Survey of Plum Island's Subtidal Marine Habitats

New York Natural
Heritage Program

InnerSpace Scientific Diving
Science in Depth

Survey of Plum Island's Subtidal Marine Habitats

A report to Save the Sound

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Cover photos (left to right, top to bottom): lined anemone (*Edwardsiella lineata)*; banded chink snail (*Lacuna vincta)* on sugar kelp (*Saccharina latissima*); diver with lion's mane jellyfish (*Cyanea capillata*); Below photos (left to right) bryozoans, algae, and sponges and northern star corals (*Astrangia poculata)*. All photos herein by the authors.

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1. Introduction

Plum Island, approximately one and a half miles northeast of Orient Point, New York (NY), is the first of several islands extending off Long Island's North Fork. The area surrounding Plum Island, where waters from the Atlantic Ocean, Long Island Sound, and Peconic estuary converge, is recognized for its ecological importance, with diverse habitats supporting a variety of marine life (New York State Division of Coastal Resources, 2005; McMullen et al., 2010; The Nature Conservancy, 2015). In 1987, in accordance with Article 42 of the State Executive Law and the State's federally approved Coastal Management Program, and in an update in 2005, New York State (NYS) designated Plum Gut a significant coastal fish and wildlife habitat. This area between the western shore of Plum Island and Orient Point includes a deep channel (>150 feet). The designation implements, in part, in federal and State regulatory and related decision-making, a specific State policy to protect, preserve, and where practical, restore the viability of the designated habitat. The combination of deep-water habitats and shoals creates a unique and productive environment, which supports a variety of marine life, including valuable sport fishes [e.g., striped bass (*Morone saxatilis*)], threatened/endangered species [e.g., loggerhead turtle (C*aretta caretta*)], and Species of Greatest Conservation Need (SGCN) in NYS [e.g., American lobster (*Homarus americanus*)] (New York State Division of Coastal Resources, 2005; New York State Department of Environmental Conservation, 2015). The area between Orient Point and Plum Island also meets the criteria of an Important Bird Area, providing habitat for state and federally listed at-risk species during the breeding [e.g., piping plover (*Charadrius melodus*), least tern (S*ternula antillarum*)] and overwintering [e.g., American black duck (*Anas rubripes*)] seasons. Plum Gut is also an important foraging area for endangered roseate terns (*Sterna dougallii*) traveling from the nearby colony on Great Gull Island (Audubon, 2021). Additionally, in 2019, New York State designated the waters surrounding Plum Island from the mean high-water line seaward to a distance of 1,500 feet (approximately 457 meters) a Marine Mammal and Sea Turtle Protection Area to protect the habitat for marine mammals, including the harbor seal (*Phoca vitulina*), gray seal (*Halichoerus grypus*), and harbor porpoise (*Phocoena phocoena*), and sea turtles (https://www.nysenate.gov/legislation/bills/2019/s5871). All four sea turtles present in NY waters [green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), and loggerhead (*Caretta caretta*)] are either threatened or endangered.

Despite Plum Island's ecological importance and the presence of several species that are recognized as SGCN in NYS, there have been few detailed efforts to describe Plum Island's subtidal communities. In 2015, the Plum Island Biodiversity Inventory (Schlesinger et al., 2016) provided a preliminary survey of eelgrass meadows surrounding Plum Island, looking for eelgrass at five points around the island. The team documented one eelgrass meadow on the west side between the ferry harbor and the lighthouse; however, the report emphasizes that more survey work would be required to fully document the extent of the eelgrass communities surrounding the island. In their report, New York Natural Heritage Program biologists also recommended additional marine benthic survey work, citing recent seafloor data suggesting complex hard bottom habitats are present to the north and west of Plum Island (Poppe and Seekins, 2000; Reid et al., 2005; McMullen et al., 2010). In 2019, the New York Natural Heritage Program and InnerSpace Scientific Diving (2020) provided an initial survey of Plum Island's marine habitats, focusing their efforts on the area designated a marine mammal and sea turtle protection area (within 1500 feet seaward of the shoreline of Plum Island or to a depth of approximately 30 feet or 9 meters). Based on our previous experiences in

2019, nautical charts, and orthoimagery, we expected that area to be the most geologically varied, physically dynamic, and biologically diverse area around Plum Island. However, more hydrographic, geological, and biological information was needed to support this.

The 2019 initial survey of Plum Island's subtidal marine habitats identified four distinct character areas surrounding the island (described in detail in section 2.1.) (New York Natural Heritage Program and InnerSpace Scientific Diving, 2020). Our goal in the 2021 effort was to expand upon the 2019 survey, which was largely qualitative, and prioritize baseline transect/quadrant survey efforts in the four distinct character areas previously identified. Efforts to describe the subtidal marine communities and document their resident organisms in greater detail will contribute to the mapping of Plum Island's offshore habitats and provide a framework for future scientific studies and monitoring efforts.

2. Methods

2.1. Study Site

Plum Island, NY, is located approximately one and a half miles northeast of Orient Point, NY (**Figure 1**). The 2019 survey identified four distinct character areas warranting further investigation, including (a) relatively flat, large expanses of gently sloping coarse-grained sandy areas with distinct sand ridges off the south side of the island; (b) dense assemblages of boulders 2–4 meters across with smaller boulders, large stones, and crevice spaces between them, most prevalent over large expanses off the north side of the island; (c) occasional assemblages of large stones and boulders unconnected with each other, scattered about in large expanses of open sandy areas, most common at the extreme southeast side of the island; and (d) an eelgrass meadow in the relatively

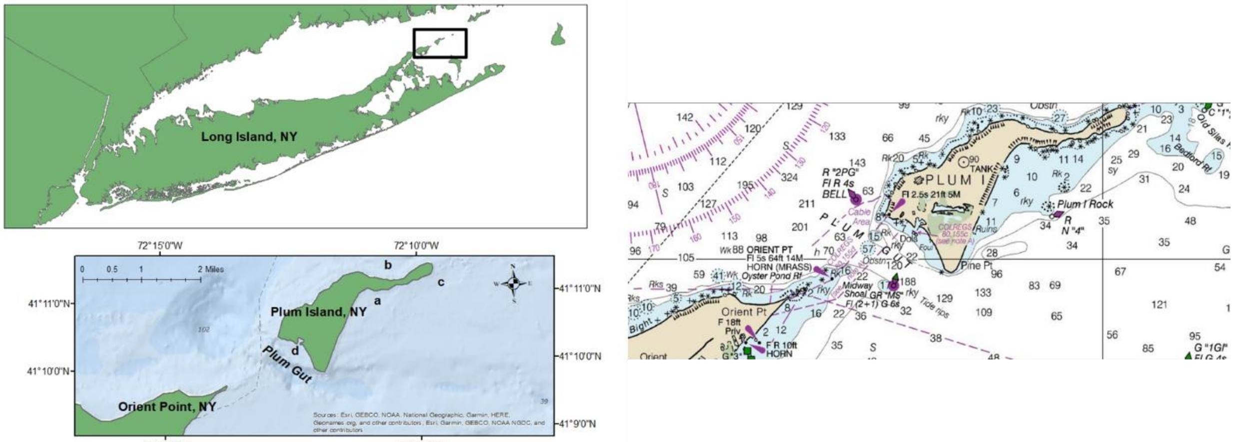

Figure 1. Top left: Location of Plum Island, NY; Bottom left: Plum Gut, an area approximately 1.5 miles across between Orient Point and the southwestern shoreline of Plum Island, is characterized by a deep channel (>150 feet) and turbulent waters. The letters coincide with the general location of the character areas identified in 2019. (a) relatively flat, large expanses of gently sloping coarse-grained sand; (b) dense assemblages of boulders 2–4 meters across with smaller boulders, large stones, and crevices between them; (c) occasional assemblages of large stones and boulders unconnected with each other, scattered about in large expanses of open sandy areas; and (d) an eelgrass meadow; Right: NOAA NOS Chart. #12354.

shallow nearshore area off the west side of the island, between a steep drop into Plum Gut and Plum Island (**Figures 1** and **2**).

2.2. SCUBA survey

As with the 2019 Initial Survey of Plum Island's Marine Habitats (New York Natural Heritage Program and InnerSpace Scientific Diving, 2020), the plan for the 2021 survey involved traditional and commonly used transect/quadrat observations and sampling using SCUBA, along with observations from adjacent readily observed areas. These methods and variations of them represent standard scientific diving practices for both qualitative and quantitative data collection (Joiner, 2001; Heine, 2011; McFall, 2017).

The 2021 follow-up survey was intended to provide more qualitative and, where appropriate and possible, quantitative information to inform our understanding of the benthic communities surrounding Plum Island. The survey involved identifying characteristics of the substrate and documenting the diversity and relative abundance of flora and fauna. As with the 2019 survey, a maximum of five days of fieldwork was planned, conditions permitting. While two divers were used in 2019, two additional divers were included in the 2021 survey to cover more area. The increased range of diver coverage provided more opportunities for observations, sampling, and recording, allowing for more quantitative data collection. The addition of two more divers required the addition of a second support vessel. Save the Sound provided its single-engine 25' Parker, which had open deck space in the stern, a cabin, and enclosed bow deck space and was captained by Save the Sound's Soundkeeper Bill Lucey. The second vessel was a 27' center console, twin-engine Boston Whaler Outrage, donated and captained by Paul Ahern (**Figure 3**). Both vessels had dive ladders and safety equipment for the surface crews and divers. On each vessel, navigation, depth, and other instrumentation were used for transport to and from the area around Plum Island and for positioning at transect start locations using GPS coordinates from the 2019 survey.

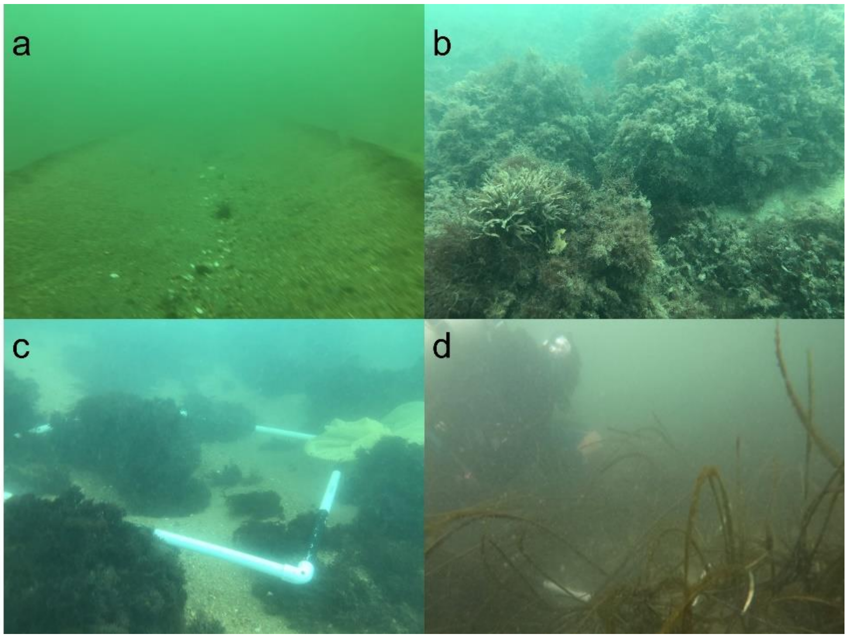

Figure 2. Representative images of character areas identified in 2019: a) relatively flat, large expanses of gently sloping coarse-grained sand; b) dense assemblages of boulders 2-4 meters across with smaller boulders, large stones, and crevices between them; c) occasional assemblages of large stones and boulders unconnected with each other, scattered about in large expanses of open sandy areas and d) an eelgrass meadow.

Figure 3. The Parker (forefront) and Boston Whaler being loaded with equipment before the start of a SCUBA survey.

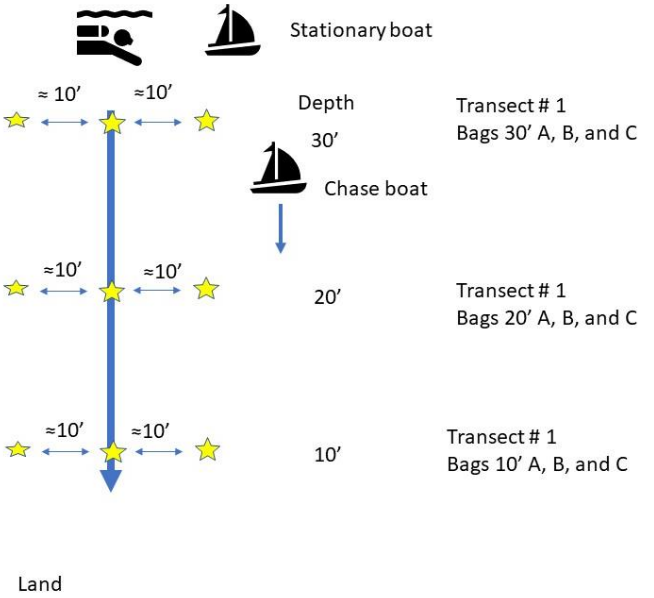

Figure 4. Conceptual diagram of SCUBA survey methodology; stars represent locations of quadrats. The thick center arrow represents the centerline of the transect and direction of the divers moving from 30’ towards the shoreline. Three sample bags were used at each depth, coinciding with the three quadrats sampled.

To improve the qualitative and quantitative data collected compared to 2019, we considered several different survey designs in an attempt to balance spatial coverage and time limitations with the varying levels of detailed data collection required for this study. In 2019, divers selected quadrats that appeared to be the best representation of the area along the transect. However, in the 2021 survey, we settled on performing a traditional transect/quadrat design, with sampling along the centerline and offsets in each of the four previously identified character areas at depths of 30’, 20’, and 10’ (approximately 9m, 6m, and 3m, respectively) (**Figure 4**). Survey transects ran perpendicular to Plum Island and were chosen based on the GPS locations of the 2019 character areas. The Parker anchored at a “start” point of each transect, approximately 1500’ from shore and in water roughly 30’ deep, except along the island’s southern shoreline where depths of >30’ occur farther offshore. We planned for only two divers to be in the water at a time, surveying a single primary transect in each character area. Divers entered the water from the anchored Parker. While the Parker acted as a stationary boat, the Boston Whaler followed the divers at a safe distance along the transects, maintaining visual and voice contact with the divers when they surfaced. In shallower areas, where uncharted boulders were prevalent, the Boston Whaler stayed farther offshore to avoid collisions. To the extent possible, the divers swam the transects along the bottom, starting from deeper water and ending in shallower water. This methodology offered broader spatial coverage of each area surveyed, providing representative information across various depths, with sufficient time to collect data from a manageable number of transects.

The divers used standard open-circuit SCUBA equipment, thermal protection, and related equipment such as digital and analog compasses, depth, time, and water temperature gauges, and digital dive computers. Survey and sampling equipment included a graduated meter used as a quadrat for observation, metal sieves for surficial sediment sifting, hand-held metal pronged rakes to expose and sample benthic organisms, zippered plastic storage bags for samples, Falcon centrifuge tubes, large mesh collection bags, and clipboards with preprinted waterproof datasheets (**Figure 5**). The divers assembled on board the Parker at the approximate 30'-depth station. After donning their gear and performing safety checks, the divers entered the water, took compass bearings at an agreed-upon point on Plum Island, and descended directly to the bottom with their sampling and recording supplies. Approaching the bottom, divers set their 1-meter-square quadrat on the bottom or on top of boulders providing the best visible representation of the area within a few feet of where the divers initially touched the bottom. The quadrat lay on the approximate centerline of the compass-bearing transect line chosen by the divers.

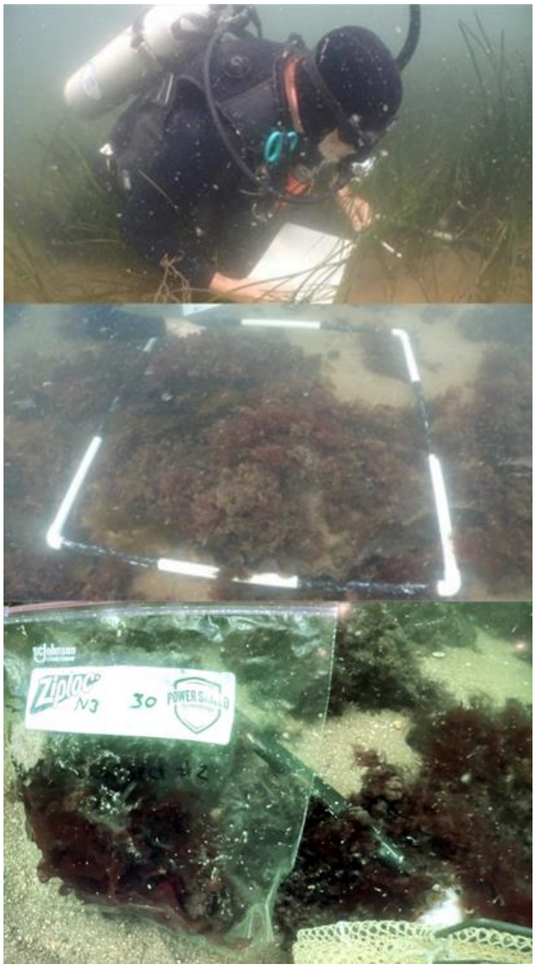

Figure 5. Diver recording information from a quadrat on waterproof datasheet (top), example of placement of 1-m square quadrat (center), and ziplock sample bag and mesh collection bag (bottom).

Using preprinted datasheets on clipboards, the divers recorded surficial sediment types and species observed along with approximate percent coverage of substrate and vegetation inside the quadrat(s) (example, **Appendix A**). They took digital images of the preprinted diver datasheets, including the transect number, depth, and quadrat letter, in order to assign photographs and videos to the appropriate quadrat. Depending on visibility and numbers of species, one or more overhead and/or oblique angle images of the quadrat were taken. The divers placed any specimen that couldn't be readily identified in the pre-marked collection containers for subsequent processing, preservation, and identification. If appropriate, given their best expert judgments, the divers recorded other species observed outside the quadrat(s), especially pelagic or other highly mobile species. Still images and videos of the adjacent areas and species of interest were also recorded as time permitted. After all data were collected for the first quadrat "A," the divers moved the quadrat approximately 10' to the left side of the landing site and repeated the process for quadrat "B." The quadrat was then moved approximately 10' to the right side of the original landing site and quadrat "C" was surveyed. The completed data collection for quadrats "A," "B," and "C" was considered a triplicate sampling for the particular depth. The divers then moved to the next shallower depth and performed the triplicate again, and so on, until the final depth was completed. If the dive team did not complete the transect because of time, low air, or other constraints, the second dive team would enter the water and complete the transect. When the divers surfaced, they passed their datasheets, samples, quadrats, collecting equipment, and tools to the crew aboard the Boston Whaler, who collected topside data during the survey (example, **Appendix B**). Samples were sorted, preserved, and bagged on ice in coolers until we returned to the field lab.

For the 2021 survey, the total numbers of possible transects and quadrats that could be sampled around the island were limited by the

- number of possible dives per day for four scientific divers working in two-person teams;
- weather and sea state conditions;
- bathymetry;
- geological characteristics (rocky, sandy, vegetated);
- tidal and wind-driven currents;
- in-water visibility;
- species abundance and diversity (e.g., quadrats with greater abundance and diversity require additional sampling time); and
- availability of topside support vessels and crews.

2.3. Sample processing

A field laboratory was set up in space provided by the Silver Sands Motel in Greenport, NY. Field laboratory equipment included a stereomicroscope, containers for preserved biological specimens, identification keys (vertebrates, invertebrates, and algae), preservatives, and related supplies. Upon return to the field lab, sample bags were emptied onto a dissecting tray for sorting and identification purposes (**Figure 6**). Algae samples were returned to pre-labeled ziplock bags with a small amount of seawater from the original collection. The ziplock bags were sealed 75% of the way and stored in a refrigerator until they could be transferred to colleagues at Cornell Cooperative Extension for pressing and species identification. Invertebrate species remaining from the sample collection were preserved in 70% ethanol in sealed plastic collection vials for later identification. This process was completed at the end of each day for all transects.

Figure 6. Equipment set up in the field lab at the Silver Sands (top), and Dan Marelli and Meaghan McCormack sorting and preserving sample collections (bottom).

2.4. Macroalgae identification

Macroalgae specimens were kept refrigerated in labeled collection site sample bags until they could be identified by Steve Schott at Cornell Cooperative Extension. For each collection bag, the macroalgae were removed and placed into a white plastic tray filled with seawater. Individual species were separated from one another using forceps and picks. Identification was completed to species level when possible, using appropriate taxonomic keys for the New England region (Sears, 1998; Villalard-Bohnsack, 2003). Voucher specimen pressings were created by arranging individual species on herbarium paper and either spreading out the thallus using tweezers and picks or by applying a gentle stream of seawater from a squeeze bottle. The pressings were covered with cheesecloth and placed in a plant press, sandwiched between layers of blotter paper and cardboard ventilators. The specimens were left to dry for at least one week before being removed from the press. Specimens were stored flat in large folders.

2.5. Invertebrate identification

Invertebrates were identified, when possible, during the actual underwater surveys. Collected specimens were identified to species level, when possible, in the lab using appropriate taxonomic keys. We were able to identify most animals to species level.

2.6. Statistical analyses

To visualize and potentially differentiate between natural communities, we used non-parametric multidimensional scaling ordinations (NMDS) based on Bray-Curtis distances in the vegan package of R version 4.1.2 (Oksanen et al., 2015). NMDS is a type of ordination analysis; ordination methods simplify multivariate data, representing the data graphically in only two dimensions. Ordination techniques make it easier to explore patterns in ecological distributions across sites. Wisconsin and square-root transformations were used, and stress values ≤ 0.2 were considered a good fit. For NMDS, we explored whether depth and substrate composition influenced the vegetation percent coverage. Data from quadrats A, B, and C from each transect and depth were averaged. The level of significance was $\alpha = 0.05$. Cluster analyses and heatmaps, based Bray-Curtis similarity indexes, were used to visualize the differences between quadrats with regard to substrate percent coverage. Some datasheets had missing or incomplete quadrat data for percent coverage of substrate or vegetation and were therefore excluded from the respective analyses.

3. Results

Weather conditions allowed for five days of diving between August 2nd and August 6th, 2021. In total, we collected data from 57 quadrats across seven transects (**Figure 7**; **Table 1**). Of these 57 quadrats, not every quadrat had complete data; however, each had at least substrate or vegetation percent coverage data. The first five transects surveyed (S2, N3, N2, N6, and S1) followed the methodologies outlined in section 2.1, although transect S1 was cut short for safety reasons due to a seal encounter. The 6th (S5A/B) and 7th (N4A/B) transects were more exploratory. In both cases, the same data were collected as the previous transects; however, the number of quadrats and the depth profiles of the quadrats differed from the previously outlined methodology. For transect S5, the two teams of divers split up and performed data collection at five quadrats at approximately 15’, resulting in five quadrats each for S5A and S5B. In the final transect, N4, the two teams of divers entered the water together, split up, and each performed transects perpendicular to the shoreline, collecting information from one quadrat at the 30’, 20’, and 10’ depth. The intent was to gain as much representative qualitative and quantitative information as possible for each area. Given the four priority areas already were sampled, and considering how time-consuming the first five transects were, we decided to amend the methodology for the last two transects.

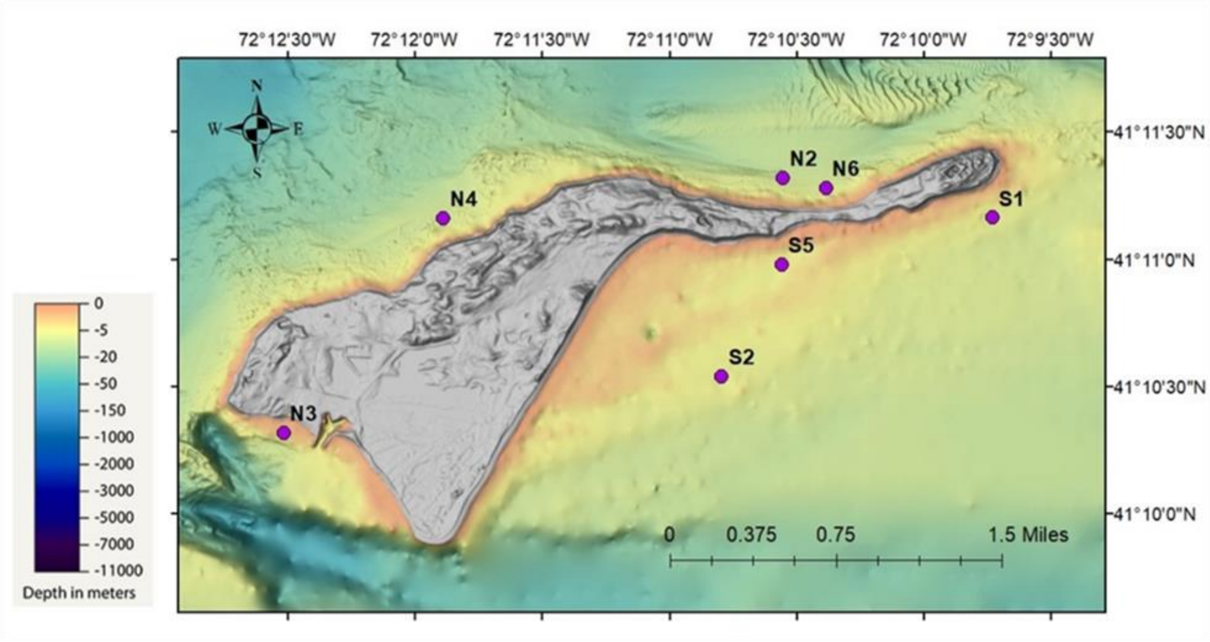

Figure 7. Start locations for transects overlaid on topographic and bathymetric mosaic; National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) (https://www.ngdc.noaa.gov/thredds/demCatalog.html).

Table 1. Survey dates and quadrat information for SCUBA survey

Survey Date	Transect #	Transect ID	Depth (ft)	Quadrats Sampled
8/2/2021	1	S2	30	A, B, C
			20	A, B, C
			10	A, B, C
	2	N3	30	A, B, C
			20	A, B, C
			10	A, B, C
8/3/2021	3	N2	30	A, B, C
			20	A, B, C
			10	A, B, C
	4	N6	30	A, B, C
			20	A, B, C
			10	A, B, C

8/4/2021	5	S1	30	A, B, C
			20	A, B
8/5/2021	6A	S5A	≈ 15	1, 2, 3, 4, 5
	6B	S5B	≈ 15	1, 2, 3, 4, 5
8/6/2021	7A	N4A	30	A
			20	A
			10	A
	7B	N4B	30	A
			20	A
			10	A

3.1. Habitat Information and Quadrat Data

Substrate in the nearshore area around Plum Island is dominated by sand. The subtidal region on the north side is more steeply sloped than the south side and is predominantly composed of sand with various amounts of shell fragments, small (<10 cm diameter) and medium (>10 cm diameter) rocks, gravel, and boulders (>1 m in diameter) in the shallow subtidal regions. Depth increases more quickly offshore on the northeast portion of the island and along transects N2 and N6, where the 30' depths were dominated by silt and sand. At shallower depths on the north side, silt was rare, and substrate consisted of boulders interspersed with coarse sand. The westernmost transect (N3) was quite different, with smaller rocks and sand offshore and a sand flat eelgrass (*Zostera marina*) community in shallow depths. The substrate composition of transect N3 likely is indicative of its proximity to upland soils and reflects the geological history of the island. Additional eelgrass meadows exist in shallower waters along the southeastern

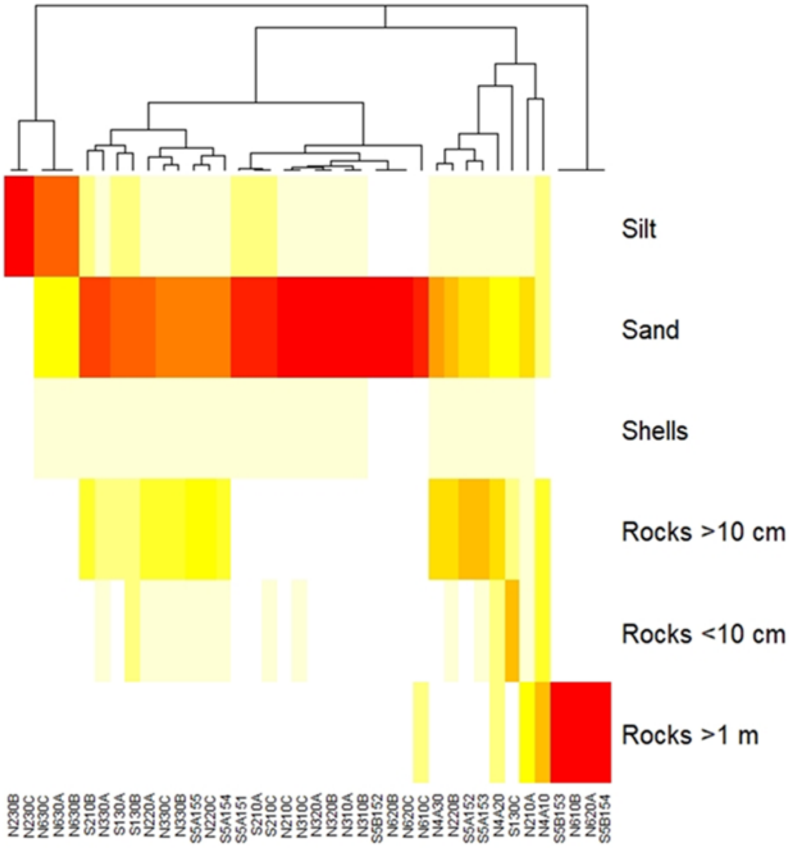

Figure 8. Heatmap visualizing the percent coverage of substrate type (y-axis) across quadrats (x-axis). Quadrats are coded by their transect number, depth, and quadrat position (A, B, and C), when applicable. Red rectangles correspond to quadrats with high values of percent coverage for a particular substrate type. Quadrats with similar colors have similar substrate compositions.

shoreline of Plum Island that were simultaneously surveyed by Cornell Cooperative Extension (CCE). However, differing methodologies between our study and monitoring efforts undertaken by CCE precluded the inclusion of the CCE data in our report. For example, CCE used smaller quadrats and did not estimate the percent coverage of substrate. The south side of Plum Island has a more gradual slope offshore, and shallow areas are almost completely sand containing some silt. In contrast to 2019, we did not observe large sand ridges along the southern shoreline. The sand ridges observed in 2019 may have resulted from a storm that passed through the area a few days before sampling or may reflect seasonal changes, as the 2019 survey occurred later in the summer (September) compared to the present study. Again, this substrate is a product of the geology of the island; finer sediments are deposited on the south shore of the island. Smaller rocks appear at greater depths on the south side amongst large, scattered boulders (outside the immediate transect), where gray seals (*Halichoerus grypus*) were observed hauling out. However, we documented more extensive assemblages of boulders on the north shore. In every region of the island, hard surface space is occupied by fouling communities of sponges, coralline algae, bryozoans, hydroids, and macroalgae. Living among these encrusting and epibenthic organisms is a robust epifaunal community of foraminiferans, amphipods, polychaetes, gastropods, bivalves, and barnacles.

Of the 57 quadrats, 40 included completed information on the percent coverage of substrate. From the plot data, four distinct areas emerged: (a) areas dominated by sand; (b) areas dominated by silt; (c) areas with a mix of sand, shells, silt, and small (<10 cm) and medium (>10 cm) rocks; and (d) areas with a high prevalence of large rocks/boulders >1 m (**Figure 8**). To understand the distribution of sediment types around Plum Island, plot data from each transect and depth profile (e.g., Transect N3 30 A, B, and C) were averaged and mapped according to their approximate

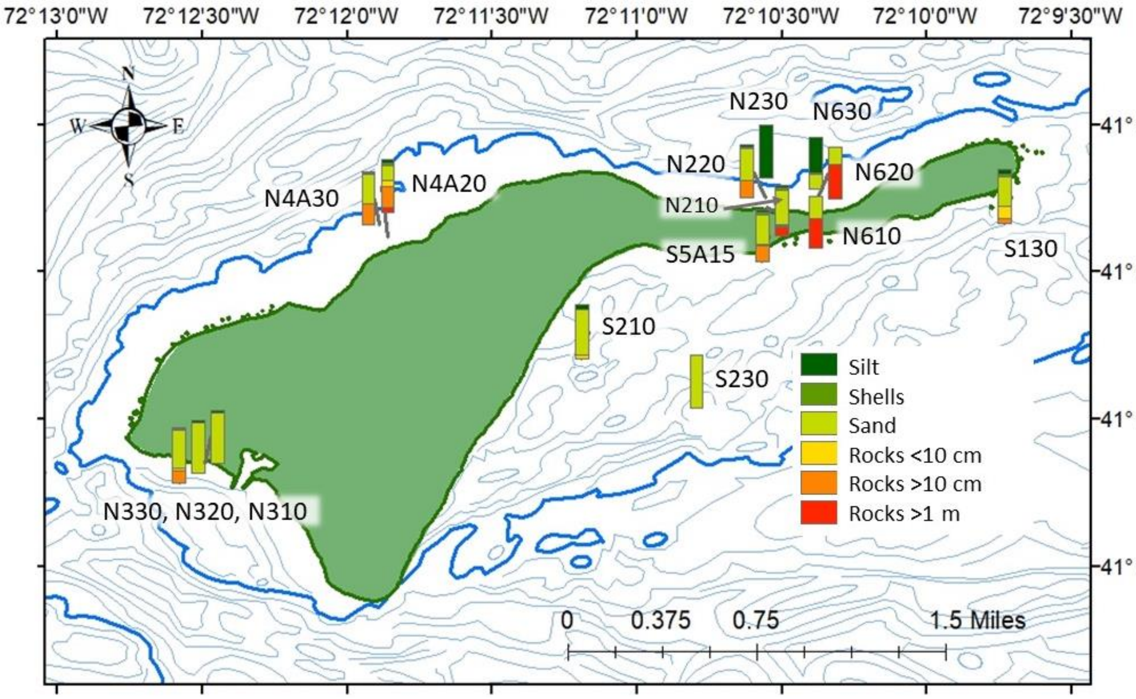

Figure 9. Map of Plum Island with 1-m bathymetric lines and distribution of substrates according to averaged plot data. Bar graphs coincide with approximate locations of plots (geographical information was not available; to represent graphs on the map, they needed to be moved to avoid overlapping). The blue bold line represents the 10-m (approximately 32-') bathymetric line. Quadrat labels correspond to transect number and depth.

locations based on transect starting locations and depth profiles (**Figure 9**). Sandy areas, those with combined plot data averaging between 70 and 100% sand, were observed on the south side of the island at transect S2 and along transect N3, where the eelgrass meadow occurs. Further to the east, on the south side of the island, plots along transects S5 and S1 were still dominated by sand, on average more than 50%, but also had a mixture of silt, shells, and small (<10 cm) and medium (>10 cm) rocks. In contrast, on the northeast side of the island, plots along transect N6 at depths of 10' and 20' had the highest average percent coverage of large boulders (>1 m). At depths of 30', along transects N6 and N2, plots were predominantly silt. Further to the west, on the northside of the island, plots from transect N4A were a mix of sediment types.

Compared with the number of plots (40) with substrate percent coverage data, fewer plots (32) had completed information on the percent coverage of vegetation. Vegetation type was split into 11 categories based on what could be identified during the underwater survey. For example, some categories corresponded to species that were easily identified in the field [e.g., sugar kelp (*Saccharina latissima*)], while others were more general (e.g., unidentified red algae). Unidentified macroalgae were sampled for later species identification. However, because there were often several species that could not be readily identified in the field, it was impossible to estimate percent coverage by species. The five categories that accounted for the largest percent coverage across the transect and depth-averaged plots in descending order were: unidentified red algae, sugar kelp, eelgrass, Irish moss, and unidentified brown algae. As with the substrate data, we averaged the percent vegetation coverage information from plots at each transect and depth profile and mapped the distribution of vegetation around the island. Despite limited information, some patterns emerged, although they were driven largely by the location of the transect (**Figure 10**). Eelgrass was

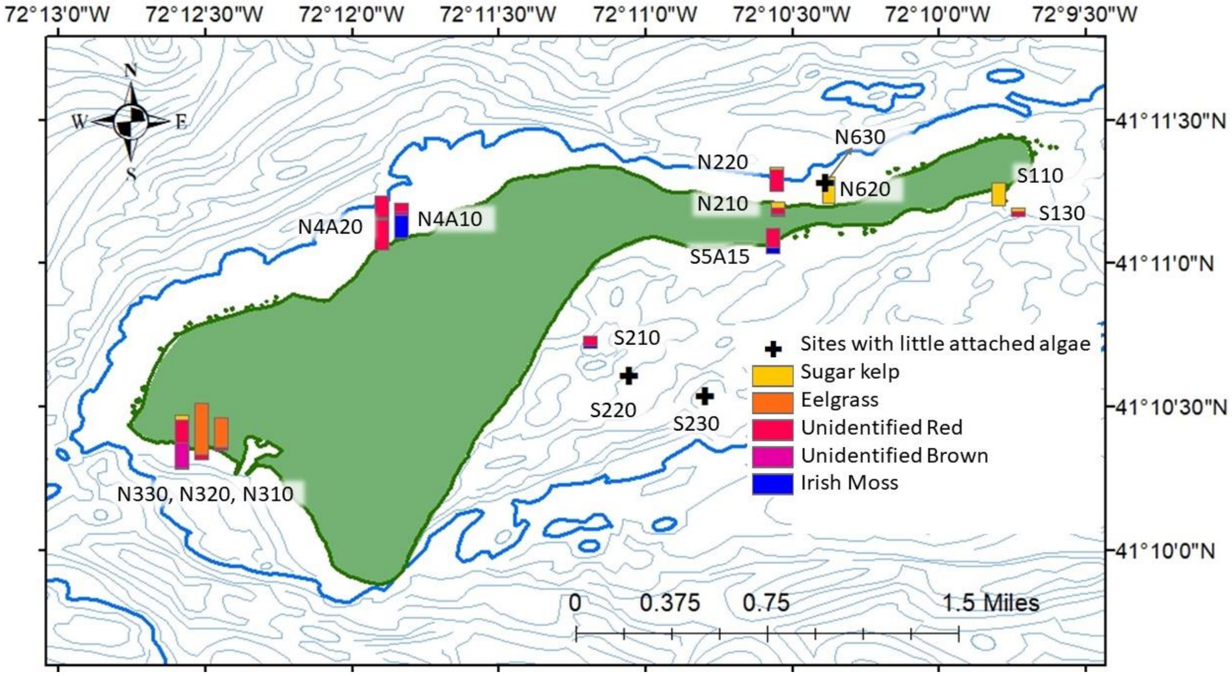

Figure 10. Map of Plum Island with 1-m bathymetric lines and distribution of prominent vegetation according to averaged plot data. Bar graphs coincide with approximate locations of plots (geographical information was not available; to represent graphs on the map, they needed to be moved to avoid overlapping). The blue bold line represents the 10-m (approximately 32-ft) bathymetric line.

only found at transect N3 and was limited to depths 20' or less. Sugar kelp was observed in the highest percentage on the southeastern shore along transact S1 and the northeastern shore along transect N6. Unidentified red algae occurred across most plots at varying percentages.

After we averaged plots, 13 observations had both substrate and vegetation percent coverage data. We ran an NMDS on the vegetation only, using depth and substrate percent coverage as environmental variables to map onto the ordination. The results of the NMDS should be viewed as descriptive with consideration of the small sample size. Only significant species and environmental vectors are displayed (**Figure 11**). The output shows differences between community types with eelgrass, sugar kelp, and unidentified red algae. Sugar kelp was more prevalent in plots with boulders >1 m, while unidentified red algae was prevalent in plots with large rocks >10 cm.

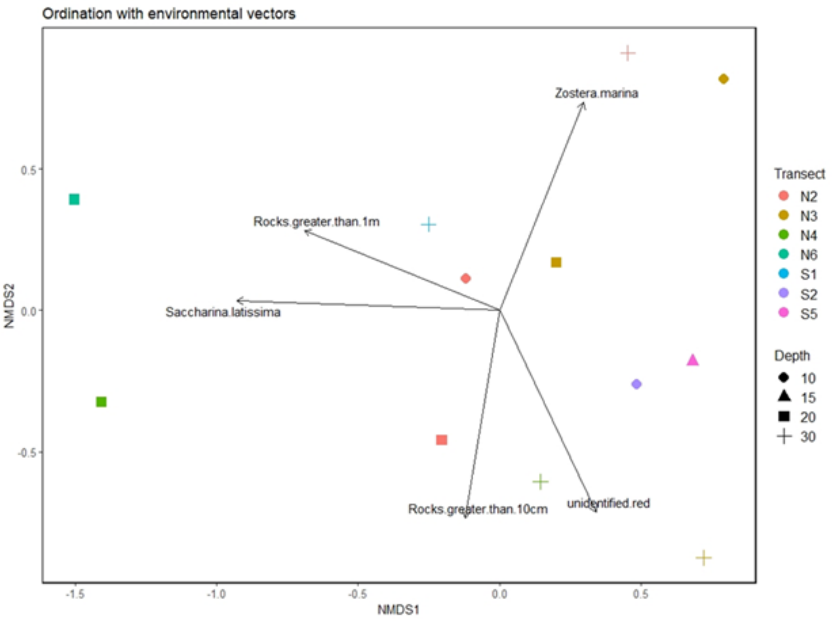

Figure 11. NMDS on vegetation percent coverage; points closer together are more similar. Depth and percent substrate coverage are plotted as environmental variables, with arrows indicating the direction of change; only significant variables are shown.

3.2. Species observed

The species listed in **Table 2** and the descriptions below reflect observations from along the transects as well as those outside the transects but within the character areas surveyed between 30' and 10' depths. As in 2019, the survey design did not emphasize infaunal sampling, although we did bring along hand-held rakes for use in some cases. Therefore, infaunal species observations were largely opportunistic, and the list generated is likely an underrepresentation of infaunal biodiversity surrounding Plum Island.

Figure 12. The red algae *Champia parvula* under the dissection scope (top left), sugar/honey kelp (*Saccharina latissima*) on boulder (top right), and eelgrass (*Zostera marina*) in a sampling quadrat (bottom).

Substrate types ranged from silt to large boulders ≥1 m in width. The eelgrass meadow on the west side of Plum Island that was surveyed in 2019 was also re-surveyed in 2021.

3.2.1. Vegetation (macroalgae and eelgrass)

In total, 34 different species of macroalgae were identified. Most species identified were red algae (27 species), followed by brown algae (4 species), and green algae (3 species and 1 genus). Between 8 and 17 different species of vegetation were identified in each transect. The most widely distributed species, occurring at five or more transects, were *Champia parvula, Chondrus crispus, Coccotylus truncates, Dasy baillouviana, Phyllophora pseudoceranoides, Polyides rotundus, Polysiphonia fucoides, Spermothamnion repens, Saccharina latissimi,* and *Ulva lactuca*. Eelgrass (*Zostera marina*) was only found at site N3 at depths < 30'.

3.2.2. Porifera - Sponges

We observed boring (e.g., *Cliona* spp.) and encrusting sponges (e.g., *Haliclona canaliculata*) at several sites. These sponges and others are likely more widely distributed than our results suggest. Divers found through direct observation that both sponges were almost anywhere where hard substrates were present. Monitoring efforts between 1991 and 2010 found that *Haliclona canaliculata* was a regularly recurring organism in the epibenthic community of Stratford Shoal in central Long Island Sound along with northern star coral (*Astrangia poculata*) and blue mussel (*Mytilus edulis*). However, after 2012, no *Haliclona canaliculata* was observed in the same area. Observations at Stratford Shoal were opportunistic, and therefore the cause of the shift is uncertain. It is interesting to consider if similar shifts in epibenthic communities surrounding Plum Island have occurred (Stefaniak et al., 2014).

3.2.3. Ctenophores and cnidarians – Comb Jellies, Anemones, Corals

The comb jelly (*Mnemiopsis leidyi)* was observed along three transects: N2, S1, and S2. The lion's mane jellyfish (*Cyanea capillata)* was found along transects S2 and N3. Comb jellies and medusae such as *C. capillata* are typically found in water masses that are driven by surface currents, and their presence and abundance are determined by a number of factors. The northern star coral (*Astrangia poculata*) was observed along transect N2, N4, and S5. We also observed large numbers of the lined anemone (*Edwardsiella lineata)* along transect N4 as well as unidentified *Diadumene* spp. (**Figure 13**). There are at least two species of *Diadumene* spp. in Long Island Sound: the ghost anemone (*Diadumene leucolena*) and the orange-

Figure 13. Anemones (*Diadumene* sp.) among *Cliona celata* (sulfur/boring sponge) and bryozoans (left), lined anemone (*Edwardsiella lineata)* (center), and northern star coral (*Astrangia poculata*) (right).

striped green anemone (*Diadumene lineata*), the latter of which is non-native.

3.2.4. Echinodermata – Sea stars, Urchins, Sea Cucumbers

We observed the Forbes sea star (*Asterias forbesi)* at two sites on the north side of the island (N2 and N6) (**Figure 14**).

3.2.5. *Ectoprocta – Bryozoans or Moss animals*

Bryozoans were found along all transects and are ubiquitous on hard substrate around Plum Island. Those identified included branching or bushy forms as well as encrusting organisms. Branching, or bushy, bryozoa provide habitat for a diverse variety of fauna, including polychaeta worms, foraminifera, and caprellid amphipods.

3.2.6. Polychaetae annelids

Polychaetes were observed in all transects on rocks, attached to algae and bushy bryozoa colonies, and on or within the sandy substrates (**Figure 14**). One species found in the sediment, *Alitta virens*, was collected by sieving, and the other, *Diopatra cuprea*, was a dominant member of the *Zostera marina* community. With additional, dedicated, infaunal sampling, we would likely encounter many more species.

Figure 14. Forbes sea star (*Asterias forbesi*) (top) and tube worm casing (worm is withdrawn in tube) in sandy substrate at base of boulder (bottom)

3.2.7. Gastropods

A wide variety of gastropods were encountered, including filter-feeding [e.g., eastern white slipper snail (*Crepidula plana*)], herbivorous [e.g., banded chink snail (*Lacuna vincta*)], and predatory snails [e.g., channeled whelk (*Busycotypus canaliculatus*)] (**Figure 15**). Gastropods are undoubtedly far more abundant and diverse than our collection would indicate. We incompletely sampled the soft-bottom community where infaunal snails can be expected, and we did not extensively collect patches of epifaunal growth on the hard substrates that can be expected to contain snails.

3.2.8. Bivalves

Most bivalves were identified from collecting empty shells; however, some were also identified in situ, particularly the blue mussel (*Mytilus edulis),* common jingle shell *(Anomia simplex),* and the transverse ark (*Anadara transversa*). None were particularly abundant except for *A. transversa* juveniles. Bivalve shells were present at every site we examined, indicating that they are

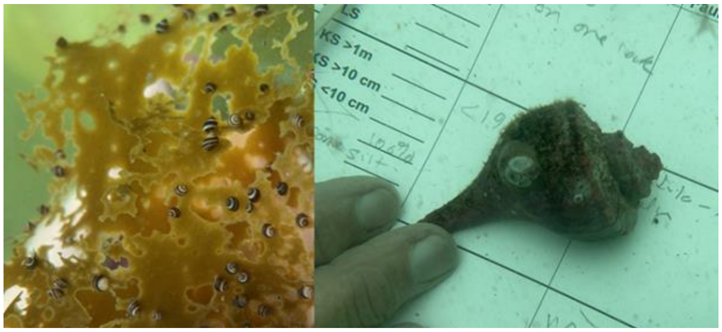

Figure 15. Banded Chink Snail (*Lacuna vincta)* grazing on sugar kelp (*Saccharina latissima*) (left) and Channeled Whelk (*Busycotypus canaliculatus*) (right).

widely distributed and probably that active predation is occurring on the soft-bottom fauna. Bay scallops (*Argopecten irradians*) were collected in the *Zoster*a bed at transect N3 and transect S2.

3.2.9. Hermit crabs

Three species of hermit crabs were collected during the sampling around Plum Island. Divers observed the larger flat-clawed hermit crab (*Pagurus pollicaris*). The flat-clawed hermit crab is a robust and active scavenger/predator and an important member of the epibenthic community. The smaller, long-wristed hermit crab (*Pagurus longicarpus*) and Acadian hermit crab (*Pagurus acadianus*) were common and widely distributed around Plum Island.

Figure 16. Hard clam (*Mercenaria mercenaria*) sampled in the eelgrass meadow in transect N3.

3.2.10. True crabs

Several species of brachyuran crabs were identified, including the following mud crabs: *Panopeus herbstii* and *Rhithropanopeus harrissii*. Spider crabs [e.g., the portly spider crab (*Libinia emarginata*)] were also observed, although not in the large numbers seen in 2019. The cryptic teardrop crab (*Pelia mutica*) was also identified. In addition, the Atlantic rock crab (*Cancer irroratus*) and lady crab (*Ovalipes ocellatu*s) were observed. Crabs were observed on both the north and south shores; the Atlantic mud crab (*Panopeus herbstii*) was the most commonly observed and was distributed across all north shore sites.

Figure 17. Native tunicate (*Styela canopus*) with anemone (*Diadumene* spp.) and bryozoans.

3.2.11. Urochordata

The following sea squirts were identified: white crust (*Didemnum candidum*), a native species, and *Styela clava* and *Styela canopus,* both non-native species. These species were often associated with hard substrate (e.g., transects N2, N4, and S5).

3.2.12. Fish

We observed black sea bass (*Centropristis striata*), scup *(Stenotomus chrysops*), cunner (*Tautogolabrus adspersus*), and tautog (*Tautoga onitis*) while surveying transects. In most cases, these were juvenile fish (**Figure 18**). The sampling strategy was not designed to survey and identify fish, and the environment around Plum Island is very dynamic; tidal currents are nearly always present, and visibility at substrate level is poor. We recommend additional surveys to understand this major component of the Plum Island nekton.

3.2.13. Seals

Quadrat sampling was cut short in transect S1 when Janet and Steve became aware of at least two gray seals (*Halichoerus grypus*). It's suspected that the seals were also responsible for snagging the mesh sample bag while Steve and Janet were sampling a quadrat (the sample bag was later found floating nearby). During a short excursion to waters near Little Gull Island, we observed both gray seals (*Halichoerus grypus*) and harbor seals (*Phoca vitulina).* Survey work conducted by the Atlantic Marine Conservation Society has documented both species in the region throughout the summer. Gray seals (*Halichoerus grypus*) tend to be more common on Little Gull Island, and harbor seals tend to be more common on Plum Island (Robert DiGiovanni, personal communication, March 23, 2022).

Figure 18. Black sea bass (*Centropristis striata)* (top) and scup (*Stenotomus chrysops)* (bottom).

Figure 19. Gray seals (*Halichoerus grypus*) hauled out near transect S1.

Table 2. Species List; species observed at ≥5 transects were recorded as widely distributed; those marked with an * are non-native.

Species	**Locations**
Rhodophyta – Red algae	
Agardhiella subulata – red wooly grass	N3
Ahnfeltia plicata – wire weed	N2, S2
Antithamnion cruciatum	N2, N3, N6
Callithamnion corymbosum	S2
Ceramium nodulosum	N2, N3, N6, S1
Champia parvula – barrel weed	Widely distributed
Chondria baileyana	S1

Chondria capillaris – slender cartilage weed	N2
Chondrus crispus – Irish moss	Widely distributed
Coccotylus truncatus – leaf weed	Widely distributed
Cystoclonium purpureum – grapevine weed	S2, S5
Dasya baillouviana – Chenille weed	Widely distributed
*Dasysiphonia japonica** – siphoned Japan weed	S2
Gracilaria sp.	N3
*Grateloupia turuturu** – Devil's tongue weed	N3, S5
Grinnellia americana – Grinnell's pink leaf	N3, N6, S2, S5
Hildenbrandia rubra – rusty rock	S2
*Neosiphonia harveyi** – Harvey's siphon weed	N3, S2, S5
Phyllophora pseudoceranoides – stalked leaf bearer	Widely distributed
Polyides rotundus – twig weed	Widely distributed
Polysiphonia denudate	N2, S5
Polysiphonia fucoides – black siphon weed	Widely distributed
Polysiphonia lanosa – wrack siphon weed	S5
Polysiphonia nigra	S5
Polysiphonia sp.	N4, S1, S5
Polysiphonia stricta – pitcher siphon weed	S5
Spermothamnion repens – red puff balls	Widely distributed
Spyridia filamentosa – beaded weed	S5

Ochrophyta – Brown algae

Ascophyllum nodosum – knotted wrack	N3, N4, S5
Desmarestia aculeata	N2
Ectocarpus siliculosus	N3, N4, N6, S2
Saccharina latissima – sugar kelp	Widely distributed

Chlorophyta – Green algae

Chaetomorpha sp.	N2
Cladophora sericea – green tuft	S2, N6
*Codium fragile** – dead-man's fingers	N2, N3
Ulva lactuca – sea lettuce	N3, N6, S1, S2

Plantae: Tracheophyta

Zostera marina – common eelgrass	N3

Foraminifera

Rosalina spp.	N4, S1, S2, S5

Porifera – Sponges

Cliona spp. – boring sponges	S1 but common on rocks around Plum Island
Haliclona canaliculata	N2
Haliclona spp.	N2
Sycon ciliatum	N4 but probably more widely distributed

Ctenophora – Comb Jellies

Mnemiopsis leidyi – common comb jelly/ctenopohore	N2, S1, S2

Cnidaria – Jellies, Anemones, Corals

Astrangia poculata – northern star coral	N2, N4, S5
Ceriantharia spp. – burrowing anemones	N2
Cyanea capillata – lion's mane jellyfish	S2, N3
Diadumene spp. – anemones	N4
Edwardsiella lineata – lined anemone	N4

Echinodermata – Sea stars, Urchins, Sea Cucumbers

Asterias forbesi – Forbes sea star	N2, N6
Chiridota laevis – silky sea cucumber	N6
Leptosynapta tenuis – white synapta	N2, N6, S1

Ectoprocta – Bryozoans or Moss animals

Amphiblestrum auritum	N4, N6
Bugula turrita	N2, N4
Celleporella hyalina	N2, N4, S1
Conopeum truitti	N6
Crisia spp.	Widely distributed
Crisularia turrita	N2, N4
Microporella ciliate	N4, N6, S5
Tricellaria gracilis	Widely distributed

Annelida: Polychaeta – Segmented worms

Alitta virens – common clam worm	N4
Ampharete acutifrons	Widely distributed
Chaetopterus variopedatus – parchment worm	N2
Clymenella spp. – bamboo worms	Widely distributed
Diopatra cuprea – plumed worm	Widely distributed
Harmothoe extenuata – 15-scale worm	N2, N6, S1
Harmothoe imbricata – 15-scale worm	N2, N3, S2
Hydroides dianthus – carnation worm	N4
Sabella spp.	N6, S5
Spirorbis spirorbis	N4, N6
Unidentified serpulidae	N2, N4, S5
Unidentified spionidae	N6

Mollusca – Gastropods

Astryis lunata – lunar dovesnail	Widely distributed
Busycotypus canaliculatus – channeled whelk	N3, S2, S5
Crepidula fornicata – common Atlantic slipper snail	Widely distributed
Crepidula plana – eastern white slipper snail	N4, S5
Costoanachis translirata	Widely distributed
Eupleura caudata – thick-lipped oyster drill	N4
Euspira heros – northern moon snail	N2
Ilyanassa trivittata – threeline mud snail	Widely distributed
Lacuna vincta – banded chink snail	Widely distributed
*Littorina littorea** – common periwinkle	N4
Turbonilla spp.	N2
Urosalpinx cinerea – Atlantic oyster drill	Widely distributed

Mollusca – Bivalves

Ameritella versicolor – many-colored tellin	N2
Anadara transversa – transverse arc	Widely distributed
Anomia simplex – common jingle shell	N4, S1, S5
Argopecten irradians – bay scallop	N3, S2
Astarte castanea – smooth astarte	N2
Caryocorbula contracta – common basket clam	N4
Cochlodesma leanum – Lea's spoon shell	N4, S5
Crassinella lunulate – lunate crassinella	N4
Cumingia sinuosa	N4
Ensis leei – Atlantic jackknife clam	N2, S5
Lunarca ovalis – blood arc	N2, N4, S1, S2
Mercenaria mercenaria – northern quahog	N2
Mytilus edulis – blue mussel	S5
Nucula proxima – Atlantic nut clam	N2, N4

Petricolaria pholadiformis – false angel wing	N4
Spisula solidissima – Atlantic surf clam	N2, N4, S5

Nematoda

Unidentified nematodes	N1, N3, N4, S5

Crustacea – Cirripedia

Semibalanus balanoides	Widely distributed

Crustacea – Amphipoda

Caprella linearis	N2, N3, N4, S1
Caprella penantis	Widely distributed
Unidentified amphipods	Widely distributed

Crustacea – Isopoda

Erichsonella filiformis	Widely distributed
Idotea phosphorea	N3, N4
Unidentified isopods	N3, N4

Crustacea – Hermit crabs

Pagurus acadianus – Acadian hermit crab	Widely distributed
Pagurus longicarpus – long-wristed hermit crab	Widely distributed
Pagurus pollicaris – flat-clawed hermit crab	N2, N3, S2

Crustacea – True Crabs

Cancer irroratus – Atlantic rock crab	S5
Libinia emarginata – portly spider crab	S1, S2, S5
Libinia sp. – spider crab	N2, S1
Ovalipes ocellatus – lady crab	N2, S5
Panopeus herbstii – Atlantic mud crab	N2, N3, N4, N6

Pelia mutica – cryptic teardrop crab	N2, N6
Rhithropanopeus harrisii – Harris mud crab	N6
Grapside megalops (larval stage)	N4
Urochordata	
Didemnum candidum – white crust	N2, N4, S5
*Styela canopus**	S2, S5
*Styela clava**	N4, S5
Vertebrata – Fish	
Centropristis striata – black sea bass	N2, N4, N6, S2
Stenotomus chrysops – scup	N2
Tautoga onitis – tautog	N4
Tautogolabrus adspersus – cunner	N4, N6, S1, S5
Vertebrata – Mammals	
Halichoerus grypus – gray seal	Near transect S1 and outside survey area nearby at Little Gull Island.
Phoca vitulina – harbor seal	Outside survey area but observed nearby at Little Gull Island

Discussion

Nearshore benthic environments are areas of high productivity that contribute to nutrient cycling and coupling with coastal waters (Norling et al., 2007). The estuaries surrounding Long Island, New York, including Long Island Sound, Peconic Estuary, and the lagoonal bays along the South Shore, are urbanized estuaries, subject to numerous environmental stressors (e.g., pollution, eutrophication, habitat degradation). The physical oceanography of the area and lack of development on Plum Island make the region unique compared to the rest of Long Island. Since the island has had relatively limited development compared with the mainland, there are fewer point sources of pollution. Waters from Long Island Sound, the Peconic Estuary, and the Atlantic Ocean converge in Plum Gut, the area between Orient Point, NY, and the western shore of Plum Island, characterized by its turbulent waters, deepwater habitats, and shoals. The area around Plum Island differs from the rest of Long Island Sound with respect to bottom complexity, salinity, and temperature profiles (The Nature Conservancy, 2015), which may influence the region's productivity and biodiversity. Plum Island is recognized for its ecological importance by several local, state, and federal agencies, including the U.S. Fish and Wildlife Service, which identified Plum Island as part of a Significant Coastal Habitat, and New York State, which designated Plum Gut as a Significant Coastal Fish and Wildlife Habitat. While the subtidal communities currently face fewer anthropogenic stressors than similar communities of the Long Island coast, the region is not immune to non-point source pollutants and other broad-scale environmental forces, such as increasing sea surface temperature. For example, the sea surface temperatures along the northeastern coast of the U.S. are increasing, causing changes in the distribution of marine species, particularly fish and invertebrates (Collie et al., 2008; Nye et al., 2009).

In 2019, our initial survey of the subtidal environments surrounding Plum Island identified four character areas that warranted further investigation: (a) relatively flat, large expanses of gently sloping coarse-grained sand; (b) dense assemblages of boulders 2–4 meters across with smaller boulders, large stones; (c) occasional assemblages of large stones and boulders unconnected with one another; and (d) an eelgrass meadow. In this study, we returned to those areas to collect more detailed information on the sediment types, vegetation, and fauna. Analysis of the percent coverage data from the 2021 quadrats supported the classifications of four general character areas identified in 2019. We also observed areas dominated by silt at depths of 30' on the north side of the island and found indications for species assemblages associated with these substrate types.

Coarse sand is the most prevalent substrate type in the eelgrass beds off the western side and the south side of the island, which are characterized by a gently sloping shoreline. Additional infauna sampling would likely result in observations of increased abundance and diversity of bivalves, amphipods, and polychaetes, in all areas around the island, but especially off the south shore, where sandy bottoms prevail (Zajac et al., 2000). Eelgrass meadows in our region have experienced dramatic declines, negatively impacting eelgrass dependent species (Keser et al., 2003). Eelgrass habitats support several species of conservation concern in New York, including invertebrates such as American lobster (*Homarus americanus*), bay scallop (*Argopecten irradians*), and blue crabs (*Callinectes sapidus*), as well as vertebrates such as winter flounder (*Pseudopleuronectes americanus*), lined seahorse (*Hippocampus erectus*), northern pipefish (*Syngnathus fuscus*), tautog (*Tautoga onitis*), and sea turtles [e.g., loggerhead sea turtle *(Caretta caretta*)]. Eelgrass habitats are complex, supporting a variety of environmental niches for infauna, epifaunal, and benthic/demersal species. Additional faunal sampling of the eelgrass meadows for the above-mentioned animals is warranted.

In contrast to the sandy bottoms of the eelgrass meadow and south of the island, the area off the southeast end of the island shows evidence of a more physically dynamic environment. Along the southeastern shoreline and the north side of the island, large boulders are present. Boulders create hard surfaces for attachment by algae, bryozoans, sponges, and other organisms, such as sea stars, bivalves, and gastropods. Fish, many species of which are thigmotropic and seek shelter from currents and prey around structures, also congregate near the boulders. Especially along transect N4, the area surveyed may serve as a nursery, given that only juvenile fish were observed. This may be because small and juvenile fish tend to be attracted to complex seafloor, using the epifauna for protection and camouflage (Auster et al., 1995; Diaz et al., 2003; Mercaldo-Allen et al., 2020a). Patches of boulders provide important habitats for juveniles, especially for structure-oriented species such as black sea bass (*Centropristis striata*), cunner (*Tautogolabrus adspersus)*, and tautog (*Tautoga onitis)*, all of which we observed in our survey (Mercaldo-Allen et al., 2020a,b). The lack of adult fish observed may also be a result of the timing of our sampling. For example, Mercaldo-Allen et al. (2020b) studied the juvenile fish assemblages in Long Island Sound around oyster aquaculture and focused their study to target juvenile fish between June and October, suggesting that juveniles are most prevalent in the summer and fall.

While our study can only speak to the few observations we could make over five days, long-term studies in Long Island Sound have reported an increase in warm-water-adapted species [(e.g., black sea bass (*Centropristis striata*) and oyster toadfish (*Opsanus tau*)] and a decrease in cold-water-adapted species [e.g., cunner (*Tautogolabrus adspersus*)] over time (Gottschall and Pacileo, 2016; Mercaldo-Allen et al., 2020a). Cunner (*Tautogolabrus adspersus*) is not a target of recreational or commercial fisheries; therefore, its decline is representative of environmental change (Mercaldo-Allen et al., 2020a). Other species that have declined with increasing temperature in the region are winter flounder (*Pseudopleuronectes americanus*) and American lobster (*Homarus americanus)*; neither species were observed in our study (Crosby et al., 2018; Synder et al., 2019).

Donaton et al. (2019) suggest that shifts in the diets of loggerhead sea turtles (*Caretta caretta*), as determined from examining stranded individuals in New York, reflect changes in prey abundance and distribution that correlate with increases in sea surface temperatures. Before 2000, larger crabs, including Atlantic rock crab (*Cancer irroratus*) and spider crab (*Libinia* spp.), were dominant prey items; however, after 2000, smaller hermit crabs (*Pagurus* spp.) were the predominant prey item. Loggerhead sea turtles (*Caretta caretta*) are listed as threatened at both the state and federal level and are a high-priority SGCN in NYS.

Study Limitations and Future Directions

We initially considered using a tripod and box assembly to take photographs of the quadrats, which would have slowed down the survey. However, centered photographs over the quadrats could have allowed us to compare field estimates of percent coverage with those obtained from the photographs. Most of the photographs we obtained were not at the appropriate angle to perform this type of comparison.

Many species of algae are present around the island, particularly red algae. We estimated percent coverage of the more conspicuous species, such as sugar kelp (*Saccharina latissimi)*, Irish moss (*Chondrus crispus*), and dead man's fingers (*Codium fragile*), while other species (e.g., unidentified red algae) were grouped together. Therefore, there was no way to determine percent coverage at a lower taxonomic level. However, by collaborating with Cornell Cooperative Extension, we were able to identify many more species than were reported in 2019.

In the future, measuring current directions and speeds during different tidal cycles would likely help us characterize the areas and relate the environmental variables to species distributions. Inherent in this type of surveying is dealing with environmental patchiness and scale. We tried to address this by sampling three quadrats at each depth, two on each offset of the center transect line. Diver-held cameras and, potentially, remotely operated cameras may provide increased spatial coverage. Although it was attempted in 2019, the currents were too strong to use the ROV provided by NYS DEC. Keeping track of the percent coverage, size, and species present within the eelgrass meadow on the west side of Plum Island would also be important for monitoring. Cornell Cooperative Extension monitors the shallower eelgrass meadow further to the east. In addition to habitat and taxon-specific surveys (e.g., fish, sea turtles, marine mammals, infauna), more intense surveying around the island could contribute to biodiversity information, including species richness and evenness.

SCUBA surveys such as those presented in this study are time-consuming but can provide a wealth of information. Even with a limited amount of quantitative data provided, the output from our analyses supported the qualitative assessments made in the 2019 survey and suggested species-substrate associations, which will require further research. Natural communities can be defined qualitatively; however, data collected from quadrat data similar to those reported in the present study is the "gold standard." With increased quantitative data and improved spatial coverage, natural breaks and transitions among natural communities can be identified and mapped.

While the primary goal of this survey was to collect data on benthic habitat type and species composition, we also found what appeared to be a large, hand or machine-tooled timber/beam almost completely buried by sand and wedged under the outcropping of a large boulder. A wreck is identified on NOAA nautical charts off the northwest side of the island and in Plum Gut. We had no means of determining whether the large timber is a disarticulated element of any shipwreck off Plum Island or whether it may be associated with something else. That would require an archaeological investigation, including investigations of records and probably some degree of excavation of the timber and any associated materials. Given the sensitivity of archaeological information, we are not publicly disclosing where that timber was found. Following standard protocols, relevant information will be provided to the New York State Historic Preservation Officer in the New York's Office of Parks, Recreation, and Historic Preservation, and the State Archaeologist in the State Education Department/State Museum.

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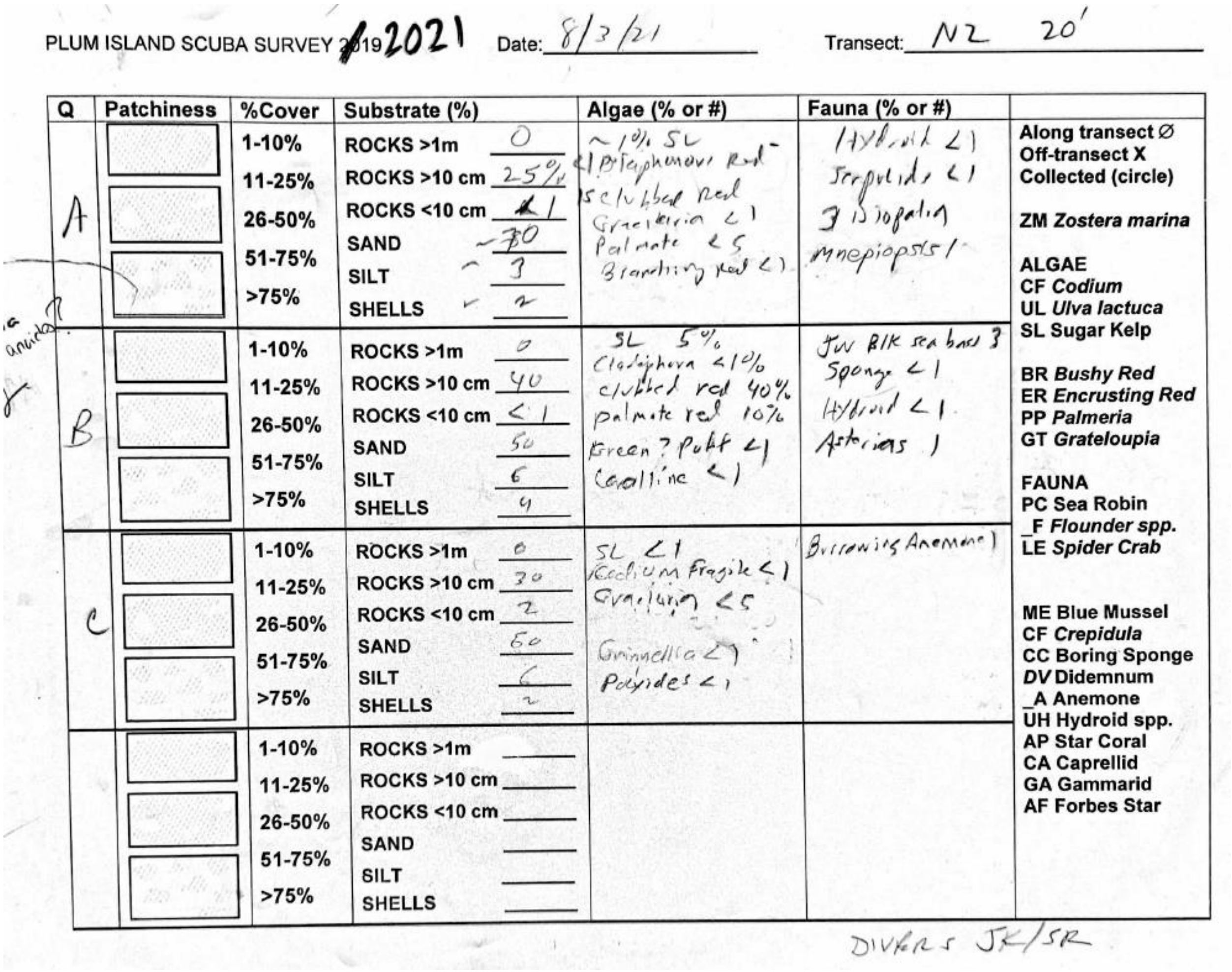
Appendix A: Example Diver Datasheet

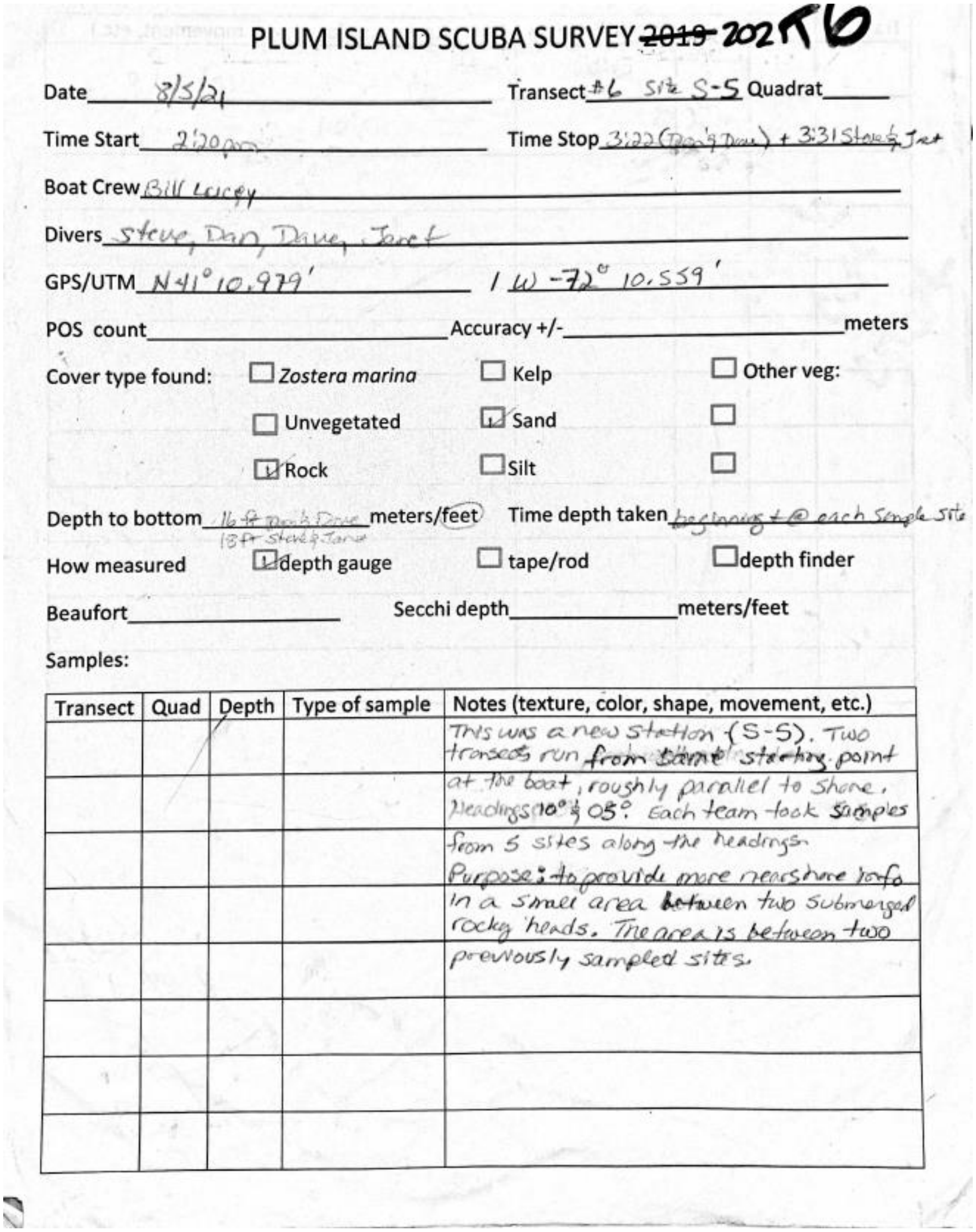


PLUM ISLAND SCUBA SURVEY ~~2019~~ 2021 Date: 8/3/21 Transect: N2 20'

Q	Patchiness	%Cover	Substrate (%)	Algae (% or #)	Fauna (% or #)	
A		1-10% 11-25% 26-50% 51-75% >75%	ROCKS >1m 0 ROCKS >10 cm 25% ROCKS <10 cm <1 SAND ~30 SILT 3 SHELLS 2	~1% SL <1 Bifaphenovi Red 15 clubbed Red Gracilaria <1 Palmate <5 Branching red <1	Hydroid <1 Serpulids <1 3 Diopatra Mnepiopsis 1	Along transect Ø Off-transect X Collected (circle) ZM *Zostera marina* ALGAE CF *Codium* UL *Ulva lactuca* SL Sugar Kelp
B		1-10% 11-25% 26-50% 51-75% >75%	ROCKS >1m 0 ROCKS >10 cm 40 ROCKS <10 cm <1 SAND 50 SILT 6 SHELLS 4	SL 5% Cladophora <1% clubbed red 40% palmate red 10% Green? Puff <1 Coralline <1	JW Blk sea bass 3 Sponge <1 Hydroid <1 Asterias 1	BR *Bushy Red* ER *Encrusting Red* PP *Palmeria* GT *Grateloupia* FAUNA PC Sea Robin _F *Flounder spp.* LE *Spider Crab*
C		1-10% 11-25% 26-50% 51-75% >75%	ROCKS >1m 0 ROCKS >10 cm 30 ROCKS <10 cm 2 SAND 60 SILT 6 SHELLS 2	SL <1 Codium fragile <1 Gracilaria <5 Grinnellia <1 Polyides <1	Burrowing Anemone 1	ME Blue Mussel CF *Crepidula* CC Boring Sponge *DV* Didemnum _A Anemone UH Hydroid spp. AP Star Coral CA Caprellid GA Gammarid AF Forbes Star
		1-10% 11-25% 26-50% 51-75% >75%	ROCKS >1m ROCKS >10 cm ROCKS <10 cm SAND SILT SHELLS			

DIVERS JK/SR

Appendix B. Example Topside Datasheet



PLUM ISLAND SCUBA SURVEY ~~2019~~ 2021 6

Date 8/5/21

Transect #6 Site S-5 Quadrat ______

Time Start 2:20 pm

Time Stop 3:22 (Dan & Dave) + 3:31 Steve & Janet

Boat Crew Bill Lacey

Divers Steve, Dan, Dave, Janet

GPS/UTM N 41° 10.979' / W -72° 10.559'

POS count ______ Accuracy +/- ______ meters

Cover type found: ☐ *Zostera marina* ☐ Kelp ☐ Other veg:

☐ Unvegetated ☑ Sand ☐

☑ Rock ☐ Silt ☐

Depth to bottom 16 ft Dan & Dave / 18 ft Steve & Janet meters/[✓ feet]

Time depth taken beginning + @ each sample site

How measured ☑ depth gauge ☐ tape/rod ☐ depth finder

Beaufort ______ Secchi depth ______ meters/feet

Samples:

Transect	Quad	Depth	Type of sample	Notes (texture, color, shape, movement, etc.)
				This was a new station (S-5). Two transects run from same starting point
				at the boat, roughly parallel to shore. Headings 10° & 05°. Each team took samples
				from 5 sites along the headings. Purpose: to provide more nearshore info
				in a small area between two submerged rocky heads. The area is between two
				previously sampled sites.