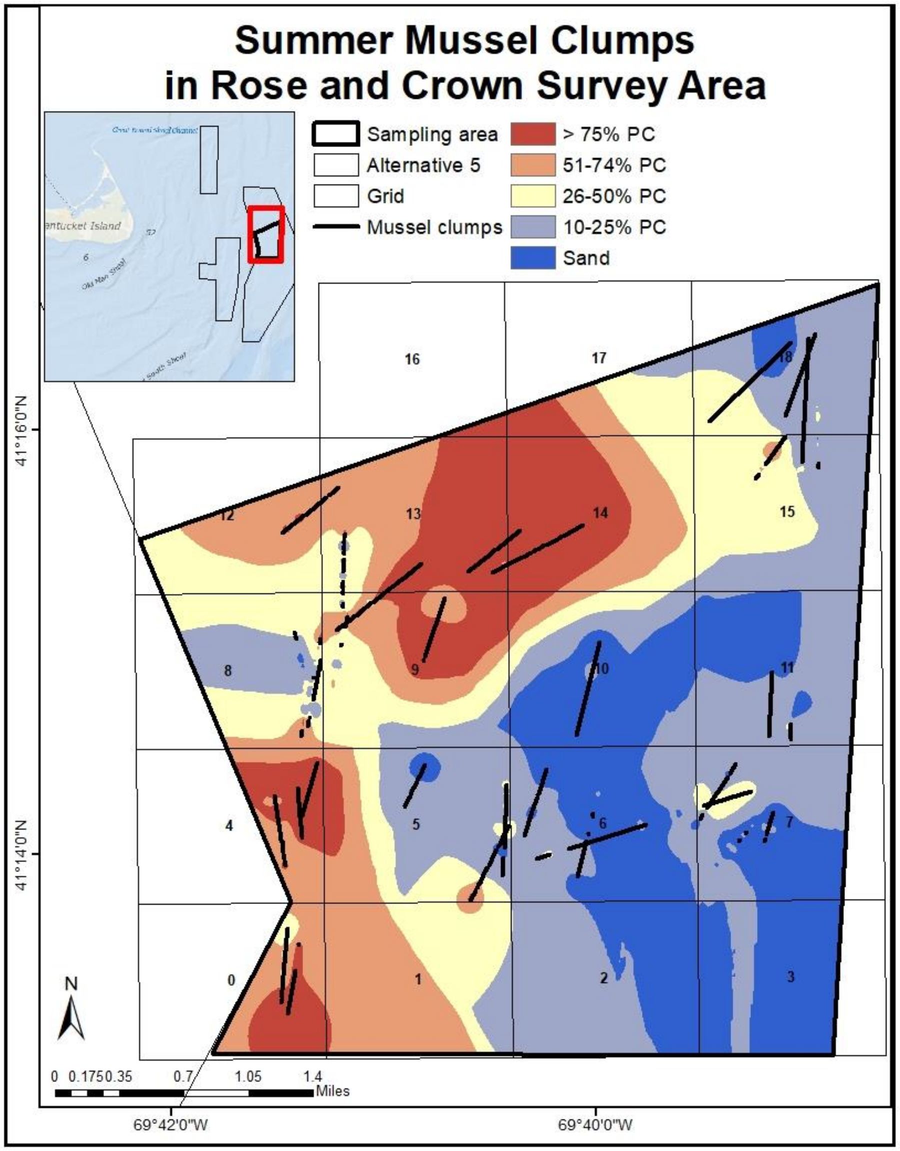


Figure 10. **a)** Summer and **b)** fall 2020 maps showing mussel bed events found along the tow tracks overlayed on the sand, pebble and cobble coverage distribution map.

a)



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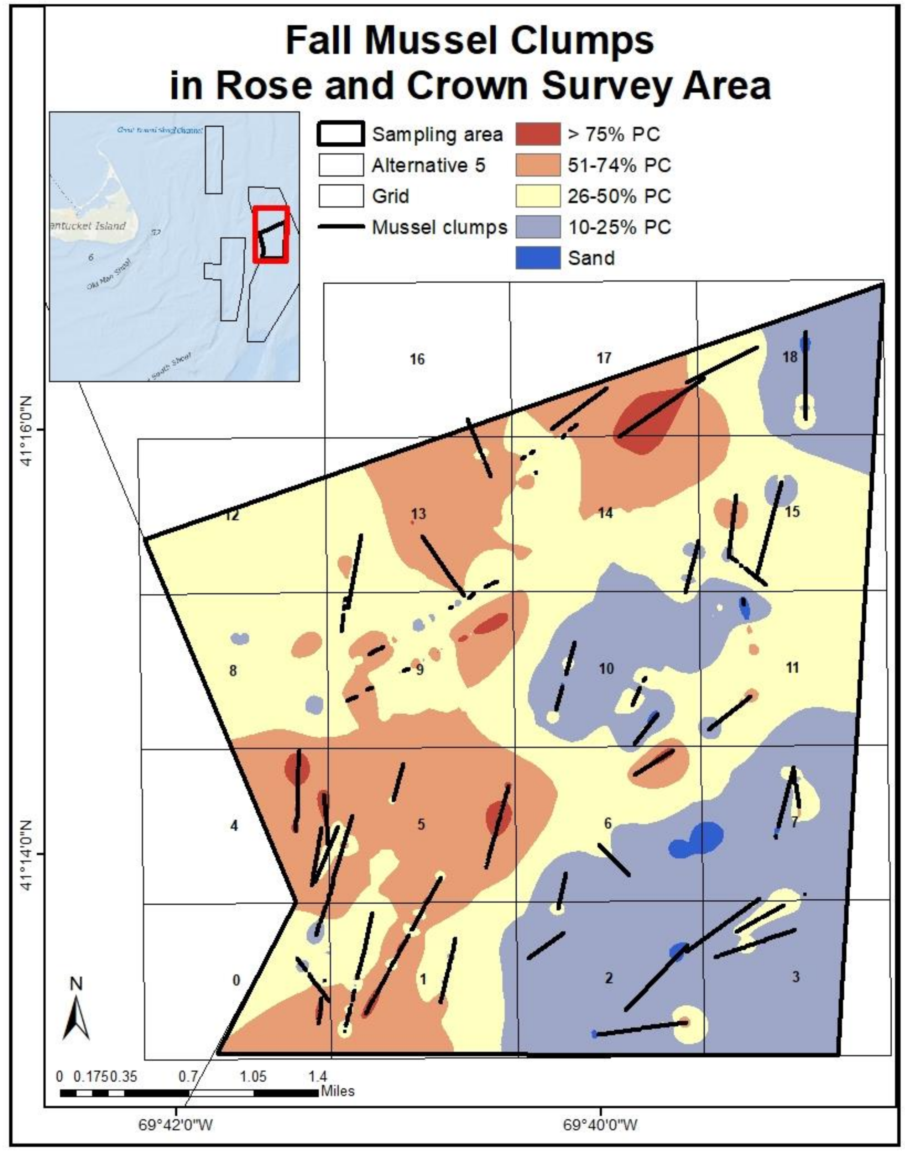
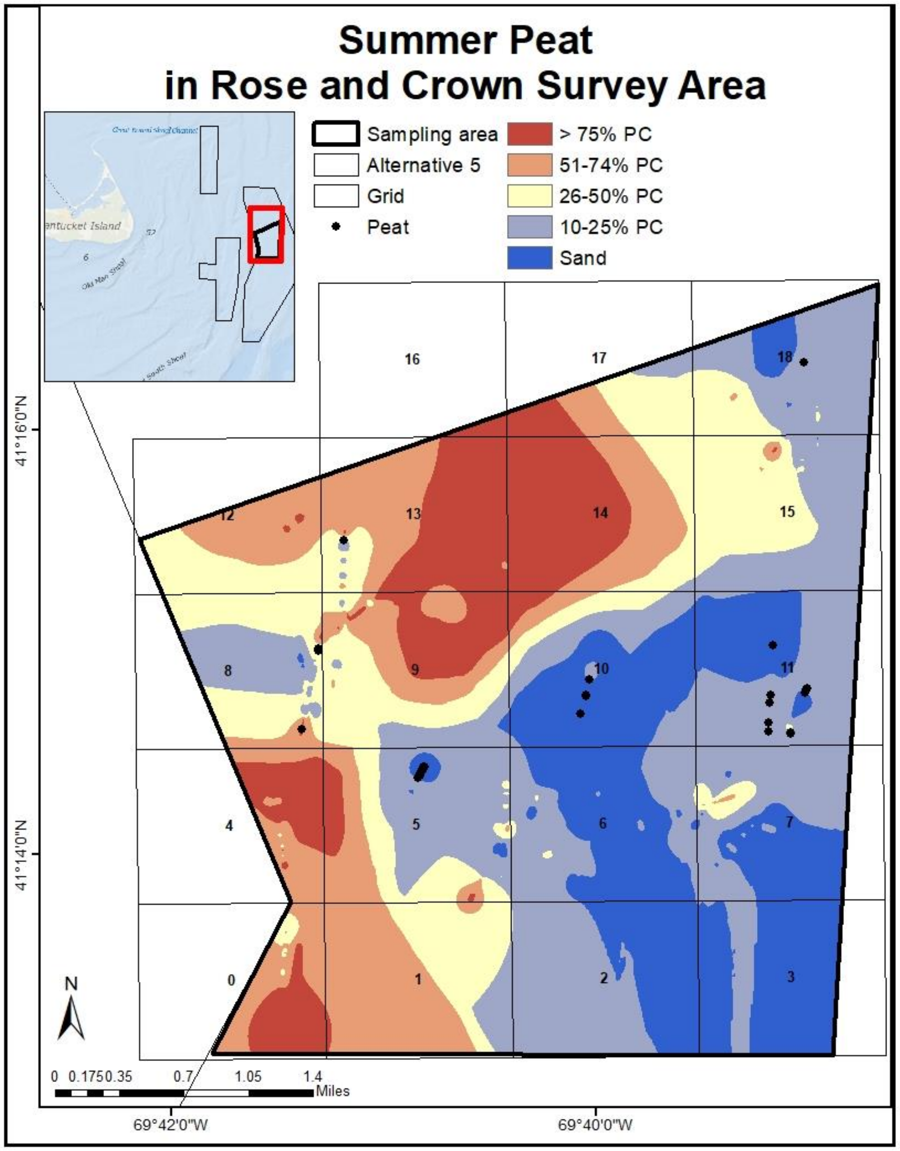


Figure 11. **a)** Summer and **b)** fall 2020 maps showing mussel clump events found along the tow tracks overlayed on the sand, pebble and cobble coverage distribution map.

a)



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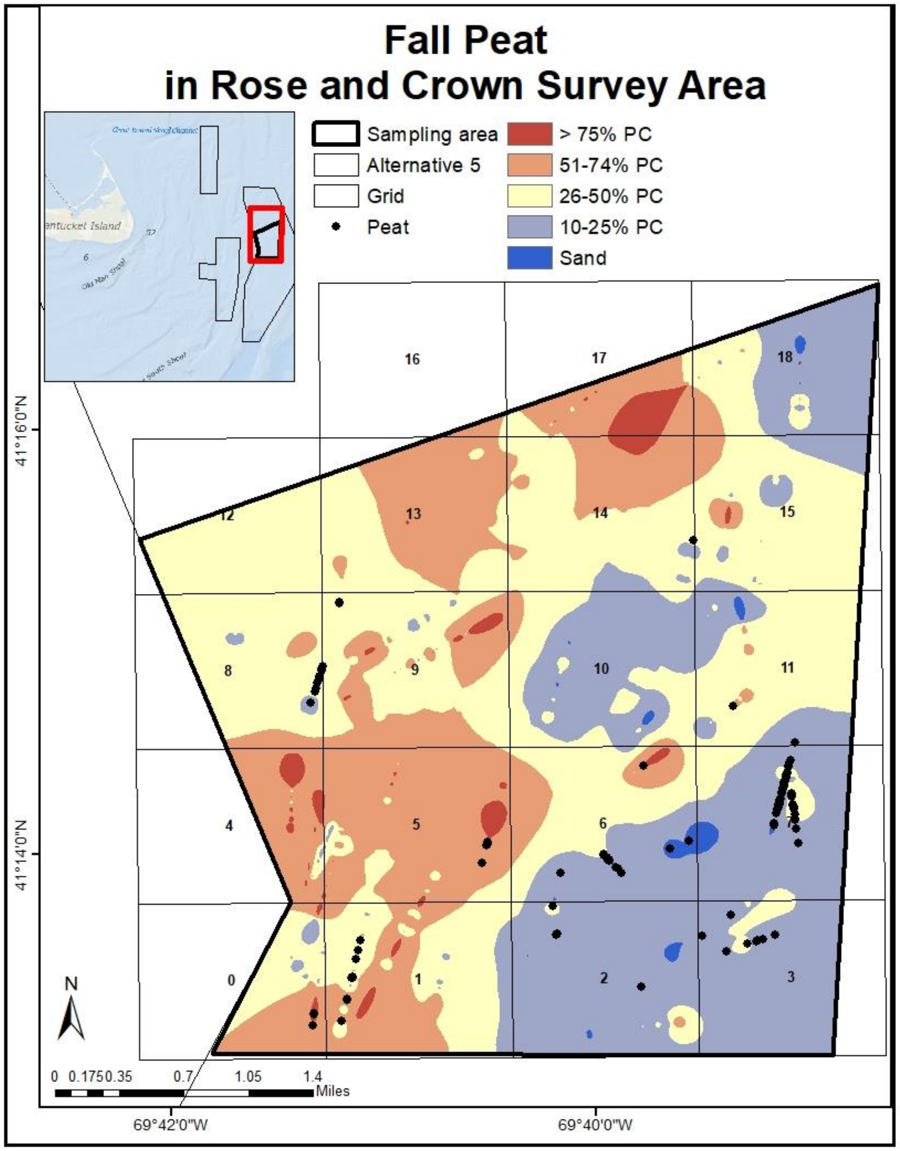
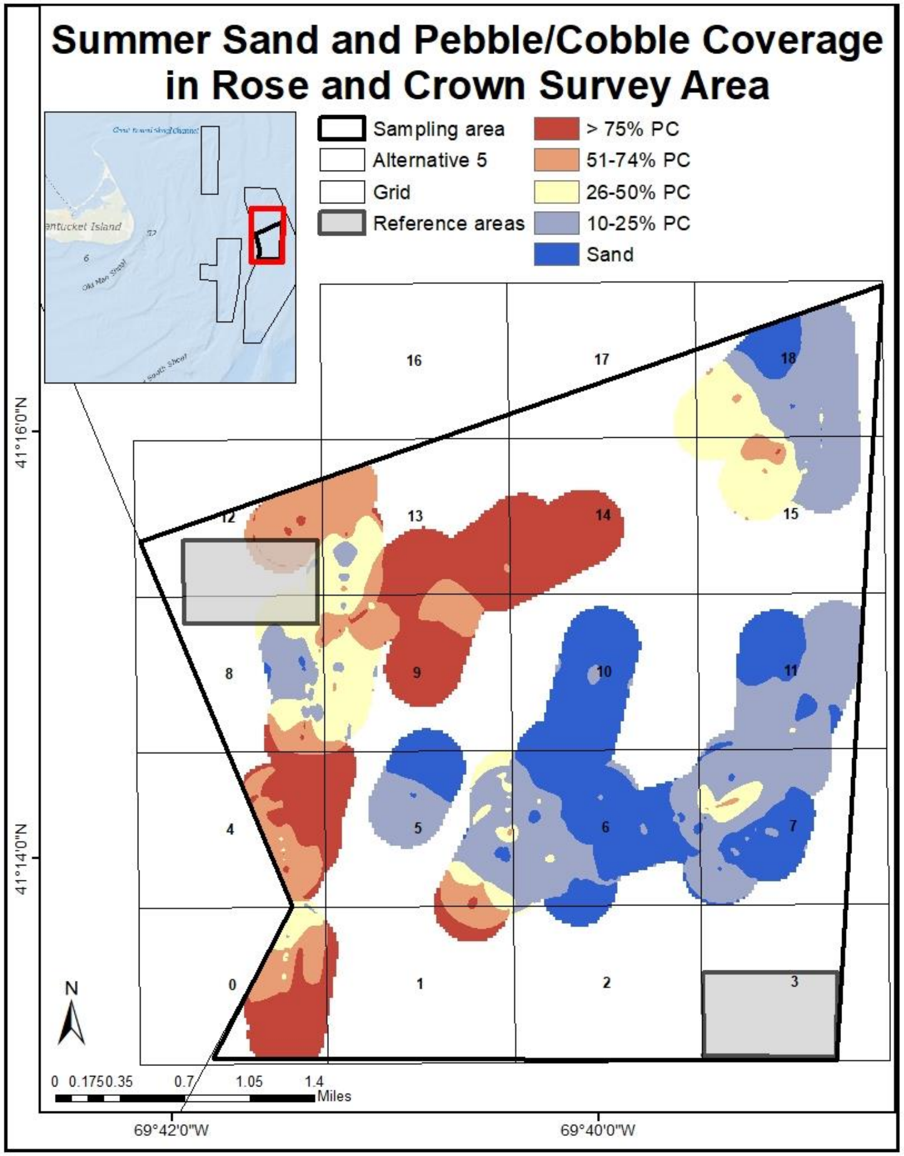


Figure 12. **a)** Summer and **b)** fall 2020 maps showing peat events found along the tow tracks overlayed on the sand, pebble and cobble coverage distribution map.

a)



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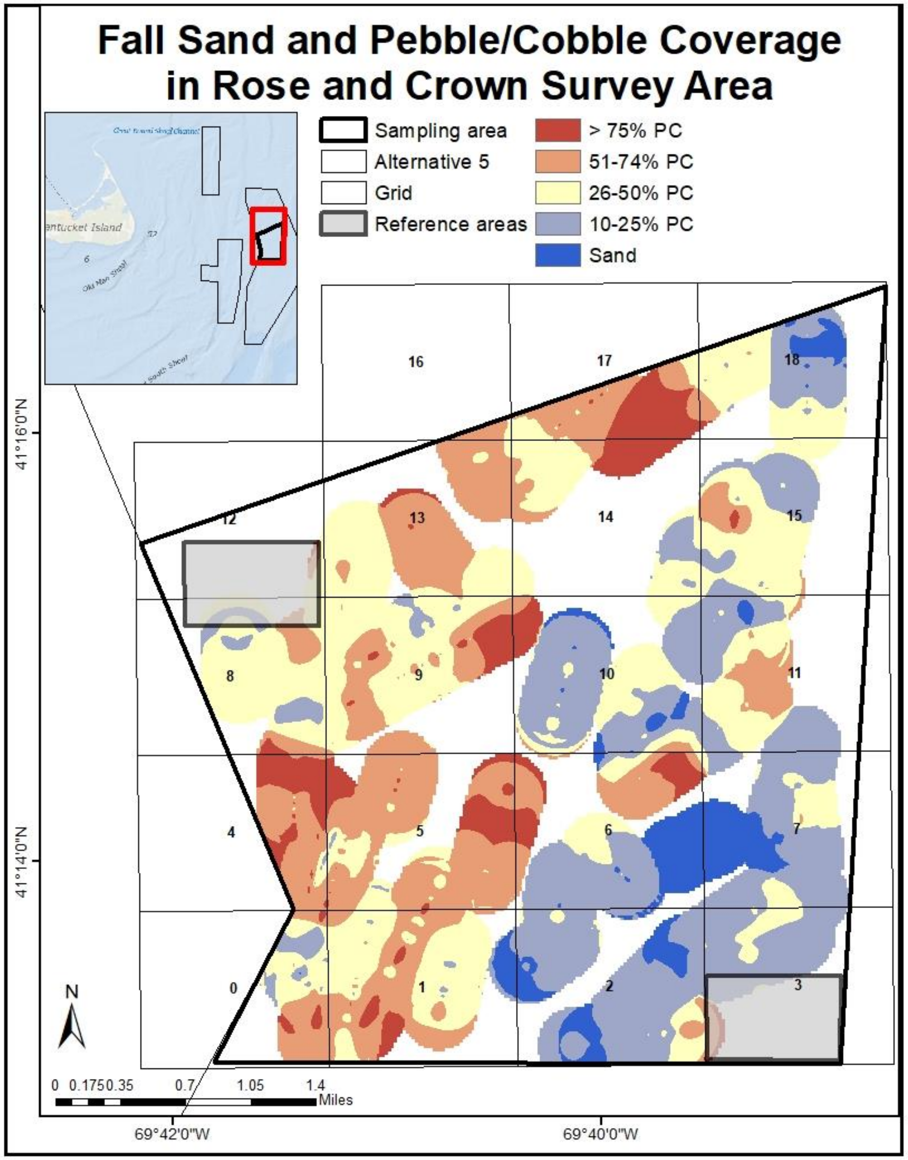

Figure 13. **a)** Summer and **b)** fall 2020 maps showing a more conservative look at the spatial heterogeneity between tow tracks.

Substrate comparison

The number of points per substrate category within each square of the grid was tabulated and the percentages were plotted by grid square and season (**Figure 14; Table 5a, b, Figure 15**). After transforming the substrate categories, a Two-Way ANOVA was used to evaluate the significance of the observed changes in substrate complexity (R Core Team 2020). The mean substrate complexity values were significantly different between grid square and season (**Table 6**). To further compare the grid square means by season separately, a Tukey's Honest Significant Difference (HSD) test was used. The paired season-grid output from the Tukey HSD test indicates that the substrate complexity changed significantly between seasons in squares (**Table 7**).

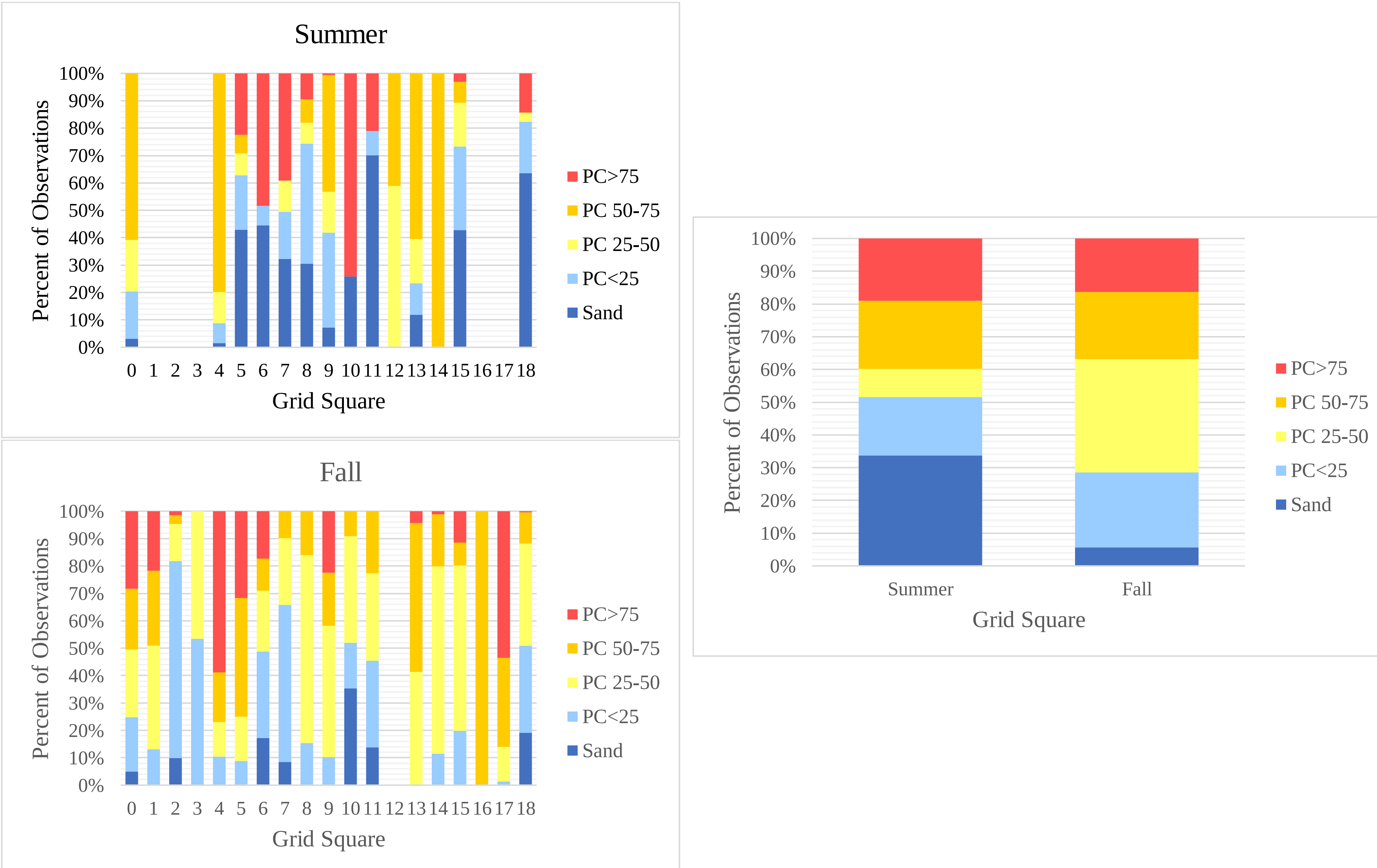

Figure 14. Percentage of substrate type per square in the grid squares and compared by season.

Table 5. Percent coverage of substrate type in each grid square by **a)** season and **b)** coverage summarized by season.

	Summer											Fall										
Grid #	***Sand***		***PC<25***		***PC 25-50***		***PC 50-75***		***PC>75***		***Total***	***Sand***		***PC<25***		***PC 25-50***		***PC 50-75***		***PC>75***		***Total***
0	12	*3%*	64	*17%*	70	*19%*	226	*61%*	0	*0%*	372	22	*5%*	88	*20%*	109	*25%*	98	*22%*	125	*28%*	442
1											0	3	*0%*	102	*13%*	305	*38%*	221	*27%*	175	*22%*	806
2					*No Data*						0	63	*10%*	462	*72%*	86	*13%*	21	*3%*	9	*1%*	641
3											0	0	*0%*	255	*53%*	223	*47%*	0	*0%*	0	*0%*	478
4	6	*2%*	28	*7%*	44	*11%*	308	*80%*	0	*0%*	386	0	*0%*	64	*10%*	77	*13%*	110	*18%*	360	*59%*	611
5	250	*43%*	116	*20%*	46	*8%*	39	*7%*	131	*23%*	582	0	*0%*	59	*9%*	109	*16%*	293	*43%*	213	*32%*	674
6	364	*44%*	58	*7%*	0	*0%*	0	*0%*	396	*48%*	818	60	*17%*	111	*32%*	78	*22%*	41	*12%*	61	*17%*	351
7	250	*32%*	133	*17%*	88	*11%*	0	*0%*	303	*39%*	774	42	*8%*	286	*57%*	121	*24%*	49	*10%*	0	*0%*	498
8	178	*30%*	257	*44%*	45	*8%*	50	*9%*	55	*9%*	585	0	*0%*	59	*15%*	264	*69%*	62	*16%*	0	*0%*	385
9	42	*7%*	200	*35%*	87	*15%*	247	*43%*	3	*1%*	579	0	*0%*	93	*10%*	438	*48%*	176	*19%*	205	*22%*	912
10	55	*26%*	0	*0%*	0	*0%*	0	*0%*	158	*74%*	213	181	*35%*	85	*17%*	199	*39%*	47	*9%*	0	*0%*	512
11	409	*70%*	51	*9%*	0	*0%*	0	*0%*	123	*21%*	583	51	*14%*	117	*32%*	118	*32%*	84	*23%*	0	*0%*	370
12	0	*0%*	0	*0%*	63	*59%*	44	*41%*	0	*0%*	107					*No Data*						*0%*
13	51	*12%*	50	*12%*	70	*16%*	262	*61%*	0	*0%*	433	0	*0%*	0	*0%*	226	*41%*	296	*54%*	24	*4%*	546
14	0	*0%*	0	*0%*	0	*0%*	221	*100%*	0	*0%*	221	0	*0%*	43	*11%*	257	*68%*	72	*19%*	4	*1%*	376
15	128	*43%*	92	*31%*	48	*16%*	23	*8%*	9	*3%*	300	0	*0%*	94	*20%*	285	*60%*	39	*8%*	54	*11%*	472
16					*No Data*						0	0	*0%*	0	*0%*	0	*0%*	44	*100%*	0	*0%*	44
17											0	0	*0%*	7	*1%*	63	*13%*	162	*32%*	268	*54%*	500
18	561	*64%*	166	*19%*	28	*3%*	1	*0%*	126	*14%*	882	102	*19%*	169	*32%*	199	*37%*	61	*11%*	2	*0%*	533
	2306	*34%*	1215	*18%*	589	*9%*	1421	*21%*	1304	*19%*	6835	524	*6%*	2094	*23%*	3157	*34%*	1876	*21%*	1500	*16%*	9151

b)

Season	***Sand***	***PC<25***	***PC 25-50***	***PC 50-75***	***PC>75***
Summer	34%	18%	9%	21%	19%
Fall	6%	23%	34%	21%	16%
diff	28%	-5%	-26%	0%	3%

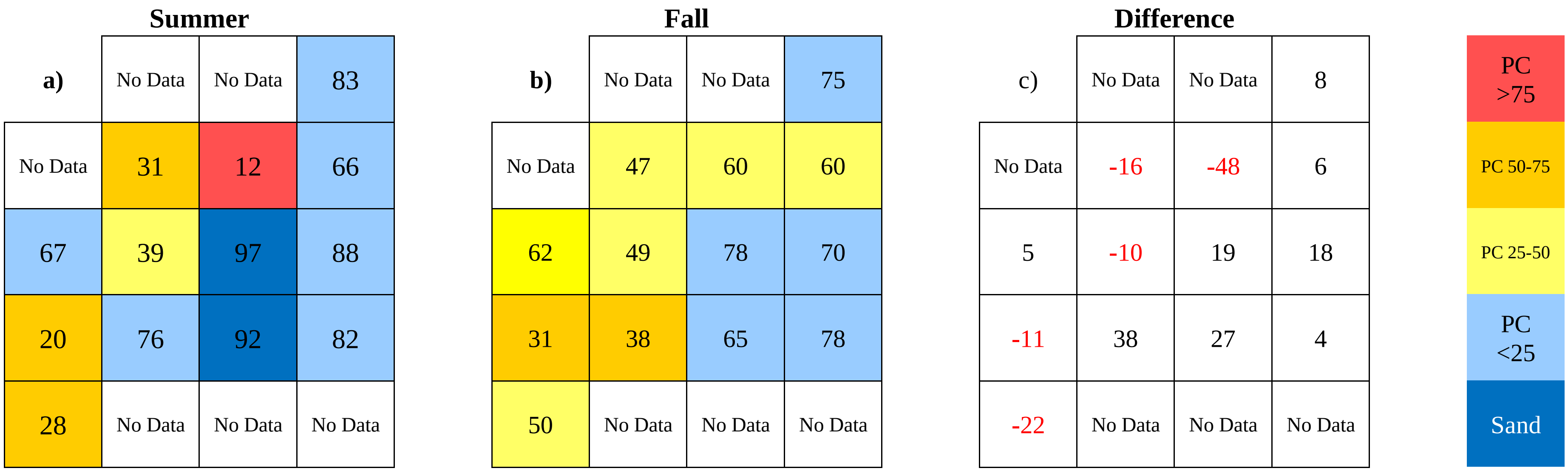

Figure 15. The mean of the substrate values in each grid square in **a)** summer 2020, **b)** fall 2020 and showing **c)** the difference between the two seasons. The "No Data" squares denotes that there was no fishing effort in one season or the other.

Table 6. Two-way ANOVA output comparing the mean complexity values of each grid and season.

	Df	*SumSq*	*MeanSq*	*F value*	*Pr(>F)*
GridSquare	12	4915653	409638	956.79	<2E-16
Season	1	41412	41412	96.73	<2E-16
GridSquare:Season	12	1292007	107667	251.48	<2E-16
Residuals	13384	5730181	428		

Table 7. Tukey test comparing substrate changes between seasons by grid square that had data collection in both seasons.

Grid #	*Summer - Fall*	*lwr*	*upr*	*p adj*
0	-21.43	-26.79	-16.08	7.55E-10
4	-11.02	-15.96	-6.07	7.55E-10
5	38.33	34.03	42.64	7.55E-10
6	26.57	21.72	31.43	7.55E-10
7	4.85	0.48	9.22	0.01140137
8	5.13	0.14	10.13	0.03547436
9	-9.56	-13.61	-5.52	7.55E-10
10	19.16	12.95	25.37	7.55E-10
11	18.05	12.99	23.11	7.55E-10
13	-15.60	-20.50	-10.70	7.55E-10
14	-47.54	-53.99	-41.09	7.55E-10
15	6.77	1.15	12.39	0.00268512
18	8.35	4.18	12.53	8.19E-10

Documented Species

Though Atlantic surfclams are the major species of concern in this project (along with Atlantic cod), they are infaunal and therefore nearly imperceptible in the dredge video. Occasionally when the seafloor has been disturbed, they are viewable on top of the substrate; however, the dredge moves at approximately 2.2 knots and it is usually not possible to see if the hinge is intact and therefore if the clam is alive. Because of this, surfclams are not documented in the annotations. The most common species noted in the annotations, out of a total of 19 species, are skate, crabs, dogfish, and black sea bass (**Table 8**). Skate are classified as "unknown" due to the difficulty to speciate between little and winter skate in the video. A majority of the time finfish species were identifiable; however, the dredge encountered several small individuals, or they were too far in the background to be determined to the species level. Two Atlantic cod were seen, one in each season. Though their sizes are not specific, their approximate lengths are 20 inches. The summer individual was located in grid 15 (**Figure 2**) on June 3, 2020. The fall individual was located in grid 0 on November 6, 2020 (see example in **Appendix A, Image 1**).

Table 8. Species annotated in dredge-mounted camera footage.

Common Name	***Scientific Name***
Atlantic surfclam	*Spisula solidissima*
Blue mussel	*Mytilus edulis*
Horse mussel	*Modiolus modiolus*
Winter skate	*Leucoraja ocellata*
Little skate	*Leucoraja erinacea*
Winter flounder	*Pseudopleuronectes americanus*
Windowpane flounder	*Scopthalmus aquosus*
Spiny dogfish	*Squalus acanthias*
Striped bass	*Morone saxitilis*
Black sea bass	*Centropristis striata*
Atlantic cod	*Gadus morhua*
Sculpin	*Myoxocephalus octodecemspinosus*
Scup	*Stenotomus chrysops*
American lobster	*Homarus americanus*
Jonah crab	*Cancer borealis*
Atlantic rock crab	*Cancer irroratus*
Hermit crab	*Pagurus pollicaris*
Northern moonsnail	*Neverita duplicata*
Common whelk	*Buccinum undatum*

3. Discussion

Most apparent in the summer and fall habitat maps are the changes in substrate coverage. The sandy bottom in the southeast region of the research area in the summer months is largely replaced with a complex distribution of pebbles and cobbles in fall (**Figure 4**). The average percent coverage of substrates is statistically different between seasons. The composition of pebble/gravel significantly increased in the Fall (**Figures 4, 14** and **15**). Nantucket Shoals is known to be a high energy environment with frequent strong hydrodynamic events; where critical sheer stress of surficial sediments is repeatedly exceeded (Harris et al. 2012). This results in resuspension and winnowing away of sediments in a net south-east direction (Twichell 1983). Sandy habitats were noted to have small and large waves or dunes (**Figure 5**). There is often shell hash and other sediment pieces like pebbles gathered in the lee side of the wave/dune (**Appendix A, Image 2**). This lends to the idea that currents are strong enough to move sediment types larger than fine sand. Rock and boulder occurrences do not seem to be associated with any substrate type (**Figure 6**).

Macroalgae is categorized together with bryozoans and hydrozoans and shown in the figures as "MBH" (**Figure 7**). This is to simplify the annotation scheme as the dredge movement coupled with the current running pushes any vertical, sessile epibionts nearly flat on the sediment. It was often clear enough in the videos to see the epibionts flutter with water movement to determine that macroalgae or hydroids were present. Hydroids were seen attached to shell hash, cobbles, rocks and boulders both in the videos and the catch subsamples (**Appendix A, Images 3, 4, 5**). The macroalgae coverage (see example in **Appendix A, Images 6** and **7**) in summer (**Figure 7a**) seem to correlate with pebble/cobble coverage of more than 51 percent. In the fall (**Figure 7b**) however, it is less associated with the higher pebble/cobble coverage but remained in similar areas between seasons.

The images gathered show epifauna attached in samples brought up from the dredge. No sponges were encountered. Rocks can be clean, encrusted with mussels, barnacles, and/or bryozoans. Barnacles are seen on cobbles and mussels brought up in the dredge as well as on rocks and boulders seen in the annotations (**Appendix A, Images 8, 9, 10** and **11**). The presence of barnacle scars on some cobbles and rocks in the annotated video denotes that the rocks can be subjected to sediment scour and burial due to the strong hydrodynamic processes that define this area.

Shell hash was annotated when it added to substrate complexity i.e., when it was whole shells gathered in enough density to support epifaunal growth, such as hydroids, shown in images listed above. Occasionally, small pieces of broken up mussel and clam shell can be seen in the video; however, these pieces move easily with the current and therefore do not support epifaunal growth. Shell hash is distributed in all areas and does not seem to have a correlation with substrate type (**Figure 8**). However, with an increase in videos annotated, relationships to other habitat characteristics or seasonal variability may be elucidated. Powell et al. (2019) found a link between small sized surfclams and areas of shell hash abundance. Further analysis of shell hash and small clam catch information will be accomplished as time permits. The maximum bushels of surfclams caught per tow in summer was 21 bushels, while in fall the max was 16

(**Figure 9**). Anecdotally, the captain and crew of the F/V Seafox say that catching one cage per hour is fishing most efficiently. If three 12-minute tows are accomplished per hour, and a cage holds 32 bushels, their optimal catch per tow is 10.67 bushels. There were a high number of tows catching at or around this rate in all substrate types in both summer and fall.

Mussels documented in the catch samples consisted of *Mytilus edilus*. Horse mussels (*Modiolus modiolus*) were rarely encountered, empty shells more than living individuals were found. Mussel beds and clumps were nearly ubiquitous in the survey area (**Figures 10** and **11**). Beds are defined by the density and length of the group of mussels, while clumps are a small number of individuals separated by substrate (examples in **Appendix A, Images 6** and **7)**. Not only were clumps common in tracts between where beds were found, they were located on all substrate types.

An unexpected finding of this study was tracts of forest peat amidst the sandy and rocky substrate (**Figure 12**). Peat and woody debris on the seafloor of this region was discovered by Emery et al. (1965) and used to determine the sea level following the last ice age. Radiocarbon dating has been used to age deposits of peat within this region as 7,000–20,000 years old, with substantial spatial variability in distribution (Emery et al. 1965, Bothner & Spiker 1980). While peat was at one time wide spread across the entire continental shelf, preservation has been variable leaving a patchy distribution in modern times. The hydraulic dredge was effective at unearthing chunks of peat and wood on the seafloor as a component of the bycatch and exposed patches of peat were visible in the video footage prior to the dredge's passing (**Appendix A**, **Image 12**). While the ecological significance of this material is as yet known, it contributes to the complexity of the Nantucket Shoals system and could be important to marine life.

The use of IDW in ArcGIS for the purposes of this research is to provide a data driven visualization of the substrate complexity within the research area by season. The program used a search radius of 371 neighboring data points for summer and 519 points for fall to formulate the substrate composition, weighing its close neighboring points more heavily than points further away. These point values were calculated using the mean of data points per grid square per season. For summer the mean was 371.42 ± 311.08; fall was 519.47 ± 233.50 (**Table 4**). The spatial heterogeneity observed over the length of the tows highlights the difficulty creating maps of substrate and epifauna coverage given the data was collected by a fisheries dependent survey. Interpolating substrate type and epifauna presence in habitats like the study area requires both a dense array of imagery and broad coverage within the study area. Different parameters were modified and several iterations of habitat maps were generated. As an exercise, data was interpolated with a smaller maximum distance radius (300 m) to show the areas with no coverage (**Figure 13**). The radius was based on the average in meters of the shortest substrate patches. Future research efforts will take this need into consideration by conducting tows more evenly across the study areas or supplementing the data collected with dredge-mounted cameras with data collected using other optical survey gear.

In addition to identifying high levels of spatial heterogeneity in the study area, the work conducted to date also noted high levels of temporal heterogeneity. Bottom types in an area changed not only between seasons, but over shorter time spans of weeks or even days following disturbance events like storms as well. To better understand the spatial and temporal patterns of substrate type and epifauna presence in the Rose and Crown and the potential impacts of fishing activity on both, future analysis of the data collected will examine the impacts of location, date, time of day, known storm events, and tow sequence during repeated tows (e.g., first tow, second tow,..., nth tow) on substrate type and epifauna presence.

4. Conclusions and Future Work

After analysis of the first two seasons of data, the survey area can be described as highly productive and consisting of a patchy distribution of sand, pebbles and cobbles that are in constant flux due to strong tides and currents that characterize Nantucket Shoals. Concrete conclusions will be made once the first year of videos are completed and the analysis methodology is determined to best represent the data. CFF scientists are currently annotating winter 2020-2021 and spring 2021. Trends in catch data will be linked with annotated videos to generate a greater understanding of surfclam densities and habitat complexity.

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Appendix A. Reference images taken from video footage.

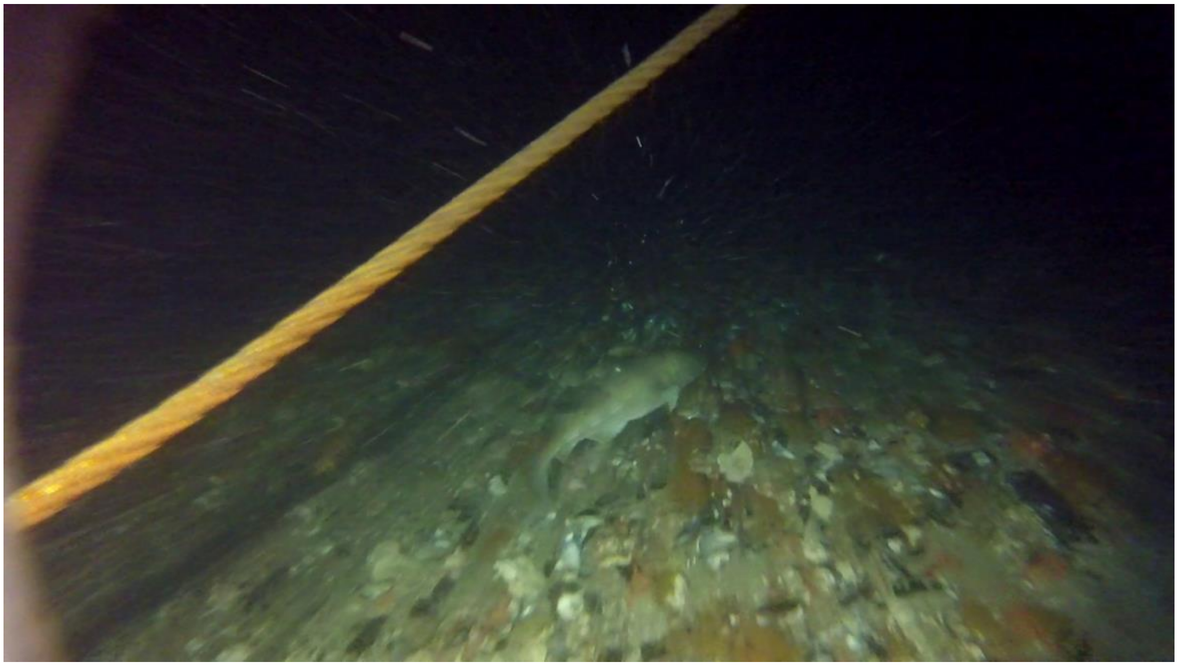

Image 1. Atlantic cod. Trip 34, Tow 12, 11/6/2020.

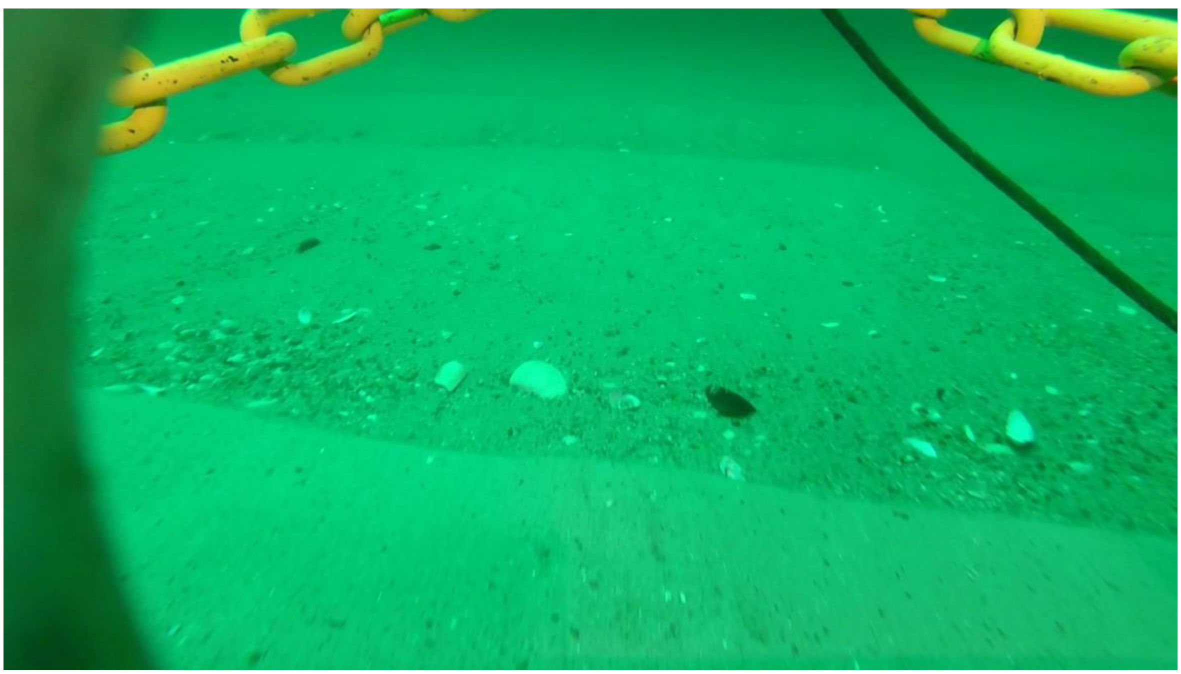

Image 2. Shell hash and pebbles gathered in the sand waves. Benthic sled image 2019.

Image 3. Clean catch pile. Note the hydroids on the clam shell hash. Trip 13, Tow 8, 8/24/2020.

Image 4. Catch pile with mussels. Note the hydroids attached. Trip 13, Tow 24, 8/24/2020.

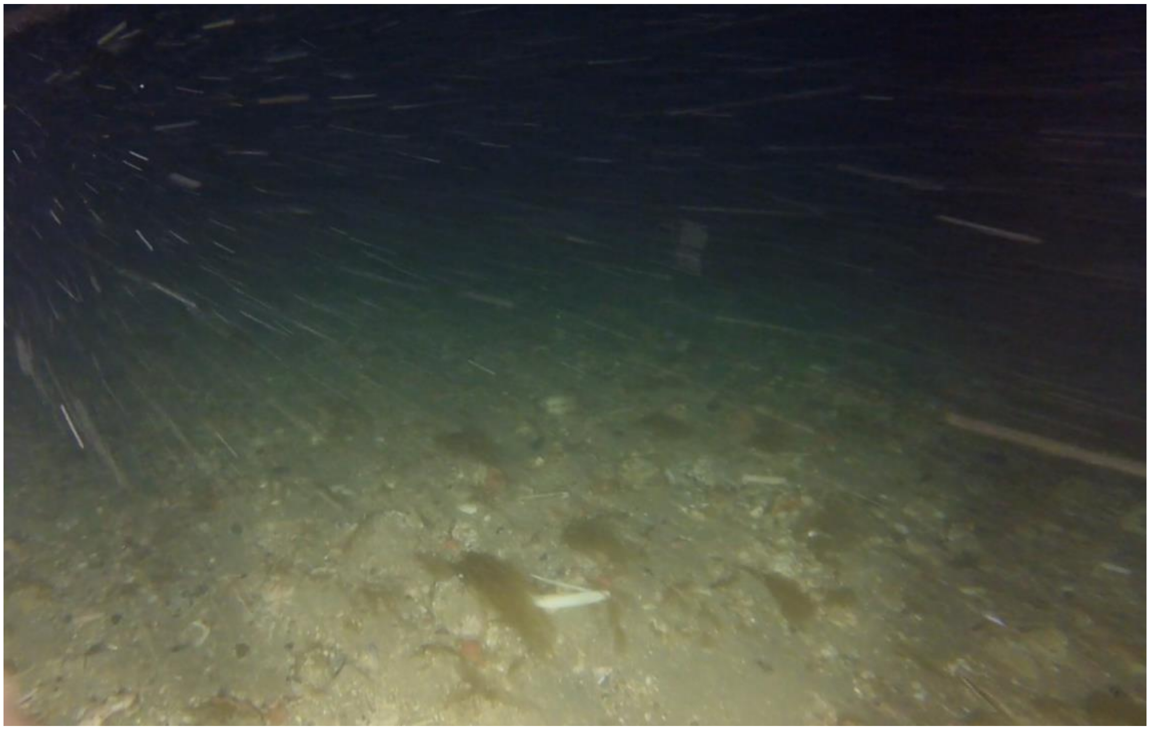

Image 5. Hydroids/macroalgae. Trip 15, Tow 16, 9/8/2020.

Image 6. Macroalgal growth on an extensive mussel bed. Trip 33, Tow 16, 11/5/2020.

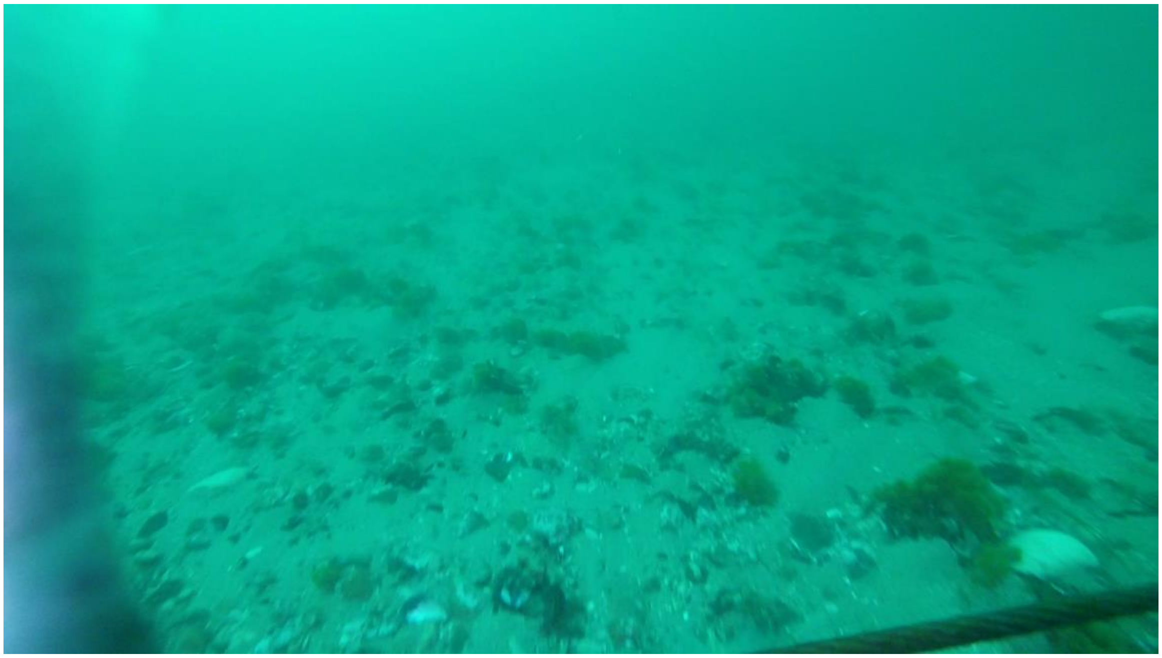

Image 7. Mussel clumps, macroalgae growth. Trip 33, Tow 16, 11/5/2020

Image 8. Mussel and barnacle encrusted boulder. Hermit crab on top. Trip 1, Tow 38, 6/3/2020.

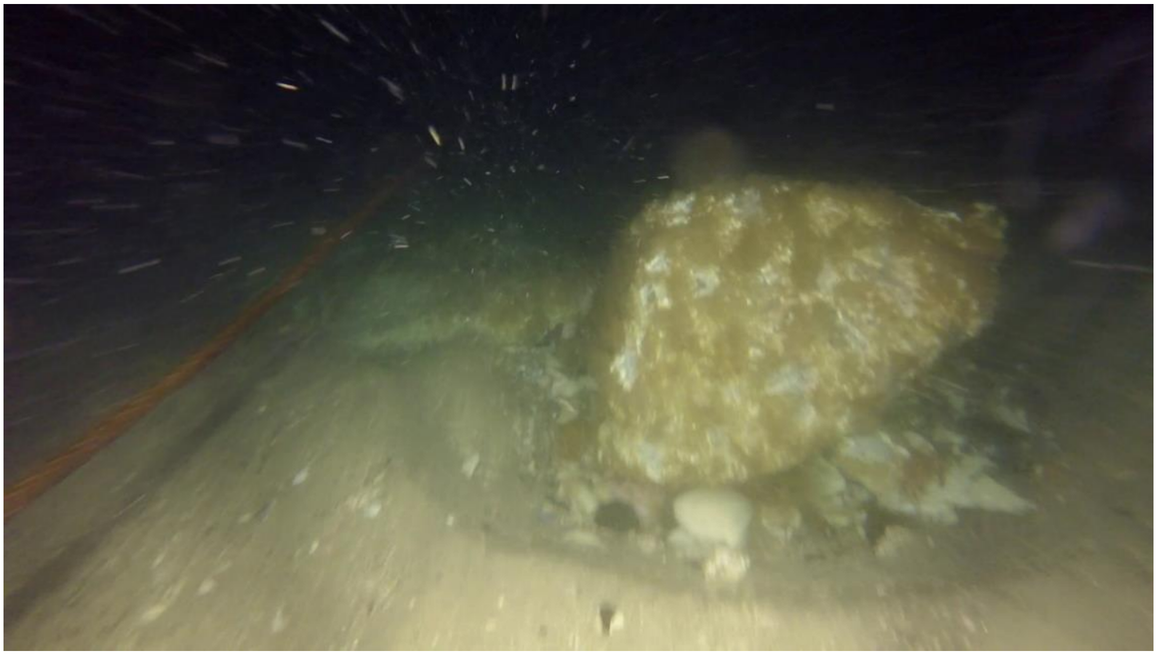

Image 9. Barnacle scars on a boulder with shell hash gathered beneath. Trip 1, Tow 38, 6/3/2020.

Image 10. Cobbles from catch subsample showing barnacles, barnacle scars, and hydroid filaments. Trip 54, Tow 18, 4/3/2021

Image 11. Barnacles on mussels from catch subsample. Trip 54, Tow 24, 4/3/2021.

Image 12. Peat veins. Trip 33, Tow 16, 11/5/2020.