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Table of Contents

Tables **Pg.**

Figures

Historical Overview

The Stock

The natural oyster beds of the New Jersey portion of Delaware Bay (Figure 1) have been surveyed regularly since 1953; initially in response to historically low oyster abundance (Fegley et al. 2003). Annual stock assessments, formalized in 1998 include the participation of scientists from Rutgers University, Haskin Shellfish Research Laboratory, the NJ Dept. of Environmental Protection, Bureau of Shellfisheries, members of the oyster industry, and several external peer reviewers. From upbay to downbay on Delaware Bay oyster beds, oysters experience increasingly higher salinity, growth rates, predation mortality, disease mortality, and generally higher recruitment. The number of beds surveyed and their groupings have changed since 1953 but as of 2007, there are 23 surveyed beds grouped into six regions designated on the basis of relative magnitude of oyster mortality and the current management scheme (Figure 1). Prior to 2007, the three beds at the upbay limit of the oyster resource (Very Low Mortality region) were not included in the survey thus, most of the long-term time series and all retrospective analyses exclude them (e.g. Figure 2). The acreage for each region is shown in Figure 3.

The long-term time series can be divided into several periods of high or low relative abundance corresponding roughly to periods of low or high levels of disease intensity (Figure 4a). MSX disease, caused by the parasite, *Haplosporidium nelsoni* became a significant periodic source of mortality in 1957 (Ford and Haskin 1982) but has been of little consequence following a widespread epizootic in 1986 after which resistance spread through much of the stock (Ford and Bushek 2012). From 1969-1985, MSX and mortality were low while oyster abundances were high. Circa-1990, Dermo disease, caused by the parasite *Perkinsus marinus* became prevalent in the Delaware Bay and has effectively doubled natural mortality rates since then (Powell et al. 2008). Throughout the time series, fishing has usually taken a low fraction of the stock compared to disease (Figure 4b). Shell planting to enhance spat recruitment has been done periodically throughout the time series when funding is available (Figures 5 a and b).

Dermo disease has exerted major control on the oyster population in the Delaware Bay since 1990. Figures 6 and 7 show abundance and mortality by region for the 'Dermo era' time series. Note that the acreage of a region is not always reflected in the total oyster abundance, particularly during periods of high disease mortality. For example, in the early 1990s, the largest region, the High Mortality region (HM), experienced high Dermo mortalities because of its more saline location downbay and its oyster abundance was lower than that of two smaller regions. The three upbay regions; Very Low Mortality (VLM), Low Mortality (LM), and Medium Mortality Transplant (MMT) are managed as intermediate transplant regions meaning, oysters are moved (transplanted) to one or more of the three downbay direct-market regions: Medium Mortality Market (MMM), Shell Rock (SR), and High Mortality (HM). Shell Rock, which otherwise would qualify as a medium-mortality bed, is separated from the medium-mortality market region due to its consistent high productivity. Until 2011, all stock status data for the medium-mortality beds were compiled with Sea Breeze assigned to the market, rather than the transplant, group. Following the 14th Stock Assessment Workshop (SAW) that reported and analyzed the 2011 season, all time series data for the medium-mortality region have been reconstituted such that Sea Breeze is now included in the transplant, rather than the market category (Figure 1).

The Fishery

From the 19th century to 1996, the natural oyster beds of New Jersey were used as a source of young oysters (seed) that were transplanted to private leases each spring; a practice called 'Bay Season' (Ford 1997). Bay Season occurred over a period of months in the earliest days but over time, it became weeks to prevent overharvesting. From about 1953, the fishery was nominally managed by the loosely applied reference point called the '40% rule' that closed beds when the percentage by volume of oysters in a dredge haul went down to 40% (Ford, 1997). Other factors such as spat set and economics were also considered in making management decisions (Fegley et al. 2003). There were years of Bay Season closures due to MSX and Dermo mortality in the 1950's, 60's, 80's, and early 90's (Figure 8).

In response to the increased number of Bay Season closures, a system called the Direct Market Fishery was adopted for the natural oyster beds in 1996. This allowed the industry to market oysters directly off the natural beds and avoid the high mortality rates present on the more downbay leases. In the early years, the direct market harvest was based on constant market-size oyster abundance estimations (HSRL 2001) and eventually, a submarket surplus model developed by Powell et al. (2009). In addition, transplanting from non-marketable beds to other beds within the surveyed resource (Intermediate Transplants) was included and an area management scheme that opened and closed beds or groups of beds developed (see HSRL reports 2001 to 2005). Transplanting and area management were designed to make use of the whole resource and avoid overfishing of any region.

At the 8th SAW in 2006, the SARC established target and threshold abundance reference points based on the 1989-2005 time series for each survey region. From this same SAW, concern over potentially unrealistic submarket surplus' in upbay regions led to the abandonment of the original submarket surplus reference point used earlier. The 2006 SARC advised adoption of a system based on the evaluation of fishery exploitation by abundance for the time period 1996-2005 (later extended to 2006). It suggested that quotas be determined on a regional basis using exploitation rates associated with the 40th to 60th percentiles for each region. The exploitation-based reference point system stabilized year-to-year variability in the quota that was a byproduct of the more volatile submarket surplus projection and this basic scheme is still in use.

Three of the six regions are designated for Intermediate Transplant. Intermediate transplanting moves an allocation of oysters from the non-marketable upbay regions to the more saline regions where they quickly depurate and attain market quality and enhance the quota in the receiving region. In 2004, a port-sampling program began to obtain fishery-dependent information on the size and number of oysters marketed, permitting the determination of exploitation-based estimates on spawning stock biomass as well as abundance (Powell et al. 2005).

The Survey

From 1953 until 1989, the annual oyster survey was conducted from a small boat and dredge and occurred throughout a number of months in the fall, winter, and spring. Over time, grids of 0.2-min latitude X 0.2-min longitude were created for the primary beds and approximately 10% of them were sampled based on a stratified random sampling design (Fegley et al. 2003). In 1989, sampling was switched to a large traditional oyster boat, the *F/V Howard W. Sockwell,* using a commercial dredge and sampling was completed in a few days. Annual sampling now occurs during four days between late-October and mid-November with samples returned to the lab for intensive processing.

Prior to 1990, oysters were not measured but were categorized as groups defined as 'spat', 'yearling', and 'oyster'. Survey protocol updated in 1990 included measurements of yearlings and oysters permitting calculation of biomass as well as abundance. Spat were still classified based on morphology and were not measured. Boxes were not measured until 1998. Also in 1998, oysters < 20 mm that had been designated 'oyster' based on morphology, were relegated to the spat category. Although counted as oyster in the assessment, the yearling category was continued until 2002. Finally, in 2003, the 20 mm 'spat cutoff' was started to define the difference between being counted as a spat recruit or an oyster that was included in total abundance estimates.

The measurement of survey swept areas and dredge calibration experiments to determine gear efficiency began in 1998 allowing survey results to be quantified per square meter (Powell et al. 2002, 2007). Results of the dredge efficiency experiments indicated that the oyster beds could be divided into two groups; upbay and downbay with Shell Rock in the downbay group (Figure 1). The dredge captured oysters, boxes, and cultch more efficiently on the downbay beds than on those upbay (Table 1). Multipliers calculated from these experiments are applied to survey dredge hauls by bed group to correct for dredge efficiency and thus account for what the dredge leaves behind to give more accurate density estimates, eg. oysters m^{-2} on the bay bottom.

In 2005 by request from the 6th SARC, the survey time series from 1953 to 1997 was retrospectively quantitated (Powell et al. 2008). The estimates were obtained by using bed-specific cultch density determined empirically from 1998-2004. This quantification assumes that cultch density is relatively stable over time. Comparison of retrospective estimates for 1998-2004, obtained using the `stable cultch' assumption with direct measurements for 1998-2004, suggests that yearly time-series estimates prior to 1997 may differ by a factor of 2 or less (HSRL, 2006 and onwards, see: Oyster Abundance; Analytical Approach). Cultch varies with input rate from natural mortality and the temporal dynamics of this variation are unknown for the 1953-1997 time frame. However, understanding of shell dynamics on Delaware Bay oyster beds shows that shell is the most stable component of the survey sample supporting the assumption that a two-fold error is unlikely to be exceeded. Accordingly, the quantitative time-series estimates are considered the best for 1953 to 1997.

Prior to 2005, each bed had three strata. For each bed, grids with 'commercial' abundances of oysters 75% or more of the time were called 'high' (or 'test'); grids with marginal or highly variable 'commercial' densities of oysters 25-75% of the time were called 'medium' (or 'high'); grids with abundances well below commercial densities were called 'low' (HSRL personnel; Fegley et al. 1994). There were many non-gridded areas between beds that were never included in the surveys. Information in the early 2000's from oystermen indicated that harvesting between gridded areas was not uncommon. Therefore, from 2005 to 2008, the grid overlay was increased to cover all areas from the central shipping channel to the New Jersey Delaware Bay shoreline with every grid being assigned to an existing bed. In 2007, an HSRL survey investigated the upbay extent of the New Jersey oyster resource based on bottom sediment mapping that was conducted by the State of Delaware Department of Natural Resources and Environmental Control and provided by B. Wilson (2007, personal communication). The HSRL survey resulted in the addition of three more beds termed the Very Low Mortality region (VLM) into the stock assessment for a total of 23 beds (Figure 1). Earlier data for these beds are not present in the survey database; therefore, reconstruction of their 1953-2006 time series is not possible.

All oyster beds, except Ledge and Egg Island, which have very low oyster abundance (survey averages < 0.5 oysters per m^2), were resurveyed during the 2005-2008 time period. This resulted in a change of strata definition and survey design from that used historically (HSRL 2006). The restratification kept the three strata system within beds and used densities to determine High, Medium, and Low strata. Details of bed stratification are given in Survey Design below. Since 2002, a fourth 'Enhanced' stratum exists to temporarily identify grids that have received shellplants or transplants (see Stratification and Bed Resurveys). A rotating schedule now restratifies each bed once per decade. Analysis of many survey simulations suggested that a random survey based on the High and Medium quality strata is sufficient (HSRL 2006).

Through 2004, the stock survey assessed most beds yearly although a selection of minor beds was sampled every other year. Since then, all beds have been sampled each year with the exception of Egg Island and Ledge that continue to alternate due to their consistent low abundance.

Stock Assessment Design

Sampling Methodology

As discussed above, the natural oyster beds of the New Jersey portion of Delaware Bay (Figure 1) have been surveyed yearly since 1953 using a stratified random sampling method. The complete extent of the natural oyster resource is divided into 0.2-min latitude X 0.2-min longitude grids of approximately 25 acres that are each assigned to one of 23 beds. Each grid on a bed is assigned to a stratum relative to the other grids on that bed. A subset of grids from the High and Medium strata on each bed is randomly selected each year for the survey (Egg Island and Ledge are sampled in alternate years). Grids assigned to the Enhanced stratum are sampled each year.

The survey instrument is a standard 1.27-m commercial oyster dredge towed from either port or starboard. The on-bottom distance for each one-minute dredge tow is measured using GPS recording positions every 2 to 5 seconds. A one-minute tow covers about 100 m^2 and usually prevents the dredge from filling completely thus avoiding the 'bulldozer' effect. The entire haul volume is recorded. Three tows are taken for each sampled grid and a $^1/_3$-bushel subsample is taken from each haul to create a composite 37-quart bushel[1].

Each bushel sample is processed in the laboratory to quantify the following: volume of live oysters, boxes, cultch (normal and blackened from burial), and debris; the number of spat[2], older oysters, and boxes per composite bushel; the size of live oysters, spat, and boxes from the composite bushel; condition index; and the intensity of Dermo and MSX infections.

Stratification and Bed Resurveys

The current stratification method is based on ordering grids within beds by oyster abundance. Grids with the lowest densities that cumulatively contain 2% of the stock are relegated to the Low quality stratum. Initial analyses of resurveys showed that this stratum could be deleted from the fall stock assessment survey to focus on the grids that support 98% of the stock on each bed. In the initial resurveys, the remaining grids were input into a Monte Carlo model in which they were subsampled repeatedly without replacement under a given set of rules. The mean abundance estimated from the subsample was compared to the mean abundance obtained from the average of all grids. Analysis of many simulations suggested that a random survey based on two further strata would suffice. These are defined by ordering the remaining grids by increasing abundance. Those that cumulatively account for the middle 48% of the stock are designated as the `Medium Quality' stratum and the rest that cumulatively account for the

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[1] The New Jersey standard bushel is 37 quarts (~35 liters).

[2] Beginning in 2003, oyster spat are defined based on size (< 20 mm, the average first-season size on the Delaware Bay natural oyster beds). Prior to 2003, oysters were classified as spat based on morphology.

upper 50% of the stock make up the `High Quality' stratum. The temporary Enhanced stratum includes transplant- or shellplant-receiving grids. Transplant grids are sampled only in the year they receive transplant and then are reassigned to their original stratum. Shellplant grids are sampled for three years after which they return to their original stratum. The Monte Carlo model is also used to determine how many grids per High and Medium quality stratum must be sampled for a statistically adequate stock assessment survey after each resurvey. Only two beds remain unsurveyed: Ledge and Egg Island. To minimize survey bias from changes in grid quality over time, a 10-year rotating spring resurvey schedule began in 2009 (Table 2)

Gear Efficiency Corrections

All quantitative and post-1997 time series estimates are corrected for dredge efficiency using the dredge efficiency measurements made from 1998 to 2003 (Powell et al. 2002, 2007)[1]. The experiments to establish catchability coefficients were conducted with the *F/V Howard W. Sockwell* using a commercial dredge and divers on another boat. Parallel transects were sampled to compare numbers of oysters caught in measured tows versus those collected in quadrats by divers presumed to be 100% efficient. Analyses revealed a differential in dredge efficiency between the upper (above Shell Rock) and lower oyster beds. It was also found that on average, the dredge caught oysters with greater efficiency than boxes, and boxes with greater efficiency than cultch. Each survey sample has multipliers applied to the number of oysters, the number of boxes, and cultch volume to account for the efficiency of the dredge. Due to concerns about the effect that natural bay bottom changes over time might have on dredge efficiency, different catchability coefficients (multipliers) are applied to the time series of survey results (Table 1). The 1998-2000 survey results use average catch multipliers from dredge efficiency experiments of that timeframe. Surveys from 2001-2004 used multipliers that also included results from the 2003 dredge calibration project in the average. These multipliers are also applied to surveys prior to 1998. Surveys since 2004 have used the 2003 dredge calibration average by itself under that assumption that it is the most accurate moving forward.

2013 Gear Efficiency Experiment Analyses

In September 2013, dredge efficiency experiments were conducted using the *F/V Howard W. Sockwell* with a commercial dredge and patent tongs on another boat (*R/V Baylor*). Parallel transects were sampled to compare numbers of oysters caught in measured tows versus those collected by the tongs that were presumed to be 100% efficient (see 2014 SAW report for details). Analyses of the data in 2014 compared the results of the 2013 patent tong experiments to the 1999, 2000, and 2003 dredge-diver experiments described above (Figure 9). Tests for spatial and temporal changes in efficiency applied a generalized linear model to arcsin square-root transformed efficiency data with year, bed, and a year*bed interaction term included. Year ($P=0.287$) did not influence efficiency, nor did the interaction between year and bed ($P=0.443$).

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[1] The catchability coefficient (q) as used here is defined as the inverse of dredge efficiency *e*: $q = 1/e$.

Bed (P=0.003) did affect efficiency. Beds grouped together in three distinct groups (Up-Bay, Mid-Bay, and Lower-Bay). The Up-Bay group included Hope Creek and Round Island, the Mid-Bay group included Arnolds, Middle, Cohansey, Ship John, and Shell Rock, and the Lower-Bay group included Benny Sand, Nantuxent, Bennies, and New Beds (Table 3).

These results indicate that dredge efficiency is not changing over time. They do, however, confirm the spatial pattern found in previous experiments (Powell et al. 2002, 2007): dredge efficiency was higher and more variable in the downbay groups of beds than in the upbay group. However, the 2013 experiments included two beds farther upbay than beds previously evaluated for dredge efficiency: Round Island and Hope Creek (Figure 9). These two beds are upbay of Arnolds, the previous most upbay bed studied (Figure 1) and were statistically separated as having higher dredge efficiency than the rest of the upbay group (Table 3). Since dredge efficiency does not appear to be time-varying, consideration should be given as to how best to integrate the most recent dredge efficiency corrections with those currently in use for the New Jersey Delaware Bay oyster stock assessment both retrospectively and going forward. This might involve averages of all data or time-steps as is the current usage. Additionally, the spatial differences shown in the latest experiments will require decisions as to how best to group the beds. Changes made will have implications for the total abundance, market abundance, and spawning stock biomass target and threshold reference points in use since 2006.

Analytical Approach

Dredge efficiency-corrected results from the survey are obtained for each sampled grid in number per m^2 as described above. Grids are then averaged within stratum for each bed. The average is multiplied by stratum area and strata are summed for each bed. Bed sums are added to get regional totals. The quantitative point estimates of abundance in this report sum the High quality, Medium-quality, and Enhanced strata only. Low-quality areas are excluded as described earlier, underestimating abundance by approximately 2%.

Throughout this report, 'oyster' refers to individuals ≥ 20 mm (0.8") in longest dimension while 'spat' refers to those < 20 mm. The 20 mm cutoff was chosen as the average spat size through the estuarine gradient of beds in the Delaware Bay. The result of this is that in upbay regions, e.g. Low Mortality, the < 20 mm size class may include oysters that are older than their first season while in the High Mortality region (HM), oysters in their first season may be > 35 mm (1.4"). Prior to 2003, spat were categorized by shell morphology rather than size. Spat abundance is not included in the estimates of oyster abundance but is shown separately. Oysters ≥ 35 mm are considered to be adults. Calculations of spawning stock biomass (SSB) are based on the ≥ 35 mm size class and were derived using bed-specific and year-specific regressions between dry weight (g) and shell length (mm) to convert size to biomass. Market-size oysters are divided into individuals ≥ 76 mm (3") and individuals ≥ 63.5 mm (2.5"), but < 76 mm (3"). These two size categories are based on a knife-edge selection of oysters for market by the fishery that has been routinely observed since monitoring began in 2005 in which nearly all harvested oysters are ≥ 63.5 mm (2.5”) and historical use of the 76-mm (3”) boundary to define a market oyster.

Uncertainty around the survey point estimate is calculated by conducting 1,000 simulated surveys, each with a selection of samples from each bed and each corrected for dredge efficiency by a randomly chosen value from all efficiency estimates available (HSRL 2008). Confidence-level values are obtained by sorting the simulated surveys on the number of all oysters and also on oysters ≥ 2.5”. Dredge efficiency is less certain for oysters < 2.5” so this approach includes uncertainty that cannot be evaluated. However, smaller oysters make up much of the population and sorting by the larger size class sometimes fails to order the surveys in hierarchical position by total abundance.

2014 Spring Resurvey

For the current assessment, the strata for Bennies, the bed with the most grids (171) were updated based on a Spring 2014 resurvey of all grids on the bed. Evaluation of oyster density on each grid was consistent with other resurveys in finding that a large number of low quality grids could be deleted from the Fall stock assessment survey to focus on the grids that support 98% of the stock on each bed (Figure 10).

The Bennies resurvey resulted in 17 grids that moved to a higher stratum designation and 37 that moved to a lower designation (Table 4a). Although this results in a change in bed footprint (Figure 11), it should not necessarily be interpreted as degradation of the bed. Examination of the previous 2005 stratification survey shows that the average oyster density for grids assigned to the High stratum was approximately 11 oysters per m^2 while the 2014 average density for a High quality grid is 37 oysters per m^2. Medium quality grids followed a similar pattern with a 2005 average oyster density of 2 oysters per m^2 while in 2014 it was 7 oysters per m^2 (Table 4b). After the 2014 resurvey, the stratification indicates a consolidation of the most productive portion of the bed to an area more inshore of the Delaware Bay Channel than before (Figure 11). Six of the grids in this area of the bed received intermediate transplants from regions upbay of Bennies from 2009-2011 and one received an unculled transplant of spat and shell from Beadons in 2011 (HSRL 2010, 2011, 2012).

2014 Fall Assessment Survey

The fall survey is constructed by randomly choosing a designated number of grids from each Medium and High quality stratum on each bed plus transplant and shellplant grids as described above. Sampling for the 2014 assessment survey was conducted October 27, 30, 31, and November 11 using the oyster dredge boat *F/V Howard W. Sockwell* with Lemmy Robbins as captain. Total sampling effort in 2014 was 165 grids (Figure 12). The Enhanced stratum consisted of 12 selectively sampled grids that included 2 grids that received intermediate transplants in 2014, 4 grids that received shellplants in 2014, 3 grids that received shellplants in 2013, and 3 grids that received shellplants in 2012 (Table 5). This stratum is not included in the general estimates for the bed but is reserved for analyses involving shellplant recruitment enhancement and transplant quota enhancement. The intermediate transplant grids revert back to their original stratum after one year. The shellplant grids revert back after 3 years. These grids are then subject to the random choice within strata for following stock assessment surveys. Effects of the transplants or shellplants on oyster density in the grids get assessed in the next bed resurvey.

Status of the Stock in 2014

Whole Stock*[1] *– excluding the VLM due to short time series

Whole stock oyster abundance in 2014 was at the 17th percentile of the long-term time series (1953-2014) and at the 26th percentile during the Dermo era from 1990-2014 (Table 6). Although low compared to either time series, 2014 abundance (1.33 billion) was higher than 2013 abundance (1.17 billion), ending a three-year trend of declining abundance (Figure 2). In contrast, whole stock mortality was only 15%, the lowest level since 2005 (Figure 4a). This rate is the 59th percentile since 1953 and the 26th since 1990 (Table 6). Lower mortality in addition to a reasonably good 2012 spat recruitment event (Figure 5b) has likely helped maintain overall oyster abundance. In 2014, however, recruitment of spat was at the lowest level since 1960 and worse than every year included in the last extended low recruitment period from 2000-2006 (Figure 5b). Spat recruitment in 2014 fell at the 4th percentile for the 1953-2014 time series and at the very bottom for the 1990-2014 surveys (Table 6). SARC members from Delaware and Maryland reported a similar lack of recruitment in their states for 2014 (personal communication, Richard Wong, DNREC and Mitch Tarnowski, MD DNR). Spawning stock biomass (SSB) and market-sized (>63.5 mm, 2.5”) abundance can only be calculated since 1990. SSB often tracks total abundance (Figure 13) and was at the 26th percentile in 2014 (Table 6). The abundance of market-sized oysters was 442 million; the 42nd percentile (Table 6). This size group has been relatively stable since 2008 when the current fishery management scheme went into effect (Figure 14).

***Stock by regions*[123]**

Upbay Regions (Very Low Mortality, Low Mortality)

The VLM and LM regions at the uppermost extent of the Delaware Bay, New Jersey oyster resource, are transplant regions of similar acreage (Figures 1 and 3). The average oyster density of non-enhanced (no shellplants or transplants) grids sampled on the VLM for the Fall 2014 survey (Figure 12) was 72 oysters per m^2 and ranged from <1 to 230 oysters per m^2 (Appendix C). On the LM, oyster densities averaged 60 per m^2 and ranged from <1 to 206 per

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[1] Extended percentile tables in Appendix A.
[2] Region trend summary figures in Appendix B.
[3] Oyster per m^2 densities by grid in Appendix C.

m^2. Aside from 2011 and 2012 when a late summer freshet caused exceptionally high mortalities on the VLM and, to a lesser degree, on the LM (Figure 7; see Munroe et al. 2013 for details), the two regions have had roughly similar oyster abundance since the inclusion of the VLM in 2007 (Figure 6). VLM abundance has recovered considerably, increasing by 65% from 221 million in 2013 to 364 million in 2014 (Figure 6). This represents the 4th highest abundance in the short time series available for the VLM. Total abundance on the LM is at the 11th percentile of the whole time series and at the 22nd since 1990 (Table 6). Although low, LM abundance increased from 275 million in 2013 to 283 million oysters in 2014 (Figure 6). Both regions had good spat sets in 2013 that have translated into higher numbers of small oysters for 2014 (Figure 15a and b). The number of large oysters (> 63.5 mm, 2.5") has increased on the VLM since the 2011 freshet and stands at about 38 million; prior to 2011, market-sized oyster abundance was about 97 million on the VLM (Figure 15c). Oyster growth rates are relatively slow in these upbay regions so the number of market-size oysters on the VLM is expected to increase slowly barring further mortality. The situation on the LM is somewhat different; numbers of market-sized oysters there have been generally decreasing since 2007 (Figure 15c). The 2014 abundance of 56 million represented the 38th percentile since 1990 (Table 6). The mortality rate on the LM has averaged 13% since 2007 and was at the 62nd percentile for the 1990-2014 time series in 2014 at 12.1% (Table 6). Transplants from the LM have occurred every year since 2008 at an average exploitation rate of 1.7% (2.2% in 2014, reference Appendix B) of total abundance. Transplants from the VLM were stopped following the freshwater mortality event in 2011. Spat recruitment was low in every region in 2014 and was at the 18th percentile in the LM for the 1990-2014 time series (Table 6).

The Central Regions (Medium Mortality Transplant, Medium Mortality Market)

The Medium Mortality Transplant region (MMT) is comprised of three beds, one of which (Sea Breeze) is separated from the other two by the Medium Mortality Market region (MMM) (Figure 1). The acreage of the MMT is nearly identical to that of the LM while the acreage of the MMM is quite a bit larger (Figure 3). The average oyster density of the non-enhanced grids sampled on the MMT for the Fall 2014 survey (Figure 12) was 31 oysters per m^2 and ranged from 1 to 93 oysters per m^2 (Appendix C). On the MMM, oyster densities averaged 51 per m^2 on non-enhanced grids and ranged from 11 to 99 per m^2. Since 1990, the MMM has often had the highest oyster abundance of all six regions with the MMT tracking its trends but at lower abundance (Figure 6). The 2014 total abundance on the MMM was 485 million oysters: the 42nd percentile for the 1990-2014 time series while that of the MMT was 187 million oysters and fell at only the 14th percentile for that region (Table 6). Both of these represent an increase over 2013 abundances. There was a 24% increase in abundance on the MMT and a 27% increase on the MMM (Figure 6) where recent management activities (described later) have included both intermediate transplants and shellplanting although there was also some shellplanting in the MMT (Figure 12). Mortality rates for these two regions have tracked each other since 1990 although prior to 2005, the MMM experienced higher mortalities than the MMT (Figure 7). The 2014 mortality rates were 15% on the MMT and 18% the MMM; the 38th and

46th percentiles respectively of the 1990-2014 time series (Table 6). Both rates represent a decrease from the previous two years when mortality averaged 24% and likely aided the increase in total oyster abundance on these regions from the preceding year. The 2014 spat abundance (14 million) was the lowest in the entire 1953-2014 MMT time series (Figure 15a). Spat abundance on the MMM was also very low at 52 million, the 6th percentile of both the 1953-2014 and the 1990-2014 time series (Table 6). Higher spat recruitment in 2012 and 2013 combined with low mortality in 2014, helped to increase small oyster (20-63.5 mm; 0.8-2.5") and possibly market-size abundances in 2014 (Figure 15b and c). Market-size oyster abundance on the MMT was 71 million and was 177 million on the MMM (Figure 15c); the 63rd and 54th percentiles respectively for the 1990-2014 time series (Table 6).

The Lower Regions (Shell Rock and High Mortality)

Shell Rock (SR) is the smallest region in acreage (Figure 3) but has maintained a relatively consistent abundance over the 1990-2014 time series (Figure 6). The High Mortality (HM) region is the largest (> 6 times larger than SR) but has had total oyster abundances similar to those on Shell Rock since about 2002 (Figure 6). The average oyster density of non-enhanced grids sampled on SR for the Fall 2014 survey was 25 oysters per m^2 and ranged from 8 to 48 oysters per m^2 (Appendix C). On the HM, oyster densities averaged 11 per m^2 and ranged from 0 to 59 per m^2. Large portions of the HM have relatively low densities of oysters compared to the other regions. In 2014, 61% of non-enhanced grids sampled on HM had fewer than 10 oysters per m^2 while only 10% of the non-enhanced grids sampled on SR in 2014 had fewer than 10 oysters per m^2 (Appendix C). Similarly, only 21% of HM non-enhanced grids sampled had more than 20 oysters per m^2 while 80% of those on SR had over 20 oysters per m^2. Total oyster abundance on SR increased in 2014 while abundance on the HM was similar to 2013 (Figure 6). The increase on SR follows intermediate transplants and shellplants there in 2012, 2013, and 2014. Total oyster abundance for these regions was near the 1990-2014 time-series median: the 54th percentile for SR and the 42nd for HM (Table 6). Although the two regions have tracked each other in mortality rate with SR typically lower than the HM since 1990, this changed in 2010 when the rate on SR dropped to 11%, increased slightly in 2011 and then spiked at 26% in 2012 above that of the HM (Figure 7). Rates on the HM have decreased since 2011 and continue to be lower than the mortality rate on SR. In 2014, the mortality rate on the HM was 15%, the lowest rate since 1990 and which was at the 6th percentile for the 1990-2014 time series (Table 6). For comparison, the mortality rate on the HM was at the 41st percentile in 2014 for the 1953-2014 time series. Although higher than the HM, rates on the SR have dropped since 2012 and the 2014 rate was 18% at the 42nd percentile (Table 6). Spat recruitment has been much higher in the HM than on SR since 2011 (Figure 15a), translating into increasing numbers of older (larger) oysters there, particularly those of market-size (Figure 15c). The decrease in mortality rates has allowed these older oysters to survive longer than they might otherwise. As in the other regions however, spat abundance in 2014 was very low and fell at the 6th percentile for the HM and was a record low for SR (Table 6).

Habitat and Recruitment

Background

Oysters are unusual in terms of stock assessment because they create their own habitat. Spat settlement requires hard surfaces and oyster shell is generally the hard surface available in their environment. Without spat recruitment (and survival) there are no oysters: without oysters, there is no habitat for spat recruitment. Moreover, oyster shell is not a permanent resource for potential oyster spat (Mann and Powell 2007). Chemical, physical, and biological processes degrade the shell over time (Powell et al. 2006). Burial of shell by sediment or fouling by epibionts make shell inaccessible to recruits. Fewer oysters produce less shell therefore, less habitat. Similarly, smaller oysters provide less shell than larger oysters and degrade faster. The circular nature of this relationship between oysters and the habitat they create makes evaluation and management of the shell resource critical (Powell and Klinck 2007; Powell et al. 2012). Without a balance between habitat and oysters, the population will decline.

Shell Half-lives

Powell et al. (2006) developed a model to estimate surficial oyster shell (cultch) half-lives for each bed. The model was developed during an extended period of low recruitment accompanied by a decline in both oyster abundance and in cultch that suggested loss of shell resource over time. Bed half-life estimates are updated yearly from the Fall survey data. The time series for which half-lives can be calculated begins with 1999, the year after the survey became quantitative. The analyses are subject to substantial yearly variations retrospectively due to limited sampling of some beds in years prior to 2005, because some conversions are poorly known (eg. the individual proportions of oysters, boxes, and shell when they are clumped together), and because the time series is still relatively short, being of the same order as many of the half-life estimates. This results in some half-life estimates being negative which is in fact undefined.

Bed-specific half-life estimates for surficial cultch were updated in 2014 (Table 7). They are presented with estimates from previous years for comparison. Half-lives ranged generally between 3 and 12 years, with a 2014 median of 7.05 years although a few beds had much higher values and some beds had undefined negative values. Shell half-lives for the VLM and Upper Middle could not be estimated in 2014 due to scant records. Continued experience with this database confirms the original conclusions of Powell et al. (2006) that half-lives routinely fall below 10 years.

Shell Budget

A shell budget was constructed using the half-life estimates for surficial shell following the model of Powell and Klinck (2007). Values for the beds with uncertain half-lives (Table 7) were borrowed from neighboring beds. Shell of oysters is not counted as input to the budget until oysters die and become boxes. The other form of input to the shell budget is when shell is introduced by planting. Shell is debited based on half-life values. Because the shell of live oysters is not included in the shell budget, oysters removed by the fishery never contribute to it.

New Jersey oyster beds have been losing around 300,000 bushels of cultch annually since 1999, with loss rates much higher early in the time series (Figure 16). Since 1998 is the first year that full survey data are available, 1999 is the first year an estimate can be made. The shell budget was updated using the 1998-2014 time series based on 2014 half-life estimates with comparisons that use the 2013 and 2012 half-life estimates. The shell budget shows a general reduction in shell loss until 2008, the last year of a large-scale shell plant program that lasted from 2005-2008 (Ashton-Alcox et al. 2009). The three estimates fall around the zero line in 2008 indicating a balanced shell budget (Figure 16). Since then, there has been annual shell planting at a reduced level and the losses of shell have increased.

Shellplanting

Shellplanting is recognized as an important management activity to maintain the oyster beds and has been practiced at various intensities throughout the survey time series with planted volumes usually dependent on funds (Figure 5a). Earlier programs planted large volumes of oyster or clamshell on NJ oyster beds, particularly in the 1960s and 70s. Efforts since 2003 have primarily used clamshell (quahog and surf clam), a by-product of local clam processing plants. There are two types of plantings: direct and replant. Both are dependent on careful timing and site selection. Direct planting places the bare shell directly on a chosen site while replanting first puts the shell downbay in a high recruitment but low survival area. Once it catches a set, the spatted shell is moved upbay by suction dredge to its final site. Shellplants are monitored monthly from April to November on the oyster beds using a small (0.81m toothbar) dredge (Bushek et al. 2015) and for their first three years, are included in the Fall survey for stock assessment. Planted shell will continue to recruit spat in years subsequent to the initial planting.

In 2014, there were three direct shellplants and one replant that were sampled in the Fall Survey (Table 8). The replant was part of a mitigation program on Middle bed, in the Medium Mortality Transplant region that began in 2011. This is further upbay than most planted areas and spat sets are less reliable here than further downbay. Because this replant program has been ongoing since 2011, the total amount of clamshell on the two grids involved has been used for the 2014 data. Highest set occurred on the Nantuxent directly planted grid, the most downbay and inshore of the planted grids (Table 8). Spat set is usually higher downbay than upbay and inshore rather than offshore toward the Delaware Bay Channel. The density of spat on the Nantuxent planted grid was 41 m^{-2} whereas the average spat density on sampled non-planted grids on Nantuxent was half that at 20 m^{-2}, ranging from 2 to 41 m^{-2} (see Appendix C). Spat densities on Middle non-planted grids ranged from 0 to 10 spat m^{-2}, averaging 3 m^{-2}, about half that of the two planted grids that had spat densities of 5 and 8 spat m^{-2} (Appendix C). Similarly the average spat density on the Ship John non-planted grids was about half that of the planted grid: non-planted average was 6 spat m^{-2} ranging from 0 to 16 and the planted grid had 11 spat m^{-2}. This did not hold true for the planted versus non-planted grids on Shell Rock in the 2014 sampling. There, the planted grid and the non-planted average were about the same: 2 spat m^{-2}, ranging from 1 to 5 spat m^{-2}. Although not included in the average, the Shell Rock grids that received shellplant in 2013 had 2014 spat densities of 2 and 4 spat m^{-2} (Appendix C).

Spat recruitment in 2014 to shellplants deployed in 2013 was also monitored in the 2014 Fall survey (Table 9). In most years, the recruitment to shell planted in the previous year is lower than the recruitment to shell planted within the season. This was not the case on Shell Rock in 2014 as mentioned in the previous paragraph regarding spat density for 2014 on those grids. Grids 29 and 30 were planted with shell in 2013 (Table 9) while grid 31 was planted with shell in 2014 (Table 8). The spat per bushel of clamshell on the older plantings were 90 and 100 (Table 9) while that for the newer planting on Shell Rock grid 31 was a mere 18 spat per bushel of clam (Table 8). Similar amounts of shell were planted in each case.

As with all other discussion about spat for 2014 in this document, the spat set on the newly planted shell was low relative to previous years. However, it still outperformed spat set on native shell from the same grid in 5 out of 6 cases (Table 10), a phenomenon that has been noted before (eg. prior SAW reports and Ashton-Alcox et al. 2009) and is one of the benefits of shellplanting. In 2014, a year of very poor spat set, Nantuxent 23 had 818 spat per bushel of clamshell from the Fall survey sample and 354 spat per bushel of native shell (including oysters, boxes, loose oyster shell) from the same survey sample. The ratio of spat on plant versus native shell was 2.3 on Nantuxent 23 and the same ratio on Shell Rock 30 was 3.3. Other planted site ratios were not as high but all were >1.25 except the Middle replant (Table 10). From 2003 to 2014, the fraction of recruits on planted shell as a portion of all recruitment in a region has ranged from 1% in more upbay regions to 58% on the downbay HM region (Table 11). Comparison of the fraction of a region's acreage planted with shell to the fraction of recruitment supplied by the plant can differ by an order of magnitude or more (Table 11). For example, the 2014 Nantuxent shellplant in the HM was on one grid (~25 acres). That grid is 0.33% of the total area on the HM yet the spat resulting from that planting was 27% of the total spat abundance on the HM for 2014 (Table 11). Similarly, single grid SR shellplantings cover only 2% of the SR area but often account for well over 20% of the total spat recruited to SR. Figure 17 shows the proportion of spat recruited to shellplants out of the total spat recruited for all regions combined. Proportions vary over the years due to different amounts of shell planted and recruitment patterns but in most years with shellplants, the enhancement due to planted shell is readily apparent. The overall proportion of recruitment due to planted shell across all regions in 2014 was 13% (Figure 17).

Projections of potential numbers of market-sized oysters (>63.5 mm, 2.5") that might result from the 2014 recruitment to each shellplanting are given in Tables 8 and 9. For these projections, years to market size were calculated using von-Bertalanffy parameters as described in Kraeuter et al. (2007) and previous reports for each region of shellplants. For all shellplanted grids surveyed in 2014, the estimate is three years to market-size oyster. The median of the regional 'juvenile' (first year post-spat) mortality rate from the 1990-2014 time series was used for year 1 and the median regional 'adult' mortality rate for the same time series was applied to the next two years to determine numbers of individuals remaining in the 3rd year. The number can be further translated into bushels of market-size oysters if desired by dividing by 266, the number of oysters in a bushel going to market. This number is determined annually by a dock-monitoring program run throughout the harvest season as part of the stock assessment process.

Spat and Small Oyster Morphology

For the purposes of this stock assessment, oysters < 20 mm are defined as spat (recruits in their first season or 'young of the year'). This assumes 20 mm to be the average size an oyster attains in its first season of growth across all regions. The estuarine salinity gradient over the Delaware Bay oyster beds corresponds to a gradient in growth that is faster downbay (higher salinity) and slower upbay (lower salinity). Further, spat sets occur at different times and locations resulting in variable sizes by the time of the Fall assessment survey (HSRL 2014). Consequently, application of the single 20 mm size cutoff to define a spat classifies a 40 mm spat as a small oyster or a 19 mm, second year oyster as a spat. It should be noted that spat are not included in oyster abundance or biomass estimates in the stock assessment although spat abundance enters deliberations when establishing quota allocations for an upcoming season. Quota allocations for transplant regions are currently based on abundance of all oysters >20 mm. Therefore, a better understanding of average regional sizes at which spat transition to oysters is required for more precise estimates of post-spat oyster abundance and transplant region quotas.

Evaluations of the transition sizes of spat-to-oyster based on morphology were conducted in 2014 using Fall survey samples from beds in all regions except Shell Rock which falls between the Medium Mortality regions on its upbay side and the High Mortality region on its downbay side. Individuals were defined as spat or oyster by experienced researchers using visual examination of morphology and shell lengths were measured. A subset of the samples was evaluated by multiple researchers to verify that spat/oyster designations were consistent. Logistic regression was used to estimate the transition size (the response variable) with shell length and region as explanatory variables (Figure 18). The predicted size at which oysters morphologically transition from spat to oyster is given as the 50% probability on the logistic regression curve calculated for each region. The results show that the predicted transition size varies in an expected way from smallest sizes in the upbay regions along the gradient to the largest size in the farthest downbay region. In 2014, the average size of transition in the most upbay region (VLM) was 23 mm with transition size for the other regions becoming progressively larger to a maximum of 32 mm at the HM furthest downbay (Figure 18). If these sizes were used as the 'spat cutoff', the estimate of the proportion of the population categorized as spat would be higher and the proportion of the population categorized as small oyster would be lower and these differences would vary regionally. Timing of spat settlement can significantly influence the early growth rate of spat (HSRL 2014) potentially influencing the size at the morphological spat-to-oyster transition in the Fall survey. Different years will also provide different conditions for growth. Therefore, it will be necessary to amass more data to assess annual variability of the predicted size at transition before consideration of its application to the Delaware Bay oyster stock assessment.

Shellplant, Spat, Oyster Relationships

Broodstock-recruitment relationships for the New Jersey Delaware Bay oyster survey time series have been illustrated in earlier reports and suggest a positive relationship between broodstock abundance and recruitment of spat that may occur in a stepwise fashion. As described in an earlier section, the shellplant programs suggest that the relationship exists irrespective of fecundity and that the bay is not larvae-limited as recruitment to newly planted shell is typically high, regardless of the abundance of broodstock. Oyster larvae may tend to set preferentially on live oysters and boxes that are generally more exposed in the water column and often have a larger, cleaner surface area than cultch that may be lying flat on the bottom so one cannot exclude the possibility that broodstock abundance modulates settlement success by being a principal source of habitat (clean shell). It is well understood that shell, whether as live reef or planted shell, is critical to oyster population stability or growth (Abbe 1988, Powell et al. 2006).

In the 1960s and early 1970s, in response to low oyster abundances, federal funds were made available to purchase and plant significant amounts of clean shell on the New Jersey oyster beds (OIRTF, 1999). Shellplanting data for this report was obtained internally from annual reports and the Director's correspondence and externally from the Bureau of Shell Fisheries. As can be seen in Figure 19, the large and consistent plantings early in the time series were followed by correspondingly large spat recruitment and in turn, oyster abundances. Examination of plantings by region during this time period show that in addition to the very large total volumes of shell planted, it was spread amongst the bed regions, a practice that likely helped ensure enhanced spat settlement even if recruitment was spatially patchy among the regions (Table 12). Further analyses are needed to explore the specific relationship between shell (habitat), salinity, oyster recruitment, and adult abundance.

Oyster Fishery

Direct Market Harvest

The 2014 direct market harvest occurred from April 7th to November 20th and included a period of curtailed harvest hours during summer months to comply with New Jersey's approved *Vibrio parahaemolyticus* management plan[1]. A total of 27 vessels including 15 single- and 12

[1] http://www.nj.gov/dep/bmw/Reports/2013vpplan.pdf

dual-dredge boats were in operation; a number that has steadily declined since at least 2009 when 74 boats harvested. Many boats now harvest multiple quotas as a result of a change in legislation that allows license consolidation. Total direct market harvest in 2014 was 76,910 bushels (Table 13)[1]. This is the median value for the 19 years since the direct market harvest was established and somewhat above the mean of 75,488 bushels (Figure 20). This harvest included both the initial quota allocations of 57,562 bushels from the three direct market regions: Medium Mortality Market (MMM), Shell Rock (SR), and High Mortality (HM) and an additional 20,109 bushel allocation resulting from intermediate transplants (Table 13). Of the 14 beds opened to the 2014 Direct Market harvest, eight plus one transplant bed were fished and 91% of the catch came from five beds: Shell Rock (31%), Ship John (32%), Cohansey (11%), Bennies (10%) and Nantuxent (7%). These proportions have been similar since 2011. Prior to that, Cohansey contributed far less to the total harvest and Bennies Sand contributed more. This change may reflect a combination of management decisions including: 1) transplants from VLM to MMM, 2) the decision to move Sea Breeze from the direct market region MMM to the transplant region MMT, 3) increasing the exploitation rate on MMM from 2-3% to 4%, and 4) shellplanting on Bennies Sand. All of these occurred between 2008 and 2011.

The catch per unit effort (CPUE) has increased the past two years, possibly helped by continued license consolidation that now allows one boat to harvest quota for up to six licenses; each license represents an individual allocation (Figure 21a). There has been a general increase in CPUE since the 2001 low point of the direct market time series. Figure 21b shows CPUE on the beds where harvest occurred in 2014. In 2014, CPUE was highest on Shell Rock and Bennies, representing 31% and 10% of the harvest respectively and lowest on Hawk's Nest and Nantuxent, representing <1% and 7% of the harvest respectively (Table 13). The fraction of each bed covered by a dredge during the harvest season was estimated using the methods described by Banta et al. (2003) and exceeded bed area in four of the nine beds fished for the 2014 direct market (Table 13). The highest fraction (2.34) occurred on Ship John. Powell et al. (2001) suggest that a cumulative annual swept area of less than four times the area of a bed is unlikely to have significant negative impacts on the oyster population. In general, these fractions have been decreasing over the years with fewer beds experiencing coverage fractions > 1 (see harvest tables in previous reports).

Port Sampling

The port-sampling program counts and measures oyster at dockside from boats unloading direct market harvest. In 2014 the average number of oysters per 37-qt bushel harvested was 303 including small but non-targeted oysters (Figure 22). This number has varied over time depending on spat sets but the number per bushel of market-sized oysters (>2.5", 63.5 mm) has remained relatively constant since port sampling began in 2004. Conversion of oysters to bushels for allocation projections used the value of 266 oysters bu^{-1} in 2014, the average of

[1] Harvest data provided by the New Jersey Department of Environmental Protection.

eleven years of port sampling. This value is the mean of the total oysters and the presumably targeted ($\geq$ 2.5”) oysters per bushel. The rationale for using the mean is that the number of attached small oysters will vary widely between years depending on recruitment dynamics so that using the total number per bushel risks underestimating the allocation. On the other hand, the smaller number does not account for all of the oyster removals and this undervalues the fishing mortality rate. The overall mean has ranged from 259-266 oysters bu^{-1} since 2006. Figure 23 illustrates the 2014 size frequency of marketed oysters compared to the average size frequency for the years before. There was a higher proportion of oysters smaller than 3” (76 mm) marketed in 2014 than there were in the years 2004-2013. It is unknown if this is due to market preference for smaller half-shell oysters or not.

Intermediate Transplant [1]

The Very Low Mortality (VLM) region has been closed to exploitation since 2011 when it experienced high oyster mortalities following an extreme late summer freshet (Munroe et al. 2013). In April and May 2014, the intermediate transplant program moved 13,900 bushels of culled material from Middle and Sea Breeze in the MMT to Shell Rock. In May, 15,500 bushels of culled material from Arnolds in the LM were moved to Ship John in the MMM (Tables 13-14). Overall 9.64 million oysters were moved reflecting the target numbers associated with exploitation decisions made for each of these regions after the 2014 SAW (Table 14). Exploitation rates in the Transplant regions are based on all sizes of oysters because high proportions of oysters smaller than market size get moved during transplanting. Boats deckloading oysters for transplant use automatic cullers as the only sorting device because of the large volumes to be moved. In a 2011 study of the intermediate transplant program, Ashton-Alcox et al. (2013) found proportions of small oysters in the transplant to be as high as 60%. The proportion of oysters < 2.5” (63.5mm) moved in the 2014 transplant program were lower. Of the over 6 million oysters removed from Arnolds, 49% were < 2.5” and the fractions of small oysters moved from Middle and Sea Breeze were 38% and 39% respectively (Table 14). These small oysters did not enter into the calculations for the quota increase in the receiver regions. Oysters $\geq$2.5” contained in the transplant were converted to market bushel equivalents using the number of market oysters per bushel (264) calculated from the Port Sampling program of 2013 (see 2014 SAW document) and were added to the quota for the receiving regions. The 2014 intermediate transplant program increased the quota by 20,109 bushels (Table 14).

Exploitation Rates

The basis for the range of exploitation rates used for the fishery is the exploitation record from the early part of the direct market era (see Historical Overview). These abundance-based rates were from a period of conservative fishery management during a time of persistent high disease pressure and were therefore deemed likely to provide conservative management goals. The 2006 SARC suggested exploitation-based reference points based on the median (50^{th}

[1] Intermediate transplant memoranda in Appendix D.

percentile) exploitation rate defined in terms of the fraction of abundance removed per region for the years 1996 to 2005, the latest data year at that time. To provide flexibility in management, the SARC recommended using the 50th percentile of exploitation as a base but to allow increasing exploitation to the 60th percentile rate when the population is expanding or to reduce it to the 40th percentile rate if the population is decreasing or appears unstable, e.g., during periods of increased disease mortality.

The basic approach was revised in 2007 using estimates of size-dependent exploitation rates because direct market fishing and intermediate transplants remove size classes differently. Two sets of exploitation percentiles were calculated: one using the assumption that all size classes were removed proportionately in transplants and one using a knife-edge assumption that size classes ≥ 2.5" were removed proportionately for direct market regions.

Fishing activity during this decade-long time series was concentrated on the more downbay regions of the stock leading to limited data for regions upbay of Shell Rock. Data were so limited for the Transplant regions that it was decided that they should share the same set of exploitation rates. An adjustment was made to the original set of Transplant region exploitation percentiles by the 2009 SARC in order to smooth a temporally biased change in exploitation rates at the 50th percentile that separated as high and low. The 50th and 60th percentile values (.0127 and .0233 respectively) from the original data were averaged. The average (.0188) is used as the 50th percentile and .0127 is used as the 40th (Figure 24).

The 1996-2006 exploitation rates for the MMM that lies between the transplant regions and Shell Rock have a relatively narrow range from 0.01% of oysters ≥ 2.5" at the 10th percentile to 3.6% at the 90th percentile. In contrast, the range of exploitation for Shell Rock, located just downbay, is much larger (4.4 - 23.6 %) from the 10th to the 90th percentiles (Figure 24). Recognizing that the 100th percentile exploitation rate of 4.0% on the MMM is below the 10th percentile exploitation rate of 4.4% on Shell Rock, the 2009 SARC recommended an experimental fishery at the 100th percentile rate of 4% exploitation on the MMM (Figure 24).

The range of exploitation rates is highest on Shell Rock, approximately 19 percentage points, yet the rates at the 40th and 50th percentiles, considered as those normally to be used for exploitation, are almost identical at 8.7 and 8.8%, respectively (Figure 24). The 60th percentile rate of 11.4% is the upper bound of the usual percentile rates considered. Consequently, when market-size oyster abundance is low on Shell Rock and other parameters are not promising, the only logical choice for conservative exploitation is to choose below the 40th percentile.

Unlike the situation on Shell Rock, the largest increase between exploitation percentiles for the High Mortality region occurs between the 40th (1.2% exploitation) and the 50th (6.5% exploitation). The change on either side of those two percentiles is very small leading to limited management choices in rates of exploitation (Figure 24). This pattern is not unlike that described above for the Transplant regions.

The exploitation rates decided upon following the advice of the 2014 SARC are compared to those achieved by the fishery during the 2014 harvest season in Table 15. The 60th percentile rate of 2.33% exploitation was chosen for both the LM and MMT region transplants in 2014. The achieved rates were 2.25% and 2.41% respectively. The number of direct market harvest bushels ultimately derived from these transplants made up 26% of the total direct market harvest in 2014.

The 2014 SARC did not recommend using the experimental rate of 4% associated with the 100th percentile for exploitation in the MMM because it was showing some signs of degradation but use of the 100th percentile rate was ultimately approved for 2014 by the commissioner of the NJ Dept. of Environmental Protection after petition by the Shellfisheries Council. This region was supplemented with oysters from an intermediate transplant as mentioned earlier, yet even with the additional allocation of 12,025 bushels to the MMM, the achieved exploitation rate was below the 100th percentile at 3.5% exploitation which is approximately the 90th percentile (Table 15). Similarly, on Shell Rock, while the chosen rate was 11.4% (60th percentile), after the region was supplemented with transplanted oysters, the final achieved exploitation rate was 10.5% falling between the 50th and 60th percentiles (Table 15). Achieved exploitation on the High Mortality region was also below the rate chosen. The 75th percentile rate of 8.3% was chosen without requiring any transplant and a 7.6% exploitation rate was achieved, a percentage approximating the 60th percentile of 7.8% (Table 15). The final harvest of 76,910 bushels fell 761 bushels below the total quota of 77,671 bushels, including the 542 bushels directly marketed from Sea Breeze in the Transplant regions. This indicates that the fishery is closely adhering to its quota limits.

Fishing Mortality

During the Bay Season years (see Historical Overview) from 1953 until the start of the Direct Market era in 1996, the oyster fishery commonly took well over 200 million oysters off the natural oyster beds of Delaware Bay, NJ (Figure 8). Since the inception of the Direct Market fishery, the number of oysters landed from the natural oyster beds in Delaware Bay, NJ has been an order of magnitude less than that; around 20 million oysters. Total harvest in 2014 was 76,910 bushels (Table 13) or approximately 23.3 million oysters using the value of 303 harvested oysters per bushel (Figure 22). This number of oysters represents a fishing mortality of 2.04% of all oysters (excluding those from the Very Low Mortality region) in 2014 (Figure 25a). This is the first time since the start of the Direct Market time series that the total exploitation rate has gone over 1.9%. The fraction of market-sized oysters fished in 2014 remained just below 5% at 4.7%, excluding the VLM (Figure 25b). To reiterate from the Status of the Stock section: although 2014 abundance (excluding VLM) increased from 2013, it remained low relative to either time series (Figure 2, Table 6). This may account for the somewhat higher fishing mortality of all oysters, however whole stock natural mortality rate was also low in 2014 at 15% (Figure 4a) and this may account for the fishing mortality staying below 5% of the market-sized oyster abundance (Figure 25b).

Regional fishing mortality is shown in Figure 26 as both percentage of all oysters and percentage of market-size (≥2.5”) oysters. The VLM was closed for the third year in 2014 to allow continued recovery from extreme freshwater mortality in 2011. Exploitation for transplant purposes was conducted on the Low and Medium Mortality Transplant regions (LM, MMT) in 2014 at the 2.3% exploitation rate and the actual rates fell just around that as mentioned earlier (Table 15). The percentage of ≥ 2.5”oysters transplanted from both regions was 3.34% each (Figure 26). For the LM, this represents the largest fraction of market-sized oysters fished in the 1997-2014 time series aside from 2004. This percentage is in line with the fraction of market-sized oysters taken from the MMT since 2011.

The percentage of market-sized oysters fished in 2014 on the three Direct Market regions (MMM, SR, HM) is listed in Table 15. The fractions are similar to those of the preceding few years in each region (Figure 26). The fraction of all oysters fished on the MMM was lower than the previous few years at 1.07%, perhaps due to the supplemental oysters from transplant and the decrease of natural mortality in this region (Appendix B.4). Shell Rock also had lower natural mortality and received transplant oysters in 2014 yet the percentage of fishing mortality for all oysters was much higher at 4.3% than in 2013 when the value was negative due to the receipt of oysters from transplant (Figure 26). The explanation must lie with the 2013 transplant of 21,050 bushels to Shell Rock (HSRL 2014) as opposed to the 13,900 bushels of transplant received by Shell Rock in 2014. Fishing mortality for all oysters also increased on the High Mortality region and was at 2.2% (Figure 26). The HM did not receive transplants in 2014 due to its recent improving condition of higher spat sets and lower natural mortality rates (Appendix B.6).

Stock Performance Targets

Overview

Long-term patterns since assessments began in 1953 indicate that disease mortality exerts significant control over the Delaware Bay oyster stock. The overall abundance and biomass of the stock is often limited or reduced by the intensity of disease and the mortality it causes. The record provides evidence of decadal or longer shifts in disease regimes driven by MSX from the 1950s to the 1980s and by Dermo disease since 1990 (Figure 4a). At least three periods are indicated in the record. The first was low abundance on the oyster beds in the 1950s that continued as MSX caused significant mortality. In the 1960s, MSX and mortality rates declined on the beds while shellplanting increased (Figure 5a) corresponding to a period marked by high abundance that lasted into the 1980s. Circa 1985, an extended drought facilitated the spread of MSX upbay causing extensive mortality that began a third period characterized by high diseaseinduced mortality and low abundance. Although the MSX epizootic had dissipated by 1990 and the population became resistant to it (Ford and Bushek 2012), abundance did not recover as Dermo disease became established and effectively doubled natural mortality (Powell et al. 2008). This state of low abundance and high mortality has persisted. Dermo disease and mortality are highly influenced by salinity along the upbay-downbay gradient creating the regions of varying oyster mortality identified in Figure 1 (Bushek et al. 2012). The continuing influence of Dermo disease on Delaware Bay oyster population dynamics has led the SARC to determine that management goals should be set relative to population assessments made during the 'Dermo era' that began around 1990.

Whole-stock

Although the oyster resource is managed by region, the population is a single stock (Hofmann et al. 2009) and thus whole-stock reference points are important criteria upon which to judge stock status. From 2006 to 2010, the SARC considered three whole-stock abundance targets. The first two were empirically derived as the sums of the regional median abundances of the total and market-size oyster targets (2.311 billion and 334 million) that are listed in Table 16 with the thresholds at half those values (1.156 billion and 167 million). The third was derived theoretically from an analysis of biological relationships and formulation of a surplus production model (Powell et al. 2009) and is described in previous stock assessment reports. Several SARCs have debated the validity or relevance of using the surplus production model to identify whole stock reference points and have thus far agreed to use the medians of the sums of regional total and market abundance from the period 1989-2005 as whole stock reference points. Note that the Very Low Mortality region (VLM) has been excluded from all stock-wide reference point estimates and comparisons because time series data are considered insufficient to include them at this time.

The 2014 total abundance was 1.334 billion oysters (excluding the VLM) of which 442 million were market-size. The 2014 point-estimate of 1.3 billion falls significantly below the whole-stock reference point of 2.3 billion (Figure 27) as it has at least since 2009 (HSRL 2010). This point-estimate falls between the 10^{th} and 15^{th} percentile of the survey uncertainty envelope where the lower 90% confidence limit is 1.324 billion and the threshold abundance for the whole stock is 1.16 billion. In contrast to total abundance, market abundance across the entire stock sits significantly above the stock performance target as it has in recent years (Figure 28). The whole stock market-sized abundance estimate of 442 million falls just over the 50^{th} percentile with the 90% confidence limits being 388 and 509 million. The difference between the total and market-size oyster whole stock abundance with regard to the target reference points indicates a current population structure skewed towards the larger oysters.

Regional[1]

In 2006, the SARC set specific targets and thresholds for total abundance, market-sized abundance, and spawning stock biomass based on the 1989-2005 and 1990-2005 time periods respectively under the assumption that this time period likely represents the entire scope of oyster population dynamics in the present climate and disease regime. For each region, the median abundance and SSB values from these time periods were set as targets with values half these levels set as threshold levels (Table 16). Due to the absence of a time series for this period, the Very Low Mortality region (VLM) targets and thresholds were established by applying Low Mortality region (LM) conditions adjusted for region area (HSRL 2012).

In 2014, total oyster abundance in four regions (LM, MMT, MMM, and HM) was just above threshold values (Figure 29) and Shell Rock abundance increased enough to cross the abundance target. Shell Rock has experienced a steady increase in abundance of all sizes of oysters since 2012, a result of spat sets, shellplants, transplants and decreasing natural mortality rates (Appendix B.5). Abundance in the VLM increased considerably in 2014 and is closer to its target level than it has been since the 2011 high mortality event (Figure 29). A very good spat set in 2013 combined with high survival during 2014 increased the number of small oysters and total abundance on the VLM in 2014 (Appendix B.1). Although 2014 abundance increased in the LM, MMT, and MMM regions relative to 2013, it remains near threshold and below abundances from 2010 through 2012 (Figure 29). Total abundance on the HM is similar to that from 2013.

SSB values for 2014 hover just above or just under the thresholds in the three upbay regions (VLM, LM, MMT), approach the target in the MMM and HM, and is almost twice the target on Shell Rock (Figure 29) where SSB is at the 78th percentile since 1990 (Table 6). Market-sized abundance is above the target for all six regions (Figure 30). In the cases of Shell Rock and the HM where Dermo levels and natural mortality have both been decreasing (Appendix B.5 and B.6), market-sized abundance is far above the targets (Figure 30). Market-abundance percentiles for Shell Rock and the HM are the 88th and the 71st for the 1990-2014 time series, respectively (Table 6). Market-sized abundance just crossed the target in the VLM in 2014 continuing its improvement since the mortality in 2011 (Figure 30), however, the 2012 SAW report stated that the VLM targets may be biased low. The 2010 pre-mortality event market abundance value tends to support that: it is an order of magnitude above the target value (Figure 30).

Sustainability

Sustainability is a key goal for management of the NJ Delaware Bay oyster fishery. The concept of a sustainable stock under federal guidelines articulated by the Magnuson-Stevens Fishery Conservation and Management Act is expressed in the concepts of `overfishing' and an

[1] Confidence limit graphics in Appendix E.

`overfished' stock. The term 'overfishing' represents a comparison of the current fishing mortality rate relative to the permitted rate at maximum sustainable yield, f_{msy}. The term 'overfished' refers to the current biomass of the stock relative to the biomass at maximum sustainable yield, B_{msy}. These concepts have not been applied to populations strongly influenced by environmentally modulated disease mortality nor for populations that create their own habitat such as oysters. The difficulty in applying these population metrics to oysters has necessitated finding other ways to evaluate sustainability in the oyster stock.

Due to a relatively short time series (since 1990) and minimal range for oyster biomass, abundance was originally used to calculate an N_{msy} reference point in place of B_{msy} (Powell et al. 2009) and to compare it to the survey point estimate of whole stock abundance (see Figure 69 in HSRL 2012). If the survey point estimate was significantly above the N_{msy} reference point, the stock might be considered 'not overfished'. Previous SARCs have debated the efficacy of relying on this measure and it is not included in this document.

The most important metric used to evaluate stock sustainability for the NJ Delaware Bay oyster stock has been the trend in market-size abundance (Figure 14). Market-size abundance is the least volatile of the stock metrics (abundance, SSB, market abundance) and so may be most likely to provide clear evidence of excessive exploitation. Abundance varied widely based on recruitment and disease dynamics from year to year. These factors can similarly impact SSB, as can timing of spawning and food availability. Therefore, conservation of the market size abundance has been an important, if not the primary, basis for management since shortly after the direct market fishery began in 1996. The 1990-2014 time series shows that the abundance of market-size oysters has remained relatively stable for over two decades, fluctuating around a median of 4.52×10^8 (Figure 14). This stability comes from two sources: 1) the balance existing between the death of larger oysters, primarily caused by disease, and the recruitment potential of the population and 2) a fishing mortality rate that has been constrained such that removals by the fishery have not exceeded the replacement capacity of the population. As a consequence, the population has been able to recover from epizootic events during periods of reduced mortality from disease. This can be considered indicative of a stock that is not in an overfished state. Finally, market size oyster abundance in 2014 is above the market size abundance target of 3.34×10^8 as it has been since 2005 (Figure 14, Figure 28), further suggesting that the stock is not overfished.

Other support to evaluate the possibility of overfishing comes from a comparison of the natural mortality rate with the fishing mortality rate. Fishing mortality on the whole stock has remained around or below 2% in the period of direct marketing, 1997-2014 (Figure 25a) whereas natural mortality rates have been 15-30% since Dermo disease became prevalent in 1990 (Figure 4a). Fishing mortality that is considerably less than natural mortality provides evidence that overfishing is not occurring. Additionally, as noted above, fishing mortality rate has been constrained such that removals by the fishery have not exceeded the replacement capacity of the population, an indication that the stock is not experiencing overfishing.

Finally, Powell et al. (2012) describe a model to simulate the shell carbonate budget of an oyster reef. Model simulations suggest that exploitation rates much above 5% of the fishable stock per year restrict availability of surficial shell and foster reef erosion in the mid-Atlantic region. Fishing mortality rates have remained below 5% consistently over most of the 1953-2014 time series, and in 2014 in particular (Figure 25). This is likely an important reason that reef loss has not occurred in Delaware Bay. Given the importance of shell in stock recruitment dynamics (it is a primary substrate to which spat recruit; the other being live oyster), a 2014 fishing mortality fraction below 5% provides additional support that overfishing is not occurring.

Summary of Stock Status

Table 17 is a 'stoplight' table summarizing the 2014 status of the oyster stock by region relative to the previous five years or the 1990-2014 time period. Different parameters of the regional stocks are designated as improving (green), degrading (orange), or neutral. Metrics include percentile ranks (40^{th} -60^{th} percentiles are considered neutral), comparison to 5-yr median, comparison to biological reference points, comparison to mortality rates in the absence of disease, or comparison to Dermo levels known to cause mortalities.

Compared to the stoplight table from 2013, conditions in 2014 were generally improved aside from spat recruitment that was at or near the bottom percentile in all regions (Table 17). In 2013, all regions except High Morality were in a generally low state (more orange than green), particularly the two Medium Mortality regions (HSRL 2014). Lower mortality rates throughout most regions in 2014 have likely played a large part in improved conditions (Table 17 and Appendix B). The only region that did not improve in 2014 and may be said to have degraded further, is the Low Mortality region (Table 17). In this region, although small oyster abundance increased a small amount after a comparatively good 2013 set, market abundance has dropped and low 2014 recruitment does not portend an increase in future small oyster abundance (Appendix B.2). The fraction of total oysters removed from the LM in the 2014 transplant was over 2% and the fraction of market-size oysters transplanted was over 3% (Figure 26). These were the highest exploitation levels since 2004. However, Dermo levels have dropped for the second year in a row and mortality is at about the same level as it has been since 2012 (Appendix B.2) although it is still above the 60^{th} percentile for the 1990-2014 time series (Table 17).

Management Advice

Use caution when exploiting the Very Low Mortality region (VLM). The 2015 SARC reiterates that the VLM may be an ephemeral resource and there is a limited time series available to assess its response to any form of mortality. Therefore, exploitation should be conservative and limited to periods of high abundance so that the shell resource is not depleted as this would likely eliminate future recovery or expansion of this region.

Shellplanting efforts should continue and be expanded when possible. While market-size oyster abundance is at or above target levels in all regions, total abundance is near thresholds in all regions except Shell Rock and the VLM and recruitment was very low everywhere (Figure 29, Table 17). To increase abundance, a shell-planting program to enhance recruitment must continue with the aim of planting 250,000 bushels or more annually. Funding mechanisms should be reviewed and sources to expand planting efforts should be sought wherever possible. A program moving spatted shell upbay (replants) should be continued to return cultch and increase recruitment to beds where shell was removed during intermediate transplant operations. Concern has been expressed regarding the limited recent success of this practice but highly successful results came from prior efforts. Therefore, future replants are recommended to the extent that funding permits. The SARC recommends directing shell plants to the Medium Mortality Market and High Mortality regions in 2015.

Harvest Recommendations

Intermediate Transplant*—all transplants must use mechanical cullers (Table 18)*

The SARC concludes that the **Very Low Mortality** region (VLM) can be reopened for a conservative experimental transplant not to exceed 1.3% of total abundance. While abundance has increased in this region, most oysters remain below market-size (Appendix B.1). As a result, most oysters transplanted are likely to be smaller than market-size and their contribution to the harvest will not be seen until a future year. Efforts should be made to maximize the proportion of market-sized oysters moved and to retain cultch and smaller oysters on the VLM. Transplants from the VLM should be moved to an appropriate area such as the Medium Mortality Market region where the smaller oysters will have the greatest chance for survival to market size.

The **Low Mortality** region appears to be declining although market abundance remains above the target level, therefore a precautionary approach is advised (Appendix B.2; Figure 30). Any 2015 transplant occurring from the LM should be at 1.3% of total abundance rather than the 2014 rate of 2.3%. Any oysters moved from this region should come from Upper Arnolds and Round Island. Placement of this transplant should consider the overall status of each market region and how to best maximize benefit.

The **Medium Mortality Transplant** region (MMT) is behaving similarly to the Low Mortality region (Appendix B.3) but the SARC concluded that transplanting at an exploitation rate not to exceed 2.3% of total abundance was feasible. Any transplant from the MMT should be taken primarily from Sea Breeze and Upper Middle with no more than 50% coming from Middle. Placement of this transplant should consider the overall status of each market region and how to best maximize benefit. Transplants from Sea Breeze should occur prior to any seasonal harvest restrictions. Furthermore, efforts should be made to ensure that Sea Breeze is not used as both a transplant and harvest bed. The SARC carefully evaluated the use of this bed as either a transplant or a direct market bed and concluded that it is more valuable to the industry as a transplant bed.

No increases in direct market quota should occur before any transplant is completed and efforts should be made to complete a significant portion of any intermediate transplant program before direct market harvest is allowed on recipient regions.

Direct Market *(Table 19)*

In 2012 and 2013, the **Medium Mortality Market** region indicated some signs of degradation in terms of abundance and disease/mortality rates (Appendix B.4). Despite a strong SARC recommendation to reduce harvest pressure from 4% to 2.7% or at most, 3.3% in 2014, the final exploitation rate approved was 4%. The actual rate achieved was 3.5% (Table 15). Relative to 2013, both small and market-sized oyster abundance increased and mortality rate decreased even though Dermo increased across this region and was at elevated levels. Therefore, the SARC feel that the 4% experimental exploitation rate supplemented with a transplant can continue.

The status of **Shell Rock** improved in 2014 along the same trajectory observed in 2013 following management efforts to increase oyster abundance and biomass (Appendix B.5, Figure 29). As in all regions, recruitment in 2014 was dismal, yet both total and market-size oyster abundance increased as did SSB. Furthermore, disease and mortality rate decreased which may account for some of the other improvements. An exploitation rate of 15.9% was discussed but the SARC was concerned about future effects on market-size abundance and did not recommend this level of harvest. Given the value of Shell Rock that provided 31% of the 2014 Direct Market harvest (Table 13), continued efforts to improve this bed are advised. In this state, an exploitation rate of 11.4% was recommended.

The **High Mortality** region has had consistent or increasing market-sized oyster abundance for at least six years and mortality has decreased steadily since 2011 (Appendix B.6). Given the condition of this region, the SARC feels that an exploitation rate of 8.3% is acceptable with or without a transplant to the region.

Science Advice

- Continue standard monitoring and assessment programs
  - Annual Fall Survey – this is the basis for the entire assessment
  - Ten-year Resurvey Program - permits re-evaluation of grid allocation to strata to take into account changes in oyster distribution on beds as a consequence of natural population dynamics and population enhancement programs.

- Monthly Seed Bed Monitoring Program - monitors and evaluates factors influencing disease, mortality, growth and survival.

- Intermediate transplant monitoring and evaluation - daily estimates of oysters moved provided to managers to gauge duration of transplanting activities. Final numbers and additional quota allocation reports given to managers and Council.

- Monthly monitoring of transplant and shellplant performance- assesses performance of these important management activities. Any 2015 transplants from the VLM should be monitored for two years as this activity will likely move a large number of small oysters, many of which will not be available to the fishery until the second year.

- Port Sampling Program - provides essential estimates required for accurate market-sized oyster abundance-to-bushel conversions, SSB estimates of landings, estimation of the shell budget, and evaluation of exploitation rates, as well as any development of size- or age-based models incorporating mortality.

• Identify and calibrate a backup survey vessel should the *F/V Sockwell* be disabled or otherwise unavailable for either spring stratification surveys or the Fall assessment survey.
• Refine the quota setting methodology and establish clearly defined control rules. The 2006 SARC suggested exploitation-based reference points based on the median (50^{th} percentile) exploitation rate defined in terms of the fraction of abundance removed per region for the years 1996 to 2005 (later 2006). It was felt that this time period represented a time of conservative fishery management. A loosely applied rule has been to increase exploitation to the 60^{th} percentile rate when the status of the stock is judged to be strong and to decrease the exploitation rate to the 40^{th} percentile when the status of the stock is judged to be weak. The 2015 SARC notes the following needs:

  - Due to the limited data from which exploitation rate percentiles were established some percentile series have dramatic shifts in exploitation rates (Figure 24). While the median rate has provided an adequate reference point for the fishery, smoother transitioning options and a firm set of control rules should be developed. The rules should describe how to move among different exploitation rates based on the status of the stock. Allocation discussion must be separated from this decision-making process. A proposal should be put forth for evaluation by the SARC before implementation.

  - The selection of exploitation rates in any given year should consider rebuilding goals for the resource as well as economic goals and needs to maintain a viable industry. For example, increasing exploitation rates because the population has increased may curtail growth of the resource and reduce future harvest quotas by returning the population abundance to lower levels.

- Develop a method to make short-term projections of the effects of hypothetical exploitation rates on regional populations. Test simulation models using historic data and employ them to examine effects under various assumptions of natural recruitment, mortality, etc.

- Dredge calibration and gear efficiency. Continue the evaluation of dredge calibration studies. Determine the best approach to grouping beds and integrating the 2013 data with previous data. Based on results so far, further analyses of existing dredge calibration data are warranted and additional dredge calibrations should be conducted on the uppermost beds (Round Island and the VLM) that have only one set of data. Before any changes are made, a formal evaluation of results should be presented to the SARC. This could occur during the year or at the next SAW.

- Explore sources of error associated with the assessment. Compare how each source of error (dredge efficiency vs. survey sampling error) is contributing to the overall assessment error. Incorporate error bars into estimates of stock parameters.

- Continue the analysis of spat-to-oyster transition sizes and examine how this impacts estimates of spat recruitment and oyster abundance across the time series.

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Table 1. Dredge efficiency multipliers (catchability coefficients) used to convert oyster, box, and cultch estimates to 'on bottom' numbers. Time series indicates how sets of multipliers are applied to the data. Sets of multipliers are averaged results from one or more dredge calibration experiments conducted at various times (see text). Upbay, all beds above Shell Rock; Downbay, Shell Rock and beds below. The oyster and box multipliers include all size classes of oysters (or boxes) >20mm recognizing that the smaller sizes are often attached to larger sizes and that oysters and boxes are often attached to each other.

Time Series	Bed Group	Oysters	Boxes	Cultch
Base	Upbay	8.22	11.12	17.11
	Downbay	2.96	5.67	8.97
1998-2000	Upbay	9.40	11.47	21.49
	Downbay	2.83	6.50	9.55
2001-2004	Upbay	8.22	11.12	17.11
	Downbay	2.96	5.67	8.97
2005-2014	Upbay	7.30	10.87	13.71
	Downbay	3.11	4.64	8.14

Table 2. Ten year resurvey schedule for NJ Delaware Bay oyster beds and number of grids on each bed. All beds were resurveyed prior to 2009 when the current schedule was implemented. One grid is 0.2" latitude x 0.2" longitude (approximately 25 acres, 101,175 m^2 or 10.1 hectares).

Year	Bed	# Grids	# Grids/Year	Resurvey Year
1	Cohansey	83		
	Bennies Sand	49	132	2009
2	Ship John	68		
	Nantuxent Point	68	136	2010
3	Beadons	38		
	Middle	51		
	Vexton	47	136	2011
4	Sea Breeze	48		
	Shell Rock	93	141	2012
5	Upper Arnolds	29		
	New Beds	112	141	2013
6	Bennies	171	171	2014
7	Arnolds	99		
	Strawberry	29	128	Scheduled 2015
8	Upper Middle	84		
	Hog Shoal	23		
	Liston Range	32	139	
9	Hawk's Nest	28		
	Hope Creek	97	125	
10	Fishing Creek	67		
	Round Island	73	140	

Table 3. Statistical significance of pairwise comparisons between beds estimated from a generalized linear model for survey gear efficiency (see text). P-values for statistically significant differences are in bold.

	Bennies	Nantuxent	Benny Sand	Shell Rock	Ship John	Cohansey	Middle	Arnolds	Round Island	Hope Creek
New Beds	NS	NS	NS	NS	**p=0.023**	**p=0.003**	**p=0.006**	**p=0.020**	NS	NS
Bennies		NS	NS	**p=0.017**	**p=0.002**	**p<0.0001**	**p<0.0001**	**p=0.0002**	NS	NS
Nantuxent			NS	NS	NS	**p=0.030**	NS	NS	NS	NS
Benny Sand				NS	NS	**p=0.045**	NS	NS	NS	NS
Shell Rock					NS	NS	NS	NS	NS	NS
Ship John						NS	NS	NS	NS	NS
Cohansey							NS	NS	**p=0.040**	NS
Middle								NS	NS	NS
Arnolds									NS	NS
Round Island										NS

Table 4. Grid quality changes on Bennies after Spring 2014 resurvey. Bennies stratification was previously completed in 2005. Strata are determined on a per-bed basis after ranking grids by oyster density (see text). Grid stratum assignment is relative to abundance on a bed at the time of the resurvey. The tables below show **(a)** the numbers of grids increasing or decreasing in stratum designation and (**b**) the change in the average and median oyster densities for medium and high quality strata in 2005 versus 2014.

a.

2014 Strata Increases	# of Grids	2014 Strata Decreases	# of Grids
Low to High	0	High to Low	1
Low to Medium	11	High to Medium	7
Medium to High	6	Medium to Low	29
Total	17	Total	37

b.

	High Quality Stratum		Medium Quality Stratum	
	2005	2014	2005	2014
Mean	10.92	37.09	2.20	7.09
Median	10.49	35.56	1.19	5.34

Table 5. Sampling scheme for the Fall 2014 survey of the Delaware Bay oyster beds in New Jersey. The numbers given are the number of sampled grids devoted to that bed stratum. The strata designations are described in the text. The Enhanced stratum includes those grids that received transplant or shellplant in the survey year or shell plant within the previous two years. Egg Island and Ledge are sampled in alternate years.

Region	Bed	High Quality	Medium Quality	Low Quality	Enhanced
Very Low Mortality	Hope Creek	4	4	0	1
	Fishing Creek	2	3	0	
	Liston Range	2	4	0	
Low Mortality	Round Island	2	3	0	
	UpperArnolds	3	4	0	
	Arnolds	3	3	0	
Medium Mort. Transplant	Upper Middle	1	3	0	
	Middle	3	4	0	2
	Sea Breeze	3	4	0	
Medium Mort. Mkt.	Cohansey	5	5	0	
	Ship John	6	5	0	4
Shell Rock	Shell Rock	4	6	0	4
High Mortality	Bennies Sand	3	6	0	
	Bennies	5	9	0	
	Nantuxent Pt.	3	3	0	1
	Hog Shoal	3	3	0	
	Strawberry	1	3	0	
	Hawk's Nest	2	3	0	
	New Beds	4	5	0	
	Beadons	2	3	0	
	Vexton	2	2	0	
	Egg Island				
	Ledge	1	4	0	
Total		64	89	0	12

Grand Total: 165

Table 6. Percentile positions in the indicated time series for the given bay regions and stock variables. A lower percentile equates to a lower value of the variable relative to the entire time series. Table is divided into the 62-year time series (1953–2014) and the 25-year time series (1990–2014). The Very Low Mortality region is not included due to its short time series. Recruitment values do not include the enhancements from shell planting.

1953 - 2014	Oyster Abundance	Spat Abundance	Box-Count Mortality
Baywide	0.169	0.040	0.589
Low Mortality	0.105	0.137	0.669
Medium Mortality Transplant	0.137	0.000	0.556
Medium Mortality Market	0.331	0.056	0.702
Shell Rock	0.444	0.073	0.605
High Mortality	0.282	0.137	0.411

1990 - 2014	Oyster Abundance	Market >2.5" Abundance	Spat Abundance	Spawning Stock Biomass	Box-Count Mortality
Baywide	0.260	0.420	0.000	0.260	0.260
Low Mortality	0.220	0.375	0.180	0.060	0.620
Medium Mortality Transplant	0.140	0.625	0.000	0.300	0.380
Medium Mortality Market	0.420	0.542	0.060	0.420	0.460
Shell Rock	0.540	0.875	0.000	0.780	0.420
High Mortality	0.420	0.708	0.060	0.580	0.060

Table 7. Average half-lives in years for surficial oyster shell on Delaware Bay oyster beds for 1999–2014 time series. Beds arranged in upbay to downbay order. --, unable to determine.

Location	99-09	99-10	99-11	99-12	99-13	99-14
Hope Creek	--	--	--	--	--	--
Fishing Creek	--	--	--	--	--	--
Liston Range	--	--	--	--	--	--
Round Island	47.45	17.94	--	--	--	88.05
Upper Arnolds	7.43	4.81	7.67	8.27	6.59	5.49
Arnolds	6.12	5.31	7.09	5.69	6.57	4.53
Upper Middle	--	--	--	--	--	--
Middle	4.09	4.18	6.29	4.72	5.54	6.85
Sea Breeze	37.39	6.64	33.17	6.63	17.27	9.16
Cohansey	3.79	5.85	5.56	5.84	7.14	7.21
Ship John	3.20	3.08	3.49	2.83	3.65	4.00
Shell Rock	4.44	2.95	4.62	2.95	4.86	4.86
Bennies Sand	5.08	4.65	10.61	5.35	8.47	6.55
Bennies	7.95	5.97	11.12	8.76	8.62	7.11
Nantuxent Pt.	2.56	3.10	3.58	3.58	5.05	4.28
Hog Shoal	3.39	3.12	4.71	5.42	5.83	5.21
Strawberry	5.82	15.56	19.65	9.06	11.91	12.47
Hawk's Nest	11.87	4.55	4.61	5.73	10.85	7.05
New Beds	20.70	9.67	36.22	109.78	--	24.54
Beadons	6.28	4.63	9.55	13.18	7.28	3.92
Vexton	3.34	3.83	18.80	7.25	22.74	7.92
Egg Island	5.40	5.60	78.65	84.18	102.88	102.30
Ledge	7.71	5.34	5.84	--	--	31.95

Table 8. Summary of shell planting activities for 2014. Direct plants occurred on Nantuxent, Ship John, and Shell Rock. Spatted shell was moved from downbay plantings by suction dredge and replanted on Middle. Spat per bushel estimates are from the clamshell volumes in Fall 2014 survey dredge samples. Projections of market-size abundance used regional natural mortality at the juvenile rate in year 1 and at the adult rate in following years. The mortality rates used were the 50th percentiles of the 1990-2014 time series for the Medium Mortality Transplant and Market regions (Middle and Ship John, respectively), Shell Rock, and the High Mortality region (Nantuxent). Calculation of years to market size used von Bertalanffy parameters (see Kraeuter et al., 2007) for the Medium Mortality regions (Middle and Ship John), Shell Rock, and the High Mortality Region (Nantuxent).

	Plant Type	Clamshell Planted (bu)	Clamshell Spat per bu	Clamshell Total Spat	Median Juvenile Mortality Rate	Juvenile Years	Median Adult Mortality Rate	Adult Years	Potential Mkt-Size Individuals
Middle 27+28	replant	53,759[1]	57	3,064,263	0.184	1	0.164	2	1,680,295
Ship John 33	direct	52,740	73	3,835,471	0.230	1	0.202	2	1,760,174
Shell Rock 31	direct	55,394	18	1,015,878	0.488	1	0.194	2	318,319
Nantuxent 23	direct	42,704	818	34,915,626	0.502	1	0.248	2	8,763,543

[1] Total includes clamshell planted from 2011 to 2014

Table 9. Summary of 2014 spat recruitment on 2013 shell plants. Spat per bushel estimates are from the clamshell volumes in Fall 2014 survey dredge samples. Projections of market-size abundance used regional natural mortality at the juvenile rate in year 1 and at the adult rate in following years. The mortality rates used were the 50th percentiles of the 1990–2014 time series for Shell Rock. Calculation of years to market size used von Bertalanffy parameters (see Kraeuter et al., 2007) for Shell Rock.

	Plant Type	Clamshell Planted (bu)	Clamshell Spat per bu	Clamshell Total Spat	Median Juvenile Mortality Rate	Juvenile Years	Median Adult Mortality Rate	Adult Years	Potential Mkt-Size Individuals
Shell Rock 29	direct	50,000	90	4,500,915	0.488	1	0.194	2	1,410,334
Shell Rock 30	direct	50,000	100	5021429	0.488	1	0.194	2	1,573,434

Table 10. Spat recruitment on planted shell compared to recruitment on native shell in 2014. The ratio of spat per bushel of planted shell to spat per bushel of native shell is shown in the last column

	Year of Planting	2014 Spat per bu. Planted Shell	2014 Spat per bu. Native Shell	Plant : Native
Middle 27+28	2011-2014	57	88	0.65
Ship John 33	2014	73	51	1.43
Shell Rock 31	2014	23	18	1.28
Nantuxent 23	2014	818	354	2.31
Shell Rock 29	2013	90	59	1.53
Shell Rock 30	2013	100	30	3.33

Table 11. Fraction of spat recruitment on planted shell and native shell during the first year of a shellplant. Subsequent years may produce additional spat. Details of 2013 and 2014 shellplants are shown in Tables 7 and 8; shellplant details from previous years can be found in earlier reports.

Region/Acreage	Year	Fraction Acreage Planted	Recruit Fraction on Planted Shell	Recruit Fraction on Native Shell
High Mortality	2003	0.0033	0.17	0.83
7625 acres	2005	0.0033	0.12	0.88
	2006	0.0164	0.58	0.42
	2007	0.0033	0.01	0.99
	2008	0.0131	0.47	0.53
	2009	0.0066	0.17	0.83
	2010	0.0033	0.26	0.74
	2011	0.0033	0.04	0.96
	2014	0.0033	0.27	0.73
Shell Rock	2005	0.0533	0.54	0.46
1182 acres	2006	0.0635	0.50	0.50
	2009	0.0212	0.31	0.69
	2010	0.0212	0.29	0.71
	2011	0.0212	0.49	0.51
	2013	0.0423	0.16	0.84
	2014	0.0212	0.09	0.91
Med. Mort. Mkt.	2007	0.0512	0.05	0.95
2443 acres	2008	0.0102	0.13	0.87
	2012	0.0205	0.01	0.99
	2014	0.0102	0.07	0.93
Med. Mort. Trans.	2007	0.0159	0.11	0.89
1576 acres	2011	0.0083	0.01	0.99
	2013	0.0083	0.01	0.99
	2014	0.0083	0.03	0.03
Very Low Mort.	2012	0.0093	0.02	0.98
1337 acres				

Table 12. Bushels of shell planted by region. Years in which no shell was planted are excluded and indicated by lines. Blank spaces indicate that shell was not planted in that region for the given year.

Year	HM	SR	MMM	MMT	LM	VLM	TOTAL
1956	119,462	47,172	27,462	40,411			234,507
1957	63,112		53,157	4,000			120,269
1958				63,917			63,917
1960		8,235	12,630	11,440			32,305
1961	8,800						8,800
1963	16,528			2,029			18,557
1965	33,658	101,950	657,238	362,763	292,539		1,448,148
1966	73,273	47,621	251,201	164,002	246,039		782,136
1967		52,041	48,075	32,091	302,056		434,263
1968		202,090	59,920	183,999			446,009
1969			43,398				43,398
1970	71,479		221,042	710,843			1,003,364
1971	232,247		194,656				426,903
1972			223,667	84,856			308,523
1973	86,913						86,913
1974	213,964				43,098		257,062
1978	36,940						36,940
1979	71,418						71,418
1982	59,400						59,400
1984	42,500						42,500
1985	39,116						39,116
1987	106,432						106,432
1988		131,504	100,000	110,604			342,108
1989	300,465						300,465
1997	83,000			82,000			165,000
1998	99,742						99,742
1999	90,226						90,226
2003	16,130						16,130
2005	12,250	89,337					101,587
2006	142,207	125,354					267,561
2007	43,360		188,523	43,800			275,683
2008	172,487		21,898				194,385
2009	86,072	58,233					144,305
2010	49,645	40,199					89,844
2011	50,000	50,000		18,000			118,000
2012			100,000			12,000	112,000
2013		100,000		23,050			123,050
2014	42,704	55,394	52,740	12,709			163,547

Table 13. Harvest and transplant data for 2014. Bed areas include medium and high quality grids only. Fraction Covered, the estimated fraction of bed area swept by industry dredges during the harvest season. Fractions above 1 indicate a total swept area greater than the bed area. Note: harvest bushels primarily contain oysters ≥63.5mm (2.5”), whereas transplant bushels may contain a large fraction of smaller oysters.

Region	Bed	Bed Area (acres)	Fraction Covered	Harvest Bushels	Harvest Fraction	Transplant Bushels	Transplant Fraction
VLM	Hope Creek	734					
	Fishing Creek	315					
	Liston Range	289					
LM	Round Island	472					
	Upper Arnolds	446					
	Arnolds	630				15,500	0.53
MMT	Upper Middle	236					
	Middle	814				6,600	0.22
	Sea Breeze	525	0.15	542	0.01	7,300	0.25
MMM	Cohansey	1234	0.97	8,652	0.11		
	Ship John	1208	2.34	24,295	0.32		
SR	Shell Rock	1182	1.82	23,589	0.31		
HM	Bennies Sand	788	0.42	3,038	0.04		
	Bennies	1577	0.55	8,010	0.10		
	Nantuxent Pt.	631	1.52	5,154	0.07		
	Hog Shoal	447	1.14	3,425	0.04		
	Strawberry	447					
	Hawk’s Nest	500	0.12	205	0.00		
	New Beds	1236					
	Beadons	210					
	Vexton	316					
	Egg Island	1000					
	Ledge	474					
	Total	15,659	1.00	76,910	1.00	29,400	1.00

Table 14. Intermediate transplant data. Transplants were conducted April-May, 2014 from the Low Mortality region (Arnolds) and the Medium Mortality Transplant region (Middle, Sea Breeze). Estimates of numbers of oysters moved reflect daily samples taken from each boat throughout the transplant and measured deckloads. Market-Equivalent bushels used the number of oysters moved that were $\geq$2.5” (63.5mm) and the Fall 2013 port-sampling result of 264 market oysters per bushel. The fraction of oysters <2.5” did not enter into additional quota allocations for 2014.

Donor	Receiver	Bushels Moved	Total # Oysters	Fraction < 2.5”	Number $\geq$2.5”	Mkt-Equiv. Bu ($\geq$2.5”)
Arnolds	Ship John	15,500	6,168,587	0.485	3,174,627	12,025
Middle	Shell Rock	6,600	1,553,053	0.381	961,033	3,640
Sea Breeze	Shell Rock	7,300	1,922,420	0.390	1,173,115	4,444
Total		29,400	9,644,060		5,308,775	20,109

Table 15. Comparison of the proposed management plan for the 2014 fishery to the actual harvest from 2014. Transplant regions (VLM, LM, MMT) are shown in the upper half of the table while direct market harvesting occurs on the regions shown in the lower half of the table (MMM, SR, HM). Oysters are moved from the Transplant regions to specified beds in the Market regions resulting in an increased allocation to the region. Exploitation rates for the Transplant regions are based on the removal of all sizes of oysters from the abundance of all sizes of oysters while those for the Market regions are based on the harvest of market sizes from all market-size oysters.

Region	Chosen Exploit. Percentile	Chosen Exploit. Rate	Chosen Allocation (bu)	Achieved Additional Allocation (bu)	Achieved Exploit. Rate	Achieved Final Harvest (bu)
VLM[1]	Closed	Closed	Closed	Closed	Closed	Closed
LM[1]	60th	0.0233	NA	NA	0.0225	15,500
MMT[1,2]	60th	0.0233	NA	NA	0.0241	14,442
MMM[3,4]	100th	0.0398	22,272	12,025	0.0353	32,947
SR[3]	60th	0.1140	15,744	8,084	0.1050	23,589
HR[3]	75th	0.0827	19,546	not req'd.	0.0761	19,832

[1]all sizes of oysters; automatic cullers used
[2]4% of this was harvested directly
[3]mkt-size oysters only; automatic cullers and/or hand-culled
[4]SARC advised no more than the 75th percentile be chosen

Table 16. Region-specific stock performance biomass and abundance targets and thresholds. The target is taken as the median of abundance or biomass for 1989-2005 (1990-2005 for biomass) with the exception of the Very Low Mortality beds. The threshold is taken as half of these values. Reference point estimates for the Very Low Mortality beds are obtained by assuming the equivalent condition on a per-area basis to the Low Mortality beds and using the Low Mortality bed numbers so-corrected as the base values.

	Very Low Mortality	Low Mortality	Medium Mortality Transplant	Medium Mortality Market	Shell Rock	High Mortality
Abundance						
Target (50^{th} Percentile)	451,681,800	531,733,632	342,824,960	850,364,224	113,350,896	473,125,088
Threshold (1/2 Target)	225,840,900	265,866,816	171,412,480	425,182,112	56,675,448	236,562,544
Spawning Stock Biomass						
Target (50^{th} Percentile)	149,078,151	175,499,360	178,104,672	337,117,920	62,450,392	267,982,768
Threshold (1/2 Target)	74,539,075	87,749,680	89,052,336	168,558,960	31,225,196	133,991,384
Market (≥ 2.5″) Abundance						
Target (50^{th} Percentile)	36,856,056	43,388,077	46,366,382	167,407,462	25,622,244	51,205,771
Threshold (1/2 Target)	18,428,028	21,694,039	23,183,191	83,703,731	12,811,122	25,602,886

Table 17. Summary status of the stock for 2014. Green indicates variables judged to have improved relative to the 1990–2014 time period, the 2009–2013 median, or the biological reference targets and thresholds. Orange indicates variables judged to be degraded for the same comparisons. A neutral color is used for near-average conditions falling within the 40th to 60th percentiles of the 1990–2014 time period.

2014 Metrics	Transplant Very Low Mortality	Transplant Low Mortality	Transplant Medium Mortality	Market Medium Mortality	Market Shell Rock	Market High Mortality
Total Abundance						
Percentile	--	0.22	0.14	0.42	0.54	0.42
vs 09-13 Median	Above	Below	Below	Below	Above	Above
vs Target-Thresh	Between	Between	Between	Between	Above	Between
SSB						
Percentile	--	0.06	0.30	0.42	0.78	0.58
vs 09-13 Median	Below	Below	Below	Above	Above	Above
vs Target-Thresh	Below	Below	Between	Between	Above	Between
Mkt. Abundance						
Percentile	--	0.38	0.63	0.54	0.88	0.71
vs 09-13 Median	Above	Below	Below	Below	Above	Above
vs Target-Thresh	Above	Above	Above	Above	Above	Above
Recruitment						
Percentile	--	0.18	0	0.06	0	0.06
vs 09-13 Median	Below	Below	Below	Below	Below	Below
Mortality						
Percentile	--	0.62	0.38	0.46	0.42	0.06
vs 09-13 Median	Below	Below	Below	Below	Below	Below
Rate	0.06	0.12	0.15	0.18	0.18	0.15
Dermo						
Percentile	0.285	0.291	0.41	0.65	0.25	0.08
vs 09-13 Median	Below	Below	Below	Above	Below	Below
Wtd. Prevalence	0.01	0.22	1.58	2.18	1.58	1.64

Table 18. Transplant region projections for intermediate transplanting in 2015. Exploitation rate and numbers to be removed are based on all oyster size classes. The estimated number of bushels to be moved is derived from the mean of the number of oysters per bushel for these regions from the 2014 intermediate transplant program or other as noted.[1] Cullers are used for these transplants. The proportion of oysters available for market is estimated based on the fraction of oysters ≥2.5" converted to bushels using the average 266 oysters/bu derived from the 2004-2014 port-sampling program. Percentiles for the Very Low Mortality and Low Mortality beds use the exploitation reference points for the Medium Mortality Transplant beds (see text for details). Footnotes identify alternatives available under specified conditions. Arrows indicate highest SARC-recommended option in each region.

Region	Percentile	Exploit. Rate	Number of Oys Removed	Deckload Oys / bu	Transpl. bu	Mkt.Equiv. bu
Very Low	➔40th	.013	4,620,702	480	9,627	1,824
Mortality	50th	.019	6,840,093	480	14,250	2,700
	60th	.023	8,477,350	480	17,661	3,346
Low	➔40th	.013	3,598,514	398	9,042	2,692
Mortality[1]	50th	.019	5,326,934	398	13,384	3,985
	60th	.023	6,601,997	398	16,588	4,939
Medium	40th	.013	2,376,831	250	9,507	3,378
Mortality	50th	.019	3,518,458	250	14,074	5,000
Transplant[1]	➔60th	.023	4,360,643	250	17,443	6,197

[1] Oysters/Bu taken from 2014 intermediate transplant samples; actual numbers for 2015 may not be similar. Very Low Mortality region deckload oys/bu is an estimate based on 2010 transplant when total abundance for this region was similar to 2014 abundance.

Table 19. Allocation projections for direct marketing on the High Mortality, Shell Rock, and Medium Mortality Market regions in 2015. Exploitation rates and numbers to be removed are based on the abundance of ≥2.5 oysters in each region (see text for details). Projections use the average oysters per marketed bushel (266) derived from the 2004-2014 port-sampling program. Arrows indicate highest SARC-recommended option in each region. Shaded percentiles require that Intermediate Transplant must occur.

Region	Exploitation Percentile	Exploitation Rate	Number of Oysters Removed	Direct Market Bushels
Medium Mortality Market	40th	.018	3,154,958	11,861
(Ship John & Cohansey)	50th	.021	3,793,040	14,260
	60th	.027	4,732,438	17,791
	75th	.033	5,784,091	21,744
	➔100th	.040	7,054,345	26,520
Shell Rock	40th	.087	4,451,028	16,733
	50th	.088	4,502,190	16,926
	➔60th	.114	5,832,382	21,926
	75th	.159	8,134,638	30,581
High Mortality	40th	.012	1,052,283	3,956
	50th	.065	5,623,679	21,142
	60th	.078	6,744,964	25,357
	➔75th	.083	7,177,333	26,982

Figure 1. The natural oyster beds of Delaware Bay with NJ regional designations. The 23 oyster beds are grouped into six regions based on long-term mortality patterns that follow the estuarine salinity gradient and current management strategies. Dark green, Very Low Mortality; red, Low Mortality; light green, Medium Mortality Transplant; light blue, Medium Mortality Market; orange, Shell Rock; dark blue, High Mortality. Bed footprints include grids from the High, Medium, and Low quality strata. Strata designation described in main document. Each grid is 0.2” latitude x 0.2” longitude; approximately 25 acres (101,175 m^2 or 10.1 hectares).

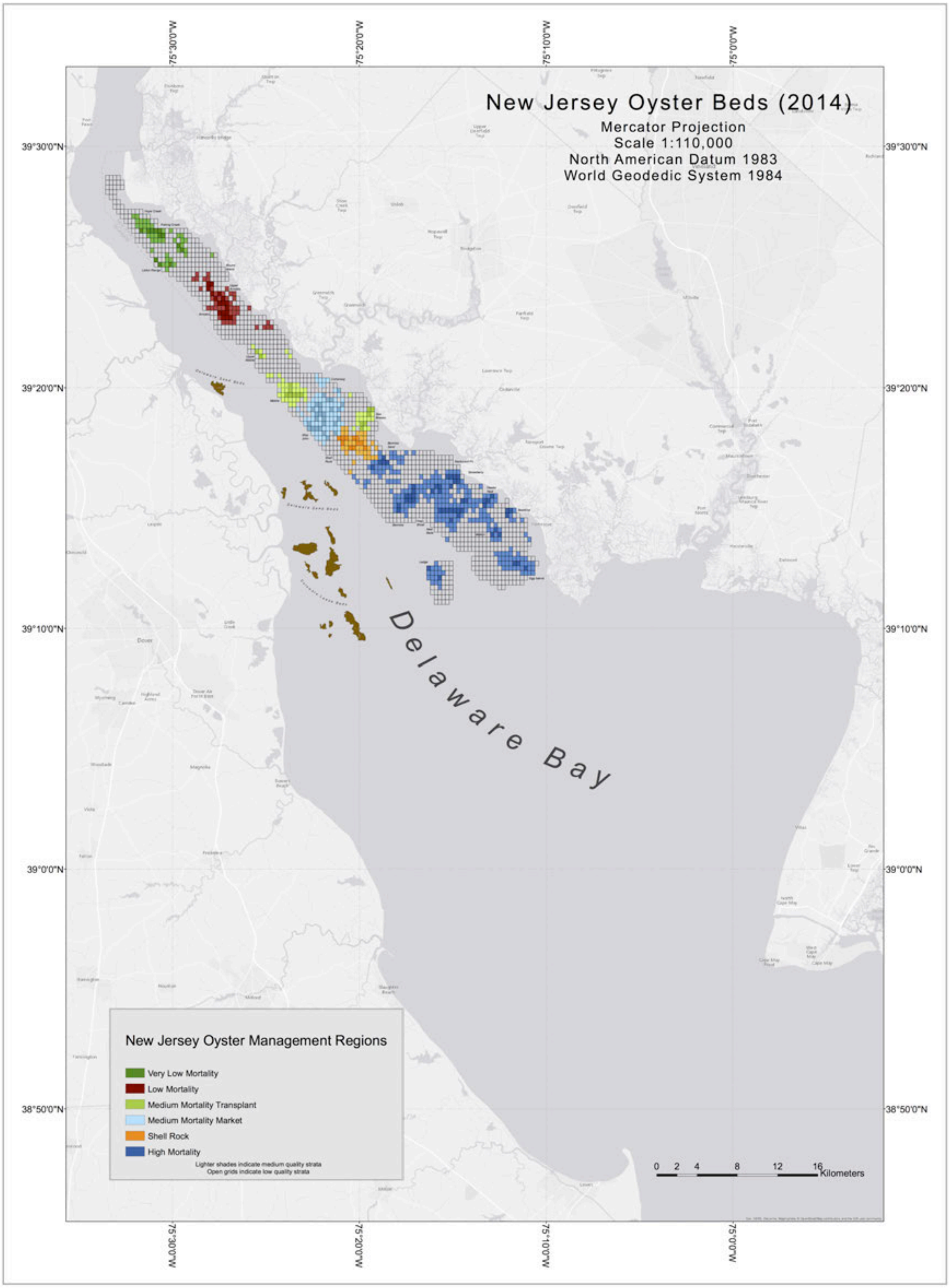


Figure 2. Abundance of oysters on the oyster beds of Delaware Bay, NJ for the entire time series of stock surveys (1953–2014). Until 2007, the three most upbay beds that comprise the Very Low Mortality Region (see Figure 1) were not included in the annual surveys and therefore they are not included in most of the whole stock analyses.

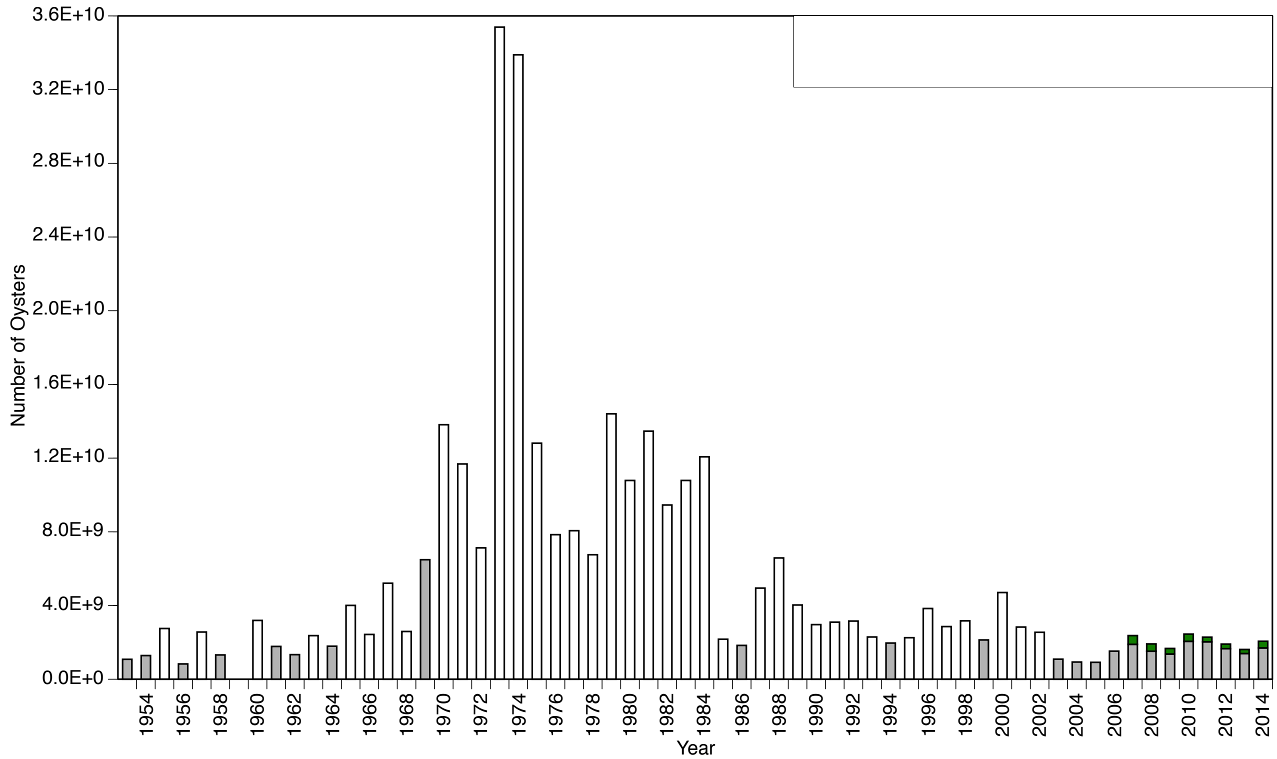


Figure 3. Acreage of the six bed regions in 2014, excluding low quality strata. From upbay to downbay: Very Low Mortality (VLM), Low Mortality (LM), Medium Mortality Transplant (MMT), Medium Mortality Market (MMM), Shell Rock (SR), High Mortality (HM). Total Acreage: 15,711 acres.

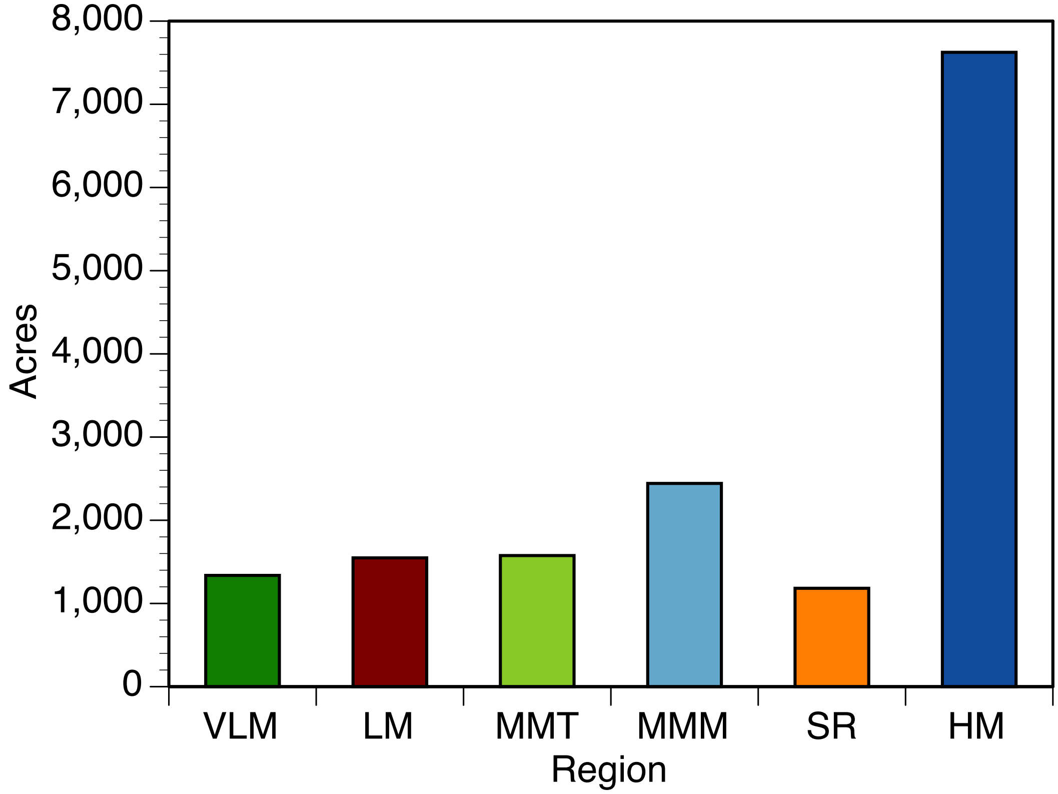
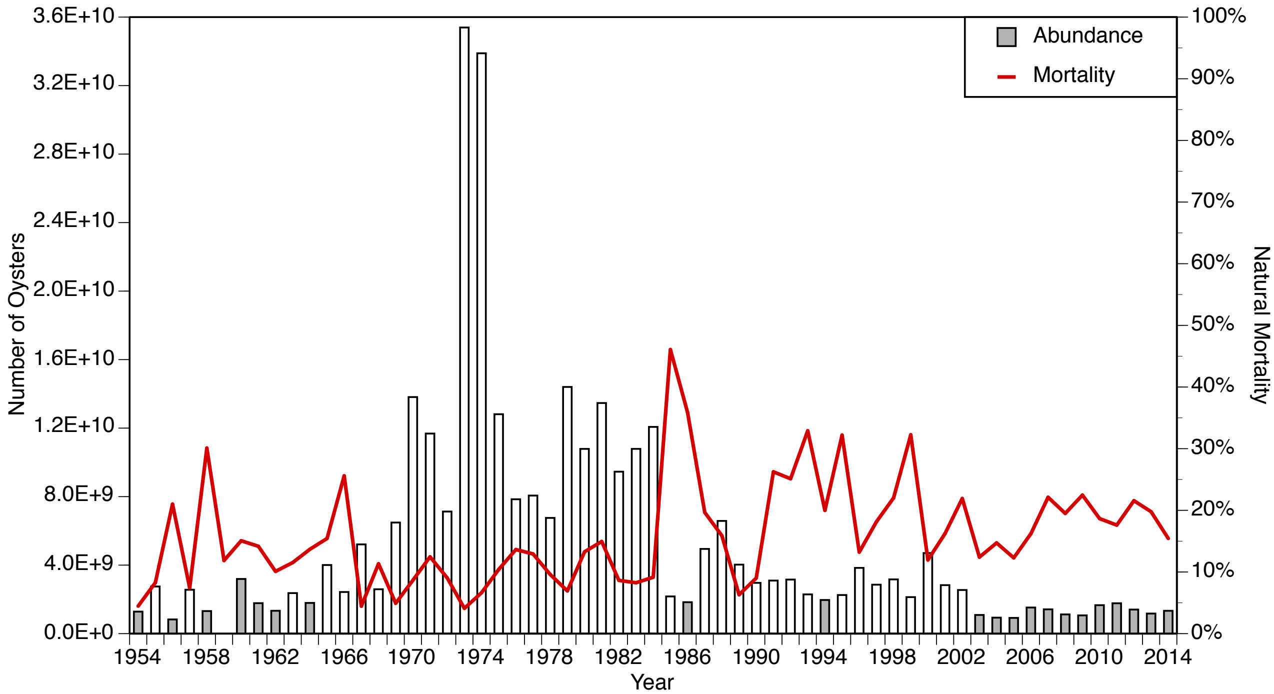


Figure 4. Box-count mortality rates (**a**) and fishing exploitation rates (**b**) compared to total abundance of oysters on the oyster beds of Delaware Bay, NJ, excluding the Very Low Mortality region, for the entire time series of stock surveys (1953–2014).

a.



b.

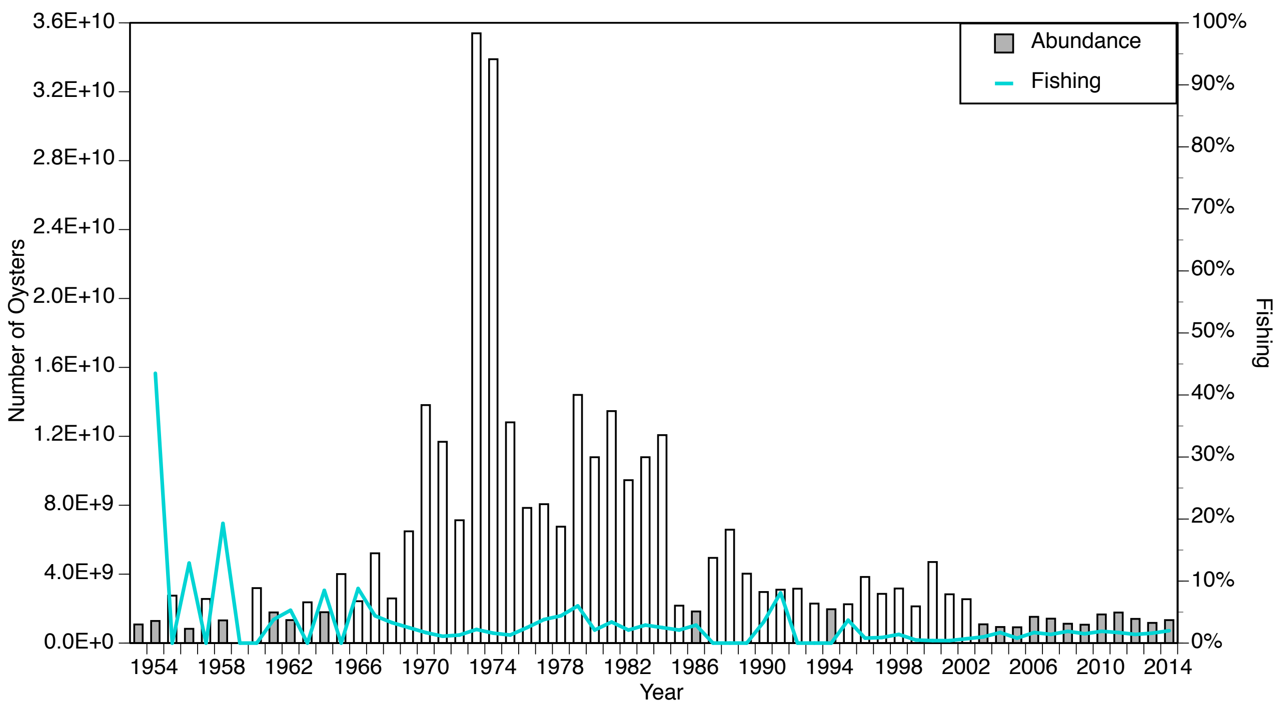
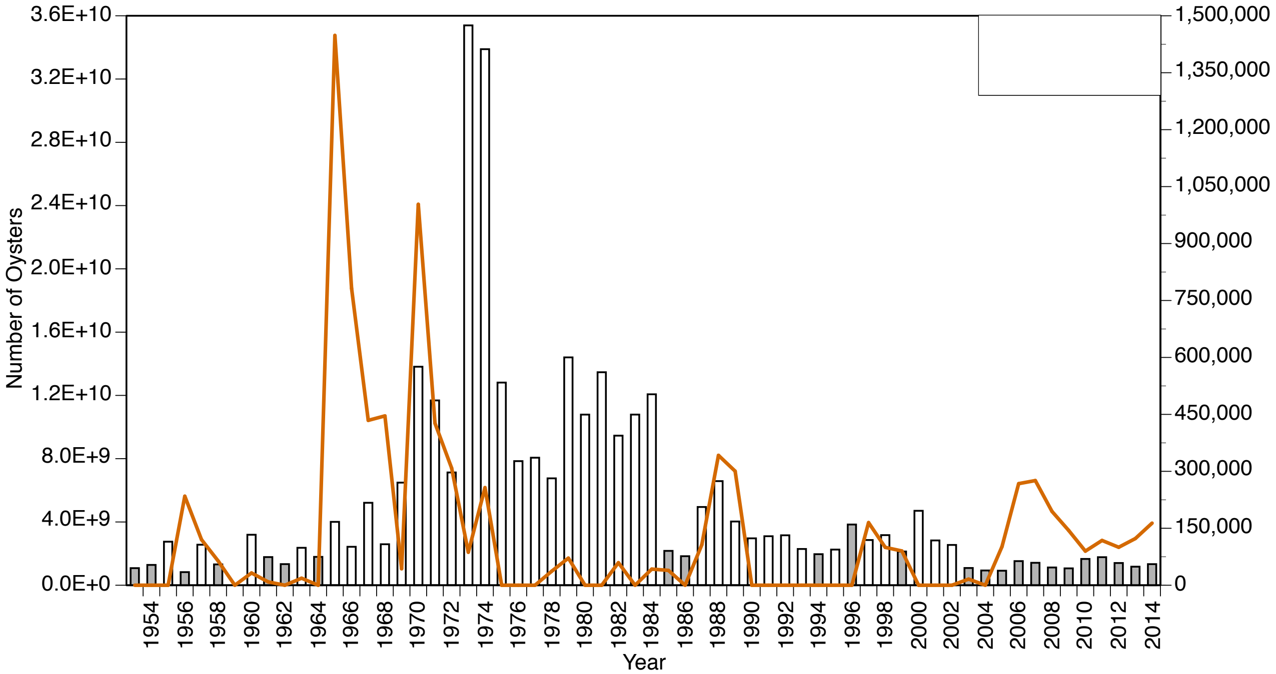


Figure 5. Bushels of shell planted for spat recruitment (**a**) and number of spat from the stock assessment time series (**b**) compared to total abundance of oysters on the oyster beds of Delaware Bay, NJ, excluding the Very Low Mortality region, for the entire time series of stock surveys (1953–2014).

a.



b.

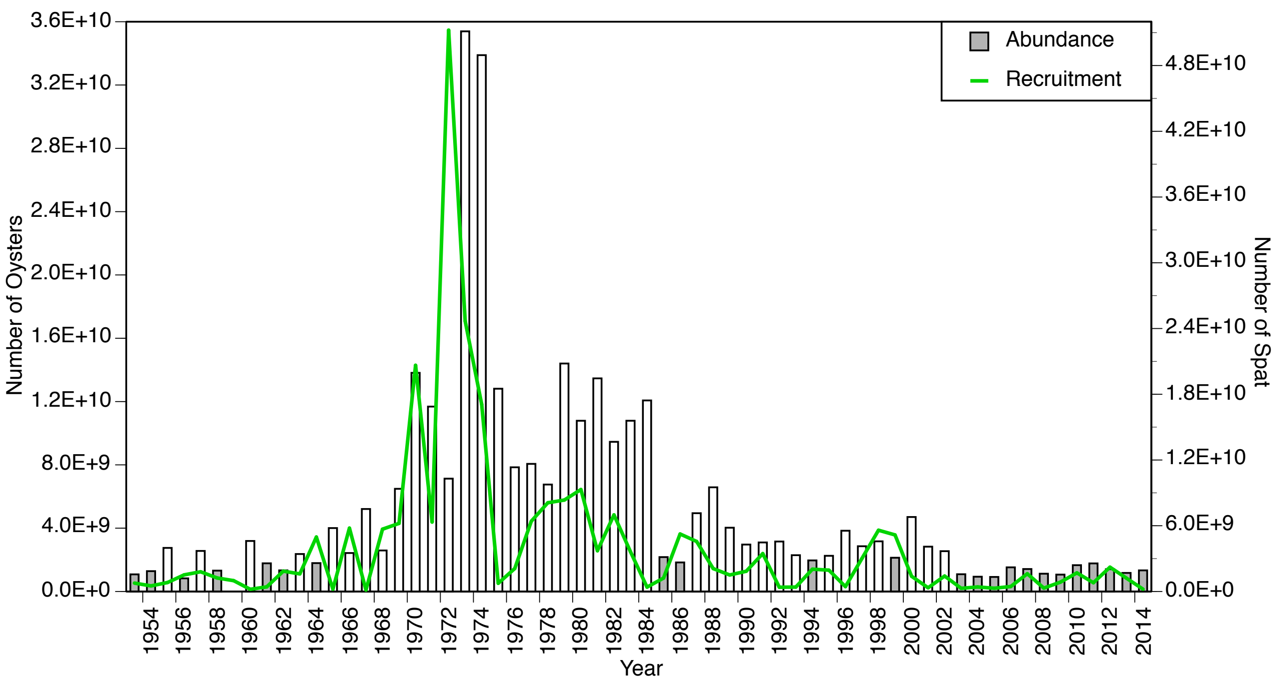


Figure 6. Oyster abundance by region for the 1990–2014 survey time series (lines). Relative acreage of each region shown in pie chart. Acreage includes only the high and medium quality strata footprint for each bed from the 2014 surveys. Regions are color-coded as in Figure 1. From upbay to downbay: Very Low Mortality (VLM); Low Mortality (LM); Medium Mortality Transplant (MMT); Medium Mortality Market (MMM); Shell Rock (SR); High Mortality (HM).

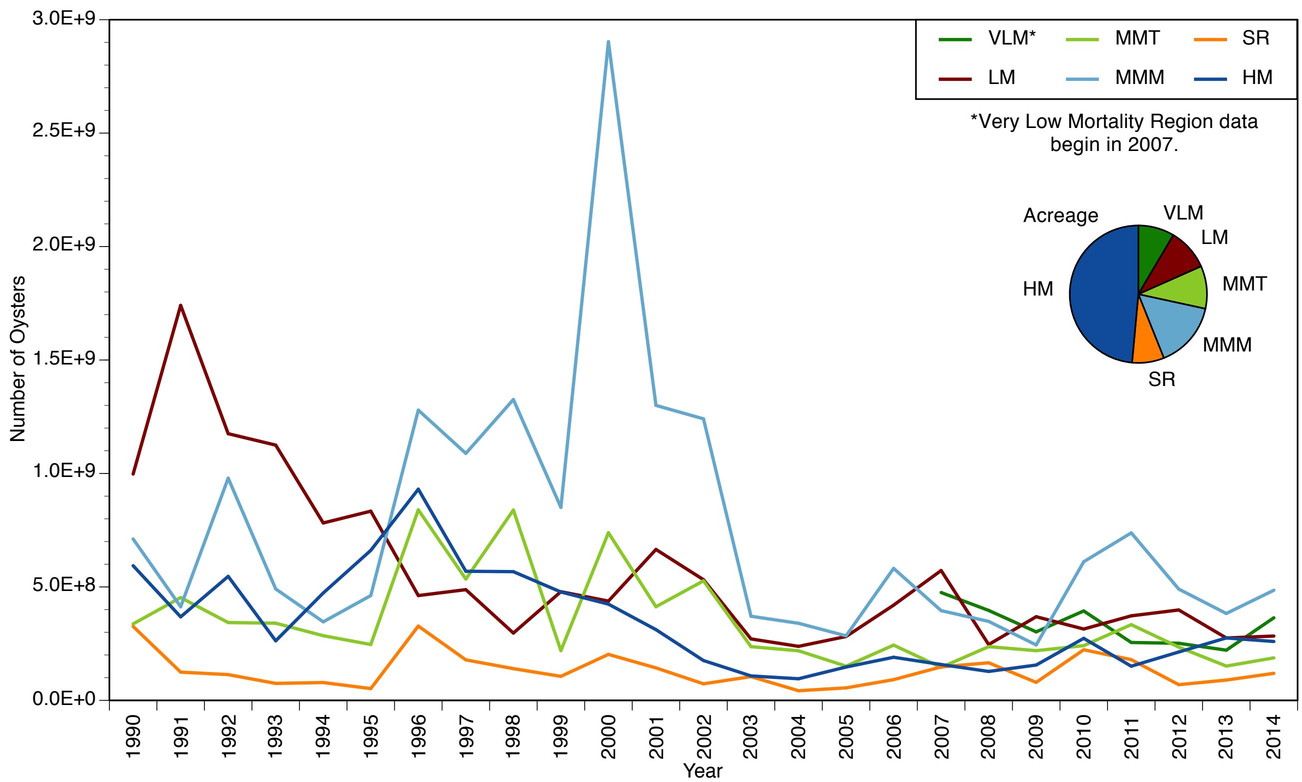


Figure 7. Box-count mortality rate by region for the 1990–2014 time series.

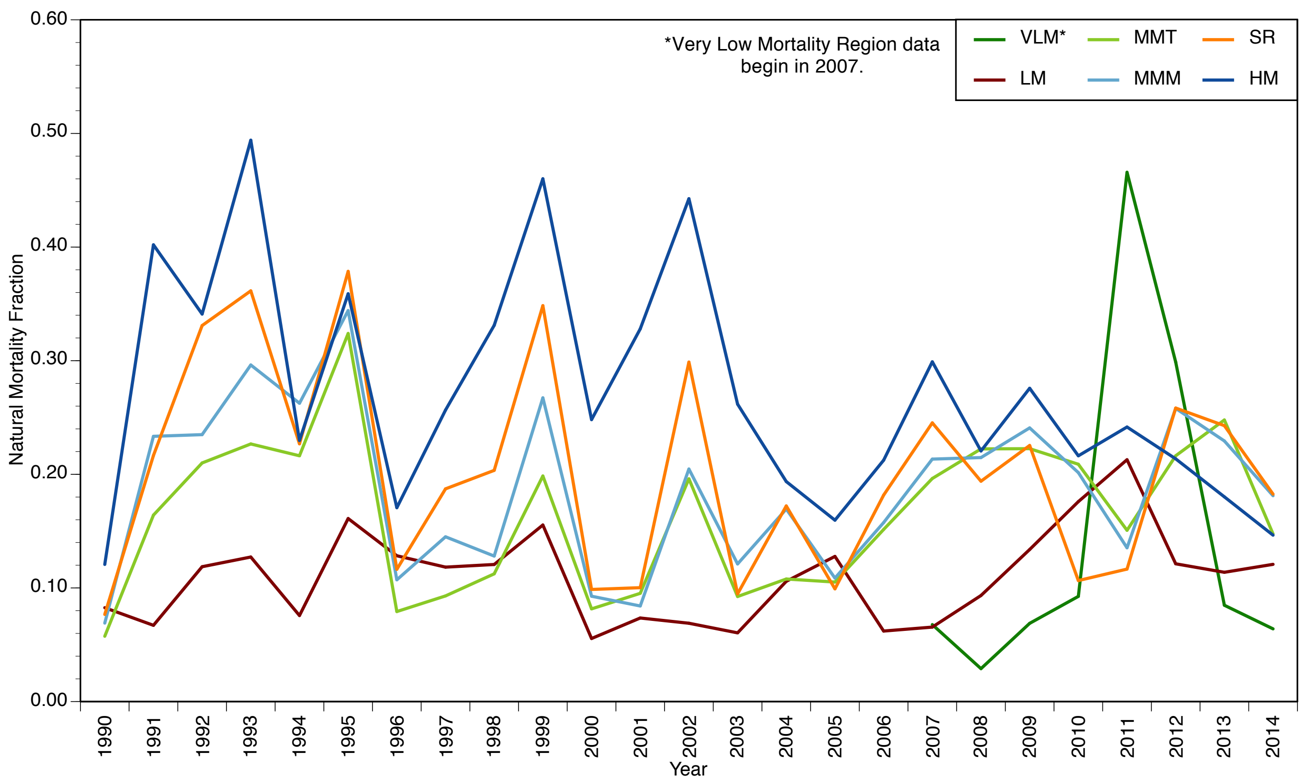


Figure 8. Number of oysters harvested from the natural oyster beds of Delaware Bay, NJ from 1953–2014. Prior to 1996, the bay-season fishery removed oysters from the natural beds and transplanted them downbay to leased grounds. The direct-market fishery began in 1996. In 1997, an intermediate transplant program began. Zeros represent years of fishery closure.

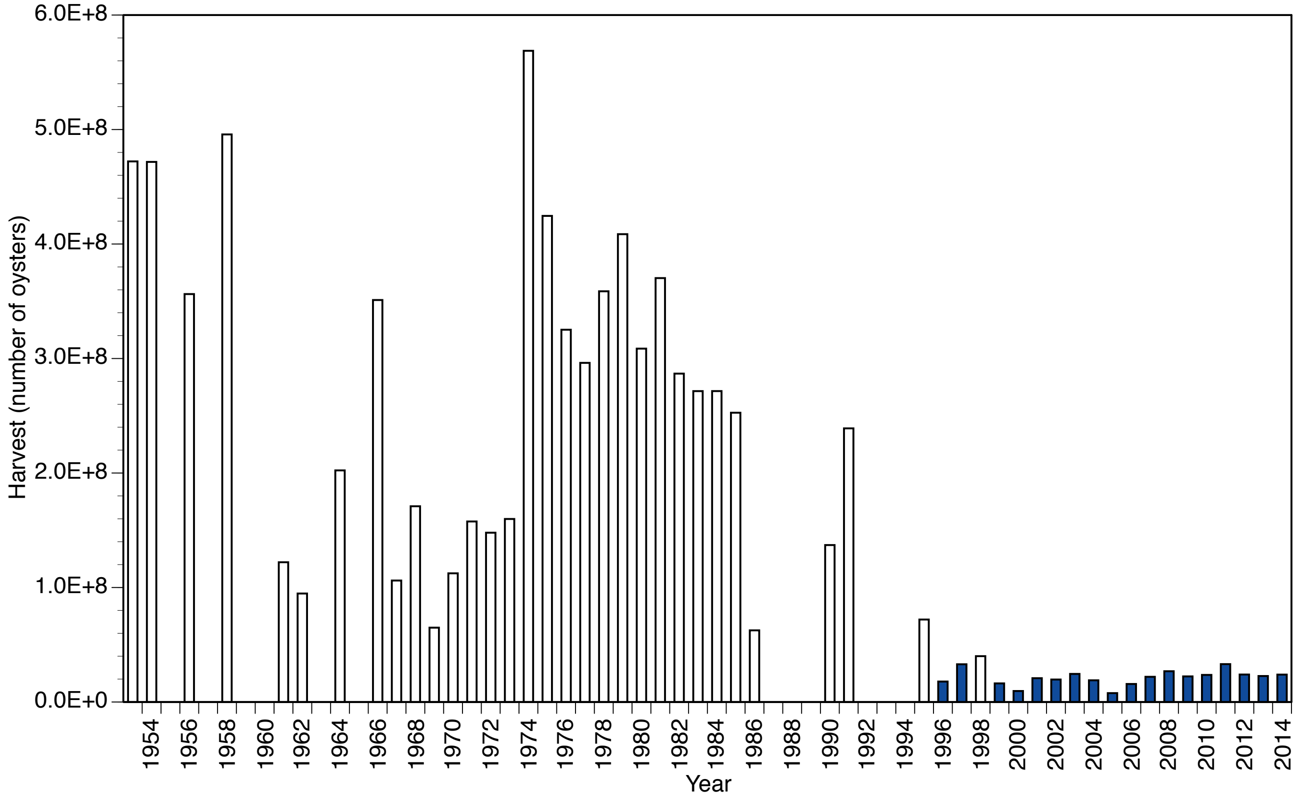


Figure 9. Survey gear efficiency estimated in 1999, 2000, 2003, and 2013 at oyster beds in Delaware Bay. Beds are ordered from the lower bay to the upper bay.

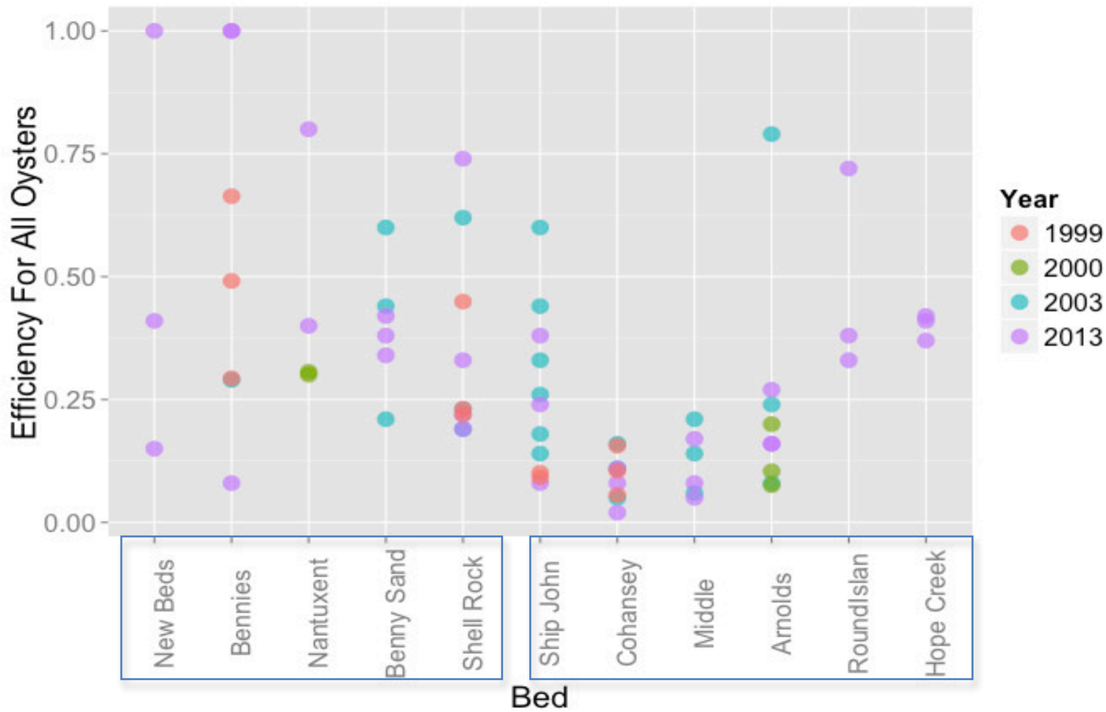


Figure 10. Relationship between cumulative oyster abundance and density for grids ordered by increasing abundance on Bennies for the Spring 2014 resurvey. This resurvey covered all navigable grids associated with Bennies. The vertical lines mark the boundary between the Low, Medium, and High quality strata. Low quality grids have no oysters or very low oyster density and account for the first 2% of the cumulative oyster abundance on a bed. Grids that account for the middle 48% of cumulative abundance on a bed are Medium quality and grids that account for the upper 50% of cumulative abundance on a bed are High quality.

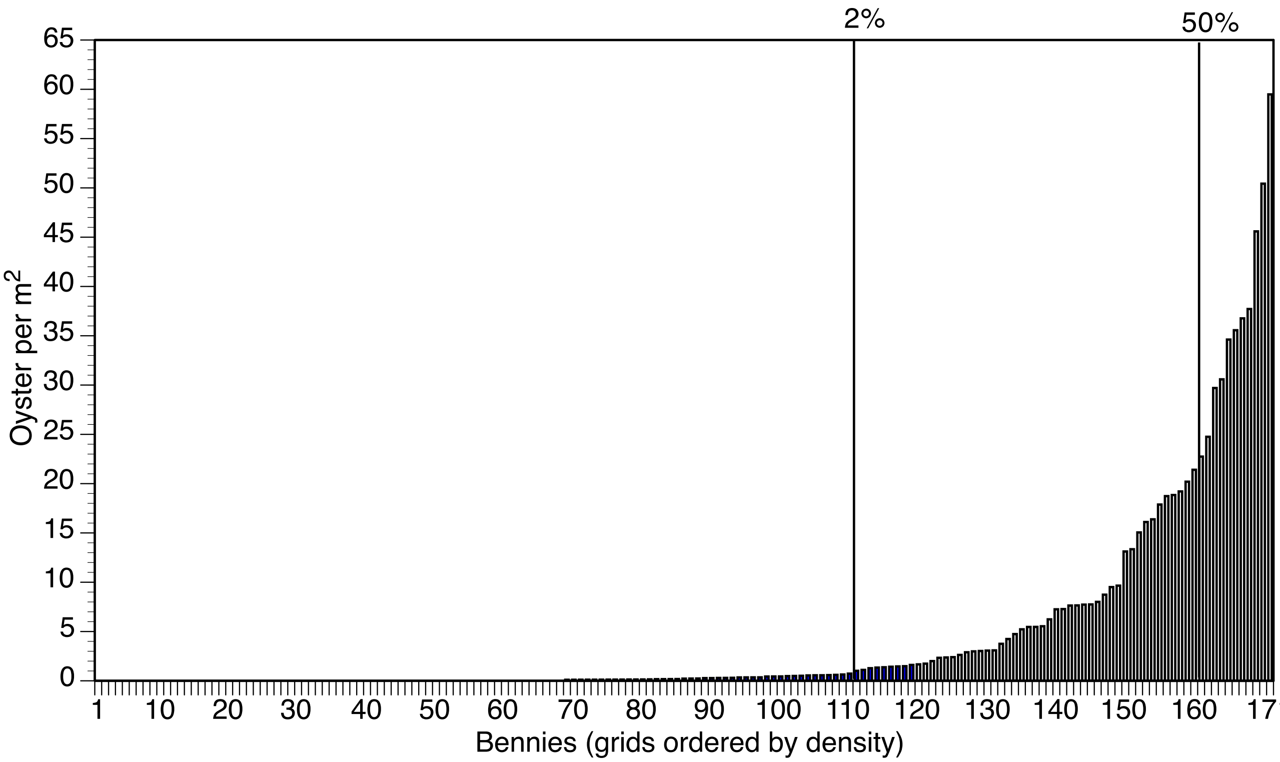


Figure 11. Distribution of grids on Bennies before (2005-2013) and after (2014) the Spring 2014 resurvey. Grids are shaded according to stratification by oyster density. The 2014 resurvey program covered all navigable grids associated with Bennies. Grids assigned to the High quality stratum are shaded darkly, those assigned to the Medium quality stratum are shaded an intermediate color, and Low quality grids are shaded a light color. Bennies has 171 grids: 11 high, 49 medium, and 111 low quality grids after the 2014 restratification.

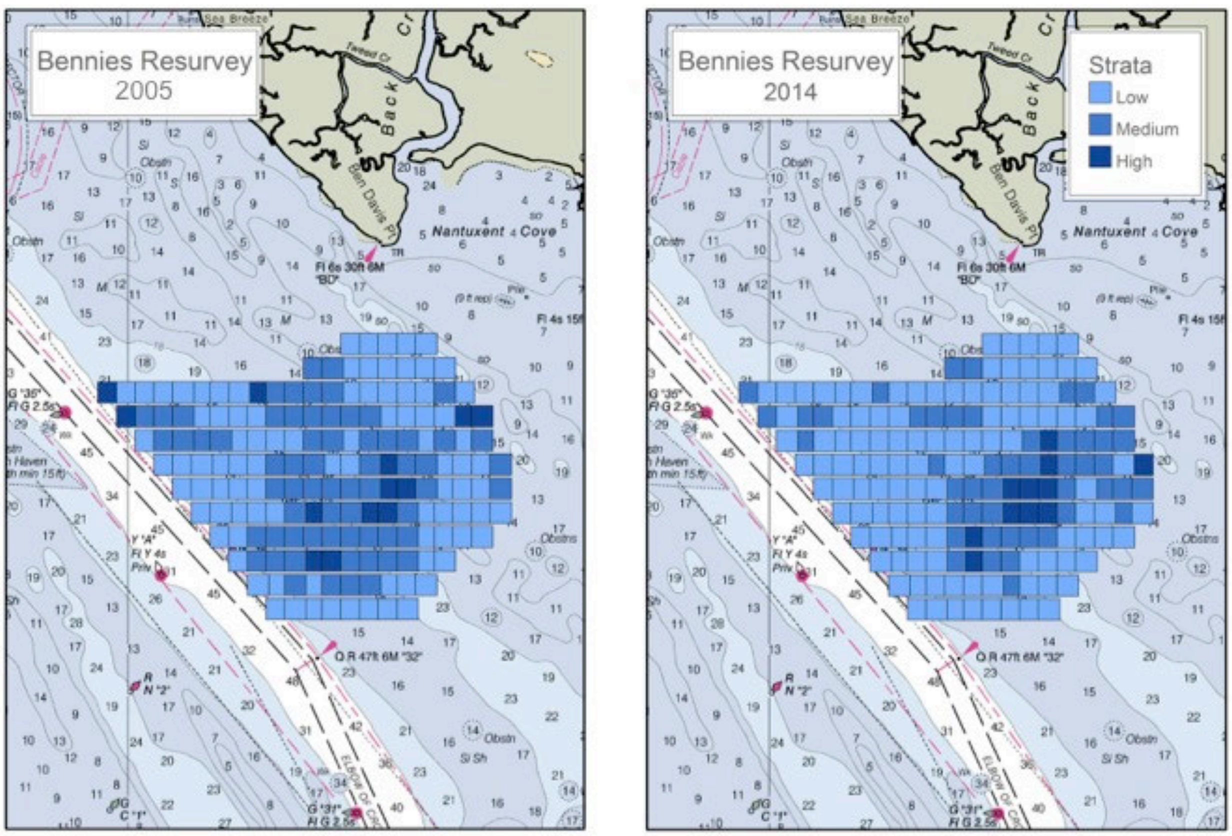


Figure 12. The natural oyster beds of Delaware Bay, NJ and their regional designations. Dark green, Very Low Mortality; red, Low Mortality; light green, Medium Mortality Transplant; light blue, Medium Mortality Market; orange, Shell Rock; dark blue, High Mortality. Beds included in each region are listed in Table 5. Bed footprints include grids from the High (dark shade) and Medium (light shade) quality strata. Strata designation is described in the text. Grids are 0.2" latitude x 0.2" longitude; approx. 25 acres (101,175 m^2 or 10.1 hectares). Bed footprints are based on resurveys beginning in 2005. Ledge and Egg Island do not have many oysters and have not been resurveyed. The sites for the 2014 stock assessment survey are indicated by white or black dots or by + for shellplant or transplant sites.

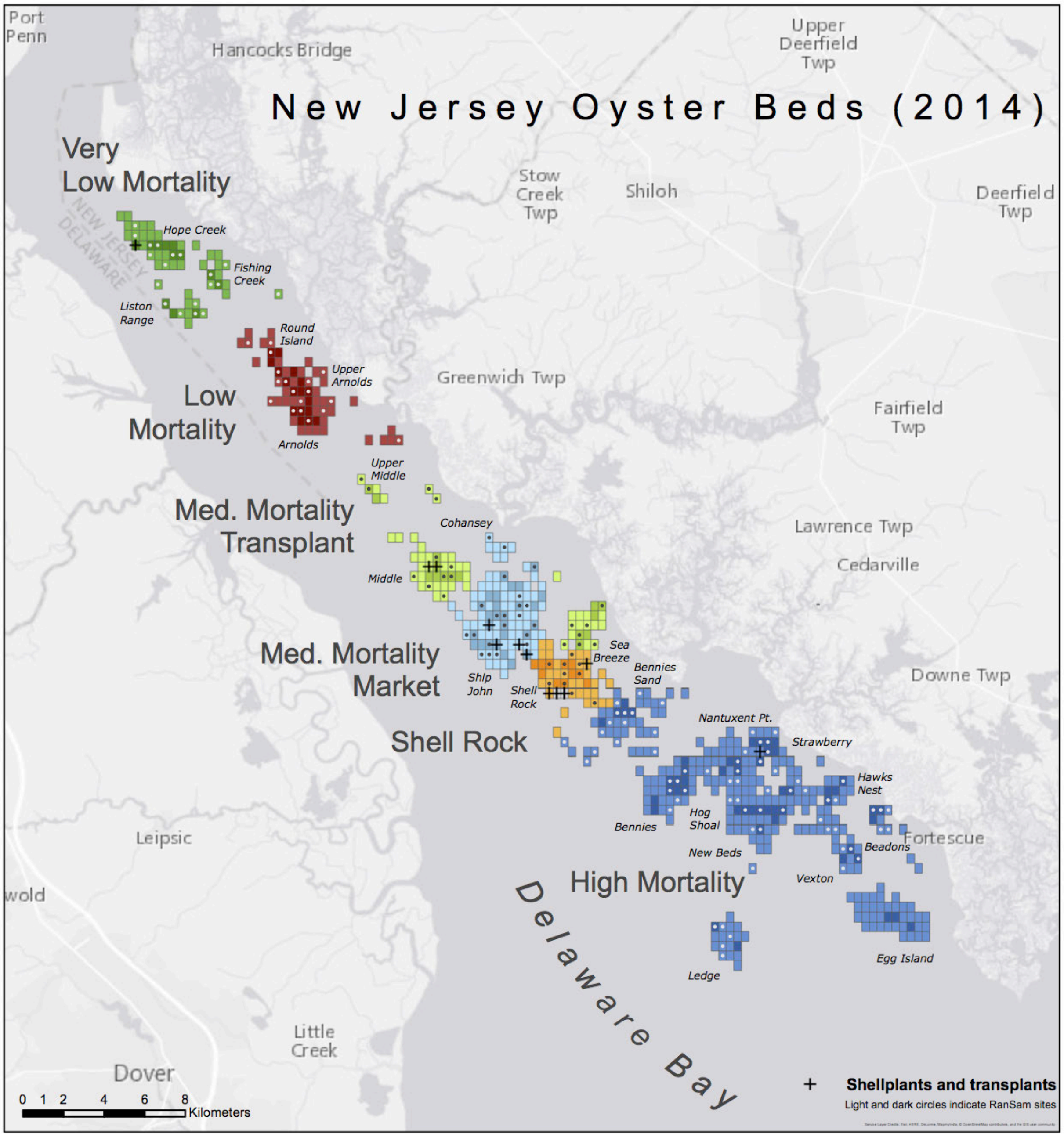


Figure 13. Total abundance of oysters >20mm on the oyster beds of Delaware Bay, NJ for the 1990–2014 time series (bars). Purple line overlay is the spawning stock biomass (SSB) which is based on oysters >35mm (right y-axis). VLM is not included in either set of data.

Figure 14. Number of market-size oysters (> 2.5 inches) for the 1990–2014 time series. Green line is the median value for the time series, 4.52 x 10^8 market-size oysters. Data from the Very Low Mortality Region is not included.

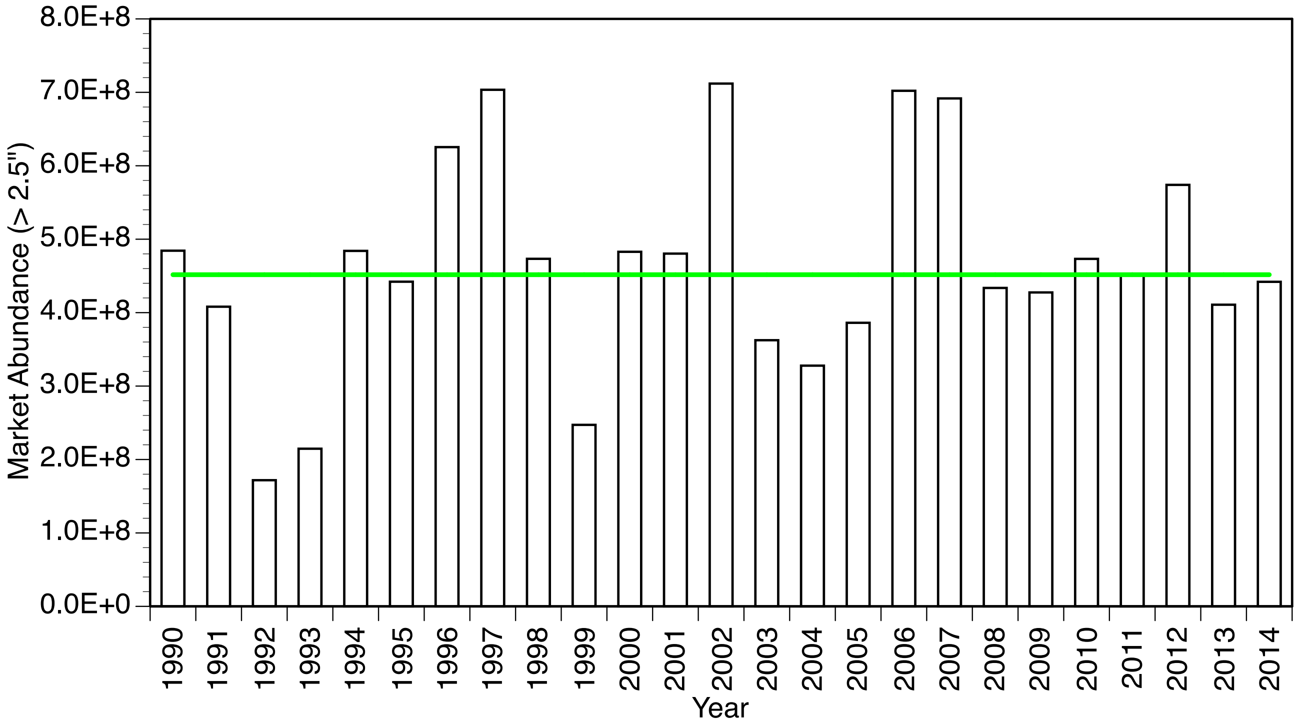


Figure 15. Oyster abundance by region and size for the 1990–2014 survey time series. (**a**) abundance of spat (< 20 mm, 0.8”); (**b**) abundance of small oysters (20–63.5 mm, 0.8”–2.5”); (**c**) abundance of market-size oysters (> 63.5 mm, ≥ 2.5”).

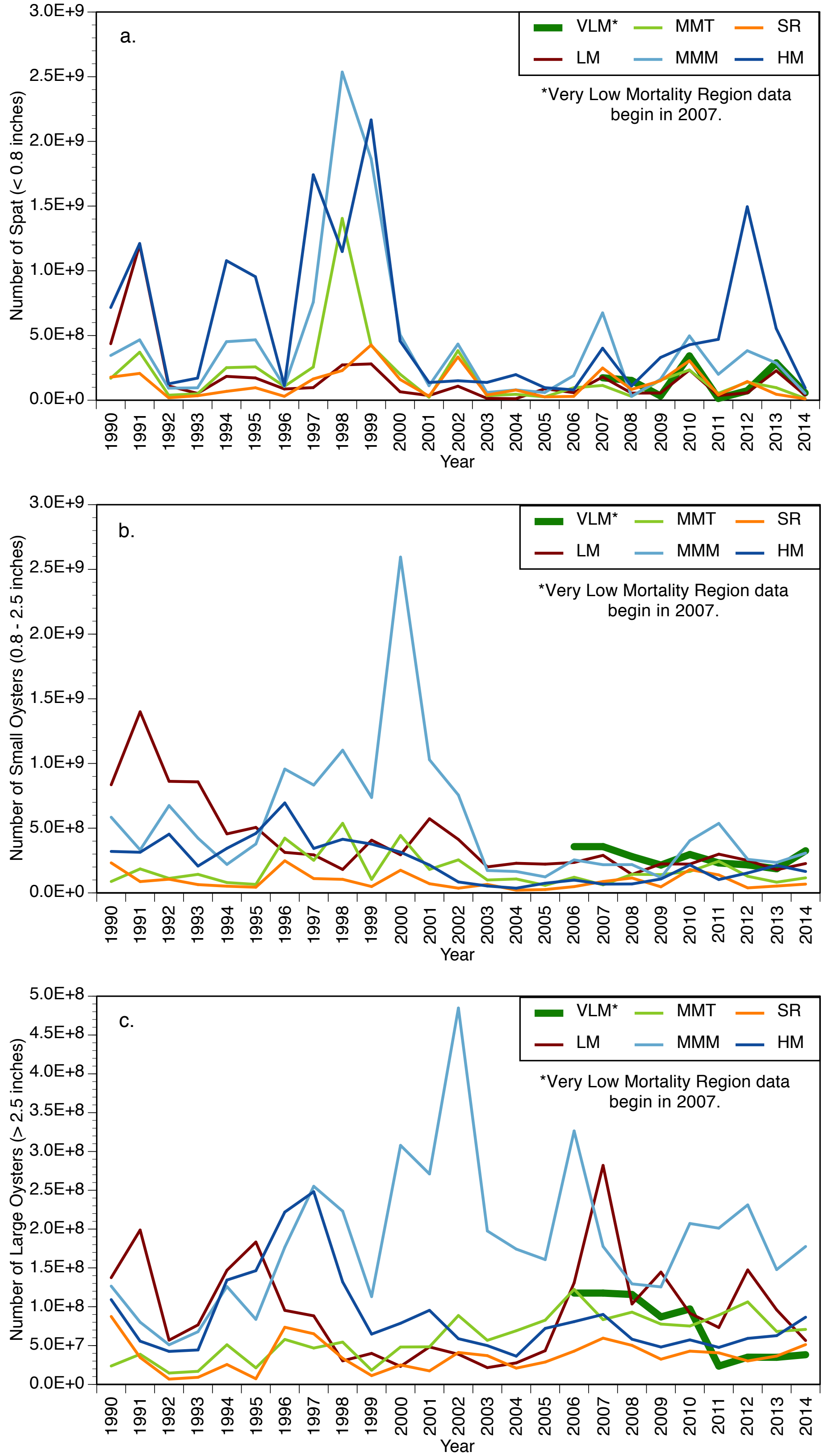


Figure 16. Estimated number of bushels of shell lost from the New Jersey oyster beds for the time period 1999–2014. Shell budgets are calculated using updated half-lives estimated in this assessment and using half-lives estimated in 2012 and 2013 for comparison.

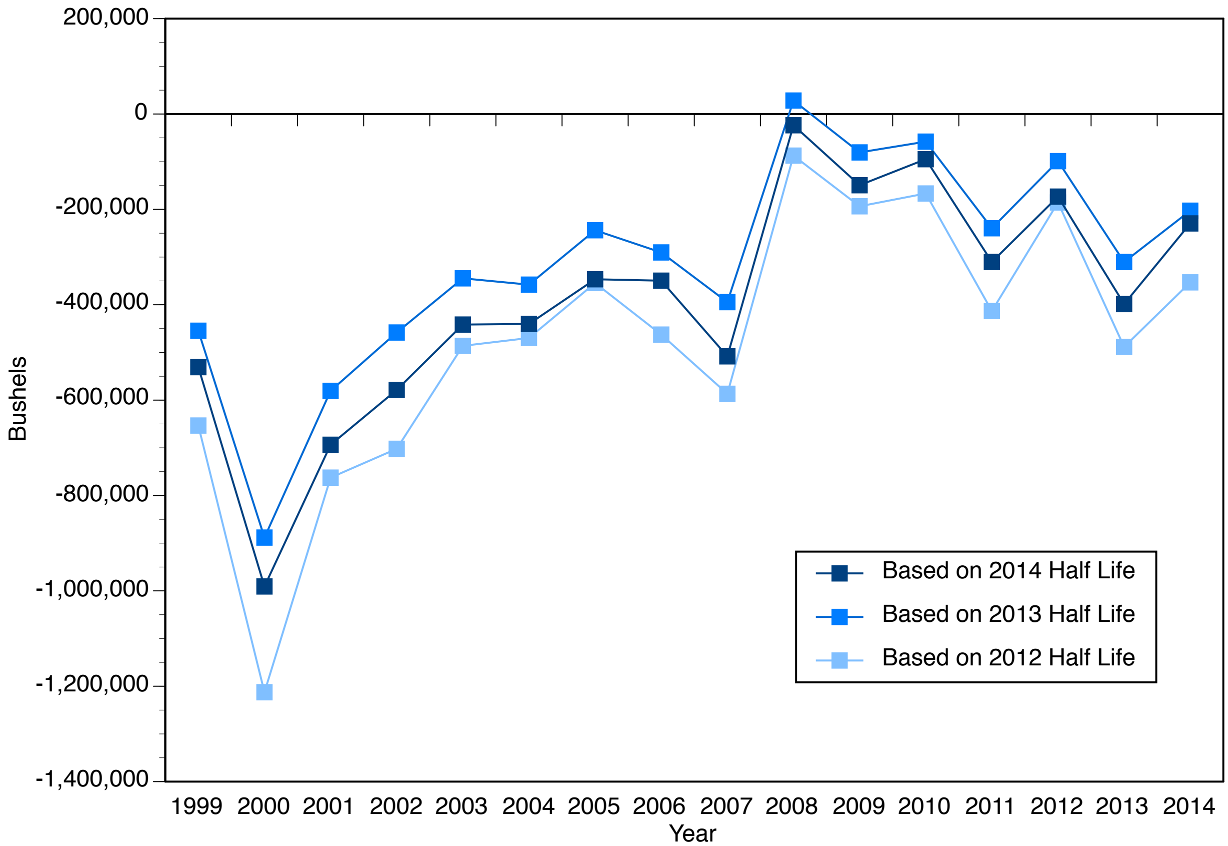


Figure 17. Spat recruitment to native shell (cultch), dark green; and to planted clam shell, light green. Recruitment to clam shell was counted for the first year of shell plant only. Clam shell will continue to attract recruits at a lower rate in subsequent years. Details on shellplanting can be found in Tables 8, 9, 12, and in previous SAW documents.

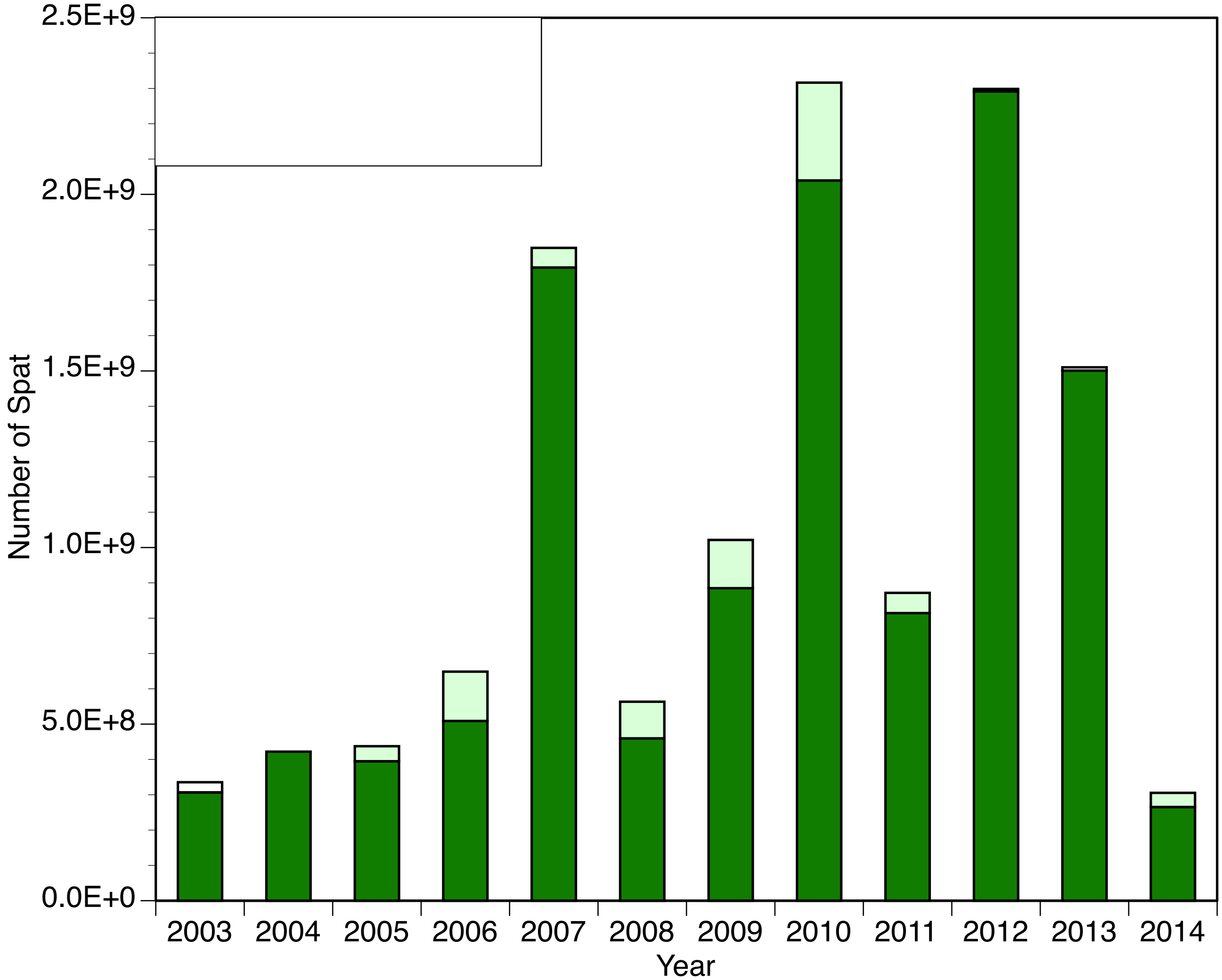


Figure 18. Spatial patterns of the size at which a newly settled oyster transitions from spat to oyster morphology based on visual evaluation of samples from Fall 2014. Left panel shows logistic regression model fits for the length at which the transition occurs by region. Lighter colors, more upbay regions; darker colors, more downbay regions. Histogram on right shows the shell length at which the logistic fit crosses the 50% probability, i.e. the predicted size at transition and increases from upbay to downbay.

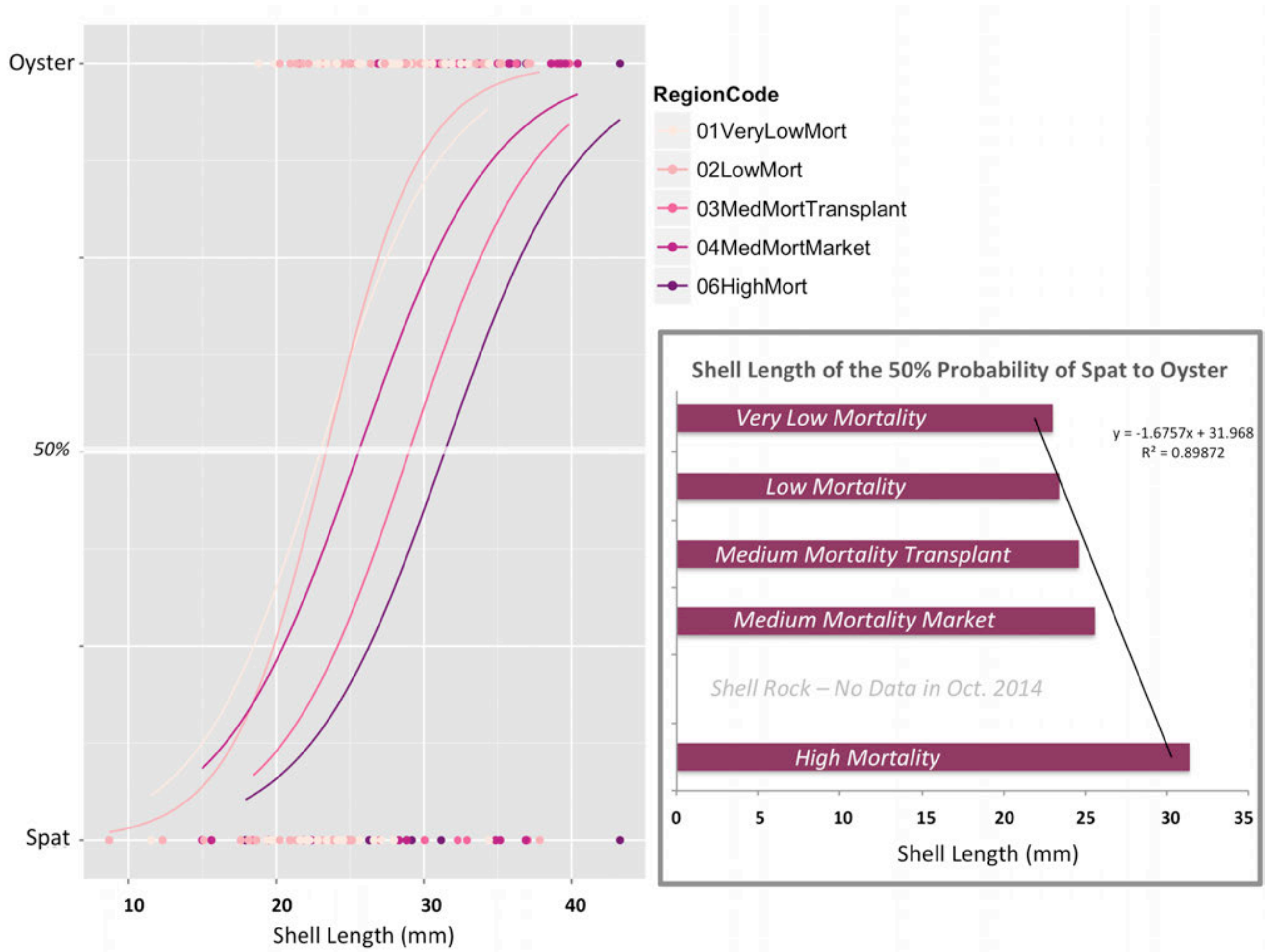


Figure 19. Time series of oyster broodstock abundance (right axis, light blue bars) in billions, bushels of shell planted in the Delaware Bay (blue line) and spat count (purple line). Broodstock abundance and spat count come from annual oyster stock surveys. Shellplant counts come from experiment station annual reports, director's correspondence, and assessment records.

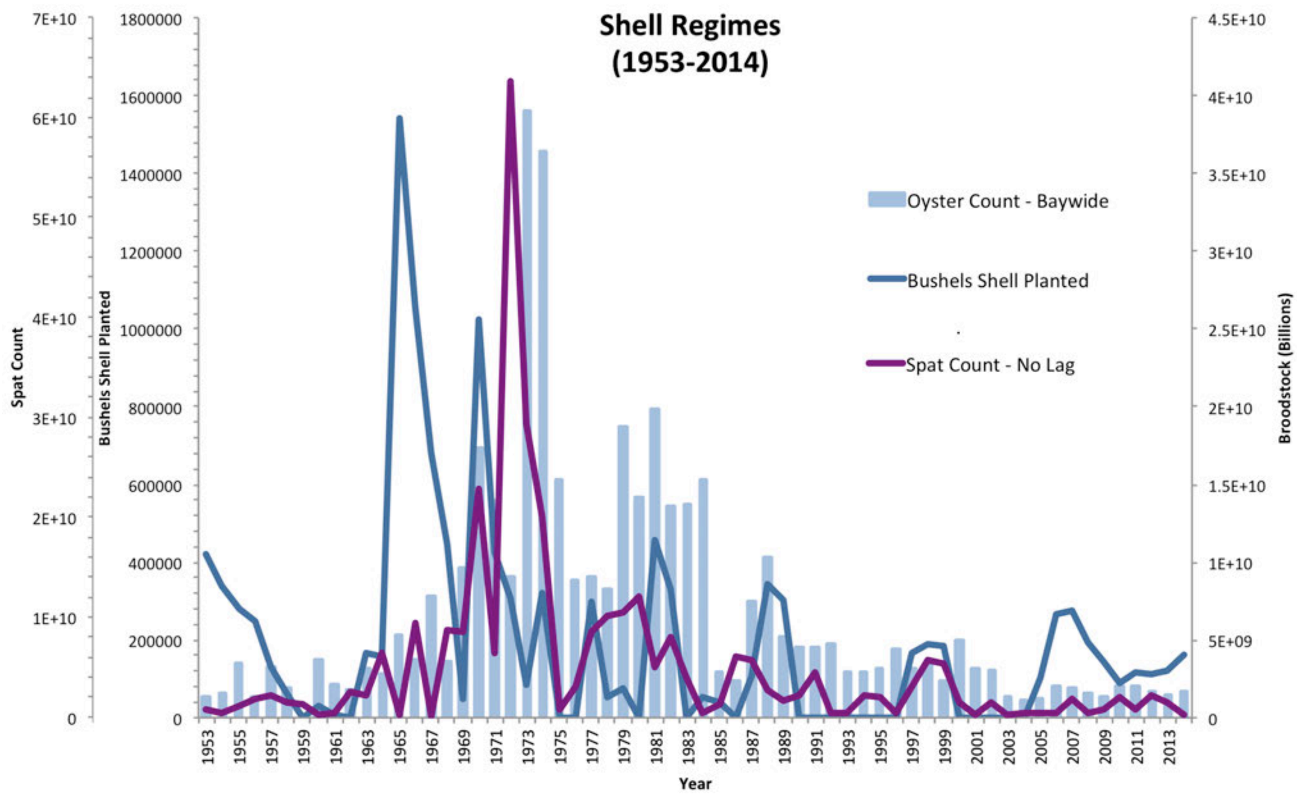


Figure 20. Number of bushels harvested from the natural oyster beds of Delaware Bay since the inception of the direct-market program in 1996. Average harvest = 75,488 bushels; median harvest = 76,910 and matches 2014 harvest.

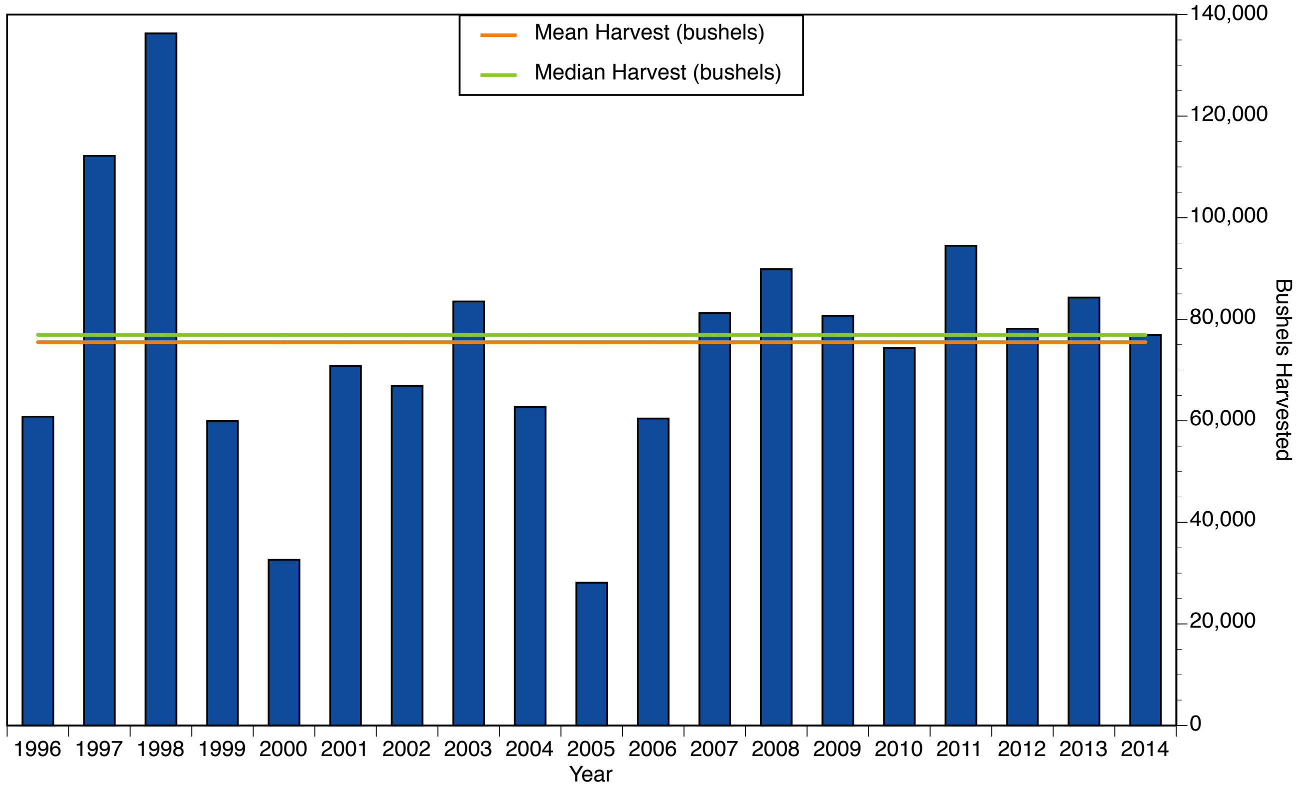
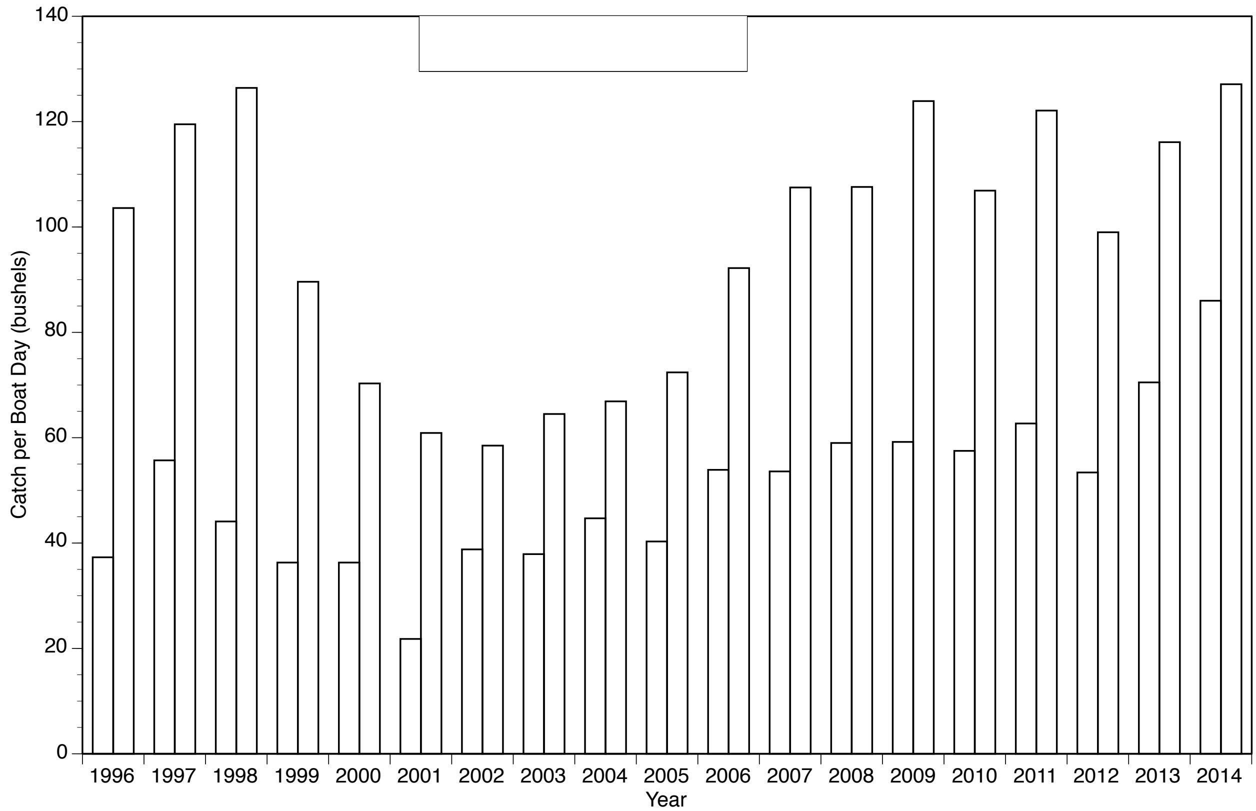


Figure 21. Catch per unit effort (cpue) in days by one- and two-dredge boats. Consolidation of licenses in recent years has allowed one boat to fish multiple licenses. Total quota is divided by the number of licenses. (a). cpue each year since direct marketing began on all harvested beds. (b) cpue in boat-days on the beds fished in 2014.

a.



b.

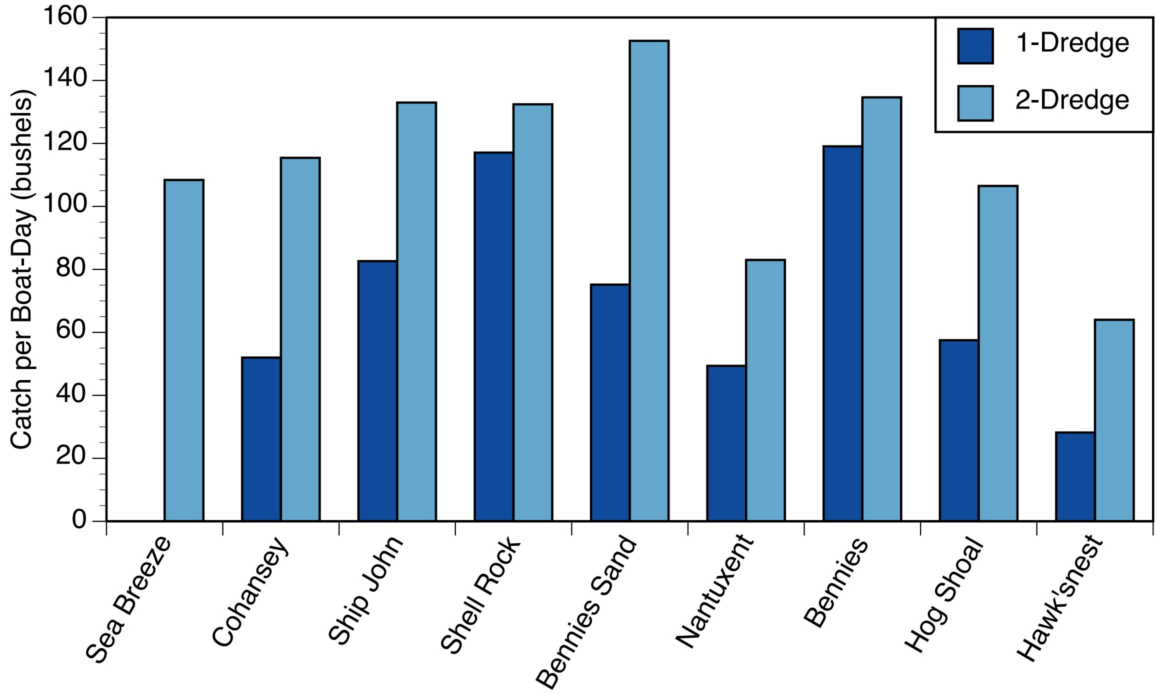


Figure 22. Landed oysters per bushel in three groups: market-size (>2.5"), smaller attached oysters, and smaller unattached oysters. The 2014 number of oysters per marketed bushel averaged 303. The long-term mean of all oysters (266) is shown as an orange line.

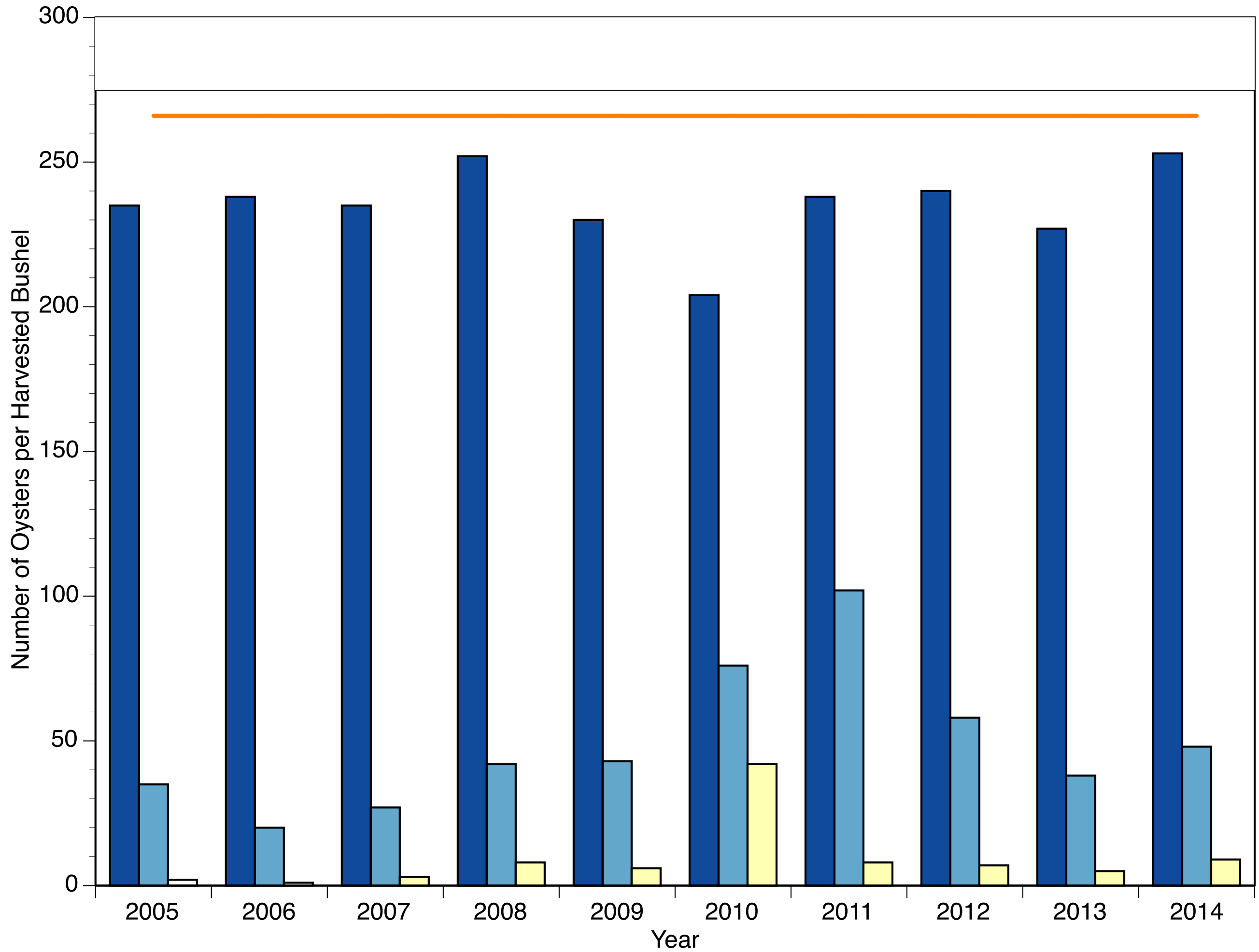


Figure 23. Size frequency of oysters landed in 2014 compared to the mean size frequency from the previous 10 years. Size class values are the lower bounds of the size class.

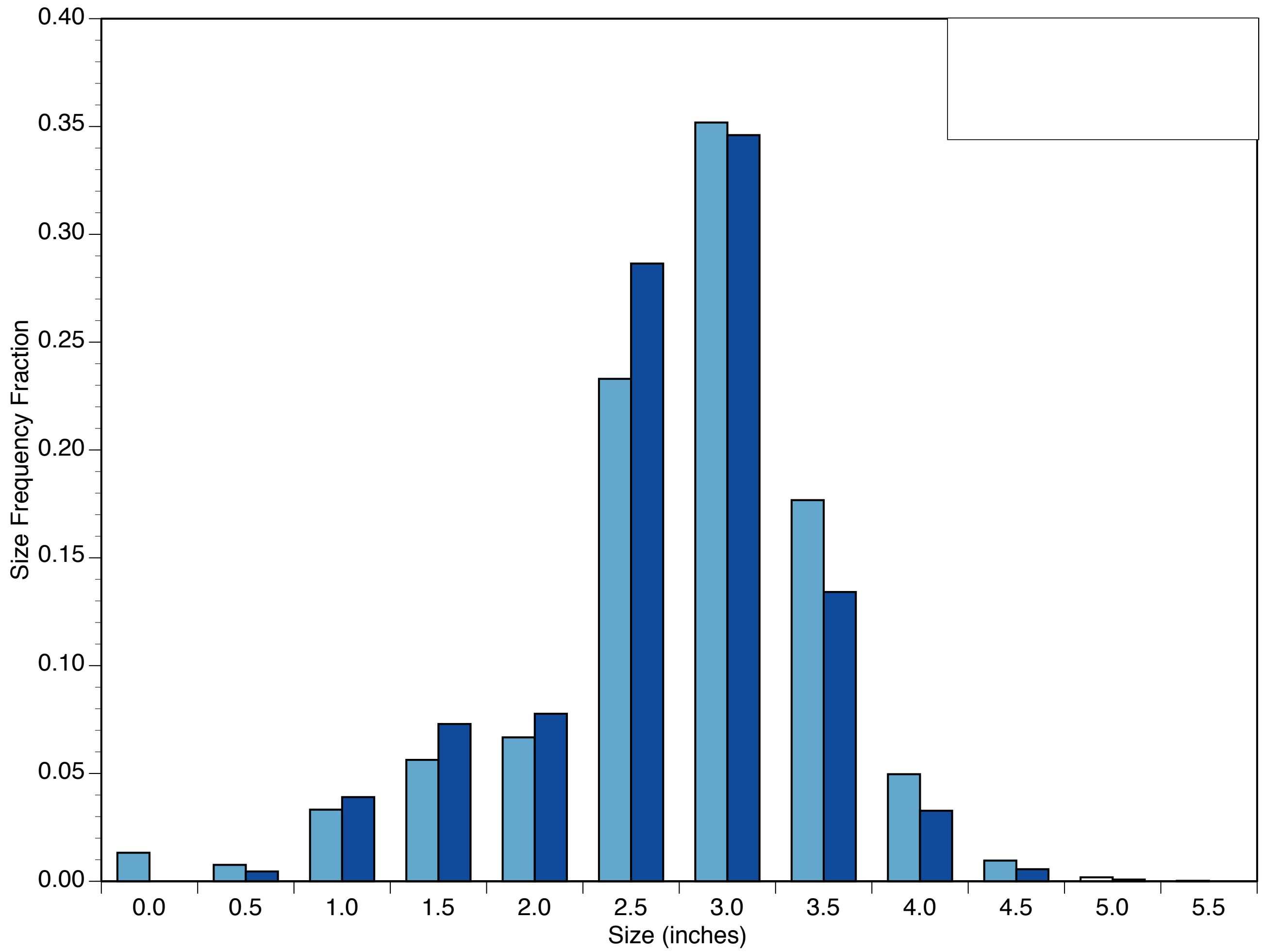


Figure 24. Exploitation rates and their percentiles used for Delaware Bay, New Jersey oyster fishery allocation decisions since 2007. SARC recommendations ca. 2006 resulted in use of the 1996-2006 decade of Direct Market exploitation as the basis for the current system of within-region, abundance-based exploitation. Limited data for the upbay regions resulted in use of one set of data for the Transplant regions. Low range of exploitation rates in the Medium Mortality Market region led to an experimental fishery at the rate associated with the 100th percentile. Limited timeframe for reference results in abrupt step changes in some cases.

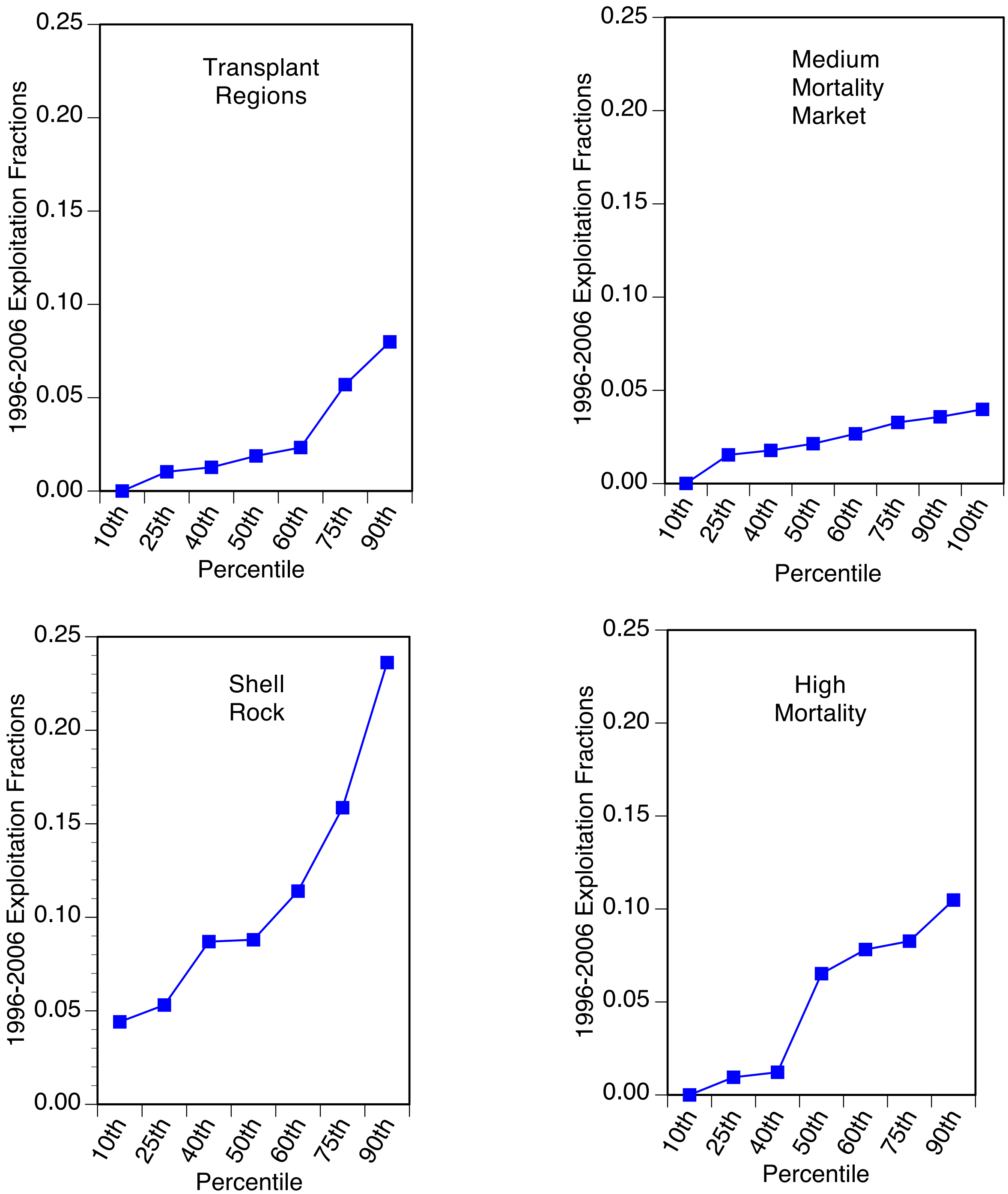


Figure 25. (**a**) Fishing mortality as a percentage of oyster abundance from the 1997–2014 time period excluding the VLM. (**b)** Fishing mortality as a percentage of the market-sized oyster abundance (>2.5") for the 1997–2014 time period excluding the VLM.

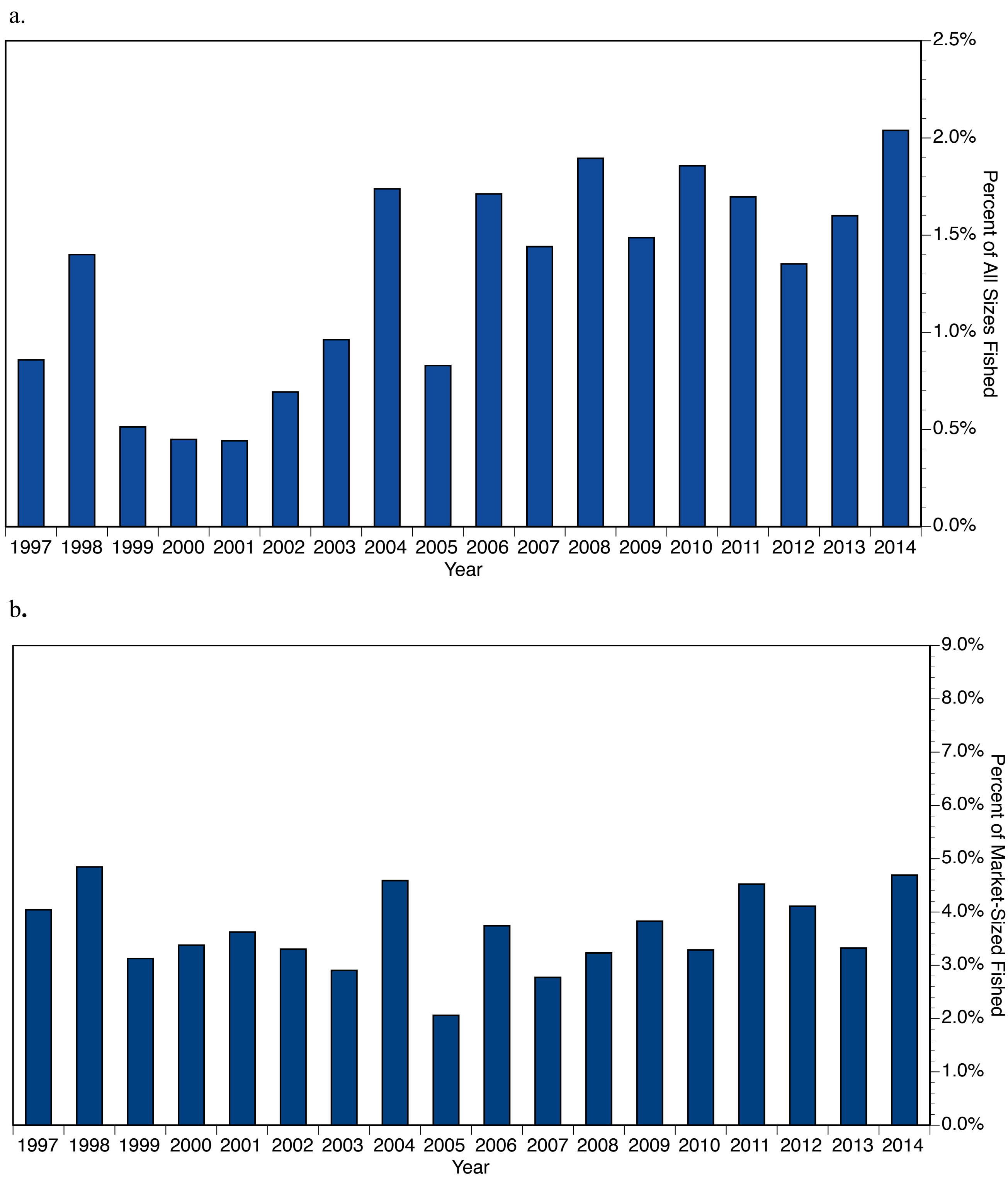


Figure 26. Fishing mortality percentages by region during the Direct Market time series (1997-2014). Percentages reflect transplant removals from the Very Low Mortality, Low Mortality, and Medium Mortality Transplant regions and transplant additions plus direct market harvest from the Medium Mortality Market, Shell Rock, and High Mortality regions. If more oysters are transplanted to a region than are directly harvested, negative percentages will result. Dark bars depict the percentage fished of all oysters in each region and light bars, the percentage fished of the market (>2.5") oysters. There was no exploitation of the Very Low Mortality region prior to 2009; otherwise, no bars indicate no oysters removed from the region in that year.

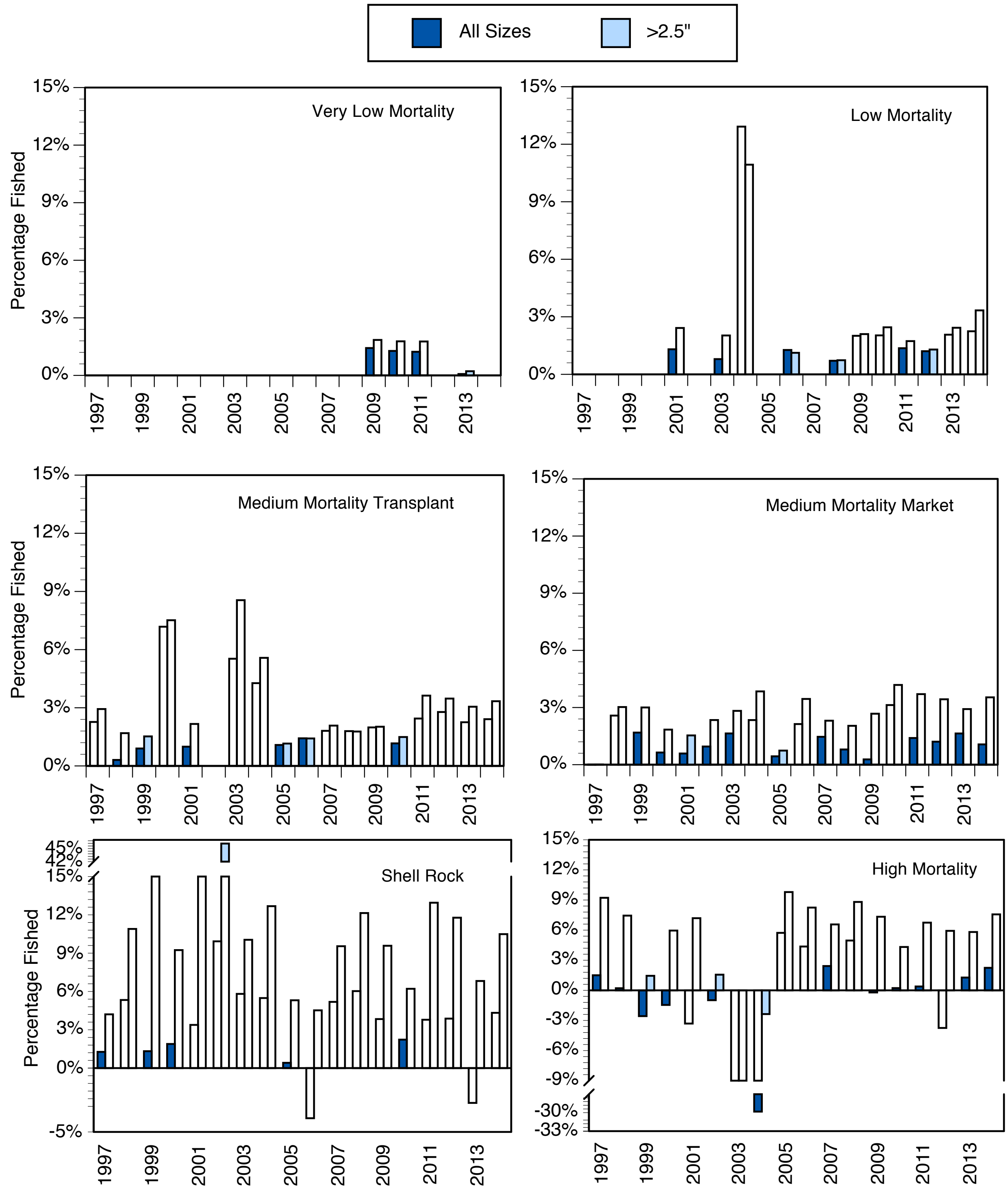


Figure 27. 2014 total abundance whole-stock estimate within confidence percentiles for the 2014 survey taking into account between-sample variation and uncertainty in dredge efficiency. Whole stock reference points are included for comparison as are two previous years of survey data. All values exclude the Very Low Mortality region. Note that the percentiles (P) above the 50th are shown as 1 – *P* so that, for example, the 60th percentile is indicated as the 40th percentile but on the right-hand side of the curve.

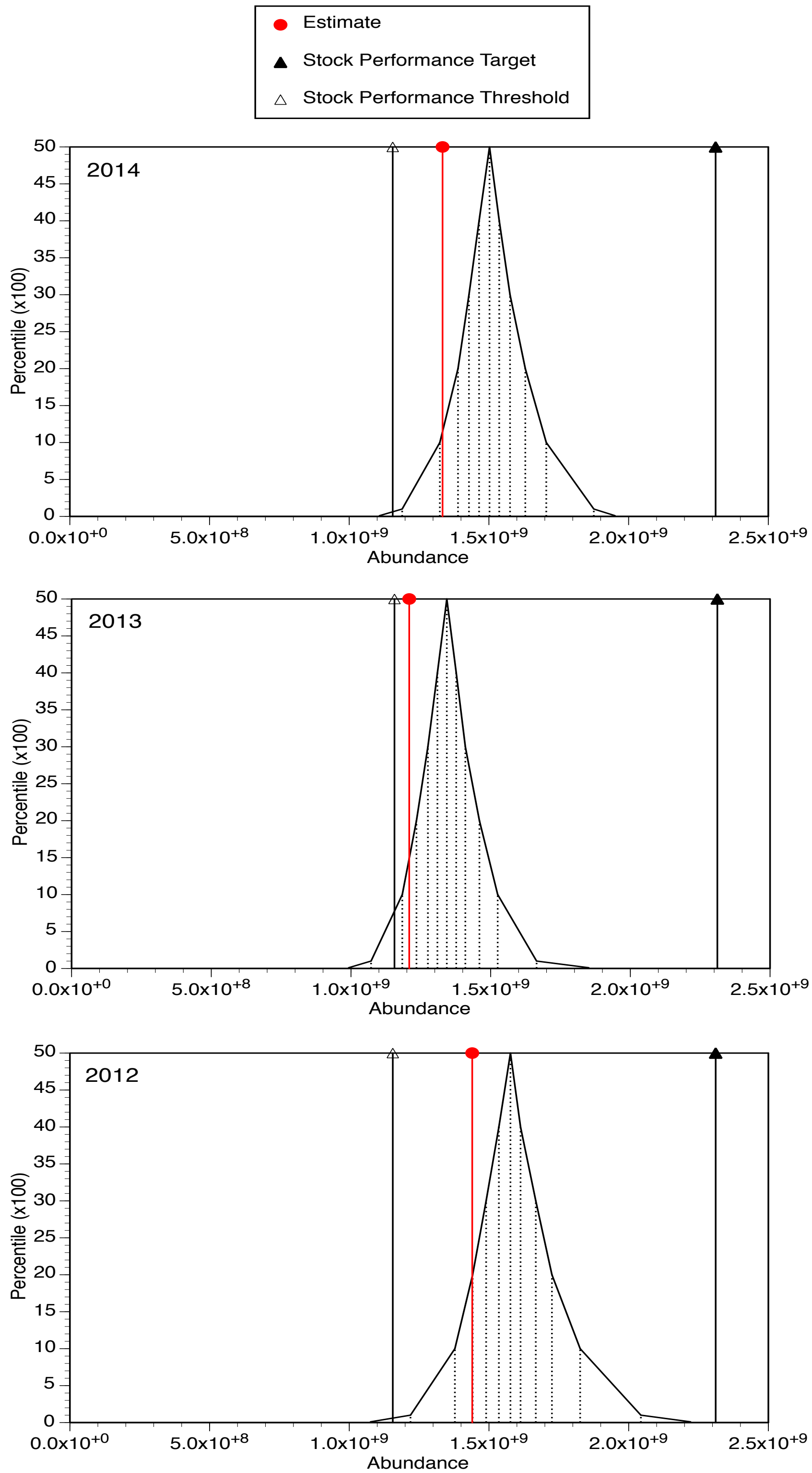


Figure 28. 2014 market-sized oyster whole-stock abundance estimate within confidence percentiles for the 2014 survey taking into account between-sample variation and uncertainty in dredge efficiency. Whole stock reference points are included for comparison as are two previous years of survey data. All values exclude the Very Low Mortality region. Note that the percentiles (P) above the 50th are shown as 1 – *P* so that, for example, the 60th percentile is indicated as the 40th percentile but on the right-hand side of the curve.

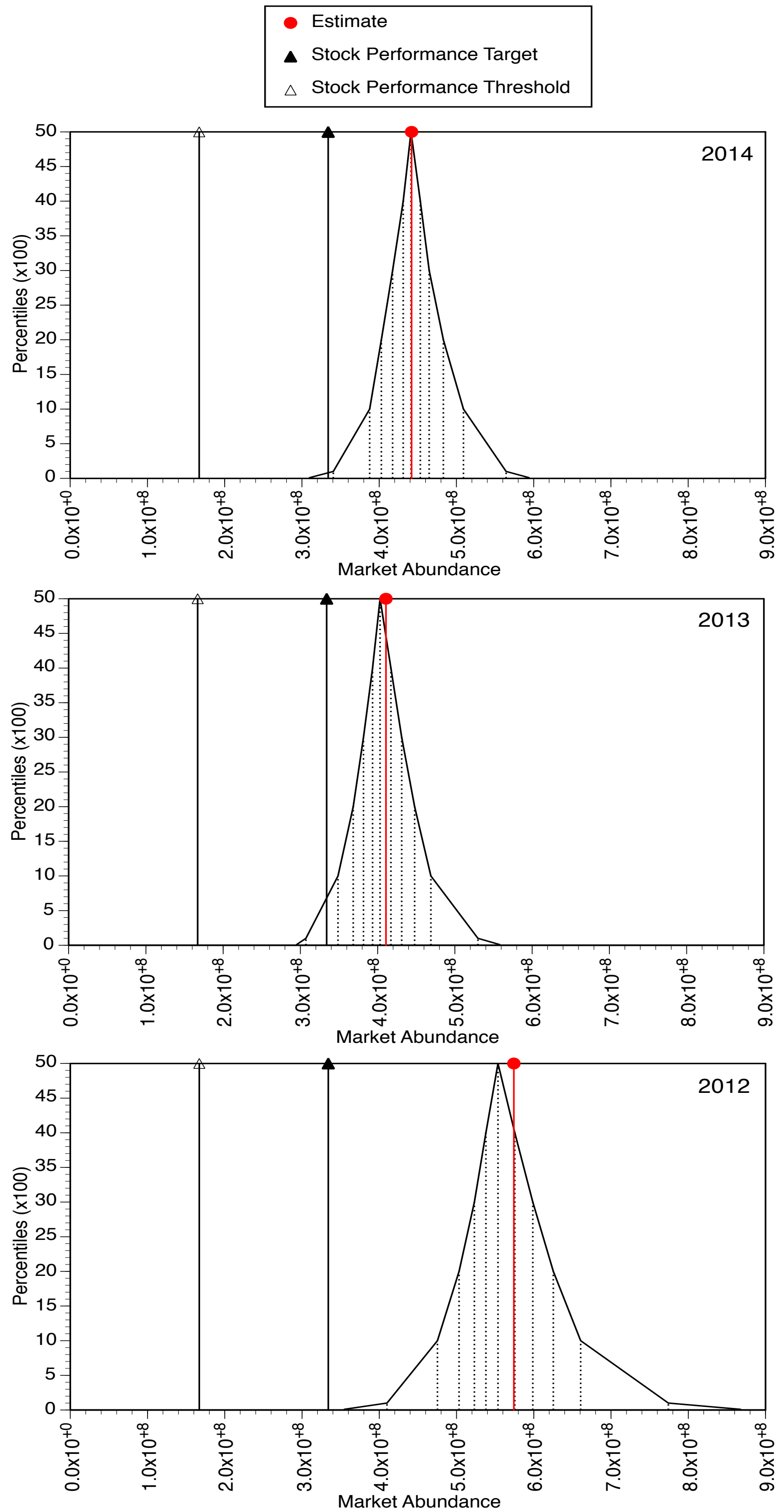


Figure 29. Position of the oyster stock in 2010–2014 with respect to regional abundance and biomass targets and thresholds. The target is taken as the median of abundance or biomass from the 1989–2005 (1990–2005) time period. The threshold is taken as half these values. Reference points and their derivation are described in previous SAW documents.

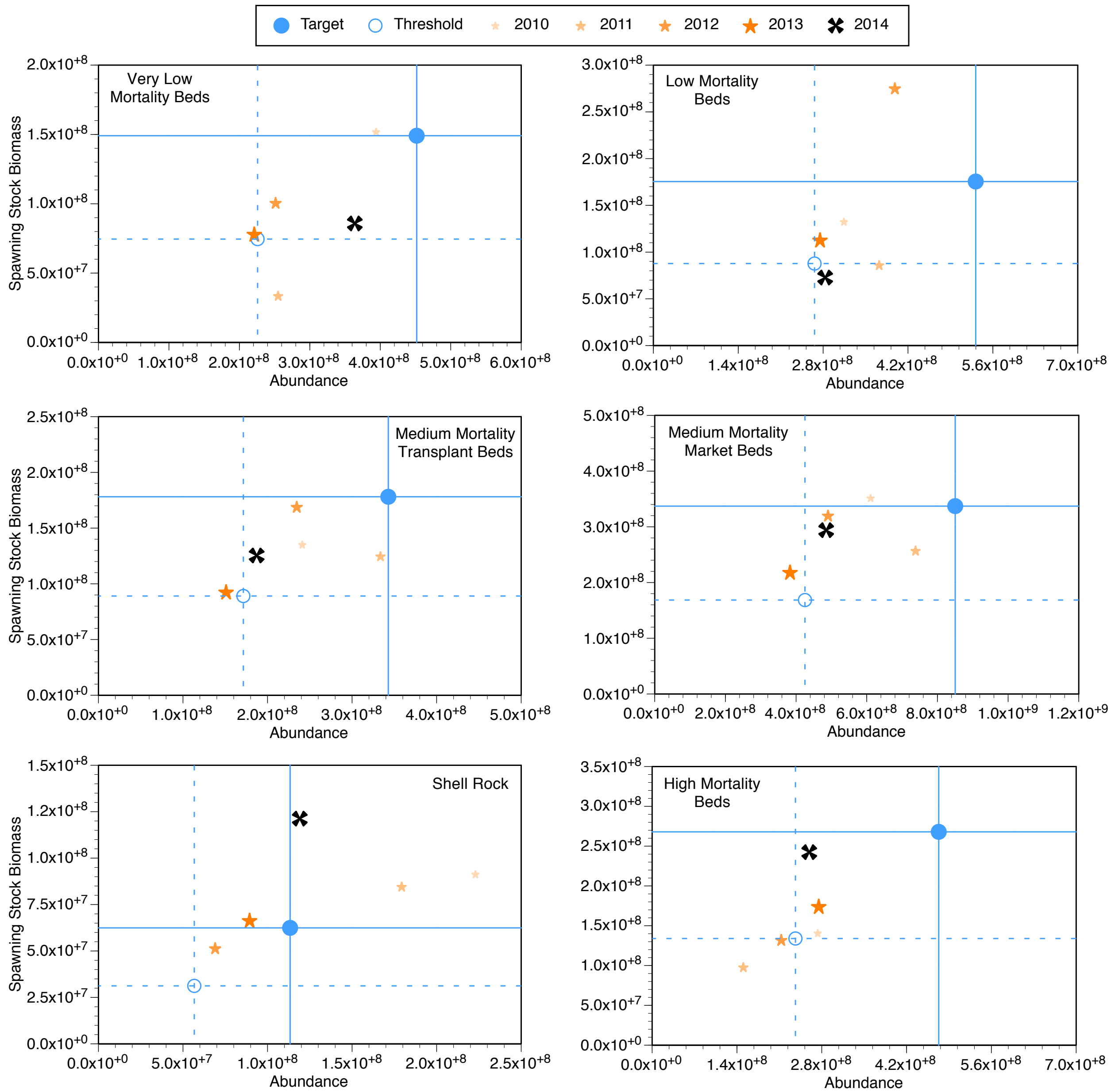
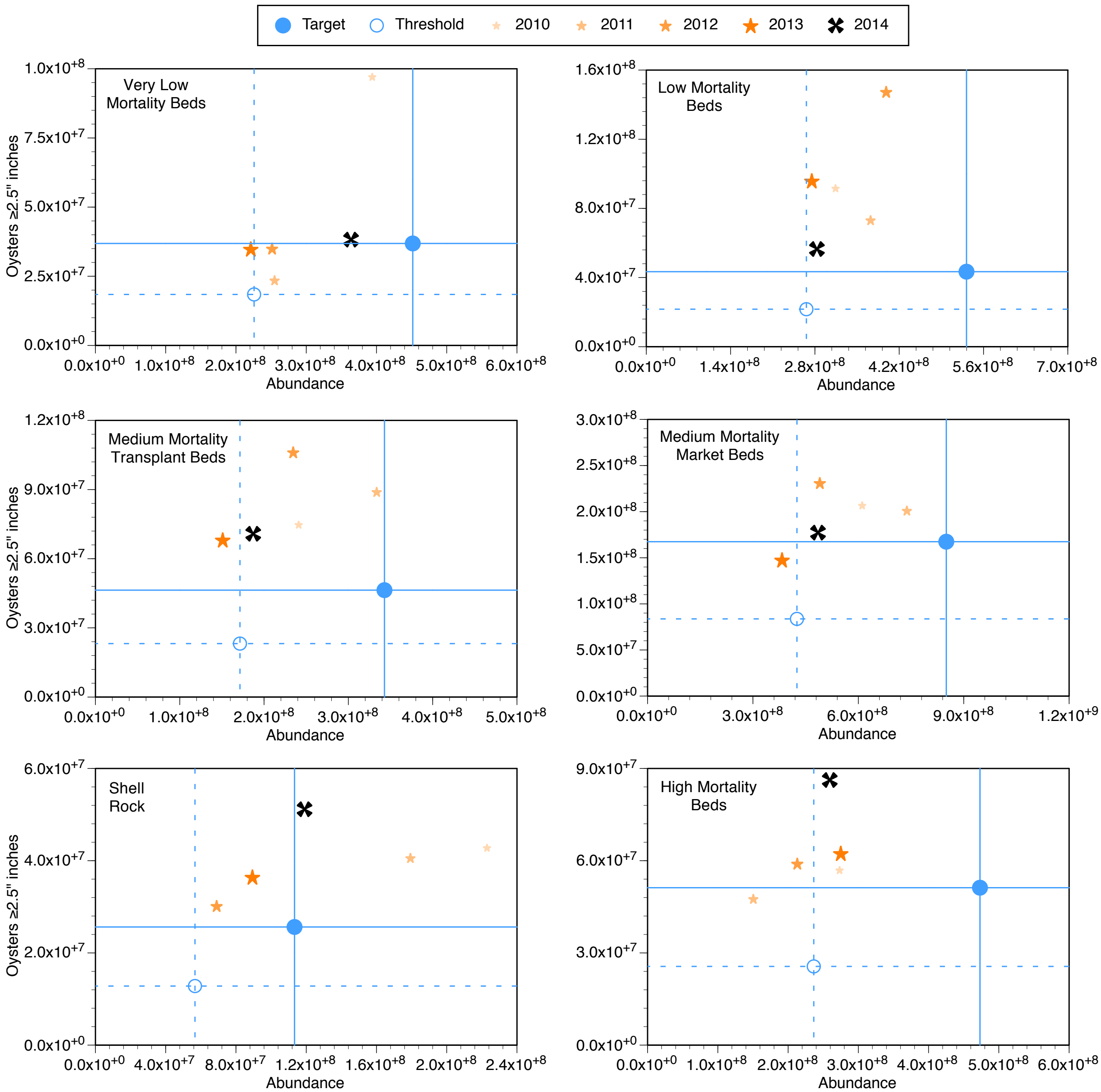


Figure 30. Position of the oyster stock in 2010–2014 with respect to regional abundance and market abundance (>2.5") targets and thresholds. The target is taken as the median of abundance or biomass from the 1989–2005 (1990–2005) time period. The threshold is taken as half these values. Reference points and their derivation are described in previous SAW documents.



Appendix A.1.1. Oyster abundance percentiles by region for time series 1953 to 2014. A series of nineteen percentile rankings are listed with their associated values and years. The specific 2014 abundance and percentile are listed at the bottom of the table. Very Low Mortality region not included due to short time series.

	Low Mortality		Medium Market Transplant		Medium Mortality Market		Shell Rock		High Mortality	
Percentile	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**
0.010	237,916,320	2004	91,298,272	1954	145,748,384	1956	9,921,834	1966	52,775,628	1958
0.050	255,534,784	1953	108,248,624	1953	198,548,640	1954	15,174,016	1963	102,289,104	1957
0.075	274,844,160	2013	150,633,056	2005	244,122,992	2009	33,389,004	1962	127,300,728	2008
0.100	281,326,400	2005	150,962,688	2013	284,364,160	2005	37,696,080	1956	137,972,672	1956
0.175	368,562,720	2009	218,406,944	2004	341,445,664	1985	54,915,568	2005	165,519,616	1964
0.250	437,471,872	2000	234,555,392	2012	382,799,648	2013	72,775,800	2002	228,017,488	1962
0.333	531,733,632	2002	243,265,376	2006	485,193,760	2014	85,542,888	1985	262,343,184	1993
0.375	572,249,408	2007	247,806,304	1964	490,317,504	2012	91,173,600	2006	274,992,096	2013
0.400	709,416,064	1960	333,580,032	2011	533,469,504	1961	104,536,544	2003	295,021,120	1986
0.500	942,695,424	1986	434,782,720	1970	698,780,672	1963	141,325,136	1968	424,087,584	2000
0.600	1,280,827,904	1955	513,501,376	1960	910,148,224	1989	178,324,512	1997	521,057,184	1965
0.625	1,405,871,104	1966	534,575,968	1997	982,767,104	1965	202,546,656	2000	567,168,384	1998
0.667	1,612,862,720	1965	547,977,344	1988	1,240,766,976	2002	225,737,056	1953	593,430,976	1990
0.750	2,043,206,016	1975	802,518,592	1957	1,497,996,288	1976	351,168,288	1981	1,181,666,432	1978
0.825	2,715,509,504	1983	1,032,760,128	1982	2,184,624,128	1981	413,561,152	1988	2,323,405,824	1976
0.900	3,979,418,112	1984	1,389,563,264	1984	2,501,338,880	1983	630,680,320	1976	3,705,328,384	1983
0.925	4,222,648,832	1982	1,625,613,696	1977	2,902,873,088	2000	646,462,080	1983	3,783,403,264	1979
0.950	4,715,567,616	1974	1,693,260,800	1981	3,657,399,552	1975	709,579,456	1979	4,746,431,488	1980
0.990	6,873,945,600	1970	4,562,212,864	1974	8,380,359,168	1974	983,651,072	1984	15,323,396,096	1974
2014 value:	**283,347,520**	**0.105**	**187,152,032**	**0.137**	**485,193,760**	**0.331**	**119,051,824**	**0.444**	**259,337,168**	**0.282**

Appendix A.1.2. Box-count mortality fraction percentiles by region for time series 1953 to 2014. A series of nineteen percentile rankings are listed with their associated values and years. The specific 2014 mortality fraction and percentile are listed at the bottom of the table. Very Low Mortality region not included due to short time series.

	Low Mortality		Medium Mortality Transplant		Medium Mortality Market		Shell Rock		High Mortality	
Percentile	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**
0.010	0.02015	1969	0.03880	1973	0.04148	1973	0.02566	1973	0.03040	1954
0.050	0.04619	1970	0.04543	1967	0.05134	1967	0.04591	1984	0.03992	1973
0.075	0.04975	1959	0.06493	1984	0.06637	1974	0.04808	1983	0.04511	1972
0.100	0.05053	1979	0.06718	1969	0.06908	1990	0.05047	1974	0.05923	1989
0.175	0.06050	2003	0.07806	1964	0.08389	1984	0.06178	1972	0.09688	1969
0.250	0.06712	1991	0.08212	1977	0.09174	1982	0.06899	1971	0.10878	1968
0.333	0.07574	1994	0.09290	1962	0.10716	1996	0.08974	1977	0.12069	1990
0.375	0.07649	1967	0.09407	1954	0.10869	2005	0.09352	1957	0.12812	1976
0.400	0.07748	1984	0.09618	1988	0.10975	1964	0.09869	2000	0.14457	1963
0.500	0.10012	1977	0.11242	1998	0.12427	1954	0.11661	2011	0.17534	1981
0.600	0.11384	1962	0.15073	2011	0.15751	2006	0.18170	2006	0.21242	2006
0.625	0.11833	1997	0.15148	2006	0.16698	1980	0.18721	1997	0.21629	2010
0.667	0.12066	1998	0.15374	1972	0.17171	1976	0.20348	1998	0.22055	2008
0.750	0.12834	1996	0.17108	1966	0.21339	2007	0.24283	2013	0.26176	2003
0.825	0.15540	1999	0.20887	2010	0.23492	1992	0.29877	2002	0.32799	2001
0.900	0.17597	2010	0.22259	2009	0.26732	1999	0.36147	1993	0.37494	1966
0.925	0.19646	1961	0.22673	1993	0.29622	1993	0.36980	1986	0.40197	1991
0.950	0.21286	2011	0.30899	1986	0.34412	1995	0.37861	1995	0.46011	1999
0.990	0.26397	1985	0.34611	1958	0.45355	1958	0.48086	1958	0.49404	1993
2014 value:	**0.12079**	**0.669**	**0.14750**	**0.556**	**0.18117**	**0.702**	**0.18256**	**0.605**	**0.14645**	**0.411**

Appendix A.1.3. Spat abundance percentiles by region for time series 1953 to 2014. A series of nineteen percentile rankings are listed with their associated values and years. The specific 2014 abundance and percentile are listed at the bottom of the table. Very Low Mortality region not included due to short time series.

	Low Mortality		Medium Mortality Transplant		Medium Mortality Market		Shell Rock		High Mortality	
Percentile	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**
0.010	6,341,157	1960	13,681,472	2014	29,888,468	2008	1,703,357	1965	17,708,886	1967
0.050	11,363,625	2004	22,412,662	2001	46,311,040	1960	8,722,600	1962	46,869,924	1965
0.075	23,646,302	1967	26,632,780	1960	59,242,884	2005	9,977,323	2014	67,711,152	1961
0.100	23,861,040	1965	29,466,212	2008	59,979,928	2003	15,724,439	1959	79,922,560	2006
0.175	51,235,388	1953	49,475,284	1993	93,091,728	1992	25,469,068	2005	99,443,856	1954
0.250	58,364,900	2006	80,776,208	1954	135,183,904	1961	31,310,548	2001	136,946,464	2001
0.333	93,936,536	1985	112,978,200	1985	170,948,416	1975	45,880,176	2013	185,739,984	1962
0.375	97,347,232	1997	122,342,464	1953	200,304,672	2011	55,280,284	1957	267,413,264	1975
0.400	110,290,208	1992	154,711,856	2009	284,657,440	1985	63,369,676	1953	329,963,168	2009
0.500	233,100,064	2010	233,567,328	2010	400,527,488	1963	96,241,536	1995	437,461,408	1966
0.600	398,030,304	1959	302,068,640	1976	474,764,736	1956	144,260,016	2012	623,761,920	1958
0.625	417,962,272	1956	365,781,312	1963	506,564,672	2000	153,135,088	1954	688,753,984	1986
0.667	539,021,952	1957	382,997,312	2002	566,856,960	1968	164,263,840	1997	716,324,736	1990
0.750	1,201,413,376	1991	526,262,080	1979	887,463,168	1987	298,899,776	1980	1,210,906,880	1991
0.825	1,808,630,528	1964	619,830,464	1964	1,471,366,144	1982	341,779,712	1987	1,742,377,728	1997
0.900	2,797,787,392	1970	926,909,696	1986	1,865,199,744	1999	646,666,816	1974	2,854,077,696	1978
0.925	2,925,273,600	1980	1,023,230,784	1982	2,536,044,032	1998	676,622,464	1977	3,733,231,616	1979
0.950	3,662,710,784	1966	1,405,040,896	1998	3,013,447,168	1970	870,054,912	1982	7,956,775,936	1973
0.990	5,468,880,896	1973	5,117,212,672	1973	5,262,717,952	1973	934,372,864	1970	12,650,579,968	1972
2014 value:	**38,164,096**	**0.137**	**13,681,472**	**0.000**	**52,294,904**	**0.056**	**9,977,323**	**0.073**	**94,607,768**	**0.137**

Appendix A.2.1. Oyster abundance percentiles by region for time series 1990 to 2014. A series of nineteen percentile rankings are listed with their associated values and years. The specific 2014 abundance and percentile are listed at the bottom of the table. Very Low Mortality region not included due to short time series.

	Low Mortality		Medium Mortality Transplant		Medium Mortality Market		Shell Rock		High Mortality	
Percentiles	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**
0.010	237,916,320	2004	145,363,376	2007	244,122,992	2009	42,383,560	2004	95,126,112	2004
0.050	237,916,320	2004	145,363,376	2007	244,122,992	2009	42,383,560	2004	95,126,112	2004
0.075	245,842,144	2008	150,633,056	2005	284,364,160	2005	51,738,080	1995	107,598,616	2003
0.100	270,634,016	2003	150,962,688	2013	339,590,432	2004	54,915,568	2005	127,300,728	2008
0.175	274,844,160	2013	187,152,032	2014	346,025,664	1994	69,002,768	2012	146,845,072	2005
0.250	283,347,520	2014	218,911,328	2009	370,523,424	2003	74,563,648	1993	155,621,056	2009
0.333	314,266,336	2010	234,555,392	2012	395,401,024	2007	79,357,816	2009	175,445,104	2002
0.375	368,562,720	2009	236,538,736	2008	412,485,312	1991	89,366,576	2013	189,821,888	2006
0.400	372,442,688	2011	236,620,112	2003	461,717,952	1995	91,173,600	2006	213,086,624	2012
0.500	437,471,872	2000	245,988,704	1995	490,803,392	1993	113,350,896	1992	273,254,656	2010
0.600	478,929,760	1999	333,580,032	2011	610,863,680	2010	124,301,552	1991	311,607,232	2001
0.625	487,858,176	1997	336,872,768	1990	711,248,640	1990	139,671,408	1998	367,911,520	1991
0.667	531,733,632	2002	339,891,072	1993	738,065,920	2011	143,028,480	2001	424,087,584	2000
0.750	665,109,696	2001	412,552,544	2001	979,248,064	1992	165,416,256	2008	477,558,656	1999
0.825	833,761,792	1995	526,736,192	2002	1,240,766,976	2002	179,320,464	2011	567,168,384	1998
0.900	1,124,952,448	1993	738,808,192	2000	1,300,023,808	2001	222,922,688	2010	593,430,976	1990
0.925	1,124,952,448	1993	738,808,192	2000	1,300,023,808	2001	222,922,688	2010	593,430,976	1990
0.950	1,175,295,360	1992	838,818,816	1998	1,325,916,800	1998	325,637,952	1990	660,948,672	1995
0.990	1,740,885,760	1991	839,637,632	1996	2,902,873,088	2000	327,349,216	1996	930,663,488	1996
2014 value:	**283,347,520**	**0.220**	**187,152,032**	**0.140**	**485,193,760**	**0.420**	**119,051,824**	**0.540**	**259,337,168**	**0.420**

Appendix A.2.2. Box-Count mortality percentiles by region for time series 1990 to 2014. A series of nineteen percentile rankings are listed with their associated values and years. The specific 2014 mortality fraction and percentile are listed at the bottom of the table. Very Low Mortality region not included due to short time series.

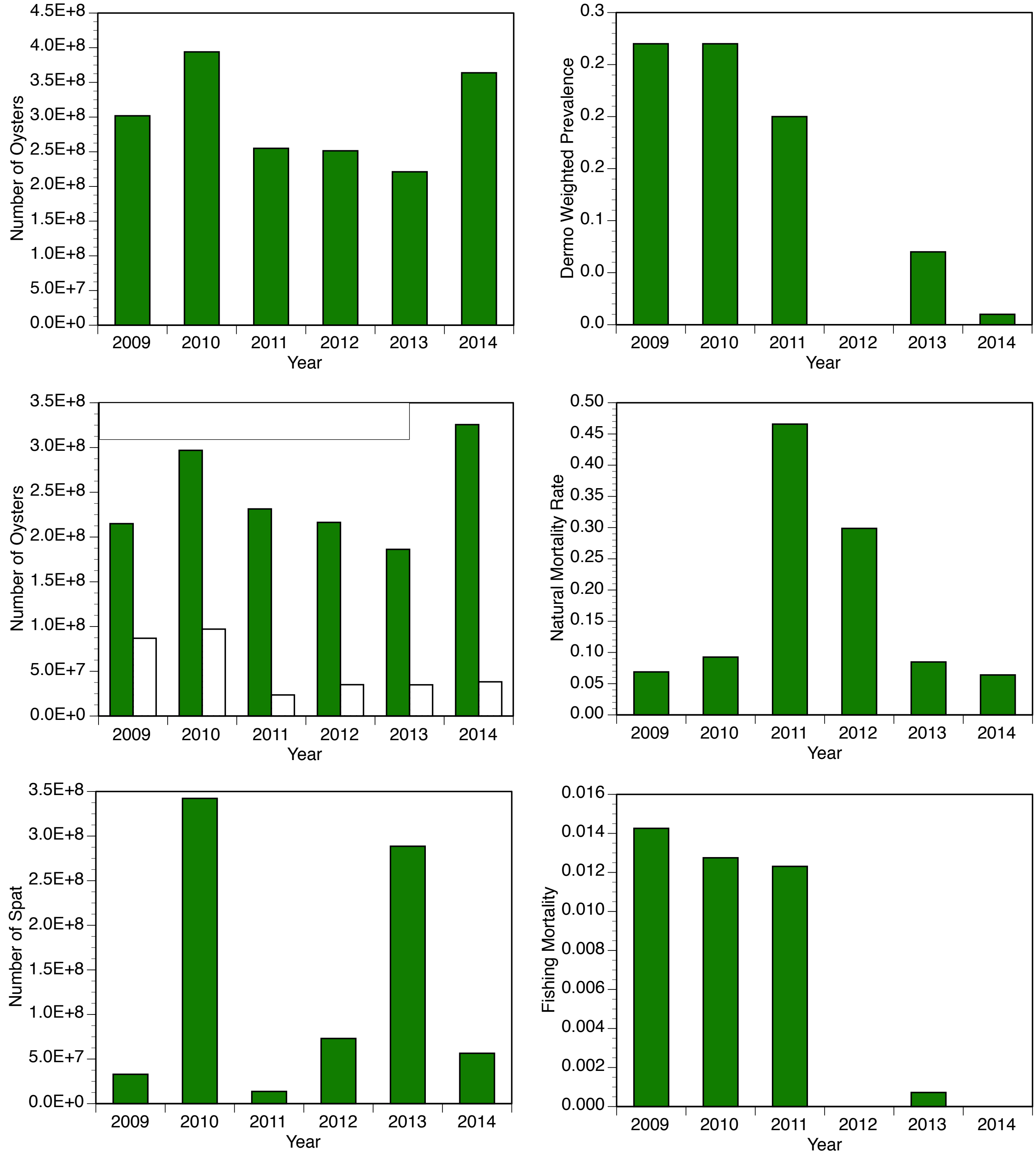
	Low Mortality		Medium Mortality Transplant		Medium Mortality Market		Shell Rock		High Mortality	
Percentile	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**
0.010	0.05551	2000	0.05750	1990	0.06908	1990	0.07670	1990	0.12069	1990
0.050	0.05551	2000	0.05750	1990	0.06908	1990	0.07670	1990	0.12069	1990
0.075	0.06050	2003	0.07924	1996	0.08414	2001	0.09478	2003	0.14645	2014
0.100	0.06208	2006	0.08160	2000	0.09274	2000	0.09869	2000	0.15964	2005
0.175	0.06556	2007	0.09246	2003	0.10716	1996	0.09919	2005	0.17063	1996
0.250	0.06895	2002	0.09528	2001	0.12112	2003	0.10651	2010	0.19363	2004
0.333	0.07574	1994	0.10787	2004	0.13533	2011	0.11661	2011	0.21362	2012
0.375	0.08264	1990	0.11242	1998	0.14503	1997	0.17219	2004	0.21629	2010
0.400	0.09336	2008	0.14750	2014	0.15751	2006	0.18170	2006	0.22055	2008
0.500	0.11833	1997	0.16410	1991	0.20152	2010	0.19393	2008	0.24815	2000
0.600	0.12066	1998	0.19632	2007	0.21339	2007	0.21657	1991	0.26176	2003
0.625	0.12079	2014	0.19854	1999	0.21474	2008	0.22539	2009	0.27575	2009
0.667	0.12126	2012	0.20887	2010	0.22936	2013	0.22684	1994	0.29903	2007
0.750	0.12777	2005	0.21632	1994	0.23492	1992	0.24530	2007	0.33110	1998
0.825	0.13384	2009	0.22236	2008	0.25801	2012	0.29877	2002	0.35892	1995
0.900	0.16109	1995	0.22673	1993	0.26732	1999	0.34845	1999	0.44257	2002
0.925	0.16109	1995	0.22673	1993	0.26732	1999	0.34845	1999	0.44257	2002
0.950	0.17597	2010	0.24783	2013	0.29622	1993	0.36147	1993	0.46011	1999
0.990	0.21286	2011	0.32394	1995	0.34412	1995	0.37861	1995	0.49404	1993
2014 value:	**0.12079**	**0.620**	**0.14750**	**0.380**	**0.18117**	**0.460**	**0.18256**	**0.420**	**0.14645**	**0.060**

Appendix A.2.3. Spat abundance percentiles by region for time series 1990 to 2014. A series of nineteen percentile rankings are listed with their associated values and years. The specific 2014 abundance and percentile are listed at the bottom of the table. Very Low Mortality region not included due to short time series.

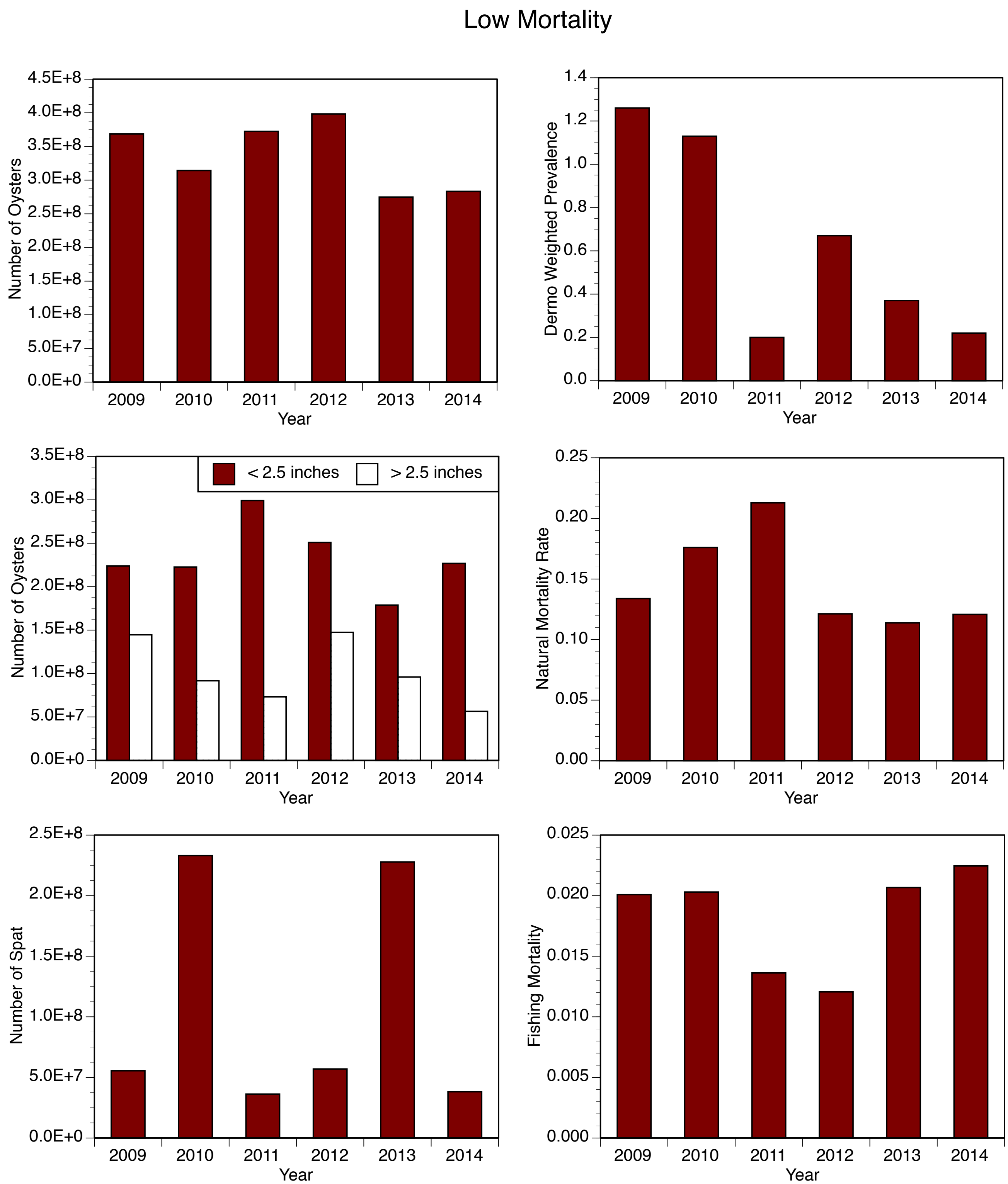
	Low Mortality		Medium Mortality Transplant		Medium Mortality Market		Shell Rock		High Mortality	
Percentile	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**
0.010	11,363,625	2004	13,681,472	2014	29,888,468	2008	9,977,323	2014	79,922,560	2006
0.050	11,363,625	2004	13,681,472	2014	29,888,468	2008	9,977,323	2014	79,922,560	2006
0.075	14,639,332	2003	22,412,662	2001	52,294,904	2014	18,908,832	1992	94,607,768	2014
0.100	36,068,292	2001	25,634,464	2005	59,242,884	2005	25,469,068	2005	96,881,712	2005
0.175	36,242,520	2011	29,466,212	2008	59,979,928	2003	29,374,136	2006	109,884,808	2008
0.250	52,443,872	1993	38,901,004	1992	93,091,728	1992	31,310,548	2001	126,761,728	1992
0.333	55,501,020	2009	49,475,284	1993	106,790,304	1996	40,145,840	2003	137,229,568	2003
0.375	56,968,308	2012	53,180,272	2011	111,771,848	2001	40,641,564	2011	150,439,952	2002
0.400	58,364,900	2006	96,108,992	2006	161,645,392	2009	45,880,176	2013	170,662,384	1993
0.500	88,436,944	2005	114,071,680	2007	287,379,552	2013	83,121,872	2008	401,858,624	2007
0.600	108,328,448	2002	154,711,856	2009	382,557,120	2012	144,260,016	2012	457,118,016	2000
0.625	110,290,208	1992	169,154,880	1990	433,925,536	2002	150,118,416	2009	470,277,568	2011
0.667	171,914,608	1995	201,046,816	2000	452,254,144	1994	160,198,048	2000	554,233,280	2013
0.750	184,130,704	1994	251,510,784	1994	466,530,048	1995	178,316,512	1990	954,389,632	1995
0.825	233,100,064	2010	257,649,104	1995	506,564,672	2000	229,115,200	1998	1,148,528,128	1998
0.900	280,419,712	1999	382,997,312	2002	757,701,632	1997	304,936,384	2010	1,495,149,568	2012
0.925	280,419,712	1999	382,997,312	2002	757,701,632	1997	304,936,384	2010	1,495,149,568	2012
0.950	436,561,664	1990	422,550,432	1999	1,865,199,744	1999	334,068,096	2002	1,742,377,728	1997
0.990	1,201,413,376	1991	1,405,040,896	1998	2,536,044,032	1998	426,902,528	1999	2,166,027,008	1999
2014 value:	**38,164,096**	**0.180**	**13,681,472**	**0.000**	**52,294,904**	**0.060**	**9,977,323**	**0.000**	**94,607,768**	**0.060**

Appendix B.1. Region Trends. Six-year time series summary for the Very Low Mortality region. Left panels show total abundance (excluding spat), abundance by size class (excluding spat), and spat abundance (= oysters < 20 mm). Right panels show Dermo levels, natural mortality rate and fishing mortality rate.

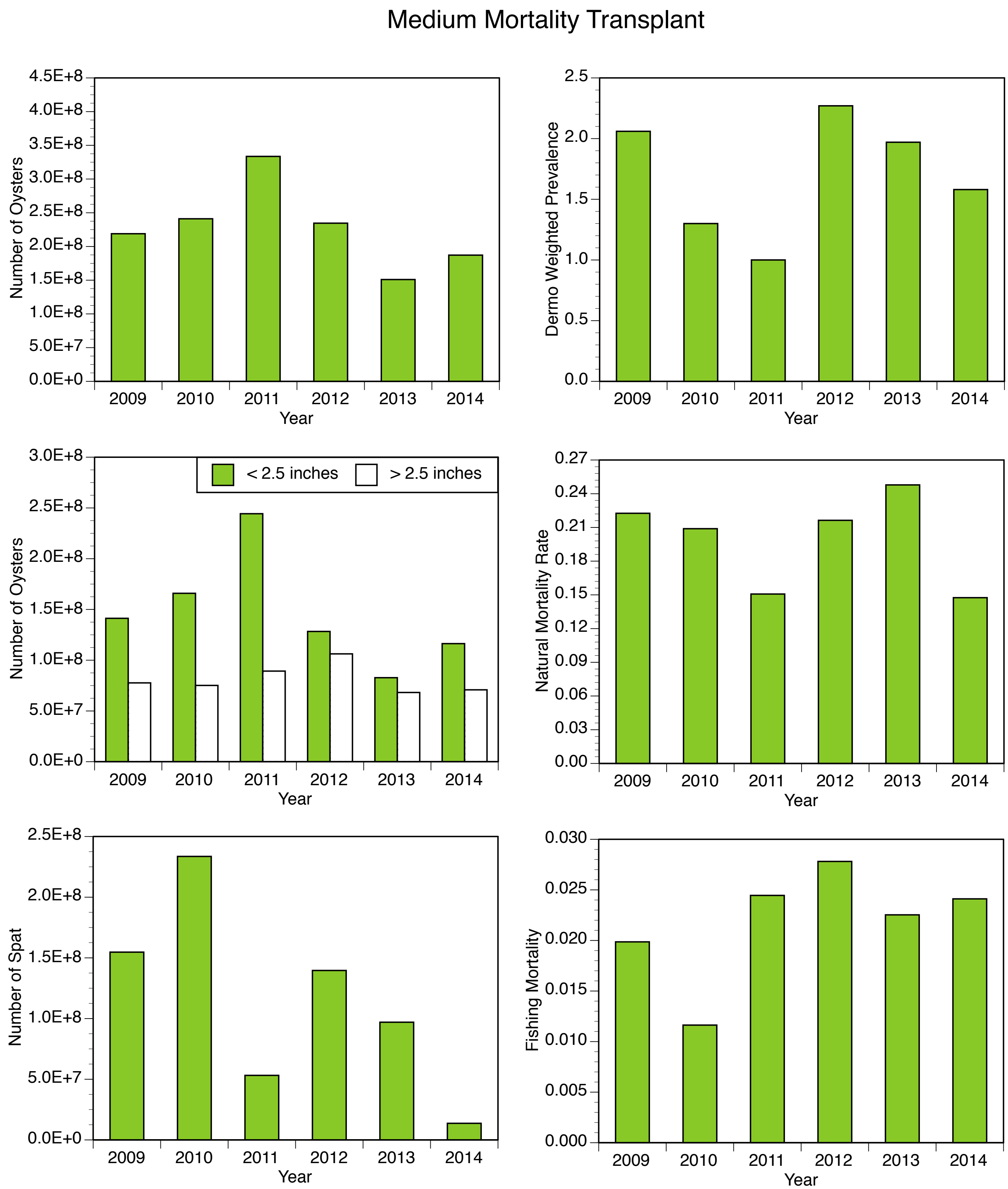
Very Low Mortality



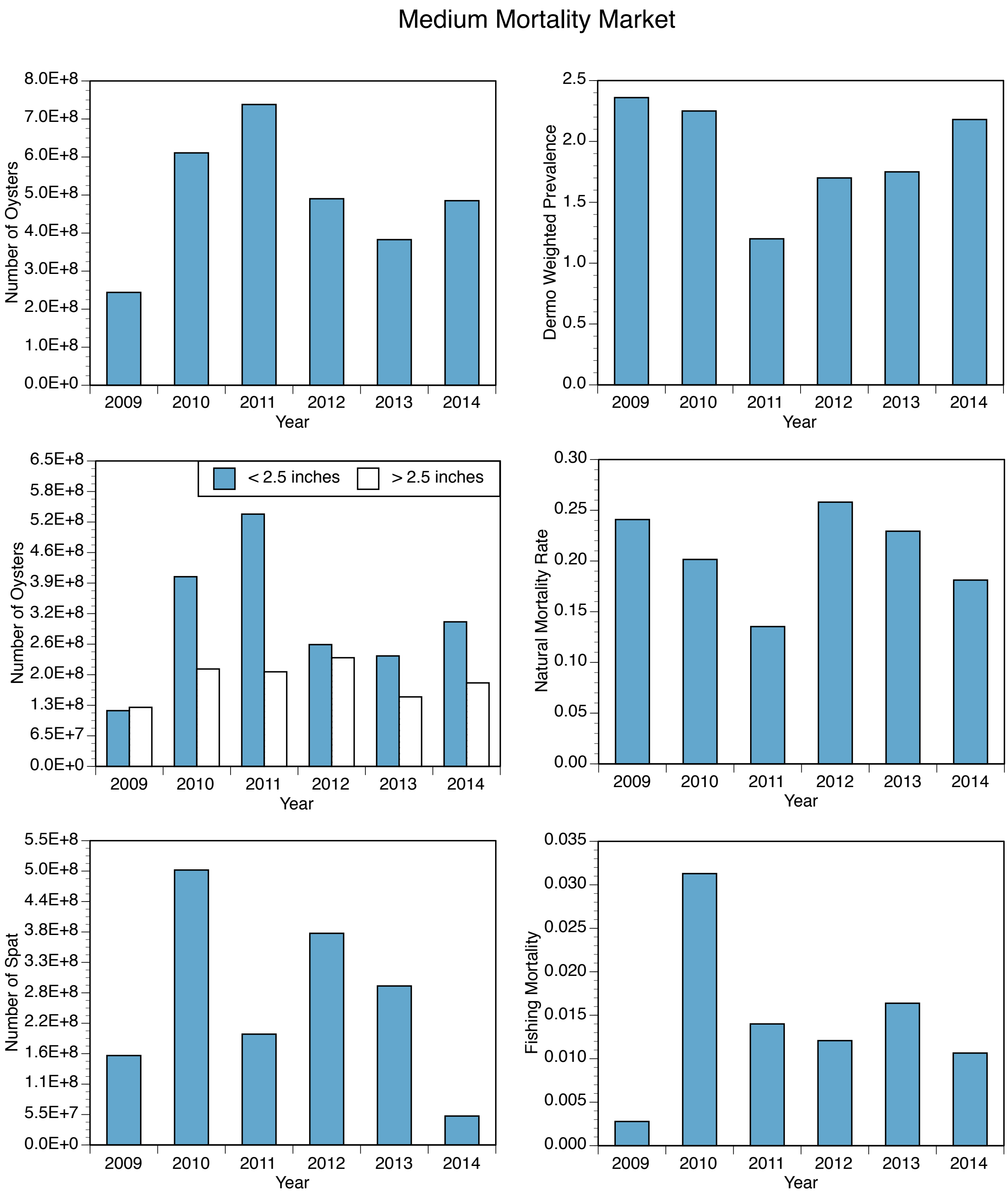
Appendix B.2. Region Trends. Six-year time series summary for the Low Mortality region. Left panels show total abundance (excluding spat), abundance by size class (excluding spat), and spat abundance (= oysters < 20 mm). Right panels show Dermo levels, natural mortality rate and fishing mortality rate.



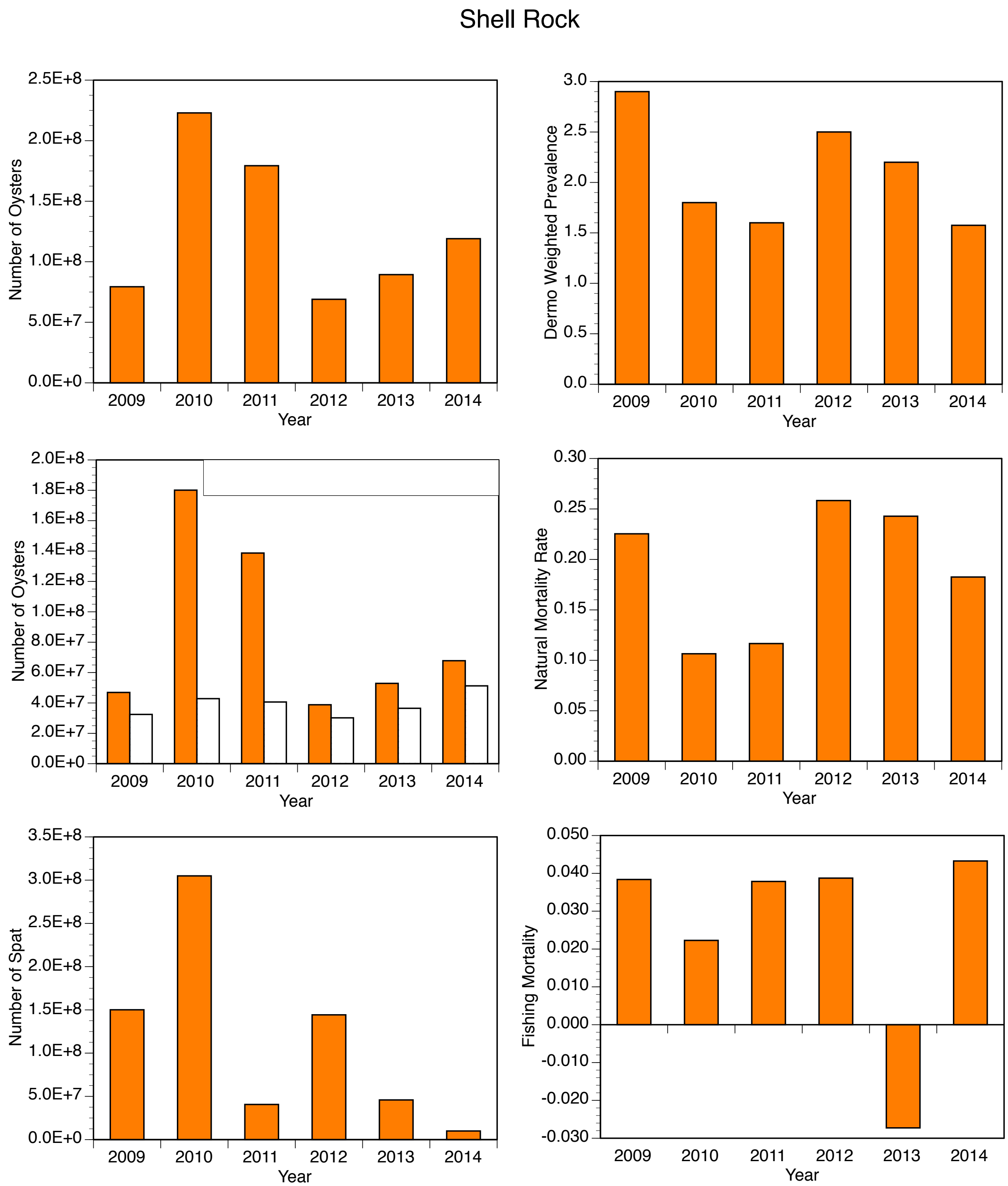
Appendix B.3. Region Trends. Six-year time series summary for the Medium Mortality Transplant region. Left panels show total abundance (excluding spat), abundance by size class (excluding spat), and spat abundance (= oysters < 20 mm). Right panels show Dermo levels, natural mortality rate and fishing mortality rate.



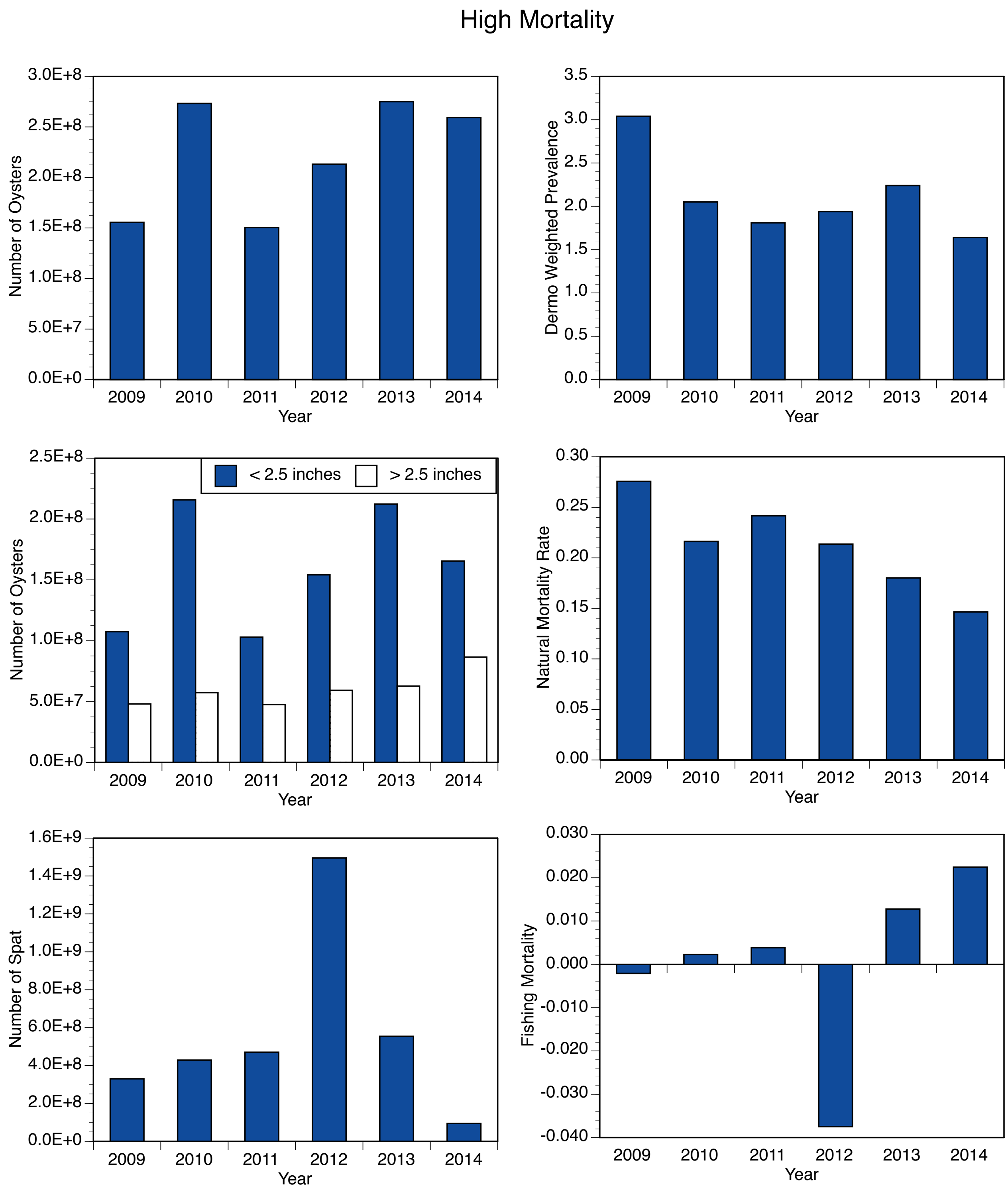
Appendix B.4. Region Trends. Six-year time series summary for the Medium Mortality Market region. Left panels show total abundance (excluding spat), abundance by size class (excluding spat), and spat abundance (= oysters < 20 mm). Right panels show Dermo levels, natural mortality rate and fishing mortality rate.



Appendix B.5. Region Trends. Six-year time series summary for the Shell Rock region. Left panels show total abundance (excluding spat), abundance by size class (excluding spat), and spat abundance (= oysters < 20 mm). Right panels show Dermo levels, natural mortality rate and fishing mortality rate.



Appendix B.6. Region Trends. Six-year time series summary for the High Mortality region. Left panels show total abundance (excluding spat), abundance by size class (excluding spat), and spat abundance (= oysters < 20 mm). Right panels show Dermo levels, natural mortality rate and fishing mortality rate.



Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2

Appendix C. Density data by sampled grid from Fall surveys (stock assessment) and Spring resurveys (bed stratification) for 2012-2014. Data year indicates the year with which survey sample data is associated, eg. Spring resurvey data are biologically closer to the previous Fall survey data. In cases where a grid is sampled in both Spring and Fall, the Fall survey data is used. Grids that were sampled in the Fall survey are in bold. Stratum to which a grid is assigned: 1= High; 2= Medium; 3= Low; 4= Enhanced. Enhanced grids are those that have received transplants in the current year or shellplants in the current or preceding two years. Each bed gets fully surveyed (all grids sampled) once a decade so grid stratum designations may change over time (see report text). The Fall survey does not sample grids designated in the Low stratum (see report text). The data are arranged by year from upbay to downbay and highest to lowest oyster per m^2 within each bed.

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2012	Oct-12	VLM	Hope Creek	**43**	2	99.683	45.364	15.495
2012	Oct-12	VLM	Hope Creek	**64**	1	91.066	24.466	14.565
2012	Oct-12	VLM	Hope Creek	**54**	2	75.528	19.257	19.034
2012	Oct-12	VLM	Hope Creek	**75**	1	71.899	16.377	10.101
2012	Oct-12	VLM	Hope Creek	**61**	1	68.872	16.601	9.040
2012	Oct-12	VLM	Hope Creek	**59**	4	57.387	19.860	4.998
2012	Oct-12	VLM	Hope Creek	**63**	1	57.046	20.322	9.753
2012	Oct-12	VLM	Hope Creek	**65**	2	49.072	16.248	7.572
2012	Oct-12	VLM	Hope Creek	**86**	2	34.702	6.139	7.467
2012	Oct-12	VLM	Liston Range	**18**	2	100.675	16.916	5.798
2012	Oct-12	VLM	Liston Range	**24**	1	98.488	22.680	5.701
2012	Oct-12	VLM	Liston Range	**2**	2	4.296	1.560	0.812
2012	Oct-12	VLM	Liston Range	**22**	2	3.704	1.761	0.291
2012	Oct-12	VLM	Liston Range	**23**	2	2.135	0.577	0.462
2012	Oct-12	VLM	Liston Range	**21**	1	0.056	0	0.146
2012	Oct-12	VLM	Fishing Creek	**25**	1	74.525	9.465	7.542
2012	Oct-12	VLM	Fishing Creek	**16**	1	14.093	1.829	3.821
2012	Oct-12	VLM	Fishing Creek	**36**	2	13.960	2.053	3.811
2012	Oct-12	VLM	Fishing Creek	**8**	2	2.461	0.340	0.534
2012	Oct-12	VLM	Fishing Creek	**43**	2	1.832	0.186	1.963
2012	Oct-12	LM	Round Island	**11**	1	112.578	17.428	19.932
2012	Oct-12	LM	Round Island	**2**	2	94.376	19.514	6.263
2012	Oct-12	LM	Round Island	**12**	1	90.171	5.128	12.109
2012	Oct-12	LM	Round Island	**27**	2	20.331	2.771	1.767
2012	Oct-12	LM	Round Island	**68**	2	2.502	0.063	0.281
2012	May-13	LM	Upper Arnolds	11	2	202.528	18.118	8.710
2012	Oct-12	LM	Upper Arnolds	**10**	1	158.164	30.671	13.273
2012	Oct-12	LM	Upper Arnolds	**16**	2	156.994	26.745	13.166
2012	May-13	LM	Upper Arnolds	3	2	146.995	25.144	20.970
2012	May-13	LM	Upper Arnolds	5	1	107.663	4.989	6.287
2012	Oct-12	LM	Upper Arnolds	**18**	1	105.235	7.748	9.525
2012	May-13	LM	Upper Arnolds	6	2	91.513	6.761	4.324
2012	May-13	LM	Upper Arnolds	22	2	87.865	10.508	22.356
2012	May-13	LM	Upper Arnolds	4	1	87.660	8.149	6.739
2012	May-13	LM	Upper Arnolds	17	3	61.445	6.656	5.172
2012	May-13	LM	Upper Arnolds	9	2	60.585	13.078	18.448
2012	May-13	LM	Upper Arnolds	25	1	53.300	4.689	5.148
2012	Oct-12	LM	Upper Arnolds	**2**	2	50.432	18.796	28.994
2012	Oct-12	LM	Upper Arnolds	**12**	2	44.730	7.550	3.870
2012	May-13	LM	Upper Arnolds	15	2	41.365	1.786	7.112
2012	May-13	LM	Upper Arnolds	14	2	39.289	3.012	9.437
2012	May-13	LM	Upper Arnolds	13	2	26.181	1.196	4.958
2012	May-13	LM	Upper Arnolds	8	2	14.052	4.197	2.605
2012	May-13	LM	Upper Arnolds	7	3	2.272	0.039	0.249
2012	May-13	LM	Upper Arnolds	21	2	1.305	0.085	0.070
2012	May-13	LM	Upper Arnolds	29	3	0.908	0.379	0.492
2012	May-13	LM	Upper Arnolds	23	3	0.611	0	0.070
2012	May-13	LM	Upper Arnolds	19	3	0.134	0	0.073
2012	May-13	LM	Upper Arnolds	20	3	0.089	0.084	0.301
2012	May-13	LM	Upper Arnolds	26	3	0.047	0	0.010
2012	May-13	LM	Upper Arnolds	1	3	0	0	0.071
2012	May-13	LM	Upper Arnolds	24	3	0	0	0.098
2012	May-13	LM	Upper Arnolds	27	3	0	0	0
2012	May-13	LM	Upper Arnolds	28	3	0	0	0.001
2012	Oct-12	LM	Arnolds	**7**	1	149.686	22.770	6.909
2012	Oct-12	LM	Arnolds	**16**	1	112.908	19.631	4.304

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2012	Oct-12	LM	Arnolds	**17**	1	100.883	11.959	6.095
2012	Oct-12	LM	Arnolds	**27**	2	80.153	12.410	9.372
2012	Oct-12	LM	Arnolds	**3**	2	5.843	0.370	2.539
2012	Oct-12	LM	Arnolds	**2**	2	2.959	0.778	2.390
2012	Oct-12	MMT	Upper Middle	**63**	2	79.150	26.471	9.527
2012	Oct-12	MMT	Upper Middle	**1**	2	77.474	4.039	12.743
2012	Oct-12	MMT	Upper Middle	**58**	1	73.834	3.427	14.265
2012	Oct-12	MMT	Upper Middle	**71**	2	45.329	4.691	9.494
2012	Nov-12	MMT	Middle	**35**	1	93.098	78.263	6.860
2012	Nov-12	MMT	Middle	**34**	1	91.671	108.246	6.069
2012	Nov-12	MMT	Middle	**28**	1	71.909	70.513	5.037
2012	Nov-12	MMT	Middle	**43**	2	24.931	12.881	6.785
2012	Nov-12	MMT	Middle	**26**	4	21.110	32.150	2.856
2012	Oct-12	MMT	Middle	**32**	2	13.275	3.996	5.587
2012	Nov-12	MMT	Middle	**17**	2	5.752	2.131	1.065
2012	Nov-12	MMT	Middle	**51**	2	5.527	2.011	2.345
2012	Nov-12	MMT	Sea Breeze	14	1	67.620	40.121	6.249
2012	Nov-12	MMT	Sea Breeze	37	2	53.202	42.821	2.452
2012	Nov-12	MMT	Sea Breeze	20	2	39.652	16.583	3.844
2012	Nov-12	MMT	Sea Breeze	29	2	34.586	33.634	2.908
2012	Nov-12	MMT	Sea Breeze	15	1	32.418	19.018	1.751
2012	Nov-12	MMT	Sea Breeze	31	1	16.663	11.719	1.481
2012	Nov-12	MMT	Sea Breeze	46	2	1.193	1.286	0.438
2012	Nov-12	MMM	Ship John	14	2	99.371	58.772	7.046
2012	Nov-12	MMM	Ship John	39	1	84.451	83.631	6.060
2012	Nov-12	MMM	Ship John	23	1	70.200	66.360	6.584
2012	Nov-12	MMM	Ship John	38	2	64.315	48.279	6.671
2012	Nov-12	MMM	Ship John	21	1	61.746	60.799	3.674
2012	Nov-12	MMM	Ship John	25	1	59.319	66.641	2.100
2012	Nov-12	MMM	Ship John	24	2	46.859	58.121	6.362
2012	Nov-12	MMM	Ship John	9	1	41.209	48.953	3.354
2012	Nov-12	MMM	Ship John	29	1	29.366	35.946	2.314
2012	Nov-12	MMM	Ship John	53	4	26.968	28.682	2.074
2012	Nov-12	MMM	Ship John	35	2	19.251	13.786	6.239
2012	Nov-12	MMM	Ship John	49	2	19.015	12.433	3.054
2012	Nov-12	MMM	Ship John	36	4	16.237	20.611	5.029
2012	Nov-12	MMM	Cohansey	**25**	1	94.234	28.033	8.701
2012	Nov-12	MMM	Cohansey	**8**	2	76.202	25.541	6.677
2012	Nov-12	MMM	Cohansey	**56**	2	64.430	53.676	4.341
2012	Nov-12	MMM	Cohansey	**44**	1	61.195	44.969	1.701
2012	Nov-12	MMM	Cohansey	**54**	1	55.232	91.918	7.106
2012	Nov-12	MMM	Cohansey	**20**	1	47.214	47.288	4.974
2012	Nov-12	MMM	Cohansey	**4**	2	40.400	29.048	14.212
2012	Nov-12	MMM	Cohansey	**35**	2	36.148	19.043	9.997
2012	Nov-12	MMM	Cohansey	**57**	1	13.825	7.846	3.661
2012	Nov-12	MMM	Cohansey	**32**	2	13.747	19.497	8.326
2012	Nov-12	SR	Shell Rock	20	1	55.233	148.813	2.925
2012	Nov-12	SR	Shell Rock	11	4	29.282	37.178	1.599
2012	Nov-12	SR	Shell Rock	90	2	19.050	23.576	1.118
2012	Nov-12	SR	Shell Rock	23	4	18.190	30.294	0.686
2012	Nov-12	SR	Shell Rock	44	2	15.705	51.608	1.692
2012	Nov-12	SR	Shell Rock	1	1	13.720	19.071	1.532
2012	Nov-12	SR	Shell Rock	46	2	13.579	29.963	2.561
2012	Nov-12	SR	Shell Rock	35	2	12.222	20.097	0.467
2012	Nov-12	SR	Shell Rock	45	2	7.901	12.320	1.017
2012	Nov-12	SR	Shell Rock	62	1	6.866	13.834	0.657

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2012	Nov-12	SR	Shell Rock	9	1	6.549	14.686	0.870
2012	Nov-12	SR	Shell Rock	7	2	6.533	12.261	0.449
2012	Nov-12	HM	Benny Sand	**7**	1	29.872	57.598	4.535
2012	Nov-12	HM	Benny Sand	**6**	2	28.316	68.223	6.568
2012	Nov-12	HM	Benny Sand	**4**	4	16.608	36.319	0.707
2012	Nov-12	HM	Benny Sand	**11**	4	16.524	23.082	2.834
2012	Nov-12	HM	Benny Sand	**12**	4	16.515	65.032	2.039
2012	Nov-12	HM	Benny Sand	**13**	2	13.844	52.196	3.818
2012	Nov-12	HM	Benny Sand	**8**	1	11.991	29.264	1.300
2012	Nov-12	HM	Benny Sand	**15**	2	11.902	34.104	0.889
2012	Nov-12	HM	Benny Sand	**5**	2	11.816	29.770	5.881
2012	Nov-12	HM	Benny Sand	**20**	2	6.896	17.884	4.504
2012	Nov-12	HM	Benny Sand	**9**	1	4.035	13.208	0.236
2012	Nov-12	HM	Benny Sand	**1**	2	1.809	2.331	0.442
2012	Nov-12	HM	Bennies	**70**	1	57.063	302.304	6.052
2012	Nov-12	HM	Bennies	**101**	1	27.757	152.079	4.660
2012	Oct-12	HM	Bennies	**148**	2	7.094	7.680	9.097
2012	Nov-12	HM	Bennies	**43**	1	6.196	83.761	2.598
2012	Oct-12	HM	Bennies	**152**	2	5.393	0.187	10.158
2012	Oct-12	HM	Bennies	**114**	2	3.457	13.198	8.427
2012	Nov-12	HM	Bennies	**102**	4	1.790	10.356	0.453
2012	Oct-12	HM	Bennies	**81**	2	1.776	0.496	7.393
2012	Oct-12	HM	Bennies	**34**	2	1.081	5.660	14.155
2012	Oct-12	HM	Bennies	**18**	2	0.353	1.308	1.390
2012	Nov-12	HM	Bennies	**38**	2	0.218	0.847	0.278
2012	Oct-12	HM	Bennies	**151**	2	0.149	0.078	1.705
2012	Oct-12	HM	Bennies	**119**	2	0.084	0	6.163
2012	Nov-12	HM	NantuxentP	**20**	4	32.016	131.208	5.871
2012	Nov-12	HM	NantuxentP	**24**	1	23.615	41.281	1.841
2012	Nov-12	HM	NantuxentP	**8**	2	17.321	14.132	6.893
2012	Nov-12	HM	NantuxentP	**18**	1	15.864	19.028	5.213
2012	Nov-12	HM	NantuxentP	**13**	2	15.325	71.747	9.625
2012	Nov-12	HM	NantuxentP	**25**	1	13.973	26.899	1.006
2012	Nov-12	HM	NantuxentP	**30**	2	1.725	4.262	2.845
2012	Nov-12	HM	Hog Shoal	**13**	1	26.299	169.352	5.134
2012	Oct-12	HM	Hog Shoal	**7**	2	18.492	74.178	13.423
2012	Nov-12	HM	Hog Shoal	**1**	1	10.372	84.067	4.149
2012	Oct-12	HM	Hog Shoal	**19**	2	7.783	49.866	12.815
2012	Oct-12	HM	Hog Shoal	**12**	2	5.198	43.470	1.420
2012	Nov-12	HM	Hog Shoal	**4**	1	4.338	17.401	2.802
2012	May-13	HM	New Beds	27	1	27.083	351.108	25.095
2012	May-13	HM	New Beds	23	2	25.633	87.547	13.497
2012	May-13	HM	New Beds	24	1	24.092	51.480	11.339
2012	May-13	HM	New Beds	26	1	22.901	105.519	14.815
2012	Nov-12	HM	New Beds	**25**	1	19.981	161.687	10.390
2012	May-13	HM	New Beds	41	2	19.513	76.482	13.553
2012	May-13	HM	New Beds	53	2	15.709	8.037	15.175
2012	May-13	HM	New Beds	3	2	15.090	104.822	17.249
2012	Oct-12	HM	New Beds	**2**	2	13.576	94.659	18.221
2012	May-13	HM	New Beds	35	3	13.307	79.358	20.855
2012	Oct-12	HM	New Beds	**22**	2	13.124	210.540	12.759
2012	May-13	HM	New Beds	39	2	12.865	44.334	9.468
2012	May-13	HM	New Beds	38	2	11.446	32.587	11.995
2012	May-13	HM	New Beds	13	1	10.663	23.511	6.384
2012	Nov-12	HM	New Beds	**28**	2	8.785	129.866	7.867
2012	May-13	HM	New Beds	37	2	8.466	34.171	12.255

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2012	May-13	HM	New Beds	59	3	8.450	16.022	13.629
2012	May-13	HM	New Beds	42	2	8.224	7.242	8.997
2012	May-13	HM	New Beds	15	1	7.864	55.993	14.874
2012	May-13	HM	New Beds	10	2	7.833	50.451	25.124
2012	May-13	HM	New Beds	36	3	7.713	23.956	21.086
2012	May-13	HM	New Beds	1	2	7.577	39.189	16.057
2012	Nov-12	HM	New Beds	**17**	1	6.787	79.210	9.242
2012	May-13	HM	New Beds	52	1	5.485	4.601	6.672
2012	May-13	HM	New Beds	54	2	4.775	0	13.978
2012	May-13	HM	New Beds	6	3	4.742	21.474	6.211
2012	May-13	HM	New Beds	40	2	4.405	2.984	11.200
2012	May-13	HM	New Beds	14	2	4.168	12.513	9.569
2012	May-13	HM	New Beds	11	2	4.128	7.481	19.425
2012	May-13	HM	New Beds	9	3	3.848	4.466	15.598
2012	May-13	HM	New Beds	21	3	2.949	7.445	10.570
2012	May-13	HM	New Beds	51	2	2.835	20.928	10.035
2012	May-13	HM	New Beds	66	2	2.369	2.685	19.684
2012	May-13	HM	New Beds	12	2	2.243	0	9.125
2012	May-13	HM	New Beds	29	2	2.112	3.160	17.036
2012	May-13	HM	New Beds	4	2	2.068	5.413	5.671
2012	May-13	HM	New Beds	65	2	2.067	1.803	28.252
2012	Oct-12	HM	New Beds	**16**	2	1.970	67.175	19.140
2012	May-13	HM	New Beds	98	3	1.742	4.905	0.385
2012	Oct-12	HM	New Beds	**55**	2	1.548	1.206	15.855
2012	May-13	HM	New Beds	67	2	1.100	0	8.119
2012	May-13	HM	New Beds	60	2	1.060	0	12.503
2012	May-13	HM	New Beds	58	3	0.988	0	23.264
2012	May-13	HM	New Beds	49	3	0.883	0.565	2.792
2012	May-13	HM	New Beds	79	2	0.838	0.274	9.714
2012	May-13	HM	New Beds	50	3	0.835	0.977	2.788
2012	May-13	HM	New Beds	80	2	0.780	0.292	6.731
2012	May-13	HM	New Beds	44	3	0.712	4.196	13.356
2012	May-13	HM	New Beds	43	2	0.703	0	11.163
2012	May-13	HM	New Beds	48	3	0.668	0.250	8.601
2012	May-13	HM	New Beds	105	3	0.633	0	11.205
2012	May-13	HM	New Beds	64	3	0.558	2.621	13.636
2012	Oct-12	HM	New Beds	**69**	2	0.500	0.873	18.690
2012	May-13	HM	New Beds	7	3	0.490	0	4.608
2012	May-13	HM	New Beds	74	3	0.413	0.541	12.102
2012	May-13	HM	New Beds	5	2	0.355	2.785	5.221
2012	May-13	HM	New Beds	93	3	0.301	0	5.088
2012	May-13	HM	New Beds	110	3	0.237	0.266	1.061
2012	May-13	HM	New Beds	95	3	0.206	0	5.505
2012	May-13	HM	New Beds	89	3	0.203	0.314	0.090
2012	May-13	HM	New Beds	84	3	0.194	0	12.243
2012	May-13	HM	New Beds	92	3	0.187	0	2.474
2012	Oct-12	HM	New Beds	**83**	2	0.175	0	7.726
2012	May-13	HM	New Beds	88	3	0.172	0.134	0.294
2012	May-13	HM	New Beds	102	3	0.146	0.096	3.363
2012	May-13	HM	New Beds	96	3	0.132	0.173	4.175
2012	May-13	HM	New Beds	71	3	0.127	0	5.159
2012	May-13	HM	New Beds	57	3	0.120	0	8.287
2012	May-13	HM	New Beds	109	3	0.119	0.155	1.584
2012	May-13	HM	New Beds	82	3	0.115	0.301	10.708
2012	May-13	HM	New Beds	104	3	0.112	0	10.092
2012	May-13	HM	New Beds	46	3	0.104	0.035	1.462

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2012	May-13	HM	New Beds	78	3	0.099	0	2.391
2012	May-13	HM	New Beds	70	3	0.094	0	6.549
2012	May-13	HM	New Beds	81	2	0.090	0.090	8.486
2012	May-13	HM	New Beds	77	3	0.057	0.087	0.657
2012	May-13	HM	New Beds	63	3	0.048	0.126	3.524
2012	May-13	HM	New Beds	31	3	0.038	0	0.100
2012	May-13	HM	New Beds	47	3	0.038	0.100	0.784
2012	May-13	HM	New Beds	20	3	0.019	0	0.149
2012	May-13	HM	New Beds	91	3	0.019	0	1.172
2012	May-13	HM	New Beds	101	3	0.019	0.051	0.203
2012	May-13	HM	New Beds	8	3	0.018	0.425	0.338
2012	May-13	HM	New Beds	34	3	0.018	0.191	0.523
2012	May-13	HM	New Beds	75	3	0.018	0	0.268
2012	May-13	HM	New Beds	99	3	0.018	0.018	0.074
2012	May-13	HM	New Beds	112	3	0.018	0	0.059
2012	May-13	HM	New Beds	18	3	0	0	0
2012	May-13	HM	New Beds	19	3	0	0	0.003
2012	May-13	HM	New Beds	30	3	0	0.479	6.007
2012	May-13	HM	New Beds	32	3	0	0	0.032
2012	May-13	HM	New Beds	33	3	0	0	0.024
2012	May-13	HM	New Beds	61	3	0	0	18.864
2012	May-13	HM	New Beds	62	3	0	0.311	4.477
2012	May-13	HM	New Beds	72	3	0	0	5.481
2012	May-13	HM	New Beds	73	3	0	0	18.440
2012	May-13	HM	New Beds	76	3	0	0.041	0.237
2012	May-13	HM	New Beds	85	3	0	0.194	5.451
2012	May-13	HM	New Beds	86	3	0	0	3.201
2012	May-13	HM	New Beds	87	3	0	0.217	5.606
2012	May-13	HM	New Beds	90	3	0	0	0.597
2012	May-13	HM	New Beds	94	3	0	0	7.386
2012	May-13	HM	New Beds	97	3	0	0.381	13.261
2012	May-13	HM	New Beds	100	3	0	0	0.055
2012	May-13	HM	New Beds	103	3	0	0	16.597
2012	May-13	HM	New Beds	106	3	0	0.058	0.089
2012	May-13	HM	New Beds	107	3	0	0	0.082
2012	May-13	HM	New Beds	108	3	0	0	0.024
2012	May-13	HM	New Beds	111	3	0	0	0.090
2012	May-13	HM	New Beds	45	2	0	0	2.516
2012	May-13	HM	New Beds	56	2	0	0.248	4.212
2012	May-13	HM	New Beds	68	2	0	0.642	8.725
2012	Oct-12	HM	Strawberry	5	1	1.525	4.431	3.455
2012	Oct-12	HM	Strawberry	1	2	1.334	1.027	3.765
2012	Oct-12	HM	Strawberry	11	2	0.505	0.132	2.799
2012	Oct-12	HM	Strawberry	16	2	0.324	0.235	4.568
2012	Oct-12	HM	Hawk's Nest	**1**	1	15.275	111.783	3.124
2012	Oct-12	HM	Hawk's Nest	**27**	1	11.277	91.659	3.480
2012	Oct-12	HM	Hawk's Nest	**28**	2	7.760	55.951	1.782
2012	Oct-12	HM	Hawk's Nest	**9**	2	0.542	7.436	3.262
2012	Oct-12	HM	Hawk's Nest	**19**	2	0	0.786	6.177
2012	Oct-12	HM	Beadons	**4**	1	24.831	518.219	5.780
2012	Oct-12	HM	Beadons	**3**	1	12.340	188.717	8.810
2012	Oct-12	HM	Beadons	**16**	2	2.150	25.972	0.712
2012	Oct-12	HM	Beadons	**15**	2	2.132	20.114	1.120
2012	Oct-12	HM	Beadons	**18**	2	0.475	22.387	3.427
2012	Oct-12	HM	Vexton	**4**	1	11.449	256.798	5.996
2012	Oct-12	HM	Vexton	**9**	1	2.723	28.488	7.416

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2012	Oct-12	HM	Vexton	**3**	2	0.787	29.106	3.857
2012	Oct-12	HM	Vexton	**2**	2	0.109	0.443	1.080
2012	Oct-12	HM	Ledge	**13**	2	0.585	2.042	16.062
2012	Oct-12	HM	Ledge	**14**	2	0.390	0.510	12.284
2012	Oct-12	HM	Ledge	**8**	2	0.330	3.456	22.859
2012	Oct-12	HM	Ledge	**6**	1	0.179	1.869	14.626
2012	Oct-12	HM	Ledge	**35**	2	0	0	0.199
2013	Nov-13	VLM	Hope Creek	**75**	1	81.547	128.786	10.386
2013	Nov-13	VLM	Hope Creek	**74**	2	75.718	146.781	12.935
2013	Nov-13	VLM	Hope Creek	**76**	1	75.707	81.497	8.026
2013	Nov-13	VLM	Hope Creek	**63**	1	64.592	96.614	6.846
2013	Nov-13	VLM	Hope Creek	**53**	2	53.812	98.932	11.572
2013	Nov-13	VLM	Hope Creek	**62**	1	49.312	88.791	5.253
2013	Nov-13	VLM	Hope Creek	**55**	2	25.335	26.278	1.709
2013	Nov-13	VLM	Hope Creek	**59**	4	19.158	19.112	2.564
2013	Nov-13	VLM	Hope Creek	**86**	2	17.424	12.661	1.744
2013	Nov-13	VLM	Liston Range	**24**	1	122.263	134.955	9.095
2013	Nov-13	VLM	Liston Range	**18**	2	54.347	50.048	3.540
2013	Nov-13	VLM	Liston Range	**12**	2	53.955	35.289	2.226
2013	Nov-13	VLM	Liston Range	**14**	1	45.843	40.760	2.318
2013	Nov-13	VLM	Liston Range	**2**	2	5.666	2.742	0.232
2013	Nov-13	VLM	Liston Range	**25**	2	1.173	0.529	0.244
2013	Nov-13	VLM	Fishing Creek	**25**	1	144.818	71.594	11.840
2013	Nov-13	VLM	Fishing Creek	**4**	2	17.687	20.910	3.299
2013	Nov-13	VLM	Fishing Creek	**26**	2	14.316	6.731	3.285
2013	Nov-13	VLM	Fishing Creek	**16**	1	14.228	5.487	5.060
2013	Nov-13	VLM	Fishing Creek	**17**	2	1.594	0.915	0.106
2013	Nov-13	LM	Round Island	**12**	1	44.947	27.607	5.758
2013	Nov-13	LM	Round Island	**24**	1	31.757	26.770	4.556
2013	Nov-13	LM	Round Island	**47**	2	25.080	10.040	3.311
2013	Nov-13	LM	Round Island	**15**	2	2.272	1.275	0.765
2013	Nov-13	LM	Round Island	**50**	2	0.209	0.019	0.043
2013	Nov-13	LM	Upper Arnolds	**17**	2	111.212	120.185	8.500
2013	Nov-13	LM	Upper Arnolds	**9**	2	91.892	84.317	11.351
2013	Nov-13	LM	Upper Arnolds	**3**	1	70.644	50.326	8.869
2013	Nov-13	LM	Upper Arnolds	**4**	2	55.126	73.253	3.794
2013	Nov-13	LM	Upper Arnolds	**11**	1	47.747	37.740	2.995
2013	Nov-13	LM	Upper Arnolds	**5**	1	35.691	49.689	2.137
2013	Nov-13	LM	Upper Arnolds	**25**	2	33.689	19.778	1.447
2013	Nov-13	LM	Arnolds	7	1	136.116	89.292	10.746
2013	Nov-13	LM	Arnolds	18	1	122.171	72.605	11.348
2013	Nov-13	LM	Arnolds	6	1	78.140	70.295	4.977
2013	Nov-13	LM	Arnolds	15	2	53.812	51.464	3.420
2013	Nov-13	LM	Arnolds	10	2	23.500	11.959	3.129
2013	Nov-13	LM	Arnolds	46	2	4.908	3.643	3.180
2013	Nov-13	MMT	Upper Middle	**48**	1	82.053	75.547	14.432
2013	Nov-13	MMT	Upper Middle	**1**	2	29.174	28.049	12.036
2013	Nov-13	MMT	Upper Middle	**63**	2	24.581	10.718	3.890
2013	Nov-13	MMT	Upper Middle	**56**	2	4.200	5.363	8.333
2013	Nov-13	MMT	Middle	**36**	1	34.458	40.587	4.248
2013	Nov-13	MMT	Middle	**28**	4	31.608	26.452	3.817
2013	Nov-13	MMT	Middle	**22**	2	30.989	14.893	11.252
2013	Nov-13	MMT	Middle	**27**	4	29.760	20.230	3.035
2013	Nov-13	MMT	Middle	**43**	2	18.506	9.219	8.497
2013	Nov-13	MMT	Middle	**38**	1	10.107	5.082	2.783
2013	Nov-13	MMT	Middle	**26**	2	6.570	5.361	1.759

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2013	Nov-13	MMT	Middle	**10**	2	5.109	2.322	13.520
2013	Nov-13	MMT	Middle	**1**	2	1.808	1.333	3.298
2013	Nov-13	MMT	Sea Breeze	**20**	2	63.217	21.499	17.462
2013	Nov-13	MMT	Sea Breeze	**25**	2	40.771	21.917	6.157
2013	Nov-13	MMT	Sea Breeze	**14**	1	39.206	45.054	11.558
2013	Nov-13	MMT	Sea Breeze	**31**	1	34.858	18.593	4.410
2013	Nov-13	MMT	Sea Breeze	**30**	1	15.671	5.591	1.832
2013	Nov-13	MMT	Sea Breeze	**29**	2	13.735	5.840	4.097
2013	Nov-13	MMT	Sea Breeze	**17**	2	12.801	3.295	4.594
2013	Nov-13	MMM	Ship John	**56**	2	80.569	91.468	22.337
2013	Nov-13	MMM	Ship John	**46**	2	77.048	44.291	13.538
2013	Nov-13	MMM	Ship John	**25**	1	70.498	52.585	8.492
2013	Nov-13	MMM	Ship John	**53**	4	69.984	9.481	5.321
2013	Nov-13	MMM	Ship John	**33**	1	52.675	56.343	5.132
2013	Nov-13	MMM	Ship John	**42**	1	47.069	44.481	5.409
2013	Nov-13	MMM	Ship John	**16**	1	40.977	54.149	7.322
2013	Nov-13	MMM	Ship John	**21**	1	37.306	34.914	7.426
2013	Nov-13	MMM	Ship John	**18**	2	29.363	13.291	3.191
2013	Nov-13	MMM	Ship John	**58**	1	27.756	36.987	13.626
2013	Nov-13	MMM	Ship John	**35**	2	20.967	8.101	5.667
2013	Nov-13	MMM	Ship John	**36**	4	12.988	3.480	4.795
2013	Nov-13	MMM	Ship John	**5**	2	12.229	6.200	4.722
2013	Nov-13	MMM	Cohansey	**59**	1	54.894	40.760	16.655
2013	Nov-13	MMM	Cohansey	**37**	1	53.998	37.810	13.051
2013	Nov-13	MMM	Cohansey	**25**	1	49.187	34.765	10.477
2013	Nov-13	MMM	Cohansey	**50**	1	42.612	38.451	8.154
2013	Nov-13	MMM	Cohansey	**24**	2	42.348	25.885	9.644
2013	Nov-13	MMM	Cohansey	**46**	2	34.469	21.218	7.779
2013	Nov-13	MMM	Cohansey	**3**	2	29.148	27.740	13.348
2013	Nov-13	MMM	Cohansey	**56**	2	27.521	12.849	3.471
2013	Nov-13	MMM	Cohansey	**35**	2	14.669	9.888	3.562
2013	Nov-13	MMM	Cohansey	**72**	1	14.038	4.571	7.056
2013	Nov-13	SR	Shell Rock	**24**	1	46.910	26.536	3.775
2013	Nov-13	SR	Shell Rock	**11**	4	40.425	7.905	3.309
2013	Nov-13	SR	Shell Rock	**34**	4	37.107	21.838	6.386
2013	Nov-13	SR	Shell Rock	**29**	4	31.916	27.553	7.627
2013	Nov-13	SR	Shell Rock	**2**	1	28.511	7.520	4.142
2013	Nov-13	SR	Shell Rock	**14**	1	23.440	20.268	4.554
2013	Nov-13	SR	Shell Rock	**30**	4	21.250	30.001	5.913
2013	Nov-13	SR	Shell Rock	**25**	2	18.134	11.374	1.724
2013	Nov-13	SR	Shell Rock	**27**	4	17.774	6.989	2.470
2013	Nov-13	SR	Shell Rock	**68**	2	17.471	10.391	5.641
2013	Nov-13	SR	Shell Rock	**4**	1	17.414	8.194	4.168
2013	Nov-13	SR	Shell Rock	**55**	2	14.123	3.107	5.254
2013	Nov-13	SR	Shell Rock	**59**	2	14.100	2.442	2.345
2013	Nov-13	SR	Shell Rock	**7**	2	8.762	5.061	1.902
2013	Nov-13	SR	Shell Rock	**89**	2	7.172	3.041	1.069
2013	Nov-13	HM	Benny Sand	**8**	1	51.209	62.095	7.112
2013	Nov-13	HM	Benny Sand	**11**	4	46.552	32.762	4.530
2013	Nov-13	HM	Benny Sand	**6**	2	23.754	23.265	4.979
2013	Nov-13	HM	Benny Sand	**14**	4	21.524	33.967	6.071
2013	Nov-13	HM	Benny Sand	**9**	1	20.894	48.573	3.707
2013	Nov-13	HM	Benny Sand	**22**	2	15.449	19.963	8.559
2013	Nov-13	HM	Benny Sand	**7**	1	10.268	8.167	2.021
2013	Nov-13	HM	Benny Sand	**44**	2	8.176	9.147	4.772
2013	Nov-13	HM	Benny Sand	**30**	2	7.688	1.624	5.288

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2013	Nov-13	HM	Benny Sand	**3**	2	6.272	5.239	1.237
2013	Nov-13	HM	Benny Sand	**37**	2	1.208	0.703	2.391
2013	Nov-13	HM	Bennies	**87**	1	59.488	39.058	4.693
2013	May-14	HM	Bennies	86	1	50.094	21.334	8.147
2013	May-14	HM	Bennies	101	1	45.381	32.968	7.882
2013	May-14	HM	Bennies	111	2	37.463	21.828	11.363
2013	Jun-14	HM	Bennies	71	2	36.498	15.750	5.579
2013	May-14	HM	Bennies	100	1	35.412	19.105	9.579
2013	Jun-14	HM	Bennies	56	2	34.475	17.947	5.473
2013	May-14	HM	Bennies	85	2	29.508	32.655	11.235
2013	Nov-13	HM	Bennies	**102**	4	27.591	14.223	1.743
2013	Nov-13	HM	Bennies	**70**	1	26.288	16.440	2.238
2013	Nov-13	HM	Bennies	**99**	2	24.774	16.804	8.697
2013	Jun-14	HM	Bennies	76	2	24.656	22.366	9.646
2013	Nov-13	HM	Bennies	**123**	1	23.283	37.923	5.281
2013	Jun-14	HM	Bennies	141	1	19.075	15.080	6.262
2013	May-14	HM	Bennies	110	2	18.813	20.876	11.110
2013	Jun-14	HM	Bennies	43	1	18.618	16.397	4.079
2013	Nov-13	HM	Bennies	**35**	2	18.220	62.301	12.502
2013	May-14	HM	Bennies	135	2	17.760	6.015	10.694
2013	May-14	HM	Bennies	84	2	16.297	20.400	10.508
2013	May-14	HM	Bennies	122	1	16.010	4.473	10.414
2013	May-14	HM	Bennies	124	2	14.883	17.063	15.954
2013	Jun-14	HM	Bennies	44	1	13.031	5.352	2.006
2013	Jun-14	HM	Bennies	58	2	9.604	11.901	6.562
2013	Jun-14	HM	Bennies	55	2	9.429	4.363	2.473
2013	May-14	HM	Bennies	114	2	8.684	4.522	11.106
2013	May-14	HM	Bennies	83	2	7.948	13.130	9.715
2013	Jun-14	HM	Bennies	149	2	7.680	9.993	9.372
2013	Jun-14	HM	Bennies	73	3	7.666	12.917	4.510
2013	Jun-14	HM	Bennies	26	3	7.596	5.568	3.897
2013	Jun-14	HM	Bennies	34	2	7.591	17.067	8.452
2013	Jun-14	HM	Bennies	6	2	7.224	4.230	1.315
2013	Jun-14	HM	Bennies	27	2	5.796	5.256	3.601
2013	Jun-14	HM	Bennies	60	2	5.506	9.811	3.929
2013	Jun-14	HM	Bennies	33	2	5.427	9.482	3.796
2013	Jun-14	HM	Bennies	36	2	5.202	3.771	6.728
2013	Jun-14	HM	Bennies	74	3	4.705	4.116	2.974
2013	May-14	HM	Bennies	113	2	4.206	3.296	11.822
2013	Jun-14	HM	Bennies	91	3	3.730	2.593	6.152
2013	Nov-13	HM	Bennies	**72**	2	3.415	4.089	1.091
2013	Nov-13	HM	Bennies	**112**	2	3.066	4.489	3.400
2013	Jun-14	HM	Bennies	148	2	3.066	4.013	4.196
2013	Jun-14	HM	Bennies	90	3	3.052	3.715	3.078
2013	Jun-14	HM	Bennies	7	2	3.016	1.808	0.594
2013	Jun-14	HM	Bennies	68	3	2.972	6.601	6.092
2013	Nov-13	HM	Bennies	**37**	2	2.925	3.307	2.042
2013	May-14	HM	Bennies	98	2	2.884	3.432	11.629
2013	May-14	HM	Bennies	97	1	2.602	7.237	14.683
2013	Jun-14	HM	Bennies	69	2	2.380	3.282	2.610
2013	Jun-14	HM	Bennies	65	2	2.357	9.506	5.677
2013	Jun-14	HM	Bennies	146	1	2.319	2.482	0.934
2013	Jun-14	HM	Bennies	16	3	1.987	2.473	1.554
2013	Jun-14	HM	Bennies	57	3	1.738	0.669	0.557
2013	Nov-13	HM	Bennies	**18**	2	1.732	3.878	3.576
2013	Jun-14	HM	Bennies	59	3	1.730	1.079	1.574

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2013	May-14	HM	Bennies	106	3	1.601	2.210	3.056
2013	May-14	HM	Bennies	115	2	1.477	1.570	2.189
2013	Jun-14	HM	Bennies	88	2	1.451	0.803	0.491
2013	May-14	HM	Bennies	82	2	1.365	7.059	10.325
2013	Jun-14	HM	Bennies	92	2	1.333	2.839	4.563
2013	May-14	HM	Bennies	103	3	1.272	0.556	0.216
2013	Jun-14	HM	Bennies	151	2	1.100	3.155	5.642
2013	Jun-14	HM	Bennies	51	2	0.726	2.744	3.987
2013	Jun-14	HM	Bennies	67	3	0.639	1.957	2.395
2013	Jun-14	HM	Bennies	53	3	0.601	0.165	0.792
2013	Jun-14	HM	Bennies	75	3	0.578	0.541	1.270
2013	Jun-14	HM	Bennies	12	3	0.562	0.553	1.350
2013	Jun-14	HM	Bennies	15	3	0.558	0.847	1.456
2013	Jun-14	HM	Bennies	38	2	0.544	0.342	0.695
2013	May-14	HM	Bennies	134	2	0.511	0.446	13.393
2013	May-14	HM	Bennies	160	3	0.491	0.127	1.428
2013	Jun-14	HM	Bennies	152	2	0.477	5.614	6.285
2013	Jun-14	HM	Bennies	54	2	0.443	0.280	0.670
2013	Jun-14	HM	Bennies	89	3	0.440	0.227	0.595
2013	Jun-14	HM	Bennies	66	2	0.436	2.117	2.774
2013	Nov-13	HM	Bennies	**125**	2	0.385	0.671	5.030
2013	Jun-14	HM	Bennies	5	3	0.352	0.102	0.951
2013	May-14	HM	Bennies	171	3	0.346	0	1.672
2013	Jun-14	HM	Bennies	14	3	0.343	1.027	2.221
2013	Jun-14	HM	Bennies	50	3	0.305	0.998	2.558
2013	Jun-14	HM	Bennies	17	1	0.296	0.181	0.860
2013	Jun-14	HM	Bennies	39	3	0.292	0.150	0.298
2013	May-14	HM	Bennies	107	2	0.278	0.727	16.771
2013	May-14	HM	Bennies	96	2	0.275	2.300	9.697
2013	Nov-13	HM	Bennies	**121**	2	0.271	0.181	8.606
2013	Jun-14	HM	Bennies	20	2	0.235	0.053	0.549
2013	May-14	HM	Bennies	126	2	0.229	1.200	6.328
2013	May-14	HM	Bennies	109	2	0.220	0.768	7.327
2013	May-14	HM	Bennies	120	2	0.180	0	13.041
2013	Jun-14	HM	Bennies	142	3	0.176	0.059	1.326
2013	May-14	HM	Bennies	132	3	0.172	0.450	7.440
2013	Jun-14	HM	Bennies	32	3	0.168	0.185	1.144
2013	Jun-14	HM	Bennies	1	3	0.147	0.025	0.016
2013	Jun-14	HM	Bennies	41	3	0.138	0.101	0.100
2013	Jun-14	HM	Bennies	49	3	0.134	0.469	1.999
2013	Jun-14	HM	Bennies	52	2	0.126	0.032	0.494
2013	Jun-14	HM	Bennies	19	2	0.125	0.068	0.253
2013	Jun-14	HM	Bennies	11	3	0.122	0.023	0.334
2013	Jun-14	HM	Bennies	45	2	0.118	0.308	1.673
2013	Jun-14	HM	Bennies	63	3	0.116	0.909	6.646
2013	Jun-14	HM	Bennies	21	2	0.113	0	0.335
2013	May-14	HM	Bennies	170	3	0.109	0.857	4.719
2013	Jun-14	HM	Bennies	40	3	0.107	0.076	0.207
2013	Nov-13	HM	Bennies	**127**	2	0.095	0.498	3.590
2013	May-14	HM	Bennies	140	3	0.094	0.123	1.922
2013	Jun-14	HM	Bennies	64	2	0.091	0.238	4.122
2013	Jun-14	HM	Bennies	31	3	0.090	0.158	0.705
2013	May-14	HM	Bennies	117	3	0.086	0.028	0.039
2013	Jun-14	HM	Bennies	2	3	0.085	0.061	0.093
2013	Jun-14	HM	Bennies	3	3	0.081	0.029	0.147
2013	Jun-14	HM	Bennies	22	3	0.078	0.111	0.195

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2013	Jun-14	HM	Bennies	23	3	0.078	0.016	0.083
2013	Jun-14	HM	Bennies	143	3	0.074	0.583	1.852
2013	May-14	HM	Bennies	139	3	0.068	0	1.503
2013	May-14	HM	Bennies	116	3	0.058	0.010	0.082
2013	Jun-14	HM	Bennies	147	2	0.056	0.146	1.229
2013	May-14	HM	Bennies	167	3	0.048	0.111	0.335
2013	Jun-14	HM	Bennies	46	2	0.047	0.367	2.348
2013	Jun-14	HM	Bennies	29	3	0.028	0.074	1.289
2013	Jun-14	HM	Bennies	48	3	0.026	0.201	1.368
2013	May-14	HM	Bennies	159	3	0.026	0	0.771
2013	Jun-14	HM	Bennies	4	3	0.024	0	0.091
2013	Jun-14	HM	Bennies	30	3	0.021	0.055	0.644
2013	Jun-14	HM	Bennies	8	3	0.018	0	0.006
2013	May-14	HM	Bennies	105	3	0.017	0.031	0.150
2013	Jun-14	HM	Bennies	42	3	0.010	0	0.071
2013	May-14	HM	Bennies	118	3	0.009	0	0.006
2013	Jun-14	HM	Bennies	24	3	0.008	0	0.012
2013	Jun-14	HM	Bennies	9	3	0	0	0
2013	Jun-14	HM	Bennies	10	3	0	0	0
2013	Jun-14	HM	Bennies	13	3	0	0.045	0.008
2013	Jun-14	HM	Bennies	25	3	0	0	0
2013	Jun-14	HM	Bennies	28	3	0	0	0.059
2013	Jun-14	HM	Bennies	47	3	0	0	0.351
2013	Jun-14	HM	Bennies	61	3	0	0.100	1.623
2013	Jun-14	HM	Bennies	62	3	0	0.088	1.521
2013	May-14	HM	Bennies	77	3	0	0	1.575
2013	May-14	HM	Bennies	78	3	0	0	1.995
2013	May-14	HM	Bennies	79	3	0	0	9.405
2013	May-14	HM	Bennies	93	3	0	0	6.665
2013	May-14	HM	Bennies	94	3	0	0	5.400
2013	May-14	HM	Bennies	95	3	0	0.987	8.937
2013	May-14	HM	Bennies	104	3	0	0	0.118
2013	May-14	HM	Bennies	128	3	0	0.027	0.101
2013	May-14	HM	Bennies	129	3	0	0	0.006
2013	May-14	HM	Bennies	130	3	0	0	4.586
2013	May-14	HM	Bennies	136	3	0	0	2.286
2013	May-14	HM	Bennies	137	3	0	0	4.903
2013	May-14	HM	Bennies	138	3	0	0	2.629
2013	Jun-14	HM	Bennies	144	3	0	0.022	0.407
2013	Jun-14	HM	Bennies	145	3	0	0	1.424
2013	Jun-14	HM	Bennies	150	3	0	0	1.608
2013	Jun-14	HM	Bennies	153	3	0	0	1.961
2013	Jun-14	HM	Bennies	154	3	0	0	0.778
2013	Jun-14	HM	Bennies	155	3	0	0	2.749
2013	May-14	HM	Bennies	156	3	0	0	2.855
2013	May-14	HM	Bennies	157	3	0	0	0.215
2013	May-14	HM	Bennies	158	3	0	0	2.414
2013	May-14	HM	Bennies	161	3	0	0	2.361
2013	May-14	HM	Bennies	162	3	0	0	3.240
2013	May-14	HM	Bennies	163	3	0	0	0.072
2013	May-14	HM	Bennies	164	3	0	0.618	2.662
2013	May-14	HM	Bennies	165	3	0	0	3.506
2013	May-14	HM	Bennies	166	3	0	0	0.668
2013	May-14	HM	Bennies	168	3	0	0.386	3.968
2013	May-14	HM	Bennies	169	3	0	0	3.262
2013	May-14	HM	Bennies	80	2	0	0.307	7.775

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2013	May-14	HM	Bennies	81	2	0	0	12.627
2013	May-14	HM	Bennies	108	2	0	0	17.189
2013	May-14	HM	Bennies	119	2	0	0.926	8.698
2013	May-14	HM	Bennies	131	2	0	0	11.170
2013	May-14	HM	Bennies	133	2	0	0.637	15.456
2013	Oct-13	HM	NantuxentP	**15**	1	30.260	39.988	6.405
2013	Oct-13	HM	NantuxentP	**25**	1	22.395	52.087	9.680
2013	Oct-13	HM	NantuxentP	**68**	2	22.237	25.811	9.718
2013	Oct-13	HM	NantuxentP	**18**	1	19.266	17.377	9.066
2013	Oct-13	HM	NantuxentP	**29**	2	11.356	25.879	8.689
2013	Oct-13	HM	NantuxentP	**13**	2	5.617	7.059	4.259
2013	Oct-13	HM	Hog Shoal	**1**	1	30.489	33.855	10.928
2013	Oct-13	HM	Hog Shoal	**6**	2	17.333	13.973	7.179
2013	Oct-13	HM	Hog Shoal	**4**	1	9.357	20.678	4.434
2013	Oct-13	HM	Hog Shoal	**5**	1	4.551	28.785	9.546
2013	Oct-13	HM	Hog Shoal	**9**	2	3.429	37.882	7.180
2013	Oct-13	HM	Hog Shoal	**16**	2	0.223	2.334	1.628
2013	Oct-13	HM	New Beds	**26**	1	45.888	46.252	14.225
2013	Oct-13	HM	New Beds	**22**	1	31.418	62.209	7.844
2013	Oct-13	HM	New Beds	**3**	2	28.576	74.757	12.649
2013	Oct-13	HM	New Beds	**2**	2	21.593	21.235	4.400
2013	Oct-13	HM	New Beds	**24**	1	13.625	44.824	10.904
2013	Oct-13	HM	New Beds	**13**	2	12.973	22.852	5.389
2013	Oct-13	HM	New Beds	**39**	2	7.248	29.141	11.681
2013	Oct-13	HM	New Beds	**53**	1	3.994	6.602	7.899
2013	Oct-13	HM	New Beds	**54**	2	3.220	19.119	9.369
2013	Oct-13	HM	Strawberry	**5**	1	2.471	11.019	8.675
2013	Oct-13	HM	Strawberry	**1**	2	0.442	0.400	3.566
2013	Oct-13	HM	Strawberry	**11**	2	0.143	1.499	4.438
2013	Oct-13	HM	Strawberry	**8**	2	0.043	0.056	0.510
2013	Oct-13	HM	Hawk's Nest	**27**	1	16.639	43.936	6.734
2013	Oct-13	HM	Hawk's Nest	**3**	2	3.506	45.750	13.660
2013	Oct-13	HM	Hawk's Nest	**5**	1	1.004	2.796	4.140
2013	Oct-13	HM	Hawk's Nest	**7**	2	0.340	7.284	8.996
2013	Oct-13	HM	Hawk's Nest	**22**	2	0.146	2.365	4.297
2013	Oct-13	HM	Beadons	**4**	1	8.140	46.525	4.920
2013	Oct-13	HM	Beadons	**9**	2	3.238	11.145	1.544
2013	Oct-13	HM	Beadons	**8**	1	1.633	2.552	1.785
2013	Oct-13	HM	Beadons	**5**	2	0.198	0.443	0.450
2013	Oct-13	HM	Beadons	**16**	2	0.191	0	2.288
2013	Oct-13	HM	Vexton	**9**	1	4.292	79.465	11.405
2013	Oct-13	HM	Vexton	**4**	1	3.207	26.031	6.182
2013	Oct-13	HM	Vexton	**3**	2	1.954	45.608	11.422
2013	Oct-13	HM	Vexton	**17**	2	0.254	13.739	10.292
2013	Oct-13	HM	Egg Island	**28**	2	1.687	18.001	11.734
2013	Oct-13	HM	Egg Island	**41**	2	0	1.533	10.807
2013	Oct-13	HM	Egg Island	**66**	2	0	0.028	0.228
2013	Oct-13	HM	Egg Island	**82**	2	0	0	12.578
2013	Oct-13	HM	Egg Island	**98**	2	0	0	0.088
2013	Oct-13	HM	Egg Island	**62**	1	0	0.522	15.179
2014	Oct-14	VLM	Hope Creek	**62**	1	229.818	51.531	11.742
2014	Oct-14	VLM	Hope Creek	**61**	1	151.920	29.295	8.909
2014	Oct-14	VLM	Hope Creek	**85**	2	151.260	17.856	4.544
2014	Oct-14	VLM	Hope Creek	**76**	1	136.921	21.064	7.819
2014	Oct-14	VLM	Hope Creek	**75**	1	135.123	27.844	8.981
2014	Oct-14	VLM	Hope Creek	**72**	2	99.919	15.002	6.147

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2014	Oct-14	VLM	Hope Creek	**52**	2	62.138	12.419	7.463
2014	Oct-14	VLM	Hope Creek	**59**	4	23.376	5.515	2.976
2014	Oct-14	VLM	Hope Creek	**44**	2	20.741	2.740	2.514
2014	Oct-14	VLM	Liston Range	**24**	1	125.264	16.012	4.485
2014	Oct-14	VLM	Liston Range	**18**	2	84.557	12.872	5.005
2014	Oct-14	VLM	Liston Range	**14**	1	26.294	2.936	1.329
2014	Oct-14	VLM	Liston Range	**2**	2	9.854	0.952	0.802
2014	Oct-14	VLM	Liston Range	**22**	2	7.293	0.555	0.766
2014	Oct-14	VLM	Liston Range	**25**	2	1.040	0.091	0.107
2014	Oct-14	VLM	Fishing Creek	**25**	1	63.956	8.481	4.550
2014	Oct-14	VLM	Fishing Creek	**24**	2	46.122	3.735	3.657
2014	Oct-14	VLM	Fishing Creek	**16**	1	18.294	1.953	1.381
2014	Oct-14	VLM	Fishing Creek	**43**	2	0.618	0	0.469
2014	Oct-14	VLM	Fishing Creek	**11**	2	0.024	0	0.036
2014	Oct-14	LM	Round Island	**11**	1	97.376	19.174	7.905
2014	Oct-14	LM	Round Island	**24**	1	88.384	14.281	9.518
2014	Oct-14	LM	Round Island	**5**	2	67.178	9.166	8.074
2014	Oct-14	LM	Round Island	**2**	2	50.998	2.646	4.944
2014	Oct-14	LM	Round Island	**73**	2	8.780	0.790	3.854
2014	Oct-14	LM	Upper Arnolds	**10**	1	205.704	31.604	7.721
2014	Oct-14	LM	Upper Arnolds	**12**	1	93.376	9.614	2.791
2014	Oct-14	LM	Upper Arnolds	**3**	1	64.087	6.062	4.963
2014	Oct-14	LM	Upper Arnolds	**17**	2	34.763	4.691	4.613
2014	Oct-14	LM	Upper Arnolds	**2**	2	31.459	6.308	4.454
2014	Oct-14	LM	Upper Arnolds	**13**	2	20.983	1.320	3.326
2014	Oct-14	LM	Upper Arnolds	**6**	2	17.438	0.814	0.555
2014	Oct-14	LM	Arnolds	**17**	1	144.051	24.477	11.692
2014	Oct-14	LM	Arnolds	**7**	1	78.390	13.254	3.491
2014	Oct-14	LM	Arnolds	**6**	1	61.552	4.782	2.396
2014	Oct-14	LM	Arnolds	**10**	2	11.606	0.891	0.514
2014	Oct-14	LM	Arnolds	**3**	2	0.342	0.023	0.183
2014	Oct-14	LM	Arnolds	**73**	2	0.045	0	0.130
2014	Oct-14	MMT	Upper Middle	**48**	1	61.740	5.246	6.645
2014	Oct-14	MMT	Upper Middle	**56**	2	6.418	0.105	2.886
2014	Oct-14	MMT	Upper Middle	**36**	2	6.038	0.351	1.327
2014	Oct-14	MMT	Upper Middle	**71**	2	1.178	0.058	0.230
2014	Oct-14	MMT	Middle	**27**	4	99.371	7.547	10.314
2014	Oct-14	MMT	Middle	**36**	1	93.330	9.561	12.098
2014	Oct-14	MMT	Middle	**37**	1	63.321	3.647	8.477
2014	Oct-14	MMT	Middle	**28**	4	50.300	4.529	6.450
2014	Oct-14	MMT	Middle	**40**	2	46.227	1.529	10.348
2014	Oct-14	MMT	Middle	**30**	2	35.333	0.896	9.494
2014	Oct-14	MMT	Middle	**20**	1	23.053	1.128	5.549
2014	Oct-14	MMT	Middle	**51**	2	11.654	1.056	3.104
2014	Oct-14	MMT	Middle	**48**	2	0.609	0	1.545
2014	Nov-14	MMT	Sea Breeze	**30**	1	79.007	8.080	5.305
2014	Nov-14	MMT	Sea Breeze	**36**	1	47.187	2.700	4.867
2014	Nov-14	MMT	Sea Breeze	**24**	2	42.338	3.738	8.896
2014	Nov-14	MMT	Sea Breeze	**22**	2	35.546	5.003	8.558
2014	Nov-14	MMT	Sea Breeze	**15**	1	10.560	1.743	0.875
2014	Nov-14	MMT	Sea Breeze	**38**	2	2.081	0.038	1.314
2014	Nov-14	MMT	Sea Breeze	**46**	2	1.050	0.142	0.457
2014	Oct-14	MMM	Ship John	**33**	4	140.617	10.694	11.783
2014	Oct-14	MMM	Ship John	**21**	4	102.389	6.432	14.685
2014	Oct-14	MMM	Ship John	**16**	1	99.169	10.904	12.351
2014	Oct-14	MMM	Ship John	**32**	1	89.964	8.006	14.206

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2014	Oct-14	MMM	Ship John	**23**	1	77.913	3.682	10.590
2014	Oct-14	MMM	Ship John	**9**	1	58.534	1.850	13.180
2014	Oct-14	MMM	Ship John	**38**	2	55.346	2.694	10.236
2014	Oct-14	MMM	Ship John	**25**	1	55.273	8.538	10.086
2014	Oct-14	MMM	Ship John	**37**	2	51.838	6.374	9.072
2014	Oct-14	MMM	Ship John	**24**	2	40.210	3.744	8.569
2014	Oct-14	MMM	Ship John	**52**	2	40.139	15.724	16.656
2014	Oct-14	MMM	Ship John	**53**	4	24.542	0.444	2.991
2014	Oct-14	MMM	Ship John	**48**	1	20.495	0.893	5.056
2014	Oct-14	MMM	Ship John	**36**	4	13.733	0.339	2.721
2014	Oct-14	MMM	Ship John	**50**	2	13.674	0.156	2.522
2014	Oct-14	MMM	Cohansey	**1**	2	70.425	8.422	9.972
2014	Oct-14	MMM	Cohansey	**20**	1	67.474	8.978	4.348
2014	Oct-14	MMM	Cohansey	**63**	1	60.718	3.618	8.383
2014	Oct-14	MMM	Cohansey	**47**	2	55.518	5.652	10.732
2014	Oct-14	MMM	Cohansey	**5**	2	55.237	6.371	13.389
2014	Oct-14	MMM	Cohansey	**25**	1	44.117	3.833	7.570
2014	Oct-14	MMM	Cohansey	**57**	1	38.225	4.966	14.803
2014	Oct-14	MMM	Cohansey	**65**	2	35.196	1.094	9.713
2014	Oct-14	MMM	Cohansey	**58**	2	32.296	3.992	8.603
2014	Oct-14	MMM	Cohansey	**72**	1	11.354	1.705	5.302
2014	Nov-14	SR	Shell Rock	**43**	2	47.544	5.078	5.044
2014	Nov-14	SR	Shell Rock	**2**	1	30.974	0.549	5.160
2014	Nov-14	SR	Shell Rock	**19**	2	30.921	0.681	4.626
2014	Nov-14	SR	Shell Rock	**21**	1	27.776	3.589	4.676
2014	Nov-14	SR	Shell Rock	**14**	1	27.037	3.117	3.950
2014	Nov-14	SR	Shell Rock	**12**	2	26.923	0.889	3.152
2014	Nov-14	SR	Shell Rock	**29**	4	25.168	4.020	4.521
2014	Nov-14	SR	Shell Rock	**30**	4	24.106	1.856	3.921
2014	Nov-14	SR	Shell Rock	**32**	2	23.641	3.205	3.327
2014	Nov-14	SR	Shell Rock	**31**	4	22.478	1.851	3.860
2014	Nov-14	SR	Shell Rock	**4**	1	21.124	1.026	2.118
2014	Nov-14	SR	Shell Rock	**7**	4	14.721	1.784	1.906
2014	Nov-14	SR	Shell Rock	**6**	2	10.895	0.607	3.954
2014	Nov-14	SR	Shell Rock	**89**	2	7.906	1.850	1.696
2014	Nov-14	HM	Benny Sand	**12**	2	53.094	13.337	5.808
2014	Nov-14	HM	Benny Sand	**8**	1	42.907	6.165	3.149
2014	Nov-14	HM	Benny Sand	**9**	1	29.664	5.995	1.710
2014	Nov-14	HM	Benny Sand	**7**	1	29.516	3.155	2.743
2014	Nov-14	HM	Benny Sand	**3**	2	26.259	5.610	2.899
2014	Nov-14	HM	Benny Sand	**14**	2	23.949	3.028	5.701
2014	Nov-14	HM	Benny Sand	**19**	2	17.498	1.399	4.987
2014	Nov-14	HM	Benny Sand	**26**	2	1.758	0.379	0.769
2014	Nov-14	HM	Benny Sand	**37**	2	0.438	0	1.089
2014	Oct-14	HM	Bennies	**71**	1	59.253	13.903	4.532
2014	Oct-14	HM	Bennies	**102**	1	40.929	7.334	2.297
2014	Oct-14	HM	Bennies	**86**	1	30.324	8.635	1.931
2014	Oct-14	HM	Bennies	**141**	2	27.899	7.108	3.744
2014	Oct-14	HM	Bennies	**149**	2	22.078	3.926	6.713
2014	Oct-14	HM	Bennies	**85**	1	21.734	9.176	3.494
2014	Oct-14	HM	Bennies	**100**	1	14.448	1.589	1.853
2014	Oct-14	HM	Bennies	**114**	2	9.632	0.447	8.549
2014	Oct-14	HM	Bennies	**7**	2	8.155	0.928	0.983
2014	Oct-14	HM	Bennies	**36**	2	6.802	0.344	2.536
2014	Oct-14	HM	Bennies	**16**	2	4.208	0.044	2.844
2014	Oct-14	HM	Bennies	**74**	2	1.306	0.091	1.648

Data Year	Coll. Date (m-yr)	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2014	Oct-14	HM	Bennies	**151**	2	0.360	0	5.265
2014	Oct-14	HM	Bennies	**125**	2	0.123	0.322	5.087
2014	Oct-14	HM	NantuxentP	**23**	4	45.893	40.860	5.487
2014	Oct-14	HM	NantuxentP	**24**	1	40.742	40.359	4.197
2014	Oct-14	HM	NantuxentP	**17**	1	31.137	41.441	7.435
2014	Oct-14	HM	NantuxentP	**16**	1	27.625	16.684	5.440
2014	Oct-14	HM	NantuxentP	**8**	2	14.467	10.781	5.792
2014	Oct-14	HM	NantuxentP	**21**	2	13.811	6.971	8.116
2014	Oct-14	HM	NantuxentP	**11**	2	7.234	1.674	1.047
2014	Oct-14	HM	Hog Shoal	**1**	1	18.444	12.600	7.824
2014	Oct-14	HM	Hog Shoal	**4**	1	16.461	15.058	6.337
2014	Oct-14	HM	Hog Shoal	**19**	2	14.221	3.448	7.054
2014	Oct-14	HM	Hog Shoal	**5**	1	7.993	2.622	5.497
2014	Oct-14	HM	Hog Shoal	**20**	2	6.734	0.696	3.259
2014	Oct-14	HM	Hog Shoal	**16**	2	0.233	0.094	0.763
2014	Oct-14	HM	New Beds	**28**	1	13.059	6.330	3.785
2014	Oct-14	HM	New Beds	**23**	1	12.460	2.504	8.611
2014	Oct-14	HM	New Beds	**25**	1	12.370	5.166	3.187
2014	Oct-14	HM	New Beds	**10**	2	8.325	2.955	7.483
2014	Oct-14	HM	New Beds	**9**	2	4.195	0	7.470
2014	Oct-14	HM	New Beds	**52**	2	3.973	1.519	8.937
2014	Oct-14	HM	New Beds	**53**	1	2.499	0.311	7.521
2014	Oct-14	HM	New Beds	**6**	2	0.587	0	3.330
2014	Oct-14	HM	New Beds	**98**	2	0.291	0.025	0.196
2014	Oct-14	HM	Strawberry	**5**	1	2.897	0.505	7.793
2014	Oct-14	HM	Strawberry	**7**	2	0.132	0.025	0.270
2014	Oct-14	HM	Strawberry	**1**	2	0.118	0	0.737
2014	Oct-14	HM	Strawberry	**18**	2	0	0	8.255
2014	Oct-14	HM	Hawk's Nest	**27**	1	3.876	1.925	0.927
2014	Oct-14	HM	Hawk's Nest	**5**	1	0.498	0	3.052
2014	Oct-14	HM	Hawk's Nest	**6**	2	0.199	0	3.863
2014	Oct-14	HM	Hawk's Nest	**17**	2	0	0	11.649
2014	Oct-14	HM	Hawk's Nest	**18**	2	0	0	2.655
2014	Nov-14	HM	Beadons	**3**	1	1.893	0.143	1.003
2014	Nov-14	HM	Beadons	**5**	2	0.669	0.309	0.619
2014	Nov-14	HM	Beadons	**4**	1	0.648	0.450	0.797
2014	Nov-14	HM	Beadons	**15**	2	0.200	0	0.626
2014	Nov-14	HM	Beadons	**16**	2	0.073	0	0.216
2014	Nov-14	HM	Vexton	**4**	1	11.680	16.282	3.801
2014	Nov-14	HM	Vexton	**11**	1	3.494	6.351	3.422
2014	Nov-14	HM	Vexton	**3**	2	0.767	1.282	5.960
2014	Nov-14	HM	Vexton	**17**	2	0.450	0	4.024
2014	Oct-14	HM	Ledge	**6**	1	0.127	0	11.253
2014	Oct-14	HM	Ledge	**15**	2	0.059	0	4.013
2014	Oct-14	HM	Ledge	**7**	2	0	0	9.671
2014	Oct-14	HM	Ledge	**21**	2	0	0	1.524
2014	Oct-14	HM	Ledge	**27**	2	0	0	1.388

Appendix D.1 2014 Intermediate Transplant memorandum for the Medium Mortality Transplant region. The transplant was conducted from April 28 to May 5.

THE STATE UNIVERSITY OF NEW JERSEY

RUTGERS

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May 6, 2014

MEMORANDUM

TO: Russell Babb, Jason Hearon, Craig Tomlin

FROM: Kathryn Alcox

Haskin Shellfish Research Laboratory

SUBJECT: Intermediate Transplant – Medium Mortality Region

An intermediate transplant from Middle, and Sea Breeze beds in the Medium Mortality Transplant region was conducted from April 28 to May 5, 2014. The goal for this transplant was to move 3,517,430 oysters: the 60th percentile exploitation rate for the Medium Mortality Transplant beds listed in Table 7 of the 16th SAW Executive Summary. The SARC advised that no more than half the amount could be taken from Middle bed. There were a total of 13,900 bushels of culled material removed from the Medium Mortality Transplant region by three boats as follows:

7,300 bushels from Sea Breeze	to Shell Rock 7
6,600 bushels from Middle	to Shell Rock 7

Deck samples were obtained from each boat each day with boatloads either measured or estimated by NJDEP. The number of oysters per bushel ranged from 201 to 317 with an average of 250. The percent cultch (not including boxes) in this transplant ranged from 15 to 36% with an average of 25%.

The 60th percentile exploitation rate maximum of 3,517,430 oysters was nearly met at 99% of the goal. Three boats moved a total of 3,473,086 oysters in 13 boat-days. This included 1,341,325 small oysters that are not included in the quota increase calculations and 2,134,148 larger oysters that are included in those calculations. Using the conversion of 264 market-size oysters per bushel, this part of the transplant can increase the quota by up to 8,084 bushels.

OYSTERS PER BU	BOAT 1	BOAT 2	BOAT 3
4/28/14	242	281	269
4/29/14	248	--	242
5/1/14	244	284	317
5/2/14	249	201	208
5/5/14	222	--	246

PERCENT CULTCH	BOAT 1	BOAT 2	BOAT 3
4/28/14	26%	20%	24%
4/29/14	24%	--	25%
5/1/14	30%	23%	18%
5/2/14	15%	36%	33%
5/5/14	26%	--	25%

PERCENT BOXES	BOAT 1	BOAT 2	BOAT 3
4/28/14	16%	11%	5%
4/29/14	7%	--	12%
5/1/14	12%	12%	6%
5/2/14	9%	12%	17%
5/5/14	4%	--	7%

Appendix D.2 2014 Intermediate Transplant memorandum for the Low Mortality region. The transplant was conducted from May 6 to May 12.

THE STATE UNIVERSITY OF NEW JERSEY

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May 13, 2014

MEMORANDUM

TO: Russell Babb, Jason Hearon, Craig Tomlin

FROM: Kathryn Alcox

Haskin Shellfish Research Laboratory

SUBJECT: Intermediate Transplant – Low Mortality Region

An intermediate transplant from Arnolds bed in the Low Mortality region was conducted from May 6-12, 2014. The goal for this transplant was to move 6,403,869 oysters: the 60th percentile exploitation rate for the Low Mortality region listed in Table 7 of the 16th SAW Executive Summary. The SARC recommended alternating donor transplant beds in this region. In 2013, the bulk of the transplant came from Upper Arnolds; this year the whole transplant came from Arnolds. There were a total of 15,500 bushels of culled material removed from Arnolds bed in the Low Mortality region by three boats. Transplants were placed on Ship John 21.

Deck samples were obtained from each boat each day with boatloads either measured or estimated by NJDEP. The number of oysters per bushel ranged from 298 to 519 with an average of 398. The percent cultch (not including boxes) in this transplant ranged from 10 to 38% with an average of 22%.

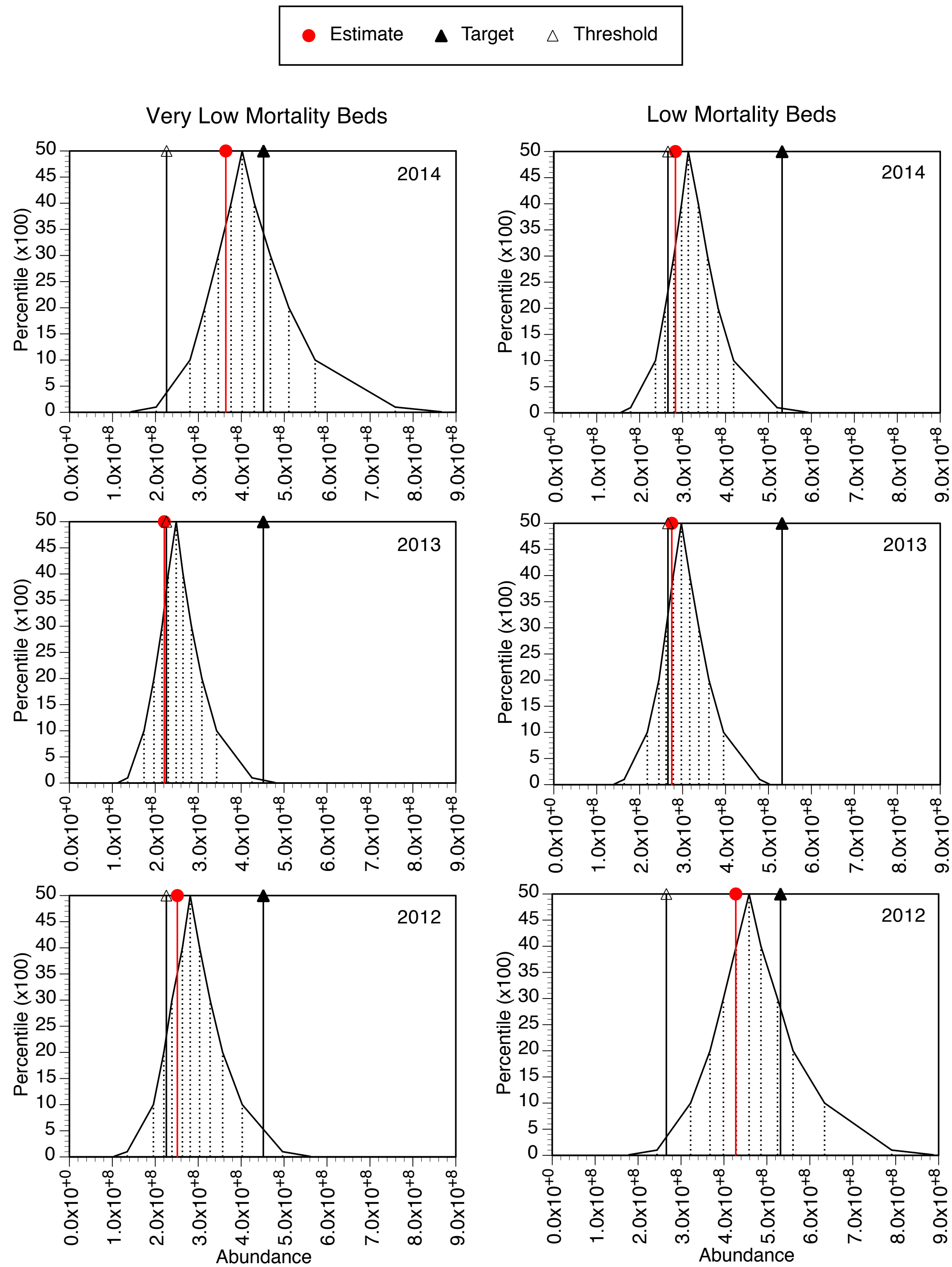
The 60th percentile exploitation rate maximum of 6,403,869 oysters was nearly met at 96% of the goal. Three boats moved a total of 6,134,370 oysters in 14 boat-days. This included 2,993,960 small oysters that are not included in the quota increase calculations and 3,174,627 larger oysters that are included in those calculations. Using the conversion of 264 market-size oysters per bushel, this part of the transplant can increase the quota by up to 12,025 bushels.

OYSTERS PER BU	BOAT 1	BOAT 2	BOAT 3
5/6/14	362	401	298
5/7/14	349	--	314
5/8/14	388	476	501
5/9/14	431	445	401
5/12/14	332	519	354

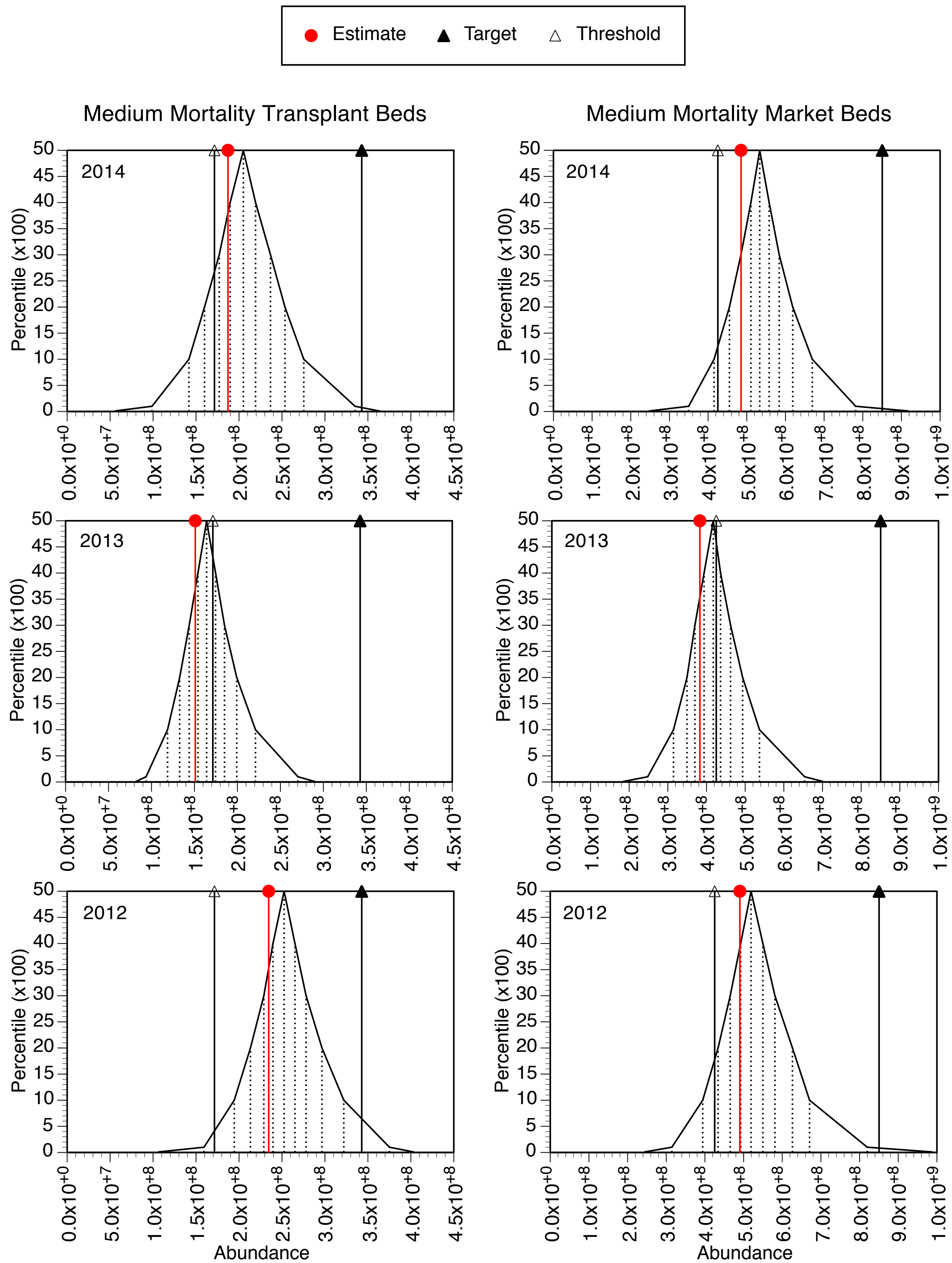
PERCENT CULTCH	BOAT 1	BOAT 2	BOAT 3
5/6/14	20%	12%	32%
5/7/14	38%	--	34%
5/8/14	14%	10%	12%
5/9/14	22%	9%	30%
5/12/14	36%	11%	31%

PERCENT BOXES	BOAT 1	BOAT 2	BOAT 3
5/6/14	7%	12%	9%
5/7/14	6%	--	7%
5/8/14	2%	7%	6%
5/9/14	2%	3%	2%
5/12/14	5%	9%	16%

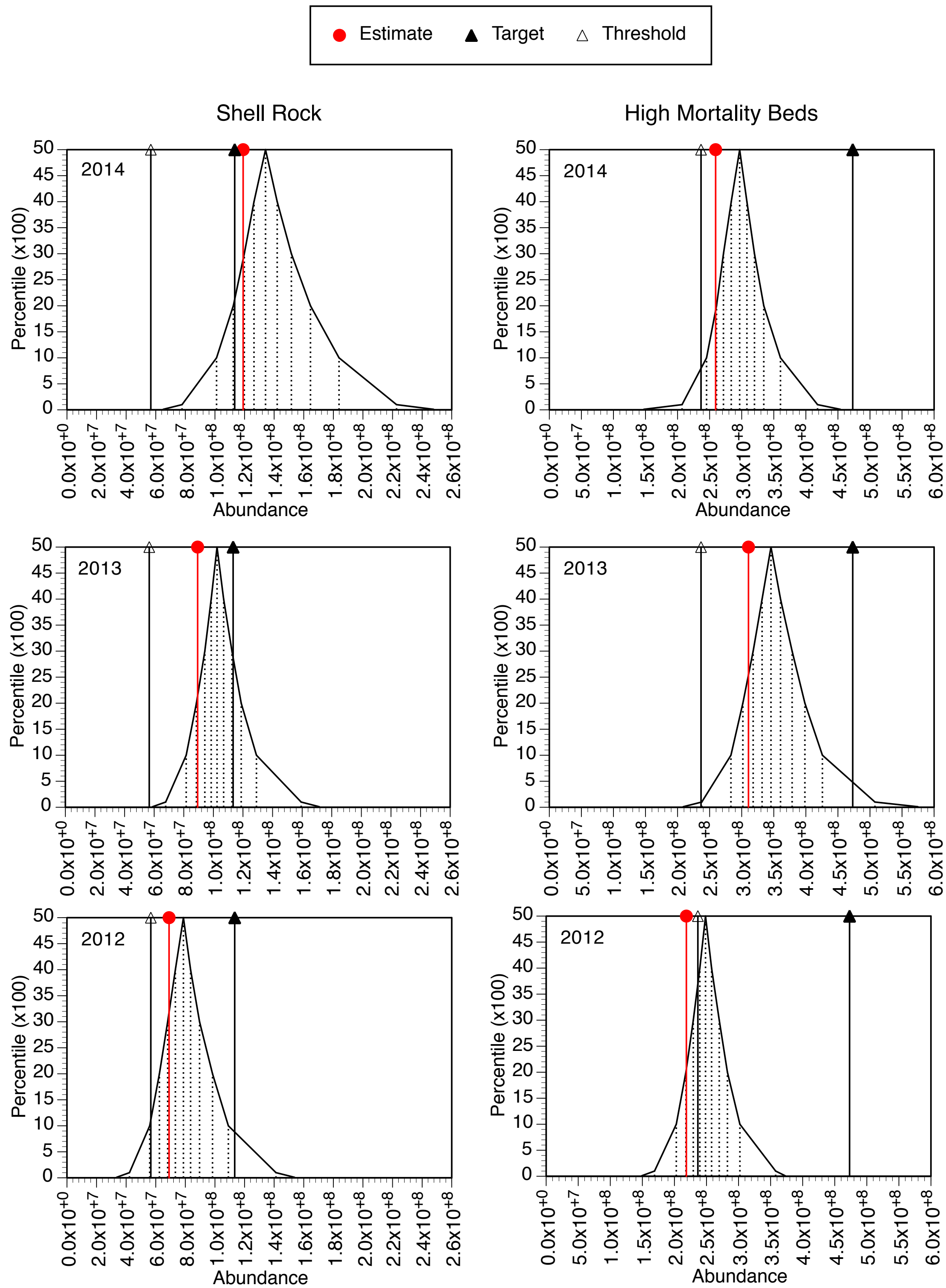
Appendix E.1.1. 2014 total abundance estimates for the Very Low Mortality and Low Mortality regions within confidence percentiles for the 2014 survey taking into account between-sample variation and uncertainty in dredge efficiency. Stock-performance reference points from Table 16 are included for comparison as are two previous years of survey data. Note that the percentiles (P) above the 50th are shown as $1 - P$ so that, for example, the 60th percentile is indicated as the 40th percentile but on the right-hand side of the curve.



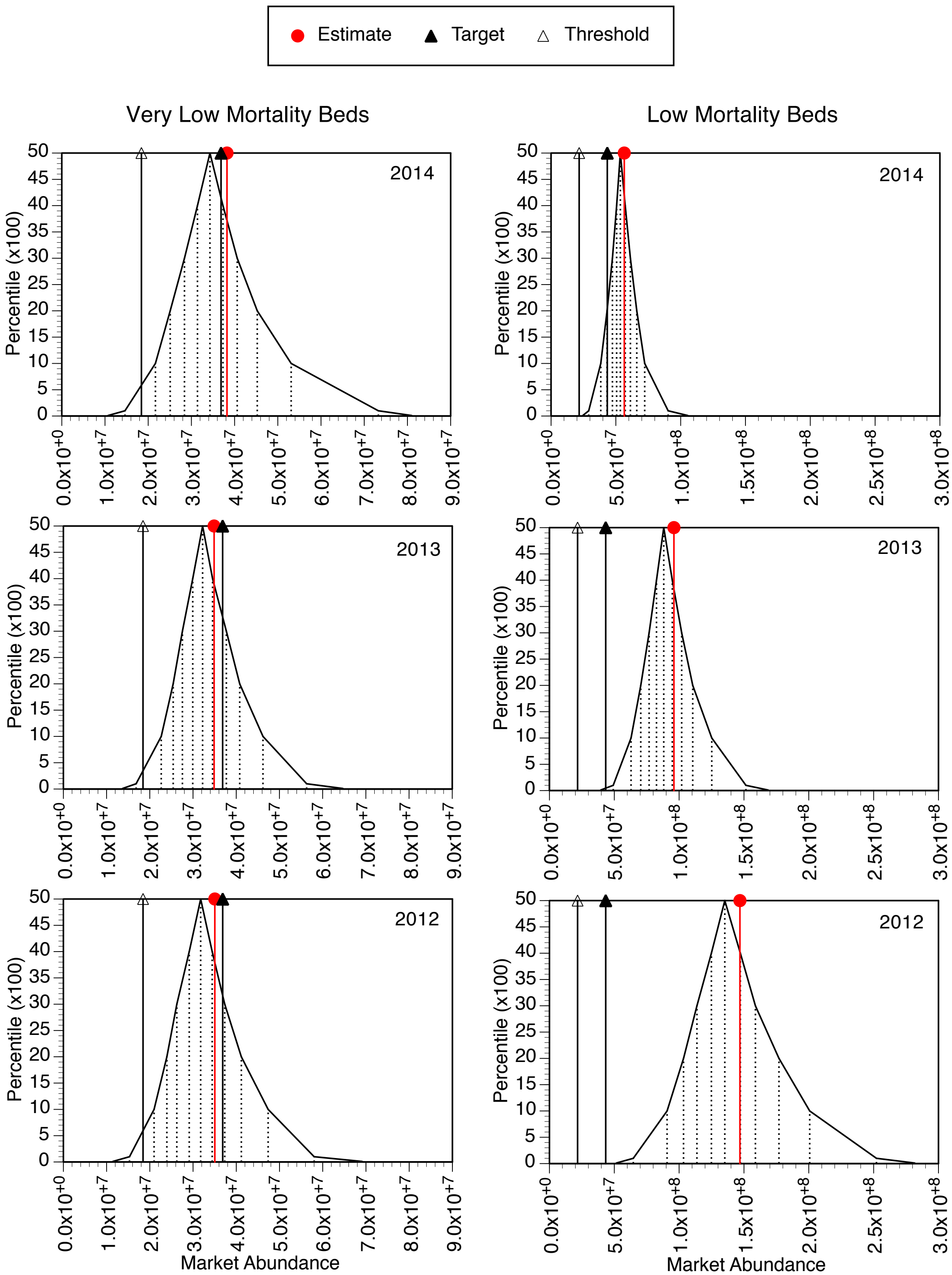
Appendix E.1.2. 2014 total abundance estimates for the Medium Mortality Transplant and Market regions within confidence percentiles for the 2014 survey taking into account between-sample variation and uncertainty in dredge efficiency. Stock-performance reference points from Table 16 are included for comparison as are two previous years of survey data. Note that the percentiles (P) above the 50th are shown as $1 - P$ so that, for example, the 60th percentile is indicated as the 40th percentile but on the right-hand side of the curve.



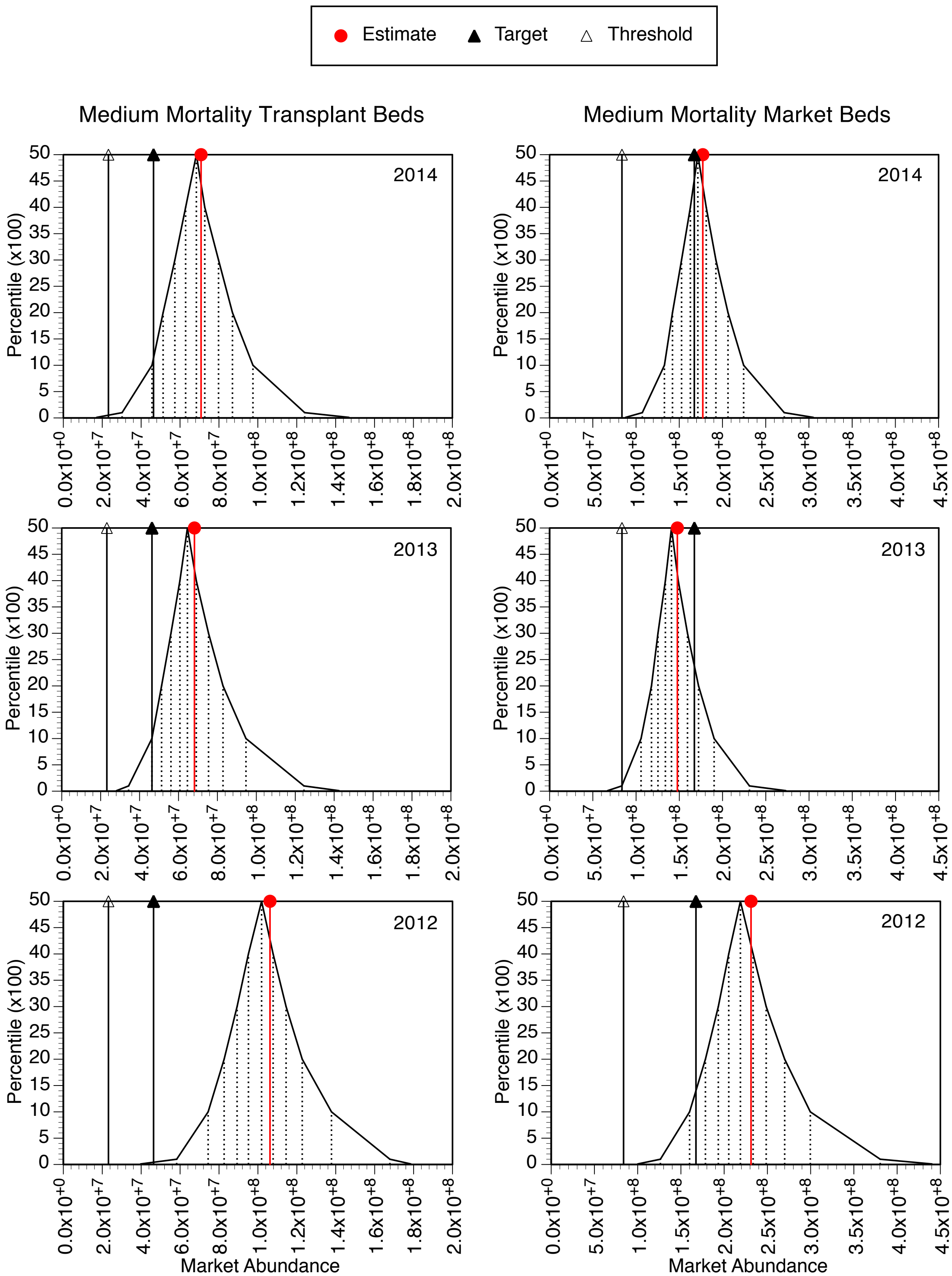
Appendix E.1.3. 2014 total abundance estimates for Shell Rock and the High Mortality region within confidence percentiles for the 2014 survey taking into account between-sample variation and uncertainty in dredge efficiency. Stock-performance reference points from Table 16 are included for comparison as are two previous years of survey data. Note that the percentiles (P) above the 50th are shown as 1 – *P* so that, for example, the 60th percentile is indicated as the 40th percentile but on the right-hand side of the curve.



Appendix E.2.1. 2014 market-size (≥2.5”) abundance estimates for the Very Low Mortality and Low Mortality regions within confidence percentiles for the 2014 survey taking into account between-sample variation and uncertainty in dredge efficiency. Stock-performance reference points from Table 16 are included for comparison as are two previous years of survey data. Note that the percentiles (P) above the 50th are shown as 1 – *P* so that, for example, the 60th percentile is indicated as the 40th percentile but on the right-hand side of the curve.



Appendix E.2.2. 2014 market-size (≥2.5") abundance estimates for the Medium Mortality Transplant and Market regions within confidence percentiles for the 2014 survey taking into account between-sample variation and uncertainty in dredge efficiency. Stock-performance reference points from Table 16 are included for comparison as are two previous years of survey data. Note that the percentiles (P) above the 50th are shown as $1 - P$ so that, for example, the 60th percentile is indicated as the 40th percentile but on the right-hand side of the curve.



Appendix E.2.3. 2014 market-size (≥2.5”) abundance estimates for Shell Rock and the High Mortality region within confidence percentiles for the 2014 survey taking into account between-sample variation and uncertainty in dredge efficiency. Stock-performance reference points from Table 16 are included for comparison as are two previous years of survey data. Note that the percentiles (P) above the 50th are shown as 1 – *P* so that, for example, the 60th percentile is indicated as the 40th percentile but on the right-hand side of the curve.