New Jersey Department of Environmental Protection

SHELLFISH STOCK ASSESSMENT OF LITTLE EGG HARBOR BAY (2011)

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ABSTRACT

The New Jersey Bureau of Shellfisheries conducted a hard clam [*Mercenaria mercenaria* (Linnæus 1758)] stock assessment of Little Egg Harbor Bay. The Bureau sampled 196 stations from 24 August to 18 October 2011 using a hydraulic dredge to determine the Bay's standing stock and relative distribution of hard clams. The hard clam resource in Little Egg Harbor Bay is estimated at 85.7 million clams, an increase of 32% from an identical survey conducted in 2001, but a 57% decline from the first comprehensive shellfish survey conducted in the Bay in 1986/87. There was no statistical change in hard clam abundance per station between the 2001 and 2011 surveys ($P = 0.2061$). The mean size of hard clams collected in 2011 was 70.0 mm, and represented a significant decrease from 2001's mean size of 78.9 mm ($P < 0.0018$). Recruitment indices, based on a percentage of hard clams between 30 and 37 mm collected at a specific site as compared to all sized clams collected at the same site, were significantly greater in 2011 than in 2001 ($P = 0.0020$). Mortality estimates were significantly lower in 2011 than in 2001 ($P = 0.0001$).

The bay contains an estimated 4,720 acres of submerged aquatic vegetation (SAV), a decrease of approximately 1,600 acres from 2001. There was a significant difference between the ratios of stations containing versus not containing SAV in 2001 versus 2011 ($P \approx 0.0001$).

This comprehensive hard clam survey is the third to be completed in 25 years. A great deal of effort is being invested in the Barnegat Bay watershed (of which LEHB is part) through initiatives of the Governor, Commissioner, and his Assistant Commissioners in an attempt to assess the status of the watershed and our survey represents an important contribution to the assessment of the health of the watershed and the management of the bay's hard clam resource. This report should be followed by subsequent monitoring efforts including harvest quantification.

INTRODUCTION

Little Egg Harbor Bay (Ocean County) has historically been one of New Jersey's most productive estuaries for hard clams, *Mercenaria mercenaria*, but a comprehensive shellfish survey conducted in 2001 (Celestino 2003) indicated that hard clam abundances declined by 66% from abundances in 1986/87[1] (the first time a comprehensive shellfish survey was conducted in LEHB; Joseph 1987). Celestino (2003) found a number of changes in the Bay relative to the 1986/87 survey that suggested cause for concern. For example, the decline in hard clam abundance per station between the two survey years was significant ($P << 0.0002$), the mean size of hard clams collected in 2001 increased significantly from 1986/87's mean size ($P < 0.0002$), and recruitment indices were not only significantly lower in 2001 than in 1986/87 ($P = 0.025$), but only 4 stations had recruitment > 0 in 2001 (compared to 58 in 1986/87).

It was on this backdrop and with increased awareness and attention focused on the Barnegat Bay watershed[2] that the Bureau of Shellfisheries thought it was imperative to update the Department's understanding of hard clam population dynamics in Little Egg Harbor Bay. This assessment is essential to the Department's efforts to monitor, maintain and enhance the status of New Jersey's coastal ecosystem.

The purpose of the 2011 survey was to assess the standing stock, distribution, and relative abundance of the hard clam, *Mercenaria mercenaria*, in Little Egg Harbor Bay. Quantitative and

[1] Data collection for this survey commenced July 1986 and concluded in October 1987.
[2] E.g., http://www.state.nj.us/dep/barnegatbay/docs/barnegat_bay_10-ptsGOV.pdf

qualitative comparisons are made primarily between this survey and an identical survey conducted in 2001, though, where apposite, comparisons (graphic or numeric) are also made with 1986/87 results. All of this is done without inference as to what happened in the years prior to or in between these surveys. Another goal of this survey was to describe the distribution of submerged aquatic vegetation (SAV) species in Little Egg Harbor Bay and, again, compare these findings to those found in 1986/87 and 2001.

MATERIALS AND METHODS

Study Site

All fieldwork was conducted in Little Egg Harbor Bay, Ocean County, New Jersey (Figure 1). Little Egg Harbor Bay is one of three shallow microtidal bays that comprise the Barnegat Bay – Little Egg Harbor estuarine system (Barnegat Bay Estuary Program 1999). Seawater enters the system through the Point Pleasant Canal, Barnegat Inlet and Little Egg Inlet (Barnegat Bay Estuary Program 1999).

Sampling

Quantitative sampling was conducted from 24 August 2011 to 18 October 2011 in Little Egg Harbor Bay. All, save one[3], stations were sampled using the Research Vessel *Jennings*[4]: a 32-foot long, Chesapeake dead rise style vessel equipped with a hydraulic dredge. The dredge is equipped with a 12-inch wide blade that cuts 4-inches into the substrate. The dredge uses water jets to loosen the bottom sediments ahead of the digging blade and to expel sediments through the body of the dredge (see Ropes and Martin 1960). Water is supplied to the jets through a 3-inch hose attached to a water pump on the deck of the vessel. At 35-40 pounds of pressure per square inch, the pump delivers approximately 300 gallons of water per minute. The dredge is designed to collect and retain all hard clams 30 millimeters (mm) in length or greater, therefore, clams less than 30 mm are not included in any analyses.

The dredge is deployed and retrieved via a 3/8-inch stainless steel wire cable attached to the main haul back winch on the vessel. The actual towing for sample collection was done with a 3/4-inch polypropylene graduated line.

Sampling protocols were identical to those used in the Bureau's 2001 (Celestino 2003b) and 1986/87 (Joseph 1987) shellfish surveys of the same area. Specifically, a systematic sampling design was employed. The original sampling design was not created to look specifically at statistical changes from year to year per se, but in large part, to describe the distribution and abundance of commercially valuable mulluscan shellfish within New Jersey's coastal estuaries (Joseph 1987). Stations sampled for the 2011 inventory were identical to those sampled in 2001 except for 10 of the 196[5] (5.1%) stations where it was not practicable due to, for example, recent obstructions, changes in bathymetry, aquaculture lease areas or submerged

[3] Because of steep depth gradients associated with a sandbar located at station LEHB-11-084, as well as limited maneuverability at this station, we sampled this station with a 22.5"-wide hard clam rake (3" teeth): we conducted replicate 25' tows. The methodology was identical to that used with dredge boat sampling with the exception that we deployed a hard clam rake off of the side of a 19' Carolina Skiff. At the end of the measured clam rake tow the contents of the rake were emptied onto the deck of the boat where the catch was sorted and identified as described in association with dredge boat sampling. No live *Mercenaria* were collected.

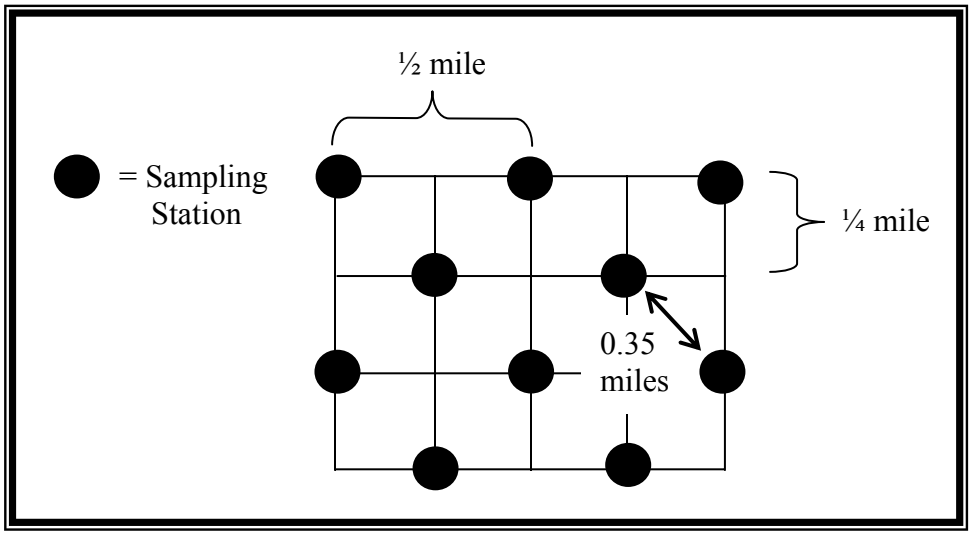
[4] Note that this is the same vessel used in both the 1986/87 and 2001 surveys; the vessel was named the R/V *Notata* during those surveys.

[5] Two stations were added in 2011 that were not sampled in 2001; the stations that were added (LEHB-11-193 & -194) were located in historic aquaculture lease areas in 2001.

telecommunication/ electric cable areas, in which case stations were relocated as close to the original stations as feasible. The range of distance between 2001 and 2011 survey stations was between 62′ and 1,102′ ($\bar{x}$ = 389′; sd = 356′). As in the original survey, station locations were established at ½-mile intervals offset along east-west transects ¼-mile apart such that stations on adjacent transects were approximately 0.35 miles apart (see Figure 2, below). All stations were located using a Garmin GPS unit with WAAS differential correction (Model 3206).

After station position was established with the GPS unit, physio-chemical parameters were determined (generally at the first and last stations sampled in a day) either in the field via YSI-85 multimeter or from water samples that were collected with a Kemmerer water sampler for later analysis of dissolved oxygen, salinity and pH at the New Jersey Division of Fish and Wildlife's Nacote Creek Research Laboratory, Port Republic, New Jersey. Water temperatures (surface and bottom) were recorded from a mercury thermometer in the field. Dissolved oxygen was determined by Winkler titration. Salinities were determined by a hand-held refractometer and pH readings were obtained using colorimetric visual analyses against known standards (Taylor ® slide comparator).

FIG. 2. Schematic of systematic sampling design grid.



Following collection of water samples, water depth was recorded from a Lowrance 3200® Computer Sonar unit and the towline length determined accordingly. A towline length-to-depth ratio of 4:1 was utilized, although, in several instances it was not possible to maintain this ratio because of water depth and water supply hose limitations (100 feet). In those instances, a ratio of 3:1 was maintained. The towline length-to-depth ratio was never less than 3:1.

Prior to each tow, the substrate was probed with a clam rake handle in order to assist with the determination of dredge nozzle selection. In hard substrates, the forward nozzles were opened and back nozzles closed. In soft substrates, the forward nozzles were closed and back nozzles opened. These nozzle positions have previously been determined to yield optimal dredge efficiency (McCloy and Joseph 1983). Upon dredge nozzle adjustment, one tow was made, the length of which was determined by tow lengths of the same station in prior years (generally, either 30', 50', or 100'). Tows shorter than 100' were generally conducted in bottoms with a high percentage of clay, submerged obstructions, or submerged aquatic vegetation (SAV). It was assumed that one tow was representative of a larger area (*i.e.*, an entire sampling cell). Unfortunately there are no data to either support or refute this assumption – as in 2001, limitations on time and funding continued to preclude an investigation. However, to minimize

this source of estimation error, sampling frequency (spatially) was increased to the maximum extent practicable (see Figure 2, above).

The tow distance was measured by paying out a graduated line attached to a weight while towing the dredge. In instances where it was suspected that the dredge was not fishing properly due to low water pump pressure, dredge knife obstruction, or erratic tow speeds for example, the tow was repeated until these concerns were resolved. In all cases, at the end of the measured tow, the vessel was held as stationary as possible until the dredge was raised off the bottom to prevent sampling more than the desired area.

The dredge catch was deposited on a culling table for sorting and counting. All live hard clams and paired hard clam valves (hereafter referred to simply as "boxes") collected in each tow were counted and measured along their anterior-posterior axis to the nearest millimeter using vernier calipers. Hard clams were graded into the following size categories: "sublegals" (30-37 mm), "littlenecks" (38-55 mm), "cherrystones" (56-76 mm) and "chowders" (> 76 mm). Hard clam abundance indices (catch per tow) for each station are expressed in terms of number per square feet. Observations were also made on the presence of other animal and plant species collected in the dredge (***e.g.,*** submerged aquatic vegetation and clam predators). Distribution charts of hard clams were developed.

Population Size/Age Structure

A composite (the sum of all clams measured) length-percent-frequency distribution graph was constructed by appropriately grouping all hard clam lengths measured in the bay. Lengths were combined into three-millimeter groupings (starting at, but not including, 29 mm) as was done in the previous two surveys; again, the dredge is designed to retain clams 30 mm in length and greater. The midpoints of each size grouping were plotted on the x-axis of the distribution graphs. To be sure that the few stations in which we collected a relatively large number of hard clams were not unduly influencing the length-percent-frequency plot we also developed length-percent-frequency plots for stations where we collected ≥ 40 hard clams (4 stations that accounted for ~26% of the measured hard clams). As in 2001, low clam abundances precluded preparation of length-percent-frequency distributions at all individual stations (<u>all</u> n < 100).

Mercenaria Distribution and Abundance Estimation

Spatial autocorrelation among stations was examined though the software module "S+SpatialStats for S-Plus."

For the purpose of delineating relative abundance and distribution patterns of the hard clam resource, four classifications of none (0.00 *Mercenaria* foot^{-2}), occurrence (0.01-0.19 *Mercenaria* foot^{-2}), moderate abundance (0.20-0.49 *Mercenaria* foot^{-2}), and high abundance (≥ 0.50 *Mercenaria* foot^{-2}) were established at each station after the data had been adjusted for the efficiency of the dredge (see below). The abundance categories selected equated with those used in the Bureau's previous surveys.

For the purpose of calculating stock estimates of the hard clam resource, the following abundance classification intervals were established: (0.00), (0.01-0.05), (0.06-0.11), (0.12-0.49), (0.50-0.99), (1.00-1.99) and (≥ 2.00) *Mercenaria* foot^{-2}, as was done in the Bureau's previous surveys. Adjacent stations within the same abundance category listed were grouped together and a mean abundance for that area determined by utilizing the *Mercenaria* abundance means of the individual stations. The mean abundance was then applied to the size of the area to yield the standing stock estimate for that particular area. We used ArcMAP v. 9.1 (2005) to estimate the size of the individual areas in feet^2. By summing the small areas, a resource estimate of the bay was developed. A 95% confidence interval was placed around the estimate (see Celestino

(2003)). The dredge has an overall mean efficiency of 88.0% (±7.7%); all hard clam raw abundances were therefore increased by a factor of 1.137 (100 ÷ 88.0%).

Mercenaria Recruitment

For the purpose of this study, recruitment is defined as the percentage of clams entering the fishery at the legal size of 38 mm in length. To estimate annual recruitment, "sublegals" (*Mercenaria* collected between 30 and 37 mm in length) represented a single year class and would thus be expected to be recruited into the fishery within the coming year. The recruitment index per station was calculated as: {[(no. of *Mercenaria* collected between 30 and 37 mm at station *i*) ÷ (total no. of *Mercenaria* collected at station *i*)] × 100%}, for $i = 1, \ldots, 196$. The total number of sublegals estimated to be present in the bay is also reported. As in previous Bureau reports, data from areas of occurrence (abundance < 0.20 *Mercenaria* foot^{-2}) were not taken into consideration when calculating recruitment indices due to concerns related to interpretation of small sample sizes[6].

Mercenaria Mortality

An index of natural hard clam mortality was determined at each station. This index was based upon the percentage of empty paired valves ("boxes") in the entire sample of paired valves and live clams: Mortality = {[(no. of boxes at station *i*) ÷ (no. of boxes at station *i* + no. of live *Mercenaria* at station *i*)] × 100%}, for $i = 1, \ldots, 196$. Our mortality index is independent of age, size, and gender of *Mercenaria*. Note that if no live hard clams or boxes were collected, mortality = NA [since 0 ÷ (0+0) is undefined][7].

Statistical Analyses: Mercenaria abundance

A single dredge efficiency adjustment factor (*i.e.,* 1.137 – see above) was applied to all *Mercenaria* abundance data from both surveys for which paired data exists [*i.e.,* "paired data" = the same station was sampled in 2001 and 2011; stations added or deleted in 2011 would not have a "companion" station from 2001, and are consequently omitted from these analyses – 3 of 196 stations did not have a companion ($\therefore$ N=193)]. Because the data are paired, and therefore not independent, Wilcoxon's distribution-free signed rank test for paired replicates was employed. The null hypothesis is that there is no shift in location (median) due to treatment (Hollander and Wolfe 1999). Because there were tied values among the data, the test is only approximate, and not exactly of significance level α [an exact level α test statistic in the tied setting requires deriving the exact conditional distribution of the test statistic (T^+) which has, in this case, 1.26×10^{58} possible outcomes] (Hollander and Wolfe 1999).

Statistical Analysis: Mercenaria mortality

Wilcoxon's distribution-free signed rank test for paired replicates was used to analyze the mortality indices from 2001 to 2011 – the large sample approximation was used. A distribution-free point estimator and confidence interval were developed as well.

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[6] While time limitations precluded examination presently, future work should explore the impact of lowering the threshold for recruitment inclusion (e.g., stations where abundance, say, > 0.1 *Mercenaria* foot^{-2}).

[7] In Celestino (2003b), when no live hard clams or boxes were collected, mortalities were entered as 0 in Table 4 of that report. To update mortalities in Table 4 of Celestino (2003b) to their correct value, use the following algorithm: if($\text{mortality}_{2001} + \text{abundance}_{2001} = 0$) { mortality = NA } else { mortality as listed in Celestino (2003b) }.

Statistical Analysis: Mercenaria recruitment

Wilcoxon's distribution-free signed rank test for paired replicates was used to analyze the recruitment indices from 2001 to 2011 – an exact test (not large sample approximation) was used. A distribution-free point estimator and confidence interval were developed as well. Only stations where *Mercenaria* abundances were ≥ 0.20 clams foot^{-2} were incorporated into the analysis, therefore total sample size is 14 (*i.e.,* only 14 pairs of stations contained *Mercenaria* abundances ≥ 0.20 clams foot^{-2} in both survey years)[8].

Statistical Analysis: Mercenaria size/age

Wilcoxon's distribution-free signed rank test for paired replicates was used to analyze mean *Mercenaria* lengths from 2001 to 2011 – the large sample approximation was used. A distribution-free point estimator and confidence interval were developed as well. Only stations where *Mercenaria* were collected during both surveys were incorporated into analyses, therefore total sample size is 101 (*i.e.,* only 101 pairs of stations contained ≥ 1 *Mercenaria* per station in both survey years). Stations where only ≥ 1 *Mercenaria* were collected were included in analyses because 0 clams collected results in a "mean size" of 0/0 (= undefined).

Submerged Aquatic Vegetation (SAV) Distribution

To develop the total acreage of SAV in Little Egg Harbor Bay, SAV was determined to be either present or absent based on the same dredge sample used to collect hard clams. No quantitative description was made in the field with respect to SAV acreage, only presence or absence. For distributional analysis, when SAV was collected at a station (*i.e.,* present), a polygon was drawn around said station using ArcMap v. 9.1. Said polygon encompassed any adjacent stations where SAV was also collected. The analysis requires the same assumption as the *Mercenaria* analysis; specifically, that SAV's presence (or absence) is constant within a given polygon [water depths aided interpolation between stations (*e.g.,* it was generally assumed that water depths in navigation channels would preclude the presence of SAV)]. This seems reasonable given station location proximity. Total acreage was derived by summing individual polygon acreages.

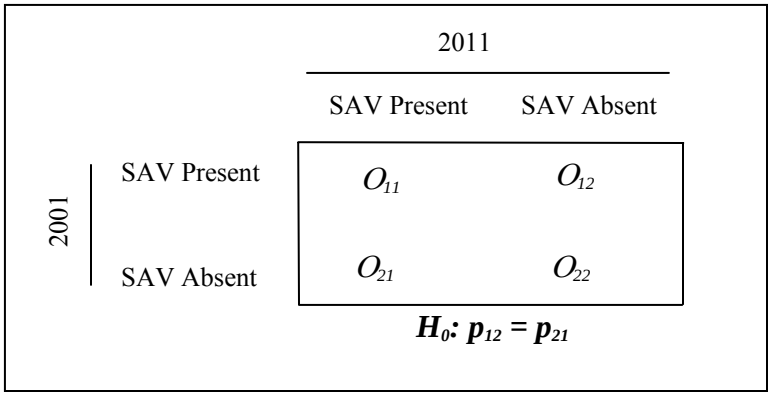
Statistical Analysis: Submerged Aquatic Vegetation

The null hypothesis (H_0) asserts that the proportions of stations containing versus not containing SAV did not change from 2001 to 2011 (Figure 3). H_0 was tested using McNemar's Test. This test is nonparametric and is appropriate for categorical data based on dependent samples (Hollander and Wolfe 1999). Our data for this analysis are paired and therefore constitute dependent data. Taking the pairing into account will provide the best chance of detecting a departure from the null hypothesis (Hollander and Wolfe 1999).

Because not all stations between the two sampling years had a direct paired station, total sample size for this analysis was 187.

[8] In 2001 27 stations had abundances ≥ 0.20 clams foot^{-2} whereas in 2011 36 stations met this threshold.

FIG. 3. Conceptualization of null hypothesis for submerged aquatic vegetation (SAV) analysis.



RESULTS

Description of Study Site

Substrates qualitatively ranged from hard sand to soft mud. In 2011, all locations were characterized by having bottom salinities between 27‰ and 33‰ ($\bar{x}$ = 31‰; SD = 2.1‰) versus a range of 26‰ and 31‰ in 2001 ($\bar{x}$ = 29‰; SD = 1.5‰), bottom water temperatures between 16° and 26°C ($\bar{x}$ = 22°C; SD = 3.2°C), compared to 23° and 30°C ($\bar{x}$ = 26°C; SD = 1.7°C) in 2001, and bottom dissolved oxygen levels between 5.4 and 8.8 mg/l ($\bar{x}$ = 7mg/l; SD = 1.1mg/l) compared to a range of 4.7 to 9.5 mg/l ($\bar{x}$ = 6.4 mg/l; SD = 1.1mg/l) in 2001. Note that the 2001 survey was conducted between 16 July 2001 and 31 August 2001, while the 2011 survey was conducted between 24 August 2011 and 18 October 2011.

Submerged Aquatic Vegetation

In 2011, a total of 4,720 acres in Little Egg Harbor Bay was mapped as submerged aquatic vegetation habitat (SAV), compared to 6,320 acres in 2001, and 6,683 acres in 1986/87 (Table 1, to the right). Between 2001 and 2011 SAV acreage declined by 25% (Table 2, below). Figures 4, 5, and 6 depict the distribution of SAVs in Little Egg Harbor Bay in 1986/87 2001, and 2011, respectively [the 1986/87 SAV distribution chart is provided for illustrative (cf regulatory) purposes only]. In 2011, *Zostera marina* (eelgrass) was the dominant SAV collected; *Ruppia maritima* (widgeon grass) was collected at three stations: 5, 10, and 12.5 (Table 3). In 2001, *Ruppia maritima* (widgeon grass) was also collected at only three stations: 12.5, 83 and 173. SAV was collected in water up to 7 feet in depth in 2011 (Table 3); maximum likelihood estimates of mean and standard deviation of log normally distributed water depths in which SAV was collected: $\bar{x}$ = 5.0′; SD = 0.8′.

TABLE 1. Comparison of acreage of submerged aquatic vegetation (SAV) mapped in Little Egg Harbor Bay from the 1986/87, 2001, and 2011 surveys.

Survey Year	Acres of SAV
1986/87	6,683
2001	6,320
2011	4,720

TABLE 2. Percent change (expressed as fraction) in SAV acreage among three surveys in Little Egg Harbor Bay.

	1986/87	2001	2011
1986/87	0.00	0.06	0.42
2001	-0.05	0.00	0.34
2011	-0.29	-0.25	0.00

McNemar's Test indicated a significant difference between the proportion of stations containing versus not containing SAV between 2001 and 2011 (*d = 3.900, P = 0.0001*).

Mercenaria **Abundance and Distribution**

All *Mercenaria* data provided is adjusted for the dredge's efficiency unless otherwise specified.

All results must be interpreted in light of autocorrelation analyses that indicated that *Mercenaria* abundances were correlated within approximately 10,000 feet for 1986/87's survey. The 2001 survey data showed a similar (but weaker) correlation, again within approximately 10,000 feet. Autocorrelation analyses of 2011 data also suggest *Mercenaria* abundances were correlated within approximately 10,000 feet.

Station location, hard clam abundance, mean length, percent mortality, commercial size class percentages [including percent sublegals (the measure of recruitment for purposes of this study)], and presence/absence of SAV at each station are presented in Table 3. The locations of the 196 stations sampled are presented in Figure 7.

The hard clam resource in Little Egg Harbor Bay (taking into account the dredge's efficiency) is estimated at 85.7 (-6.9 / +8.2) million clams (Table 4) – a conservative estimate of the resource (*i.e.,* not taking into account the dredge's efficiency) is approximately 75.4 million clams. Table 5 shows the percent-change in stock estimates among the three surveys. Stock estimates by commercial size class are presented in Table 6 and Figure 8.

TABLE 4. Comparison of hard clam stock estimates in Little Egg Harbor Bay from the 1986/87, 2001, and 2011 hard clam surveys.

Survey Year	Clams
1986/87	201,476,066
2001	64,803,901
2011	85,745,065

TABLE 5. Percent change (expressed as fraction) in hard clam abundance among the three surveys conducted in Little Egg Harbor Bay.

	1986/87	2001	2011
1986/87	0.00	2.11	1.35
2001	-0.68	0.00	-0.24
2011	-0.57	0.32	0.00

TABLE 6. Abundance of hard clams by commercial size class for the 2001 and 2011 surveys.

Survey year	Sublegals (30-37 mm)	Littlenecks (38-55 mm)	Cherrystones (56-76 mm)	Chowders (> 76 mm)
2001	1,088,308	6,130,523	14,614,435	42,970,475
2011	6,406,049	17,552,053	25,041,375	36,745,588

Figure 9 depicts the number and percentage of stations sampled with no *Mercenaria*, low, moderate and high abundances of *Mercenaria* in Little Egg Harbor Bay for the 1986/87, 2001, and 2011 surveys.

Figures 10, 11, and 12 depict the distribution and abundance of hard clams in Little Egg Harbor Bay in 1986/87, 2001, and 2011 respectively [NOTE: the 1986/87 chart shows unadjusted hard clam abundances (*i.e.,* not adjusted for dredge efficiency), while the 2001 and 2011 charts depict dredge-efficiency adjusted abundances]. See Figure 13 for geometric mean per-station hard clam abundances for each of the surveys (as well as other measures of central tendency). Wilcoxon's signed rank test (on all dredge efficiency adjusted data) indicated no significant change in hard clam abundances in 2001 versus 2011 *($T^* = 1.264$, $P = 0.2061$)*.

Population Structure

To give an overall description of the hard clam population in Little Egg Harbor Bay, composite (the sum of all clams measured) length-percent-frequency distribution graphs are presented in Figure 14 for the surveys conducted in 1986/87, 2001, and 2011. Figure 15 is a length-percent-frequency plot that examines the influence of 4 stations that account for ~26% of the total number of hard clams collected and measured. The total number of clams collected in each survey, mean lengths, standard deviations and other measures of central tendency are listed in Table 7, above. Wilcoxon's signed rank test indicated a significant decrease in the size of hard clams collected in 2011 versus 2001 (*$T^* = 3.117$, $P = 0.0018$*). The decrease ($\hat{\theta}$) is estimated at 6.7 mm *[Pr (2.51 mm < θ < 11.00 mm) = 95%]*.

TABLE 7. Comparison of hard clam population statistics (number collected, arithmetic mean size, standard deviation, median, and mode of sizes) in Little Egg Harbor Bay for the 1986/87, 2001, and 2011 surveys. *In 1986/87, two tows were performed at every station.

	1986/87	2001	2011
n =	7,113*	939	948
$\bar{x}$ =	74.6 mm	78.9 mm	70.0 mm
SD =	11.0 mm	15.3 mm	20.2 mm
Median	78 mm	84 mm	72 mm
Mode	84 mm	90 mm	81 mm

Recruitment

Recalling that we are only considering data where abundance ≥ 0.20 clams foot^{-2}, recruitment indices were variable among stations in 2011, ranging from 0 to 27.3%. See Table 8 for measures of central tendency and comparisons with 1986/87 and 2001 survey results. Wilcoxon's signed rank test indicated a significant increase in the recruitment indices in 2011 versus 2001 *($T+ = 65.00$, $P = 0.0020$)*. The mean increase ($\hat{\theta}$) is estimated at 8.33% *[Pr (2.00%*

$< \theta < 13.64\%) = 95\%]$. Figure 16 spatially depicts recruitment indices in Little Egg Harbor Bay in 1986/87, 2001, and 2011.

TABLE 8. Comparison of hard clam recruitment statistics (%) in Little Egg Harbor Bay for the 1986/87, 2001, and 2011 surveys. n = stations where total hard clam abundance ≥ 0.20 clams ft^{-2}. R > 0 = stations where total hard clam abundance ≥ 0.20 clams ft^{-2} and recruitment > 0.

	1986/87	2001	2011
n =	88	27	36
R > 0	58	4	23
$\bar{x}$ =	3.9 %	1.2 %	7.4 %
SD =	5.3 %	3.1 %	7.9 %
Median	2.2 %	0 %	5.6 %
Mean (LN^*)	3.9 %	0.8 %	8.8%
SD (LN^*)	6.0 %	1.6 %	18.5 %

*LN = mean and sd of log-normally distributed recruitments.

Mortality

The distribution of mortalities in 2011 was distinctly bimodal with peaks at 0% and 100% (Figure 17: 50% of mortalities = 0%; ~20% of mortalities = 100%), so measures of central tendency are not particularly useful. The distribution of mortalities in 2001 was similarly distinctly bimodal, with 20% of mortalities = 0% and ~30% of mortalities = 100%; see Figure 17 and Table 9). To provide a means of comparing surveys, Table 9 provides the frequency of binned mortalities.

Wilcoxon's signed rank test indicated a significant decrease in mortality indices in 2011 versus 2001 $(T^* = 3.898, P = 0.0001)$. The decrease ($\hat{\theta}$)is estimated at -10.7% $[Pr (-15.2\% < \theta < -4.4\%) = 95\%]$. Note that the test is unaffected by the bimodality of the mortality distribution – the test requires a symmetric distribution of the paired differences, which the data have. Mortality indices are spatially depicted in Figure 18 for the 1986/87 survey, 2001, and 2011 surveys[9].

[9] Due to the improper recording of mortalities in the 2001 report (Celestino 2003b) when no hard clams or boxes were collected (26 instances of 0/0 = 0, when it should have = NA), the results of the 1986/87 vs. 2001 Wilcoxon's signed rank test should be updated as: Wilcoxon's signed rank test indicated a significant increase in mortality indices in 1986/87 versus 2001 $(T^* = 8.355, P << 0.0001)$. The increase ($\hat{\theta}$) is estimated at 34.19% $[Pr (27.05\% < \theta < 41.05\%) = 95\%]$. Note that the increase in $\hat{\theta}$ represents an increase of 2.22 percentage points over what was reported in Celestino (2003b).

TABLE 9. Comparison of mortality index bins among the 1986/87, 2001, and 2011 surveys: a) number of stations; b) fraction of stations. Note that totals for 1986/87 and 2001 differ slightly from those reported in Celestino (2003) where mortality equaled 0 when no live or dead boxes were collected. This is changed below (mortality = 'NA' if no live or dead hard clams were collected).

a)

Mortality Index	1986/87 (number of stations)	2001 (number of stations)	2011 (number of stations)
0%	42	37	73
>0 - 25%	115	31	28
26 – 50%	24	37	13
51 – 75%	2	15	2
> 75%	1	48	30

b)

Mortality Index	1986/87 (fraction)	2001 (fraction)	2011 (fraction)
0%	0.23	0.22	0.50
>0 - 25%	0.62	0.18	0.19
26 – 50%	0.13	0.22	0.09
51 – 75%	0.01	0.09	0.01
> 75%	0.01	0.29	0.21

DISCUSSION AND CONCLUSIONS

The survey results of 2011 suggest a mixed picture of Little Egg Harbor Bay in comparison to survey results from 2001. The 2011 results continue to suggest a less optimistic picture with respect to historic survey results (Joseph 1987). However, as with the survey of 2011, all results must be viewed in light of the fact that data are not available for hard clam population dynamics for the years prior to or in between the two surveys discussed in this report. Consequently, definitive statements cannot be made regarding interpretation of observed differences among the surveys. However, as previously mentioned, the purpose of the study was to assess the standing stock, distribution and abundance of the hard clam in Little Egg Harbor Bay and compare those results with those from previous surveys, without making any inference as to what happened in the years prior to or in between these surveys.

The estimated standing stock of hard clams in Little Egg Harbor Bay is 85.7 million clams, a 32% increase over 2001's abundance estimate, but still 57% below 1986/87's estimate (Table 5). While the increase from 2001 to 2011 is promising, 13% of the total stock in 2011 is attributable to 2 stations, and nearly 25% of the total stock is associated with the 5 most abundant stations sampled.

Figure 13 indicates that geometric mean abundance (per station sampled) in the Bay has increased by 25% between 2001 and 2011, though the median abundance actually decreased by 11% (Figure 13). The change in per-station abundance while not significantly different ($P < 0.2061$) between 2001 and 2011, is still 60% below the geometric mean from 1986/87.

There is a great deal of similarity in the distribution and relative abundance of hard clams between the 2001 and 2011 surveys (Figures 11 and 12, respectively). In general, large portions of western Little Egg Harbor Bay have no hard clams – this was the case in 2001 and remained so in 2011. The northern portion of LEHB was historically dominated by low abundances with pockets of moderate abundance (Figure 10); in 2001 and 2011 this remained the case, except that some high abundance areas were found (Figures 11 and 12). As was the case in 2001, in 2011 there is a tract of moderate and high abundance that extends from Goosebar Sedge, northward to Barrel Island and to Marshelder Island. However, unlike 2001 in which this tract was contiguous, in 2011 there was some fragmentation. The biggest change in distribution and relative abundance between the 2001 and 2011 surveys is in the southwestern portions of Little Egg Harbor Bay in the vicinity of Story Island (southeastern Little Egg Harbor Township). Much of this area had low abundances in 2001, but in 2011 contained either moderate or high hard clam abundances. The 2011 distribution chart (Figure 12) in this region appears intermediate between the distribution charts from 1986/87 (Figure 10) and 2001 (Figure 11).

Figure 9 indicates that the proportion of stations sampled in 2011 with no clams increased by 5 percentage points to 40% and represents the most common relative abundance in Little Egg Harbor Bay as it did in 2001. This is a strong departure from the 1986/87 survey results where only 3% of the stations contained no clams. The percentage of stations with moderate and high abundances of hard clams accounted for 19% of the total stations in 2011, compared to 14% in 2001, and 47% in 1986/87.

With respect to recruitment in Little Egg Harbor Bay, there are some encouraging signs. Sublegals, our measure of recruitment, increased to 7% of the stock in 2011, compared to 2% of the stock in 2001 (Table 6 and Figure 8[10]). Part of this increase is due to either the harvest or natural mortality of chowder sized clams which declined by 6.2 million clams (15% decline) between 2001 and 2011. However, part of the recruitment increase was due to the almost 6-fold increase in the number of sublegal sized clams in the Bay. Not surprisingly, analysis of mean sizes of hard clams collected in 2001 versus 2011 indicated that clams were significantly ($P = 0.0018$) smaller in 2011 than in 2001 (~7 mm smaller). Interestingly, the composite length-percent-frequency plot for Little Egg Harbor Bay in 2011 looks very similar to that of Sandy Hook Bay in 2000 (see Figure 13 in Celestino 2003a) where there is evidence of recurring recruitment. Inspection of the composite length-percent-frequency distribution graph (Figure 14) for 2011 shows a much different population than observed in either 1986/87 or 2001 – the mean, median, and mode in 2011 were the lowest of the three surveys (Table 7). The plots of 1986/87 and 2001 data are very similar, near-bell-shaped curves that shifted over time, whereas the plot of 2011 data is clearly broadened with no dominant year classes evident, suggesting frequent recruitment since 2001. Figure 15 suggests that the all-hard clams length-frequency plot was not unduly influenced by the 4 stations that accounted for ~26% of the total number of hard clams collected in the survey. Those 4 stations have a narrower length-percent-frequency distribution with fewer recruits and fewer older hard clams than the remaining stations (as a percent of their respective totals). Figure 16 suggests that recruitment in Little Egg Harbor Bay in 2011 is more representative of a 1986/87 condition rather than 2001's situation. In 2001, with the exception of four stations, all areas of the bay exhibited 0% recruitment, whereas in 2011, recruitment is spread from Barrel Island through Marshelder Islands, and farther north. Additional recruitment

[10] Figure 8 suggests size-dependent dredge efficiencies may be appropriate. Currently, a single dredge efficiency is applied to all sizes of hard clams. Future work will focus on size-dependent dredge efficiency estimates.

is present in the vicinity of Story Island. Tempering some of the enthusiasm for the increase in recruitment is the raw number of stations on which we are calculating recruitment (abundance ≥ 0.20 hard clams ft^{-2}), which, while still greater than in 2001, is still considerably less than in 1986/87 (Table 8).

Mortality in 2011 was, in general, lower and less wide spread than in 2001 (Figure 16). Table 9 and Figure 16 indicate that 50% of stations sampled in 2011 had 0% mortality (noting that mortality = NA, not 0%, if no clams or boxes were collected), compared to 22% in 2001. As in 2001, mortalities > 0% are more common along the eastern and western edges of LEHB. As was the case in 2001, a review of the literature uncovered no information on the amount of time hard clam paired valves remain intact. Consequently, the mortality index is of an indeterminate period of time and hence its importance difficult to judge. It is possible that the reason mortality estimates were higher in 2001 relative to 1986/87 is that they include 1986/87's estimates as well, but that by 2011 enough time had passed for disarticulation. Changes in ocean acidification (NRC 2010) may have affected disarticulation rates as well, decreasing our recent estimates of mortality.

Finally, with respect to submerged aquatic vegetation (SAV) in Little Egg Harbor Bay, there was a decline of approximately 25% in the total estimated acreage from 2001 to 2011[11]. McNemar's Test indicated that the ratio of stations containing versus not containing SAV significantly declined (SAV was collected at 30% of stations in 2011 whereas it was collected at 42% of stations in 2001) *($d = 3.900$, $P = 0.0001$)*. Some of the more prominent changes in SAV distribution include further fragmentation of the extensive beds located in the northern and central portions of the Bay (Figures 4, 5, and 6). The extensive SAV bed that was observed at Barrel Island in 2001 was reduced in 2011. Of note in the interpretation of the SAV results is that the various surveys were completed during different times of the year which might contribute to some of the observed differences (2001 survey conducted between 16 July 2001 & 31 August 2001, while 2011 survey was conducted between 24 August 2011 & 18 October 2011; note too that Hurricane Irene made landfall at Beach Haven, NJ 28 August 2011). Other potential influential factors affecting our results include SAV phenology and concerns have been raised about the potential for habitat change. The present survey is inadequate to judge whether there has been a change in habitat.

This comprehensive survey is the third to be completed in 25 years. A great deal of effort is being invested in the Barnegat Bay watershed (of which LEHB is part) through the initiatives of the Governor, Commissioner, and his Assistant Commissioners in an attempt to assess the status of the watershed, and our survey represents an important contribution to the assessment of the health of the watershed and the management of the bay's hard clam resource. Our conclusions are necessarily limited by the availability of data among the surveys – with more frequent surveys and landings data, we can improve this situation (MSFCMA 2007; MacCall 2009; Hilborn and Walters 1992).

[11] Comparison of Figures 4-6 (SAV distribution) with Figures 10-12 (hard clam relative abundance and distribution) suggesting potentially inverse distributions may be a result of poor dredge efficiency in SAV. We do not have a quantitative estimate of efficiency in substrates with SAV. One interpretation of our change in hard clam abundance is that with less SAV our dredge is simply able to capture hard clams that were previously unavailable to the dredge in SAV. Preliminary attempts at fitting logistic regressions to quantify the relationship produced unsatisfactory results [poor fits (Rutter and Bence 2004)] – future work will attempt to resolve this issue. However, at a more basic level, median hard clam abundance is greater where we found SAV than where we did not.

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Table 3. Station locations, hard clam abundances, percent mortalities, commercial size class percentages and presence/absence of submerged aquatic vegetation (SAV) for the 2011 hard clam stock assessment of Little Egg Harbor Bay.

Station	Date	Latitude	Longitude	Depth (feet)	*Abundance* $_{adj}$ ** (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV$^{\Delta}$ present?
LEHB-11-001	24-Aug-11	39 39.75	74 12.79	4.0	0.00	NA	NA	NA	NA	NA	NA	Z
LEHB-11-002	24-Aug-11	39 39.50	74 12.79	4.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-003	24-Aug-11	39 39.25	74 12.79	5.0	0.07	90.0	0.00	0.00	0.00	0.00	1.00	N
LEHB-11-004	24-Aug-11	39 39.00	74 12.79	5.0	0.07	59.5	0.25	0.00	0.00	1.00	0.00	N
LEHB-11-005	14-Sep-11	39 39.25	74 12.15	5.0	0.00	NA	1.00	NA	NA	NA	NA	RZ
LEHB-11-006A	24-Aug-11	39 39.713	74 12.518	5.0	0.02	68.0	0.00	0.00	0.00	1.00	0.00	N
LEHB-11-006B	24-Aug-11	39 39.70	74 12.47	9.0	0.09	75.0	0.20	0.00	0.00	0.75	0.25	N
LEHB-11-007	24-Aug-11	39 39.50	74 12.47	4.0	0.05	83.5	0.00	0.00	0.00	0.00	1.00	Z
LEHB-11-008	24-Aug-11	39 39.00	74 12.47	5.0	0.02	88.0	0.00	0.00	0.00	0.00	1.00	N
LEHB-11-009	14-Sep-11	39 38.75	74 12.15	5.0	0.08	70.0	0.00	0.00	0.00	1.00	0.00	Z
LEHB-11-010	14-Sep-11	39 38.75	74 11.51	4.0	0.02	61.0	0.00	0.00	0.00	1.00	0.00	RZ
LEHB-11-011	14-Sep-11	39 38.976	74 11.405	12.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-11.5	14-Sep-11	39 39.05	74 11.30	5.0	0.02	66.0	0.00	0.00	0.00	1.00	0.00	N
LEHB-11-012	14-Sep-11	39 39.286	74 11.429	14.0	0.41	58.7	0.00	0.17	0.22	0.44	0.17	N
LEHB-11-12.5	14-Sep-11	39 39.25	74 11.35	4.0	0.00	NA	NA	NA	NA	NA	NA	RZ
LEHB-11-013	14-Sep-11	39 39.00	74 11.19	15.0	0.34	78.7	0.12	0.00	0.07	0.29	0.64	N
LEHB-11-014	21-Sep-11	39 38.501	74 11.242	9.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-015	14-Sep-11	39 38.50	74 11.83	4.0	0.00	NA	NA	NA	NA	NA	NA	Z
LEHB-11-016	24-Aug-11	39 38.489	74 12.467	4.0	0.05	74.0	0.50	0.00	0.00	0.50	0.50	Z
LEHB-11-017	14-Sep-11	39 38.75	74 14.07	6.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-018	8-Sep-11	39 38.25	74 13.43	5.0	0.08	63.0	0.00	0.00	0.00	1.00	0.00	Z
LEHB-11-019	8-Sep-11	39 38.100	74 12.966	5.0	0.00	NA	NA	NA	NA	NA	NA	Z
LEHB-11-020	8-Sep-11	39 38.00	74 13.75	5.0	0.05	74.5	0.00	0.00	0.00	0.50	0.50	Z
LEHB-11-021	20-Sep-11	39 37.50	74 13.75	5.5	0.05	52.5	0.00	0.00	0.50	0.50	0.00	N
LEHB-11-022	13-Sep-11	39 37.75	74 14.07	5.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-023	8-Sep-11	39 38.00	74 14.39	5.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-024	8-Sep-11	39 37.50	74 14.39	6.0	0.09	65.2	0.33	0.00	0.00	0.50	0.50	Z
LEHB-11-025	13-Sep-11	39 37.75	74 14.71	6.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-026	13-Sep-11	39 37.25	74 14.71	5.0	0.14	56.2	0.14	0.17	0.33	0.33	0.17	Z
LEHB-11-027	20-Sep-11	39 36.75	74 14.71	6.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-028	20-Sep-11	39 36.50	74 15.03	6.0	0.05	48.0	0.00	0.00	1.00	0.00	0.00	N
LEHB-11-029	20-Sep-11	39 37.00	74 14.39	6.0	0.02	38.0	0.50	0.00	1.00	0.00	0.00	N
LEHB-11-030	20-Sep-11	39 37.25	74 14.07	5.5	0.20	61.7	0.00	0.11	0.44	0.11	0.33	N
LEHB-11-031	20-Sep-11	39 36.75	74 14.07	6.0	0.02	75.0	0.00	0.00	0.00	1.00	0.00	Z
LEHB-11-032	13-Sep-11	39 36.50	74 13.75	5.0	0.02	88.0	0.00	0.00	0.00	0.00	1.00	Z
LEHB-11-033	20-Sep-11	39 36.50	74 14.39	6.0	0.05	60.5	0.00	0.50	0.00	0.00	0.50	Z

Table 3. Station locations, hard clam abundances, percent mortalities, commercial size class percentages and presence/absence of submerged aquatic vegetation (SAV) for the 2011 hard clam stock assessment of Little Egg Harbor Bay.

Station	Date	Latitude	Longitude	Depth (feet)	*Abundance* $_{adj}$ ** (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV$^{\Delta}$ present?
LEHB-11-034	14-Sep-11	39 37.00	74 15.03	7.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-035	20-Sep-11	39 36.75	74 15.35	6.5	0.36	52.6	0.11	0.13	0.50	0.31	0.06	N
LEHB-11-036	14-Sep-11	39 37.00	74 15.67	6.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-037	14-Sep-11	39 37.25	74 15.35	6.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-038	20-Sep-11	39 37.25	74 15.03	8.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-039	14-Sep-11	39 37.730	74 15.266	5.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-040	14-Sep-11	39 38.25	74 14.71	6.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-041	8-Sep-11	39 38.25	74 14.07	5.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-042	14-Sep-11	39 38.50	74 14.39	7.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-043	14-Sep-11	39 38.50	74 13.75	6.0	0.00	NA	NA	NA	NA	NA	NA	Z
LEHB-11-044	14-Sep-11	39 38.50	74 13.11	10.0	0.02	85.0	0.00	0.00	0.00	0.00	1.00	N
LEHB-11-045	24-Aug-11	39 38.25	74 12.15	4.0	0.03	31.0	0.00	1.00	0.00	0.00	0.00	Z
LEHB-11-046	14-Sep-11	39 38.00	74 12.00	4.0	0.04	78.0	0.00	0.00	0.00	0.00	1.00	Z
LEHB-11-047	8-Sep-11	39 38.00	74 12.47	5.0	0.00	NA	NA	NA	NA	NA	NA	Z
LEHB-11-048	8-Sep-11	39 37.75	74 12.79	5.0	0.02	79.0	0.00	0.00	0.00	0.00	1.00	Z
LEHB-11-049	20-Sep-11	39 37.50	74 13.11	5.5	0.04	71.0	0.00	0.00	0.00	1.00	0.00	N
LEHB-11-050	20-Sep-11	39 37.25	74 13.43	5.8	0.05	50.5	0.00	0.00	1.00	0.00	0.00	Z
LEHB-11-051	20-Sep-11	39 37.00	74 13.75	6.5	0.07	73.7	0.25	0.00	0.33	0.00	0.67	N
LEHB-11-052	20-Sep-11	39 37.50	74 12.47	5.0	0.18	74.5	0.00	0.00	0.13	0.50	0.38	Z
LEHB-11-053	21-Sep-11	39 37.50	74 12.15	4.8	0.02	78.0	0.00	0.00	0.00	0.00	1.00	N
LEHB-11-054	21-Sep-11	39 37.75	74 12.15	7.0	1.48	71.2	0.07	0.03	0.09	0.54	0.34	N
LEHB-11-055	21-Sep-11	39 37.85	74 11.80	4.0	0.07	74.7	0.00	0.00	0.00	0.33	0.67	Z
LEHB-11-056	8-Sep-11	39 37.75	74 13.43	5.0	0.07	70.0	0.00	0.00	0.00	1.00	0.00	Z
LEHB-11-057	13-Sep-11	39 37.25	74 12.79	5.0	0.07	64.0	0.25	0.00	0.00	0.33	0.67	Z
LEHB-11-058	13-Sep-11	39 37.00	74 13.11	5.0	0.07	75.0	0.50	0.00	0.00	0.67	0.33	Z
LEHB-11-059	13-Sep-11	39 36.75	74 13.43	5.0	0.14	68.9	0.00	0.00	0.00	0.50	0.50	Z
LEHB-11-060	21-Sep-11	39 36.50	74 13.11	5.0	0.00	NA	1.00	NA	NA	NA	NA	Z
LEHB-11-061	13-Sep-11	39 36.25	74 14.07	6.0	0.04	62.0	0.00	0.00	0.00	1.00	0.00	Z
LEHB-11-062	20-Sep-11	39 36.25	74 14.71	4.0	0.04	33.0	0.00	1.00	0.00	0.00	0.00	Z
LEHB-11-063	20-Sep-11	39 36.00	74 15.03	6.0	0.07	75.0	0.25	0.33	0.00	0.00	0.67	Z
LEHB-11-064	21-Sep-11	39 37.70	74 11.80	18.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-065	21-Sep-11	39 37.00	74 12.40	4.3	0.04	82.0	0.00	0.00	0.00	0.00	1.00	Z
LEHB-11-066	21-Sep-11	39 36.75	74 12.79	4.5	0.07	82.7	0.00	0.00	0.00	0.00	1.00	Z
LEHB-11-067	21-Sep-11	39 36.00	74 13.11	5.0	0.07	49.0	0.25	0.00	0.67	0.33	0.00	N
LEHB-11-068	21-Sep-11	39 35.75	74 13.43	6.5	0.00	NA	1.00	NA	NA	NA	NA	Z
LEHB-11-069	21-Sep-11	39 35.50	74 13.75	11.0	0.00	NA	NA	NA	NA	NA	NA	N

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Station	Date	Latitude	Longitude	Depth (feet)	*Abundance* $_{adj}$ ** (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV$^{\Delta}$ present?
LEHB-11-070	21-Sep-11	39 35.50	74 13.43	10.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-071	20-Sep-11	39 35.25	74 14.07	6.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-072	21-Sep-11	39 35.10	74 14.00	8.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-073	20-Sep-11	39 35.50	74 14.39	7.0	0.30	72.2	0.00	0.23	0.08	0.08	0.62	Z
LEHB-11-074	18-Oct-11	39 35.50	74 15.03	7.0	0.34	74.3	0.10	0.11	0.11	0.22	0.56	N
LEHB-11-075	13-Sep-11	39 35.75	74 14.71	6.0	0.23	67.3	0.00	0.00	0.10	0.20	0.70	Z
LEHB-11-076	13-Sep-11	39 36.00	74 14.39	5.0	0.08	70.5	0.00	0.00	0.00	0.50	0.50	Z
LEHB-11-077	13-Sep-11	39 35.75	74 14.07	6.0	0.00	NA	1.00	NA	NA	NA	NA	Z
LEHB-11-078	13-Sep-11	39 36.00	74 13.75	4.0	0.00	NA	NA	NA	NA	NA	NA	Z
LEHB-11-079	13-Sep-11	39 36.25	74 13.43	5.0	0.02	79.0	0.00	0.00	0.00	0.00	1.00	Z
LEHB-11-080	21-Sep-11	39 36.538	74 12.575	3.8	0.00	NA	NA	NA	NA	NA	NA	Z
LEHB-11-081	21-Sep-11	39 37.017	74 12.110	3.8	0.00	NA	1.00	NA	NA	NA	NA	Z
LEHB-11-082	14-Sep-11	39 38.00	74 11.51	6.0	0.00	NA	NA	NA	NA	NA	NA	Z
LEHB-11-083	14-Sep-11	39 38.25	74 11.34	5.0	0.05	66.5	0.33	0.00	0.00	1.00	0.00	Z
LEHB-11-084*	18-Oct-11	39 37.240	74 12.047	4.5	0.00	NA	0.50	NA	NA	NA	NA	Z
LEHB-11-085	21-Sep-11	39 35.757	74 13.146	10.5	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-086	18-Oct-11	39 36.25	74 15.35	9.0	0.02	34.0	0.00	1.00	0.00	0.00	0.00	N
LEHB-11-087	20-Sep-11	39 35.25	74 15.35	7.5	0.14	76.5	0.73	0.00	0.17	0.17	0.67	N
LEHB-11-088	20-Sep-11	39 35.00	74 15.67	7.5	0.36	67.2	0.11	0.06	0.38	0.06	0.50	N
LEHB-11-089	13-Sep-11	39 34.758	74 15.219	4.8	0.27	78.3	0.00	0.00	0.00	0.43	0.57	Z
LEHB-11-090	13-Sep-11	39 35.00	74 15.03	6.0	0.08	84.0	0.00	0.00	0.00	0.50	0.50	Z
LEHB-11-091	20-Sep-11	39 35.25	74 14.71	7.0	0.23	67.0	0.23	0.10	0.40	0.00	0.50	Z
LEHB-11-092	13-Sep-11	39 34.75	74 14.71	6.0	0.07	60.3	0.00	0.00	0.67	0.00	0.33	N
LEHB-11-093	13-Sep-11	39 34.50	74 14.39	5.0	0.05	70.0	0.00	0.00	0.50	0.00	0.50	N
LEHB-11-094	21-Sep-11	39 34.77	74 13.87	8.0	0.02	53.0	0.50	0.00	1.00	0.00	0.00	N
LEHB-11-095	18-Oct-11	39 35.75	74 15.35	8.0	0.05	104.0	0.50	0.00	0.00	0.00	1.00	N
LEHB-11-096	18-Oct-11	39 36.00	74 15.67	9.0	0.02	36.0	0.00	1.00	0.00	0.00	0.00	N
LEHB-11-097	18-Oct-11	39 35.50	74 15.67	8.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-098	13-Oct-11	39 34.50	74 17.61	9.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-099	22-Sep-11	39 34.25	74 17.29	5.8	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-100	22-Sep-11	39 34.25	74 17.94	5.3	0.02	81.0	0.83	0.00	0.00	0.00	1.00	N
LEHB-11-101	22-Sep-11	39 34.25	74 18.58	5.5	0.19	39.8	0.38	0.50	0.25	0.25	0.00	N
LEHB-11-102	13-Oct-11	39 33.80	74 18.60	5.5	0.25	53.8	0.00	0.18	0.45	0.18	0.18	N
LEHB-11-103	22-Sep-11	39 34.00	74 18.90	5.0	0.57	75.3	0.00	0.04	0.08	0.28	0.60	N
LEHB-11-104	13-Oct-11	39 33.999	74 17.670	6.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-105	22-Sep-11	39 34.25	74 16.65	6.5	0.31	83.6	0.18	0.00	0.11	0.11	0.78	N

Table 3. Station locations, hard clam abundances, percent mortalities, commercial size class percentages and presence/absence of submerged aquatic vegetation (SAV) for the 2011 hard clam stock assessment of Little Egg Harbor Bay.

Station	Date	Latitude	Longitude	Depth (feet)	*Abundance* $_{adj}$ ** (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV$^{\Delta}$ present?
LEHB-11-106	22-Sep-11	39 33.50	74 16.33	5.3	0.04	69.0	0.50	0.00	0.00	1.00	0.00	Z
LEHB-11-107	22-Sep-11	39 33.25	74 16.01	3.0	0.10	90.1	0.00	0.00	0.11	0.00	0.89	N
LEHB-11-108	21-Sep-11	39 34.00	74 15.03	5.0	0.14	64.8	0.00	0.00	0.33	0.50	0.17	Z
LEHB-11-109	18-Oct-11	39 34.25	74 15.25	6.0	0.46	84.4	0.14	0.00	0.08	0.08	0.83	N
LEHB-11-110	18-Oct-11	39 33.75	74 15.35	11.0	0.15	66.0	0.00	0.25	0.00	0.25	0.50	N
LEHB-11-111	21-Sep-11	39 33.50	74 15.67	7.0	0.04	65.0	0.00	0.00	0.00	1.00	0.00	N
LEHB-11-112	18-Oct-11	39 33.00	74 15.67	8.0	0.02	39.0	0.75	0.00	1.00	0.00	0.00	N
LEHB-11-113	18-Oct-11	39 32.70	74 15.82	6.0	0.05	43.5	0.00	0.00	1.00	0.00	0.00	N
LEHB-11-114	11-Oct-11	39 32.50	74 15.74	5.0	0.11	105.0	0.17	0.00	0.00	0.00	1.00	N
LEHB-11-115	11-Oct-11	39 32.25	74 16.01	5.0	0.11	75.5	0.00	0.00	0.50	0.00	0.50	Z
LEHB-11-116	11-Oct-11	39 31.940	74 17.065	3.0	0.61	55.5	0.00	0.04	0.22	0.52	0.22	N
LEHB-11-117	12-Oct-11	39 33.35	74 15.30	4.0	0.43	84.5	0.00	0.00	0.11	0.21	0.68	Z
LEHB-11-118	22-Sep-11	39 33.75	74 16.01	6.3	0.50	67.5	0.08	0.07	0.25	0.27	0.41	N
LEHB-11-119	18-Oct-11	39 34.00	74 15.67	8.0	0.41	66.8	0.00	0.06	0.22	0.44	0.28	N
LEHB-11-120	21-Sep-11	39 35.302	74 13.790	5.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-121	13-Sep-11	39 36.691	74 12.525	4.5	0.16	75.9	0.00	0.00	0.00	0.57	0.43	Z
LEHB-11-122	21-Sep-11	39 36.282	74 12.798	5.0	0.11	58.2	0.17	0.40	0.20	0.00	0.40	N
LEHB-11-123	13-Oct-11	39 36.00	74 16.33	10.5	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-124	13-Oct-11	39 36.25	74 16.65	9.5	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-125	13-Oct-11	39 36.50	74 16.97	9.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-126	13-Oct-11	39 36.25	74 17.29	9.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-127	13-Oct-11	39 36.00	74 16.97	10.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-128	13-Oct-11	39 35.75	74 16.65	11.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-129	18-Oct-11	39 35.50	74 16.33	7.8	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-130	20-Sep-11	39 35.25	74 16.01	7.0	0.42	60.8	0.00	0.18	0.09	0.45	0.27	N
LEHB-11-131	18-Oct-11	39 35.25	74 16.65	7.5	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-132	13-Oct-11	39 35.50	74 16.97	11.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-133	13-Oct-11	39 35.75	74 17.29	10.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-134	13-Oct-11	39 36.00	74 17.61	10.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-135	13-Oct-11	39 36.00	74 18.26	10.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-136	13-Oct-11	39 35.75	74 17.94	9.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-137	22-Sep-11	39 31.709	74 17.813	18.0	NA	NA	NA	NA	NA	NA	NA	NA
LEHB-11-138	11-Oct-11	39 32.50	74 17.61	5.0	0.32	66.8	0.13	0.00	0.38	0.31	0.31	N
LEHB-11-139	11-Oct-11	39 32.610	74 17.961	4.0	0.05	80.0	0.00	0.00	0.00	0.50	0.50	N
LEHB-11-140	22-Sep-11	39 32.50	74 18.26	7.5	1.14	74.0	0.00	0.00	0.20	0.28	0.52	N
LEHB-11-141	11-Oct-11	39 32.769	74 16.709	3.8	0.36	73.1	0.00	0.06	0.19	0.19	0.56	N

Table 3. Station locations, hard clam abundances, percent mortalities, commercial size class percentages and presence/absence of submerged aquatic vegetation (SAV) for the 2011 hard clam stock assessment of Little Egg Harbor Bay.

Station	Date	Latitude	Longitude	Depth (feet)	*Abundance* $_{adj}$ ** (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV$^{\Delta}$ present?
LEHB-11-142	11-Oct-11	39 32.449	74 16.945	4.0	0.32	57.2	0.13	0.00	0.36	0.64	0.00	N
LEHB-11-143	11-Oct-11	39 32.700	74 17.403	4.0	0.16	70.6	0.13	0.00	0.43	0.14	0.43	N
LEHB-11-144	22-Sep-11	39 32.00	74 17.71	7.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-145	22-Sep-11	39 32.25	74 17.84	6.0	0.34	76.7	0.00	0.00	0.14	0.21	0.64	N
LEHB-11-146	11-Oct-11	39 32.25	74 17.29	7.0	0.03	115.0	0.00	0.00	0.00	0.00	1.00	N
LEHB-11-147	11-Oct-11	39 31.75	74 17.29	15.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-148	13-Oct-11	39 34.50	74 18.26	8.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-149	13-Oct-11	39 34.50	74 18.90	8.0	0.07	82.3	0.00	0.00	0.00	0.00	1.00	N
LEHB-11-150	22-Sep-11	39 34.36	74 19.18	6.0	0.02	36.0	0.89	1.00	0.00	0.00	0.00	N
LEHB-11-151	22-Sep-11	39 34.076	74 19.954	5.0	0.14	84.8	0.25	0.00	0.00	0.17	0.83	N
LEHB-11-152	22-Sep-11	39 34.000	74 19.926	5.0	0.11	88.7	0.25	0.00	0.00	0.00	1.00	N
LEHB-11-153	13-Oct-11	39 33.75	74 19.87	7.0	0.51	70.5	0.00	0.00	0.31	0.15	0.54	N
LEHB-11-154	11-Oct-11	39 33.50	74 19.55	4.0	0.46	84.8	0.00	0.00	0.00	0.17	0.83	N
LEHB-11-155	22-Sep-11	39 33.00	74 18.90	15.0	0.50	84.1	0.08	0.00	0.00	0.24	0.76	N
LEHB-11-156	11-Oct-11	39 33.25	74 18.65	3.5	0.41	58.2	0.00	0.18	0.29	0.12	0.41	N
LEHB-11-157	13-Oct-11	39 33.50	74 18.90	4.0	0.73	64.2	0.00	0.03	0.28	0.50	0.19	N
LEHB-11-158	11-Oct-11	39 33.75	74 19.23	3.8	0.32	62.6	0.07	0.07	0.36	0.14	0.43	N
LEHB-11-159	11-Oct-11	39 33.25	74 19.23	5.0	2.05	60.0	0.03	0.06	0.34	0.40	0.20	N
LEHB-11-161	13-Oct-11	39 34.75	74 20.20	7.0	0.11	79.6	0.29	0.00	0.00	0.20	0.80	N
LEHB-11-162	11-Oct-11	39 32.75	74 18.58	4.0	0.16	63.0	0.00	0.00	0.43	0.29	0.29	N
LEHB-11-163	13-Oct-11	39 34.75	74 17.94	9.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-164	13-Oct-11	39 35.25	74 17.94	10.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-165	13-Oct-11	39 35.00	74 17.61	9.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-166	13-Oct-11	39 34.75	74 17.29	9.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-167	18-Oct-11	39 34.50	74 16.97	7.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-168	18-Oct-11	39 34.75	74 16.65	6.3	0.02	48.0	0.50	0.00	0.00	1.00	0.00	Z
LEHB-11-169	22-Sep-11	39 34.00	74 16.33	6.5	0.42	69.5	0.00	0.18	0.18	0.18	0.45	N
LEHB-11-170	22-Sep-11	39 33.00	74 16.33	4.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-171	11-Oct-11	39 32.50	74 16.33	5.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-172	11-Oct-11	39 32.220	74 16.585	3.8	0.30	72.0	0.00	0.15	0.08	0.31	0.46	N
LEHB-11-173	12-Oct-11	39 33.75	74 14.95	3.5	0.08	91.0	0.00	0.00	0.00	0.00	1.00	N
LEHB-11-174	12-Oct-11	39 33.55	74 14.85	4.5	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-175	13-Sep-11	39 34.25	74 14.39	5.0	0.11	57.6	0.00	0.40	0.20	0.00	0.40	Z
LEHB-11-176	18-Oct-11	39 34.25	74 16.01	9.0	0.42	47.8	0.08	0.27	0.45	0.18	0.09	N
LEHB-11-177	18-Oct-11	39 34.50	74 16.33	7.3	0.23	68.3	0.14	0.17	0.33	0.00	0.50	N
LEHB-11-178	18-Oct-11	39 34.75	74 16.01	4.0	0.00	NA	NA	NA	NA	NA	NA	N

Table 3. Station locations, hard clam abundances, percent mortalities, commercial size class percentages and presence/absence of submerged aquatic vegetation (SAV) for the 2011 hard clam stock assessment of Little Egg Harbor Bay.

Station	Date	Latitude	Longitude	Depth (feet)	*Abundance* $_{adj}$ ** (clams/foot^2)	Mean Length (mm)	Percent Mortality	Percent Sublegals	Percent Littlenecks	Percent Cherrystones	Percent Chowders	SAV$^{\Delta}$ present?
LEHB-11-179	18-Oct-11	39 35.00	74 16.33	8.0	0.11	78.3	0.00	0.33	0.00	0.00	0.67	N
LEHB-11-180	13-Oct-11	39 35.00	74 16.97	8.0	0.00	NA	1.00	NA	NA	NA	NA	N
LEHB-11-181	13-Oct-11	39 35.25	74 17.29	10.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-182	13-Oct-11	39 35.50	74 17.61	10.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-183	13-Oct-11	39 35.50	74 18.26	10.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-184	13-Oct-11	39 35.70	74 18.40	10.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-185	13-Oct-11	39 36.25	74 17.94	9.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-186	13-Oct-11	39 35.50	74 18.90	9.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-187	13-Oct-11	39 34.972	74 19.463	10.0	0.05	53.0	0.50	0.00	1.00	0.00	0.00	N
LEHB-11-188	13-Sep-11	39 34.500	74 15.030	3.8	0.11	83.0	0.00	0.00	0.00	0.33	0.67	Z
LEHB-11-189	13-Sep-11	39 34.500	74 15.350	4.0	0.19	75.2	0.00	0.00	0.20	0.20	0.60	Z
LEHB-11-190	22-Sep-11	39 32.000	74 16.330	13.0	0.04	32.0	0.00	1.00	0.00	0.00	0.00	N
LEHB-11-191	22-Sep-11	39 31.75	74 16.65	20.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-192	22-Sep-11	39 31.500	74 17.050	17.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-193	13-Oct-11	39 35.00	74 18.26	10.0	0.00	NA	NA	NA	NA	NA	NA	N
LEHB-11-194	13-Oct-11	39 34.75	74 18.58	9.0	0.00	NA	1.00	NA	NA	NA	NA	N

* LEHB-01-084 sampled with hard clam rake.

Δ SAV: Z = *Zostera marina* collected, N = *no SAV* collected, *RZ* = *Ruppia maritima* and *Z. marina* collected.

** Abundance$_{adj}$ = Hard clam abundances adjusted for dredge efficiency.

Figure 1. Location of the 2011 shellfish inventory sampling area (Little Egg Harbor Bay, New Jersey: Route 72 causeway to Little Egg Harbor Inlet). See Figure 7 for specific locations of sampled stations.

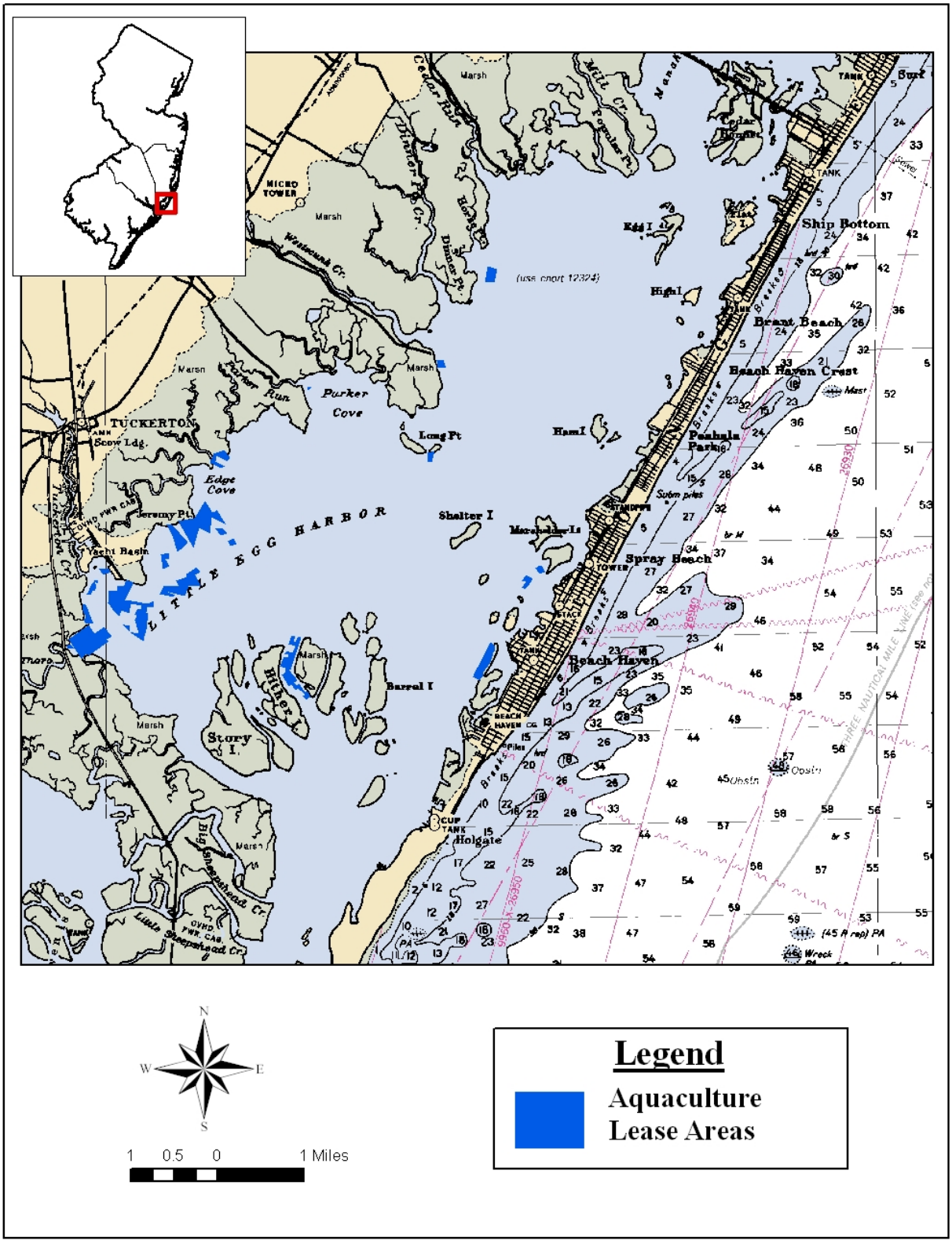

Figure 4. 1986/87 Little Egg Harbor Bay Shellfish Inventory: SAV distribution. Note that data are provided for illustrative purposes only.

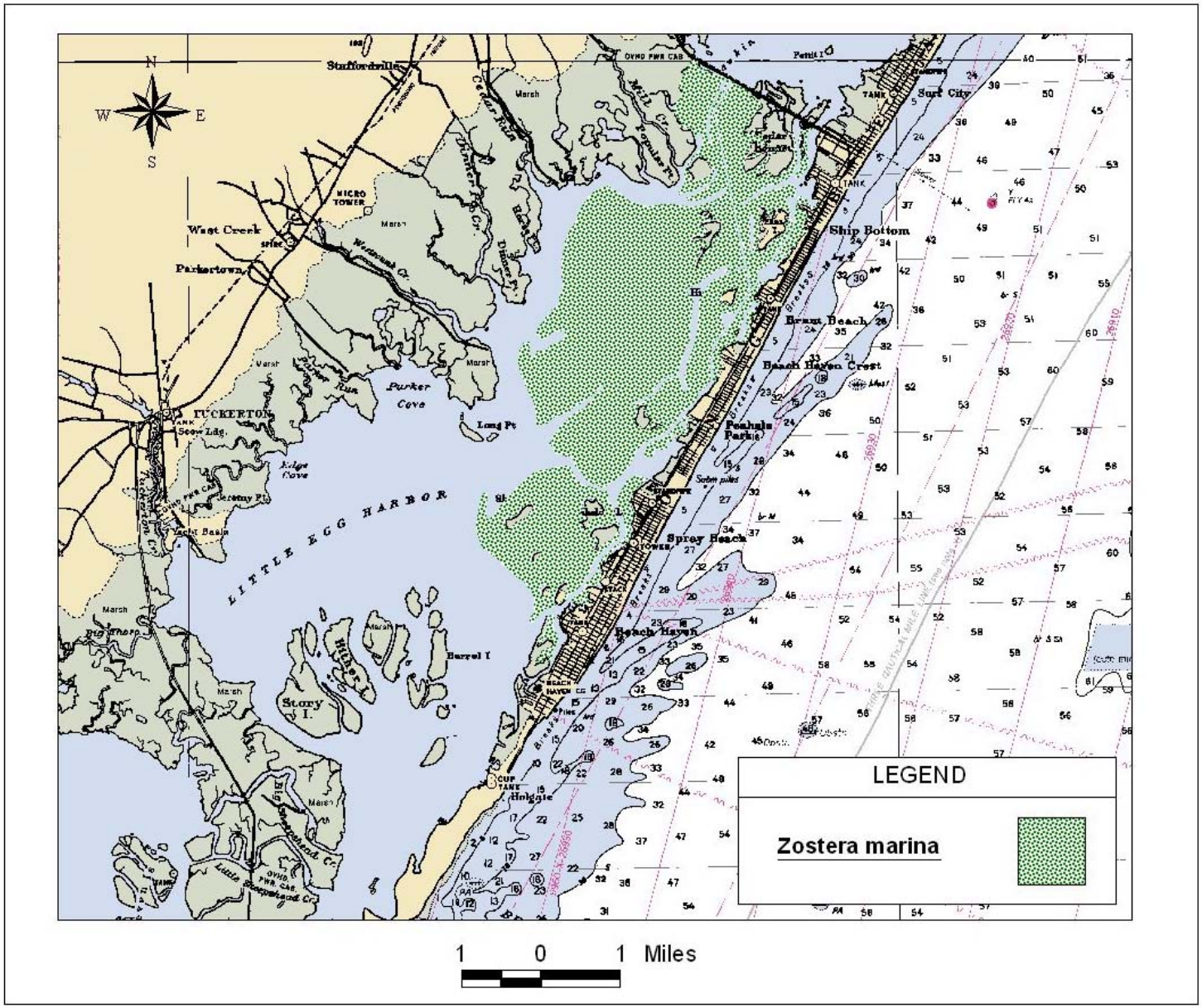

Figure 5. 2001 Little Egg Harbor Bay Shellfish Inventory: SAV distribution.

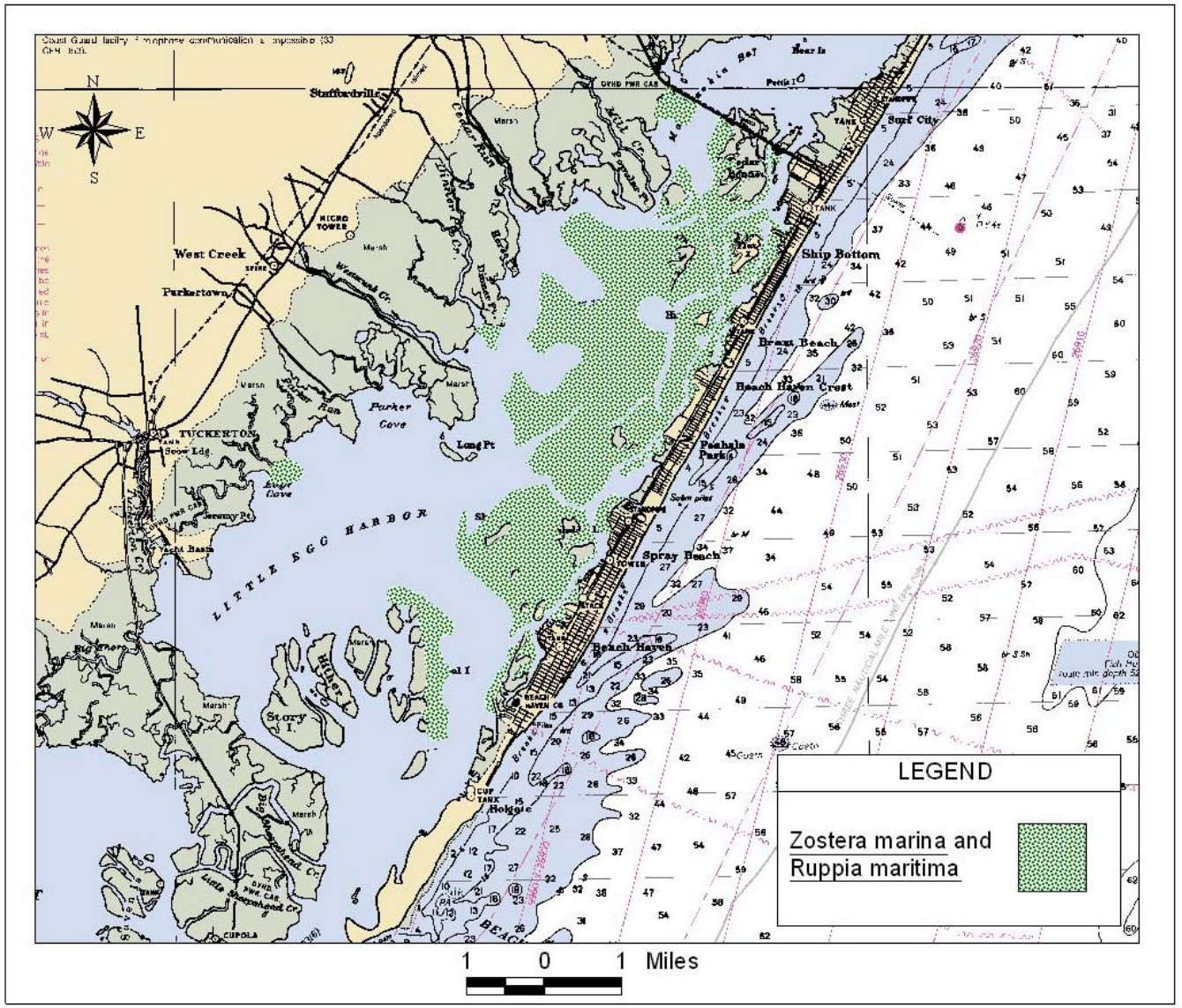

Figure 6. 2011 Little Egg Harbor Bay Shellfish Inventory: SAV distribution.

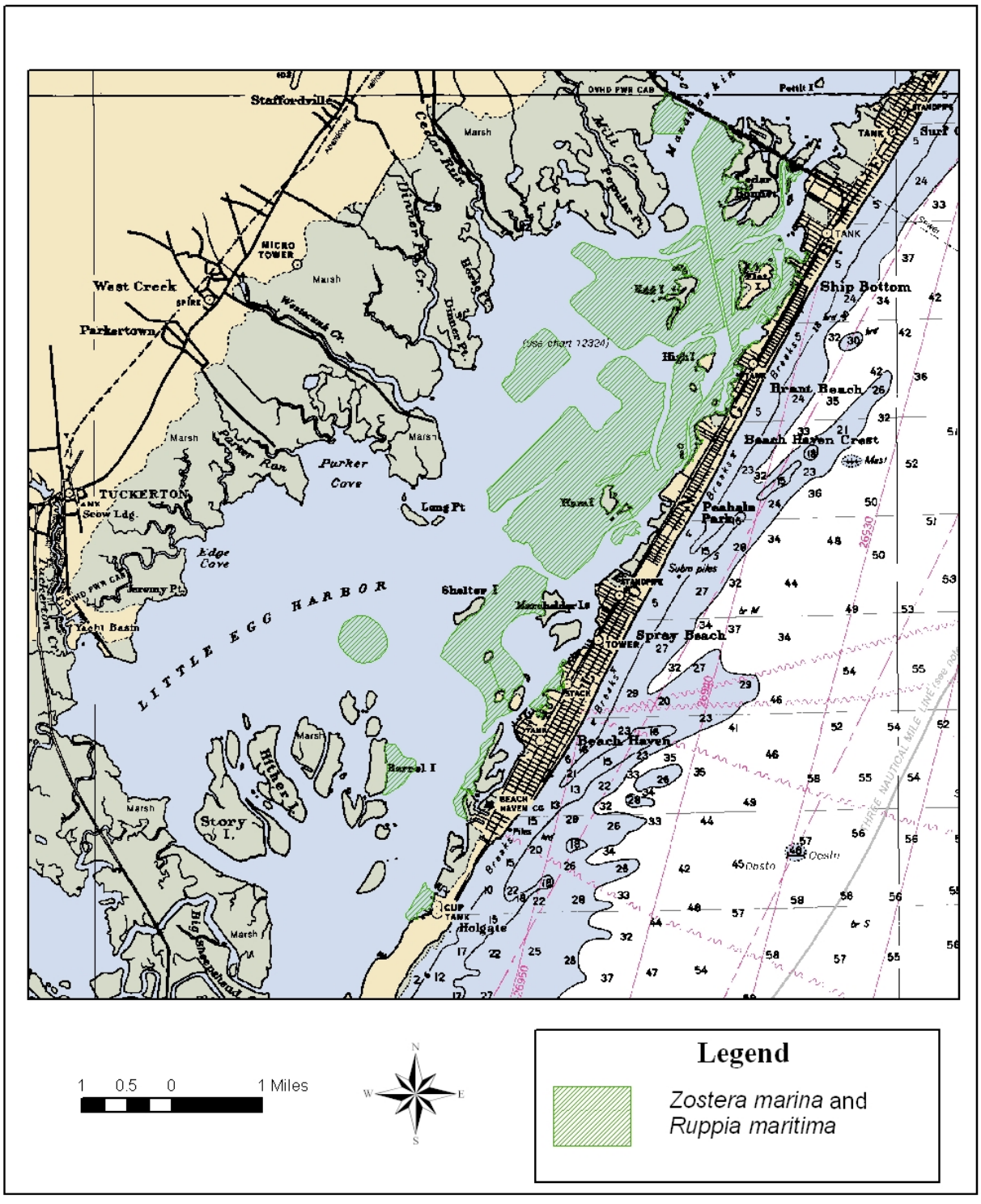

Figure 7. 2011 Little Egg Harbor Bay Shellfish Inventory: station locations.

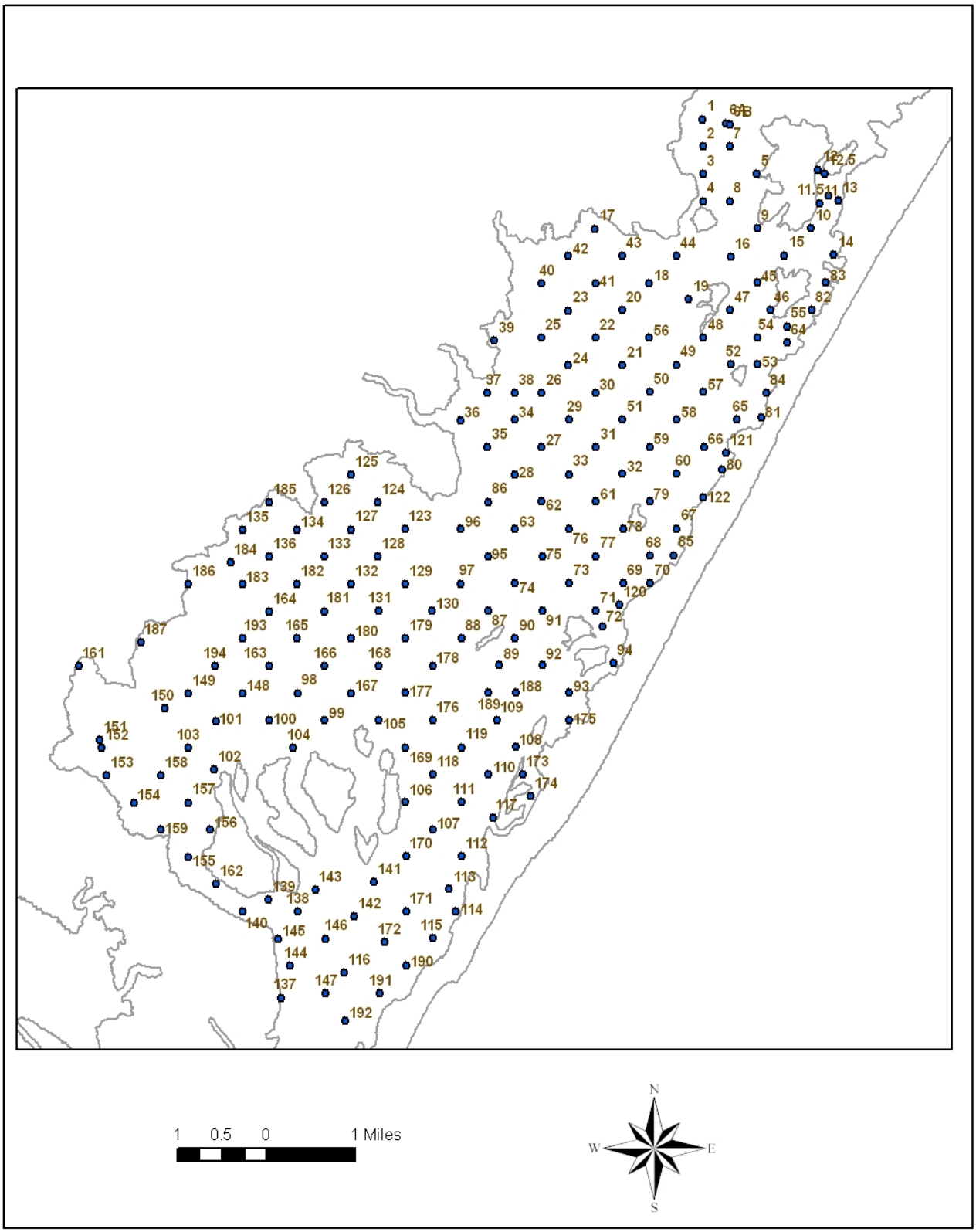

Figure 8. Hard clam stock size (a) and (b) fraction by commercial size class from 2001 and 2011 Little Egg Harbor Bay surveys. Sublegals = 30-37 mm; littlenecks = 38-55 mm; cherrystones = 56-76 mm; chowders > 76 mm.

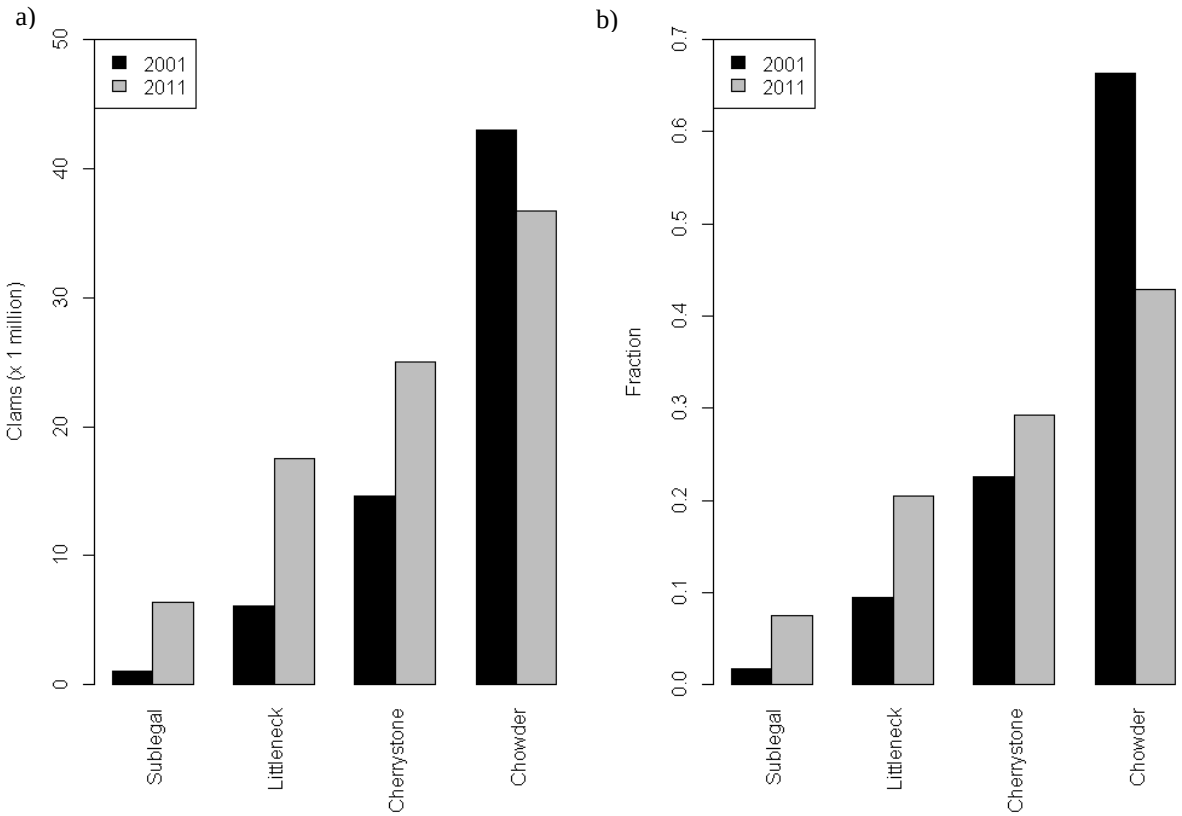

Figure 9. The number (a) and (b) frequency of stations sampled with no [0 clams ft^{-2}], low [0.01-0.19 clams ft^{-2}], moderate [0.20-0.49 clams ft^{-2}], and high [0.50+ clams ft^{-2}] abundances of hard clams from surveys conducted in 1986/87, 2001, and 2011.

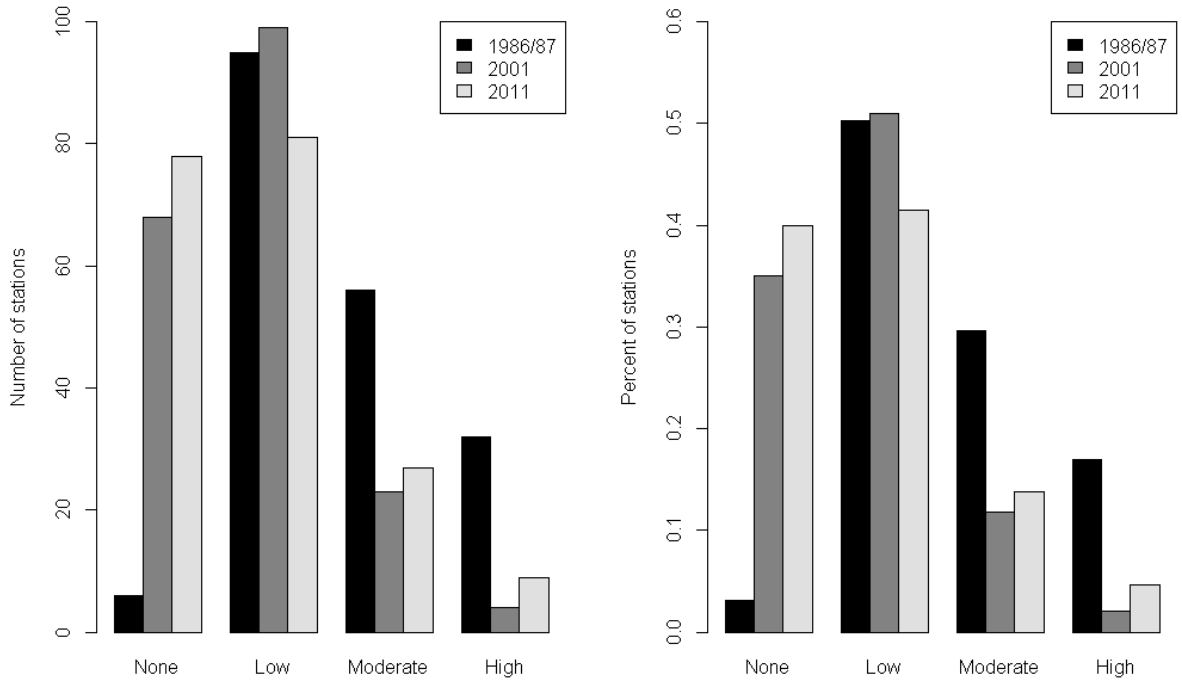

Figure 10. 1986/87 Little Egg Harbor Bay Shellfish Inventory: distribution and relative abundance of the hard clam, *Mercenaria mercenaria*. **Note that data are *not* adjusted for dredge efficiency and are provided for illustrative purposes only**.

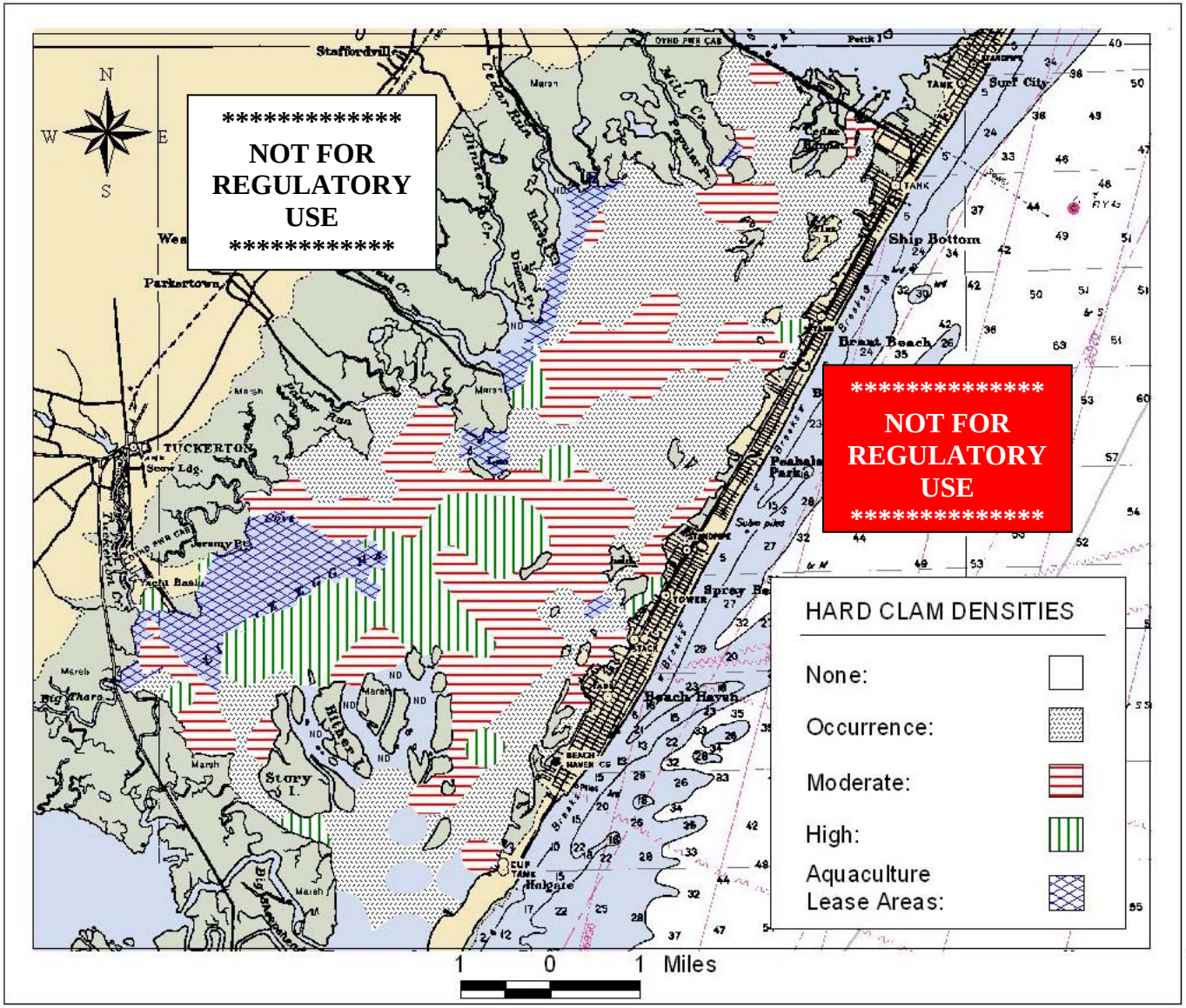

Figure 11. 2001 Little Egg Harbor Bay Shellfish Inventory: distribution and relative abundance of the hard clam, *Mercenaria mercenaria*.

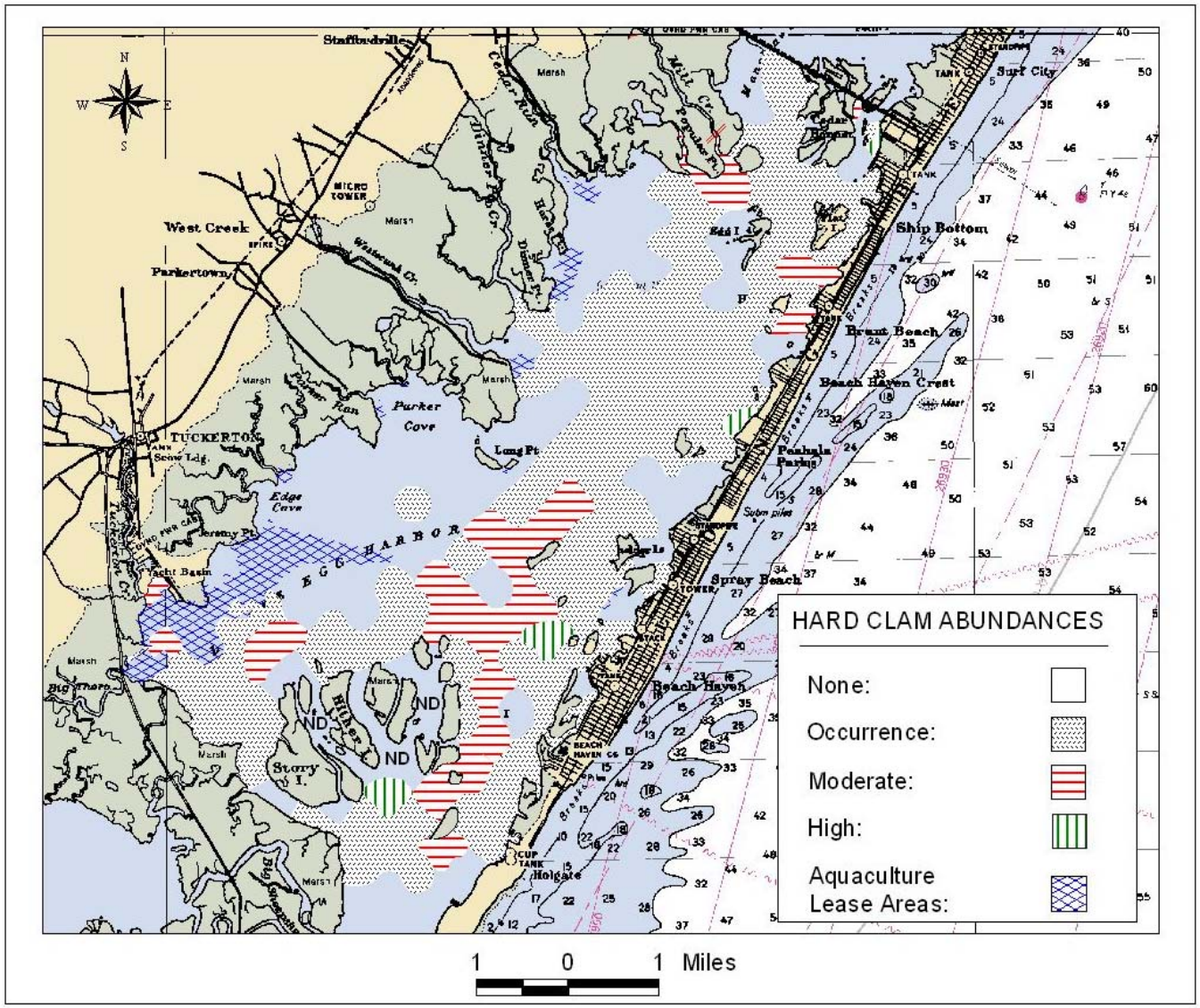

Figure 12. 2011 Little Egg Harbor Bay Shellfish Inventory: distribution and relative abundance of the hard clam, *Mercenaria mercenaria.* (ND = no data).

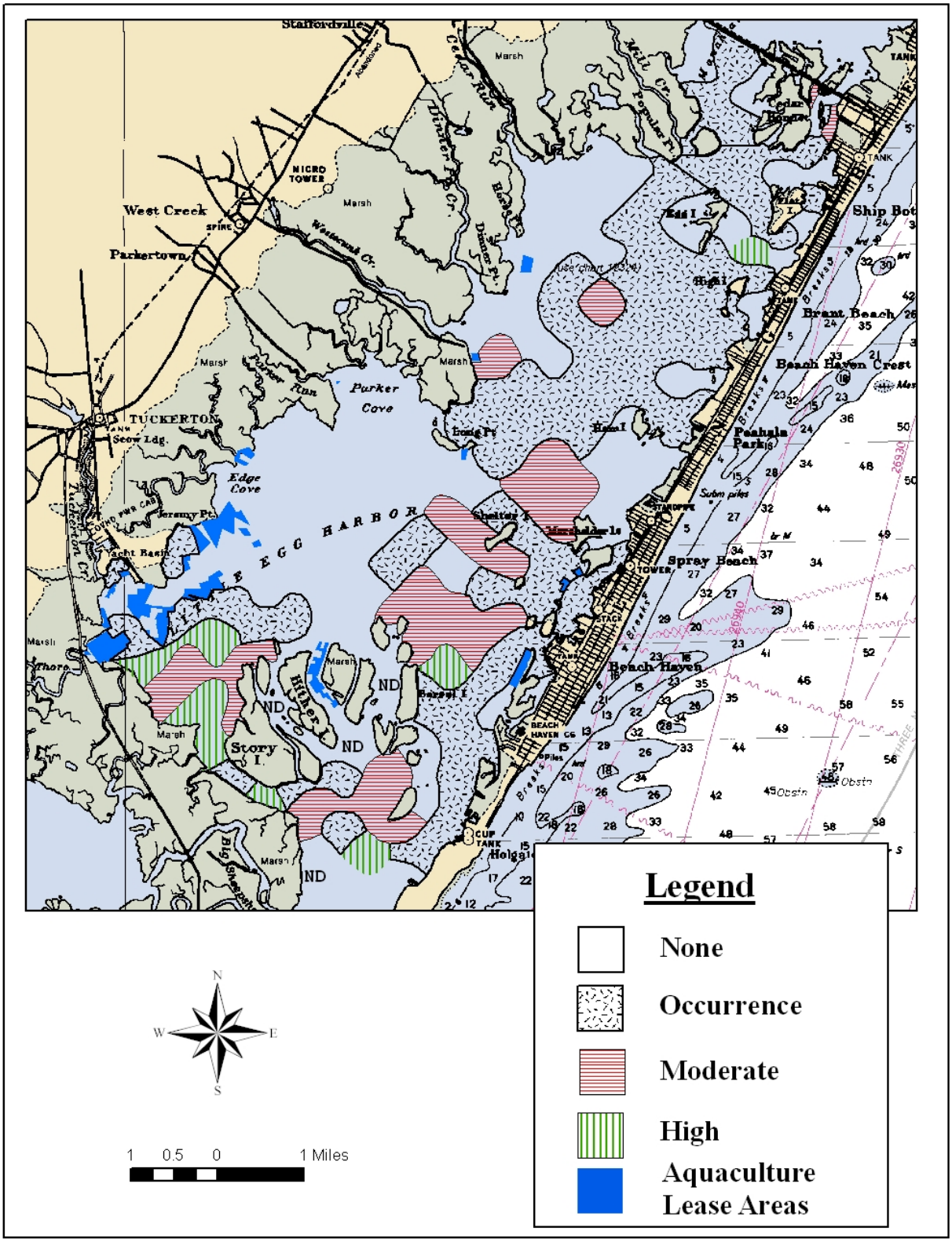

Figure 13. Relative abundance and geometric mean per-station abundance by survey year. For each survey year, the total number of stations sampled is provided; additionally, the number of stations within each relative abundance category are also provided, as well as the range of (minimum and maximum) and geometric mean of abundances (with 95% confidence intervals); units are number of *Mercenaria* foot^{-2}. A plot of geometric means with 95% confidence intervals is also provided (along with other measures of central tendency for comparison). See Figure 9 or report for definition of relative abundance categories.

1986/87

n	189
None	6
Low	95
Moderate	56
High	32
Min	0
Max	2.98
Geo. Mean	0.25
LCL	0.21
UCL	0.28
Geo. SD	0.23

2001

n	194
None	68
Low	99
Moderate	23
High	4
Min	0
Max	0.75
Geo. Mean	0.08
LCL	0.06
UCL	0.10
Geo. SD	0.12

2011

n	196
None	78
Low	81
Moderate	27
High	9
Min	0
Max	2.05
Geo. Mean	0.10
LCL	0.08
UCL	0.13
Geo. SD	0.17

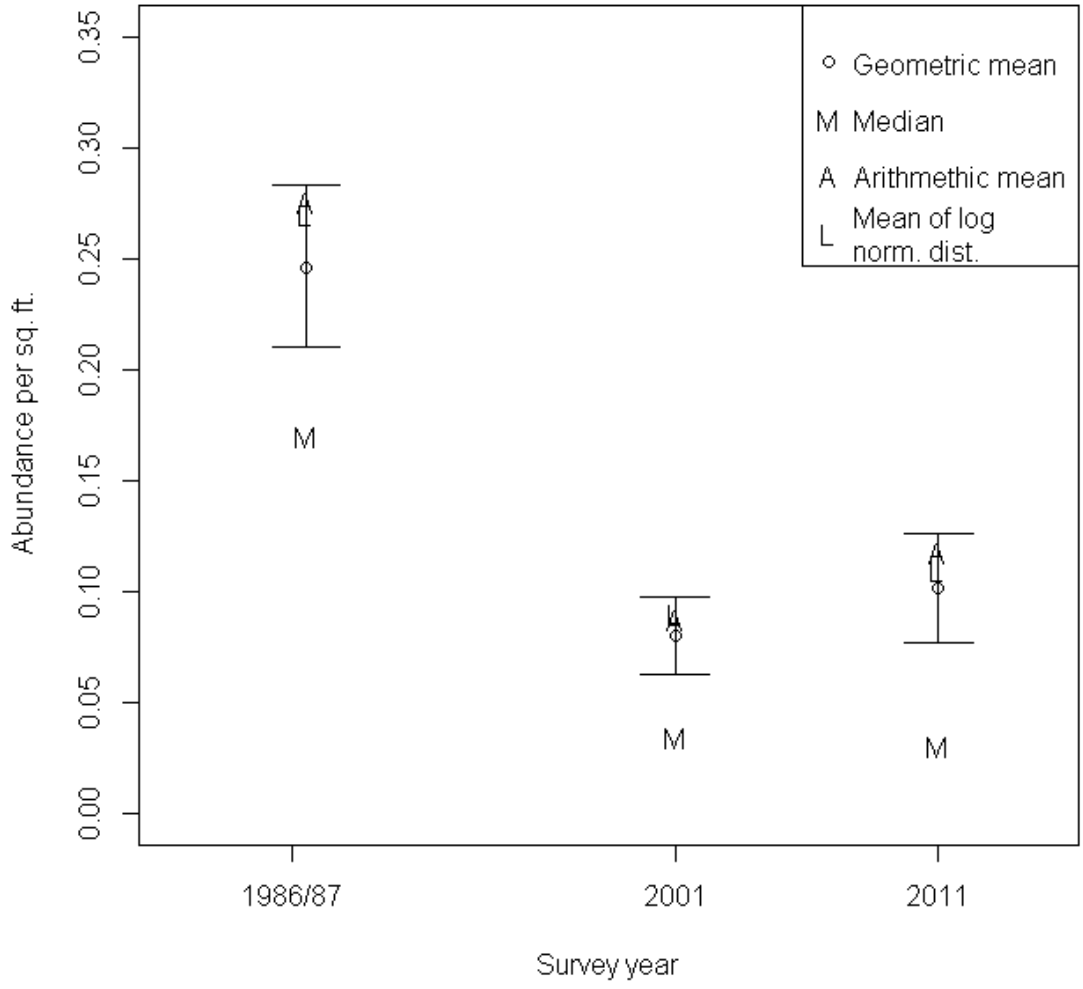

Figure 14. Length-frequency (a) and (b) length-percent-frequency plots from surveys of Little Egg Harbor Bay in 1986/87, 2001, and 2011. Note that in the 1986/87 survey, the number of clams measured was the total from two tows at each station, whereas in 2001 and 2011, the number of clams measured was the total from a single tow (see Materials and Methods of the present report).

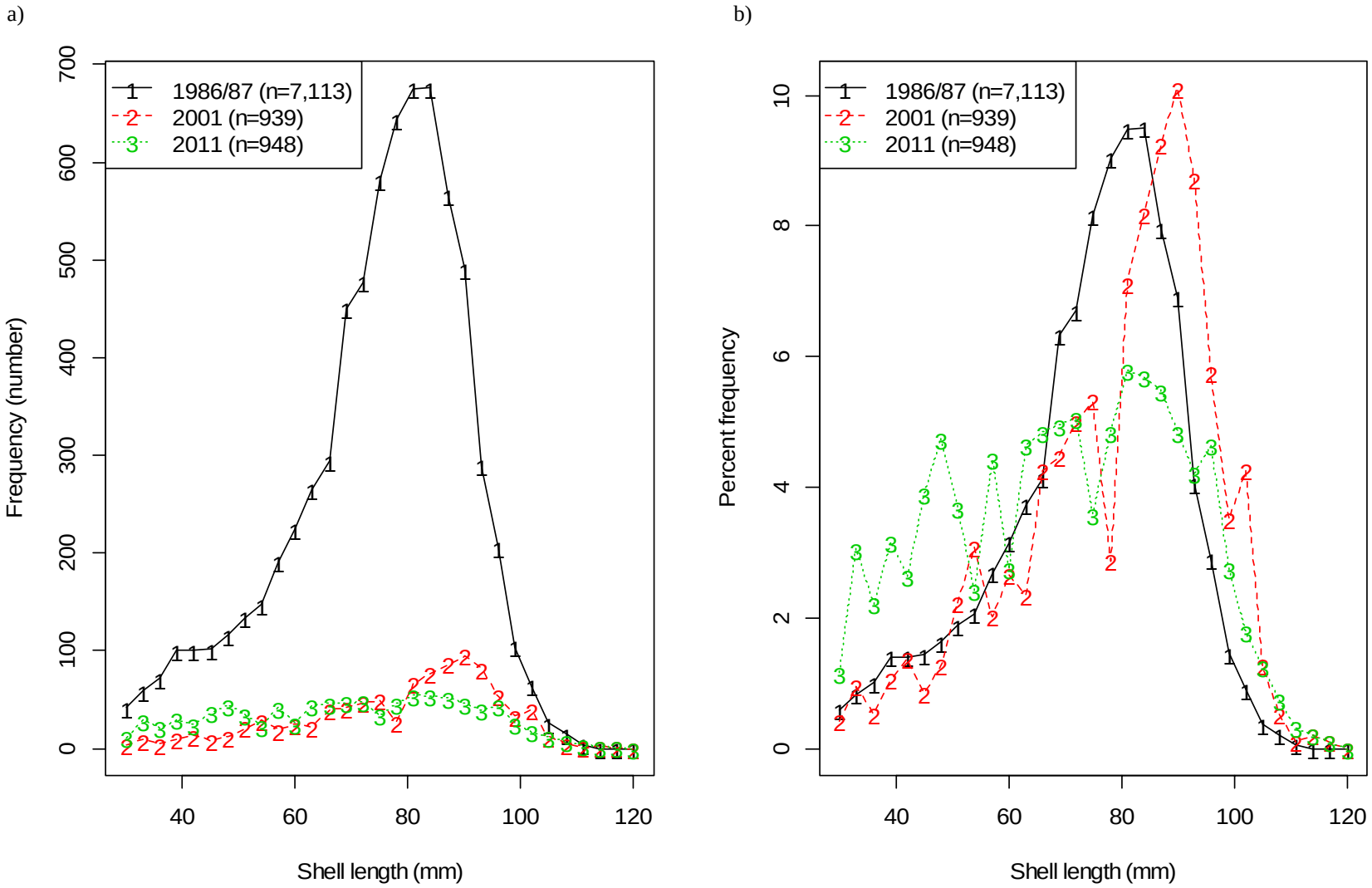

Figure 15. Length-percent-frequency from 2011 survey: a) individual plots of the 4 most abundant stations (for n > 40; number in legend is station number followed by n), and b) overlays of the all-station length-percent-frequency, 4 most abundant station length-percent-frequency, and all stations minus the 4 most abundant stations length-percent-frequency plot.

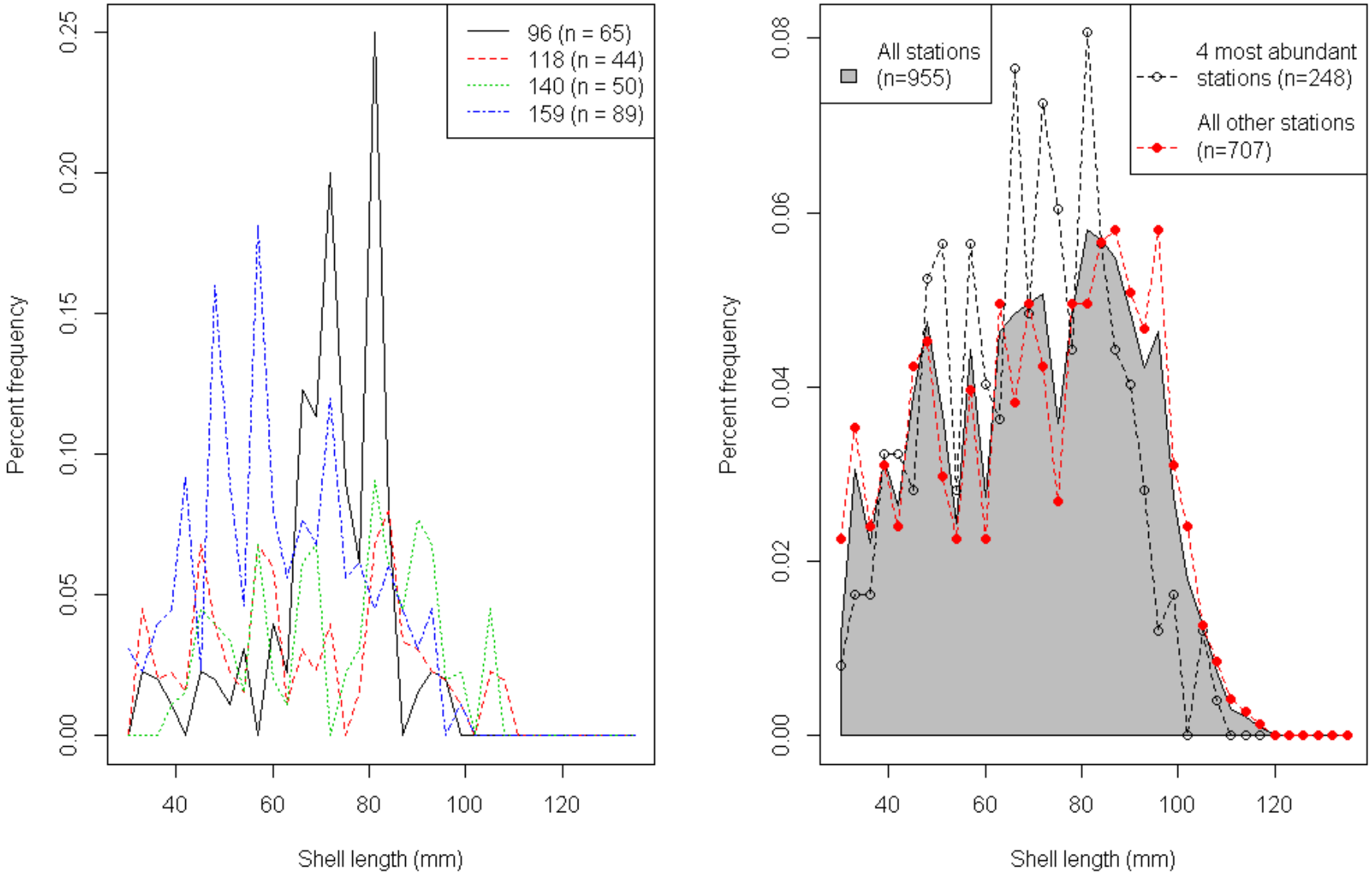

Figure 16. Indices of recruitment (%) in Little Egg Harbor Bay among three surveys. Recall that recruitment = {[(no. of *Mercenaria* collected between 30 and 37 mm at station *i*) ÷ (total no. of *Mercenaria* collected at station *i*)] × 100%} in Little Egg Harbor Bay. Note that recruitment is calculated for stations where abundance ≥ 0.2 *Mercenaria* foot^{-2}. Note that an arrow is added to 2001's plot to draw the reader's attention to an obscured, low (in the (0,5] bin) recruitment station.

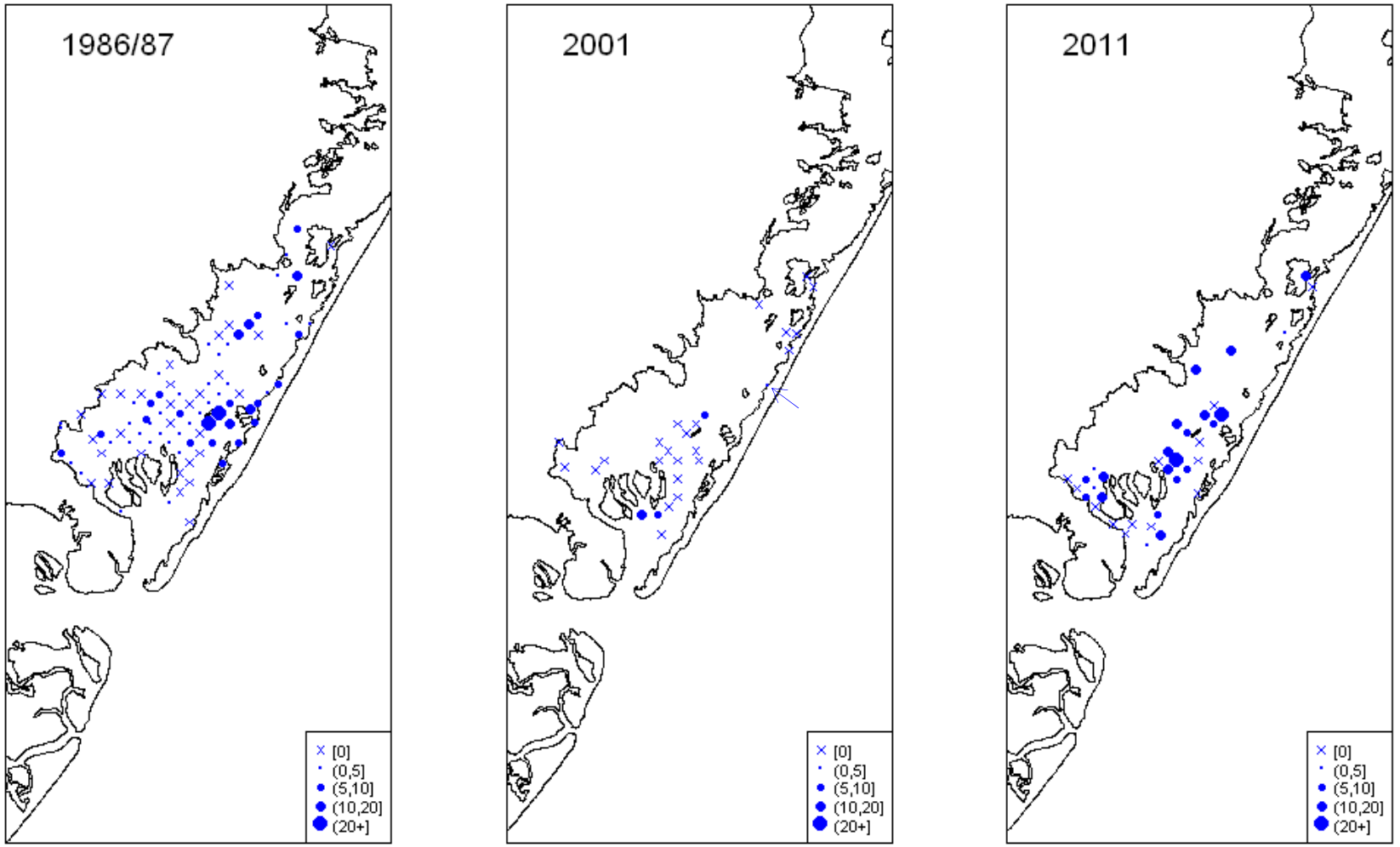

Figure 17. Plot of empirical cumulative distribution function of mortality data in Little Egg Harbor Bay from the three hard clam surveys. Fn(x) = the fraction of observations ≤ a given plotted point.

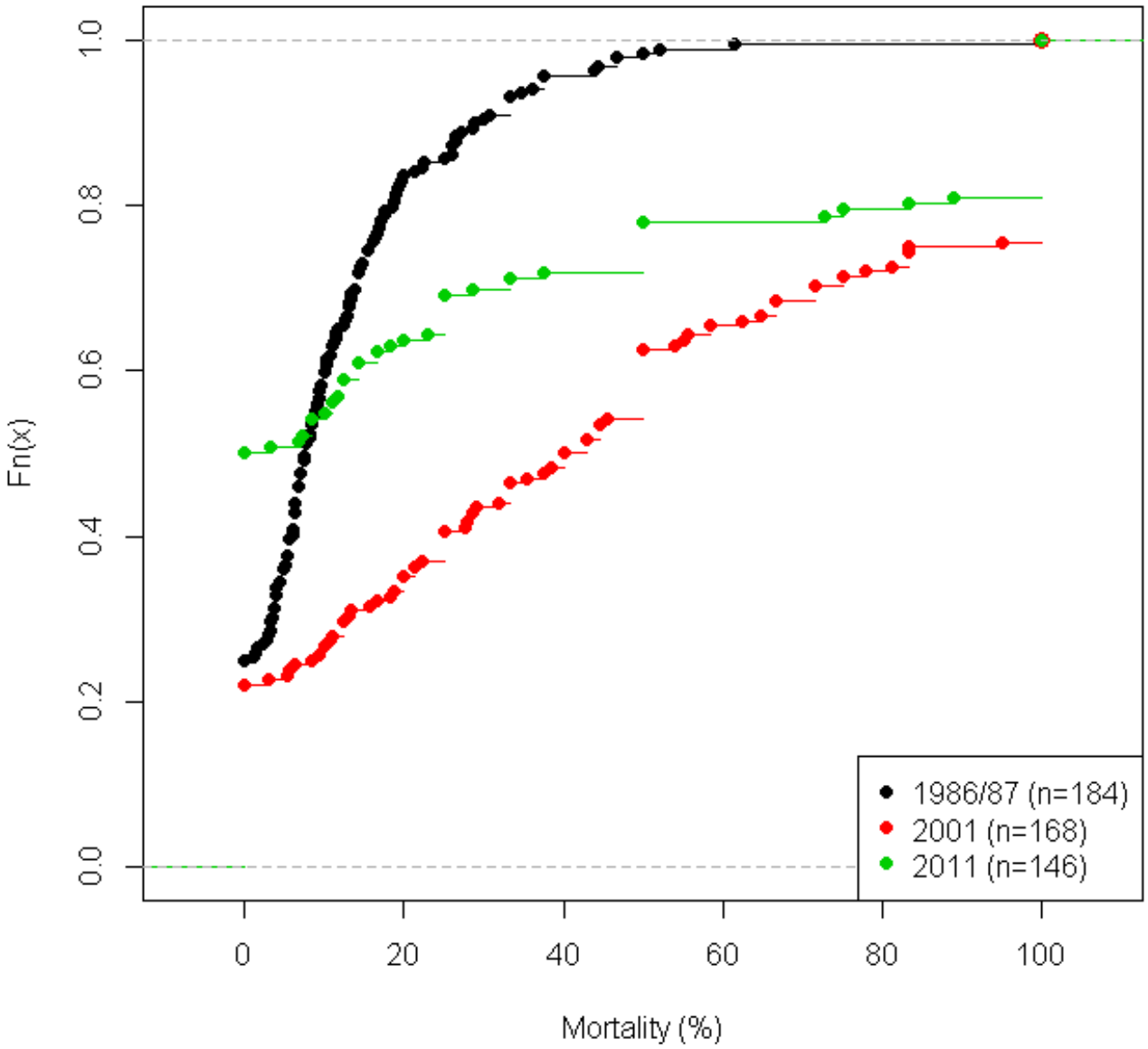

Figure 18. Mortality estimates (%) in Little Egg Harbor Bay among three surveys. Recall that recruitment = {[(no. of boxes at station *i*) ÷ (no. of boxes at station *i* + no. of live *Mercenaria* at station *i*)] × 100%}, and that if the denominator = 0, morality = NA, and hence not plotted.