Massachusetts Division of Marine Fisheries
B-120 Buzzards Bay Shellfish Injury and Lost Shellfishing
2019 Progress Report

Prepared for the B-120 Buzzards Bay Trustee Council
Submitted March 2020

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Executive Summary

In response to the 2003 Bouchard oil spill, which resulted in the release of 98,000 gallons of fuel oil into Buzzards Bay, Massachusetts, a settlement was secured between the B-120 Buzzards Bay Trustee Council and the responsible party to restore natural resources and manage natural use injuries across the impacted area. Among the issues addressed were injuries to shellfish resources and the recreational shellfishery in Buzzards Bay, for which the Massachusetts Division of Marine Fisheries (*DMF*) is addressing through three specified restoration strategies. These include 1) a project in which fecal coliform-contaminated quahog broodstock are transferred from donor areas in the Taunton River into designated sites within spill-affected Buzzards Bay communities, 2) out-planting of hatchery quahog seed reared in municipally maintained upwellers, and 3) out-planting of hatchery oyster seed reared in municipally maintained upwellers (Final Programmatic Restoration Plan and Environmental Assessment, 2014). The following report summarizes methods and results of these restoration activities and ongoing monitoring by *DMF* during 2019.

In October 2015, DMF initiated a quahog relay project to oversee the planned and scheduled relay of quahog broodstock secured from a fecal coliform-contaminated closure area (donor site) in the Taunton River and placement into designated sites within Buzzards Bay municipalities. Surveys of the relay sites were conducted prior to relay activities during each year. The rationale for this project is that broodstock taken from closed waters with high quahog densities will be relocated to municipally managed sites and strategically opened with a delayed harvest in order to enhance recreational fisheries and contribute to stock enhancement within and in the vicinity of the relay site(s). It is anticipated that this program will result in enhancement of local quahog populations that are then expected to contribute to managed, sustainable, recreational shellfisheries. Quahog relays were successfully conducted in 2015, 2016, 2018, and 2019 with eight Buzzards Bay municipalities (Bourne, Dartmouth, Fairhaven, Marion, Mattapoisett, New Bedford, Wareham, and Westport) receiving quahogs in 2019, as scheduled.

With the advent of commercial and municipal shellfish hatcheries and the development of cost-effective nursery techniques such as upwellers (i.e., moored, floating flow-through systems termed “FLUPSYs”), oyster and quahog reseeding programs have flourished throughout the Northeast. Many municipal and certain non-governmental organizations implement oyster and/or quahog management programs that include reseeding shellfish to enhance local stock populations. The B-120 Buzzards Bay recreational shellfishing injury funds are being utilized to purchase seed quahogs and oysters from commercial hatcheries for intermediate grow-out and out-planting to restoration sites. In Massachusetts, many municipalities do not have upweller capacity or staff to tend and manage the nursery grow-out of substantial numbers of oysters. As a result, municipal shellfish managers often purchase larger, field plant sized oysters ($\geq$ 20 mm) for direct seeding in municipal public shellfish beds.

In 2019, B-120 funds were utilized to purchase hatchery-reared, disease-free certified oysters from Muscongus Bay Aquaculture in Maine. The Wareham, Marion, and Bourne Shellfish Departments purchased one size class of oysters for intermediate grow out; small oysters ($\geq$ 2 mm) were placed in upwellers and overseen by DMF and town shellfish staff. Wareham used the upweller purchased with B-120 funds, and Marion and Bourne used their town-owned upwellers. All oysters were out planted to restoration sites during fall 2019.

During 2016 and 2017, *DMF* oversaw a program whereby the towns of Wareham, Dartmouth, and Fairhaven purchased upweller kits for growing out small quahog seed for restoration of recreational fishing areas, and then purchased 5-9 mm quahogs for grow-out and eventual out-planting. Due to a poor growth-year for quahog seed and time constraints for adequate grow-out, quahog seed was not purchased in 2018. However, B-120 funds set aside for this quahog order were utilized in 2019 to purchase additional quahog seed for nursery grow-out in Fairhaven using their B-120 and town owned upwellers. Fairhaven took responsibility for growing out all B-120 quahog seed in 2019. Dartmouth did not have the staff or town support to participate in the quahog seed project and as result did not utilize their B-120 upweller.

This report summarizes the rationale, methods, and results of these three projects.

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I. *Quahog Relays and Stock Enhancement*

Obtaining Quahog Broodstock

During June-November 2019, *DMF* oversaw the relay of bacterial-contaminated quahogs from closed waters in the Taunton River (donor site) to a total of eight municipal sites in Bourne, Dartmouth, Fairhaven, Marion, Mattapoisett, New Bedford, Wareham, and Westport (Refer to Appendix I for specific relay site locations).

Prior to conducting relays, *DMF* collected quahog samples from the Taunton River donor site for shellfish disease testing at Kennebec River Biosciences in Maine. A full suite of pathology screenings was performed by Kennebec River Biosciences, including examination for any external or internal morphological abnormalities and pests, predators, and parasites. No evidence of shellfish diseases was found in any of the samples. Pathology screening results for the tested donor site quahogs are presented in Appendix ll.

DMF established contracts with two qualified dredge boat captains to collect and transport broodstock quahogs from the donor site to each of the relay sites. *DMF* issued contaminated shellfish relay permits to the participating municipalities to relay quahogs under predetermined and specific conditions into the preselected areas within each of the localities' waters. In 2019, *DMF* estimated that each municipality would receive a minimum of 800 bushels of quahogs based on an estimated price of $22.00 per bushel for project relay. Gosnold decided not to receive a relay delivery for 2019 due to limited acreage of suitable quahog habitat and a minimal demand for recreational shellfishing resources.

Site Selection Methods

Subsequent to receiving the pathology report, *DMF* worked with the local shellfish departments to determine prospective relay (receiving) sites. Each municipality planted quahogs at one site (Refer to Appendix I). As an important factor driving restoration success, site selection was determined by the following six criteria:

- Suitable quality and quantity of benthic habitat available
- Appropriate public access and availability and proximity of the site for public recreational shellfishing
- A recreational shellfishing-only site designation with no commercial harvesting
- Degree to which the area was previously affected by the B-120 oiling that resulted in harvest closures
- Proper Designated Shellfish Growing Area classification
- Lack of a substantial resident quahog population in the area

Prior to planting, *DMF* biologists and local Shellfish Constables worked collaboratively to select potential sites and conduct surveys in order to document habitat conditions, level of resident shellfish abundance, and size classes of shellfish at each of the sites. All selected sites were designated as exclusively recreational shellfishing areas under the municipalities' authority at M.G.L. 130 sec 52.

Sampling methods for these surveys varied slightly based on the varying hydrographic conditions at each site. At each site, the proposed area was initially assessed for potential suitability of quahog habitat and any sections of the area that were unsuitable (shoreline boulder field, eelgrass beds, and/or soft muddy substrate) were noted and avoided. Transect locations were then selected within the suitable areas to obtain a representative sample of the habitat and substrate conditions, as well as the existing resident shellfish population. Transects were run perpendicular to shore to allow for the quantification of resident shellfish resources as well as habitat and substrate variability that is often affected by water depth. Transect locations were marked with rebar stakes and measured out to approximately 100 feet with transect tapes (transects were occasionally less than 100 feet in areas where depth increased rapidly and prevented wading out further). Most surveys were conducted by *DMF* and town shellfish department staff within the subtidal zone during low tide. One site (Westport) required sampling from a boat using a bull-rake; the most suitable planting area corresponded to a depth of 5-8 feet, which was too deep to be surveyed via shoreline wading.

In 2019, transects were approximately 100-150 feet in length and quadrats were again sampled at 10-foot intervals along the transect line. The total number of quadrats that were sampled per survey varied somewhat depending on the number of personnel helping with the survey, weather conditions, and bottom type of the site. However, a minimum of 30 quadrats per site remained consistent for all sites. Total number of quadrats sampled per site is noted in each site summary section below. These quadrats were 1-square foot in area and were raked using either a mesh-lined basket rake (12-inches across) or bull rake (18 inches across, boat surveys) to a depth of 8-12 inches. All quahogs were counted and measured, and all other shellfish, predators, vegetation type and percent cover, substrate type, and sampling depth were recorded. The threshold density for resident shellfish in potential planting sites was one quahog per 1-square foot, three soft-shell clams per 1-square foot, and three oysters per 1-square foot; locations with densities above the thresholds were deemed productive and were generally not considered for a relay site. GPS coordinates were taken at the start and end of each transect so that sampling locations could be mapped and to ensure planting occurred in the surveyed areas.

Site Selection Results

Summaries of each pre-planting site survey from 2019 are detailed below, and a summary table of B-120 quahog relay sites is presented in Table 1. The range of water depths at each site are reported as feet below mean lower low water (MLLW). Positive depth values indicate depths below MLLW and depth values indicate height above MLLW (within the intertidal zone).

An overview map of the nine B-120 relay sites is provided below (Figure 1), and individual maps of each town's quahog relay sites are provided in Appendix I.

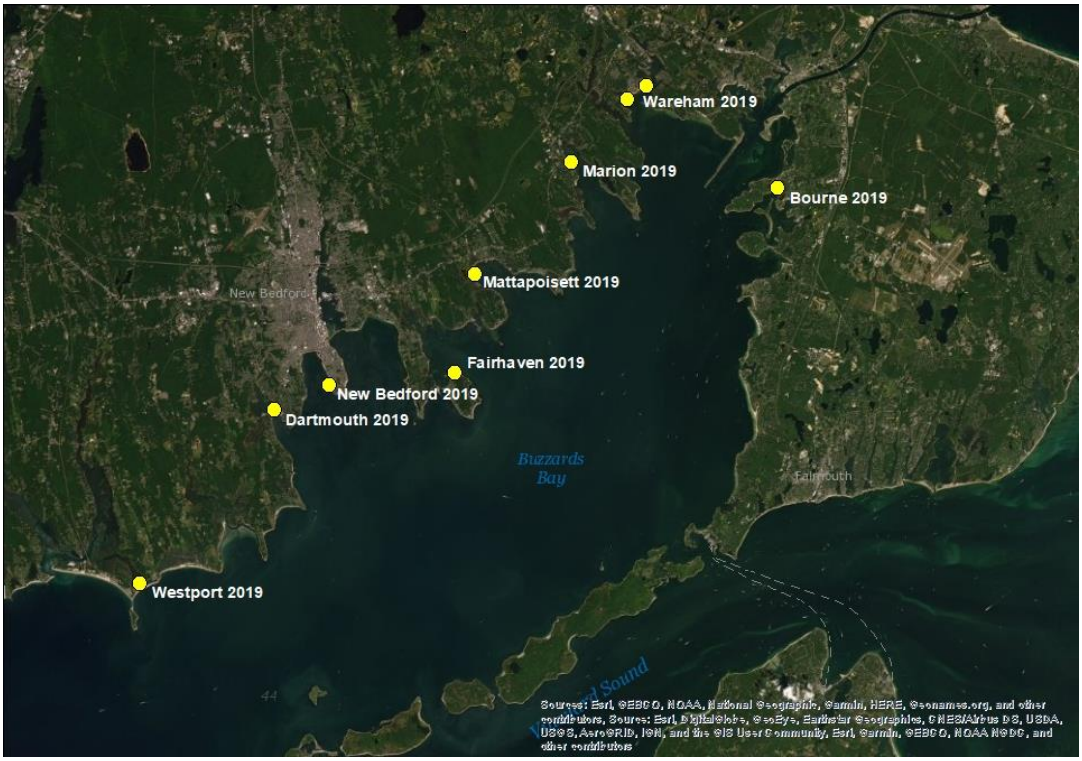

Figure 1. Map of the eight 2019 B-120 contaminated quahog relay sites around Buzzards Bay.

Municipality	Site Name	Year Planted	Area Planted (acres)	Depth Range at MLLW (ft.)
Bourne	Barlow's Landing	2019	10.8	0.3-3.8
Dartmouth	Gulf Bridge Road-North	2019	2.7	1.0-4.5
Fairhaven	North Cove	2019	19.7	0.5-2.5
Marion	Town Landing	2019	0.45	0.8-4.8
Mattapoisett	Mattapoisett Harbor	2019	40.5	0.2-4.2
New Bedford	Clarks Cove-Coral Street	2019	0.82	0.2-3.7
Wareham	Marks Cove; Swifts Neck Beach	2019	22.4 + 6.9	0.2-2.8
Westport	The Let - SW Quadrant	2019	13.9	1.3-1.3

Table 1. Summary of 2019 B-120 contaminated quahog relay sites. Positive depth values indicate depth below MLLW.

2019 Sites

***Bourne* – Barlow's Landing**

In consultation with *DMF* personnel, the Bourne Shellfish Constable, Tim Mullen, chose an area off Barlow's Landing Beach within Pocasset Harbor for the 2019 quahog relay due to the suitability of the substrate and public access for recreational shellfishing. All of Bourne municipal waters including Pocasset Harbor was closed to shellfishing on April 28, 2003 due to the oil spill and re-opened on May 22, 2003. The relay site is in DSGA BB: 49.3, which is classified as "CONDITIONALLY APPROVED" and meets NSSP standards for direct harvest of shellfish during the time period that the area is open. The nearby parking lot at Barlow's Landing provides public parking and beach access points.

On June 17, 2019, a pre-relay site survey was conducted by *DMF* staff and town shellfish officials. Survey results indicated a firm sand/mud substrate with some gravel, and an absence of any submerged aquatic vegetation (SAV). Water depth in Pocasset Harbor at Barlow's Landing ranged between 0.3 to 3.8 feet below MLLW. A total of four transects of 10 quadrats each were sampled within the site (40 quadrats). Twenty-two quahogs were observed for a density of 0.55 quahogs/ft.^{2} (Table 2). The area will be closed for one year and is expected to reopen to recreational shellfishing in the fall of 2020.

Mean (mm)	48.01
Min (mm)	8.62
Max (mm)	95.10
Total #	19
# Quadrats	40
Density/sq.ft.	0.48

Table 2. Summary table of the resident quahog population at the Bourne B-120 relay site. Size measurements denote shell length.

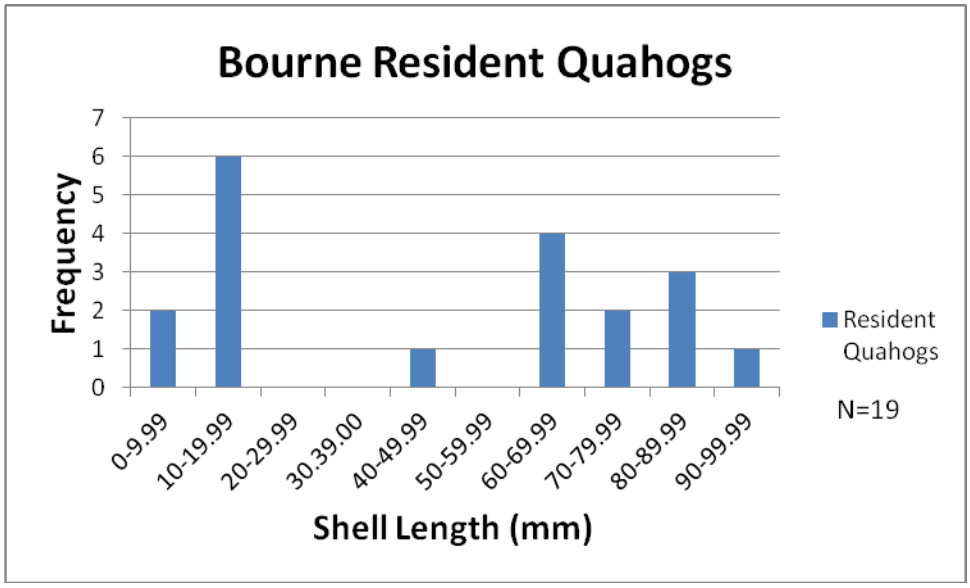

Figure 2. Resident quahog length frequencies at the Bourne B-120 relay site.

Dartmouth – Gulf Road Bridge (North)

In consultation with *DMF* personnel, the Dartmouth Shellfish Constable, Steve Mello, chose an area directly north of the Gulf Road Causeway in Apponagansett Bay for the 2019 quahog relays. All of Dartmouth municipal waters, including Apponagansett Bay, were closed to shellfishing on April 28, 2003 due to the oil spill and re-opened on October 13, 2003. The relay site is in DSGA BB: 12.3, which is classified as "CONDITIONALLY APPROVED" and meets NSSP standards for direct harvest of shellfish during the time period that the area is designated as open. This 2.7-acre area has favorable habitat for quahogs and does not currently support a recreational shellfishery due to the lack of a sufficient quahog resource. The access points for the relay area include a large parking lot at Apponagansett Point Recreation Area as well as limited street parking on Smith Neck Road.

On June 12, 2019, a pre-relay site survey was conducted by *DMF* staff. Survey results indicated a sand/mud substrate, with minimal SAV coverage. Water depth in the area ranges between 1.0-4.5 feet below MLLW. A total of four transects of 10 quadrats each were sampled within the site (40 quadrats total). 26 quahogs were found for a density of 0.65 quahogs/ft.^{2} (Table 3). Due to limited recreational shellfishing areas in Dartmouth, the site will be closed for one year, and reopened in the fall of 2020.

Mean (mm)	59.77
Min (mm)	12.28
Max (mm)	94.84
Total #	26
# Quadrats	40
Density/sq.ft.	0.65

Table 3. Summary table of the resident quahog population at the Dartmouth B-120 relay site. Size measurements denote shell length.

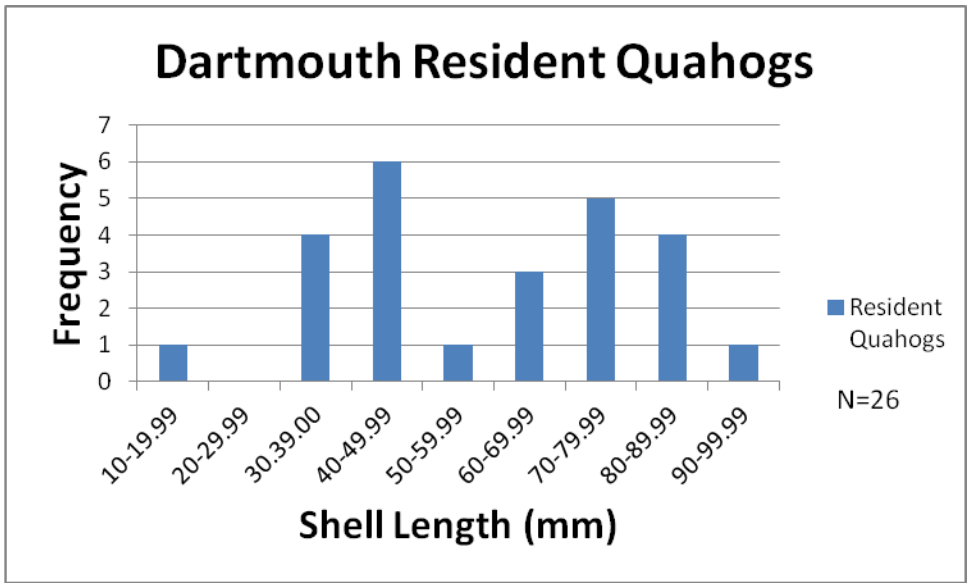

Figure 3. Resident quahog length frequencies at the Dartmouth B-120 relay site.

Fairhaven – North Cove

In consultation with *DMF* personnel, the Fairhaven Shellfish Constable, Tim Cox, selected a portion of Nasketucket Bay known as North Cove for the 2019 quahog relays. All of Fairhaven waters were closed to shellfishing on April 28, 2003 due to the oil spill and re-opened on October 13, 2003. The relay site is in DSGA BB: 21:21, which is classified as "APPROVED" and meets NSSP standards for the direct harvest of shellfish throughout the year. This location has parking availability along the road and multiple access points.

On June 29, 2019, a pre-relay site survey was conducted by *DMF* staff and the Shellfish Constable. Survey results indicated a sand/mud substrate, with minimal SAV coverage. Water depth at the North Cove site ranged between 0.5-2.5 feet below MLLW. A total of nine transects of 10 quadrats each were sampled within the site (90 quadrats total). Fifty-six quahogs were found for a density of 0.62

quahogs/ft.^{2} (Table 4). The site will be closed for one year and reopen to recreational shellfishing in the fall of 2020.

Mean (mm)	50.55
Min (mm)	16.85
Max (mm)	80.20
Total #	51
# Quadrats	90
Density/sq.ft.	0.57

Table 4. Summary table of the resident quahog population at the Fairhaven B-120 relay site. Size measurements denote shell length.

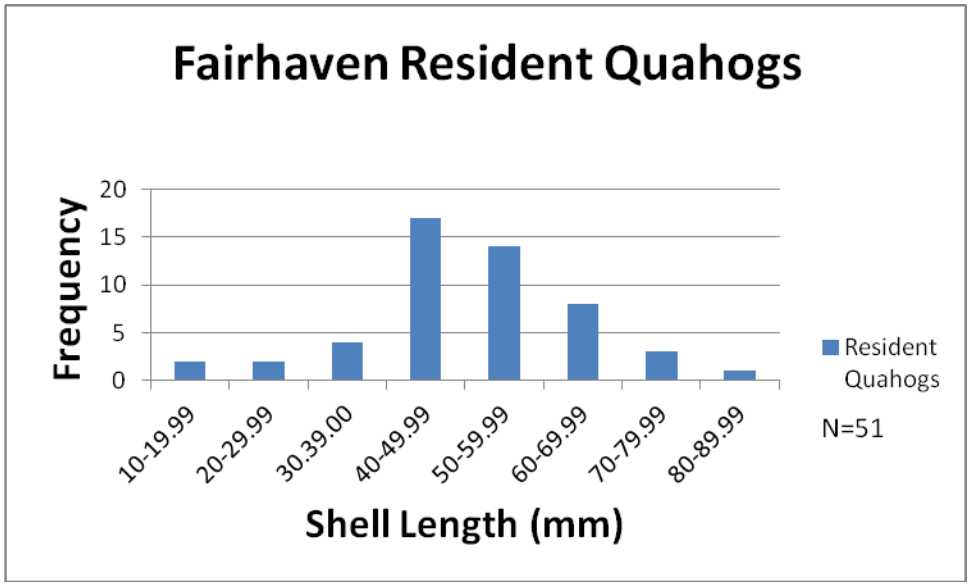

Figure 4. Resident quahog length frequencies at the Fairhaven B-120 relay site.

Marion-Marion Town Beach

In consultation with *DMF* personnel, Marion Shellfish Department staff (Isaac Perry, Harbormaster and Adam Murphy, Shellfish Constable) selected the Marion Town Landing located within Sippican Harbor for the quahog relay in 2019. This location was chosen as an alternative to Planting Island Cove Site due to significant beds of eel grass (*Zostera marina*) within the cove. All of Marion municipal waters, including Planting Island Cove, were closed to shellfishing on April 28, 2003 due to the oil spill and re-opened on November 12, 2003. The relay site is in DSGA BB: 32.13, which is classified as "CONDITIONALLY APPROVED" and meets NSSP standards for direct harvest of shellfish when the area is designated as open to shellfishing. This area has ample parking spots and an access point for recreational shellfishing.

On July 2, 2019, a pre-relay site survey was conducted by *DMF* staff. Survey results indicated a mud/sand substrate with some gravel and minimal SAV coverage. Water depths at the Town Landing site ranged between 0.8-4.8 feet below MLLW. A total of six transects with 5-12 quadrats each were sampled within the site (40 quadrats total). 19 quahogs were found for a density of 0.48 quahogs/ft.^{2}

(Table 5). The site will be closed to shellfishing for one year and reopened to recreational shellfishing in the fall of 2020.

Mean (mm)	54.04
Min (mm)	18.83
Max (mm)	91.35
Total #	19
# Quadrats	40
Density/sq.ft.	0.48

Table 5. Summary table of the resident quahog population at the Marion B-120 relay site. Size measurements denote shell length.

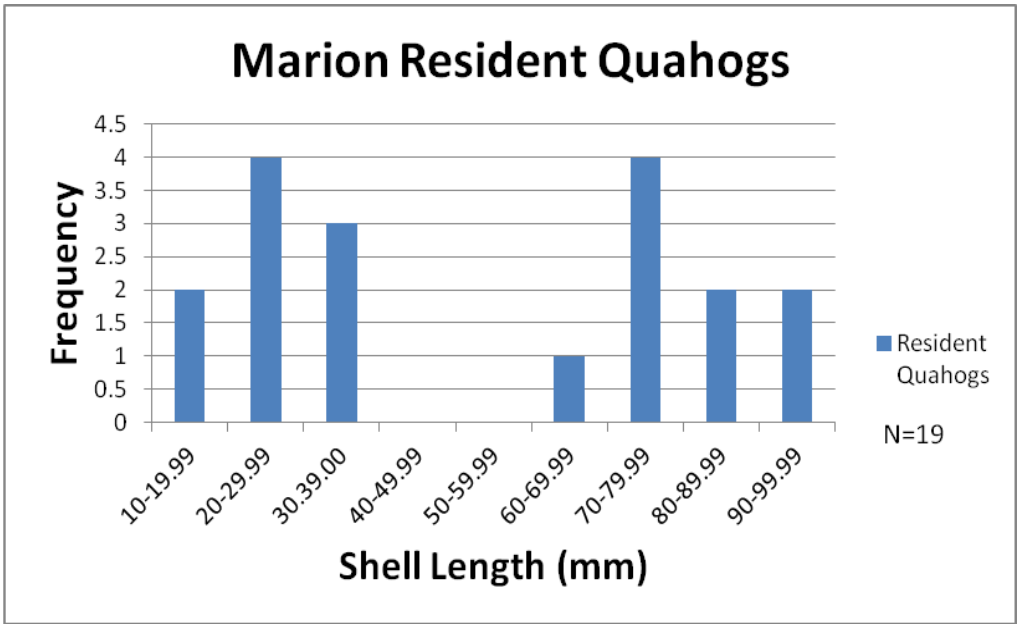

Figure 5. Resident quahog length frequencies at the Marion B-120 relay site.

Mattapoisett – Mattapoisett Harbor

In consultation with *DMF* personnel, the Mattapoisett Shellfish Constable, Kathy Massey, chose a portion of Mattapoisett Harbor for the location of the 2019 quahog relay. All of Mattapoisett waters were closed to shellfishing on April 28, 2003 due to the oil spill and re-opened on October 13, 2003. The 40.5-acre relay site located within DSGA BB: 25.2, which is classified as "APPROVED", meets NSSP standards for direct harvest throughout the year. There is parking located at the end of Reservation Road and access points within this area.

On June 11, 2019, a pre-relay site survey was conducted by *DMF* staff. Survey results indicated a sand/mud substrate with some gravel and minimal SAV coverage. The water depth within this portion of Mattapoisett Harbor ranged between -0.2 and +4.2 feet below MLLW. A total of eight transects with 10 quadrats each were sampled within the site (80 quadrats total). Forty-four quahogs were found for a density of 0.55 quahogs/ft.^{2} (Table 6). The site will be closed for one year and will reopen in the fall of 2020.

Mean (mm)	40.94
Min (mm)	7.92
Max (mm)	94.95
Total #	44
# Quadrats	80
Density/sq.ft.	0.55

Table 6. Summary table of the resident quahog population at the Mattapoisett B-120 relay site. Size measurements denote shell length.

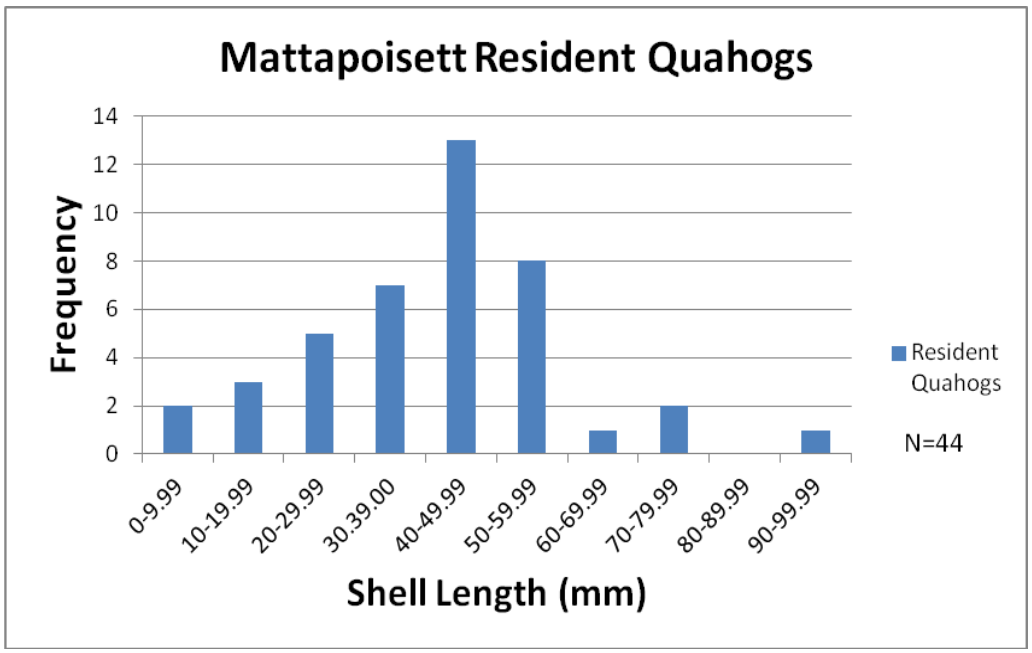

Figure 6. Resident quahog length frequencies at the Mattapoisett B-120 relay site.

New Bedford – Clark's Cove-Coral Street

In consultation with *DMF* personnel, the New Bedford Shellfish Constable, Tom Ringuette, chose a 0.8-acre area adjacent to the Coral Street boat ramp within a portion of Clark's Cove, as the 2019 B-120 relay site. Initially, the proposed site extended further south, but pre-planting survey results revealed unsuitable planting habitat with the presence of eel grass beds. Given the limited availability of shoreline for recreational shellfishing in New Bedford, the Constable decided to plant the entire 800 bushels in this 0.8-acre site. All New Bedford municipal waters, including New Bedford harbor, were closed to shellfishing on April 28, 2003 due to the oil spill and re-opened on October 13, 2003. The relay site is in DSGA BB: 13.37, which is classified as "CONDITIONALLY APPROVED" and meets NSSP standards when the area is designated as open to shellfishing.

On June 6, 2019, pre-relay site survey was conducted by *DMF* staff. Survey results indicated a bottom substrate consisting of a sand/shell mixture with some rocks closer to shore, overall conditions that are suitable quahog habitat. Water depth at the site ranged from 0.2-3.7 feet below MLLW. A total of five transects with six to eight quadrats each (30 quadrats total) were sampled within the site. Eleven quahogs were found for a density of 0.37 quahogs/ft.^{2} (Table 7). The site will likely be closed to shellfishing for one year and will reopen in the fall of 2020.

Mean (mm)	66.81
Min (mm)	25.75
Max (mm)	104.13
Total #	11
# Quadrats	30
Density/sq.ft.	0.37

Table 7. Summary table of the resident quahog population at the New Bedford B-120 relay site. Size measurements denote shell length.

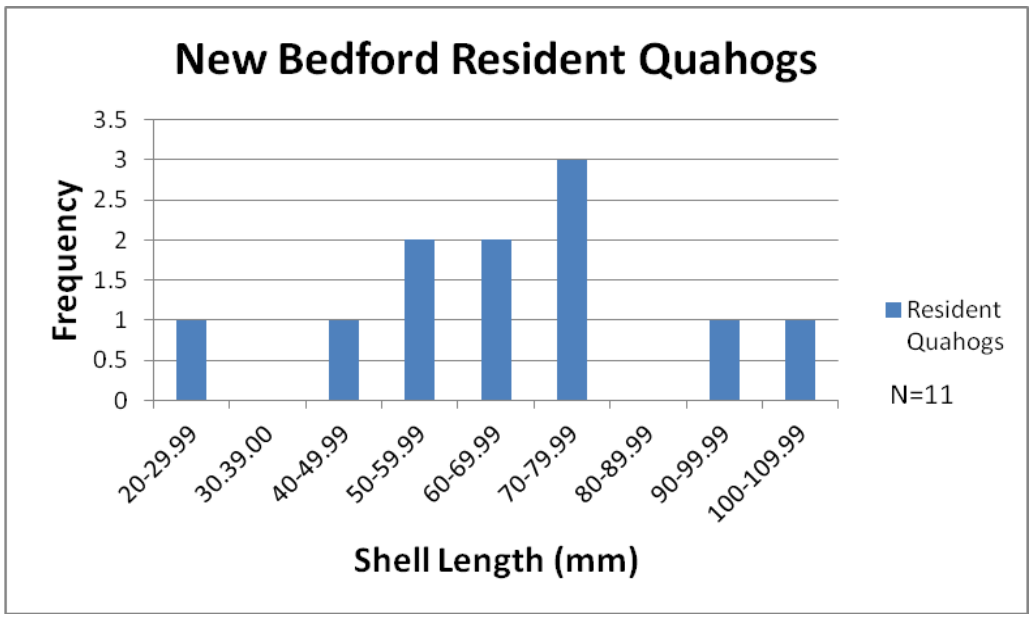

Figure 7. Resident quahog length frequencies at the New Bedford B-120 relay site.

Wareham – Mark's Cove; Swifts Neck Beach

In consultation with *DMF* personnel, the Wareham Shellfish Constable, Garry Buckminster, selected two locations for the 2019 quahog relay, portions of the Wareham River known as Swift's Beach (BB:36.2) and Mark's Cove (BB:36.21). Both locations have parking and an access point to recreational fishing. All of Wareham municipal waters, including Swift's Neck Beach and Mark's Cove, were closed to shellfishing on April 28, 2003 due to the oil spill and re-opened on May 22, 2003. These relay sites are in DSGA BB: 36.2 and BB: 36.21 and are classified as "CONDITIONALLY APPROVED", meeting NSSP standards for direct harvest of shellfish when designated as open to shellfishing.

On May 28, 2019, a pre-relay site survey was conducted by *DMF* staff and Wareham shellfish officials. Mark's Cove survey results indicated a sand/mud substrate with some silt and minimal SAV coverage. The water depth within this portion of the Wareham River ranged between -0.2-2.8 feet below MLLW. A total of six transects with 12 quadrats each were sampled within the site (72 quadrats total). Twenty quahogs were found for a density of 0.28 quahogs/ft.^{2} (Table 8). Swift's Neck Beach survey results indicated a firm sand/mud substrate with minimal SAV coverage. The water depth within this portion of the Wareham River ranged between -0.1 and +2.4 feet below MLLW. A total of three transects with

10 quadrats each were sampled within the site (30 quadrats total). 10 quahogs were found for a density of 0.33 quahogs/ft.^{2} (Table 9). Both sites will be closed for two years and will reopen in the fall of 2021.

Mean (mm)	17.82
Min (mm)	6.45
Max (mm)	80.29
Total #	20
# Quadrats	72
Density/sq. ft.	0.28

Table 8. Summary table of the resident quahog population at Wareham's Mark's Cove B-120 relay site. Size measurements denote shell length.

Mean (mm)	18.94
Min (mm)	6.97
Max (mm)	43.76
Total #	10
# Quadrats	30
Density/sq. ft.	0.33

Table 9. Summary table of the resident quahog population at the Wareham's Swift's Beach B-120 relay site. Size measurements denote shell length.

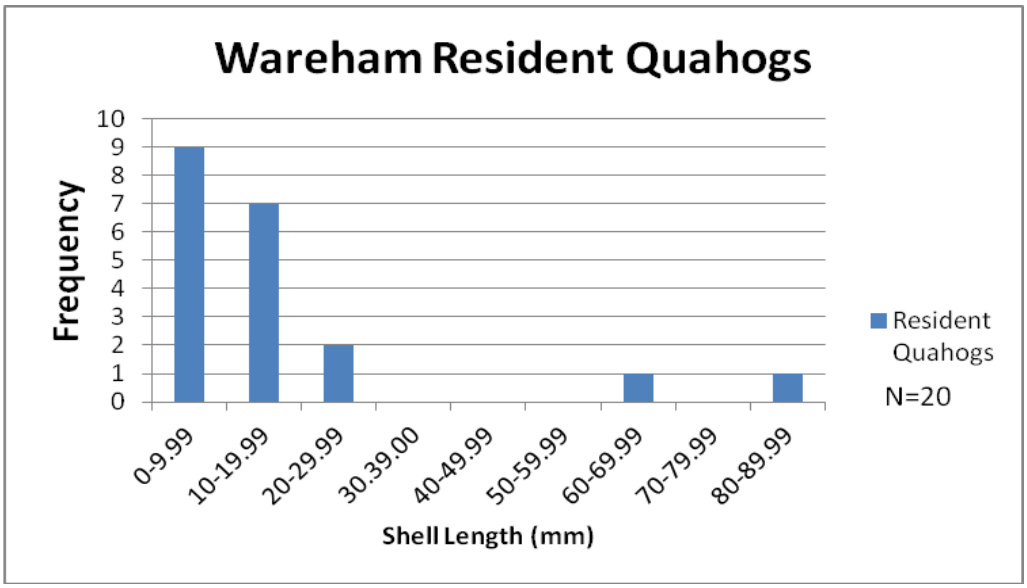

Figure 8. Resident quahog length frequencies at the Wareham's Mark's Cove B-120 relay site.

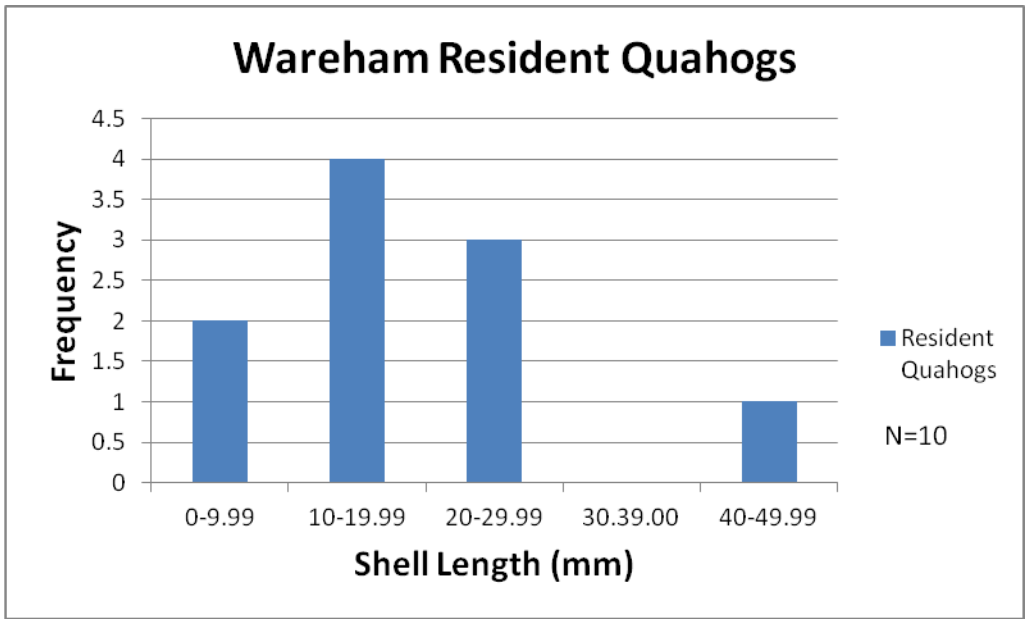

Figure 9. Resident quahog length frequencies at the Wareham's Swift's Beach B-120 relay site.

Westport – Westport River-The Let, Southwest Quadrant (#4)

In consultation with *DMF* personnel, the Westport Shellfish Constable, Chris Leonard, chose a site in the northwestern portion of the Let in the East Branch of the Westport River (North of "East Beach Road") for a quahog relay in 2019. The constable states that the nearshore area is favorable habitat for quahogs. All of Westport municipal waters, including The Let, were closed to shellfishing on April 28, 2003 due to the oil spill and re-opened on May 22, 2003. The relay site is in DSGA BB: 4.31, which is classified as "APPROVED", and meets NSSP standards for direct harvest of shellfish year-round. Emma Tripp Landing, located at the southern end of The Let, provides adequate parking. Additional parking and access to this area are provided along Beach Road. This area is often accessed by shallow-draft boats.

On June 13, 2019, a pre-relay site survey was conducted by *DMF* staff and the Westport Shellfish Constable. The survey was conducted from a boat with the use of a bull rake for the deeper water. The proposed relay area consisted primarily of mud and sand sediment which is favorable habitat for quahogs. Water depth of The Let site was 1.3 feet below MLLW. A total of 80 randomly distributed quadrats were sampled, and 14 quahogs were found. Mean quahog density was 0.18 quahogs/ ft.^{2} (Table 10). The site will be closed to recreational shellfishing for two years and will reopen in the fall of 2021.

Mean (mm)	75.14
Min (mm)	60.40
Max (mm)	97.50
Total #	14
# Quadrats	80
Density/sq.ft.	0.18

Table 10. Summary table of the resident quahog population at the Westport B-120 relay site. Size measurements denote shell length.

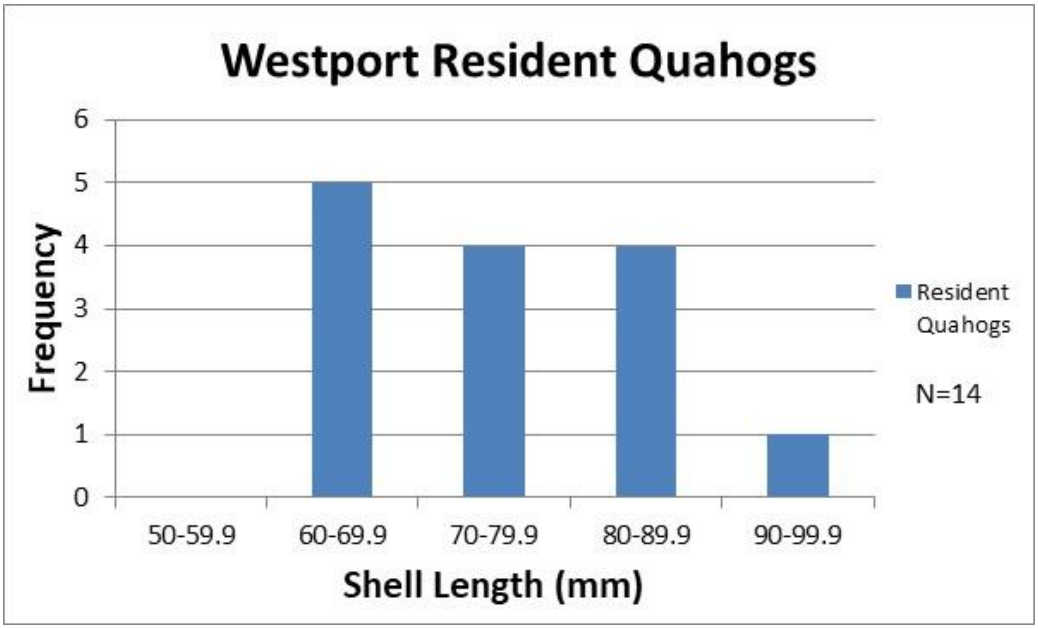

Figure 10. Resident quahog length frequencies at the Westport B-120 relay site.

2019 Quahog Relay Methods

DMF biologists sampled quahogs from the Taunton River donor site as they were loaded into boats for planting at the B-120 sites. Random quahog subsamples of a known volume (1-peck basket) were collected from the 800+ bushels of relayed quahogs prior to planting in each municipality, and all sub-sample individuals were counted and measured for shell length (mm). Sample size during each sampling event ranged between 3 and 12 pecks on a given day and varied depending on availability of personnel. These measurements were used to estimate the total number and size frequency of relayed quahogs within each B-120 site. Following sampling, quahogs were planted by boat/barge across the designated area. In 2019, all quahog relay activities were conducted between June and November.

Figure 11. Photographs depicting the B-120 contaminated quahog planting off a barge in Fairhaven (top), and the delivery of contaminated quahogs prior to planting in New Bedford (bottom).

Site Marking and Closure Period

Prior to commencement of the relays, *DMF* prepared and distributed closure notices for each B-120 contaminated quahog relay site to local and state law enforcement agencies, U.S. Food and Drug Administration (FDA), MA Department of Public Health (DPH), and the MA Department of Environmental Protection (DEP). The notices specify geographic boundaries for each relay area and prohibit shellfishing or attempting to shellfish in the area during the specified closure period. The eight sites in 2019 were marked with posted signs on the shoreline and/or buoys for outer boundary markings prior to and during the closure period (see Figure 12), and regular enforcement patrols are routinely carried out by municipal shellfish department personnel.

In order to maximize quahog spawning and recruitment within and around the B-120 relay sites, *DMF* works with the municipalities to keep B-120 quahog relay sites closed for as long as possible. The amount of available suitable quahog habitat within Approved or Conditionally Approved shellfish growing areas varies by town. As a result, municipalities with limited area available for recreational shellfishing generally close the B-120 relay sites for one year, while others close their sites for two or three years. In 2019, the municipalities of Wareham and Westport closed their relay sites for two years (reopening in the fall of 2021), while Bourne, Dartmouth, Fairhaven, New Bedford and a portion of the Mattapoisett site will reopen in the fall of 2020, one year after the relays and transplanting of quahogs. Due to the size of the planted area of the B-120 relay site in Mattapoisett, a portion of the 40.5-acre site will be closed for a period of two years.

Prior to allowing any harvest from the B-120 quahog relay sites within the municipalities, *DMF* collects shellfish and water samples for bacteriological analysis to determine if health standards are met for direct harvest and human consumption. For sites where results are within acceptable values, DMF will lift the contaminated area closure status and municipal shellfish departments will generate management opening notices that allow recreational shellfishing in those areas. All 2019

contaminated quahog relay sites are currently closed, and the earliest that some of them will re-open will be the fall of 2020 (a one-year closure).

Figure 12. Posted signage for the B-120 contaminated quahog relay sites.

2019 Quahog Relay Results

Except for Marion, all participating Buzzards Bay municipalities relayed a minimum of 800 bushels of quahogs to their respective B-120 restoration sites. Due to a disagreement with the two dredge boat captains, Marion's Shellfish Constable and Harbor Master terminated further B-120 deliveries after receiving 61 bushels of B-120 quahogs on November 5,019. The 145-bushel delivery refused by Marion on November 5th, was redirected to New Bedford and planted using mitigation funds from a separate mitigation project. A total of 5,661 bushels and an estimated 1,956,543 quahogs were relayed from the Taunton River to the eight Buzzards Bay municipalities over the course of the 2019 season.

A summary of estimated number, size range, and planting density of quahogs at each 2019 B-120 site is presented in Table 11, as well as the total number of bushels and quahogs relayed across all sites in 2019. Length frequencies of relayed quahogs within each B-120 site are provided in Figures 13 through 20.

Municipality	Site Name	# Bushels Relayed	Estimated # of Quahogs	Size Range (mm)	Mean Size (mm)	Area Planted (acres)	Area Planted ($ft.^2$)	Planting Density ($\#/ft.^2$)	Closure Area (acres)
Bourne	Barlows Landing	800	278,808	64 - 112	87.0	10.8	470448	0.59	51.4
Dartmouth	Gulf Bridge Road-North	800	282,480	51 - 110	88.1	2.7	117612	2.40	3.8
Fairhaven	North Cove	800	282,880	57 - 114	88.2	19.7	858132	0.33	31.9
Marion	Town Landing	61	20,215	68 - 101	82.8	0.45	19602	1.03	1.2
Mattapoisett	Mattapoisett Harbor	800	277,280	66 - 110	86.8	40.5	1764180	0.16	145.9
New Bedford	Clarks Cove-Coral Street	800	272,400	48 - 108	84.9	0.82	35719.2	7.63	1.8
Wareham	arks Cove; Swifts Neck Bea	800	266,800	42 - 112	85.1	22.4 + 6.9	1276308	0.21	16.6 + 40.0
Westport	The Let - SW Quadrant	800	275,680	63 - 109	86.1	13.9	605484	0.46	21.2
	Total	5661	1,956,543	**MEAN**	86.1	12.70	643435.7	1.60	

Table 11. Summary table of the 2019 B-120 contaminated quahog relay results. Size measurements denote shell length.

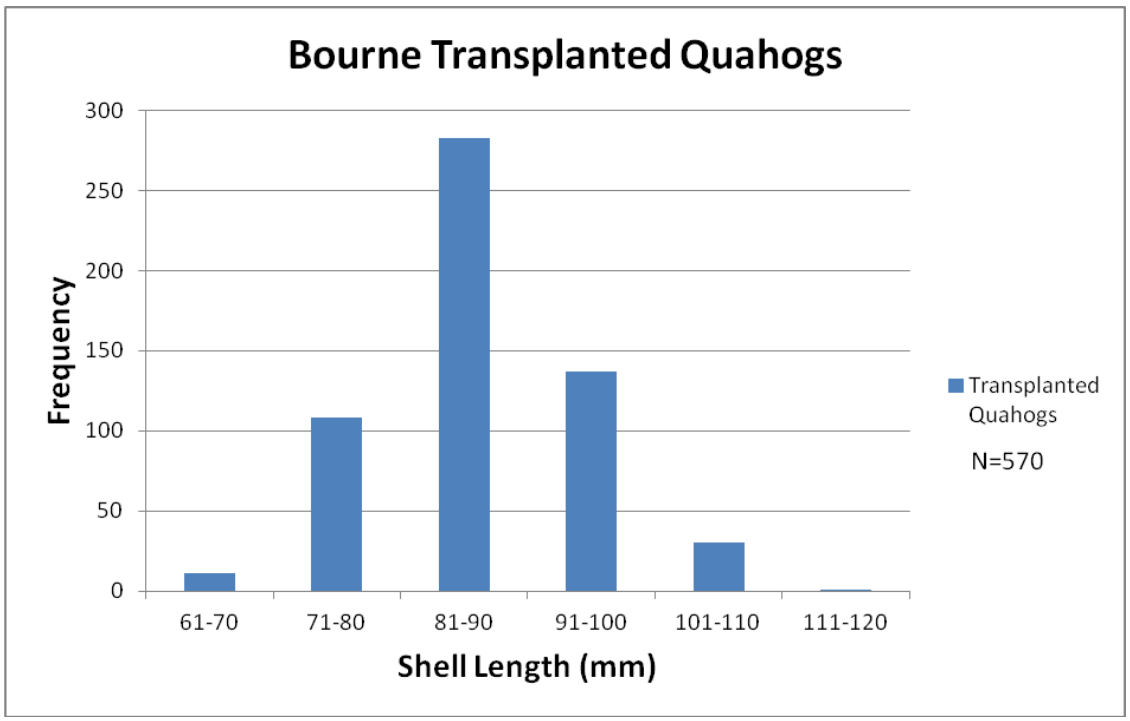

Figure 13. Quahog length frequencies at Bourne B-120 relay site.

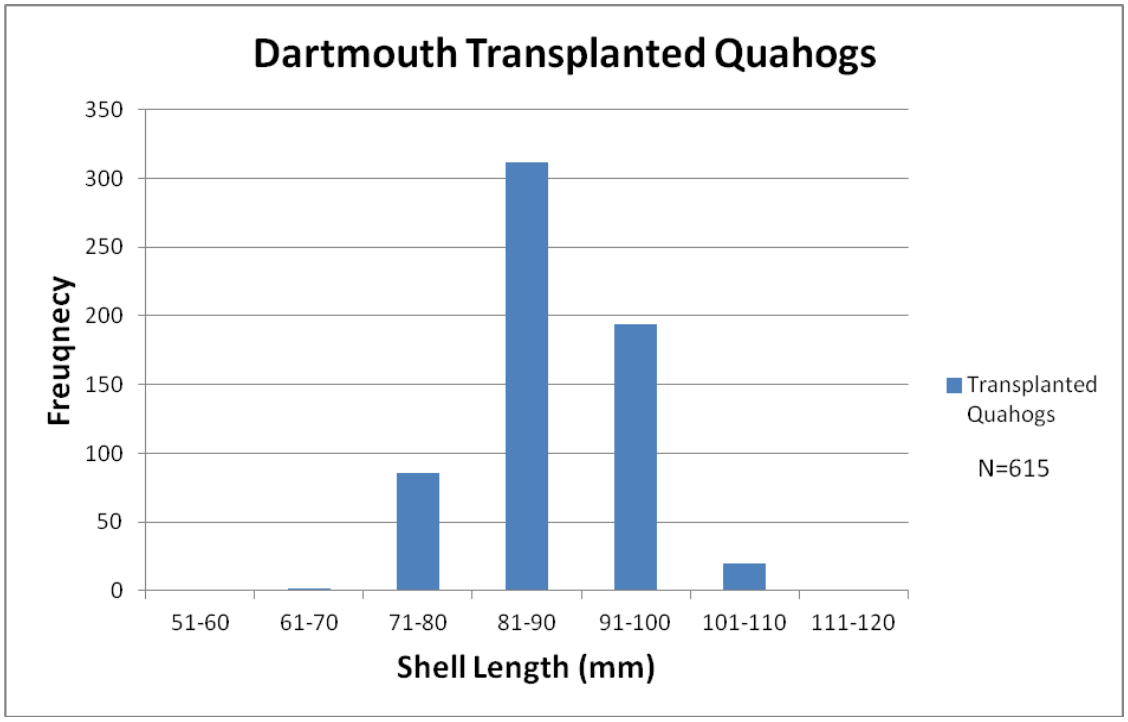

Figure 14. Quahog length frequencies at Dartmouth B-120 relay site.

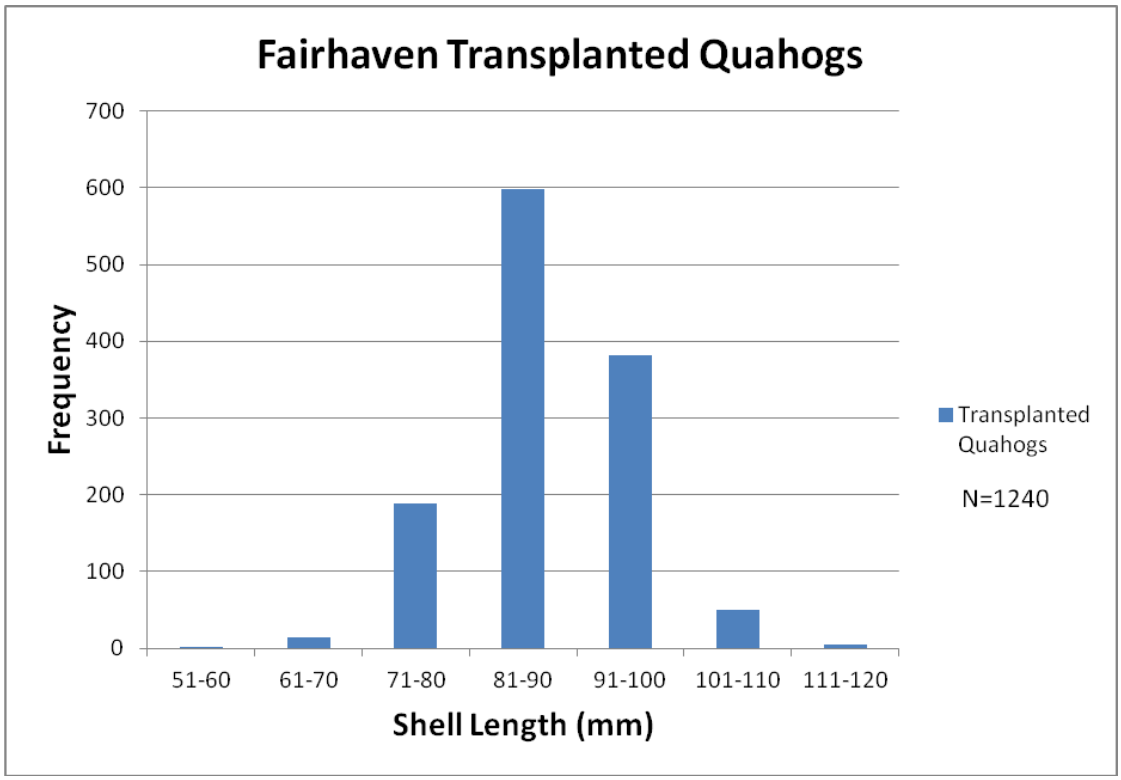

Figure 15. Quahog length frequencies at Fairhaven B-120 relay site.

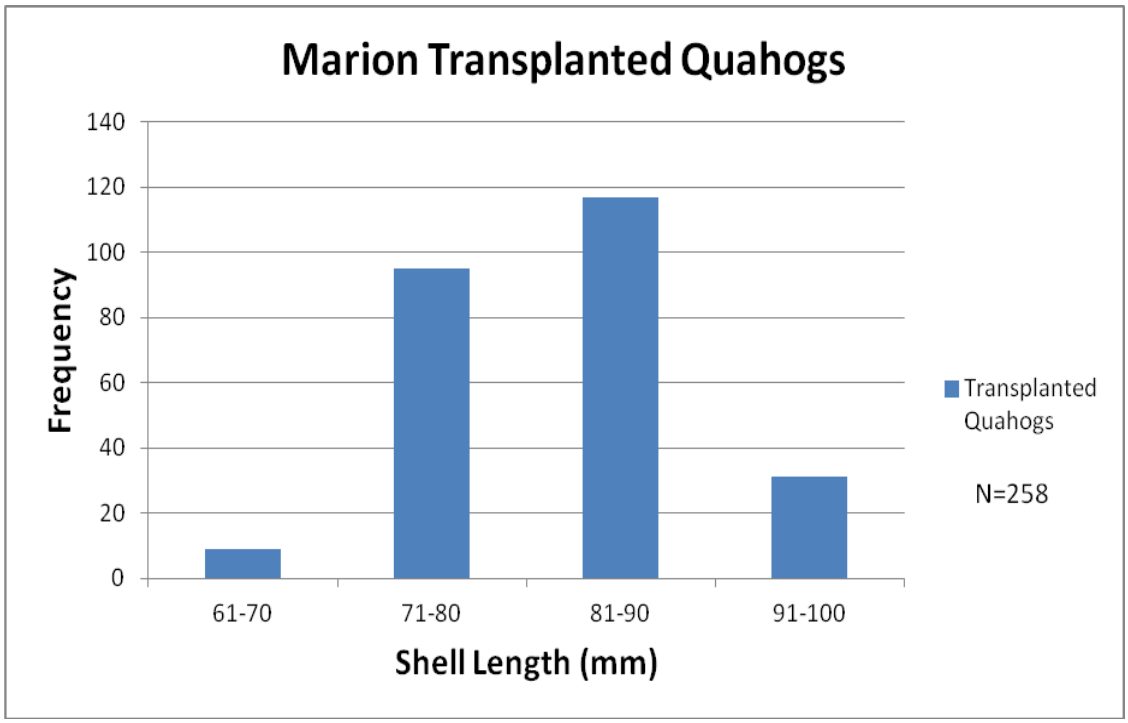

Figure 16. Quahog length frequencies at Marion B-120 relay site.

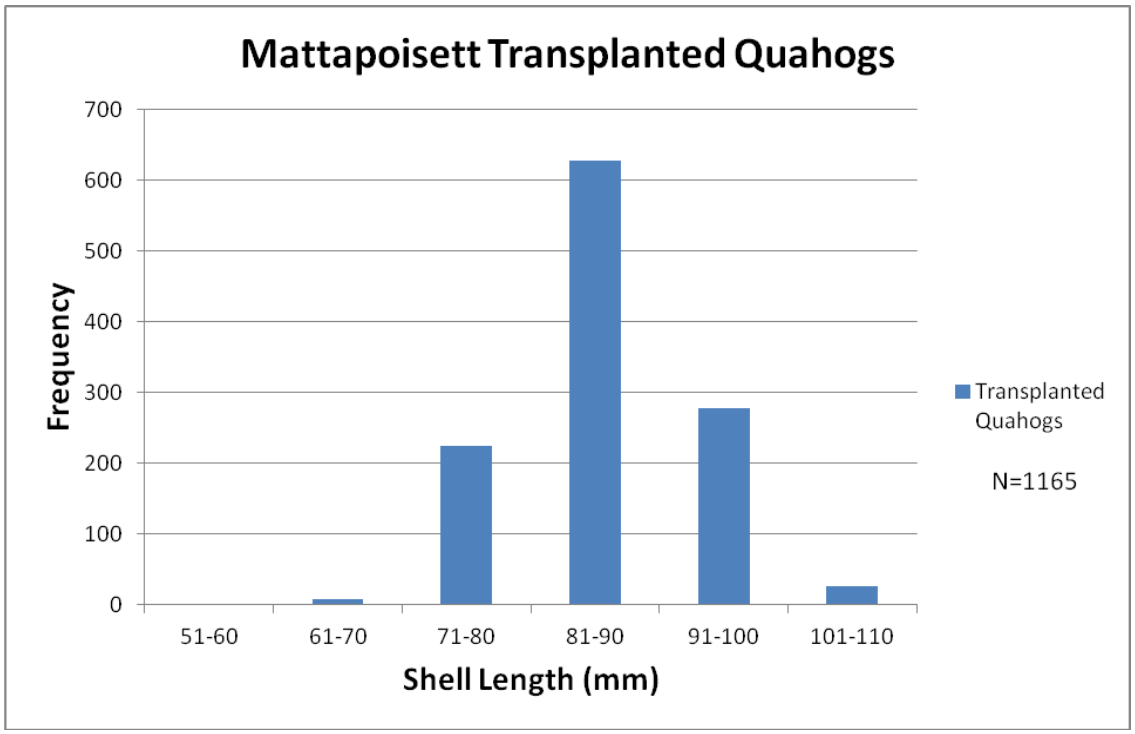

Figure 17. Quahog length frequencies at Mattapoisett B-120 relay site.

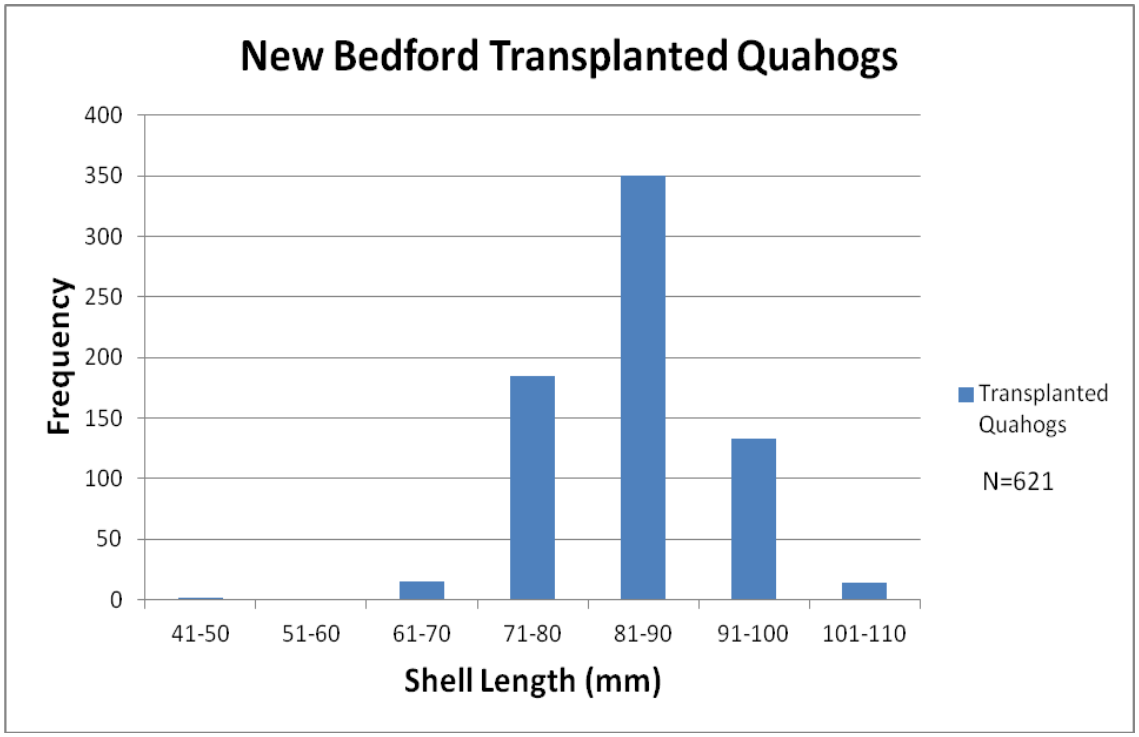

Figure 18. Quahog length frequencies at New Bedford B-120 relay site.

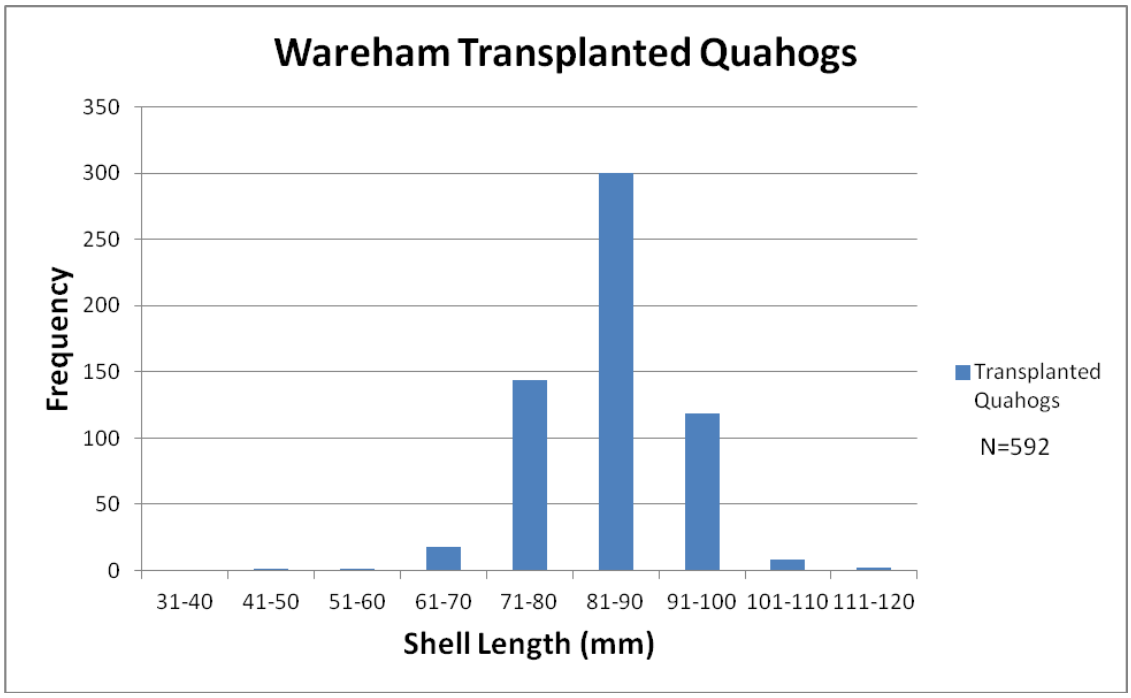

Figure 19. Quahog length frequencies at Wareham B-120 relay sites.

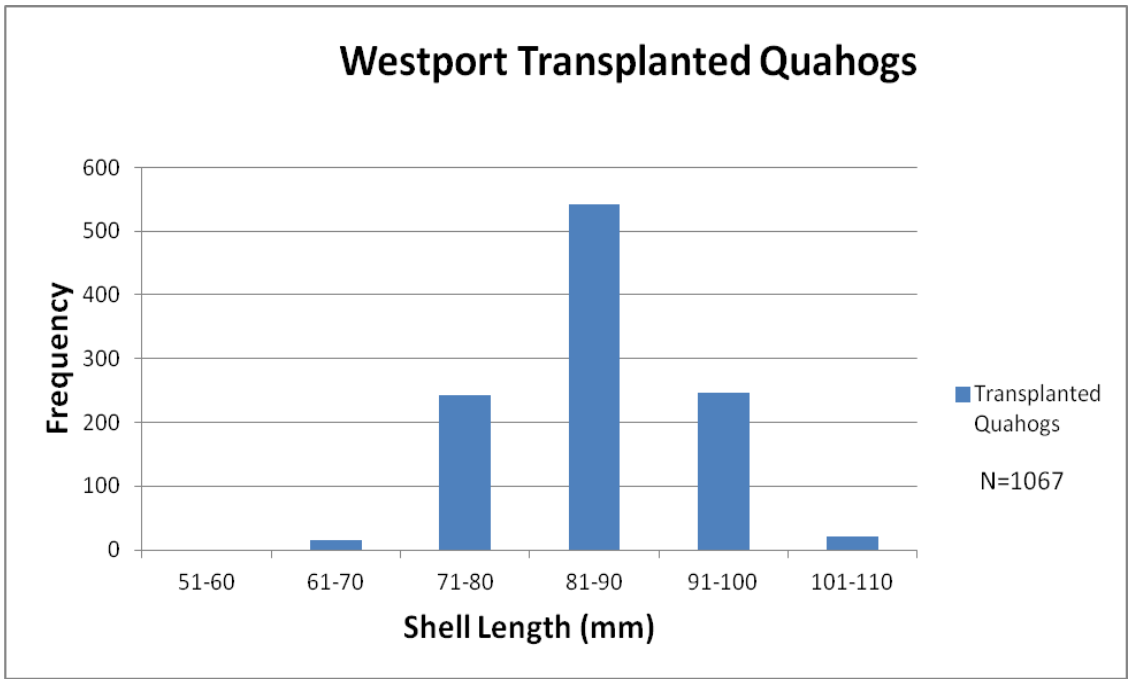

Figure 20. Quahog length frequencies at Westport B-120 relay site.

Condition Index Methods and Results

In 2019, *DMF* collected samples of relayed quahogs from the B-120 study sites in Fairhaven, Mattapoisett, and Westport for the determination of Condition Index (CI). These samples were taken at

the time of harvest from the Taunton River and will be compared against samples that will be taken one-year post-planting in the summer of 2020. Although CI is not a direct indication of the reproductive potential of quahogs, it is a good indicator of their general condition, gonadal development, and health (Marroquin-Mora and Rice 2008). It is believed that CI in the range of computed values of upper 60s to 70s indicates generally good condition, with documented values for quahogs ranging from below 60 to over 100 (Marroquin-Mora and Rice 2008). Condition index categories in the table below are general grouping based on this documented range, and it is widely accepted that CI values are most useful as a comparative tool across and within seasons and between individuals and populations rather than an independent metric of reproductive health. Twenty quahogs were collected from each site for lab processing and determination of CI. At the *DMF* New Bedford Lab, staff used the procedures and formula of Crosby and Gale (1990) to determine the CI of the collected quahogs:

CI = [dry soft tissue wt. (g) X 1,000/total weight g) – shell weight (g)

All weights were estimated to the nearest 0.01 g. The CI results from 2019 are presented in Table 12. Due to the loss of broken shell while processing, only 17 of the 20 quahog samples for Fairhaven could be processed.

Municipality	Relay Dates	CI Processing Period	Sample Size	CI Range	Mean CI	Standard Deviation
Fairhaven	6/27/19 - 7/9/19	7/1 - 7/3	17	37.0 - 85.3	66.28	10.68
Mattapoisett	7/10/19 - 7/30/19	7/15 - 7/17	20	59.2 - 85.4	72.70	7.39
Westport	6/14/19 - 6/26/19	6/19 - 6/21	20	41.9 - 76.3	64.50	10.20

Table 12. 2019 B-120 condition index summary of relayed quahogs.

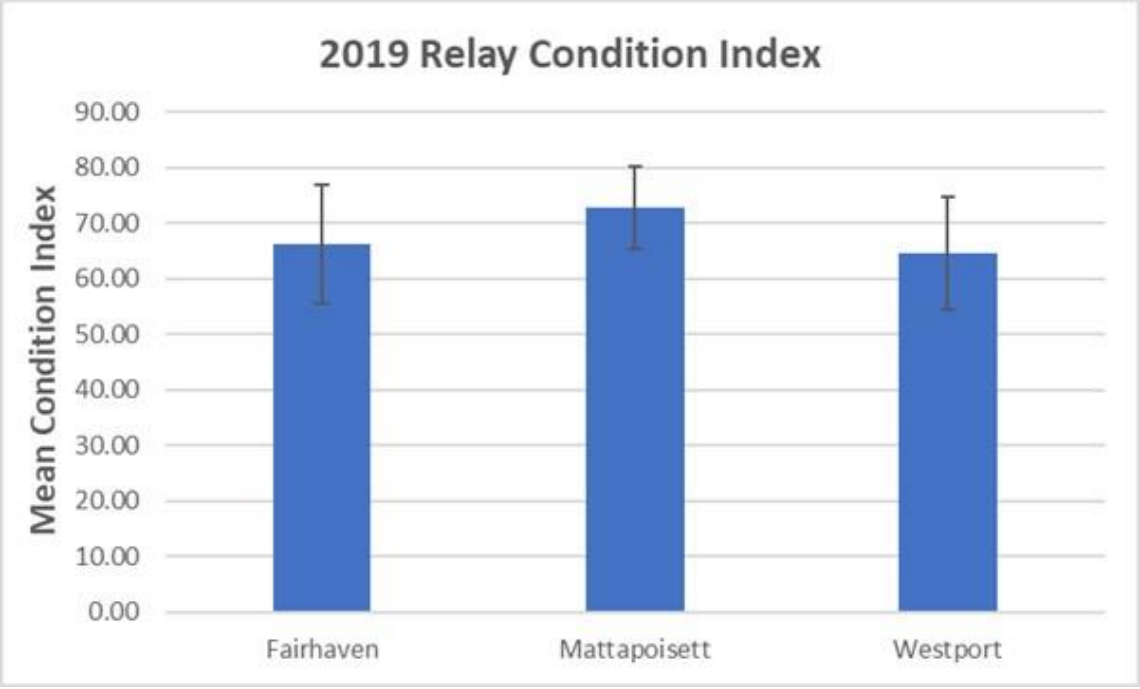

Figure 21. Mean condition index (+/- SD) of relayed contaminated quahogs at the three intensively-sampled sites: Fairhaven, Mattapoisett, and Westport. Condition index was assessed at the time of planting during summer 2019.

Condition index values of the Fairhaven, Mattapoisett, and Westport quahog samples were within the 60-70s range (Figure 21). Fairhaven had a mean CI value of 66.28, Mattapoisett with a mean of 72.70, and Westport with a mean of 64.50. These values generally indicate good reproductive health and overall condition. Similar values were expected because all samples came from the Taunton River donor site and during the approximate same time of year.

2018 Relay Monitoring Methods and Results

Methods

As part of the B-120 restoration project in 2019, DMF personnel completed monitoring surveys of all nine sites that received adult contaminated quahog relays in 2018. Six of these towns received at least 800 bushels (Bourne, Dartmouth, Fairhaven, Marion, New Bedford, Wareham, and Westport), while Mattapoisett received 619 bushels and Gosnold received 50 bushels. These quahogs were planted between August and November 2018, and pre-planting site surveys were conducted at all sites between July and August 2018. Monitoring surveys were conducted at all sites between June-October 2019, and survey methods were identical to those used for pre-relay site surveys.

Below is a table of summary data (Table 13) from the resident quahog populations at B-120 sites prior to planting contaminated quahog relays in 2018 and the results of the post-planting surveys conducted one-year following the relays in 2019. As expected, mean densities of quahogs increased at almost all sites following the relays. Mean quahog length varied slightly across sites and between 2018 and 2019, most likely due to slight differences in planting sizes and the effect of randomized sampling in the survey design.

In addition to gathering data on quahog size and densities, in 2019 data was collected to assess the mortality rate of relayed quahogs into each planting site. Over the past several years of B-120 relays, *DMF* staff has intermittently noticed patches of high-density relayed quahogs in some towns and planting sites; planted quahogs were occasionally found in large “mounds”, while others were spread out and more evenly distributed. These differences in quahog distribution are directly linked to the planting techniques of town shellfish personnel; some take the time to dump quahogs slowly off their boats, planting across all areas of the site, while others have been observed to simply dump bushels on top of each other in the same area. Areas with large mounds of relayed quahogs and very high planting densities generally had higher numbers of dead planted quahogs, or “clappers” (hinged quahog shells, single/broken shells were not included). To begin to evaluate the extent of planted quahog mortality, *DMF* personnel noted whether each quadrat was on a mound or not and counted any planted clappers alongside planted living quahogs during each monitoring survey (Table 13). Using these data, a mortality rate was estimated for each planting area in the towns. While these data are valuable as a general gauge of planted quahogs across towns, it is important to note that these mortality rates are a snapshot of the areas sampled and likely do not reflect the characteristics across the entire planting site. Quahog distribution can be very patchy, even when distributed well, and while randomized survey designs capture as much information as possible, more data would need to be collected to extrapolate an accurate mortality rate across entire planting sites. Regardless, this new data emphasizes the importance of planting techniques in the survival and health of the planted quahog population, and data

on local quahog densities and mortality will be continually collected and methods refined in 2020 monitoring surveys.

Municipality	Site Name	# of Bushels Planted - 2018	# of Quahogs Planted	2018 Mean Size (mm)	2018 Survey Density	2019 Mean Size (mm)	2019 Survey Density	# of Quadrats Sampled	2019 # of Living Quahogs	2019 # of Clappers	% Mortality
Bourne	Little Bay	803	152,463	86.1	0.77	84.50	0.88	40	35	1	2.78
Dartmouth	Gulf Bridge Road - South	800	159,872	83.8	0.64	71.30	2.34	80	187	72	27.80
Fairhaven	Seaview Avenue	800	145,304	86.6	0.25	84.10	1.05	40	42	10	19.23
Gosnold	Cuttyhunk Pond - SE	50	8,800	88.3	0.00	81.50	1.4	15	21	0	0.00
Marion	Planting Island Cove, #2	801	152,190	86.1	0.05	85.70	3.73	30	112	75	40.11
Mattapoisett	Nyes Cove	619	118,494	86.3	0.34	77.40	0.45	42	19	3	13.64
New Bedford	Monkey Pier	800	161,524	84.2	0.51	68.50	0.31	55	17	6	26.09
Wareham	Agawam Beach	902	167,922	85.4	0.40	81.80	1.4	80	112	79	41.36
Westport	The Let - NW Quadrant	800	143,754	85.7	0.08	84.40	1.68	25	42	0	0.00

Table 13. Summary table comparing B-120 contaminated quahog relay planting data (2018) and post-planting monitoring data (2019).

Results

<u>Bourne –Little Bay</u>

On September 26, 2019, a monitoring survey was conducted by *DMF* staff and town shellfish officials. Survey results indicated a sand/mud substrate with some gravel/shell, and minimal SAV. Water depth in Little Bay ranged between 0.5 to 3.5 feet below MLLW. A total of six transects of 5-10 quadrats each were sampled within the site (40 quadrats). Thirty-five quahogs were harvested for a density of 0.88 quahogs/ft.^{2} (Table 14). This area has a two-year closure and is expected to reopen to recreational shellfishing in the fall of 2020.

Mean (mm)	84.45
Min (mm)	70.25
Max (mm)	100.30
Total #	35
# Quadrats	40
Density/sq.ft.	0.88

Table 14. Summary table of the post-planting quahog population at the Bourne B-120 relay site. Size measurements denote shell length.

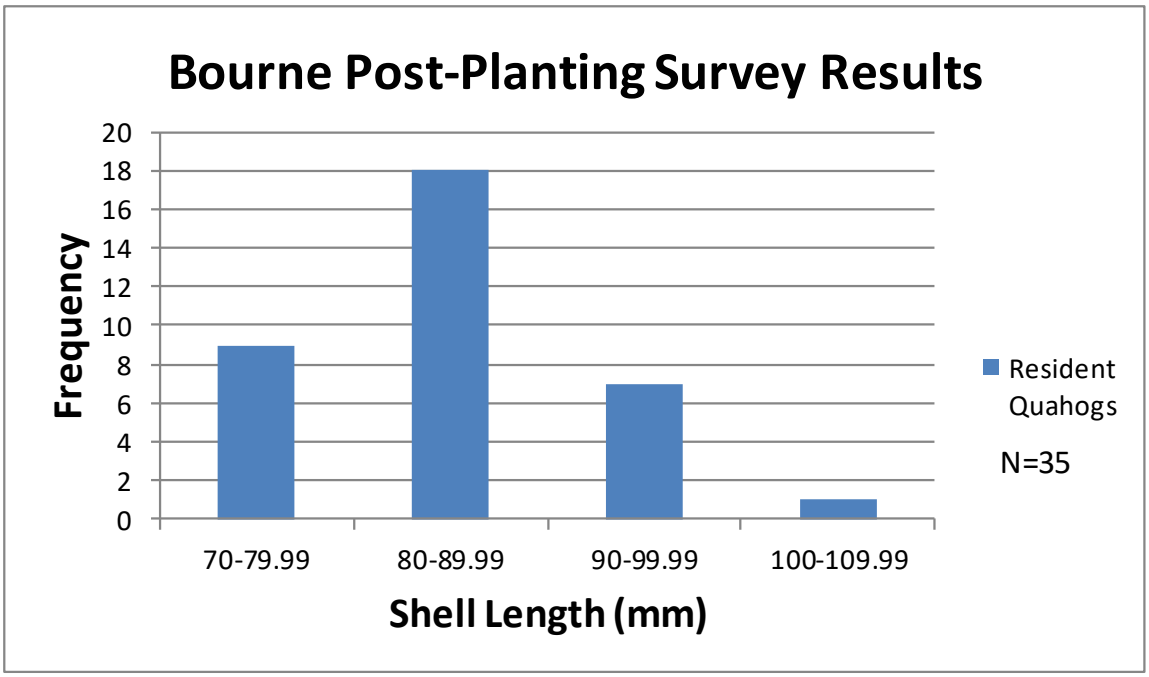

Figure 22. Quahog length frequencies post-planting at the Bourne B-120 relay site.

Dartmouth – Gulf Road Bridge

On September 9 and 10, 2019, a monitoring survey was conducted by *DMF* staff. The survey was completed over a two-day period because this site was one of the three B-120 *DMF* sites in 2018 and required two days to secure a minimum of 80 sampled quadrats. Survey results indicated a sand/mud substrate with some *Codium* throughout the site. Water depth in Apponagansett Bay ranged between 1.5 to 4.0 feet below MLLW. A total of four transects of 20 quadrats each were sampled within the site (80 quadrats). 125 quahogs were collected for a density of 1.56 quahogs/ft.^{2} (Table 15). This area had one-year closure and reopened to recreational shellfishing in November of 2019.

Mean (mm)	86.05
Min (mm)	56.43
Max (mm)	108.78
Total #	125
# Quadrats	80
Density/sq.ft.	1.56

Table 15. Summary table of the post-planting quahog population at the Dartmouth B-120 relay site. Size measurements denote shell length.

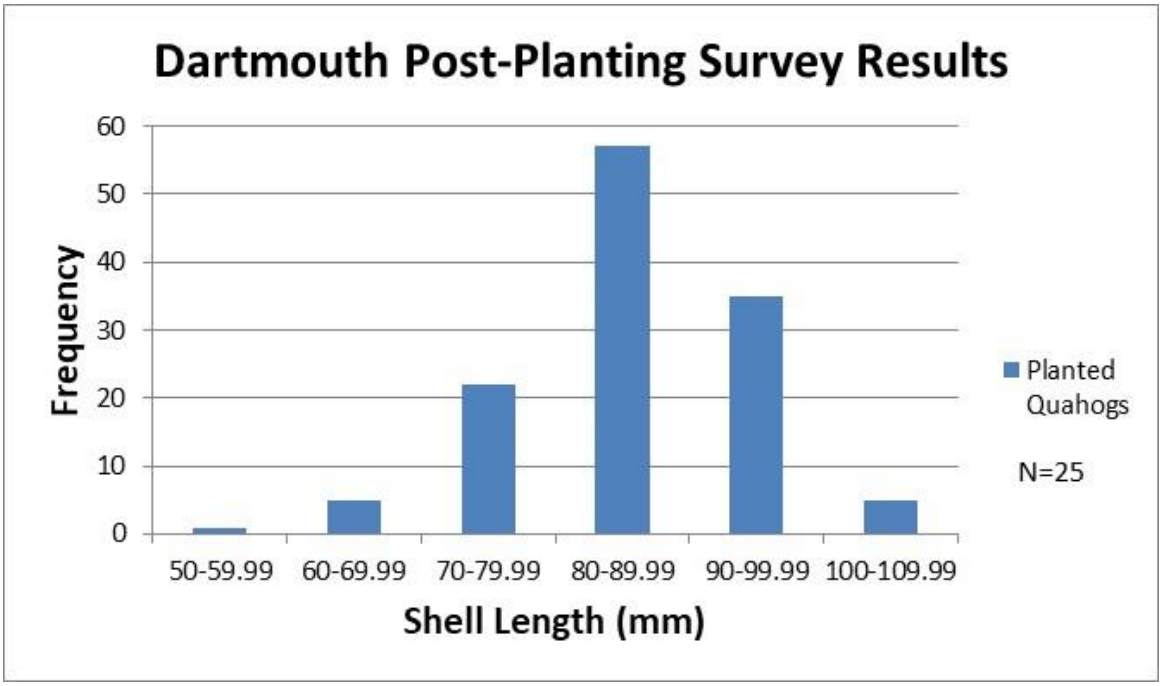

Figure 23. Quahog length frequencies post-planting at the Dartmouth B-120 relay site.

Fairhaven – Seaview Avenue

On June 26, 2019, a monitoring survey was conducted by *DMF* staff and the Fairhaven shellfish constable. Survey results indicated a sand substrate with some rock and minimal SAV coverage. Water depth at this site ranged between 1.5-4.0 feet below MLLW. A total of nine transects with 10 quadrats each were sampled within the site (90 quadrats total). Fifty-six quahogs were sampled at a density of 0.62 quahogs/ft.^{2} (Table 16). The site will be closed for two years and reopen to recreational shellfishing in the fall of 2020.

Mean (mm)	84.10
Min (mm)	70.08
Max (mm)	96.85
Total #	42
# Quadrats	40
Density/sq.ft.	1.05

Table 16. Summary table of the post-planting quahog population at the Fairhaven B-120 relay site. Size measurements denote shell length.

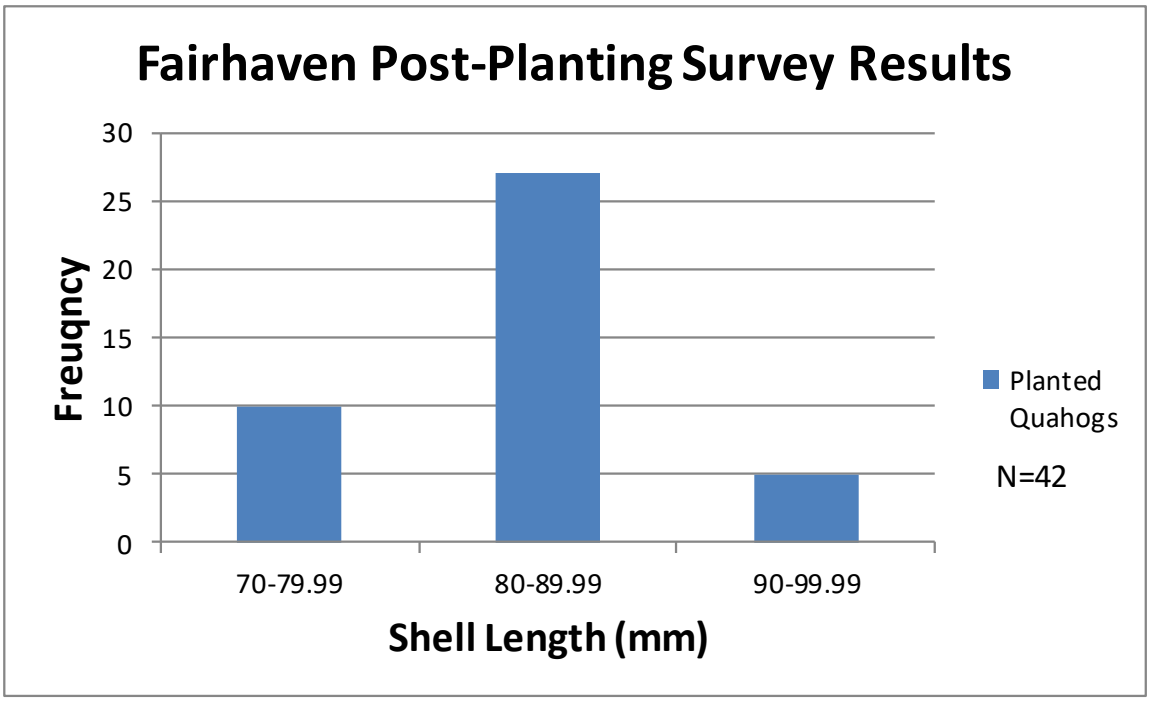

Figure 24. Quahog length frequencies post-planting at the Fairhaven B-120 relay site.

Gosnold –Cuttyhunk Pond-SE corner

On September 2, 2019 a monitoring survey was conducted by *DMF* staff members and Seth Garfield. Survey results indicated a sand/mud substrate and minimal SAV coverage. Because of the small size and apparent uniformity of the area, 15 randomly selected quadrats were sampled. Water depth was 1.5 feet below MLLW. Twenty-one quahogs were collected for a density of 1.40 quahogs/ft.^{2} (Table 17). The area was closed for one year following the contaminated quahog relay and reopened in the fall 2019.

Mean (mm)	81.46
Min (mm)	61.79
Max (mm)	95.77
Total #	21
# Quadrats	15
Density/sq.ft.	1.40

Table 17. Summary table of the post-planting quahog population at the Gosnold B-120 relay site. Size measurements denote shell length.

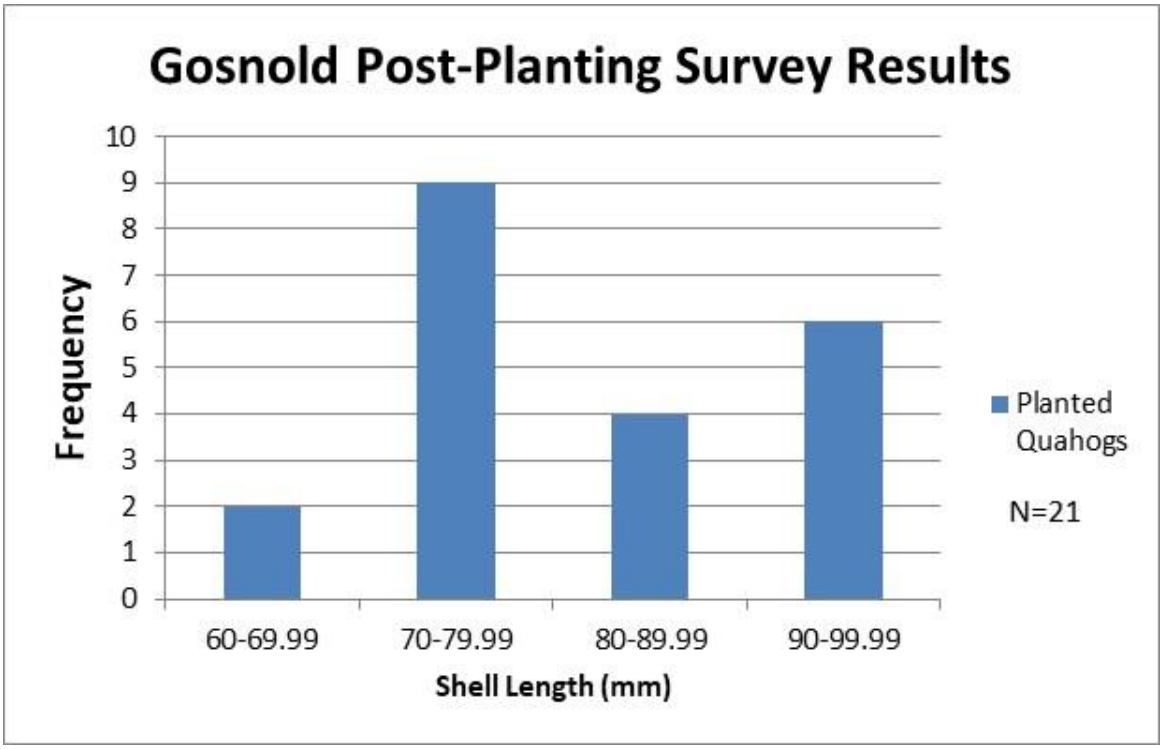

Figure 25. Quahog length frequencies post-planting at the Gosnold B-120 relay site.

Marion – Planting Island Cove, Site #2

On August 29th, 2019, a monitoring survey was conducted by *DMF* staff. Survey results indicated a soft mud/sand substrate, with some filamentous red algae and eel grass coverage. Water depth of the Planting Island Cove site ranged between 0.5 – 3 feet below MLLW. A total of three transects with 10 quadrats each were sampled within the site (30 quadrats total). 112 quahogs were found for a density of 3.73 quahogs/ft.^{2} (Table 18). Rows of quahog mounds were found within all transects consisting of densely packed quahogs and dead shell. The site closed to shellfishing for one year and reopened to recreational shellfishing in the fall of 2019. These findings were relayed to Marion's Shellfish Constable by DMF staff. The constable said he would make every effort to better distribute quahogs while conducting the Town's 2019 B-120 planting activities.

Mean (mm)	85.70
Min (mm)	68.7
Max (mm)	103.14
Total #	112
# Quadrats	30
Density/sq.ft	3.73

Table 18. Summary table of the post-planting quahog population at the Marion B-120 relay site. Size measurements denote shell length.

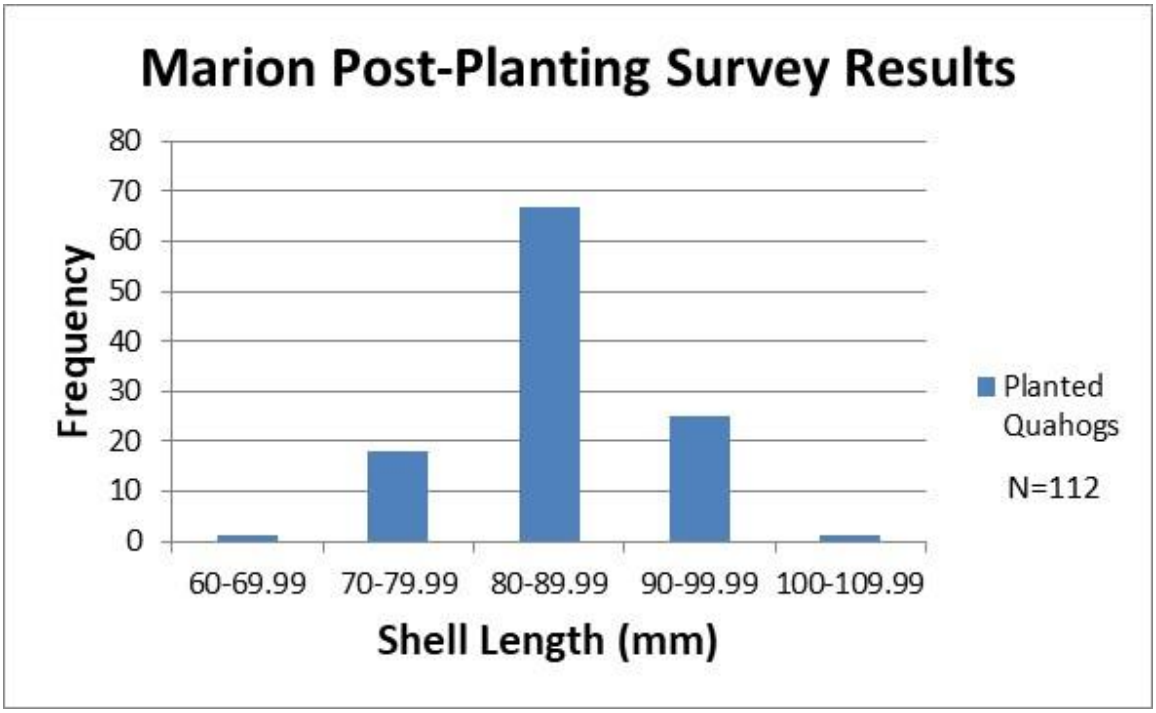

Figure 26. Quahog length frequencies post-planting at the Marion B-120 relay site.

Mattapoisett – Nyes Cove

On August 28, 2019, a monitoring survey was conducted by *DMF* staff. Survey results indicated a sand/mud substrate and minimal SAV coverage. The water depth of Nyes Cove ranged between 0.5-2.0 feet below MLLW. A total of four transects with 10 quadrats each were sampled within the site (40 quadrats total). Nine quahogs were found for a density of 0.21 quahogs/ft.^{2} (Table 19). This site closed for one year and reopened to recreation shellfishing in the fall of 2019.

Mean (mm)	60.25
Min (mm)	15.15
Max (mm)	99.29
Total #	9
# Quadrats	42
Density/sq.ft	0.21

Table 19. Summary table of the post-planting quahog population at the Mattapoisett B-120 relay site. Size measurements denote shell length.

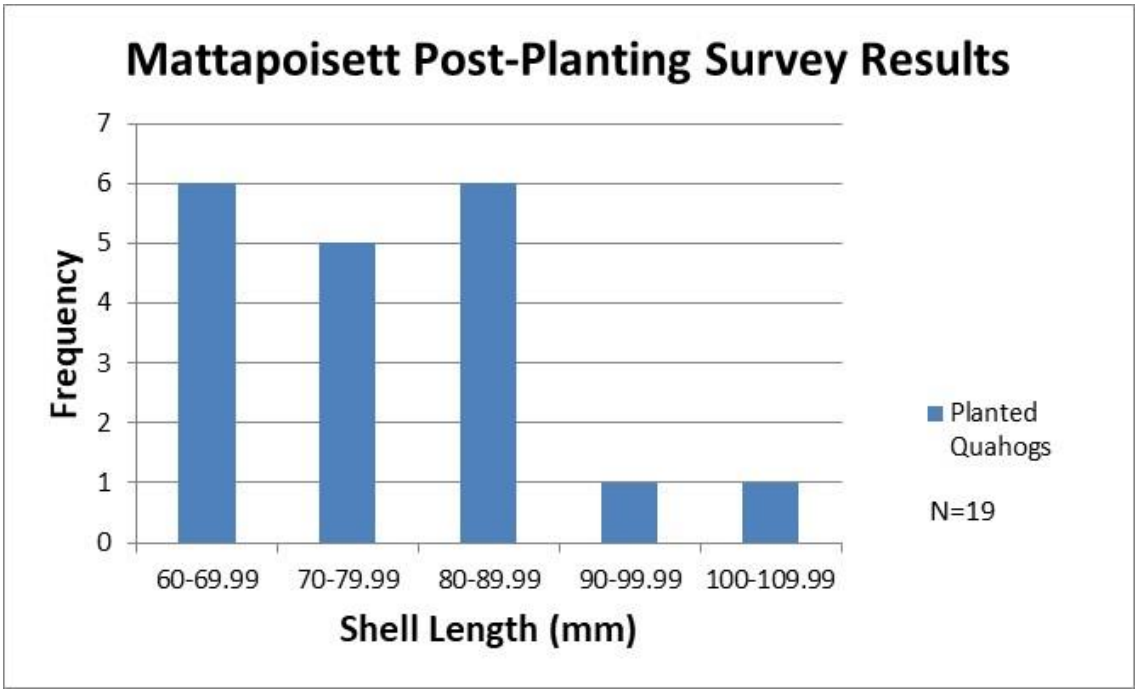

Figure 27. Quahog length frequencies post-planting at the Mattapoisett B-120 relay site.

New Bedford – Monkey Pier

On August 27th, 2019, a monitoring survey was conducted by *DMF* staff. Survey results indicated a bottom substrate consisting of a sand/mud/gravel mixture and some rocks closer to shore. A significant amount of *Codium* and eel grass was found throughout the near-shore area. Water depth at the site ranged from 0.5-4.5 feet below MLLW. A total of 9 transects with 2-10 quadrats each (55 quadrats total) were sampled within the site. 17 quahogs were found for a density of 0.31 quahogs/ft.^{2} (Table 20). *DMF* personnel were informed by the New Bedford shellfish constable that the quahogs were planted out in deeper water than wading could access due to heavy storms at the time of planting, therefore an additional dive survey was conducted to reach a minimum of 80 quadrats at this site. 25 quahogs were harvested during the dive survey but are excluded from the table below because they were not measured. The collected quahogs were documented as resident quahogs rather than B-120 relayed quahogs which have a black appearance on the shell. This site was closed to shellfishing for one year and reopened in the fall of 2019.

Mean (mm)	68.50
Min (mm)	48.03
Max (mm)	91.06
Total #	17
# Quadrats	55
Density/sq.ft	0.31

Table 20. Summary table of the post-planting quahog population at the New Bedford B-120 relay site. Size measurements denote shell length.

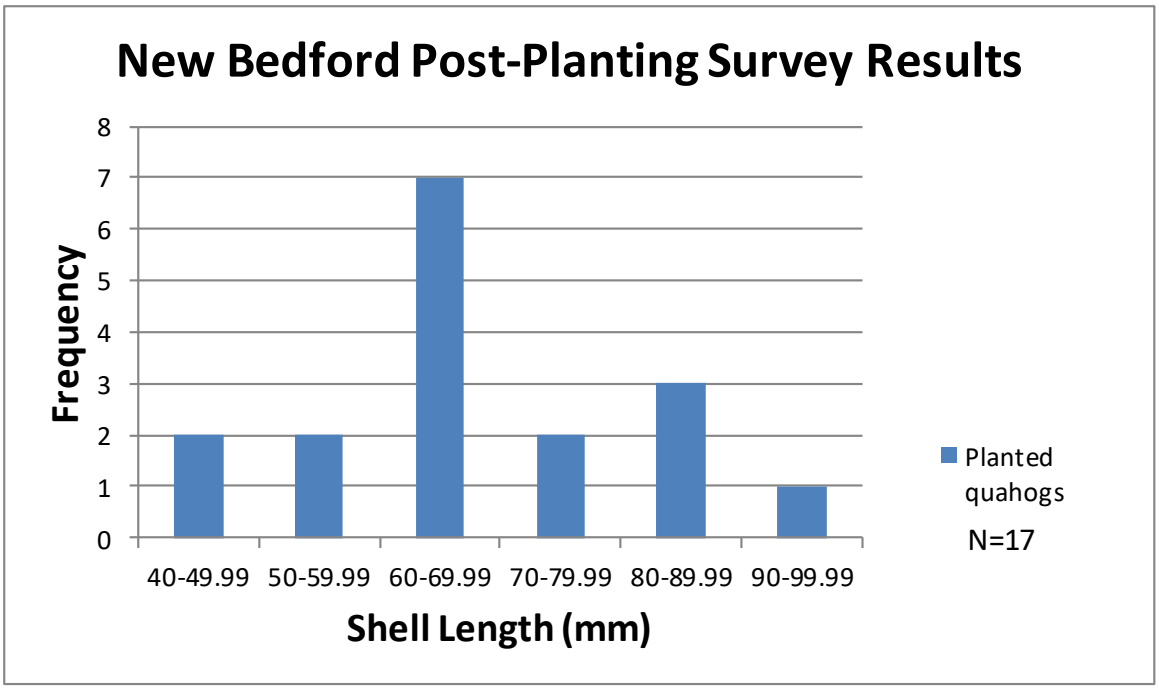

Figure 28. Quahog length frequencies post-planting at the New Bedford B-120 relay site.

Wareham – Agawam Beach

On October 7th and 8th, 2019, a two-day monitoring survey was conducted by *DMF* staff. Survey results for this *DMF* intensive sampling site indicated a bottom substrate consisting of sand/mud with some gravel and minimal SAV coverage. Water depth at Agawam Beach ranged from 0.5 – 4.0 feet below MLLW. A total of 9 transects with 5-10 quadrats each (80 quadrats total) were sampled within the site. Small physical mounds of quahogs were present in high densities within some of the transects. Despite this, the quahogs appeared to be well distributed across the site. 112 quahogs were found for a density of 1.40 quahogs/ft.^{2} (Table 21). The site will be closed to recreational shellfishing for two years and will reopen in the fall of 2020.

Mean (mm)	81.81
Min (mm)	57.82
Max (mm)	102.66
Total #	112
# Quadrats	80
Density/sq.ft.	1.40

Table 21. Summary table of the post-planting quahog population at the Wareham B-120 relay site. Size measurements denote shell length.

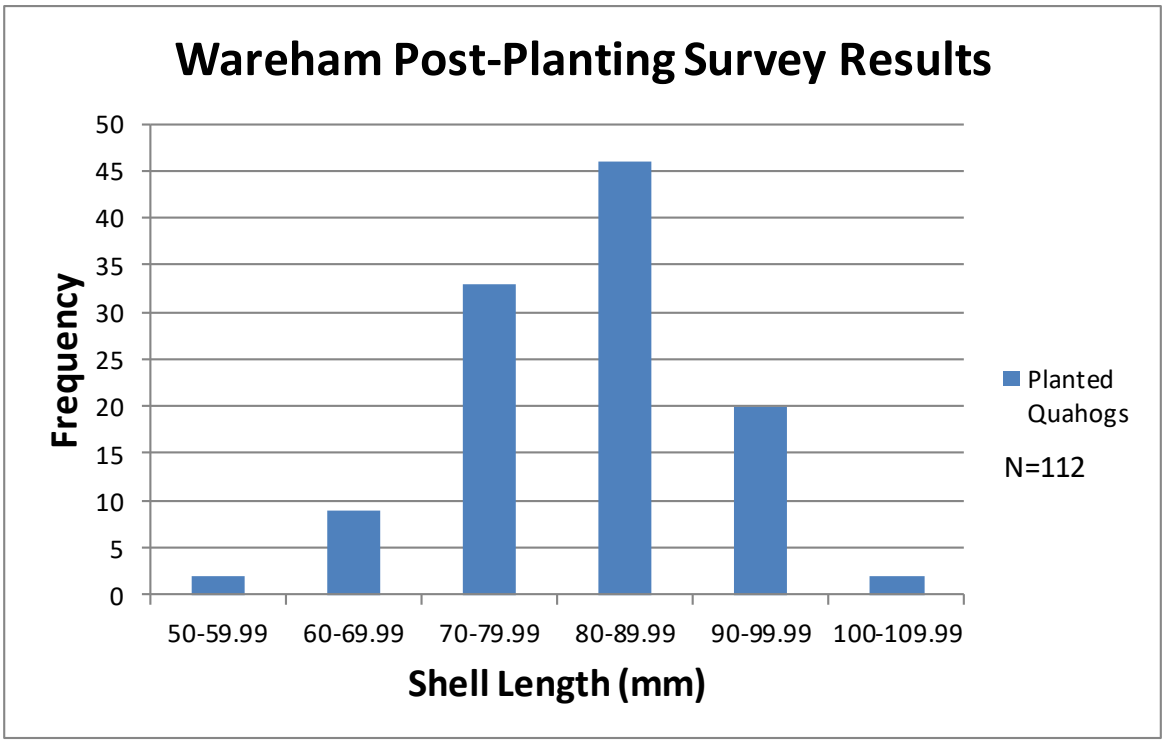

Figure 29. Quahog length frequencies post-planting at the Wareham B-120 relay site.

Westport – Westport River-The Let, Northwest Quadrant

On June 13th, 2019, a monitoring survey was conducted by *DMF* staff members and the Westport Shellfish Constable. The survey was conducted from a boat with the use of a bull rake to access this deep-water site during high tides. A total of 25 randomly distributed quadrats were sampled. Survey results indicated a substrate consisting of mud/sand sediment and minimal SAV coverage. This site had a water depth of 2.7 feet below MLLW at the time of the survey. 25 quahogs were collected with a mean quahog density of 1.68 quahogs/ ft.^{2} (Table 22). The site is closed to recreational shellfishing for two years and will reopen in the fall of 2020.

Mean (mm)	84.42
Min (mm)	69.50
Max (mm)	99.00
Total #	42
# Quadrats	25
Density/sq.ft.	1.68

Table 22. Summary table of the post-planting quahog population at the Westport B-120 relay site. Size measurements denote shell length.

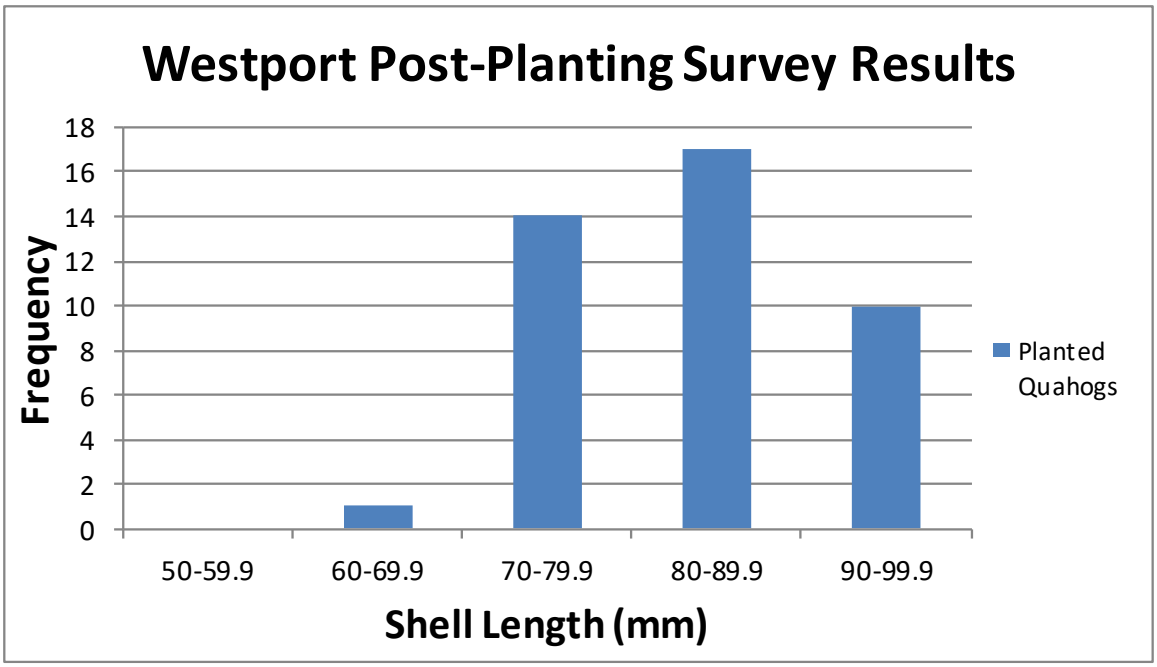

Figure 30. Quahog length frequencies post-planting at the Westport B-120 relay site.

2018 Relay Monitoring Condition Index Methods and Results

In 2019, *DMF* collected samples of relayed quahogs from the 2018 B-120 study sites in Dartmouth, New Bedford, and Wareham for the determination of a monitoring Condition Index (CI). These samples were taken one-year post-planting and were compared against samples taken in 2018 at the time of harvest from the Taunton River for each designated town. As previously mentioned, CI is a good indicator of the quahog's general condition, gonadal development, and health with ranges of computed CI values of upper 60-70s indicating good condition (Marroquin-Mora and Rice 2008). Condition index categories in the table below are general grouping based on this documented range, and CI values are most useful as a comparative tool across and within seasons and between individuals and populations rather than an independent metric of reproductive health. 20 quahogs were collected from each site for lab processing and determination of CI. At the *DMF* New Bedford Lab, staff used the procedures and formula of Crosby and Gale (1990) to determine the CI of the collected quahogs:

CI = [dry soft tissue wt. (g) X 1,000/total weight g) – shell weight (g)

All weights were estimated to the nearest 0.01 g. The CI results from monitoring condition index are presented in Table 23. Five outliers were subtracted from New Bedford due to a wet tissue weight error during processing.

Municipality	2018 CI Date	2019 CI Date	2018 Sample Size	2019 Sample Size	Mean CI 2018	Standard Deviation	Mean CI 2019	Standard Deviation
Dartmouth	9/11 - 9/13	9/9 - 9/11	19	20	74.30	9.62	61.06	7.90
New Bedford	9/25 - 9/27	9/30 - 10/2	20	15	55.20	6.93	65.44	13.50
Wareham	10/9 - 10/11	10/7 - 10/9	20	20	59.80	7.60	68.14	11.87

Table 23. B-120 monitoring condition index summary of relayed quahogs planted in 2018.

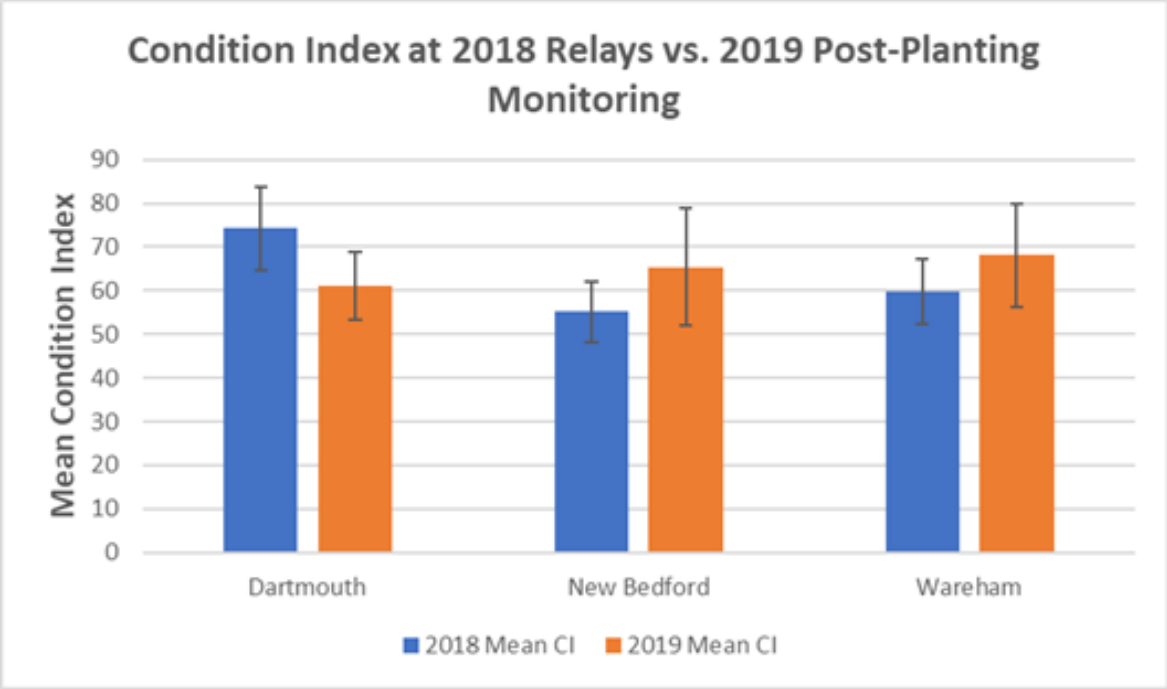

Figure 31. Mean monitoring condition index (+/- SD) of relayed contaminated quahogs from 2018 compared to one-year post-planting (2019) at the three intensively-sampled sites: Dartmouth, New Bedford, and Wareham.

The post-planting condition index conducted in 2019 had a similar range compared to the initial CI conducted in 2018 for Dartmouth, New Bedford, and Wareham (Figure 31). This post-planting condition index allows us to monitor the health of the relayed quahogs and track any changes taking place. The mean CI for the 2019 quahog monitoring remains within the acceptable range (60-70), which depicts an overall healthy condition.

II. Single Oyster Purchase, Grow-out, and Out-Planting

Methods Overview

Oyster Seed Purchases

The B-120 oyster project began in 2017 in Bourne, Marion, and Wareham. Each town committed to planting oysters at one site per year over two years (2017 and 2018), amounting to a total of six planted sites within municipally managed waters of Buzzards Bay. In response to a request from the three participating towns for additional single oysters and following discussions with the Trustees, an additional year was added to the B-120 oyster project for 2019. Each year, the participating three towns pool their resources to purchase hatchery oyster seed at the best available price. Prior to procuring oyster seed, the participating towns work collaboratively with *DMF* to determine the size and quantity of oyster seed best suited to meet town needs. Municipalities provide *DMF* with information detailing the locations and characteristics of the proposed planting sites, anticipated planting densities, information on the availability of upweller space, and alternative nursery systems

(i.e., floating bags). Generally, each municipality purchases small-sized oyster seed to be placed in upwellers and/or larger-sized oysters for placement in nursery grow-out systems. These nursery systems are located at designated areas in each town that are easily accessible for management and maintenance. Generally, they consist of floating rack and bag systems with bags held within large cages, or single bags strung together in lines and secured with buoys and anchors on either end.

The participating towns and *DMF* work together closely to ensure these efforts support the B-120 goal to create and maintain sustainable, recreationally available oyster resources at each of the oyster planting sites. Through monitoring of the oyster seed within the upwellers, and monitoring the growth, survival, and density of out-planted oysters, we intend to refine these efforts and seek to enhance restoration success.

Grow-out Sampling

During June through October, when the oysters were in the upwellers or floating bags and cages for intermediate grow-out, *DMF* personnel worked closely with town personnel to monitor growth and survival of the seed. From late June, when the order of oysters arrived, to the time of out-planting in the fall, bi-weekly (every two weeks) size measurements of oyster shell height was taken on a subsample of oysters in each town. *DMF* personnel provided participating town shellfish departments with standardized datasheets for these measurements, taken with digital calipers to the nearest 0.01 mm. A minimum of 50 measurements for each size class (and often up to 100-150 animals) were collected during each sampling event, and general maintenance of grow-out units and survival of oysters were noted at the time of sampling. In Bourne and Wareham, which had staff dedicated to this data collection, these data were collected irrespective of *DMF* personnel availability, and results were emailed to *DMF*. Marion lacked the dedicated staff to monitor oyster growth and survival in the upwellers and nursery grow-out systems, therefore this data was collected by *DMF* personnel during bi-weekly site visits.

Figure 32. Photograph depicting Bourne's FLUPSY upweller system.

Figure 33. Photograph depicting Marion's dock based upweller system.

Figure 34. Photograph depicting the oyster grow-out sites in Bourne (Toby's Island).

Prior to out-planting, *DMF* personnel worked with town staff to collect data on oyster survival during this grow-out phase and estimated total number of oysters using volumetric methods. Bourne's shellfish

department worked closely with *DMF* to develop these methods, which Bourne employed throughout the entire grow-out season. These sampling techniques were also used at the other two towns throughout the growing season by *DMF* personnel. To estimate survival, a measured volume of oysters (0.5-1 liter container, depending on oyster size) was counted for numbers of living and dead seed. Three replicates of these counts were taken for each size class, and a mean count of living and dead oysters was calculated across replicates. For total survival in each size class, these estimates were scaled up using the total volumes of each bag and the total number of bags per site. Bag volumes were measured by counting the number of volume units (1-2 liter container) of oysters in each bag. The total number of oysters out-planted was calculated using the number of living oysters per unit volume (liter), the total volume of each bag, and the total number of bags out-planted.

Figure 35. Photograph depicting the pre-planting sampling for oyster size, survival, and total volume in Bourne.

Pre-Planting Surveys and Post-Planting Surveys

In 2019, surveys of the proposed oyster restoration sites were conducted prior to out-planting. *DMF* personnel collaborated with town staff to conduct these surveys. Surveys consisted of running multiple transects across each site and using basket rakes to excavate 1-ft.^{2} quadrats at 10-foot intervals along each transect. Quadrats were dug to a depth of 8-12 inches and all oysters were counted and measured, and any other shellfish, predators, vegetation presence, type and percent cover, and substrate type were recorded. The length of individual transects and number of quadrats varied based on site dimensions. Marion and Wareham had two planting sites while Bourne had one. Post-planting surveys are conducted one year following planting to assess survival and growth of planted oysters. These surveys use the same methods as described above for the pre-planting surveys of oyster restoration sites.

Results

Oyster Seed Purchase and Grow-out

In 2019, Bourne, Marion, and Wareham purchased varying numbers of juvenile oysters with B-120 funds (Table 24). On June 27th, 2019, an order consisting of 785,000 ≥2 mm oysters from Muscongus Bay Aquaculture in Maine was shipped to towns, with Wareham receiving 498,334 oysters, Marion receiving 143,333 oysters, and Bourne receiving 143,333 oysters. The oyster seed was placed in town-owned upwellers for grow-out and eventual out-planting within B-120 restoration sites. The upwellers and floating bags and cages were maintained on a regular basis to maximize survival and growth prior to out-planting. All purchased oysters were certified as disease-free by *DMF*-approved shellfish pathology laboratories prior to receipt by the towns (refer to Appendix I).

Municipality	Destination	Initial Size (mm)	Quantity	Source	Outplanting Site
Bourne	Upweller/bags	2 mm	143,333	Muscongus Bay	Barlows Landing/Pocasset Harbor
Marion	Upweller/bags	2 mm	143,333	Muscongus Bay	Tabor Academy; Silvershell Beach
Wareham	Upweller/bags	2 mm	498,334	Muscongus Bay	Lydia's Island; Tempest Knob

Table 24. Summary of 2019 B-120 oyster purchases by towns of Bourne, Marion, and Wareham. Size range refers to shell height.

Bourne

Pre-Planting Survey – Barlow's Landing in Pocasset Harbor, Bourne

On September 26th, 2019, *DMF* personnel and the town of Bourne personnel conducted a pre-planting survey of the proposed oyster restoration site, located at Barlow's Landing within Pocasset Harbor (8.1 acres) (Figure 36). A total of 6 transects were run perpendicular to shore, starting at the water's edge, and 5-10 1-ft.^{2} quadrats were sampled along each transect (a total of 45 quadrats). Mesh-lined basket rakes were utilized to rake 1 ft.^{2} quadrats. Data was collected on substrate type, vegetation, presence of predators, and water depth for each quadrat. All quahogs and oysters were counted and collected for measuring. A significant number of resident oysters were observed along the shoreline going out approximately 10 feet into water. A total of 13 oysters and 43 quahogs were found in the 45 quadrats, for a density of 0.29 oysters/ft.^{2} and 0.96 quahogs/ft.^{2}. Resident oysters were mainly adults, with a mean size of 57.56 mm, and quahogs tended to be adults with a mean size of 72.45 mm (Table 25). This site is also the location of the 2019- B-120 quahog relay therefore some of the observed quahogs were likely placed from the recent relay. Substrate consisted of sand/mud with some gravel, suitable habitat for oysters and other shellfish.

Figure 36. Map of the Bourne B-120 oyster planting area in Pocasset Harbor.

Species	Oysters	Quahogs
Mean (mm)	57.56	72.45
Min (mm)	9.88	13.74
Max (mm)	93.90	102.72
Total #	13	43
# Quadrats	45	45
Density/sq.ft.	0.29	0.96

Table 25. Summary table of pre-planting survey results at Bourne's Barlow's Landing oyster planting site. Size measurements denote shell height (oysters) and shell length (quahogs).

Grow-out Sampling – Monument Beach Marina and Toby's Island

During the grow-out season, Bourne Shellfish Department staff and *DMF* personnel sampled all oyster size classes for growth, survival, and total volume estimates at the upweller site and the grow-out bags site. At the upweller site, data was collected from the docks. At the grow-out site, the oyster bags were sampled from the town's vessel. In 2018 and 2019, Bourne hired a full-time shellfish technician, which allowed them to intensively sample the oysters every two weeks, and *DMF* personnel assisted whenever schedules allowed in order to be involved in the data collection and provide oversight. Bourne staff maintained and cleaned grow-out equipment as well as sorted the oysters regularly. From early July to early November, the oysters grew from an average of 4.9 mm to an average of 47.1 mm in shell height (Figure 37). The survival rate based on the total number of oysters purchased was 79.9 % (Table 28).

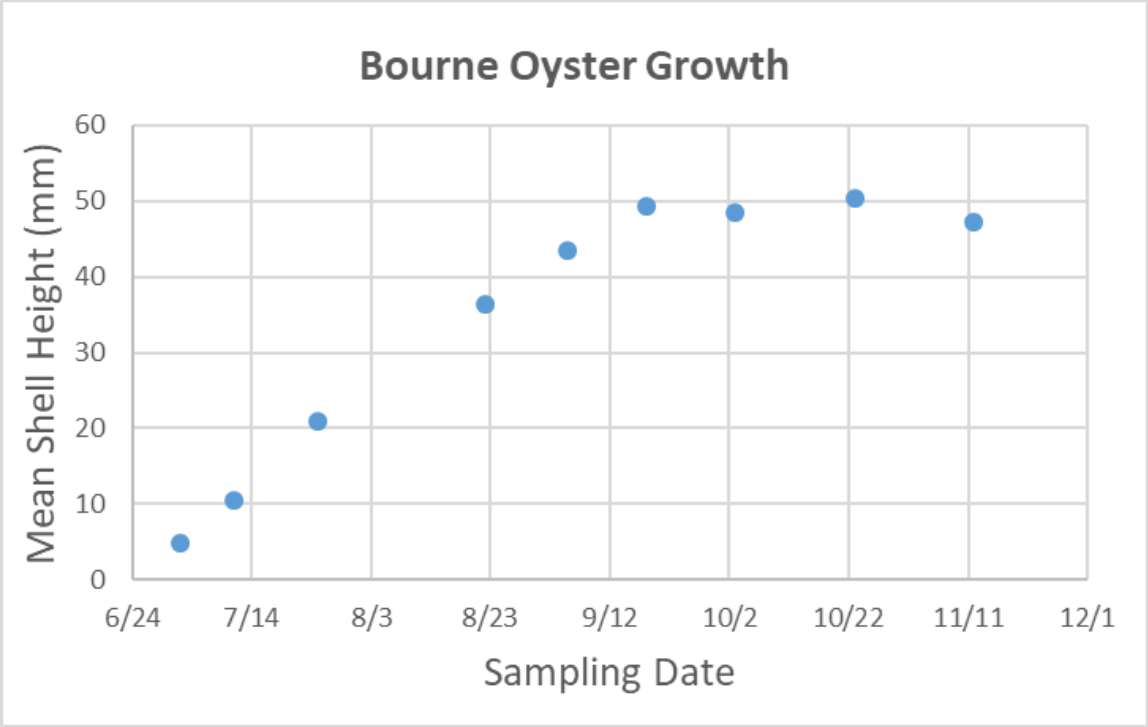

Figure 37. Mean shell height of oysters across the grow-out season.

Out-Planting – Barlow's Landing in Pocasset Harbor

On November 12th, 2019, the strings of oyster bags that were kept near Toby's Island for grow-out were collected and planted at the Barlow's Landing planting site. Each bag was opened and emptied within the site. *DMF* personnel were not present for this planting, but Bourne shellfish staff provided the data indicating that a total of 71 bags were planted. Based on the pre-planting sampling, this amounts to an estimated total of 114,573 oysters, and a planting density of 0.32 oysters/ft.^{2} (Table 29). At the time of planting, the oyster size ranged from 26.0-71.0 mm and mean oyster size was 47.1 mm (Table 29).

Marion

Pre-Planting Survey – Tabor Academy and Silvershell Beach in Sippican Harbor, Marion

Sippican Harbor supports an abundant resident oyster population at several intertidal areas along the shoreline. In an effort to enhance the oyster population within this embayment, the Constable selected

the Tabor Academy and Silvershell Beach sites because they contain suitable habitat and few if any oysters.

On September 25th, 2019, *DMF* conducted a pre-planting survey of the two proposed oyster restoration sites, the first located at Tabor Academy (0.7 acres) and the second at Silvershell Beach (0.1 acres), both of which are within Sippican Harbor (Figure 38). For the Tabor Academy site survey, a total of five transects were run perpendicular to the shore with five 1-ft.^{2} quadrats sampled along each transect (a total of 25 quadrats). A total of zero oysters and 20 quahogs were found, for a density of zero oysters/ft.^{2} and 0.80 quahogs/ft.^{2} (Table 25). The substrate consisted of sand, firm mud, and gravel with patches of filamentous red algae, suitable habitat for out-planting oysters.

A pre-planting survey of the second site at Silvershell Beach was conducted on the same day. A total of four transects were run perpendicular to the shore with four 1-ft.^{2} quadrats sampled along each transect (a total of 20 quadrats). The habitat was mainly rock, and sand/firm mud, with patches of filamentous red algae. Zero Oysters and Quahogs were found during this survey.

Figure 38. Map of the B-120 oyster planting area and acreage in Marion.

Quahogs	
Mean (mm)	48.01
Min (mm)	10.78
Max (mm)	81.19
Total #	20
# Quadrats	25
Density/sq.ft.	0.80

Table 26. Summary table of pre-planting survey results at Marion's Tabor Academy oyster planting site. Size measurements denote shell length (quahogs). Zero oysters were collected.

Grow-out Sampling – Town Dock, Marion

During the grow-out season, *DMF* personnel sampled oysters for growth, survival, and total volume estimates. Marion lacked personnel dedicated to collecting data on their oyster seed therefore *DMF* personnel made bi-weekly site visits to collect data throughout the season (Figure 39). From Late June to mid-October, the oysters grew from an average of 2.55 mm to an average 35.26 mm (Figure 40). The overall survival was estimated to be 61.2 % (Table 28).

Figure 39. Photograph depicting oyster data collection at the Marion town dock.

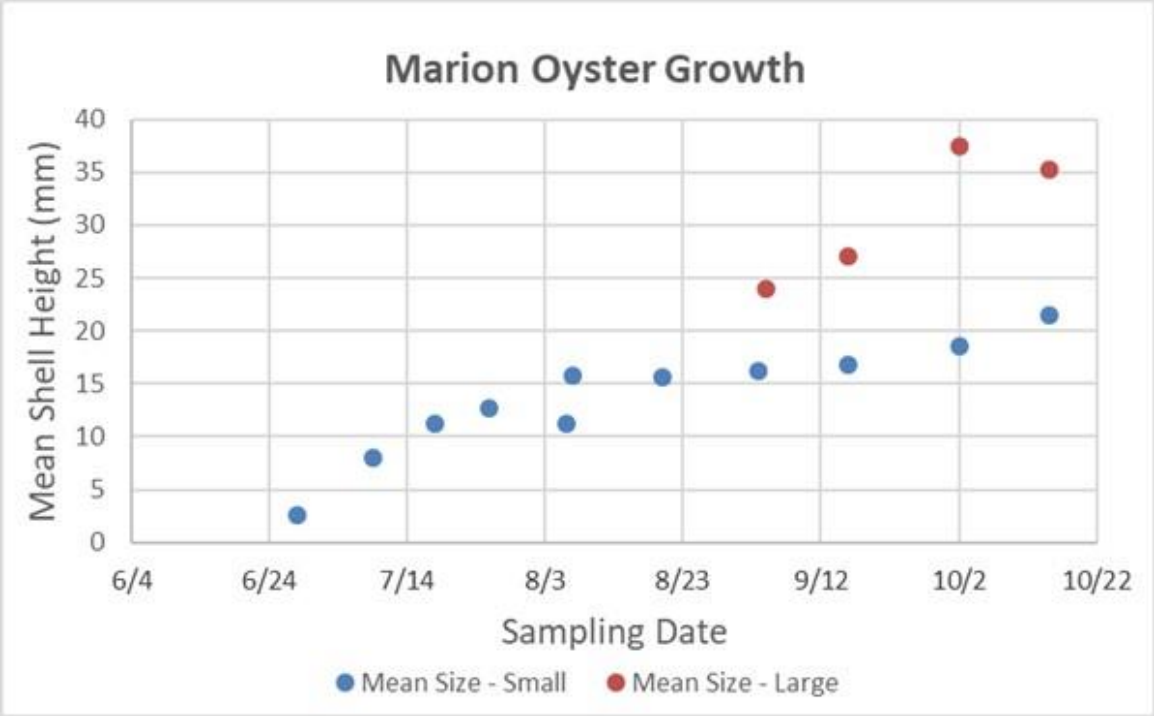

Figure 40. Mean shell height of oysters across the grow-out season. Blue circles denote the smaller-sized cohort, and red circles denote the second, larger-sized cohort

Out-Planting –Tabor Academy and Silvershell Beach, Sippican Harbor, Marion

DMF personnel were not present when the Marion Shellfish department staff planted the oysters. A total of 31 bags were planted in late October. Based on the pre-planting sampling event, an estimated 87,670 oysters were planted between the two sites. Planting density was estimated to be 2.58 oysters/ft.^{2} (Table 29). At the time of planting, the size range of the oysters was 9.91-93.91 mm, with a mean oyster shell height of 28.35 mm (Table 29).

Wareham

Pre-Planting Survey – Lydia's Island, Tempest Knob, Wareham

On October 24th, 2019, *DMF* personnel and Town of Wareham personnel conducted a pre-planting survey of the two proposed oyster restoration sites in Wareham, the first located on the northwestern shore of Lydia's Island (1.9 acres) and the second at Tempest Knob within the Wareham River (0.3 acres) (Figure 41). The restoration site at Lydia's Island was one of Wareham's planting sites last year and was reselected to continue building an oyster reef. At the Lydia's Island site, a total of four transects were run perpendicular to shore and 10 1-ft.^{2} Quadrats were sampled along each transect (a total of 40 quadrats). A total of 326 oysters and 13 quahogs were found in the 40 quadrats for a density of 8.15 oysters/ft.^{2} and 0.33 quahogs/ft.^{2} The mean size of oysters was 76.95 mm (Table 26). Observed oysters were almost exclusively adults that had been planted through the B-120 oyster restoration project in 2017 and 2018. Quahogs were not measured due to tidal time constraints. Substrate throughout this site was firm sand and gravel, becoming solely firm sand at 6-8 inches of water depth. At the Tempest Knob site, a total of four transects were run perpendicular to shore and five 1-ft.^{2} quadrats were sampled along each transect (a total of 20 quadrats). A total of seven oysters and three quahogs were found in the 20 quadrats for a density of 0.35 oysters/ft.^{2} and 0.15 quahogs/ft.^{2} The mean size of the oysters was 69.05 mm (Table 27). The substrate consisted of sand/mud with some gravel and

filamentous red algae in the muddier areas. The town personnel stated that they avoided planting in areas consisting of mud and SAV coverage.

Figure 41. Map of the two B-120 oyster planting areas and acreage in Wareham.

Species	Oyster	Quahogs
Mean (mm)	76.95	
Min (mm)	21.98	
Max (mm)	124.01	
Total #	326.00	13.00
# Quadrats	40.00	10.00
Density/sq.ft.	8.15	0.31

Table 27. Summary table of pre-planting survey results at Wareham's Lydia's Island oyster planting site. Size measurements denote shell height.

Species	Oysters	Quahogs
Mean (mm)	69.05	
Min (mm)	58.00	
Max (mm)	76.42	
Total #	7.00	3.00
# Quadrats	20.00	20.00
Density/sq.ft.	0.35	0.15

Table 28. Summary table of pre-planting survey results at Wareham's Tempest Knob oyster planting site. Size measurements denote shell height.

Grow-out Sampling – Onset Pier, Burgess Point, Wareham

During the grow-out season, the Wareham shellfish department staff and *DMF* personnel sampled oysters for growth, survival, and total volume estimates. Wareham has one aquaculture technician who conducted the bi-weekly size sampling and routinely emailed the data to *DMF* project personnel. *DMF* staff would also make bi-weekly site visits to help with sampling and provide oversight. During the early grow-out phase, most of the oysters were kept in the town upweller at Onset Pier and transferred to bags within floating cages at Burgess Point in early August. A subset of ~2000 oysters were placed in a mesh bag within a grow-out cage at Tempest Knob to determine growth rates at this site with non-upweller methods. From July to early October, the oysters grew from an average of 2.84 mm to an average of 45.55 mm in shell height (Figure 42). The survival rate based on the total number of oysters purchased was 63.1 % (Table 28).

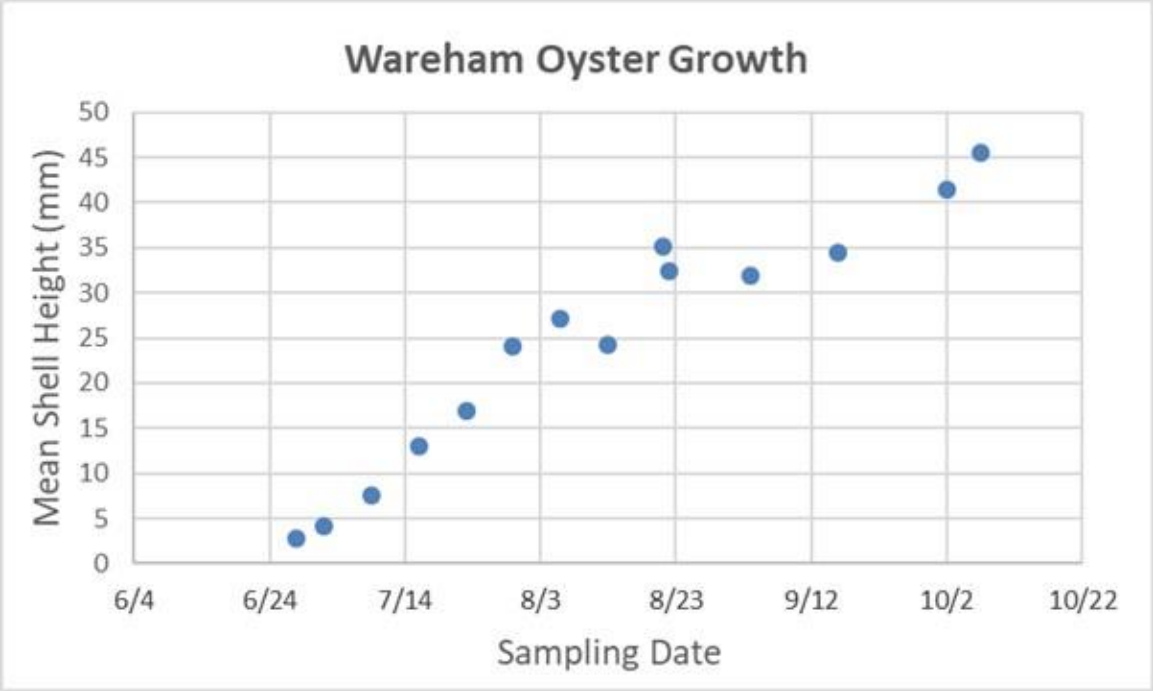

Figure 42. Mean shell height of oysters across the grow-out season.

Out-planting – Lydia's Island, Tempest Knob, Wareham

In mid-October, the strings of oyster bags within cages kept at Burgess Point for grow-out were collected and planted at the Lydia's Island planting site. Each bag was opened and emptied within the site. *DMF* personnel were not present during the planting period, but Wareham shellfish staff provided the data indicating that a total of 202 bags were planted. 12 bags kept at Tempest Knob were planted in late October at the Tempest Knob site. With a total of 214 bags planted in throughout Wareham, this amounts to an estimated 314,344 oysters planted between each site and a planting density of 3.37 oysters/ft.^{2} (Table 29). The size range of oysters planted was 17.59-73.45 mm and the mean oyster size at the time of planting was 42.80 mm (Table 29).

Town Comparison of Single Oyster Project

The B-120 oyster project was successfully completed in 2019 with Bourne, Marion, and Wareham all purchasing single oysters that were grown in upwellers and floating bags/cages before they were out-planted in the fall. Pre-planting site surveys were completed at all 5 restoration sites (1 in Bourne, 2 in Wareham, and 2 in Marion) and growth and survival data were collected throughout the grow-out season and prior to planting. As seen in Tables 29 and 30, and Figure 43 (below), final oyster size and survival rates differed among towns. Due to diligent monitoring and maintenance of grow-out equipment, Bourne achieved especially high survival rates prior to planting, while Wareham and Marion varied in their pre-planting sizes and survival rates (Table 28). Planting density varied based on the number and size of propagation sites available in each town (Table 29), and post-planting survival rates of planted oysters will be documented during B-120 monitoring surveys in 2020. An estimated total of 516,587 oysters were out-planted across the five sites in 2019 (Table 28).

Municipality	Initital Size (mm)	Pre-plant Sampling Date	# Oyster Planted	# Oysters Purchased	Survival Rate (%)
Bourne	2 mm	11/12	114,573	143,333	79.9%
Marion	2 mm	10/15	87,670	143,333	61.2%
Wareham	2 mm	10/2, 10/7	314,344	498,334	63.1%

Table 29. Summary table of pre-planting survival rates of B-120 oysters.

Municipality	Planting Site	Planting Area (acres)	Planting Area (sq. ft.)	Total # Oysters Planted	Mean Size (mm)	Size Range (mm)	Planting Density (#/sq.ft.)
Bourne	Barlows Landing	8.1	352,836	114,573	47.12	26.0 - 71.0	0.32
Marion	Tabor Academy; SilverShell Beach	0.68 + 0.10	33,977	87670	28.35	9.91 - 93.91	2.58
Wareham	Lydia's Island; Tempest Knob	0.26 + 1.88	93,218	314,344	42.80	17.59 - 73.45	3.37

Table 30. Summary table of planting data from the three B-120 oyster restoration towns. Size measurements denote shell height.

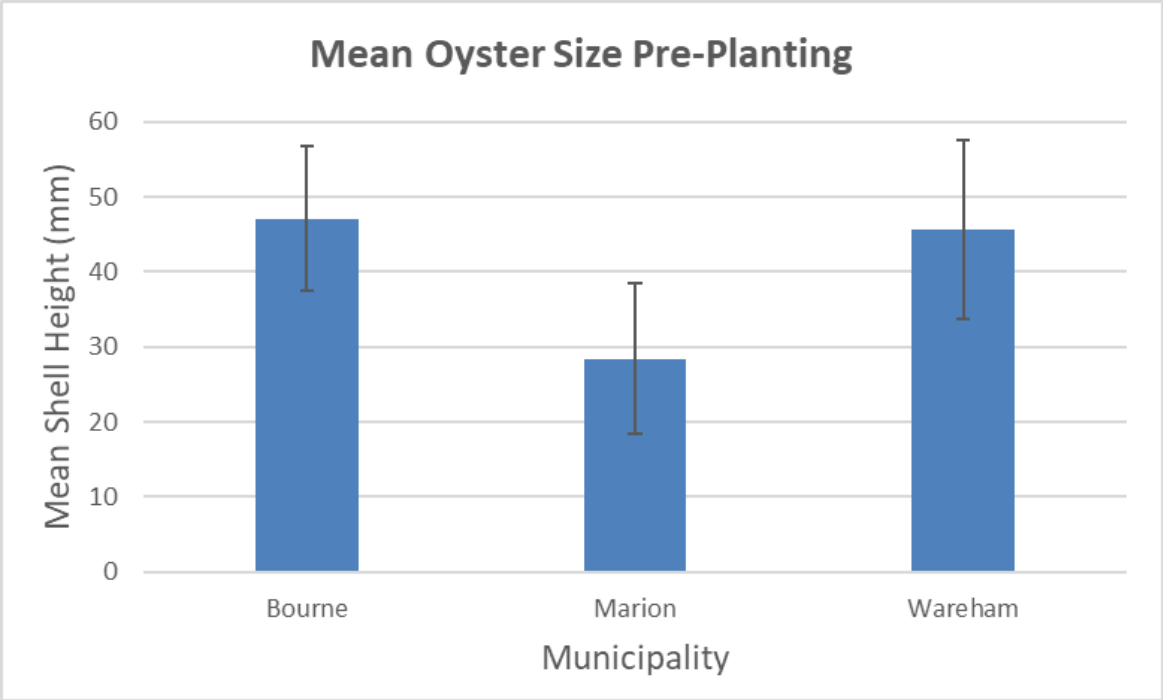

Figure 43. Mean oyster size (+/- SD) at each B-120 oyster restoration town prior to planting.

Monitoring of Single Oysters Planted in 2018

As part of the B-120 oyster restoration project in 2019, *DMF* personnel completed monitoring of the 2018 oyster restoration sites in Bourne, Marion, and Wareham. As described in the above site survey section and summarized in Table 30, in Bourne a total of 260 oysters within 40 sampled quadrats were found in Little Bay, for a density of 6.50 oysters/ft.^{2} In Bourne's second planting site at Winsor Cove, four oysters were found within the 30 sampled quadrats, for a density of 0.13 oysters/ft.^{2}

In Marion, a total of 61 oysters were collected in the 30 sampled quadrats within the Black Point planting site, for a density of 2.03 oysters/ft.^{2}. The mean size of these oysters was 75.15 mm, and these were assumed to be primarily planted oysters due to a lack of a resident population prior to the start of propagation efforts. In Wareham's Lydia's Island site, 280 oysters were found within the 40 sampled quadrats for a density of 7.00 oysters/ft.^{2}. Mean oyster size at this site was 76.95 mm and were also

identified as exclusively B-120 oysters planted in 2017-18. At the Onset Reef in Wareham, 29 oysters were found within the 12 sampled quadrats for a density of 2.42 oysters/ft.^{2}. Mean oyster size was 67.84 mm. While all surveyed propagation sites appeared to support a significant oyster population, Wareham's Lydia's Island site continues to stand out as a highly successful area in terms of planted oyster growth and density. This location was used as the B-120 oyster site from 2017-2019, receiving three years of oysters in an effort to build an oyster reef at this location.

Municipality	Planting Site	Planting Date	2018 Pre-planting Survey Density	2018 Mean Planting Size	2019 Survey Density	2019 Mean Size
Bourne	Little Bay	11/14/18	0.23	49.30	6.50	71.53
Bourne	Winsor Cove	11/6/18	0.00	42.17	0.13	80.87
Marion	Black Point	10/4/18	0.97	21.84	2.03	75.15
Wareham	Lydia's Island	10/26/18	6.35	49.14	7.00	76.95
Wareham	Onset Reef	9/22-9/29/18	1.33	49.89	2.42	67.84

Table 31. Summary table comparing B-120 oyster restoration planting data (2018) and monitoring data collected in 2019. Size measurements denote shell height.

Considerations for Baseline and Performance Monitoring in 2019

The primary objectives of the B-120 oyster project were met in 2019 with the acquirement of ≥2 mm oyster seed for all three towns and the subsequent out-planting of these oysters to suitable sites in Buzzards Bay. Continued improvements to performance monitoring and record-keeping were made that allowed for an increase in quantity and quality of data collected. Bourne and Wareham personnel frequently cleaned and maintained their grow-out systems, as well as conducted frequent thinning and sorting of oysters as they grew. At *DMF*'s request, their shellfish staff dedicated time to collecting bi-weekly size measurements at the minimum, Bourne's Shellfish Technician, Mike Corson, collected additional bi-weekly survival and volumetric data. *DMF* provided datasheets and digital calipers (if needed) to each town to streamline and standardize data collection as much as possible. Marion's shellfish department staff did not collect any data therefore it was primarily driven by *DMF* personnel during their bi-weekly site visits.

Data collection was successful throughout the oyster out-planting process because of a continued increase in communication and collaboration between Wareham and Bourne Shellfish Departments and *DMF* personnel. In 2019, all site surveys were completed, and a final pre-planting sampling event was coordinated and conducted by a combination of *DMF* and town personnel which resulted in the collection of final grow-out size, survival, and oyster density data. Additionally, all towns followed instructions about notifying *DMF* personnel prior to out-planting their seed so that *DMF* personnel could plan surveys accordingly and collect any final data that was needed. All oysters were planted at the targeted, pre-surveyed sites in each town, and the involvement of *DMF* personnel will allow for improved methods when conducting post-planting surveys in 2020.

Going forward in 2020, *DMF* will work with shellfish department staff in Bourne, Marion and Wareham to conduct post-planting monitoring surveys of single oysters planted in 2019. Additionally, DMF proposed to expland shellfish restoration activities in 2020 to include the planting of single oysters throughout two oyster reefs placed collaboratively by Wareham, Bourne, and The Nature Conservancy in 2017-18.

III. *Quahog Seed Purchase, Grow-out, and Over-Wintering*

Methods Overview

Quahog Seed Purchase

In 2016 and 2017, *DMF* oversaw a program whereby the towns of Wareham, Dartmouth, and Fairhaven purchased upwellers (FLUPSY's) for the grow-out of small quahog seed for the restoration of recreational fishing areas. Each town was responsible for all costs associated with operation of the upwellers, including electricity and routine maintenance. Each town operated and maintained the upweller facilities to produce larger-sized quahog seed (15mm-20 mm shell length) for out-planting into town managed shellfishing sites.

In 2019, Wareham repurposed their B-120 upweller to culture ≥2mm oysters for out-planting within the town's restoration site(s). Fairhaven and Dartmouth originally agreed to use their B-120 upwellers to produce larger-sized quahog seed for out-planting into priority shellfish sites managed for sustainable recreational shellfisheries. However, the Dartmouth shellfish constable cancelled his town's quahog seed order due to health issues and lack of staff to maintain the upwellers. The Fairhaven shellfish constable agreed to receive all 846,000, 1.5 mm quahog seed by expanding their grow-out capacity and adding a second town-built upweller. All quahog seed was disease-free certified and purchased from Muscongus Bay Aquaculture in Maine.

Grow-out Sampling

During June through November, the hatchery reared quahogs were grown in two FLUPSY's, one purchased with B-120 funds and the second owned by the Town of Fairhaven. The seed was distributed to 16 silos, eight silos for each upweller.

DMF personnel worked closely with town personnel to monitor growth and survival of the seed during the 2019 grow-out period. From late June, when the 1.5 mm quahog seed arrived, to the time they were over overwintered in early November, bi-weekly size measurements of quahog shell length were taken on a subsample of quahogs randomly selected from the silos. A minimum of 100 measurements for each size class were collected during each sampling event. Survival and total volume data were also collected throughout the grow-out season. Due to varying quahog growth rates within the silos, two seed sorting events took place. This allowed *DMF* personnel to create distinct size classes and determine the amounts and bag sizes needed for the overwintering process. On August 15th, 2019, during the first sorting event, the seed was divided into a small (≤4 mm) and large (≥4 mm) cohorts. On October 9th, 2019, during the second sorting event, the seed quahogs were further divided into four size classes, <4mm, 4-6 mm, 6-9 mm, >9 mm. Bi-weekly quahog seed sampling continued for each size class until they were over-wintered. Pictures of the quahog seed at various sizes throughout the grow-out season are presented below in Figure 44.

On October 29, 2019, DMF personnel received a call from the shellfish constable reporting that one of the FLUPSYs containing 8 silos broke and sank into the harbor due to a storm with high winds. Fairhaven personnel utilized SCUBA capabilities to retrieve the gear with the quahogs still within the silos. It appeared most of the quahogs were recovered, with an estimated 15% of lost quahog seed. All the quahogs were transferred into the remaining silos holding the same size classes.

Figure 44. Photos of the quahog seed at various sizes during bi-weekly data collection on shell lengths, survival, and total volume.

Over-wintering Site Selection and Seed Deployment

Because the quahog seed in Fairhaven did not reach the field plant size of 15 mm-20 mm in shell length, DMF personnel and Fairhaven's shellfish constable decided to over-winter the quahogs in grow-out bags secured in suitable subtidal sandy habitat (10ft. depth). The overwintered quahogs will be retrieved by *DMF* certified divers in early spring and placed back into Fairhaven's upwellers for further grow-out. Following a second growing season in the upwellers, the quahogs will be broadcasted into a *DMF* approved site managed for sustainable recreational shellfishing in the fall of 2020.

DMF worked with the Fairhaven shellfish constable to determine a suitable location to over-winter the quahog seed. Following a site-selection drop camera survey on October 24th, 2019, a location near Fort Phoenix in Fairhaven (Figure 43) was chosen because it had a minimum depth of 10 feet, minimum freshwater influence, minimal SAV coverage, sandy/silty substrate, and no history of freezing.

On November 14th, 2019, the quahog seed grown in Fairhaven's FLUPSY's since June was deployed into eight various sized mesh bags for over-wintering near Fort Phoenix. There was one 9 mm mesh box bag containing the largest size class of ≥9 mm, four 6 mm mesh box bags with seed ranging from 6-9 mm, two 4 mm mesh box bags with seed ranging from 4-6 mm–, and one 2mm soft mesh bag containing ≤4 mm seed. Different colored zip ties were used to mark the different mesh-sized bags. The bags of quahogs were stored overnight in a walk-in cooler owned by Taylor Seafood. On the following day, *DMF* personnel and divers along with Fairhaven shellfish personnel used the town vessel to deploy the bags for over-wintering at the Fort Phoenix location A marked winter stick attached to a 150 lb. mushroom anchor was deployed to mark the site. To secure the bags, *DMF* divers deployed 30 feet of sinking line laid out between two rebar stakes which was further secured by three rebar staples distributed along its length. Each bag was clipped to the rope in an alternating pattern (left and right of the 30 ft. line), laid

horizontal on the bottom, and staked with stainless steel staples (Figures 46-47). With the secured sinking line, as well as the individual bag stakes, the bags of seed should be secure and immobile throughout the winter.

The seed will be left at this site throughout the winter and collected in April or May 2020. Divers will retrieve the bags, and the seed will be assessed for overall survival and condition. The seed will then be placed back in Fairhaven's FLUPSYs for continued grow-out until they reach ~20mm in shell length or the condition at the end of the growing season (October 2020). At this point, the seed will be broadcast planted at a designated site(s) to be determined by DMF and Fairhaven. Site locations for broadcast seeding of the upweller-reared quahogs in Fairhaven will be proposed by the town Shellfish Constable in close collaboration with *DMF*. Site selection criteria will include factors such as suitable quality and quantity of the benthic habitat available, the proximity of the site to public access for recreational fishing, a recreational shellfishing-only site designation, the area affected by the B-120 oiling and harvest closure, proper Shellfish Growing Area classification and absence of a substantial quahog resource; and municipal strategy for quahog population sustainability including municipal enforcement and management.

Figure 45. Map of the Quahog seed over-wintering location at Fort Phoenix in Fairhaven.

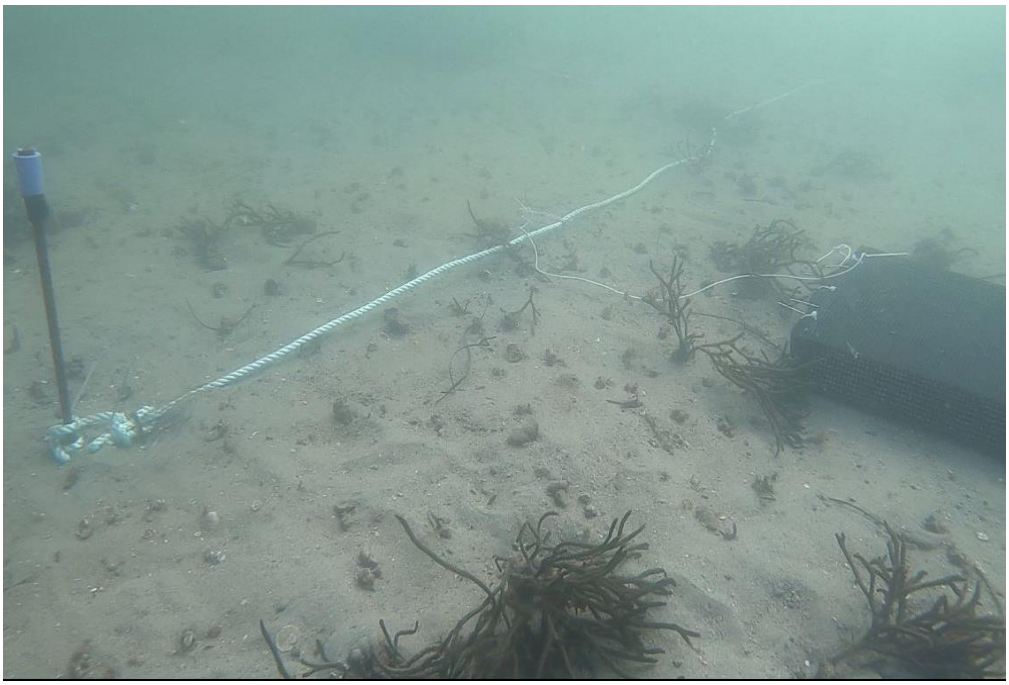

Figure 46. Photo of the sinking line attached to a rebar stake and one of the bags submerged at the over-wintering location near Fort Phoenix, Fairhaven.

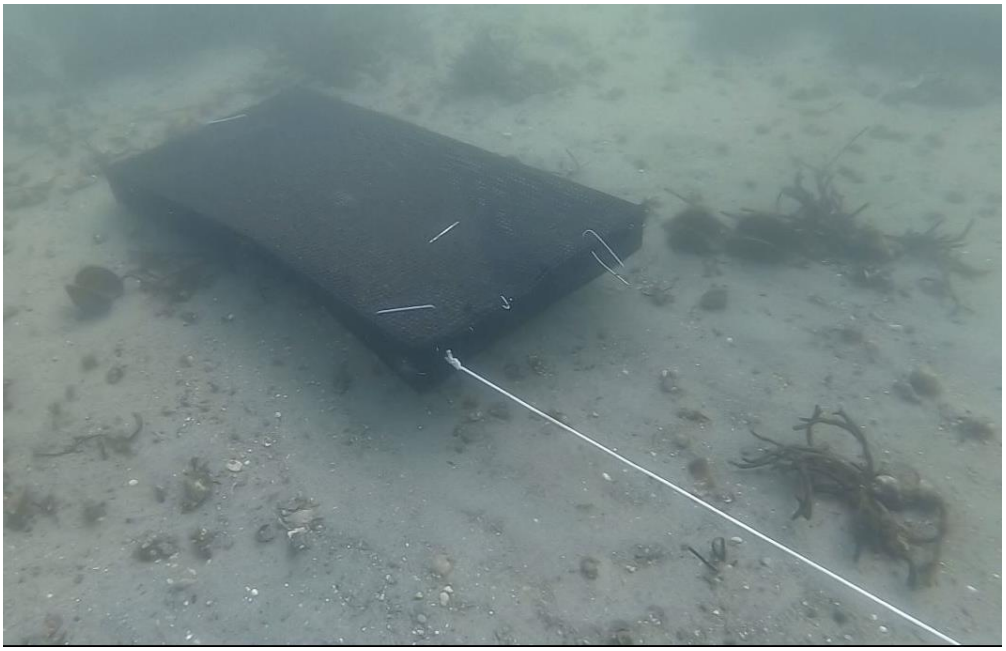

Figure 47. Photo of a submerged bag staked with stainless steel staples at the over-wintering location near Fort Phoenix, Fairhaven.

Results

Quahog Seed Purchase and Grow-out

On June 26th, 2019, Fairhaven received 846,000 1.5mm quahog seed from Muscongus Bay Aquaculture in Maine (Table 31). The quahog seed was divided between two FLUPSY upwellers for grow-out and eventual over-wintering near Fort Phoenix in Fairhaven. The upwellers were maintained on a regular basis by Fairhaven shellfish personnel to maximize survival and growth prior to over-wintering. All purchased quahogs were certified as disease-free by *DMF*-approved shellfish pathology laboratories prior to receipt by the towns (refer to Appendix II).

Data on survival, growth, and planting density were collected throughout the grow-out period. Quahog seed shell length showing growth throughout the season is provided in Figure 48. Two separate seed sorting events occurred throughout this period resulting in four size classes: <4 mm, 4-6 mm, 6-9 mm, and > 9mm. Within these size classes 270,400 <4 mm seed, 323,900 4-6 mm seed, 226,800 6-9 mm seed, and 13,433 >9mm seed were over-wintered (Table 32). The combined survival rate percentage of the over-wintered quahog seed was 98.60 % (Table 31).

Quantity Purchased	Delivery Date	Initial Size	Date Overwintered	Over-wintering location	# Quahogs Over-wintered	Final Size pre-over-wintering	Survival Rate % pre-over-wintering
846,000	6/26/2019	1.5 mm	11/15/2019	Fort Phoenix	834,533	4.3, 5.7, 8.5, 11.1 mm	98.60%

Table 32. Summary of the 2019 Fairhaven quahog seed overwintered.

Seed Size Class	# Over-Wintered	% of Total	Mean Size (mm)	# OW Bags
< 4mm	270,400	32.4	4.3	1
4-6 mm	323,900	38.8	5.7	2
6-9 mm	226,800	27.2	8.5	4
> 9 mm	13,433	1.6	11.1	1

Table 33. Summary of the 2019 Fairhaven quahog seed size classes over-wintered. Seed Class and mean size refer to shell length.

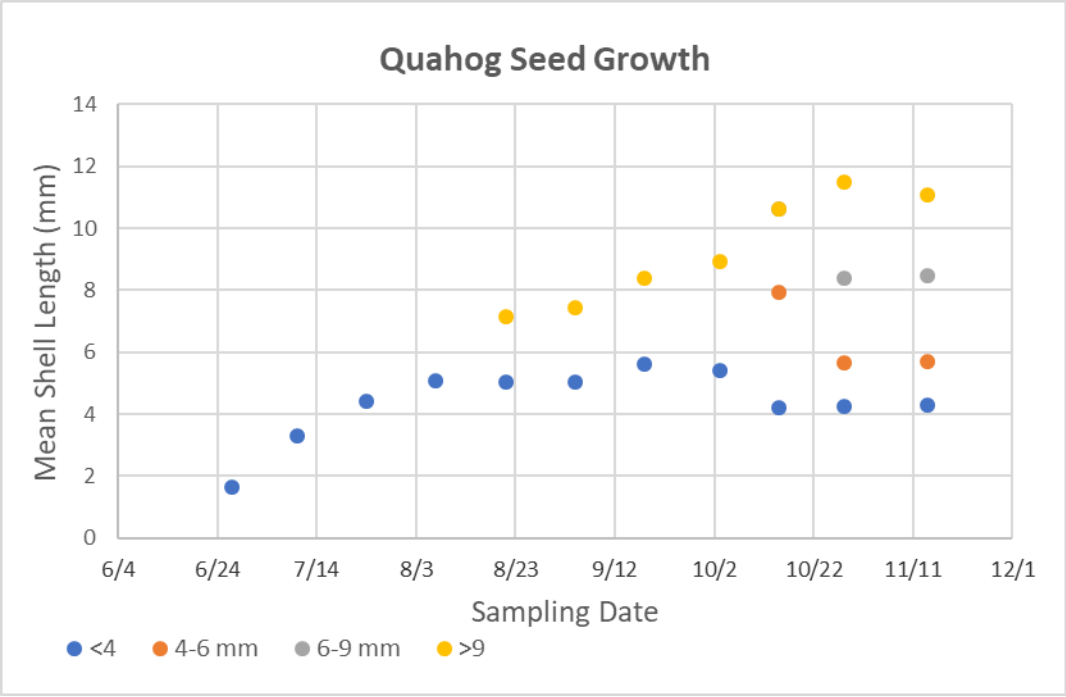

Figure 48. Quahog seed shell length (mm) showing growth over the season. Blue dots denote the small seed (<4 mm), orange dots denote the intermediate seed (4-6 mm), grey dots denote the intermediate seed (6-9 mm), and the yellow dots denote the large seed (>9 mm).

Considerations for Baseline and Performance Monitoring in 2019

As the first year of over-wintering the B-120 quahog seed, several things will be addressed in the 2020 season. *DMF* plans to remove the eight various sized mesh bags from their over-wintering location near Fort Phoenix in April 2020 and access them for overall survival. The seed will then be placed back in Fairhaven's FLUPSYs for continued grow-out until then reach ~20mm in shell length or the end of the growing season in the fall of 2020. *DMF* biologists and Fairhaven Shellfish Department personnel will sample the quahog seed for survival and growth on a bi-weekly basis until they are broadcasted at a to-be-determined location(s).

The Fairhaven Shellfish Department will continue to maintain their two FLUPSY's during the second grow-out season. They will assist with routine sampling, seed sorting events, site surveys, and out-planting. Collaboratively, we will once again focus on proper shellfish husbandry practices that include routine cleaning of the upwellers to control biofouling and buildup of pseudofeces, as well as culling the seed as the quahogs grow. Fast-growing, larger quahogs need to be routinely sorted and separated from smaller individuals in order to lessen competition and achieve uniformly high growth rates across size classes. *DMF* will coordinate with the Fairhaven Shellfish Constable to ensure they have appropriate staff and resources to manage the project.

Literature Cited

Crosby, Michael P. and Laurence D. Gale. 1990. A Review and Evaluation of Bivalve Condition Index Methodologies with a Suggested Standard Method. Journal of Shellfish Research, Vol. 9, No. 1, 233-237.

Marroquin-Mora, D.C. and Rice, M.A. 2008. Gonadal cycle of northern quahogs, Mercenaria mercenaria (Linne, 1758) from fished and non-fished subpopulations in Narragansett Bay. Journal of Shellfish Research 27(4):643-652.

APPENDIX I

2019 Contaminated Quahog Relay Site Maps


Town of Bourne
B-120 Contaminated Quahog Relay Site (2019)
Barlows Landing/Pocasset Harbor
Closure Boundary
Planted Boundary
0
405
810
1,620 Feet
Buzzards Bay
Onset
Monument Bea
Pocasset
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin,


Town of Dartmouth
B-120 Contaminated Quahog Relay Site (2019)
Gulf Road Bridge-South
Closure Boundary
Planted Boundary
0
13,000
26,000
52,000 Feet
New Bedford
Fairhaven
Content may not reflect National Geographics current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS,


Town of Fairhaven
B-120 Contaminated Quahog Relay Site (2019)
North Cove
Closure Boundary
Planted Boundary
0
410
820
1,640 Feet
Fairhaven
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS,


Town of Marion
B-120 Contaminated Quahog Relay Site (2019)
Sippican Harbor-Town Landing
Closure Boundary
Planted Boundary
0 8,750 17,500 35,000 Feet
BEAR SWAMP
Wareham Rd
Main St
Marion
195
Mill St
Content may not reflect National Geographics current map policy. Sources: National Geographic, Esri, Garmin,


Town of Mattapoisett
B-120 Contaminated Quahog Relay Site (2019)
Mattapoisett Harbor
Closure Boundary
Planted Boundary
0
20,500
41,000
82,000 Feet
Rochester
Marion
Acushnet
Mattapoisett
Fairhaven
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS,


Town of New Bedford
B-120 Contaminated Quahog Relay Site (2019)
Coral Street Boat Ramp
Closure Boundary
Planted Boundary
0 16,000 32,000 64,000 Feet
Acushnet
New Bedford Rgnl Airport
New Bedford
Fairhaven
stport
SMITH NECK
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS,


Town of Wareham
B-120 Contaminated Quahog Relay Site (2019)
Mark's Cove
Closure Boundary
Planted Boundary
0
650
1,300
2,600 Feet
Wareham
Blue Star Memorial Hwy
Buzzards B
Onset
Marion
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS,


Town of Westport
B-120 Contaminated Quahog Relay Site (2019)
Westport River, The Let, Southwest quadrant (#4)
Closure Boundary
Planted Boundary
0
305
610
1,220 Feet
Fall River
New Bedford
Tiverton
Portsmouth
NEW BEDFORD RGNL AIRPORT
195
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin,

APPENDIX II

Pathology Screening Results for Quahogs from the 2019 Taunton River Donor Site

KENNEBEC RIVER BIOSCIENCES

Shellfish Health Inspection

Company:	Massachusetts Division of Marine Fisheries	**Report Date:**	17-Apr-19
Address:	706 South Rodney French Blvd.	**Receipt Date:**	26-Mar-19
	New Bedford, MA 02740	**Accession:**	M19032602
Site:	N. side of Braga Bridge, Somerset, MA		
Species:	*Mercenaria mercenaria*	**Collected By:**	Harriet Booth
Age:	Adults	**Date Collected:**	25-Mar-19
Size:	Avg. 90 mm	**Witnessed by:**	John Mendes

Agent	Common Name	Results	Prevalence	Comments
Perkinsus marinus	Dermo	not detected		
Haplosporidium nelsoni	MSX	n/a		
Haplosporidium costale	SSO	n/a		
n/a	QPX	not detected		
Roseovarius crassostreae	JOD/ROD	n/a		
n/a	Neoplastic cells	not detected		
Bonamia ostreae		n/a		
Bonamia exitiosa		n/a		

n/a = not applicable or not requested

Methods:

Shellfish were inspected at an assumed pathogen prevalence level of 5% (60 individuals tested), according to current USFWS & AFS-FHS and OIE protocols. Shellfish were examined for any external or internal morphological abnormalities and fouling organisms. Cross-sections and additional tissues collected were screened for targeted etiologic agents using a combination of RFTM, histology and PCR.

Comments:

External and internal examination did not indicate presence of any fouling, parasitic or infective agents. Testing results for targeted agents are summarized above.

Please feel free to call with any questions or concerns. Thank you for working with Kennebec River Biosciences, Inc.

Sincerely,

Cem Giray Ph.D., CSO

KENNEBEC RIVER BIOSCIENCES

Shellfish Health Inspection

Company:	Massachusetts Division of Marine Fisheries	**Report Date:**	17-Apr-19
Address:	706 South Rodney French Blvd.	**Receipt Date:**	26-Mar-19
	New Bedford, MA 02740	**Accession:**	M19032603
Site:	N. side of Mantaup Electric, Somerset, MA		
Species:	*Mercenaria mercenaria*	**Collected By:**	Harriet Booth
Age:	Adults	**Date Collected:**	25-Mar-19
Size:	Avg. 72 mm	**Witnessed by:**	John Mendes

Agent	Common Name	Results	Prevalence	Comments
Perkinsus marinus	Dermo	not detected		
Haplosporidium nelsoni	MSX	n/a		
Haplosporidium costale	SSO	n/a		
n/a	QPX	not detected		
Roseovarius crassostreae	JOD/ROD	n/a		
n/a	Neoplastic cells	not detected		
Bonamia ostreae		n/a		
Bonamia exitiosa		n/a		

n/a = not applicable or not requested

Methods:

Shellfish were inspected at an assumed pathogen prevalence level of 5% (60 individuals tested), according to current USFWS & AFS-FHS and OIE protocols. Shellfish were examined for any external or internal morphological abnormalities and fouling organisms. Cross-sections and additional tissues collected were screened for targeted etiologic agents using a combination of RFTM, histology and PCR.

Comments:

External and internal examination did not indicate presence of any fouling, parasitic or infective agents. Testing results for targeted agents are summarized above.

Please feel free to call with any questions or concerns. Thank you for working with Kennebec River Biosciences, Inc.

Sincerely,

Cem Giray Ph.D., CSO

KENNEBEC RIVER BIOSCIENCES

Shellfish Health Inspection

Company:	Massachusetts Division of Marine Fisheries	**Report Date:**	17-Apr-19
Address:	706 South Rodney French Blvd.	**Receipt Date:**	26-Mar-19
	New Bedford, MA 02740	**Accession:**	M19032604
Site:	Winslow Point, Fall River, MA		
Species:	*Mercenaria mercenaria*	**Collected By:**	Harriet Booth
Age:	Adults	**Date Collected:**	25-Mar-19
Size:	Avg. 74 mm	**Witnessed by:**	John Mendes

Agent	Common Name	Results	Prevalence	Comments
Perkinsus marinus	Dermo	not detected		
Haplosporidium nelsoni	MSX	n/a		
Haplosporidium costale	SSO	n/a		
n/a	QPX	not detected		
Roseovarius crassostreae	JOD/ROD	n/a		
n/a	Neoplastic cells	not detected		
Bonamia ostreae		n/a		
Bonamia exitiosa		n/a		

n/a = not applicable or not requested

Methods:

Shellfish were inspected at an assumed pathogen prevalence level of 5% (60 individuals tested), according to current USFWS & AFS-FHS and OIE protocols. Shellfish were examined for any external or internal morphological abnormalities and fouling organisms. Cross-sections and additional tissues collected were screened for targeted etiologic agents using a combination of RFTM, histology and PCR.

Comments:

External and internal examination did not indicate presence of any fouling, parasitic or infective agents. Testing results for targeted agents are summarized above.

Please feel free to call with any questions or concerns. Thank you for working with Kennebec River Biosciences, Inc.

Sincerely,

Cem Giray Ph.D., CSO