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INVENTORY OF NEW JERSEY'S ESTUARINE SHELLFISH RESOURCES: HARD CLAM STOCK ASSESSMENT

BARNEGAT BAY (Survey Year 2012)

With

POST-SUPERSTORM SANDY INVESTIGATION (2013)

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Abstract

The New Jersey Marine Fisheries Administration - Bureau of Shellfisheries ("Bureau"), conducted a hard clam [*Mercenaria mercenaria* (Linnaeus 1758)] stock assessment in Barnegat Bay in Ocean County, New Jersey. This was the first comprehensive survey conducted by the Bureau in Barnegat Bay since 1985/86. The Bureau sampled 356 stations using a hydraulic clam dredge and estimated the bay's standing stock and relative distribution of hard clams. Work was conducted between May 30, 2012 and October 25, 2012. The survey resampled stations that were sampled during the 1985/86 survey plus an additional 51 new stations to cover areas not previously sampled. The standing stock of hard clams in the bay for 2012 was estimated at 138.2 million clams. For the purpose of a direct comparison, the stock was also estimated using only those stations that were sampled during both surveys, which yielded an estimate of 136.7 million clams. That estimate represents an approximately 23% decrease in the standing stock compared with the 177.3 million clams estimated in the 1985/86.

Statistical analysis indicated a significant decrease in hard clam abundance when comparing stations sampled in 2012 to those same stations sampled in 1985/86. The mean length of hard clams collected in 2012 was 69.3mm and was a significant increase in length from the mean length of 66.9mm in 1985/86. There was no significant difference in recruitment indices (the percentage of clams sized 30-37mm collected at each station compared with all clams >37 collected at the same station) between the two surveys. Analysis showed a significant decrease in mortality estimates in 2012 as compared with 1985/86.

Ancillary information on the presence or absence of live submerged aquatic vegetation (SAV) was noted from the same dredge sample of hard clams at each station. There was no significant difference found for the proportion of stations containing SAV in 1985/86 compared with those stations in 2012. In 1985/86, 36% of the stations sampled for hard clams contained SAV and in 2012, 35% of the stations contained SAV.

This report also includes results and analysis from an investigation of impacts to hard clams and SAV in Barnegat and Little Egg Harbor Bays conducted following Superstorm Sandy. Superstorm Sandy officially made landfall on October 29, 2012 and survey work was conducted in summer of 2013. No significant difference was found in hard clam abundance or mortality when comparing stations sampled before and after the storm. A significant decrease was found in the proportion of stations containing SAV that were sampled before and after the storm. Of the stations sampled prior to the storm, 60% contained SAV, whereas 45% of the same stations sampled after the storm contained SAV.

Introduction

The Barnegat Bay complex is located in Ocean County, New Jersey (Figure 1). The Route 72 Manahawkin Bay Bridge divides the waterbody, distinguishing Barnegat Bay to the north of the bridge and Little Egg Harbor Bay to the south. The area immediately surrounding the bridge is also known as "Manahawkin Bay" but is not distinguished as such in this report.

The first modern comprehensive survey of clams in Barnegat Bay was performed in 1985/86 by the Bureau as part of its Estuarine Shellfish Research and Inventory Program (Joseph 1986). The purpose of that survey, as well as the one performed in 2012, was to determine the standing stock, distribution, and relative abundance (density) of hard clams in Barnegat Bay. The survey completed in 2012 is nearly identical to the survey performed in 1985/86. Quantitative and qualitative comparisons were made between the two surveys where appropriate.

Additionally, ancillary data on the presence or absence of live SAV at each hard clam sampling station was compared with the ancillary SAV data also collected in 1985/86.

For recent stock assessments of hard clams in the Little Egg Harbor Bay, please see Celestino (2013 and 2003b).

The Barnegat Bay complex has become a focal point for research and management due to Governor Chris Christie's year 2010 announcement of a comprehensive 10-point plan to address the ecological health of the bay (Barnegat Bay Background 2012). This survey provides important information on the hard clam resource in the bay. Unfortunately, complementary data on commercial and recreational harvests are not available because reporting of hard clam harvest in Atlantic coastal bays is not mandatory in New Jersey. Future efforts to manage the resource and understand stock dynamics would benefit from having this data available.

Materials and Methods

Study Site

All field work was conducted in Barnegat Bay, Ocean County, New Jersey (Figures 1-3). All sampling stations were located between the Mantoloking Bridge to the north and the Rt 72 Manahawkin Bay Bridge to the south. Barnegat Bay is one of three micro-tidal bays in the Barnegat Bay estuary, the other two being Manahawkin Bay and Little Egg Harbor Bay. The estuary receives seawater through the Point Pleasant Canal via the Manasquan inlet in the north and from the Barnegat Inlet and Little Egg Inlet in the south (Barnegat Bay Partnership 2010).

Sampling

A total of 356 stations were quantitatively sampled between May 30, 2012 and October 25, 2012. All stations except six (6)[1] were sampled with a hydraulic clam dredge on board the research

[1] Due to shallow water conditions, these stations were sampled using a 22.5" – wide hard clam rake with 3" teeth. Rake distance varied between 50' and 100' depending upon substrate composition. The rake was deployed off the

vessel *Jennings*[2], a 32-foot long, Chesapeake dead rise style vessel. The dredge was equipped with a 12" – wide blade that cut 4" in to the substrate and a stainless steel cage with bars spaced to retain clams 30mm and larger. Although clams less than 30mm were occasionally obtained, clams less than 30mm were not included in any analyses. Water was jetted through nozzles to either loosen the substrate ahead of the knife or to push sediment to the back of the dredge. The forward nozzles, located above the knife, were opened when towing through harder, sandy substrates to loosen the sediments. The rear nozzles, positioned towards the back of the dredge cage, were opened while towing through softer, muddy substrates, to help prevent the knife from becoming clogged with sediment and to expel sediment through the back of the cage. Occasionally, both sets of nozzles were opened when towing through "sticky" sediments, where the sand/mud substrate needed to be both loosened and expelled.

Water was supplied to the nozzles through a 3" hose attached to a hydraulically powered Berkeley irrigation water pump on the deck of the vessel. At 35-40 pounds of pressure per square inch, the pump delivered approximately 300 gallons of water per minute. The dredge was deployed and retrieved using a 3/8" stainless steel wire cable attached to the main haul back winch on the vessel. Towing was accomplished using a 3/4" polypropylene graduated line.

A total of 304 stations were sampled in the 1985/86 survey and these stations were revisited for the 2012 survey. For the 1985/86 survey, Joseph (1986) established a grid system that placed stations at ½ - mile intervals offset along east-west transects spaced ¼ - mile apart, such that stations on adjacent transects were approximately 0.35 miles apart (Figure 4, below). However, due to prior knowledge of reduced hard clam distribution north of Forked River because of lower salinities, Joseph (1986) altered that grid system and established stations at ½ - mile by ½ - mile offset intervals beginning at Stouts Creek and continuing northward to the Mantoloking Bridge. Where necessary, some station positions were adjusted to avoid obstructions or shellfish aquaculture leases that were encountered in 2012 but not in 1985/86[3]. Fifty-one new stations were added in 2012. Where feasible, the new stations adhered to the grid sampling design established by Joseph (1986). For some new stations, following the grid system was not feasible, and stations were placed as close as possible to the grid system. The additional stations increased the overall sampling area, including some areas previously designated as "no data" on the 1985/86 distribution charts. One additional station was a substation #294.

Stations were located using a Garmin GPS 4210 chart plotter. Water quality parameters (salinity, temperature, and dissolved oxygen) were determined in the field at the first and last stations sampled each day using a YSI-85 multimeter.

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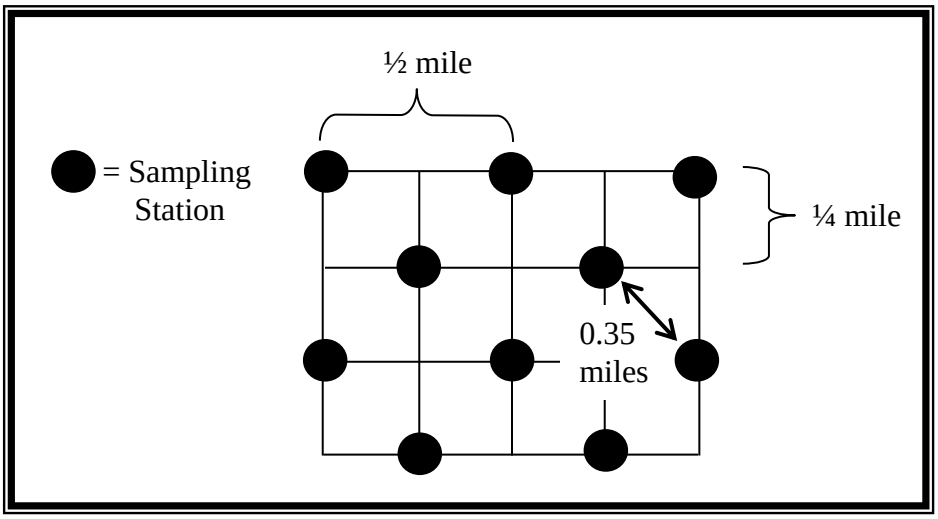
side of a 21' Carolina Skiff and all clams retained were counted and measured. One rake attempt was made at each station. A total of 8 clams were obtained across the 6 raked stations.

[2] This was the same vessel that was used to complete the 1985/86 inventory but was then named R/V *Notata*.

[3] Four stations needed to be relocated from the original location in the 1985/86 survey due to conflicts with currently existing shellfish aquaculture leases and one relay lot. The adjusted stations were placed outside of the lease areas but as close to the original stations as possible. Eight stations had minor corrective coordinate changes in 2012 from the 1985/86 survey. When mapped in ArcGIS, some of the original coordinates placed stations on land or in conflict with other stations. Notes on the data sheets suggest that transcription errors or errors due to dead reckoning or interference occurred. All 8 stations were adjusted to place them at the locations intended by the original station plan chart from 1985.

Figure 4. Schematic of systematic sampling design grid.



Water depth was established using a Lowrance 3200® Computer Sonar unit. The towline length was set at a length-to-depth ratio of 4:1, plus an additional 10' of length to account for the distance from the tow bit to the water line. Prior to towing, the substrate was probed to assist with nozzle selection and the general substrate type (ex. "sand" or "mud") was recorded. Sediment retained in the dredge (if any) also contributed to the qualitative evaluation. A 100' tow was attempted at each station, although 100' was not always achievable due to submerged obstructions, submerged aquatic vegetation, high percentages of clay, or high percentages of decayed marsh. In instances where it appeared that the dredge was not fishing properly, nozzles were adjusted and the tow was repeated. As previously noted (see footnote 1), in instances where water depths were too shallow to effectively navigate the vessel and deploy the dredge, a hard clam rake was used to sample the station.

A graduated distance measuring line with a weight attached to the end was deployed perpendicularly to the vessel and released gradually as the vessel moved forward. When the 100' mark was achieved, the dredge was hauled back while the vessel was kept as stationary as possible to avoid sampling additional area. Additional length was added to the distance line to account for water depths and the angle of the line to the bottom.

After the dredge was retrieved, the dredge was either "washed" by towing it briefly at the surface to expel remaining sediment, or brought on board the vessel immediately if washing was not necessary. The contents of the dredge were deposited on the culling table and sorted. All live hard clams were counted and lengths were measured to the nearest millimeter. Empty, paired hard clam valves, referred to hereafter as "boxes" were also enumerated and measured to the nearest millimeter. Associated species were noted for presence only. Observations of live submerged aquatic vegetation and macroalgae collected in the dredge were also noted.

Hard Clam Analysis

Note that all statistical comparisons were for paired data available from the original 304 stations sampled during the 1985/86 survey and sampled again in 2012. Summary analysis for 2012 data was completed for the original 304 stations and also for all stations sampled in 2012.

Abundance and Distribution

Hard clam abundance, expressed as number of clams per square foot, was calculated for the catch per tow at each station. All data were adjusted for the dredge's overall mean efficiency of 88.0% (±7.7%) by increasing raw abundances by a factor of 1.137 (100 ÷ 88) (see Celestino 2003a). For the purpose of understanding relative abundance and distribution of *Mercenaria*, the following categories were employed: none (0.00 clams/ft^2), occurrence (0.01 - <0.20 clams/ft^2), moderate abundance (0.20 - <0.50 clams/ft^2) and high abundance (≥0.50 clams/ft^2). Each station was assigned a category once the data had been adjusted for dredge efficiency. This category system was employed in previous studies by the Bureau. Figures were produced that visualize the distribution of the different densities of hard clams throughout the bay.

For the purpose of estimating the standing stock of hard clams, stations were categorized according to the same classification intervals established in prior surveys: (0.00 clams/ft^2), (0.01 - <0.06 clams/ft^2), (0.06 - <0.12 clams/ft^2), (0.12 - <0.50 clams/ft^2), (0.50 - <1.0 clams/ft^2), (1.0 - <2.0 clams/ft^2) and (≥2.0 clams/ft^2). Adjacent stations of the same density category were grouped together in polygons using ESRI ArcMap v10.2. The mean density of clams was calculated for each polygon and multiplied by the area of the polygon to get an estimate of the standing stock for that particular area. All areas were summed for a total stock estimate of the bay.

A t-Test for paired means where $\alpha=0.05$ was conducted on hard clam density data for individual stations that were sampled in both surveys. The null hypothesis was that there was no difference in densities of clams between the two surveys. Data for n= 303 paired stations were analyzed.

Population Age/Size Structure

All clams collected that were 30mm and greater were measured for length and graded in to the following commercial size classifications: sublegals (30-37mm), littlenecks (38-55mm) cherrystones (56-76mm) and chowders (>76mm). A composite (sum of all clams measured) length-percent-frequency distribution graph and length-frequency graph were produced, where lengths were combined in to three-millimeter groupings (starting at, but not including clams obtained at 29mm). This three-millimeter bin system was employed in previous estuarine inventories. Length-percent-frequency plots were not produced for individual stations because of low clam abundances (less than 100 clams) per station.

A paired t-Test where $\alpha=0.05$ was used to analyze mean clam lengths between 1985/86 and 2012, where paired data were available (n=202 stations where ≥1 clam was collected in both survey years). The null hypothesis was there was no change in mean clam lengths between the two surveys.

Recruitment

The percentage of sublegal clams collected at each station was calculated as a measure of recruitment at each station. Sublegal clams (30-37mm) collected represented a single year class and thus were expected to recruit in to the fishery at the legal length of 38mm the following year. The recruitment index per station was calculated as

$$\left\{\frac{\text{no. of clams collected between 30 and 37mm at station } i}{\text{total no. of clams collected at station } i}\right\} \text{ x } 100\%$$

If no live clams were collected, recruitment = NA as 0÷0 is undefined. The result from each station was binned and plotted, except those stations were recruitment was undefined.

Statistical analysis was performed for paired stations where abundances were ≥0.20 clams/ft^2 in both survey years (n=9 pairs of stations). The null hypothesis was that there was no change in recruitment between the two survey years, where α=0.05. Because of the low numbers of pairs, the analysis was repeated with an expanded data set that included all stations with >0 clams/ft^2 and where recruitment was >0 (n=14 pairs of stations). The test used α=0.05 and also α=0.01.

Mortality

Natural mortality was calculated for each station using the number of boxes relative to the station's entire sample of boxes and live hard clams.

$$\left\{\frac{\text{no. of boxes at station } i}{\text{no. of boxes at station } i + \text{no. of live clams at station } i}\right\} \text{ x } 100\%$$

The calculation was independent of age, size, or gender of *Mercenaria*. If no live clams or boxes were collected, mortality = NA as 0÷(0+0) is undefined. The result from each station was binned and plotted, except those stations were recruitment was undefined.

A paired t-Test for means (n=210 pairs of stations) where α=0.05 was used to compare mortality indices between the two survey years 1985/86 and 2012. The null hypothesis was that there was no difference in mortality percentages between the two surveys.

Submerged Aquatic Vegetation (SAV) Analysis

The presence or absence of SAV in the same dredge sample used for collecting hard clams was noted for all stations sampled. While reviewing the data, it became evident that some stations where SAV was recorded in the field seemed at odds with the characteristics of the site. Where this occurred, spot-checks using clams tongs were conducted in 2014 to better understand the site characteristics and presence/absence of SAV.

McNemar's Test was used to test the null hypothesis that the proportion of stations containing versus not containing SAV did not change from 1985/86 to 2012.

Results

Description of the Study Site

Sediment type ranged from hard sand to soft mud, and occasionally included clay and peat (decayed marsh). Bottom salinities ranged from 17‰ to 30‰ ($\bar{x}$ = 25‰; SD = 3.5‰) while surface salinities ranged from 15‰ to 28‰ ($\bar{x}$ = 24‰; SD = 3.9‰). Bottom water temperatures ranged from 15°C to 29°C ($\bar{x}$ = 23°C; SD = 3.8°C) and surface temperatures ranged from 15°C to 29°C ($\bar{x}$ = 23°C; SD = 3.9°C). Bottom dissolved oxygen levels ranged from 3.5mg/l to 12.9mg/l ($\bar{x}$ = 6.3mg/l; SD = 2.2mg/l) while surface dissolved oxygen levels ranged from 4.1mg/l to 16.0mg/l ($\bar{x}$ = 6.8mg/l; SD = 2.5mg/l).

Hard Clam Abundance and Distribution

A summary of station location, hard clam abundance, mean length, percent mortality, commercial size classes percentages, and the presence/absence of SAV are provided in Table 1.

The total hard clam resource in Barnegat Bay was estimated at 138.2 million clams (Table 2). This number reflects the estimate based upon the original 304 stations sampled in the 1985/86 survey plus the additional 51 new stations sampled in 2012, which provides a more accurate estimation since the additional stations allow for a more comprehensive analysis. For a direct comparison using only those stations which were sampled in both surveys (stations 1-304), the 2012 estimate of the hard clam resource was 136.7 million clams. This represents a 23% decline in the estimated population compared with the 1985/86 estimate of 177.3 million clams. When the dredge efficiency factor was not applied to the raw data (in order to produce a conservative estimate), the stock was estimated at 121.6 million clams for all stations sampled and 120.2 million clams for stations 1-304 only. An estimate of the stock based upon commercial size classes is presented in Table 3 and Figure 5.

Figures 6a and 6b show the number and frequency (respectively) of stations sampled with low, moderate, and high abundances of hard clams for the 1985/86 and 2012 surveys.

Figures 7-9 depict the distribution and abundance of hard clams in Barnegat Bay for the year 2012 (using all stations sampled). For visual comparison, copies of the distribution charts produced from the 1985/86 survey are included in this report (Figures 10-12). A t-Test for means of paired samples indicated a significantly lower hard clam abundance on a station-by-station basis in 2012 versus 1985/86. The statistical analysis is summarized in Table 4.

Table 2. Summary of hard clam stock estimates for Barnegat Bay.

Survey Year	Clams
1985/86	177,371,706
2012 (1-304)	136,748,617
2012	138,247,723

Table 3. Stock estimate based upon commercial size classes.

	Sublegals	**Littlenecks**	**Cherrystones**	**Chowders**
2012 (all stations)	2,604,596	10,566,526	86,530,695	38,509,443

Table 4. Summary of abundance analysis.

	1985/86	***2012 (1-304)***
Mean	0.151449635	0.101919688
Observations	303	303
df	302	
t Stat	5.815680604	
P(T<=t) two-tail	1.53686E-08	

Population Age/Size Structure

A composite (sum of all clams measured) length-frequency graph and length-percent-frequency distribution graph were produced (Figures 13a and 13b), where lengths were combined in to three-millimeter groupings (starting at, but not including clams obtained at 29mm). Data is presented for 1985/86, 2012 (all stations), and 2012 (stations 1-304 only, for direct comparison with 1985/86 data). A summary of the total number of clams collected and measured in each survey year, along with mean lengths, standard deviation, and other measures of central tendency are presented in Table 5. A t-Test for means of paired samples indicated significantly greater mean lengths in 2012 than in 1985/86 (Table 6).

Table 5. Summary statistics for hard clams lengths. *Two tows were completed in the 1985/86 survey whereas one tow was completed in the 2012 survey.

	1985/86	***2012***	***2012 (1-304)***
N =	6684*	2,709	2,494
$\bar{x}$ =	66.9mm	69.5mm	69.3mm
SD =	10.2mm	11.9mm	11.7mm
Median	69mm	71mm	70.5mm
Mode	68mm	74mm	74mm

Table 6. Summary of hard clam lengths analysis.

	1985/86	*2012(1-304)*
Mean	66.90286566	69.35343288
Observations	202	202
df	201	
	-	
t Stat	4.157631626	
P(T<=t) two-tail	4.75909E-05	

Recruitment

Summary analysis for recruitment was conducted for stations with abundances of ≥ 0.20 clams/ft^2. Table 7 provides a synopsis of measures of central tendency for 1985/86, 2012 (all stations) and 2012 (stations 1-304 only). Figure 14 provides the percentage of recruitment (the percentage of sublegal clams found) at each station throughout the bay.

Table 7. Comparison of hard clam recruitment summary statistics in Barnegat Bay for the 1985/86 and 2012 surveys.

	1985/86	*2012*	*2012 (1-304)*
n=	79	60**	56**
R>0	37	24	21
$\bar{x}$ =	3.5%	6.9%	7.0%
SD=	2.0%	4.3%	4.5%
Median	3.0%	5.6%	5.8%
Minimum	9.2%	2.0%	1.6%
Maximum	98.0%	21.0%	21.1%

n= the number of stations where hard clam abundances were ≥0.20 clams/ft^2.
R>0 = stations where total hard clam abundance was ≥ 0.20 clams/ft^2 and recruitment was >0.
**Excludes stations 197 & 215 due to recording errors in lengths. For completeness, only station 197 had abundance of ≥ 0.20 clams/ft^2.

Initial statistical comparison between the 1985/86 and 2012 surveys used only data from paired stations with abundances of ≥0.20 clams/ft^2 and found no significant difference between the two years. When the analysis was expanded to include all stations where clams were >0 clams/ft^2 and where recruitment was >0, no significant difference was found, nor was significant difference found when α=0.01 was used (Table 8).

Table 8. Summary of recruitment analyses.

	Abundance ≥ 0.20 clams/ft^2		**Abundance >0 clams/ft^2**		**Abundance >0 clams/ft^2 where α=0.01**	
	85-86	***2012(1-304)***	***85-86***	***2012(1-304)***	***85-86***	***2012(1-304)***
Mean	0.043	0.054	0.060	0.098	0.060	0.098
Observations	9.000	9.000	14.000	14.000	14.000	14.000
df	8.000		13.000		13.000	
t Stat	-0.817		-1.148		-1.148	
P(T<=t) two-tail	0.438		0.272		0.272	

Mortality

The distribution of mortality percentages in 2012 (for all stations and for stations 1-304 only) was skewed right, each with >60% of stations showing 0% mortality. Due to the skewness, measures of central tendency were not calculated. See Table 9 for a comparison of mortality bins for 1985/86, 2012, and 2012 (stations 1-304 only). Figure 15 plots the binned mortality percentages throughout the bay.

Table 9. Summary of mortality estimates expressed as numbers of stations and percent of stations.

Mortality Index	***1985/86*** number of stations	***2012*** number of stations	***2012 (1-304)*** number of stations
0	56 (27%)	153 (62%)	127 (60%)
>0-25%	131 (62%)	73 (30%)	66 (31%)
25-50%	18 (9%)	15 (6%)	13 (6)
51-75%	2 (1%)	1 (<1%)	0 (0%)
>75%	3 (1%)	5 (2%)	4 (2%)

Statistical analysis using a paired t-Test showed a significant decrease in natural mortality in 2012 versus 1985/86 (Table 10).

Table 10. Summary of mortality analysis.

	85-86	***2012(1-304)***
Mean	0.12567537	0.072982153
Observations	210	210
df	209	
t Stat	3.383002807	
P(T<=t) two-tail	0.000855936	

Submerged Aquatic Vegetation

McNemar's Chi-squared test with continuity correction indicated no statistically significant change in the proportion of stations containing SAV between the two survey years (p=0.504). Of the 51 newly sampled stations in 2012, 25 stations contained SAV. Figures 16 and 17 visualize the presence/absence information.

Associated Species

At each sampling location, the presence of associated species was noted, but not enumerated. For some species, such as blue crabs (*Callinectes sapidus*) and horseshoe crabs (*Limulus polyhemus*), length and sex were recorded. The data are not presented in this report but are available upon request.

Discussion and Conclusions

Although two stock estimates were produced for this report, the difference in those estimates is approximately 1%, or 1.5 million clams. Of the newly sampled 51 stations in 2012, only 23 contained one or more clams. The direct comparison of the estimates for the two survey years indicates a decline of 23% since 1985/86, while the indirect comparison (using the estimate that includes the new stations) is a decline of 22%. Since the new stations provided information for areas not previously sampled, it is assumed that the estimated 138.2 million clams is more accurate than the estimate produced from only those stations sampled during both surveys. Further, the difference in the two estimates appears to be negligible, and the decline from the 1985/86 estimate remains notable.

Interestingly, the mean abundance at stations appears to have decreased by 33% over time, yet the overall stock appears to have declined only 23%. The difference is likely a result of a greater number of stations with fewer clams, increasing the coverage of lower density areas and decreasing the coverage of higher density areas.

Figures 6a and 6b show that in 2012, more stations contained no clams or low abundances of clams than in 1985/86. Table 11 below summarizes the changes in abundance category from 1985/86 to 2012.

Table 11. Summary of station changes in abundance category from 1985/86 to 2012.

Upgrade	Low to High	2	Downgrade	High to Low	1
	Low to Moderate	22		High to Moderate	7
	None to Low	14		Low to None	25
	Moderate to High	1		Moderate to None	1
	No Change	187		Moderate to Low	44
				n = 304	

While it is encouraging that some stations experienced an upgrade in density category, just over 25% of stations experienced a downgrade. Notably, 25 stations that previously contained low densities of clams contained zero clams in 2012.

With respect to relative abundance and distribution of the resource, note that the following discussion/conclusions are based upon all available data for the year 2012.

Upper Barnegat Bay continued to be categorized by the absence of hard clams, but with notable presence of two pockets (near Mantoloking Bridge) where low abundances of hard clams were found in 2012 but not during the previous survey. One of these pockets showed the presence of soft clams in 1985/86 but no live soft clams were collected during the 2012 survey. Although a shellfish aquaculture lease site was located near these two new pockets of hard clams, it is the Bureau's understanding at the time of this report that those leases were and continue to be used for oyster culture only.

The central portion (with respect to North/South) of the bay remained mostly low density with pockets of moderate densities, although the locations of the moderate density pockets in 2012 are different than in 1985/86 (Figures 8 and 11). Additionally, the central portion in 2012 was fragmented by pockets of areas without clams, and this was not as prevalent in 1985/86. Interestingly, the general stretch of area from just north of Forked River to south of Waretown on the western side of the bay remained largely moderate or high density with only slight fragmentation by low density or no-clam areas. A high density pocket between Forked River and Oyster Creek was lost in 2012, but a new area of high density was found south of Oyster Creek and in a previously designated moderate density area. In particular, the western coast of the bay from Waretown Creek to Barnegat Beach was nearly identical across both survey years with respect to the pattern of abundance and distribution. Shellfish aquaculture leases were present in that area in 2012 (Figures 8 and 9). Leases were also present throughout the 80s but the Bureau has no data on use or productivity of those leases, because such reporting was not mandatory. Thus, there is no conclusive evidence that leases (past or present) influenced the 2012 distribution of hard clams.

The center of the bay (with respect to East/West) near the inlet and north of Gulf Point continued to be mostly moderate density, but with reduced area coverage and without pockets of high density areas mixed in, as was the case in 1985/86. Additionally, the "arm" of the moderate density area centrally located and extending southward off of Gulf Point in 1985/86 was categorized as a low density area in 2012. Closer to the inlet and on the western side of Barnegat Light, a high density area remained present in 2012, although an adjacent moderate density area in 1985/86 was designated as low density in 2012. Also of note in the central portion of the bay was a shift in location of a moderate density pocket associated with the Vol Sedge islands, which are located between Loveladies and Barnegat Light. In 1985/86, the moderate density pocket was present on the southern side of the larger island, whereas in 2012 it was located on the western side of the island (Figure 9).

From about Harvey Cedars south to the Rt 72 bridge, as in 1985/86, the area continued to support only low densities of clams, but was fragmented by areas without clams. A pocket of moderate density clams was present near Harvey Cedars which was designated as low density in 1985/86. Also, a previously designated pocket of moderate density off Surf City was classified as high density in 2012.

The population in both survey years was distinctly dominated by cherrystone sized clams (Figures 13a and 13b). Although mean lengths in 2012 were found to be significantly greater than mean lengths in 1985/86, the difference in average lengths was <3mm and not particularly meaningful at this time.

In terms of recruitment, Table 7 shows that in 2012, thirteen fewer stations had moderate densities of hard clams and the presence of sublegal clams (our indicator of recruitment) than in 1985/86. However, the average percent recruitment for stations with moderate density or higher in 2012 was almost double that of 1985/86 (6.9% in 2012 vs. 3.5% in 1985/86). In Figure 14, the distribution of stations showing recruitment changed only slightly over time. Compared with 1985/86, more stations north of Barnegat Inlet show >0% recruitment in 2012. However, there was a decrease in the number of stations south of the inlet showing recruitment.

In 2012, mortality was significantly lower and also less prevalent than in 1985/86 (Figure 15). It is encouraging that a much greater number of stations in 2012 had 0% mortality, but as noted in previous Bureau studies, it is not generally known how long paired valves remain intact (Celestino 2013). Further, as the dredge was only designed to retain clams 30mm and greater, the data offer no insights on mortality of larvae and clams <30mm.

With respect to submerged aquatic vegetation, it is encouraging that no statistical difference was found in the proportion of stations containing SAV between the two surveys.

Shortcomings exist in estimating the acres of SAV habitat based upon retention of vegetation in the dredge. Because the dredge was washed prior to being emptied on to the culling table, it was possible that vegetation captured by the dredge during the tow was washed out through the cage (and thus the station was considered devoid of vegetation when it may have been present). This phenomenon was more likely to occur in areas of sparser, less dense beds, than it was in areas of lush, dense beds. Additionally, shallower, more protected coves may have been be suitable for

vegetation but because the nearest station was in deeper, open waters, the presence of the habitat may not have been captured in the sampling. In other words, it was possible that near shore areas supported SAV but these areas were undocumented by this inventory. A combination of aerial photography and investigations targeting SAV would significantly improve the estimate, distribution, and density of seagrass beds in New Jersey.

In conclusion, it is disconcerting that the hard clam population was estimated to be 23% lower than the population estimated in 1985/86. This survey was designed only to characterize the hard clam population in Barnegat Bay, and therefore does not provide insight into the causes or factors contributing to the 23% decline in stock. To some extent, commercial and recreational landings data may provide some insights in to the decline, but the reporting of hard clam harvest information is not required by the State.

SUPERSTORM SANDY INVESTIGATION

A truncated survey of Barnegat and Little Egg Harbor Bays was conducted between September 20 and October 4, 2013. The purpose of the investigation was to determine if there were storm-induced changes to hard clams and/or SAV populations and habitats. A total of 132 stations were sampled, with 89 stations in Barnegat Bay and 43 stations in Little Egg Harbor Bay. The number of stations sampled represents approximately 25% of the total stations in the Barnegat Bay complex. The stations were selected as representative of different parts of the bay, different densities of shellfish, and the prior (2012 or 2011) presence or absence of SAV. Figure 18 shows the stations that were sampled. A total of eight additional stations were attempted but unsuccessfully sampled due to changes in bathymetry that prevented navigating to the station. Of the 89 stations sampled in Barnegat Bay, two stations were too shallow to obtain hard clam data but SAV was observed from the vessel.

The sampling methodology employed was identical to that described in the "Materials and Methods" section of this report. The only difference between the two surveys was the survey vessel. The *R/V Zephyrus*, a 42' Chesapeake style dead-rise vessel, was used to tow the same clam dredge previously used on the *R/V Jennings*. A new water pump was also used, but the nozzle selection and pressures used remained consistent with previous values. Due to time constraints, a dredge-calibration study using the new vessel and pump was not performed prior to sampling in 2013. As such, the efficiency value previously calculated for the *R/V Jennings* was applied to all post-Sandy data. The Bureau anticipates performing the calibration study in spring of 2015, and if the efficiency value is determined to be significantly different than that of the *Jennings*, the Bureau will revisit the pre-and post-Sandy analysis.

It should be noted that the washing of the dredge by the *R/V Zephyrus* appeared more powerful than that of the *R/V Jennings*. While this would not have an effect on the dredging efficiency or retention of clams, it may have had an effect on retention of SAV in the dredge, especially in areas where SAV was sparse or of low density. The same possibility existed while using the *Jennings*, but the more powerful nature of the *Zephyrus* made the potential for that phenomenon more likely. Thus, it was possible that SAV existed in parts of the bay that were not reflected by this method of data collection.

Data from the 2012 Barnegat Bay survey and the 2011 Little Egg Harbor Bay survey (Celestino 2013) was used to compare with the data collected post- Superstorm Sandy. A paired t-Test for means showed no significant difference in the densities of shellfish on a station-by-station basis for pre-Sandy and post-Sandy data (Table 12 below).

Table 12. Summary of Pre- and Post-Sandy abundance analysis.

	Pre-Sandy	*Post-Sandy*
Mean	0.25656751	0.2537792
Observations	130	130
df	129	
t Stat	0.14103754	
P(T<=t) two-tail	0.88806029	

Figures 19-21 show side-by-side comparisons of pre- and post-Sandy station densities, beginning at the northern part of Barnegat Bay and continuing south to Little Egg Harbor Bay.

In terms of mortality, there was no significant difference found between pre-Sandy and post-Sandy mortality on a station-by-station basis (Table 13 below). Recall that only stations where at least one live clam was collected can be included in mortality analysis. Figure 22 shows mortality estimates for all post-Sandy data. The length-frequency of boxes collected before and after the storm was plotted for visual comparison (Figure 23). Based upon the visual, it appears that mortality impacts across lengths were distributed similarly before and after the storm.

Table 13. Summary of Pre- and Post-Sandy mortality analysis.

	Pre-Sandy	*Post-Sandy*
Mean	0.05944987	0.055985065
Observations	113	113
df	112	
t Stat	0.25486752	
P(T<=t) two-tail	0.79929283	

McNemar's Chi-squared test with continuity correction revealed that there was a significant difference in the proportion of stations containing SAV prior to the storm versus after the storm ($p << 0.01$). Of the stations sampled prior to the storm, 60% contained SAV, whereas 45% of the same stations sampled after the storm contained SAV.

Figures 24-26 show side-by-side comparisons of pre- and post-Sandy presence/absence of SAV at sampled stations, beginning at the northern part of Barnegat Bay and continuing south to Little Egg Harbor Bay. Note than in Figure 23, an area on the western side of the bay and just south of Toms River was considered "needs more investigation." This station noted the presence of SAV

in both pre-and post-Sandy datasets, but was considered one of the stations that was "at odds" and discussed previously. Because of this, a more thorough investigation of this area is needed.

Superstorm Sandy Discussion

No significant difference in hard clam abundance or hard clam mortality was found for the stations in the Barnegat Bay complex sampled prior to Superstorm Sandy compared with the same stations sampled one year after the storm. Although slight variations exist between the pre- and post-Sandy data, there was nothing to suggest that hard clams experienced a significant adverse impact from the storm. It is also not certain that the boxes collected after the storm were exclusively related to the storm.

The absence of SAV in some areas post-Sandy was not surprising, considering that the storm's main trajectory was the Barnegat Bay complex. However, it is possible that changes observed between the two surveys were unrelated to Sandy, particularly with respect to the 2011 data in Little Egg Harbor. Without 2012 data for Little Egg Harbor Bay, it is impossible to be certain that Sandy caused the absence of SAV at some stations. Further, the potential issues with SAV being retained in the dredge after washing could contribute to observed differences. Regardless of the reasons for changes at stations, it does not appear that Sandy caused wide-spread, catastrophic damage to SAV beds in the complex. During the "spot checks" and other field work in the Bay (unrelated to the stock estimate or post-Sandy investigation) during 2013 and 2014, the Bureau observed SAV beds that appeared to be healthy and thriving. Further, without subsequent post-Sandy data in the years following the storm, it would be premature to assume that immediate, post-Sandy changes are permanent.

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Note: The July 2015 revision reflects and updated stock estimate, increasing the estimated stock by about 2 million clams.

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Figure 1. Location of Barnegat Bay complex in Ocean County, New Jersey

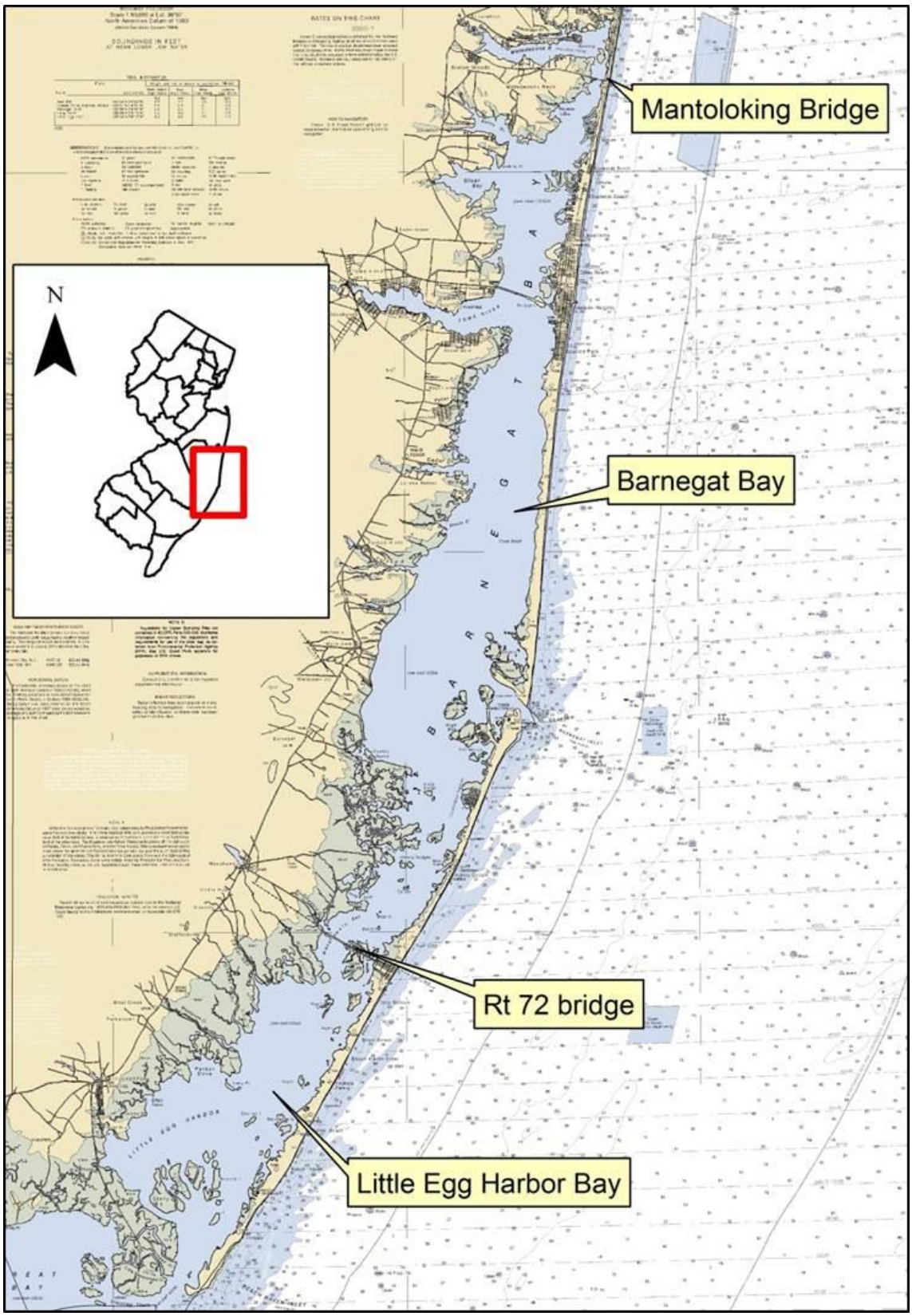


Figure 2. 2012 Barnegat Bay estuarine inventory station locations (chart 1 of 2)

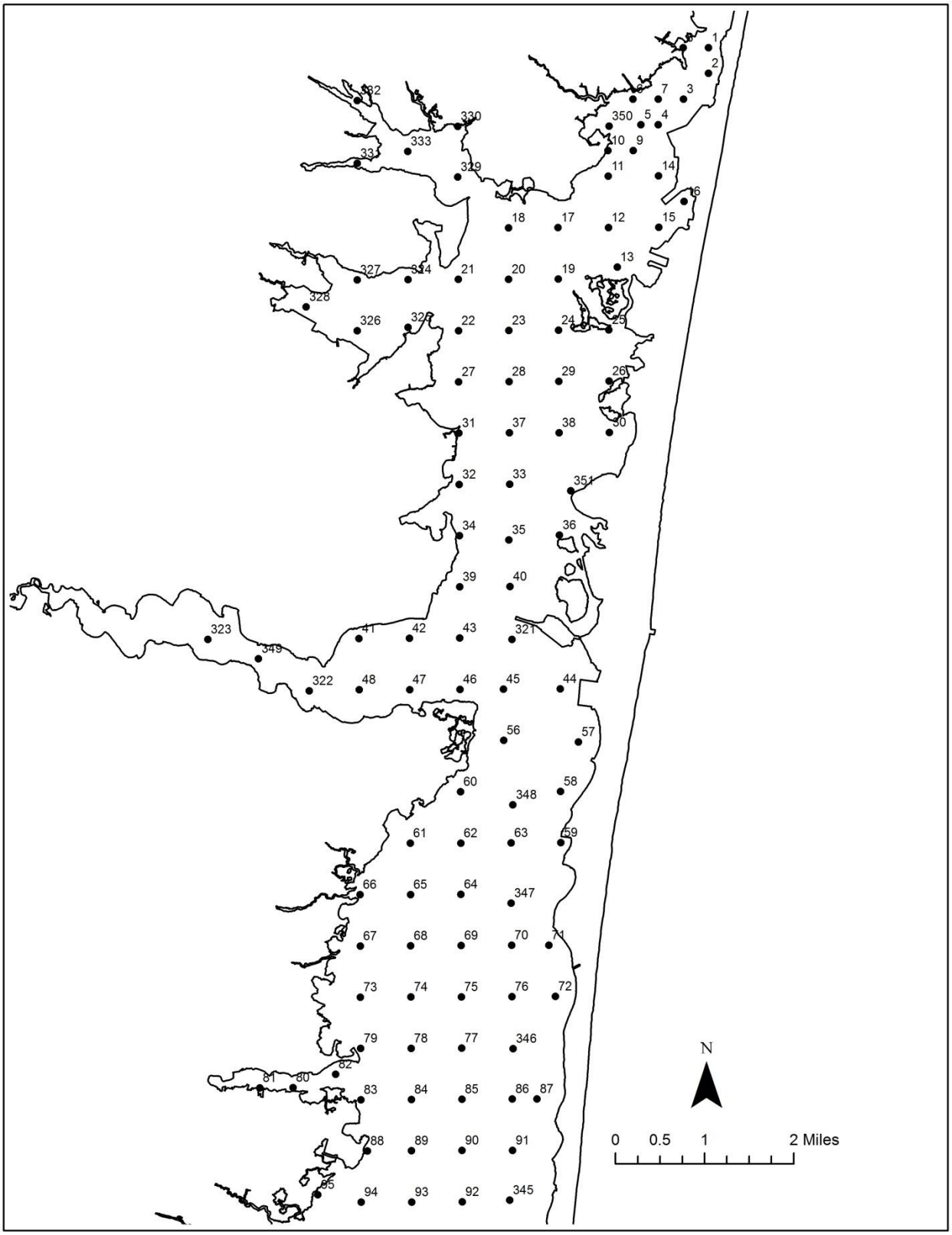


Figure 3. 2012 Barnegat Bay estuarine inventory station locations (chart 2 of 2).

Table 1. Station locations, hard clam abundances, percent mortalities, commercial size class percentages and presence/absence of submerged aquatic vegetation (SAV) for the 2012 inventory of Barnegat Bay.

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-001	5-Oct-12	40 02.250	74 03.360	10.0	0.10	59.9	0.10	0.00	0.22	0.67	0.11	N
BB-12-002	4-Oct-12	40 02.000	74 03.360	8.0	0.01	74.0	0.00	0.00	0.00	1.00	0.00	N
BB-12-003	4-Oct-12	40 01.750	74 03.680	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-004	4-Oct-12	40 01.500	74 04.000	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-005	4-Oct-12	40 01.500	74 04.220	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-006	5-Oct-12	40 01.750	74 04.320	7.0	0.06	70.8	0.50	0.00	0.00	1.00	0.00	N
BB-12-007	4-Oct-12	40 01.750	74 04.000	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-008	5-Oct-12	40 02.250	74 03.680	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-009	4-Oct-12	40 01.250	74 04.320	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-010	5-Oct-12	40 01.250	74 04.640	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-011	4-Oct-12	40 01.000	74 04.640	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-012	4-Oct-12	40 00.500	74 04.640	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-013	9-Oct-12	40 00.114	74 04.530	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-014	5-Oct-12	40 01.000	74 04.000	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-015	9-Oct-12	40 00.500	74 04.000	5.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-016	9-Oct-12	40 00.750	74 03.680	5.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-017	4-Oct-12	40 00.500	74 05.280	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-018	4-Oct-12	40 00.500	74 05.910	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-019	9-Oct-12	39 60.000	74 05.280	5.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-020	4-Oct-12	39 60.000	74 05.910	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-021	4-Oct-12	39 60.000	74 06.550	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-022	4-Oct-12	39 59.500	74 06.550	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-023	4-Oct-12	39 59.500	74 05.910	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-024	9-Oct-12	39 59.500	74 05.280	4.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-025	9-Oct-12	39 59.500	74 04.640	4.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-026	9-Oct-12	39 59.000	74 04.640	4.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-027	4-Oct-12	39 59.000	74 06.550	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-028	4-Oct-12	39 59.000	74 05.910	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-029	4-Oct-12	39 59.000	74 05.280	6.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-030	9-Oct-12	39 58.500	74 04.640	4.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-031	4-Oct-12	39 58.500	74 06.550	5.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-032	4-Oct-12	39 58.000	74 06.550	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-033	4-Oct-12	39 58.000	74 05.910	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-034	2-Oct-12	39 57.500	74 06.550	4.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-035	2-Oct-12	39 57.457	74 05.921	4.0	0.00	NA	NA	NA	NA	NA	NA	R

Table 1. continued

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-036	2-Oct-12	39 57.500	74 05.280	3.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-037	4-Oct-12	39 58.500	74 05.910	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-038	4-Oct-12	39 58.500	74 05.280	6.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-039	2-Oct-12	39 57.000	74 06.550	4.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-040	2-Oct-12	39 57.000	74 05.910	6.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-041	2-Oct-12	39 56.500	74 07.830	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-042	2-Oct-12	39 56.500	74 07.190	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-043	2-Oct-12	39 56.500	74 06.550	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-044	27-Sep-12	39 56.000	74 05.280	5.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-045	27-Sep-12	39 56.000	74 06.000	9.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-046	27-Sep-12	39 56.000	74 06.550	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-047	2-Oct-12	39 56.000	74 07.190	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-048	2-Oct-12	39 56.000	74 07.830	9.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-049	24-Sep-12	39 50.500	74 08.470	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-050	24-Sep-12	39 50.500	74 08.150	10.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-051	24-Sep-12	39 50.500	74 07.830	11.0	0.01	65.0	0.00	0.00	0.00	1.00	0.00	N
BB-12-052	24-Sep-12	39 50.500	74 07.510	11.0	0.02	72.3	0.00	0.00	0.00	0.67	0.33	N
BB-12-053	24-Sep-12	39 50.500	74 07.190	9.0	0.22	67.8	0.17	0.00	0.05	0.84	0.11	N
BB-12-054	24-Sep-12	39 50.500	74 06.870	11.0	0.03	63.3	0.00	0.00	0.00	1.00	0.00	N
BB-12-055	24-Sep-12	39 50.500	74 06.550	7.0	0.05	70.5	0.20	0.00	0.00	1.00	0.00	N
BB-12-056	27-Sep-12	39 55.500	74 06.000	7.0	0.01	65.0	0.00	0.00	0.00	1.00	0.00	N$^{\Sigma}$
BB-12-057	27-Sep-12	39 55.482	74 05.050	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-058	1-Oct-12	39 55.000	74 05.280	5.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-059	1-Oct-12	39 54.500	74 05.280	4.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-060	27-Sep-12	39 55.000	74 06.550	9.0	0.01	61.0	0.00	0.00	0.00	1.00	0.00	N$^{\Sigma}$
BB-12-061	27-Sep-12	39 54.500	74 07.190	7.0	0.03	59.0	0.00	0.00	0.33	0.67	0.00	N
BB-12-062	27-Sep-12	39 54.500	74 06.550	7.0	0.00	NA	NA	NA	NA	NA	NA	N$^{\Sigma}$
BB-12-063	1-Oct-12	39 54.500	74 05.910	6.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-064	1-Oct-12	39 54.000	74 06.550	5.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-065	27-Sep-12	39 54.000	74 07.190	9.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-066	27-Sep-12	39 54.000	74 07.830	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-067	27-Sep-12	39 53.500	74 07.830	8.0	0.01	54.0	0.00	0.00	1.00	0.00	0.00	N
BB-12-068	27-Sep-12	39 53.500	74 07.190	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-069	1-Oct-12	39 53.500	74 06.550	6.0	0.00	NA	NA	NA	NA	NA	NA	ZR
BB-12-070	1-Oct-12	39 53.500	74 05.910	5.0	0.00	NA	NA	NA	NA	NA	NA	R

Table 1. continued

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-071	1-Oct-12	39 53.500	74 05.440	6.0	0.01	42.0	0.00	0.00	1.00	0.00	0.00	N
BB-12-072	1-Oct-12	39 53.000	74 05.360	6.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-073	27-Sep-12	39 53.000	74 07.830	9.0	0.01	40.5	0.00	0.00	0.00	1.00	0.00	N
BB-12-074	27-Sep-12	39 53.000	74 07.190	8.0	0.09	62.9	0.00	0.00	0.13	0.88	0.00	N
BB-12-075	27-Sep-12	39 53.000	74 06.550	7.0	0.06	61.2	0.17	0.00	0.40	0.60	0.00	N
BB-12-076	1-Oct-12	39 53.000	74 05.910	4.0	0.01	64.0	0.00	0.00	0.00	1.00	0.00	R
BB-12-077	25-Sep-12	39 52.500	74 06.550	8.0	0.05	70.8	0.00	0.00	0.00	1.00	0.00	N
BB-12-078	25-Sep-12	39 52.500	74 07.190	10.0	0.01	61.0	0.00	0.00	0.00	1.00	0.00	N
BB-12-079	25-Sep-12	39 52.500	74 07.830	8.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-080	27-Sep-12	39 52.120	74 08.690	5.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-081	27-Sep-12	39 52.137	74 07.104	5.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-082	27-Sep-12	39 52.250	74 08.150	5.0	0.00	NA	1.00	NA	NA	NA	NA	N
BB-12-083	25-Sep-12	39 52.000	74 07.830	7.0	0.00	NA	1.00	NA	NA	NA	NA	N
BB-12-084	25-Sep-12	39 52.000	74 07.190	10.0	0.03	63.7	0.00	0.00	0.33	0.67	0.00	N
BB-12-085	25-Sep-12	39 52.000	74 06.550	9.0	0.02	62.0	0.33	0.00	0.00	1.00	0.00	N
BB-12-086	1-Oct-12	39 52.000	74 05.910	6.0	0.05	61.5	0.00	0.00	0.50	0.50	0.00	ZR
BB-12-087	1-Oct-12	39 52.000	74 05.600	6.0	0.05	54.0	0.00	0.00	0.50	0.50	0.00	ZR
BB-12-088	25-Sep-12	39 51.500	74 07.750	6.0	0.02	43.0	0.00	0.50	0.50	0.00	0.00	N
BB-12-089	25-Sep-12	39 51.500	74 07.190	11.0	0.01	76.0	0.00	0.00	0.00	1.00	0.00	N
BB-12-090	25-Sep-12	39 51.500	74 06.550	10.0	0.02	65.5	0.00	0.00	0.00	1.00	0.00	N
BB-12-091	1-Oct-12	39 51.500	74 05.910	6.0	0.07	65.7	0.00	0.00	0.00	1.00	0.00	ZR
BB-12-092	25-Sep-12	39 51.000	74 06.550	9.0	0.18	60.6	0.16	0.00	0.25	0.69	0.06	N
BB-12-093	25-Sep-12	39 51.000	74 07.190	11.0	0.03	69.0	0.00	0.00	0.00	1.00	0.00	N
BB-12-094	25-Sep-12	39 51.000	74 07.830	10.0	0.02	66.5	0.33	0.00	0.00	1.00	0.00	N
BB-12-095R	25-Sep-12	39 51.074	74 08.380	7.0	0.22	63.9	0.05	0.00	0.16	0.74	0.11	N
BB-12-096	24-Sep-12	39 50.250	74 08.670	6.0	0.33	64.1	0.00	0.03	0.14	0.69	0.14	N
BB-12-097	24-Sep-12	39 50.250	74 08.470	7.0	0.28	68.4	0.04	0.00	0.12	0.72	0.16	N
BB-12-098	24-Sep-12	39 50.250	74 07.830	11.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-099	24-Sep-12	39 50.250	74 07.190	8.0	0.14	68.0	0.08	0.00	0.00	0.83	0.17	N
BB-12-100	24-Sep-12	39 50.250	74 06.550	6.0	0.19	70.5	0.35	0.00	0.00	0.82	0.18	Z
BB-12-101	24-Sep-12	39 50.250	74 05.910	7.0	0.20	68.2	0.00	0.00	0.06	0.89	0.06	Z
BB-12-102	24-Sep-12	39 50.500	74 06.230	6.0	0.09	63.8	0.33	0.00	0.00	0.88	0.13	Z
BB-12-103	27-Sep-12	39 50.000	74 09.110	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-104	27-Sep-12	39 50.000	74 08.790	8.0	0.30	63.1	0.00	0.00	0.12	0.77	0.12	N
BB-12-105	27-Sep-12	39 50.000	74 08.150	11.0	0.05	73.3	0.00	0.00	0.00	0.75	0.25	N

Table 1. continued.

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-106	1-Oct-12	39 50.000	74 07.510	10.0	0.22	69.4	0.05	0.00	0.00	0.84	0.16	N
BB-12-107	1-Oct-12	39 50.000	74 06.870	10.0	0.19	70.2	0.00	0.00	0.06	0.76	0.18	N
BB-12-108	24-Sep-12	39 50.000	74 06.230	7.0	0.09	62.3	0.00	0.00	0.13	0.88	0.00	Z
BB-12-109	24-Sep-12	39 50.000	74 05.910	6.0	0.09	63.5	0.33	0.00	0.00	1.00	0.00	Z
BB-12-110	13-Sep-12	39 49.750	74 06.000	6.0	0.10	63.9	0.10	0.00	0.11	0.89	0.00	ZR
BB-12-111	13-Sep-12	39 49.750	74 06.550	6.0	0.13	64.4	0.27	0.09	0.09	0.82	0.00	ZR
BB-12-112	13-Sep-12	39 49.750	74 07.190	10.0	0.05	70.8	0.00	0.00	0.00	1.00	0.00	N
BB-12-113	13-Sep-12	39 49.750	74 09.430	7.0	0.10	69.7	0.00	0.00	0.00	0.89	0.11	N
BB-12-114	13-Sep-12	39 49.750	74 09.110	9.0	0.07	65.7	0.00	0.00	0.00	1.00	0.00	N
BB-12-115	13-Sep-12	39 49.750	74 08.470	10.0	0.02	78.5	0.00	0.00	0.00	0.50	0.50	N
BB-12-116	13-Sep-12	39 49.750	74 07.830	10.0	0.02	70.5	0.00	0.00	0.00	1.00	0.00	N
BB-12-117	12-Sep-12	39 49.500	74 06.230	6.0	0.07	67.2	0.14	0.00	0.00	1.00	0.00	Z
BB-12-118	12-Sep-12	39 49.500	74 06.870	8.0	0.11	62.8	0.00	0.10	0.20	0.60	0.10	Z
BB-12-119	12-Sep-12	39 49.500	74 07.510	10.0	0.06	66.4	0.00	0.00	0.00	1.00	0.00	N
BB-12-120	12-Sep-12	39 49.500	74 08.150	12.0	0.06	72.4	0.00	0.00	0.00	0.60	0.40	N
BB-12-121	12-Sep-12	39 49.500	74 08.790	10.0	0.05	80.0	0.00	0.00	0.00	0.50	0.50	N
BB-12-122	3-Oct-12	39 49.500	74 09.750	7.0	0.08	68.9	0.30	0.00	0.00	0.86	0.14	N
BB-12-123	3-Oct-12	39 49.500	74 09.430	9.0	0.01	79.0	0.00	0.00	0.00	0.00	1.00	N
BB-12-124	12-Sep-12	39 49.250	74 09.430	6.0	0.30	66.9	0.04	0.08	0.04	0.58	0.31	N
BB-12-125	12-Sep-12	39 49.250	74 09.170	6.0	0.17	65.9	0.06	0.07	0.20	0.33	0.40	N
BB-12-126	12-Sep-12	39 49.250	74 08.470	12.0	0.01	77.0	0.00	0.00	0.00	0.00	1.00	N
BB-12-127	12-Sep-12	39 49.250	74 07.830	10.0	0.07	67.8	0.00	0.00	0.00	1.00	0.00	N
BB-12-128	12-Sep-12	39 49.250	74 07.190	8.0	0.15	65.0	0.13	0.00	0.23	0.69	0.08	N
BB-12-129	12-Sep-12	39 49.250	74 06.550	5.0	0.14	63.4	0.00	0.00	0.08	0.83	0.08	Z
BB-12-130	13-Sep-12	39 49.250	74 05.910	4.0	0.02	57.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-131	13-Sep-12	39 49.000	74 06.230	5.0	0.00	NA	1.00	NA	NA	NA	NA	Z
BB-12-132	13-Sep-12	39 49.000	74 06.870	4.0	0.00	NA	NA	NA	NA	NA	NA	Z
BB-12-133	12-Sep-12	39 49.000	74 07.510	8.0	0.41	70.3	0.00	0.06	0.00	0.61	0.33	N
BB-12-134	3-Oct-12	39 49.620	74 10.150	4.0	0.07	55.7	0.00	0.00	0.67	0.33	0.00	N
BB-12-135	3-Oct-12	39 49.554	74 10.354	4.0	0.01	80.0	0.50	0.00	0.00	0.00	1.00	N
BB-12-136	3-Oct-12	39 49.539	74 10.710	12.0	0.20	62.9	0.05	0.11	0.08	0.72	0.08	N
BB-12-137	3-Oct-12	39 49.420	74 11.036	8.0	0.41	68.7	0.10	0.11	0.00	0.56	0.33	N
BB-12-138	3-Oct-12	39 49.667	74 10.843	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-139	3-Oct-12	39 49.660	74 11.030	3.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-140	12-Sep-12	39 49.000	74 09.750	7.0	0.01	63.0	0.00	0.00	0.00	1.00	0.00	N

Table 1. continued

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-141	12-Sep-12	39 49.002	74 09.432	7.0	0.40	64.6	0.05	0.00	0.11	0.74	0.14	N
BB-12-142	12-Sep-12	39 49.000	74 08.790	11.0	0.11	77.9	0.00	0.00	0.00	0.20	0.80	N
BB-12-143	12-Sep-12	39 49.000	74 08.150	11.0	0.07	80.3	0.00	0.00	0.00	0.17	0.83	N
BB-12-144	12-Sep-12	39 48.750	74 10.070	4.0	0.06	66.4	0.17	0.00	0.00	1.00	0.00	N
BB-12-145	12-Sep-12	39 48.750	74 09.750	8.0	0.09	71.3	0.00	0.00	0.13	0.38	0.50	N
BB-12-146	7-Sep-12	39 48.750	74 09.110	13.0	0.01	85.0	0.00	0.00	0.00	0.00	1.00	N
BB-12-147	7-Sep-12	39 48.750	74 08.470	10.0	0.28	61.4	0.04	0.04	0.32	0.56	0.08	N
BB-12-148	7-Sep-12	39 48.750	74 07.830	9.0	0.27	61.5	0.08	0.13	0.21	0.58	0.08	N
BB-12-149	13-Sep-12	39 48.750	74 07.190	4.0	0.01	67.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-150	13-Sep-12	39 48.750	74 06.550	5.0	0.05	71.3	0.00	0.00	0.00	0.75	0.25	ZR
BB-12-151	13-Sep-12	39 48.750	74 06.000	5.0	0.10	59.7	0.18	0.00	0.00	1.00	0.00	ZR
BB-12-152	3-Oct-12	39 48.678	74 11.920	11.0	0.40	67.9	0.15	0.11	0.06	0.51	0.31	N
BB-12-153	3-Oct-12	39 48.620	74 11.520	10.0	0.22	65.2	0.05	0.05	0.21	0.32	0.42	N
BB-12-154	3-Oct-12	39 48.643	74 11.224	4.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-155	3-Oct-12	39 48.580	74 10.950	11.0	0.03	65.3	0.00	0.00	0.00	1.00	0.00	N
BB-12-156	3-Oct-12	39 48.600	74 10.590	7.0	0.02	39.5	0.00	0.50	0.50	0.00	0.00	N
BB-12-157	3-Oct-12	39 48.650	74 10.350	14.0	0.01	79.0	0.00	0.00	0.00	0.00	1.00	N
BB-12-158	12-Sep-12	39 48.500	74 10.070	4.0	0.20	70.7	0.10	0.00	0.06	0.72	0.22	Z
BB-12-159	7-Sep-12	39 48.500	74 09.430	11.0	0.14	70.1	0.00	0.08	0.08	0.42	0.42	N
BB-12-160	7-Sep-12	39 48.500	74 08.790	8.0	0.19	81.7	0.00	0.00	0.06	0.12	0.82	N
BB-12-161	7-Sep-12	39 48.500	74 08.150	6.0	0.19	77.4	0.11	0.00	0.00	0.47	0.53	Z
BB-12-162	7-Sep-12	39 48.500	74 07.510	7.0	0.38	71.4	0.06	0.00	0.12	0.42	0.45	Z
BB-12-163	12-Sep-12	39 48.250	74 10.390	5.0	0.26	66.2	0.04	0.00	0.09	0.83	0.09	Z
BB-12-164	7-Sep-12	39 48.250	74 10.070	7.0	0.17	66.7	0.00	0.00	0.07	0.87	0.07	N
BB-12-165	7-Sep-12	39 48.250	74 09.750	9.0	0.14	74.8	0.00	0.00	0.00	0.58	0.42	N
BB-12-166	7-Sep-12	39 48.250	74 09.110	10.0	0.22	58.9	0.05	0.21	0.26	0.21	0.32	N
BB-12-167	7-Sep-12	39 48.250	74 08.470	7.0	0.70	76.0	0.02	0.02	0.08	0.31	0.60	Z
BB-12-168	7-Sep-12	39 48.000	74 09.430	10.0	0.09	76.4	0.00	0.00	0.00	0.38	0.63	N
BB-12-169	12-Sep-12	39 48.000	74 10.010	9.0	0.06	71.2	0.00	0.00	0.00	0.80	0.20	N
BB-12-170	12-Sep-12	39 48.000	74 10.390	7.0	0.73	65.6	0.03	0.00	0.09	0.84	0.06	N
BB-12-171	12-Sep-12	39 48.000	74 10.710	5.0	0.05	65.0	0.00	0.00	0.25	0.75	0.00	Z
BB-12-172	6-Sep-12	39 47.750	74 10.710	6.0	0.25	65.6	0.08	0.09	0.00	0.77	0.14	Z
BB-12-173	6-Sep-12	39 47.750	74 10.390	9.0	0.34	61.8	0.00	0.03	0.10	0.77	0.10	N
BB-12-174	6-Sep-12	39 47.750	74 09.750	10.0	0.06	68.0	0.00	0.00	0.20	0.60	0.20	N
BB-12-175	6-Sep-12	39 47.750	74 09.110	6.0	0.42	74.9	0.00	0.00	0.19	0.22	0.59	N

Table 1. continued

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-176	6-Sep-12	39 47.500	74 10.070	11.0	0.09	70.6	0.11	0.00	0.00	0.75	0.25	N
BB-12-177	6-Sep-12	39 47.500	74 09.430	9.0	0.44	73.0	0.05	0.00	0.03	0.69	0.28	N
BB-12-178	6-Sep-12	39 47.500	74 10.710	6.0	0.53	67.3	0.00	0.00	0.04	0.81	0.15	N
BB-12-179	6-Sep-12	39 47.502	74 10.918	4.0	0.10	62.6	0.00	0.11	0.22	0.56	0.11	Z
BB-12-180	13-Sep-12	39 48.500	74 06.870	5.0	0.01	63.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-181	13-Sep-12	39 48.500	74 06.230	5.0	0.11	72.0	0.09	0.00	0.00	0.80	0.20	ZR
BB-12-182	28-Aug-12	39 47.250	74 09.750	9.0	0.16	80.9	0.00	0.00	0.00	0.21	0.79	N$^{\Sigma}$
BB-12-183	28-Aug-12	39 47.250	74 10.390	9.0	0.19	68.6	0.06	0.00	0.00	1.00	0.00	N
BB-12-184	6-Sep-12	39 47.310	74 10.692	8.0	0.48	65.3	0.07	0.02	0.07	0.79	0.12	N
BB-12-185	6-Sep-12	39 47.236	74 10.918	8.0	0.01	47.0	0.50	0.00	1.00	0.00	0.00	N
BB-12-186	28-Aug-12	39 47.000	74 11.030	6.0	0.55	66.9	0.13	0.00	0.17	0.65	0.19	Z
BB-12-187	6-Sep-12	39 47.000	74 10.710	8.0	0.49	68.4	0.00	0.05	0.07	0.63	0.26	N
BB-12-188	30-May-12	39 47.000	74 10.070	9.0	0.22	71.7	0.05	0.00	0.00	0.84	0.16	N
BB-12-189	30-May-12	39 47.000	74 09.430	8.0	0.10	66.7	0.00	0.11	0.11	0.33	0.44	N
BB-12-190	28-Aug-12	39 46.750	74 09.110	5.0	0.42	75.4	0.00	0.00	0.03	0.49	0.49	Z
BB-12-191	28-Aug-12	39 46.750	74 09.750	9.0	0.30	74.1	0.07	0.00	0.04	0.56	0.40	Z
BB-12-192	28-Aug-12	39 46.750	74 10.390	10.0	0.16	69.2	0.00	0.00	0.14	0.64	0.21	N
BB-12-193	28-Aug-12	39 46.750	74 11.030	6.0	0.20	71.3	0.10	0.06	0.00	0.61	0.33	Z
BB-12-194	28-Aug-12	39 46.500	74 11.030	5.0	0.19	65.4	0.00	0.00	0.18	0.71	0.12	Z
BB-12-195	28-Aug-12	39 46.500	74 10.710	9.0	0.44	66.7	0.09	0.00	0.15	0.69	0.15	Z
BB-12-196	28-Aug-12	39 46.500	74 10.070	10.0	0.32	70.3	0.03	0.00	0.00	0.89	0.11	N
BB-12-197$^{\Omega}$	28-Aug-12	39 46.500	74 09.750	9.0	0.28	NA	0.04	0.08	0.00	0.58	0.35	N
BB-12-198	28-Aug-12	39 46.250	74 09.750	9.0	0.27	75.0	0.04	0.00	0.00	0.58	0.42	N
BB-12-199	28-Aug-12	39 46.250	74 10.390	11.0	0.05	70.1	0.11	0.00	0.00	0.88	0.13	N$^{\Sigma}$
BB-12-200	28-Aug-12	39 46.250	74 11.030	8.0	0.36	65.6	0.09	0.00	0.13	0.78	0.09	N
BB-12-201	28-Aug-12	39 45.991	74 11.319	8.0	0.13	71.4	0.00	0.00	0.00	0.64	0.36	N
BB-12-202	28-Aug-12	39 46.000	74 10.710	10.0	0.07	70.5	0.00	0.00	0.00	0.83	0.17	N
BB-12-203	28-Aug-12	39 46.000	74 10.070	10.0	0.38	67.6	0.00	0.00	0.00	1.00	0.00	N
BB-12-204	27-Aug-12	39 46.000	74 09.430	5.0	0.20	76.7	0.22	0.00	0.00	0.39	0.61	Z
BB-12-205	27-Aug-12	39 45.750	74 09.110	3.0	0.01	91.0	0.00	0.00	0.00	0.00	1.00	ZR
BB-12-206	20-Aug-12	39 45.750	74 09.750	9.0	0.31	71.5	0.13	0.00	0.00	0.81	0.19	N$^{\Sigma}$
BB-12-207	20-Aug-12	39 45.750	74 10.390	11.0	0.08	72.0	0.00	0.00	0.00	0.71	0.29	N$^{\Sigma}$
BB-12-208	20-Aug-02	39 45.750	74 11.030	10.0	0.07	76.7	0.00	0.00	0.00	0.67	0.33	N
BB-12-209	20-Aug-12	39 45.750	74 11.350	9.0	0.15	71.9	0.00	0.00	0.00	0.85	0.15	Z
BB-12-210	20-Aug-12	39 45.500	74 11.350	5.0	0.30	69.0	0.04	0.04	0.15	0.46	0.35	Z

Table 1. continued

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-211	20-Aug-12	39 45.500	74 10.710	10.0	0.02	79.0	0.00	0.00	0.00	0.50	0.50	N
BB-12-212	20-Aug-12	39 45.500	74 10.070	10.0	0.13	68.4	0.31	0.00	0.00	1.00	0.00	N
BB-12-213	20-Aug-12	39 45.250	74 11.350	8.0	0.02	56.5	0.00	0.00	0.50	0.50	0.00	N
BB-12-214	20-Aug-12	39 45.250	74 11.030	9.0	0.07	71.2	0.25	0.00	0.00	0.67	0.33	N
BB-12-215$^{\Omega}$	20-Aug-12	39 45.250	74 10.390	10.0	0.03	NA	0.25	0.00	0.00	1.00	0.00	N$^{\Sigma}$
BB-12-216	20-Aug-02	39 45.250	74 09.750	9.0	0.19	70.1	0.15	0.00	0.06	0.76	0.18	N
BB-12-217	20-Aug-12	39 45.000	74 11.350	8.0	0.14	67.9	0.10	0.00	0.11	0.78	0.11	N
BB-12-218	20-Aug-12	39 45.000	74 10.710	10.0	0.10	72.3	0.00	0.00	0.00	0.78	0.22	N
BB-12-219	20-Aug-12	39 45.000	74 10.070	10.0	0.05	69.0	0.20	0.00	0.00	0.75	0.25	N
BB-12-220	8-Aug-12	39 45.000	74 09.430	7.0	0.42	71.1	0.10	0.03	0.00	0.65	0.32	N
BB-12-221	8-Aug-12	39 44.750	74 11.030	7.0	0.18	70.6	0.00	0.00	0.00	0.88	0.13	R
BB-12-222	8-Aug-12	39 44.751	74 10.389	8.0	0.27	65.5	0.04	0.00	0.13	0.75	0.13	N
BB-12-223	8-Aug-12	39 44.750	74 09.750	6.0	0.49	67.4	0.07	0.07	0.12	0.49	0.33	N
BB-12-224	8-Aug-12	39 44.752	74 09.111	8.0	0.25	73.1	0.00	0.00	0.05	0.68	0.27	N
BB-12-225	8-Aug-12	39 44.750	74 08.470	5.0	0.14	75.9	0.00	0.00	0.00	0.58	0.42	ZR
BB-12-226	8-Aug-12	39 44.500	74 08.150	6.0	0.20	69.2	0.00	0.00	0.17	0.61	0.22	ZR
BB-12-227	8-Aug-12	39 44.500	74 08.790	7.0	0.11	71.3	0.09	0.00	0.00	0.90	0.10	N
BB-12-228	8-Aug-12	39 44.500	74 09.430	7.0	0.38	64.2	0.06	0.06	0.21	0.52	0.21	N
BB-12-229	8-Aug-12	39 44.500	74 10.070	6.0	0.30	67.8	0.07	0.00	0.15	0.58	0.27	ZR
BB-12-230	30-Aug-12	39 44.250	74 09.750	7.0	0.06	71.2	0.00	0.00	0.00	1.00	0.00	Z
BB-12-231	8-Aug-12	39 44.250	74 09.110	7.0	0.30	63.1	0.04	0.08	0.12	0.77	0.04	N
BB-12-232	8-Aug-12	39 44.250	74 08.470	5.5	0.15	71.2	0.00	0.00	0.00	0.77	0.23	R
BB-12-233	8-Aug-12	39 44.250	74 07.830	5.0	0.10	72.4	0.00	0.11	0.00	0.33	0.56	R
BB-12-234	30-Aug-12	39 44.250	74 07.510	4.0	0.02	63.0	0.00	0.00	0.50	0.50	0.00	ZR
BB-12-235	30-Aug-12	39 44.000	74 07.510	6.0	0.07	72.8	0.00	0.00	0.00	0.67	0.33	Z
BB-12-236	8-Aug-12	39 44.000	74 09.340	7.0	0.02	72.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-237	8-Aug-12	39 44.000	74 08.790	6.0	0.18	62.7	0.16	0.06	0.25	0.44	0.25	N
BB-12-238	6-Sep-12	39 47.450	74 08.400	4.0	0.25	80.5	0.08	0.00	0.05	0.23	0.73	Z
BB-12-239	6-Sep-12	39 47.413	74 07.778	7.0	0.01	76.0	0.50	0.00	0.00	1.00	0.00	N
BB-12-240	6-Sep-12	39 47.300	74 07.510	15.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-241	6-Sep-12	39 46.370	74 06.870	13.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-242	6-Sep-12	39 45.300	74 06.870	6.0	0.23	73.2	0.13	0.00	0.10	0.45	0.45	Z
BB-12-243	6-Sep-12	39 45.800	74 07.090	15.0	0.03	101.0	0.00	0.00	0.00	0.00	1.00	N$^{\Sigma}$
BB-12-244	6-Sep-12	39 47.480	74 08.800	5.0	0.26	77.9	0.00	0.00	0.00	0.43	0.57	Z
BB-12-245	27-Aug-12	39 46.000	74 08.900	4.0	0.02	79.5	0.00	0.00	0.00	0.50	0.50	Z

Table 1. continued

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-246	27-Aug-12	39 46.250	74 08.850	5.0	0.13	78.5	0.08	0.00	0.18	0.09	0.73	N
BB-12-247	27-Aug-12	39 46.500	74 08.400	11.0	0.05	84.8	0.20	0.00	0.00	0.00	1.00	N
BB-12-248	27-Aug-12	39 46.452	74 07.907	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-249	27-Aug-12	39 46.460	74 07.076	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-250	27-Aug-12	39 46.000	74 07.510	5.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-251	27-Aug-12	39 45.550	74 07.390	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-252	27-Aug-12	39 45.800	74 07.700	4.0	0.02	78.5	0.00	0.00	0.00	0.00	1.00	R
BB-12-253	30-Aug-12	39 43.500	74 08.950	7.0	0.01	70.0	0.00	0.00	0.00	1.00	0.00	N
BB-12-254	30-Aug-12	39 43.750	74 09.110	7.0	0.01	79.0	0.00	0.00	0.00	0.00	1.00	N
BB-12-255	30-Aug-12	39 43.750	74 09.430	6.0	0.01	45.0	0.00	0.00	1.00	0.00	0.00	R
BB-12-256	30-Aug-12	39 43.750	74 08.470	6.0	0.08	68.7	0.42	0.00	0.00	0.71	0.29	ZR
BB-12-257	30-Aug-12	39 43.750	74 08.150	4.0	0.02	86.5	0.00	0.00	0.00	0.00	1.00	Z
BB-12-258	30-Aug-12	39 44.100	74 07.830	5.0	0.07	72.0	0.00	0.00	0.17	0.50	0.33	R
BB-12-259	30-Aug-12	39 44.150	74 08.150	6.0	0.08	68.9	0.00	0.00	0.29	0.43	0.29	ZR
BB-12-260	30-Aug-12	39 43.400	74 08.500	6.0	0.02	72.5	0.00	0.00	0.00	1.00	0.00	Z
BB-12-261	16-Aug-12	39 43.200	74 08.400	4.0	0.06	65.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-262	30-Aug-12	39 43.250	74 08.790	6.0	0.22	76.8	0.00	0.00	0.00	0.32	0.68	ZR
BB-12-263	16-Aug-12	39 42.750	74 08.470	4.0	0.00	NA	0.00	NA	NA	NA	NA	Z
BB-12-264	16-Aug-12	39 42.900	74 08.200	6.0	0.08	64.7	NA	0.00	0.29	0.43	0.29	Z
BB-12-265	16-Aug-12	39 43.002	74 08.791	4.0	0.08	72.3	0.00	0.00	0.00	0.86	0.14	Z
BB-12-266	16-Aug-12	39 42.520	74 08.770	3.0	0.00	NA	NA	NA	NA	NA	NA	Z
BB-12-267	16-Aug-12	39 42.300	74 08.400	15.0	0.00	NA	NA	NA	NA	NA	NA	ZR
BB-12-268	16-Aug-12	39 42.250	74 09.110	5.0	0.03	70.7	0.00	0.00	0.00	1.00	0.00	Z
BB-12-269	16-Aug-12	39 42.300	74 09.530	6.0	0.01	55.0	0.00	0.00	1.00	0.00	0.00	N
BB-12-270	16-Aug-12	39 42.500	74 09.430	10.0	0.18	72.4	0.00	0.00	0.13	0.63	0.25	N
BB-12-271	16-Aug-12	39 42.700	74 09.110	5.0	0.03	65.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-272	16-Aug-12	39 43.000	74 09.430	7.0	0.06	74.4	0.00	0.00	0.00	0.40	0.60	N
BB-12-273	16-Aug-12	39 43.000	74 10.070	7.0	0.03	78.7	0.00	0.00	0.00	0.33	0.67	R
BB-12-274	16-Aug-12	39 43.250	74 09.750	6.0	0.02	80.5	0.50	0.00	0.00	0.00	1.00	Z
BB-12-275	30-Aug-12	39 43.600	74 09.800	5.0	0.07	66.8	0.00	0.00	0.00	0.83	0.17	Z
BB-12-276	16-Aug-12	39 42.000	74 08.720	4.0	0.04	84.0	0.00	0.00	0.00	0.00	1.00	Z
BB-12-277	16-Aug-12	39 42.000	74 09.440	6.0	0.02	82.0	0.00	0.00	0.00	0.00	1.00	N
BB-12-278	16-Aug-12	39 41.750	74 09.750	6.0	0.03	69.7	0.00	0.00	0.00	0.67	0.33	N
BB-12-279	7-Aug-12	39 41.700	74 09.100	9.5	0.39	71.5	0.11	0.00	0.00	0.82	0.18	Z
BB-12-280	7-Aug-12	39 41.500	74 09.150	4.5	0.07	64.7	0.00	0.00	0.33	0.67	0.00	Z

Table 1. continued

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-281	7-Aug-12	39 41.250	74 09.600	3.5	0.00	NA	NA	NA	NA	NA	NA	Z
BB-12-282	7-Aug-12	39 40.986	74 09.274	5.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-283	7-Aug-12	39 40.750	74 09.600	6.0	0.16	76.4	0.00	0.00	0.00	0.71	0.29	N
BB-12-284	2-Aug-12	39 40.500	74 09.910	7.0	0.09	77.3	0.00	0.00	0.00	0.50	0.50	Z
BB-12-285	2-Aug-12	39 40.750	74 10.230	6.0	0.07	75.7	0.00	0.00	0.00	0.67	0.33	Z
BB-12-286	2-Aug-12	39 40.995	74 10.645	6.0	0.16	73.1	0.00	0.00	0.00	0.57	0.43	Z
BB-12-287	2-Aug-12	39 41.250	74 10.870	7.0	0.16	79.3	0.00	0.00	0.00	0.29	0.71	N
BB-12-288	2-Aug-12	39 41.000	74 11.190	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-289	2-Aug-12	39 40.840	74 11.620	7.0	0.00	NA	1.00	NA	NA	NA	NA	N
BB-12-290	2-Aug-12	39 40.950	74 11.660	5.5	0.06	79.0	0.00	0.00	0.00	0.00	1.00	N
BB-12-291	1-Aug-12	39 40.521	74 10.564	8.5	0.07	83.3	0.00	0.00	0.00	0.00	1.00	N
BB-12-292	1-Aug-12	39 40.750	74 10.870	8.0	0.01	89.0	0.00	0.00	0.00	0.00	1.00	N
BB-12-293	2-Aug-12	39 40.500	74 11.190	8.5	0.05	87.5	0.00	0.00	0.00	0.00	1.00	N
BB-12-294	1-Aug-12	39 40.250	74 10.550	7.0	0.14	70.2	0.00	0.00	0.00	0.83	0.17	N
BB-12-294.1	2-Aug-12	39 40.250	74 10.872	7.5	0.02	61.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-295	2-Aug-12	39 40.000	74 10.550	7.0	0.05	64.5	0.33	0.00	0.00	1.00	0.00	Z
BB-12-296	1-Aug-12	39 40.250	74 10.230	12.0	0.15	73.8	0.20	0.00	0.00	0.50	0.50	N
BB-12-297	7-Aug-12	39 39.750	74 10.870	20.0	0.86	70.6	0.00	0.00	0.05	0.73	0.22	R
BB-12-298	2-Aug-12	39 39.350	74 10.970	20.0	0.11	52.6	0.00	0.20	0.40	0.40	0.00	N
BB-12-299	7-Aug-12	39 39.600	74 11.000	17.0	0.00	NA	NA	NA	NA	NA	NA	Z
BB-12-300	2-Aug-12	39 40.050	74 11.100	7.0	0.02	32.0	0.00	1.00	0.00	0.00	0.00	Z
BB-12-301	2-Aug-12	39 40.250	74 11.510	8.0	0.00	NA	NA	NA	NA	NA	NA	Z
BB-12-302	2-Aug-12	39 40.500	74 11.700	6.0	0.05	68.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-303	1-Aug-12	39 39.915	74 11.884	5.5	0.07	63.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-304	1-Aug-12	39 39.750	74 11.500	5.0	0.02	61.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-305	1-Aug-12	39 40.017	74 12.411	6.0	0.00	NA	1.00	NA	NA	NA	NA	N
BB-12-306	1-Aug-12	39 40.251	74 12.151	6.0	0.02	79.0	0.00	0.00	0.00	0.00	1.00	N
BB-12-307	7-Aug-12	39 41.000	74 09.860	5.0	0.11	75.2	0.00	0.00	0.00	0.60	0.40	Z
BB-12-308	7-Aug-12	39 41.198	74 10.232	3.0	0.00	NA	NA	NA	NA	NA	NA	Z
BB-12-309	7-Aug-12	39 41.500	74 10.550	6.0	0.09	73.8	0.00	0.00	0.00	0.75	0.25	N
BB-12-310	7-Aug-12	39 41.749	74 10.286	4.0	0.00	NA	NA	NA	NA	NA	NA	Z
BB-12-311	7-Aug-12	39 42.126	74 10.551	4.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-312	7-Aug-12	39 42.108	74 09.901	4.0	0.00	NA	NA	NA	NA	NA	NA	Z
BB-12-313	30-Aug-12	39 43.250	74 09.266	5.0	0.05	69.1	0.00	0.13	0.00	0.50	0.38	N
BB-12-314	16-Aug-12	39 43.146	74 10.665	5.0	0.03	78.3	0.00	0.00	0.00	0.33	0.67	N
BB-12-315	30-Aug-12	39 43.881	74 10.070	5.0	0.11	69.7	0.00	0.00	0.10	0.60	0.30	N

Table 1. continued

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-316	8-Aug-12	39 44.547	74 10.716	3.0	0.05	72.0	0.00	0.00	0.00	0.75	0.25	ZR
BB-12-317	8-Aug-12	39 44.999	74 08.952	7.0	0.20	69.6	0.05	0.06	0.06	0.56	0.33	ZR
BB-12-318	8-Aug-12	39 45.250	74 09.110	5.0	0.07	75.2	0.14	0.00	0.00	0.50	0.50	Z
BB-12-319	20-Aug-12	39 45.503	74 09.429	7.0	0.28	70.3	0.04	0.00	0.00	0.84	0.16	Z
BB-12-320	6-Sep-12	39 45.103	74 06.871	21.0	0.28	60.0	0.00	0.04	0.32	0.48	0.16	N
BB-12-321	2-Oct-12	39 56.485	74 05.888	5.0	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-322	2-Oct-12	39 55.992	74 08.463	9.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-323	2-Oct-12	39 56.497	74 09.748	9.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-324	5-Oct-12	40 00.000	74 07.189	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-325	5-Oct-12	39 59.535	74 07.191	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-326	5-Oct-12	39 59.504	74 07.837	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-327	5-Oct-12	40 00.001	74 07.835	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-328	5-Oct-12	39 59.739	74 08.482	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-329	5-Oct-12	40 00.999	74 06.552	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-330	5-Oct-12	40 01.494	74 06.549	5.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-331	5-Oct-12	40 01.135	74 07.826	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-332	5-Oct-12	40 01.748	74 07.825	6.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-333	5-Oct-12	40 01.251	74 07.186	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-334	1-Aug-12	39 40.205	74 12.906	4.5	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-335	1-Aug-12	39 40.390	74 12.789	4.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-336	28-Aug-12	39 47.002	74 08.789	4.0	0.06	78.4	0.00	0.00	0.00	0.40	0.60	Z
BB-12-337	28-Aug-12	39 47.252	74 09.110	4.0	0.05	67.8	0.00	0.00	0.00	1.00	0.00	Z
BB-12-338	7-Sep-12	39 48.004	74 08.789	4.0	0.74	74.9	0.04	0.09	0.02	0.25	0.64	Z
BB-12-339	13-Sep-12	39 48.251	74 07.830	6.0	0.14	80.5	0.14	0.00	0.00	0.25	0.75	N
BB-12-340	13-Sep-12	39 48.001	74 07.511	4.0	0.05	81.8	0.60	0.00	0.00	0.25	0.75	Z
BB-12-341	13-Sep-12	39 48.251	74 07.190	4.0	0.01	63.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-342	13-Sep-12	39 48.005	74 06.865	5.0	0.01	61.0	0.00	0.00	0.00	1.00	0.00	Z
BB-12-343**	25-Oct-12	39 48.251	74 06.550	4.0	0.00	NA	NA	NA	NA	NA	NA	ZR
BB-12-344**	25-Oct-12	39 50.493	74 05.590	2.5	0.01	54.0	0.00	0.00	1.00	0.00	0.00	ZR
BB-12-345	1-Oct-12	39 51.014	74 05.950	4.0	0.09	65.5	0.00	0.00	0.25	0.75	0.00	ZR
BB-12-346	1-Oct-12	39 52.493	74 05.899	5.0	0.02	54.0	0.00	0.00	0.50	0.50	0.00	ZR
BB-12-347	1-Oct-12	39 53.913	74 05.915	4.0	0.00	NA	NA	NA	NA	NA	NA	ZR
BB-12-348	1-Oct-12	39 54.872	74 05.887	5.0	0.00	NA	NA	NA	NA	NA	NA	ZR
BB-12-349	2-Oct-12	39 56.306	74 09.106	9.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-350	5-Oct-12	40 01.489	74 04.627	6.0	0.00	NA	NA	NA	NA	NA	NA	N

Table 1. continued

Station	Date	Latitude	Longitute	Depth (feet)	Abundance $_{adj}^{*}$ (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV Present?$^{\Delta}$
BB-12-351	9-Oct-12	39 57.934	74 05.136	7.0	0.00	NA	NA	NA	NA	NA	NA	N
BB-12-352**	25-Oct-12	39 50.489	74 05.910	3.0	0.00	NA	NA	NA	NA	NA	NA	Z
BB-12-353**	25-Oct-12	39 44.751	74 07.830	2.0	0.01	82.5	0.00	0.00	0.00	0.50	0.50	ZR
BB-12-354**	25-Oct-12	39 44.751	74 07.190	2.5	0.00	NA	NA	NA	NA	NA	NA	R
BB-12-355**	25-Oct-12	39 44.501	74 07.510	4.0	0.03	73.4	0.00	0.00	0.00	0.60	0.40	R

*= hard clam abundances adjusted for dredge efficiency, except those stations sampled by hard clam rake
Δ= Z= Zostera marina, R = Ruppia maritima, ZR= Zostera & Ruppia, N= no SAV
** = stations sampled with hard clam rake
Ω= stations where length frequency data is not available due to improper recording of live clams and boxes
Σ = stations where SAV presence was recorded in field, but subsequent review of data and spot-check in 2014 excludes station from being considered as eligible SAV habitat

Figure 5. Hard clam stock estimate by commercial size class.

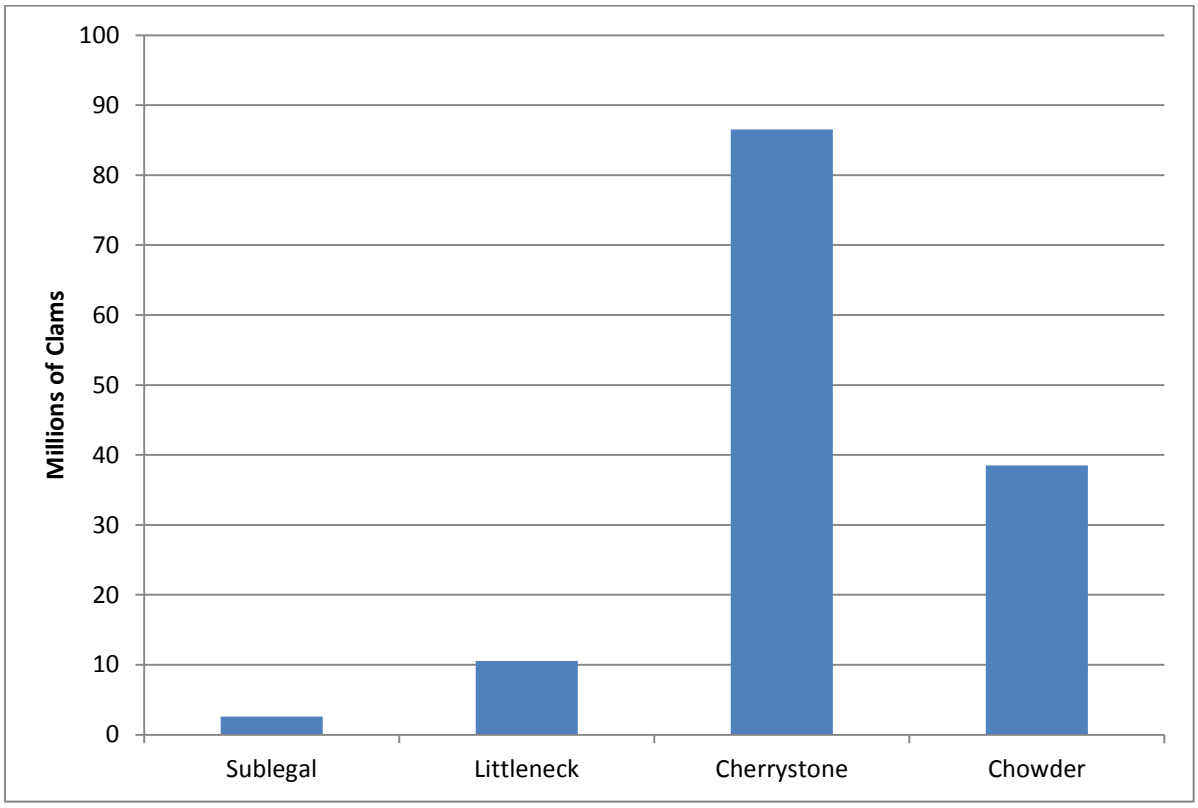
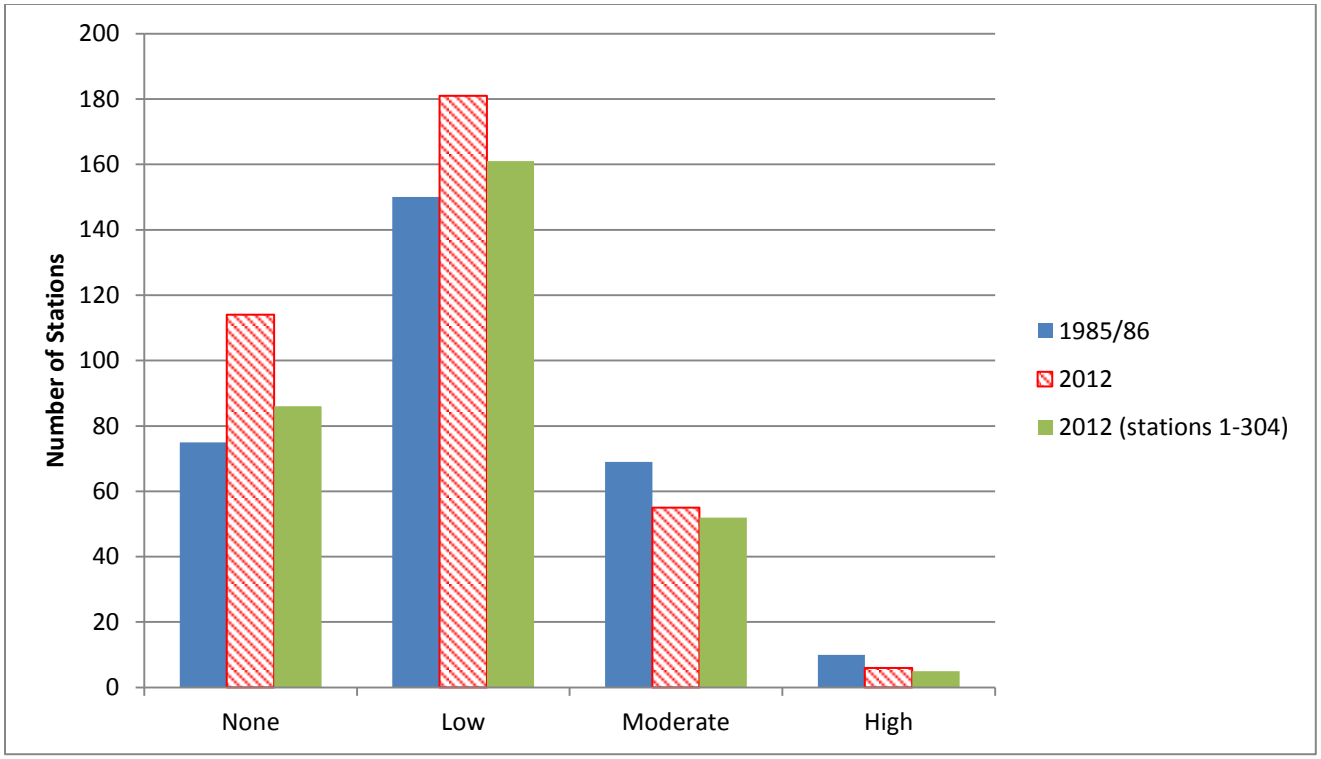


Figure 6. The number (a) and frequency (b) of stations sampled with no (0 clams/ft^2), low (0.01-0.19clams/ft^2), moderate (0.20-0.49 clams/ft^2) and high (>0.50 clams/ft^2) abundances of hard clams from surveys conducted in 1985/86 and 2012.

(a)



(b)

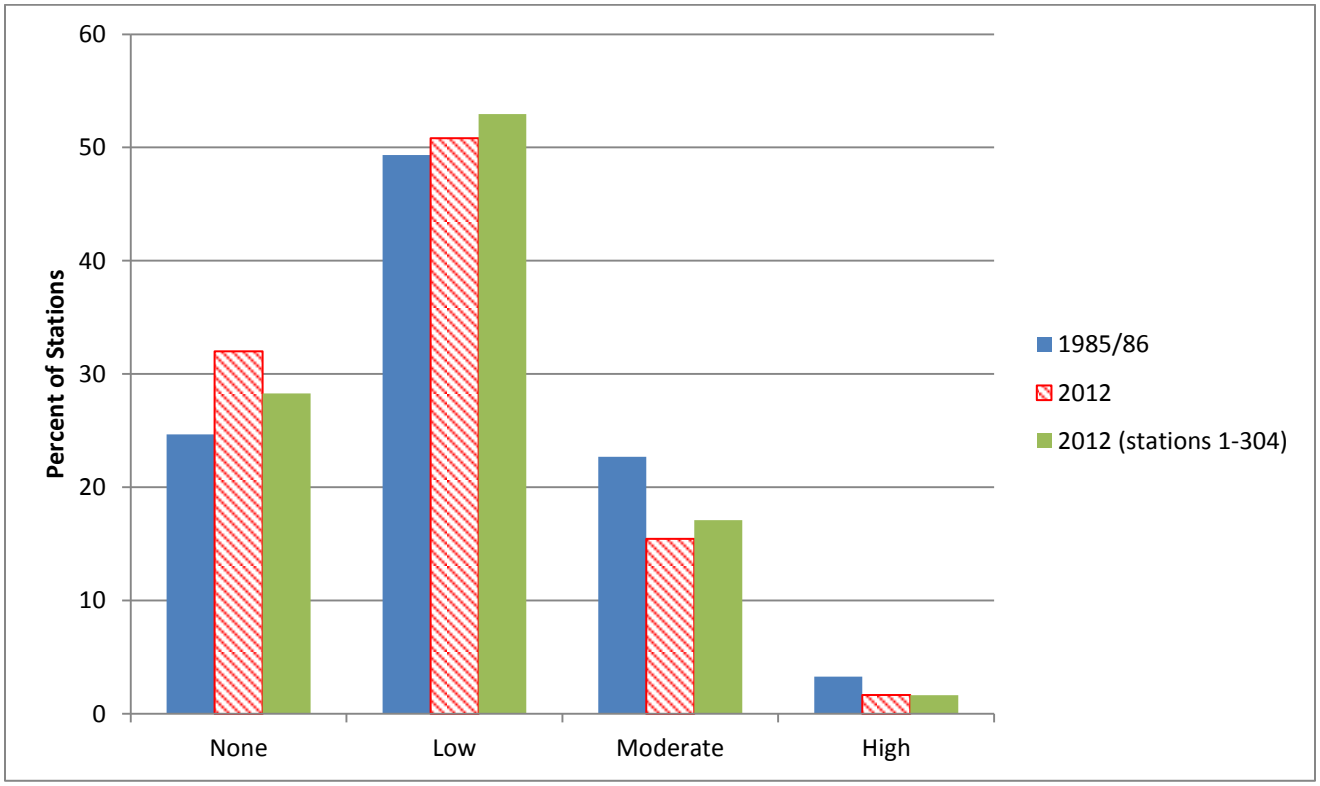


Figure 7. Hard clam distribution for upper Barnegat Bay, 2012. Areas without shading or coloring are read as "None."

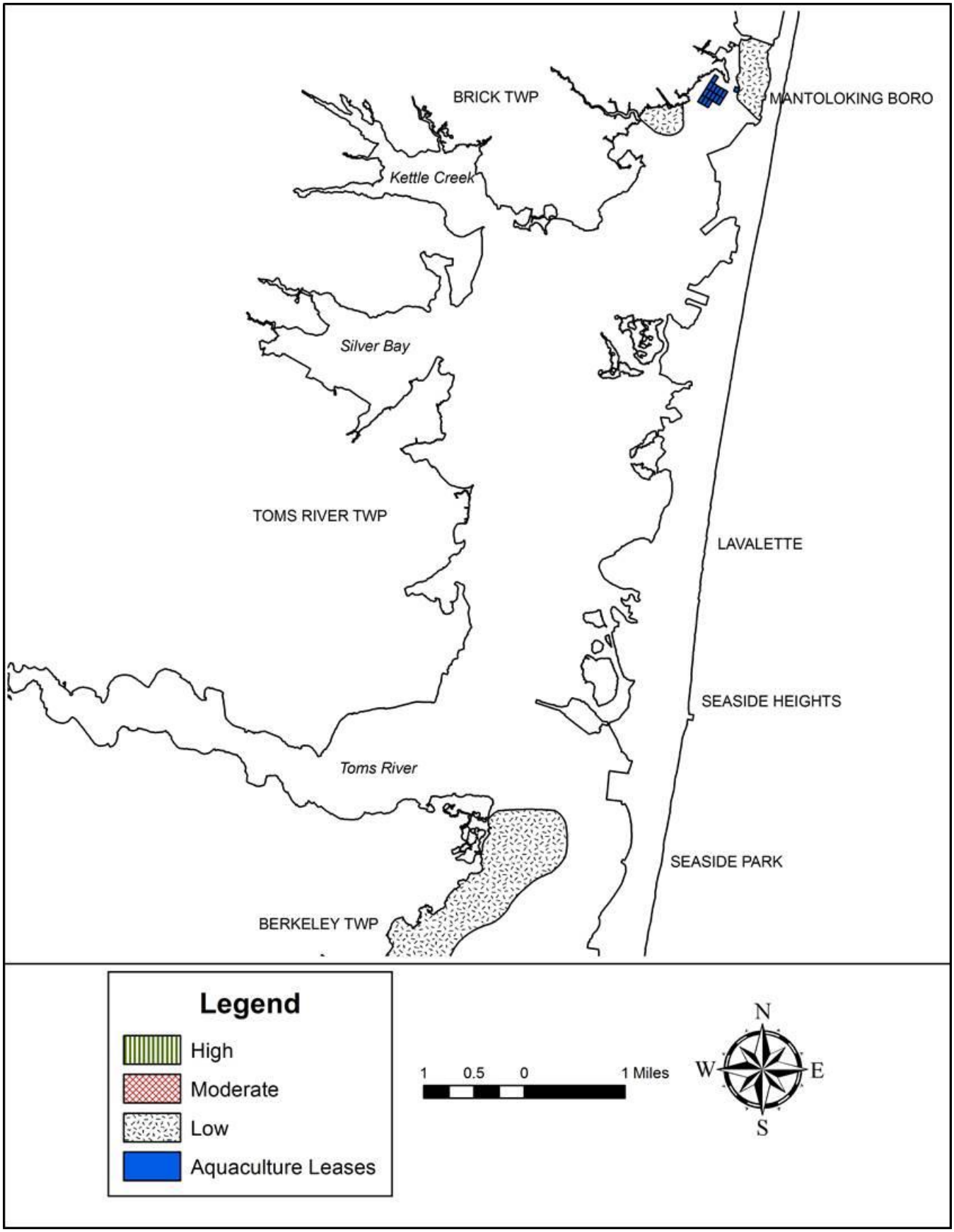


Figure 8. Hard clam distribution for central Barnegat Bay, 2012. Areas without shading or coloring are read as "None."

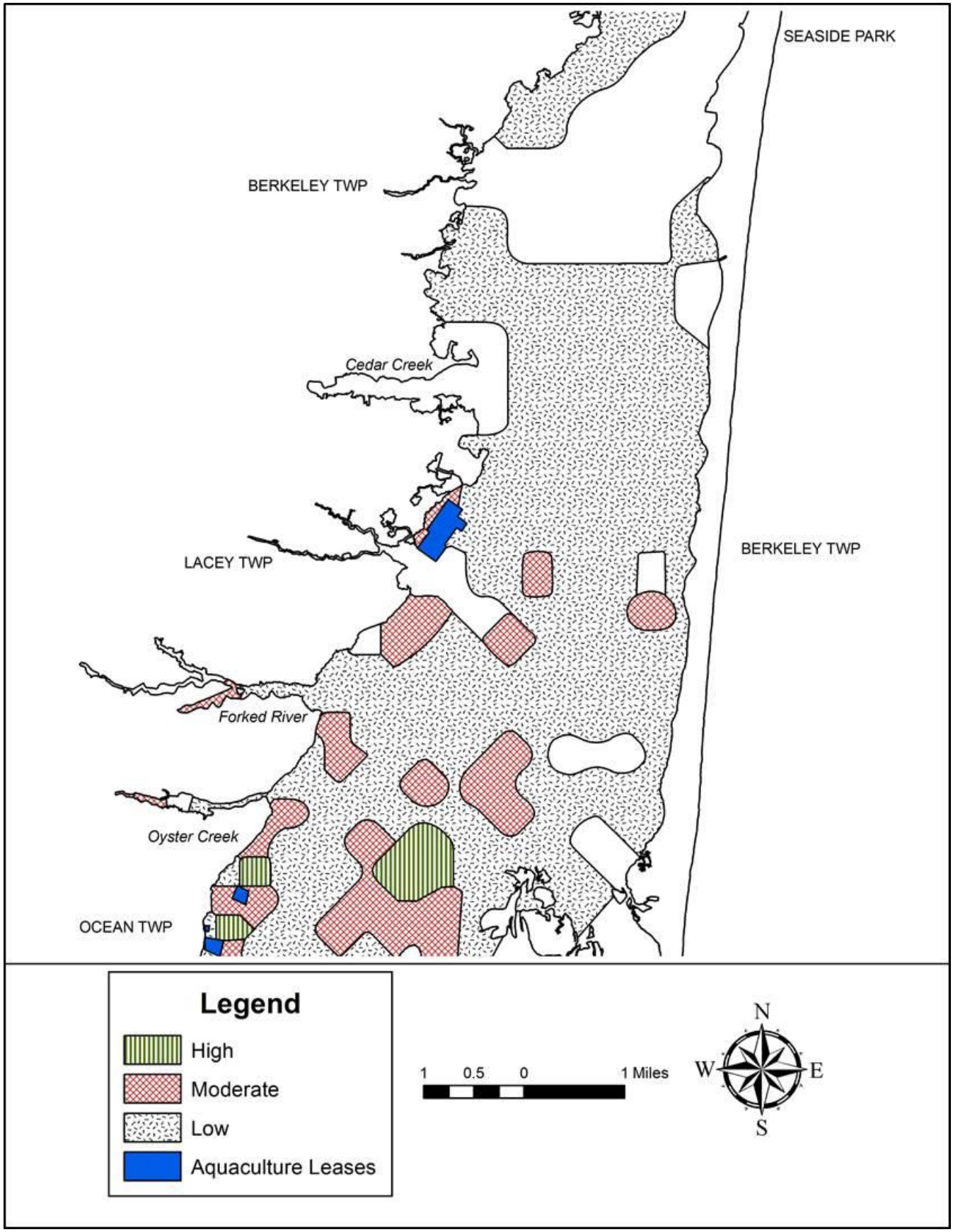


Figure 9. Hard clam distribution for lower Barnegat Bay, 2012. Areas without shading or coloring are read as "None."

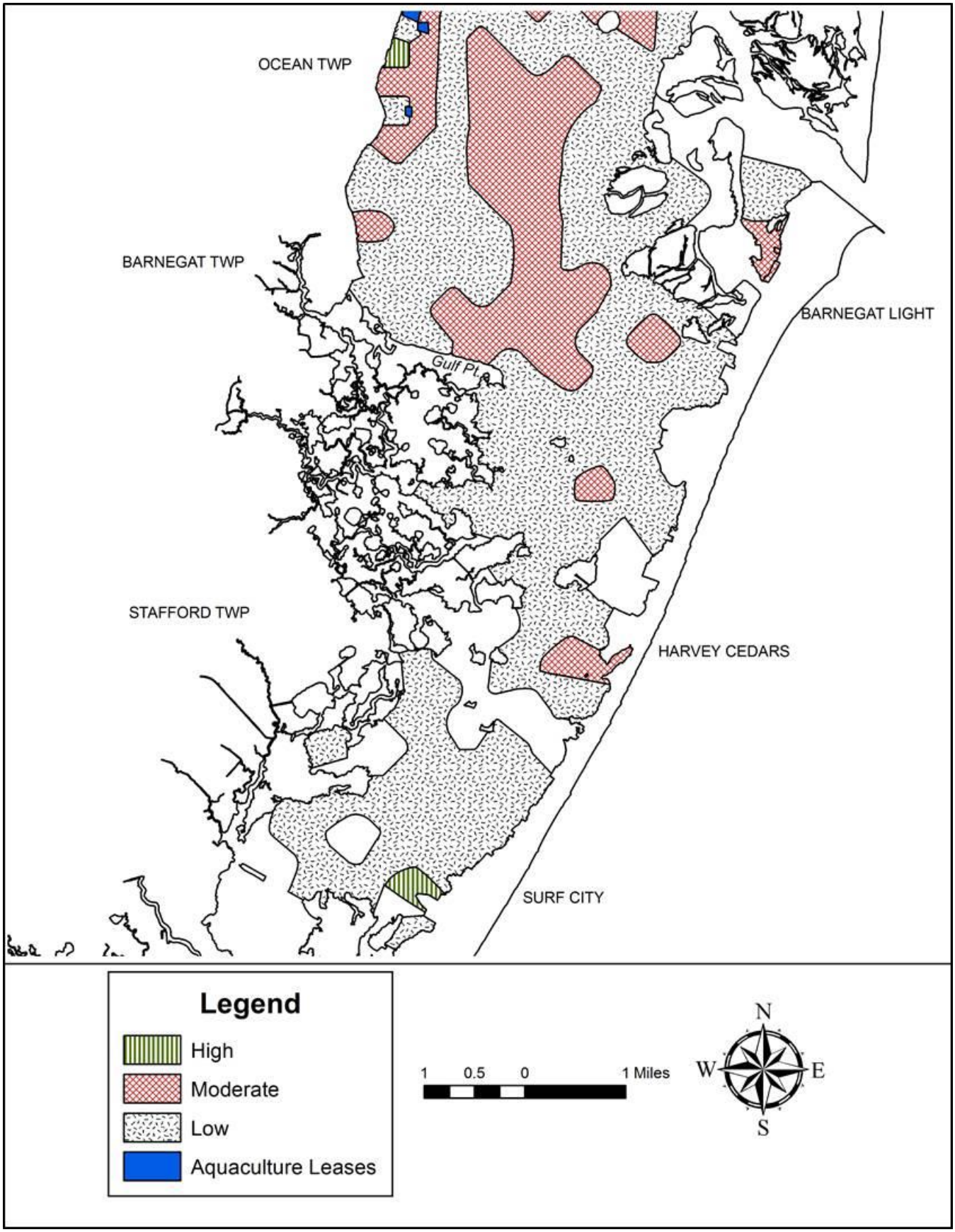


Figure 10. Upper Barnegat Bay Hard Clam Chart, 1986.

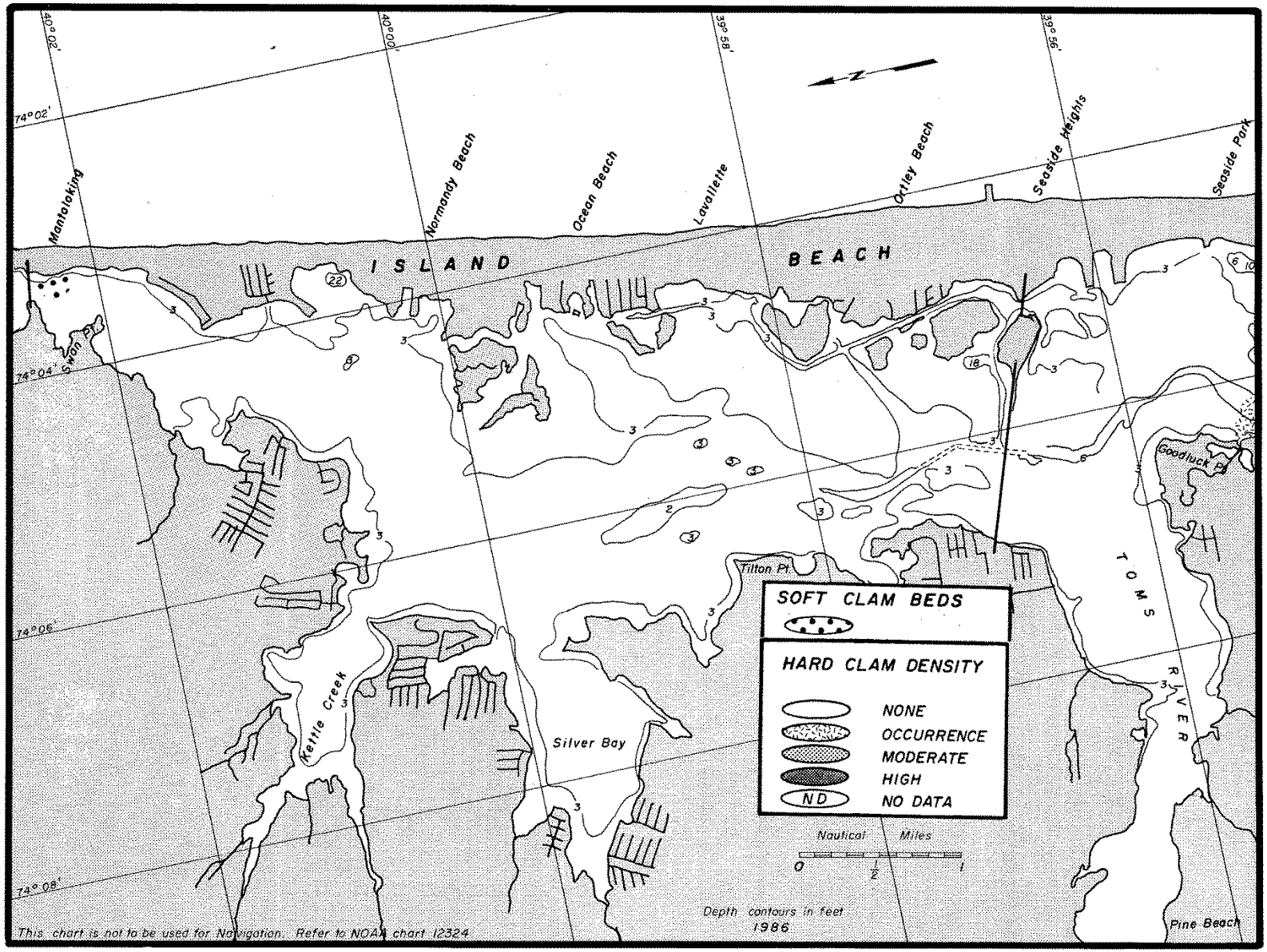


Figure 11. Central Barnegat Bay Hard Clam Chart, 1986.

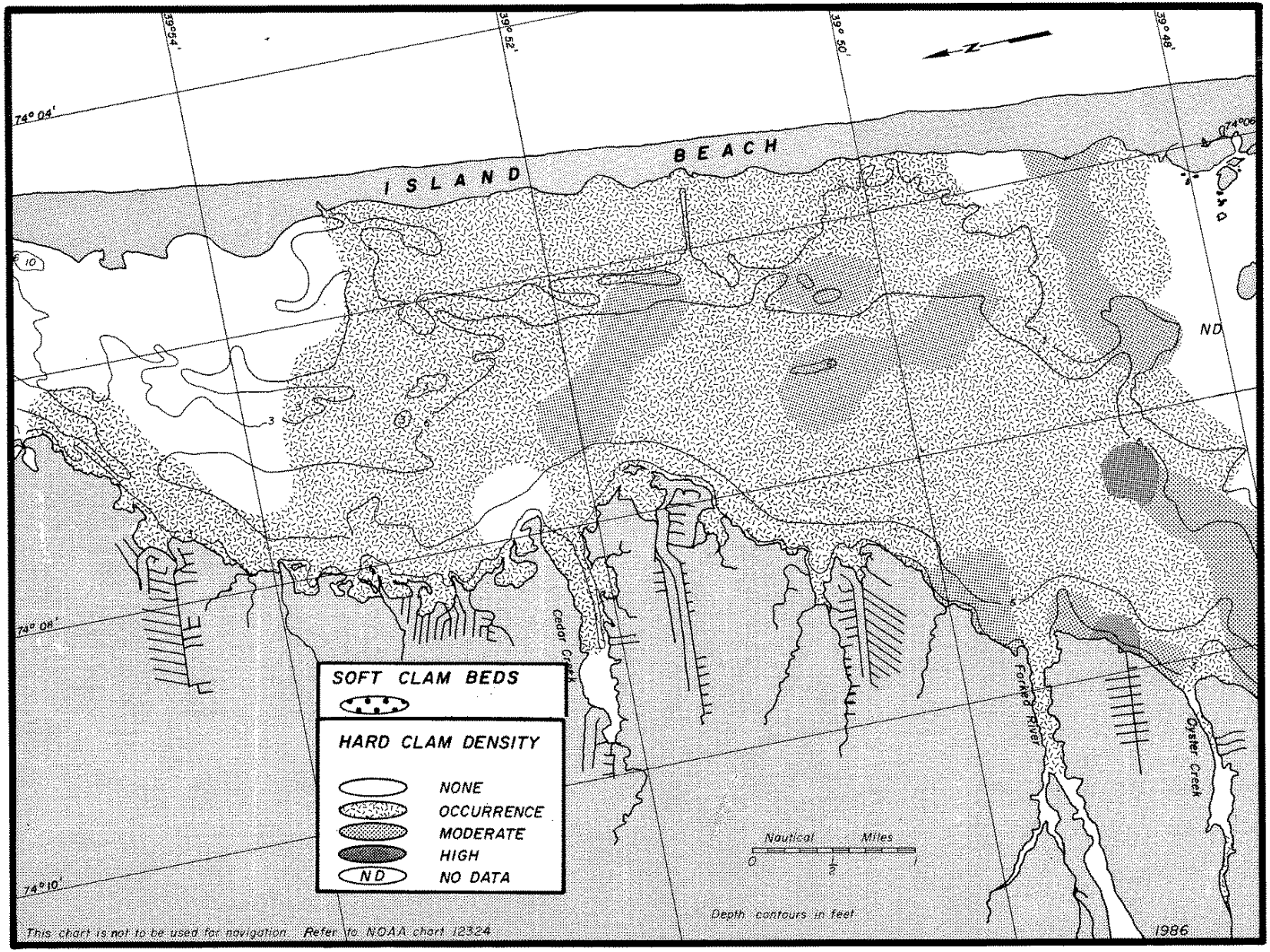
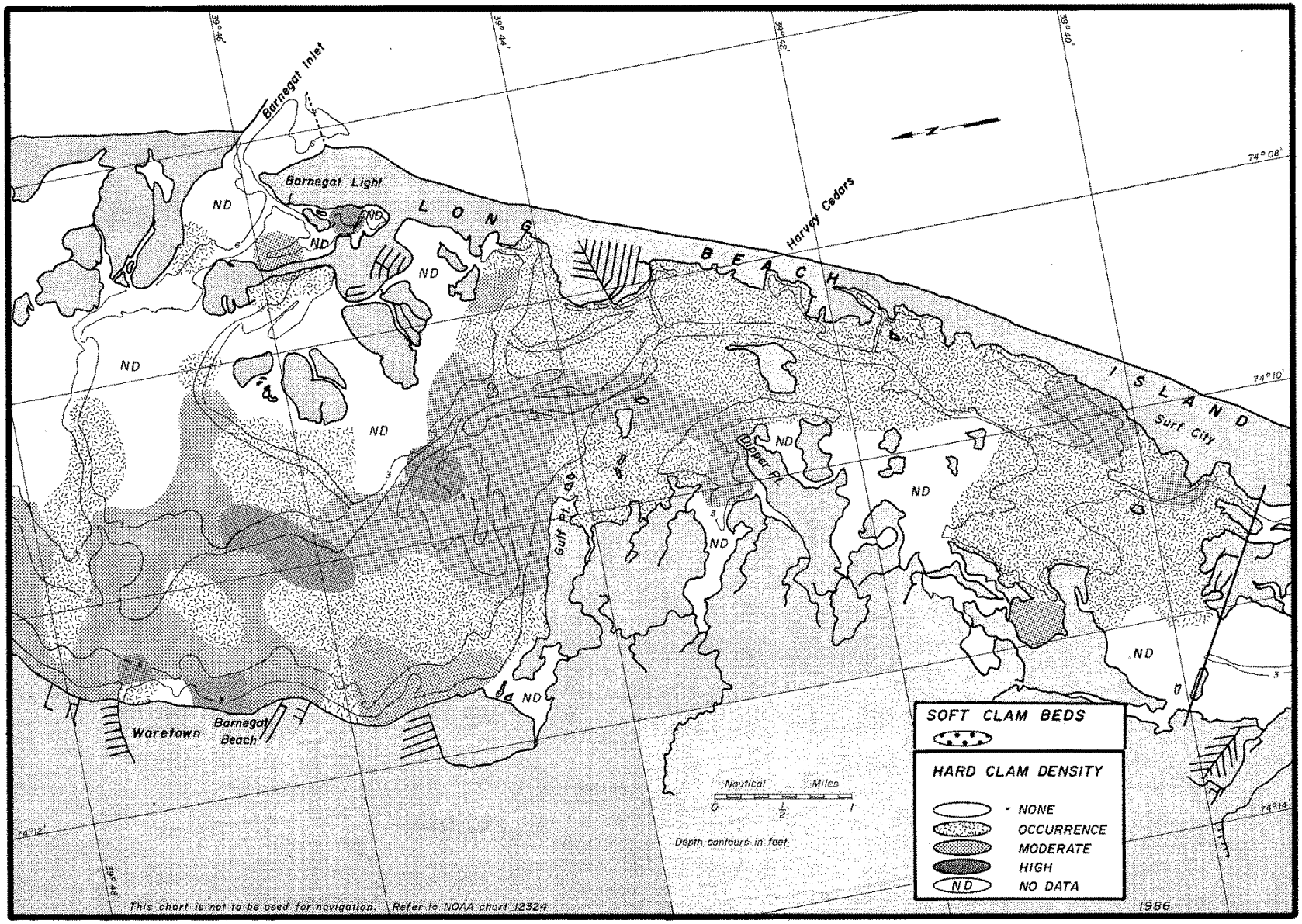
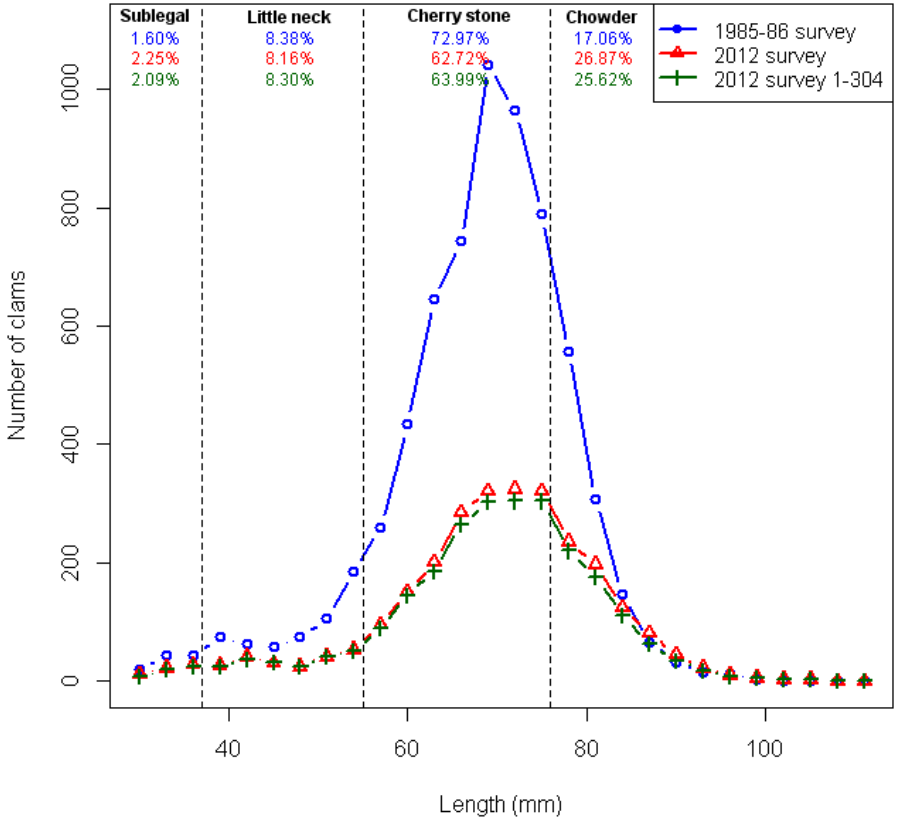


Figure 12. Lower Barnegat Bay Hard Clam Chart, 1986.



Figures 13a and 13b. Length-frequency and length-percent-frequency for all clams measured during the 1985/86 and 2012 surveys. Data from 2012 represent all stations sampled. Note that in the 1985/86 survey, two tows were completed at each station, for a total measured sample of n= 6684 clams. Total of n=2709 clams were measured in 2012. Additionally, the 2012 data omits n=30 clams collected from stations 197 and 215, due to recording errors.



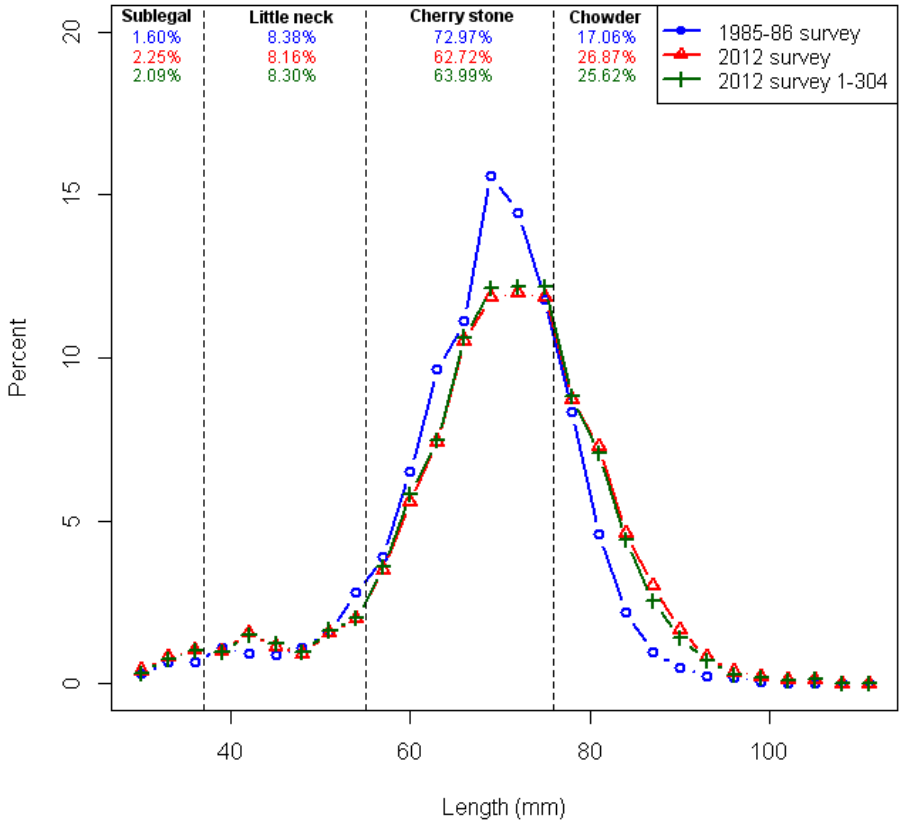


Figure 14. Recruitment indices in Barnegat Bay for 1985/86 and 2012. If no live clams were found at a station, recruitment = NA, and is therefore not plotted.

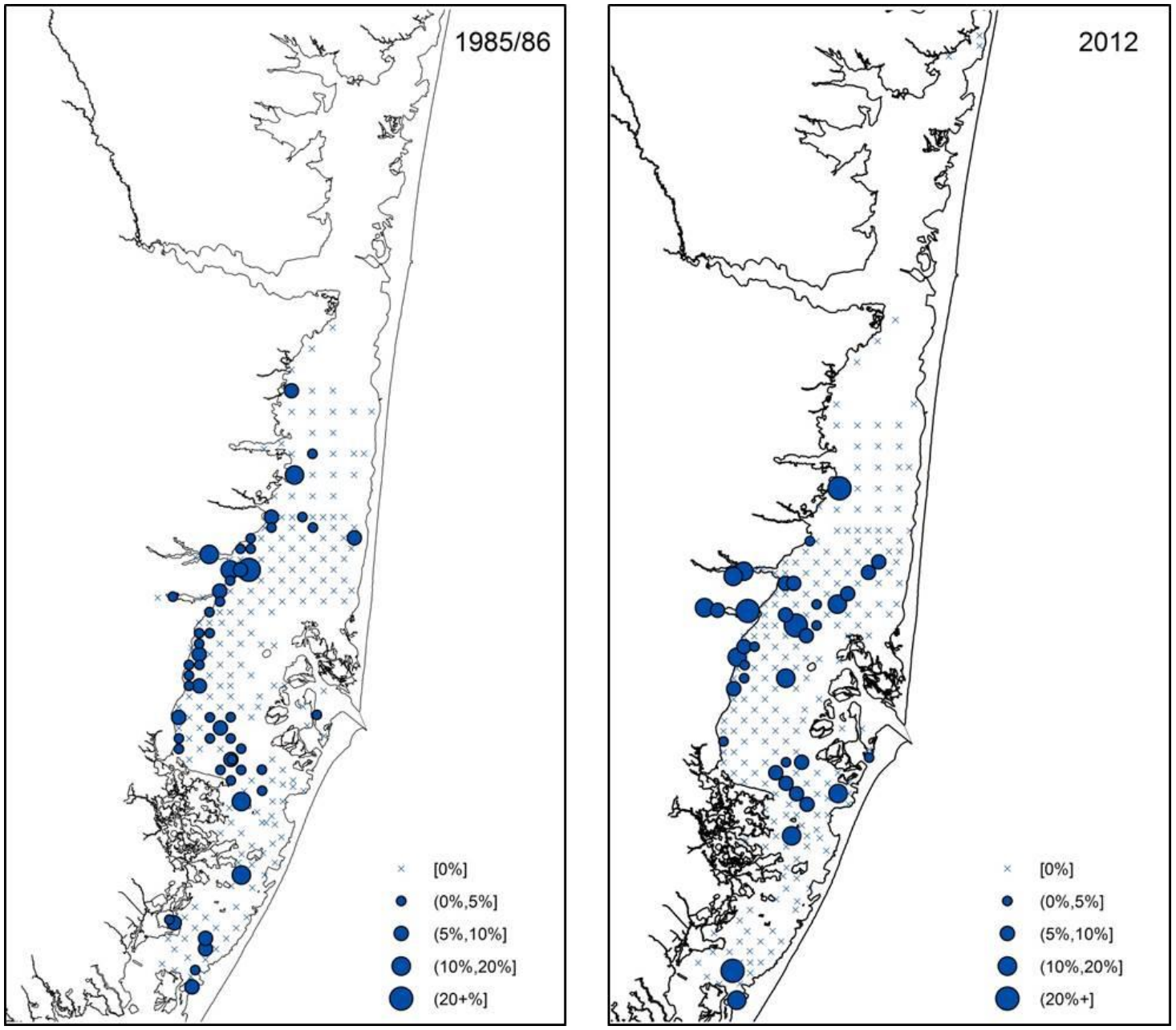


Figure 15. Mortality estimates (%) in Barnegat Bay for 1985/86 and 2012. If no live clams were found at a station, mortality = NA, and is therefore not plotted.

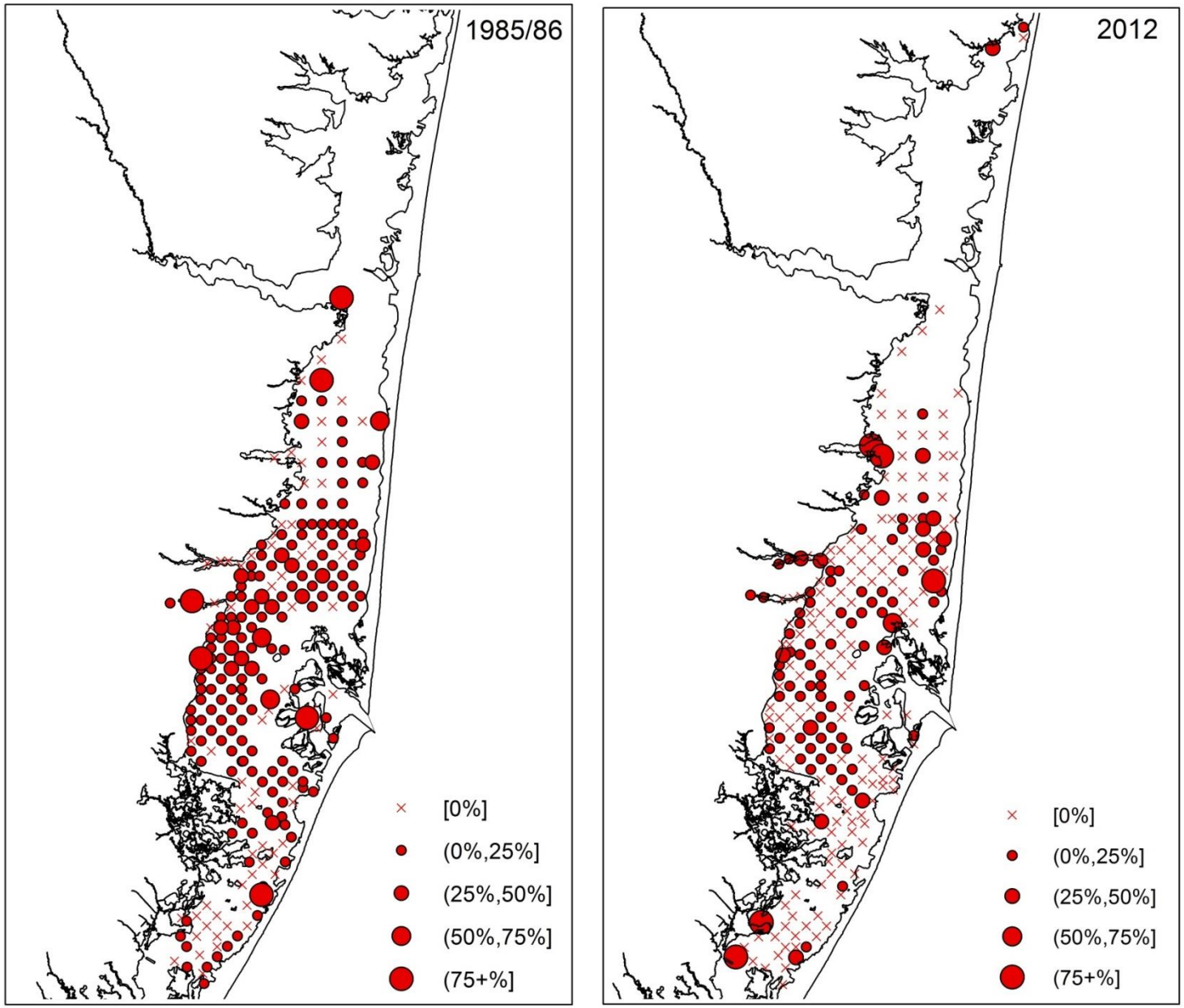


Figure 16. Presence (Y) or Absence (N) of SAV in upper Barnegat Bay, 2012.

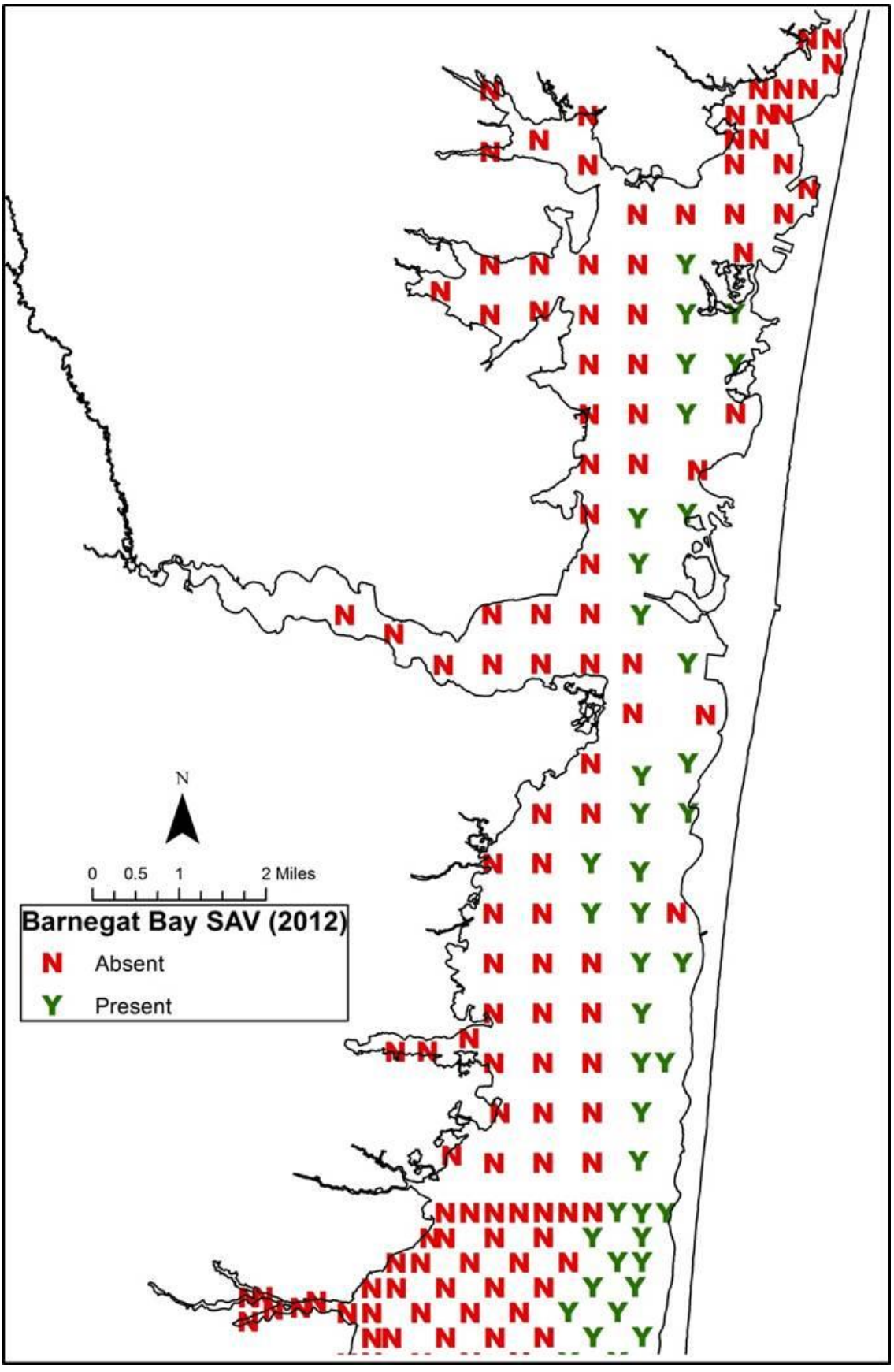


Figure 17. Presence (Y) or Absence (N) of SAV in central and lower Barnegat Bay, 2012.

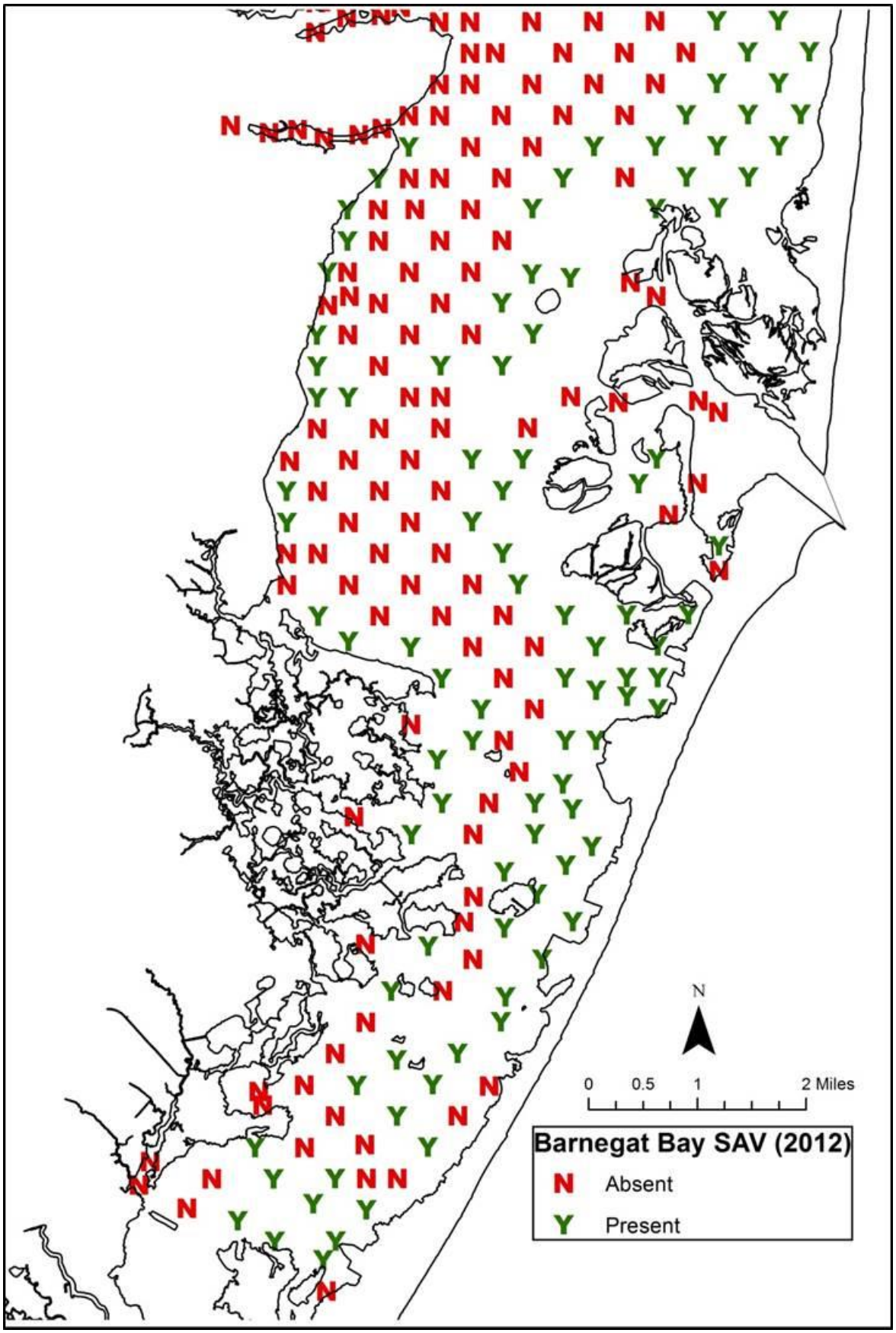


Figure 18. Stations sampled in Barnegat Bay (first 2 panels) and Little Egg Harbor Bay (third panel) after Superstorm Sandy (landfall October 2012). All sampling occurred in 2013.

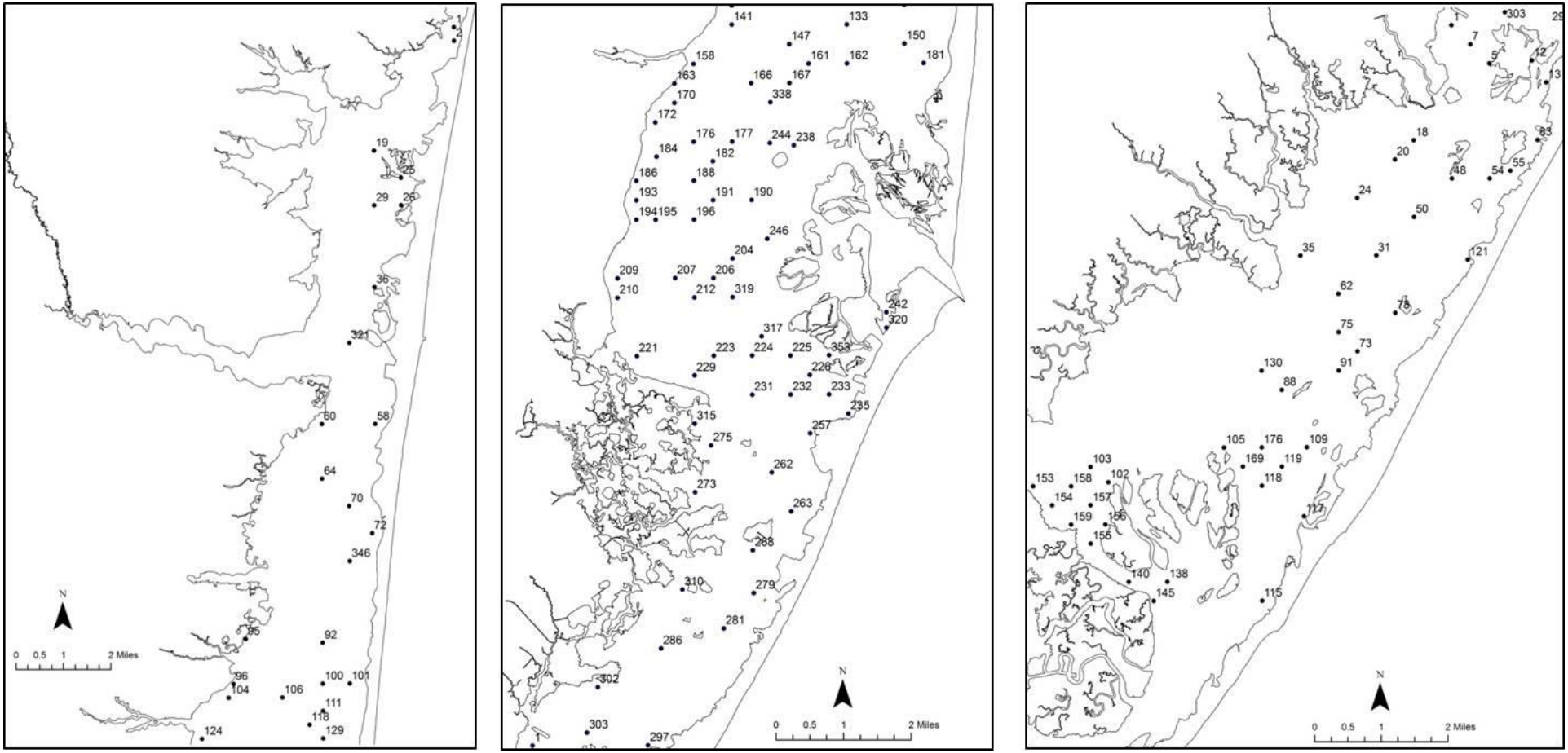


Figure 19. Upper Barnegat Bay hard clam abundance, pre- and post-Superstorm Sandy

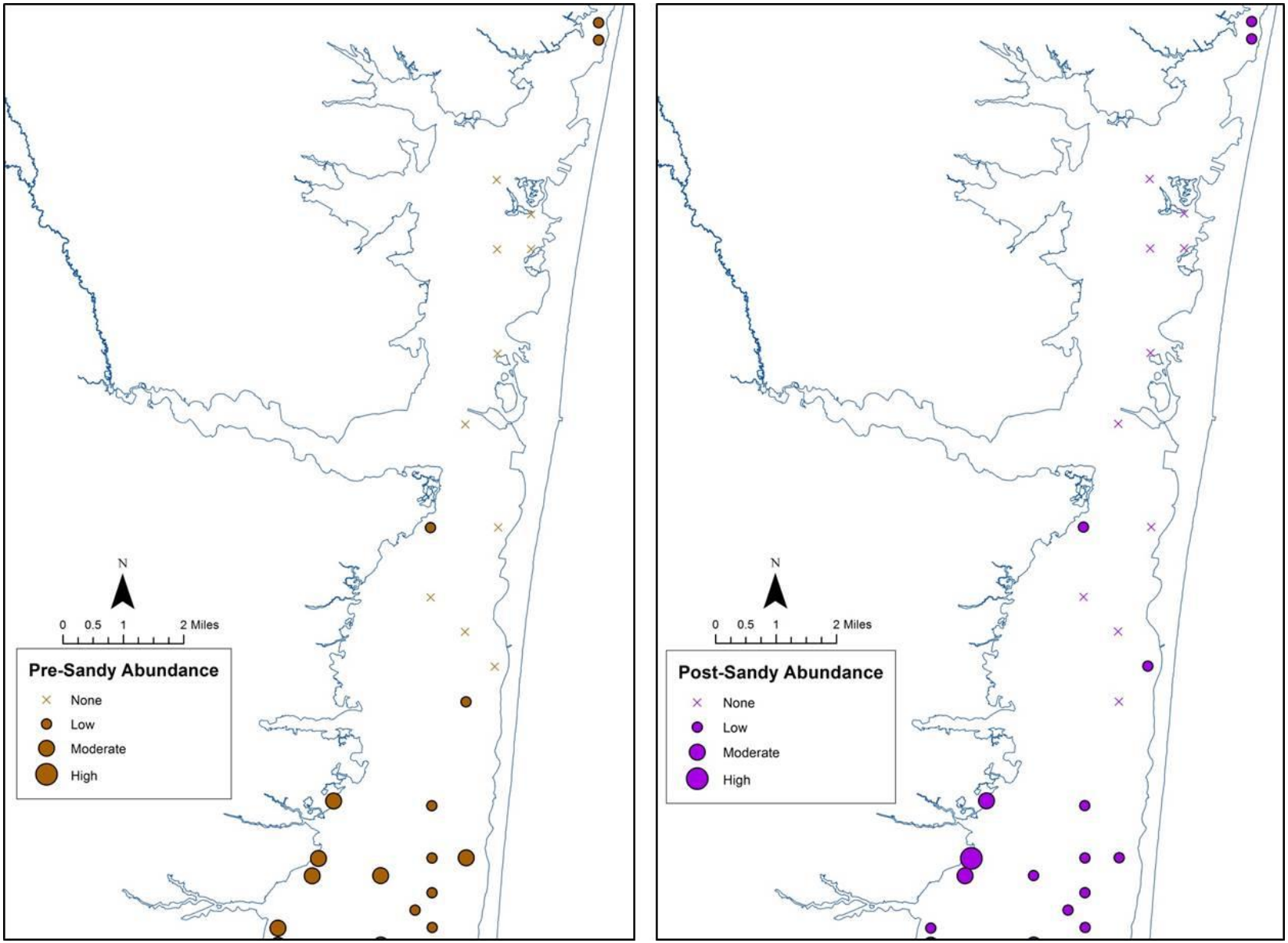


Figure 20. Central and Lower Barnegat Bay hard clam abundances, pre- and post-Superstorm Sandy

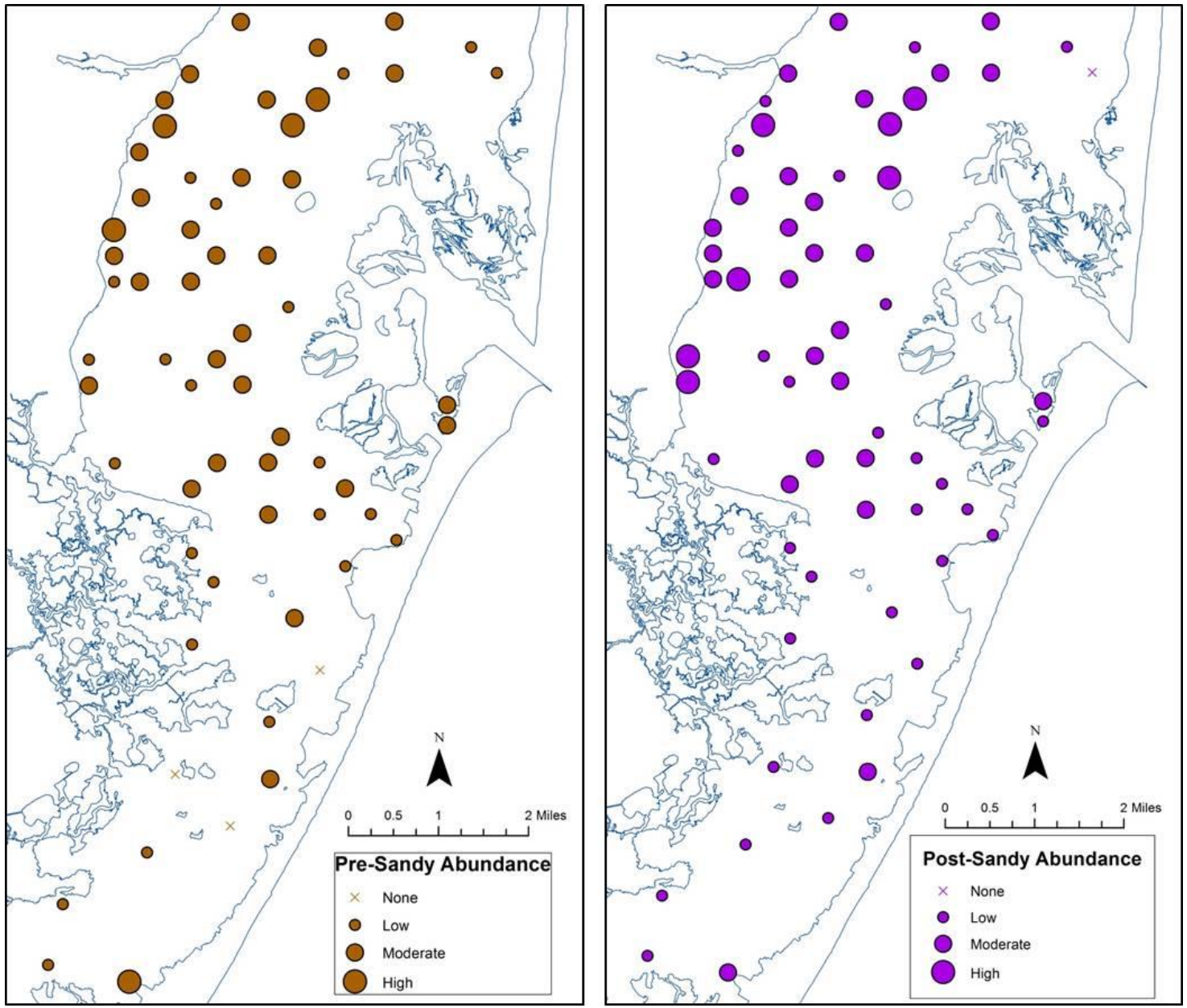


Figure 21. Little Egg Harbor Bay hard clam abundances pre-and post-Superstorm Sandy

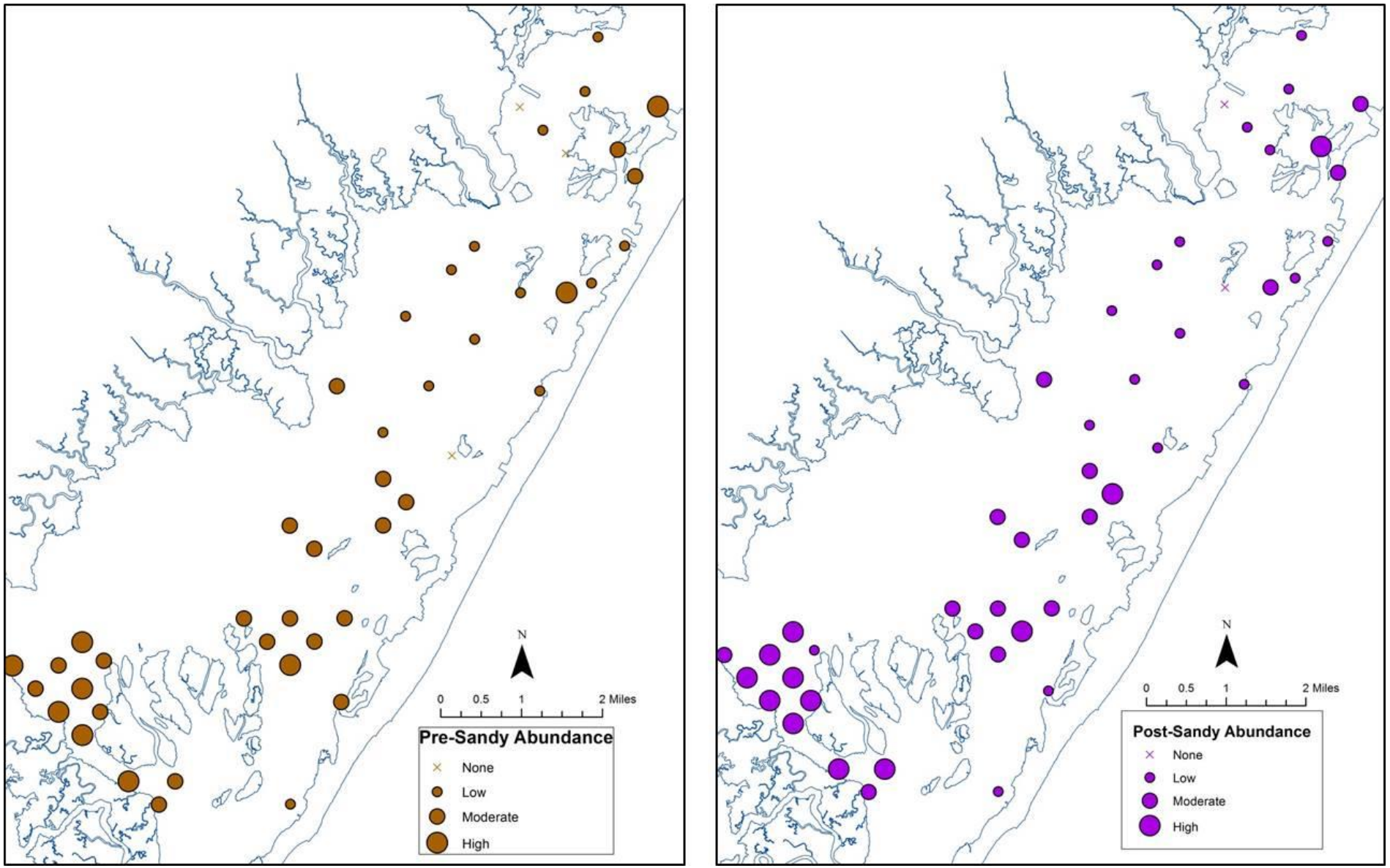


Figure 22. Mortality indices for post-Sandy Barnegat Bay and Little Egg Harbor Bays.

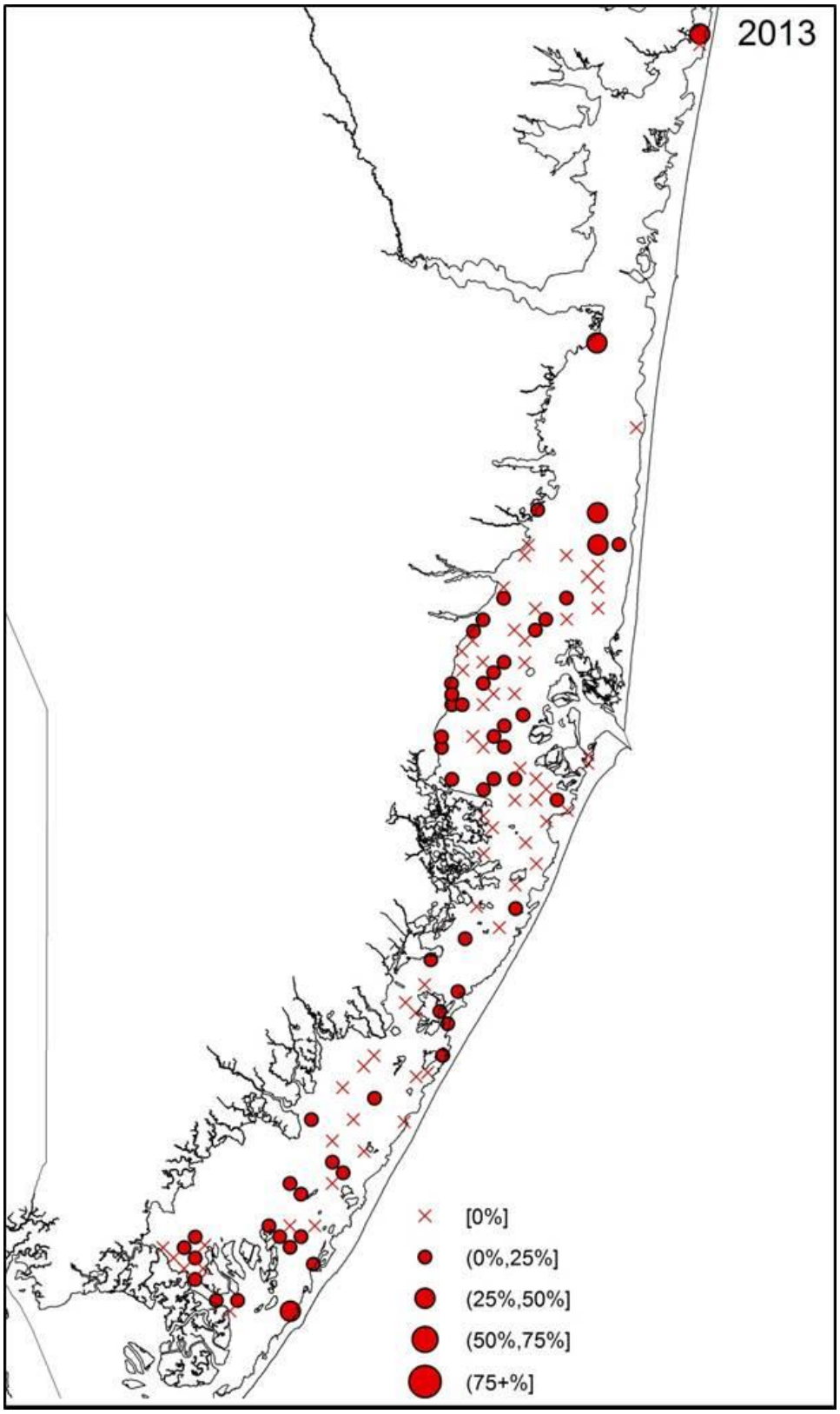


Figure 23. Length-frequency of boxes at stations sampled pre-Sandy and post-Sandy

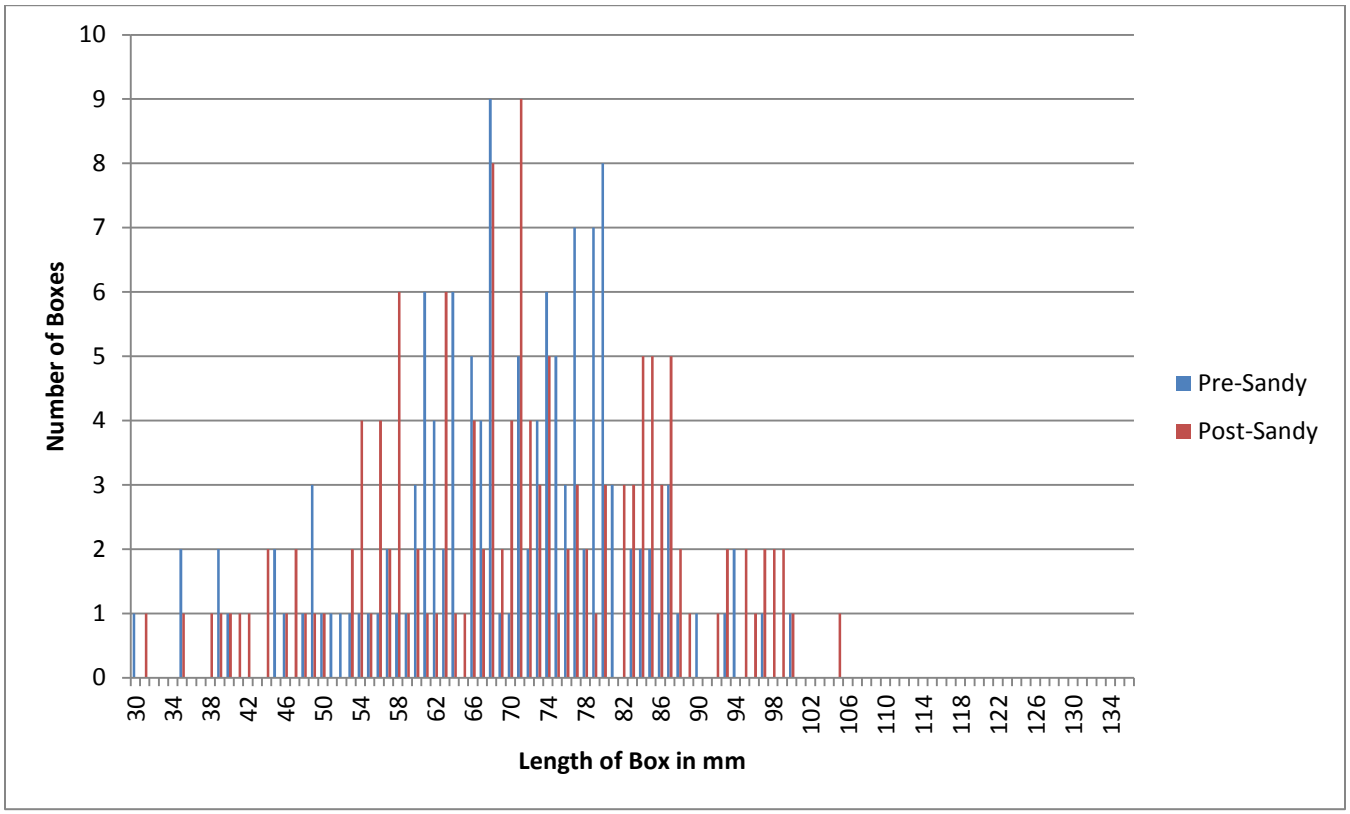


Figure 24. Upper Barnegat Bay submerged aquatic vegetation presence/absence for pre-and post-Superstorm Sandy

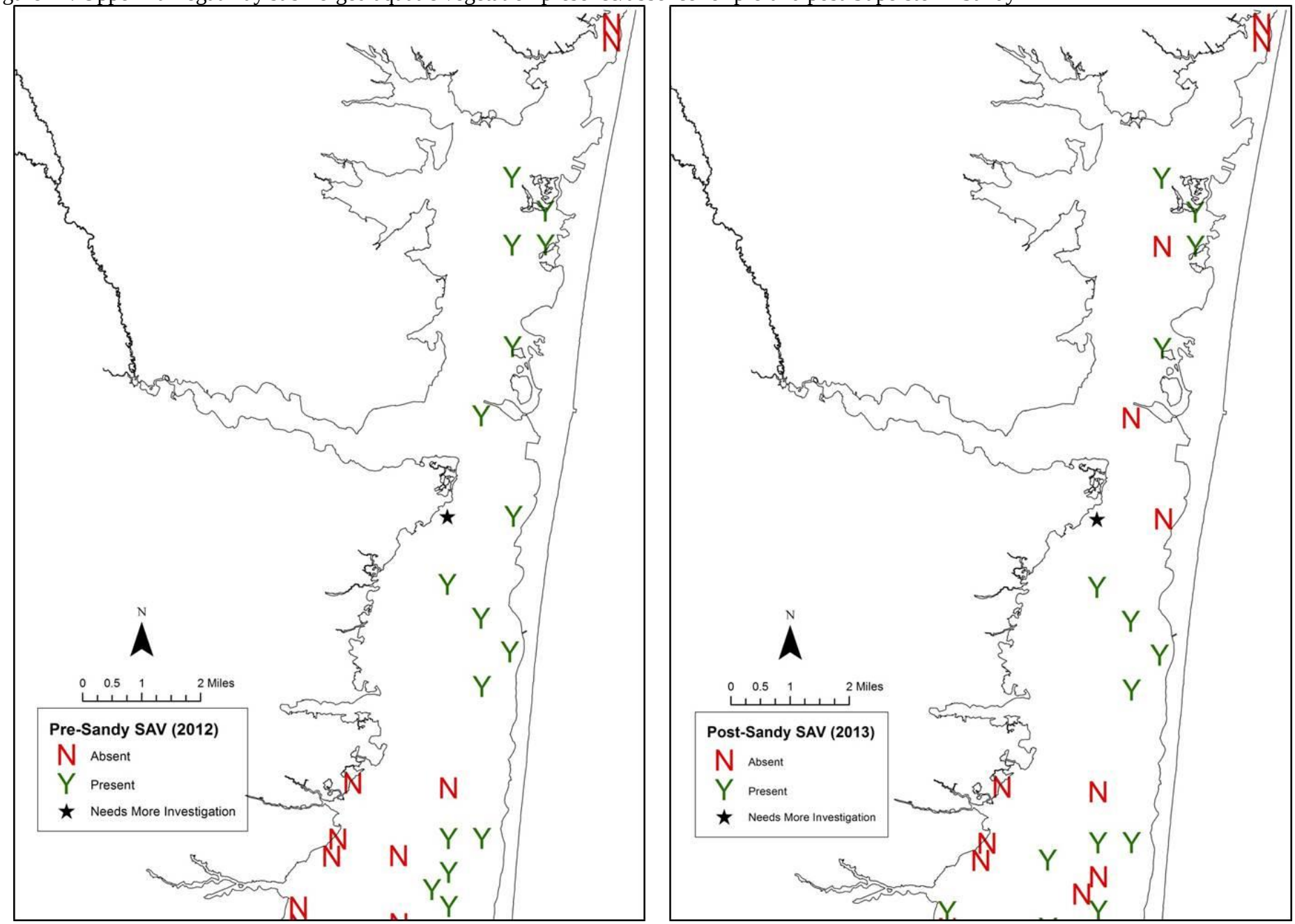


Figure 25. Central and Lower Barnegat Bay submerged aquatic vegetation pre-and post-Superstorm Sandy

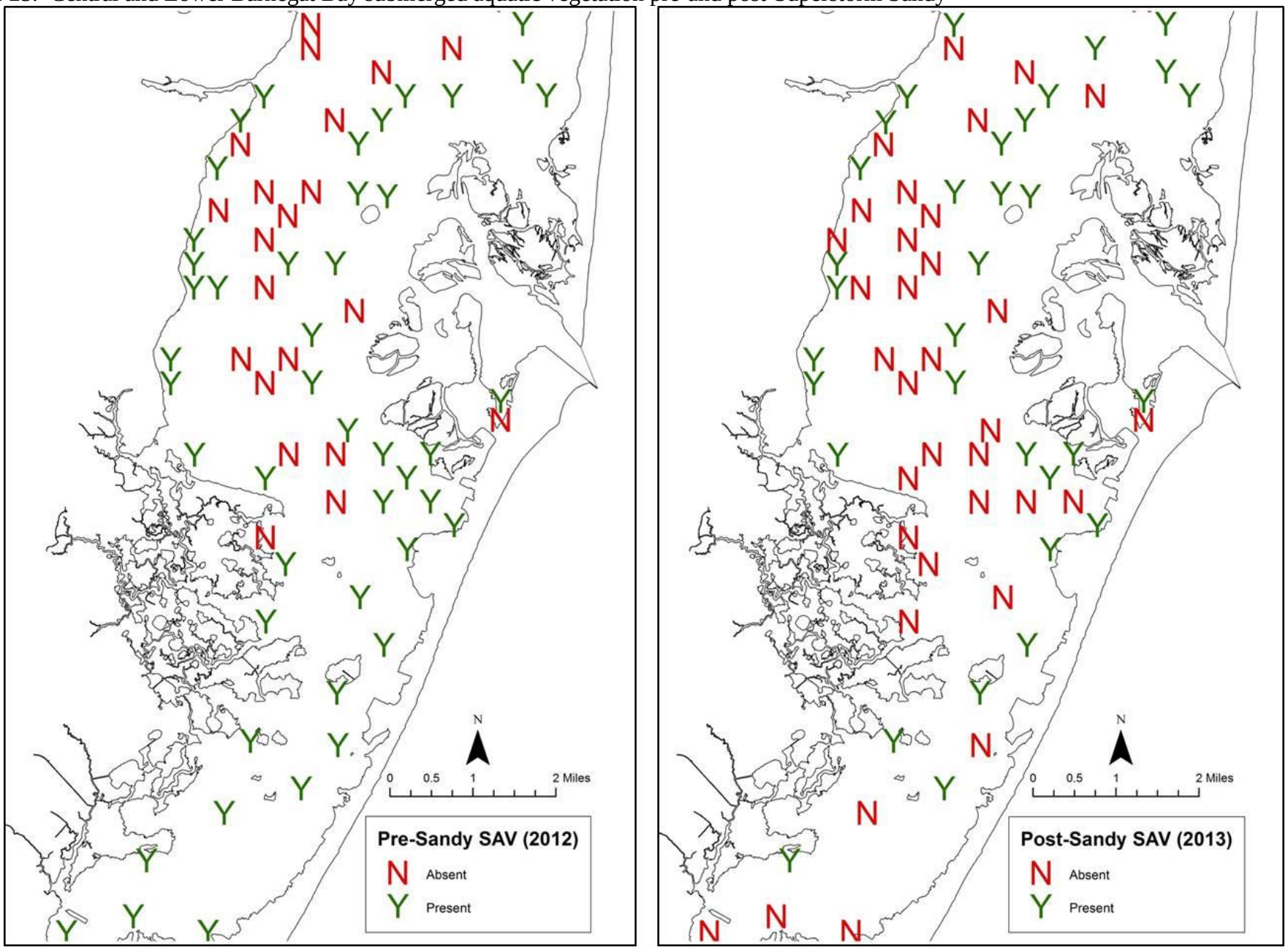


Figure 26. Little Egg Harbor Bay submerged aquatic vegetation pre-and post-Superstorm Sandy