

APPENDIX 2

Shellfish surveys in Pleasant Bay, Cape Cod, Massachusetts

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Introduction

Pleasant Bay is a coastal lagoon system featuring diverse habitats and separated from the North Atlantic Ocean by a barrier beach. The Bay is surrounded by ca. 69 km of coastline, and its watershed includes the towns of Orleans, Chatham, Harwich and Brewster. The 2013 Pleasant Bay Resource Management Plan (PBRMP) noted the changes in shellfish and finfish abundance, species composition and fishing activity within the Bay since a 1965-66 study conducted by the Massachusetts Division of Marine Fisheries (MADMF; Fiske et al., 1967). The Bay historically supported a variety of shell-fisheries, most notably targeting quahogs (*Mercenaria mercenaria*), bay scallops (*Argopecten irradians*), and softshell clams (*Mya arenaria*; Fiske et al., 1967). A comprehensive history of the last few decades of the Bay's shellfisheries was compiled by Macfarlane (2002). According to the PBRMP, abundances of the above and other shellfish species have changed over the last few decades, as have the associated fisheries. Softshell clams continue to be a mainstay of the Bay's shellfish harvest, while quahogs have declined in abundance. Bay scallops have only occasionally increased in sufficient abundance to support a small fishery for a single season. Blue mussels (*Mytilus edulis*) support a small commercial fishery in the Bay, and razor clams (*Ensis directus*) have supported a small harvest in recent years, but are currently not found in abundance.

Among the recommendations of the comprehensive MADMF study was that it be repeated in ten years; to date, no efforts have been made to repeat this study. A recommendation in the Fisheries Management section of the PBRMP was to conduct research on the status of Pleasant Bay's fisheries habitat, specifically to develop and conduct a long term monitoring program of the Bay's finfish and shellfish habitat. Following the recommendations of the PBRMP and supported by the Friends of Pleasant Bay, we conducted an inventory of shellfish and finfish in the Bay, with a focus on commercially and recreationally important species (Chapter 2; Nichols et al., 2018). During meetings with stakeholders, it became apparent that focused surveys targeting specific species and areas would be of greater utility to individuals and agencies tasked with managing activities related to shellfish resources. The goals of these surveys were to develop replicable survey methods and to establish a baseline of shellfish abundance at select areas identified by natural resource management agencies.

Methods

Stakeholder Interviews

Leading up to the Pleasant Bay fisheries resource assessment, meetings with stakeholder groups indicated that focused surveys targeting specific species and areas would be useful to individuals and agencies tasked with managing activities related to shellfish resources. In order to identify areas to be targeted for dedicated subtidal and intertidal shellfish surveys, we interviewed natural resource managers from the towns of Orleans, Harwich, and Chatham and consulted with fishermen and retired managers. Interviews included a mapping component during which interviewees were asked to sketch areas of interest onto maps of shellfish habitat excerpted from the 2013 PBRMP. We then combined the maps to generate a single hand-drawn map of areas of interest for each species.

Subtidal Surveys

Given the associated logistical challenges, subtidal (vessel-based) surveys were identified as a priority by town resource managers. While subtidal surveys were conducted at randomly selected locations during the fisheries resource inventory component of this study (Chapter 2; Nichols et al., 2018), the random sampling methodology missed many areas identified as a priority during stakeholder meetings and interviews. While a lightweight bay scallop dredge was used by Nichols et al. (2018) for benthic sampling, it was not ideal for sampling quahogs buried in the sediment or clumped aggregations of mussels.

Due to the patchy distribution of blue mussels, it was deemed most useful to document locations of mussel beds and collect qualitative information on size composition and density. In addition to a broad area identified during stakeholder interviews, areas identified as potential mussel beds during the fisheries resource inventory component of this study (Chapter 2; Nichols et al., 2018) were also surveyed and sampled. Mussel surveys were conducted on board R/V *Shackleton*, a 20' (~7 m) center-console v-hull vessel with a 110 hp outboard engine. The approximate boundaries of blue mussel beds were mapped by navigating the research vessel around the perimeter of each bed, guided by an observer on the bow, while an onboard Garmin 76 GPS recorded vessel track data. If mussel beds were exposed at low tide, researchers disembarked from the vessel and walked around the perimeter of beds while carrying the GPS as it logged their track. At selected locations, short test tows (~1 minute) were made using a bay scallop dredge. The bay scallop dredge was a standard commercial design consisting of a 31" (79 cm) wide lightweight frame with a 5' (152 cm) sweep chain and a catch bag made of 2" (5 cm) steel rings (9 rings deep) and 1.5" (3.5 cm) square mesh (Figure 1).



Figure 1. Commercial scallop dredge used for sampling blue mussels and bay scallops.

Test tows were used to gather information on mussel size composition (shell length) and to confirm surface observations of mussel presence. Underwater video was used to observe performance of the dredge in real time and to collect qualitative information on habitat type and mussel patchiness. If conditions were too shallow for dredging, a long-handled rake was used to collect a small sample.

Bay scallop surveys were conducted using the dredge described above (Figure 1), deployed from R/V *Shackleton* in a standardized manner, with consistent tow times and speeds (3 minutes at 3 knots). The tow line was set at ca. 4:1 scope and adjusted for depth. Tow start and end locations and depths were recorded using a Garmin 76 GPS and the boat's sounder (Faria Instruments DS1002 dual-temperature depth sounder). A duplicate tow was conducted immediately adjacent to the location of the first, in the opposite direction. Seawater and air temperature was recorded at the beginning of each tow using the sounder. Surveys were conducted in fall and winter to avoid damage to eelgrass growth. Bay scallops were counted and their shell height measured.

Quahog surveys were conducted using a commercial fishing vessel specifically outfitted for quahog dredging. A quahog "dry dredge" was towed from F/V *Miss Em*, a 31' (~10 m) vessel powered by a 210 hp inboard diesel engine (Figure 2), with tow times and speeds as consistent as possible given bottom type and navigable water. The dredge was a custom commercial design in active use in the

Cape Cod Bay fishery (Figure 3), measuring 77" (196 cm) long and 27" (69 cm) wide, with a 17" (43 cm) wide knife set at 6" (15 cm) depth. The tow line was set at ca. 2:1 scope and adjusted for depth. Tow start and end locations and depths were recorded using the boat's GPS and sounder. Underwater video was recorded to document performance of the dredge. Quahogs were counted and their shell height and length measured.



Figure 2. F/V *Miss Em*, used for quahog dredge surveys.

Intertidal Surveys

Intertidal sites identified by stakeholder interviews as of interest for quahogs or softshell clams were scouted in advance to find public ramps, beaches, and walkways that allowed access for surveys. We drove down any street with possible public access to the Bay and came up with all possible access points for surveying. From there, each of these sites was visually surveyed as far as walking distance would allow for signs of softshell clams or quahogs. Potential areas of clam presence as indicated by possible siphon holes were noted, as were general habitat characteristics. In order to plan surveys, actual tide height was checked against NOAA tide projections (Station 8447291, 41° 44.2' N 69° 58.9' W) and differences noted. When assigning priority to survey sites, preference was given to specifically selected areas of interest by the natural resource officers of Chatham, Harwich, and Orleans. Effort was also made to have each town equally represented in the surveys. Final site selection was based on logistical constraints (accessibility, site conditions).



Figure 3. Dredge used for quahog surveys. Note camera housing mounted on top of dredge frame.

To ensure consistency between our survey methods and previous efforts, we reviewed studies previously done on Cape Cod, with a focus on those conducted in the three towns (Chatham, Harwich, and Orleans) that surround Pleasant Bay, including Fiske et al. (1967) and several unpublished reports. We based our survey methods on protocols used by the town of Chatham, developed by Americorps volunteer Tom Bryson under the supervision of Renee Gagne (Chatham Shellfish Department). Intertidal surveys were performed using random sampling within areas previously identified during scouting expeditions. We surveyed each area for approximately a half hour before and after expected low tide. For each sample, we randomly placed a 0.25 m² quadrat approximately 2 m above the low-tide line (Figure 4). We used a standard softshell clam rake to collect all material within the quadrat to a depth of approximately 7" (18 cm), placing contents on a ¼" (6 mm) screen and sieved in a water-filled basin. Clams were counted and shell height and length were measured. At each area, we sampled at least three quadrats.



Figure 4. Intertidal shellfish sampling. Left to right: 0.25 m² quadrat, 6 mm screen and clam rake, basins.

Results

Stakeholder Interviews

Maps generated during stakeholder interviews were combined to create a single hand-drawn map of areas of interest for blue mussels, bay scallops, quahogs, and softshell clams (Figure 5). Areas for survey were chosen based on available resources, field conditions, and priority level as identified by resource managers. Not all areas identified could be surveyed due to the above constraints. Subtidal surveys were identified as a priority due to the associated logistical challenges.

Subtidal Surveys

Mussel surveys were conducted on July 27 and October 6/7, 2016, and on August 16, 2017. Boundaries of mussel beds mapped and locations of samples collected are shown in Figure 6. Some of the mussel beds sampled in July 2016 were gone when sites were revisited in October 2016. Mussel size composition and patchiness varied between and among beds (Figures 7-8). Mussel beds to the north (Figure 6) tended to be in relatively deep water and in the case of those in Chatham waters, were actively being commercially harvested.

Pleasant Bay
Resource
Management Plan
2013

**Soft Shell
Clam Beds**

ORLEANS
BREWSTER
HARVICH
CHATHAM
Pleasant Bay

0 0.25 0.5 1
Miles

0 0.5 1 2
Kilometers

0 0.25 0.5 1
Miles

0 0.5 1 2
Kilometers

0 0.25 0.5 1
Miles

0 0.5 1 2
Kilometers

0 0.25 0.5 1
Miles

0 0.5 1 2
Kilometers

Figure 5. Sample map generated during stakeholder interviews.

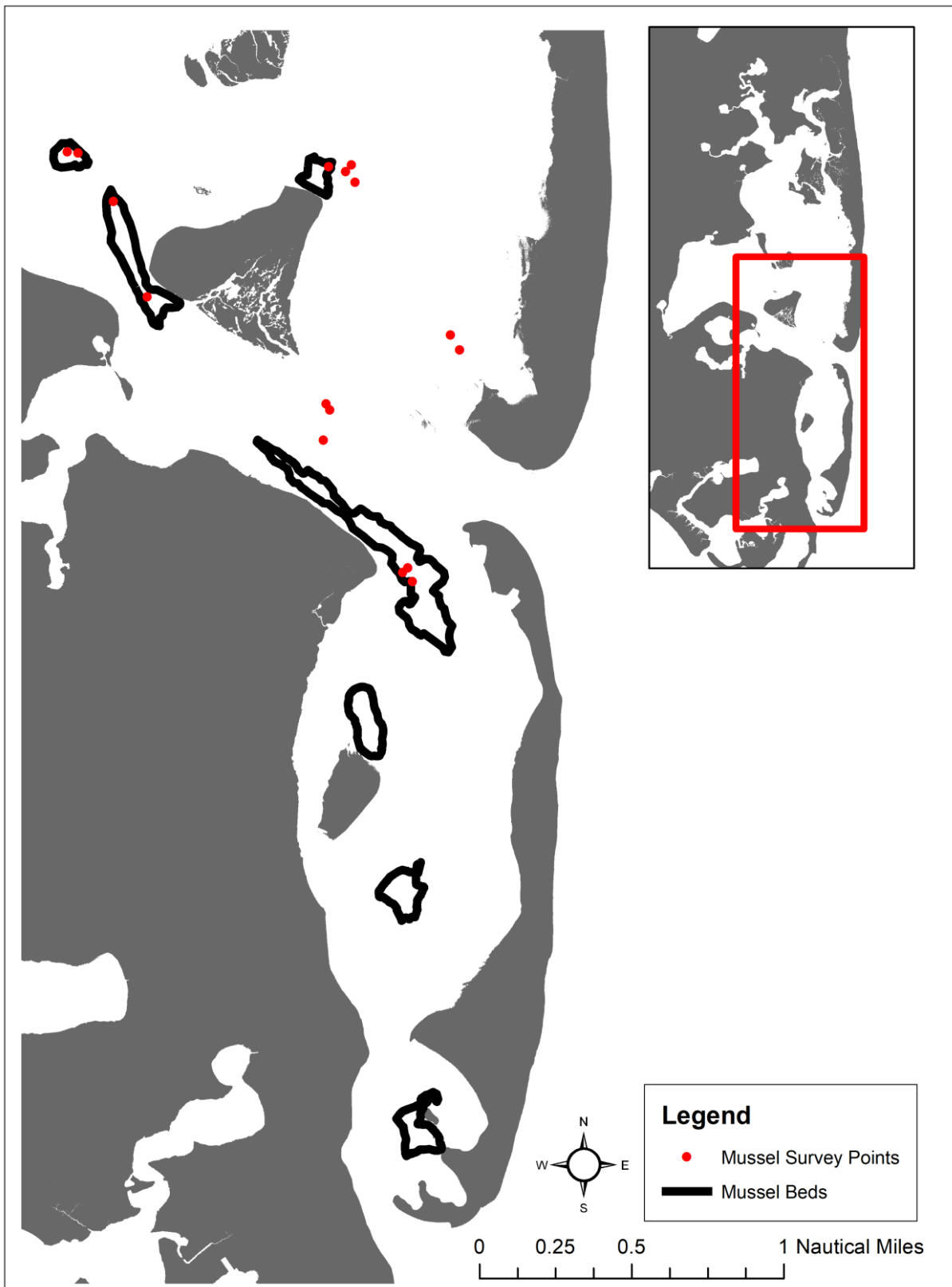


Figure 6. Mussel bed boundaries and sample locations.



Figure 7. Mussel samples from test tows. Left: Large (>2" length) mussels mixed with algae and shells. Right: Medium (~2" length) mussels, "clean tow" with minimal debris. Note underwater video camera attached to dredge frame at left.

Mussel beds to the south in Chatham waters (Figure 6) were in shallower water than those to the north, partially or fully exposed at low tide, and often overlapped with softshell clam beds at which commercial harvest was taking place. These beds tended to be patchier than those to the north, although dense aggregations of mussels were sometimes observed (Figure 8). At the southernmost bed near the inlet, mussels were often deeply imbedded in sand (Figure 9). There were other small patches of mussels visible on shore at low tide (e.g. east of Chatham Bars Inn) that were not sampled.

Bay scallop surveys were conducted on October 21, 2016, and December 14, 2017. Dredge tows were distributed throughout Pleasant Bay; only one bay scallop was captured (Figure 10).

The quahog dredge survey was conducted on December 22, 2017. Dredge tows were distributed throughout Pleasant Bay (Figure 11). Average tow duration was seven minutes. Quahogs were found at most survey stations (Figure 11) and consisted primarily of large, presumably older animals, colloquially referred to as "blunts" (mean shell height = 8 cm, mean shell length = 9 cm; Figure 12). Quahog relative abundance ranged from zero to 63 organisms/tow (mean = 10 organisms/tow).



Figure 8. Mussel bed exposed at low tide. Note patchy distribution, clam holes visible at right.

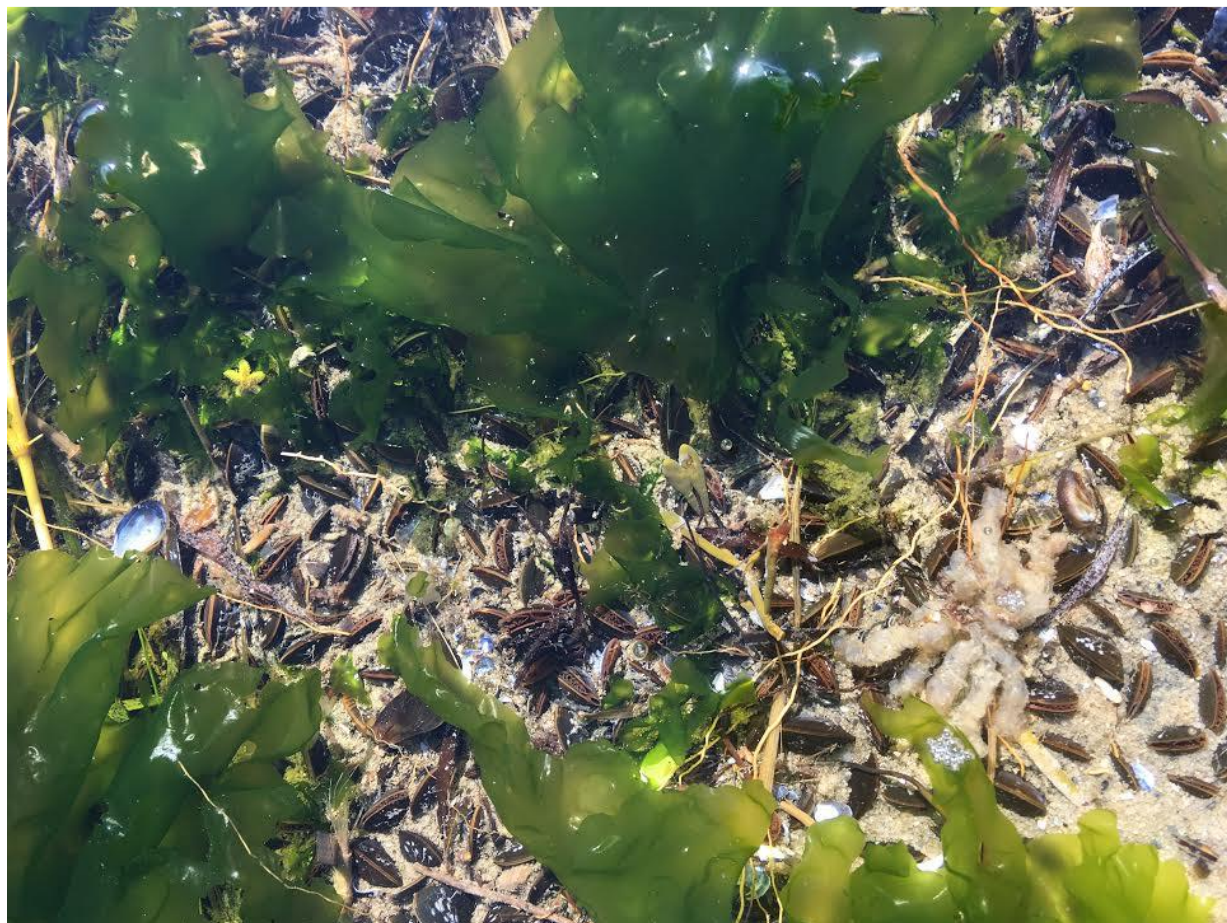


Figure 9. Mussel bed in shallow water near inlet, note mussels deeply imbedded in sand.

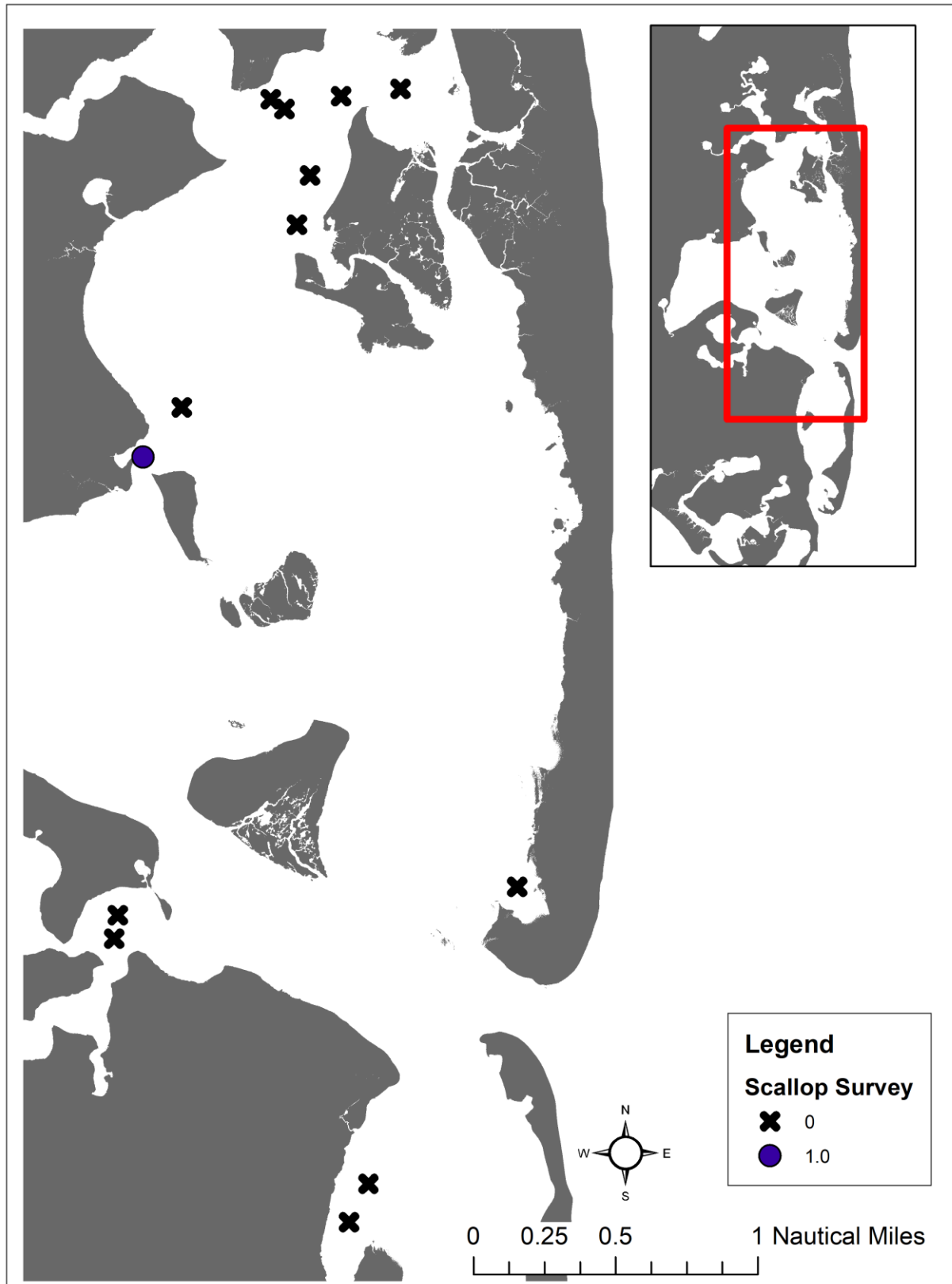


Figure 10. Locations of bay scallop survey dredge tows. Filled circles indicate scallop relative abundance (organisms/tow), tows without scallop catch denoted by an X.

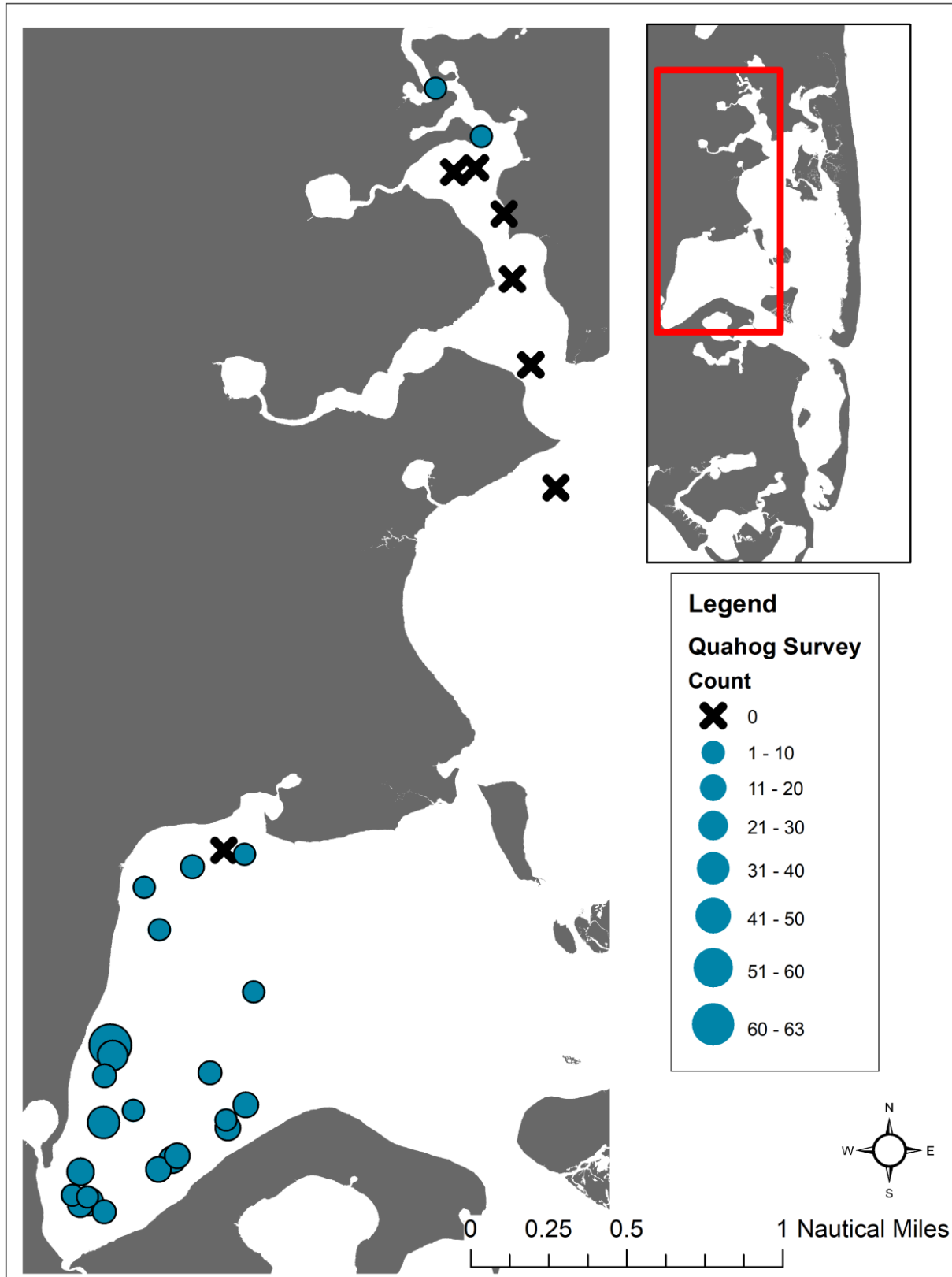


Figure 11. Locations of quahog survey dredge tows. Filled circles indicate quahog relative abundance (organisms/tow), tows without quahog catch denoted by an X.



Figure 12. Typical “blunt” quahogs captured during dredge surveys.

Intertidal Surveys

Intertidal surveys were conducted at six sites (Table 1, Figure 13). Softshell clams were more abundant than quahogs, and both were most abundant at sites 5 and 6 (Crow’s Pond, Chatham). Softshell clams and quahogs were all sublegal or “seed” size (Figure 14). Mean shell length of softshell clams was 3.1 cm (all sites pooled). While no clams were found during sampling at site 4 (Round Cove, Harwich) we noted approximately 10 oysters (*Crassostrea virginica*) and two bay scallops on the bottom while wading in shallow water (Figure 15).

Table 1. Softshell clam and quahog relative density at intertidal survey sites. Site numbers correspond to those indicated in Figure 13.

Site #	Survey Date	# Quadrats	Softshell Clams/m ²	Quahogs/m ²
1	11/2/2017	5	8	2
2	11/1/2017	3	16	0
3	12/15/2017	5	10	1
4	11/3/2017	4	0	0
5	11/16/2017	6	25	0
6	10/27/2017	3	39	4



Figure 13. Intertidal survey sites.



Figure 14. Softshell clams sampled during intertidal shellfish surveys.



Figure 15. Oyster and bay scallop sampled opportunistically during intertidal sampling at site 4.

Discussion

During this project, we developed replicable survey methods and established a baseline of shellfish abundance at select areas identified by natural resource management agencies. These surveys were logistically challenging in many cases, and not all areas of interest could be surveyed. The perimeter mapping approach worked well for documenting the spatial extent of mussel beds. Mussel beds changed in distribution during this investigation. Bay scallops were essentially absent from areas identified by natural resource managers and local fishermen. During the June 2015 – June 2016 fisheries resource inventory (Nichols et al., 2018), bay scallops were most abundant in November 2015 off Pochet (Orleans), although the same station was surveyed again later in the study and scallops were virtually absent. The same vicinity was surveyed during this study in 2016 and 2017 but no scallops were found. Most of the bay scallops sampled during the 2015-2016 study were small (mean shell height = 5.3 cm); this cohort may not have survived in sufficient abundance to be detected by our surveys. The quahog dredge survey captured primarily large, presumably old, “blunt” quahogs in relatively low abundance when compared to catches with the same dredge in Cape Cod Bay. These large “blunts” are generally not sought after by harvesters. We found little evidence of smaller quahogs during the dredge survey. Our relative abundance estimates (organisms/tow) could be converted into density estimates by calculating the area swept by the dredge during each tow using GPS track data. Intertidal surveys provided a quantitative index for small/seed shellfish abundance but were not likely a suitable index for abundance estimation of harvestable-size clams due to the random quadrat sampling and shallow depth of samples. Some areas of known abundance of clams were not surveyed (e.g. Clam Flat, Chatham). This survey design is replicable and ideal for assessing recruitment, although it is labor intensive and logistically challenging due to time and tide. Razor clams were not a priority species for targeted surveys due to the current lack of a fishery and logistical challenges associated with developing a survey method. Our opportunistic sample of a number of oysters in Round Cove was of interest; oysters were historically planted in the Cove and were at one time of sufficient abundance in the area to support harvest (Fiske et al., 1967). Oysters grown at an experimental aquaculture site in Lonnie’s Pond have recently been released in Pleasant Bay. It may be of interest to survey these sites for oysters in the future. This study established baseline estimates of relative abundance of select species in discrete areas, but it was not designed to determine the cause of the declines in bay scallop and quahog abundance. While the Fiske et al. (1967) inventory was comprehensive, it lacked spatially-explicit density estimates for shellfish species, limiting comparison with the present study. It is notable that the Bay is home to many shellfish predators; two of the four most abundant organisms captured in Bay-wide dredge sampling during the 2015-2016 inventory were specialist shellfish predators (sea stars and oyster drills; Nichols et al., 2018). Changes in circulation patterns may have affected larval dispersal and recruitment, and the above factors combined with harvesting pressure should be considered when developing hypotheses regarding species declines in the Bay.

Recommendations

The standardized, replicable methods employed during this study established baseline data on distribution and relative abundance of several species of commercially and recreationally important shellfish species. Surveys can be repeated and expanded in future years for long-term monitoring of changes in the Bay's shellfish community, particularly in important population statistics such as recruitment. Subtidal surveys could be further developed by refining and expanding dredge surveys to cover more area and generate density estimates based on area swept. Survey protocols should be developed to target razor clams. Intertidal surveys should be continued and expanded. Employing a team of volunteers would mitigate many of the logistical challenges encountered during this study.

Acknowledgements

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