Haskin Shellfish Research Laboratory
Rutgers, The State University of NJ
6959 Miller Avenue, Port Norris, NJ 08349

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New Jersey Delaware Bay Oyster Beds
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Final Report

Presenters (Haskin Shellfish Research Laboratory)
Kathryn Ashton-Alcox, David Bushek, Jason Morson, Daphne Munroe

Stock Assessment Review Committee
Scott Bailey, Delaware Bay Oyster Industry
Michael Celestino, New Jersey Department of Environmental Protection
Steve Fleetwood, Delaware Bay Section of the Shell Fisheries Council
Jason, Hearon, New Jersey Department of Environmental Protection
Gerald Kauffman, University of Delaware
Patrick Sullivan, Cornell University
Mitchell Tarnowski, Maryland Department of Natural Resources
John Wiedenmann, Rutgers University
Richard Wong, Department of Natural Resources and Environmental Control

Editors (Haskin Shellfish Research Laboratory)
Kathryn Ashton-Alcox, David Bushek, Jenn Gius, Jason Morson, Daphne Munroe

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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 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 (Table 1). 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 mortality, generally corresponding 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 and oyster abundances were high. Circa-1990, Dermo disease, caused by the parasite *Perkinsus marinus* became prevalent in the Delaware Bay and effectively doubled natural mortality rates (Powell et al. 2008b). It has been the major control on the oyster population in the Delaware Bay since 1990. 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 5a and b).

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)]. The VLM, LM, and MMT became intermediate transplant regions because oysters there are generally smaller and of insufficient quality to market directly. Use of them by intermediate transplanting helps alleviate harvest pressure on the direct market regions when natural mortality has been high and recruitment has been low in those regions.

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, Sea

Breeze, a medium-mortality bed, was assigned to the market, rather than the transplant, group. As a direct market bed, Sea Breeze was rarely used for harvest. 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 was shortened to 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 6).

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 (Powell et al. 2001a) and eventually, a submarket surplus model developed by Powell et al. (2009). The direct market harvest is conducted in three regions (Figure 1): High Mortality (HM), Shell Rock (SR), and Medium Mortality Market (MMM). In 2004, a port-sampling program began to obtain fishery-dependent information on the size and number of oysters marketed, permitting the calculation of exploitation rates on spawning stock biomass as well as abundance (Powell et al. 2005).

As explained above, three of the six regions are designated for Intermediate Transplant (Figure 1): Very Low Mortality (VLM), Low Mortality (LM), and Medium Mortality Transplant (MMT). Intermediate transplanting moves an allocation of oysters from the non-marketable upbay regions to the more saline, direct market regions where they quickly depurate, attain market quality, and enhance the quota in the receiving region. Transplanting and area management were instituted to make use of the whole resource and to avoid overfishing of any one region (see HSRL SAW reports 2001 to 2005).

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. During this 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. The 2016 SARC refined this exploitation system by using the median of the regional exploitation rate histories from 2007-2015 as the starting point for quota decision-making and allowing percentage changes from that median in either direction from no harvest up to the maximum exploitation rate from 2007-2015 based on stock status for the region (see 2015 Science Advice Progress later in this report).

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 initiated to differentiate oysters counted as a spat (young-of-the-year recruits) from the oysters included in total abundance estimates.

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 dredge efficiency experiments performed between 1998 and 2003 indicated that the oyster beds could be divided into two groups; upbay and downbay with Shell Rock in the downbay group. The dredge captured oysters, boxes, and cultch more efficiently on the downbay beds than on those upbay. Catchability coefficients[1] calculated from these experiments are applied to survey dredge hauls 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

[1] The catchability coefficient (q) as defined in Powell et al. (2002) is the reciprocal of dredge efficiency *e*: q =*1/e*.

bay bottom. Additional dredge efficiency data and analyses have led to changes in the way dredge efficiency is applied in the stock assessment although the basics remain the same. The changes are described in a later section.

In 2005 by request from the 6^{th} SARC, the survey time series from 1953 to 1997 was retrospectively quantitated. For a complete explanation of the time series reconstruction, see Powell et al. 2008b. In brief, survey samples were divided into volumes of oysters and cultch, and oysters per bushel were calculated throughout the time series. The survey was quantified in 1998 using measured tows and dredge efficiency corrections, permitting estimates of oysters and cultch per m^2. Using the assumption that cultch density is relatively stable over time, oysters per m^2 for each survey sample can be estimated by the relationship between oysters per bushel and cultch per bushel in a sample and the relationship between the cultch per bushel and the average cultch density for each bed (see equation 3 in Powell et al. 2008b). The latter estimates were obtained by using bed-specific cultch density determined empirically from 1998-2004. 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. 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 (Kraeuter et al. 2006). The restratification kept the three strata system within beds and used oyster 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 restratifies each bed approximately once per decade (Table 2). Analysis of many survey simulations suggested that a random survey based on the High and Medium quality strata is sufficient (Kraeuter et al. 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.

2015 Science Advice Progress

Backup Survey Vessel

The annual NJ oyster stock assessment survey has used the commercial fishing vessel *F/V Howard W. Sockwell* and standard commercial dredges since the 1989 survey. This wooden boat is over 100 years old, and one of the larger vessels in the fleet. Due to the demands on it for marketing and for maintenance, it is sometimes logistically difficult to schedule survey days for the spring resurvey program and the fall assessment program. The suggestion was made to evaluate a similar boat to be used as a substitute if necessary. The overall estimate of oyster abundance can be influenced if the efficiency between survey vessels for catching oysters varies, so a field comparison is necessary. The *F/V Peter Paynter* is a similarly designed boat and was chosen as the comparison vessel.

On May 21, 2015, an experiment comparing the estimated oyster abundance from dredge catches by the *Sockwell* versus the *Paynter* was performed. Each boat carried a captain, mate, and science crew. There were identical port and starboard dredges on each boat, with 50" toothbar, 3" teeth and chain mesh bags of the same link diameters and maximum capacity (6-7 US bushels-37qt). The hoppers for each of the 4 dredges were calibrated to bushels of oysters and marked with solder. Differences between the boats include the draw (6 ft for the *Sockwell*, 4.5-5 ft for the *Paynter*) and the shape of the hoppers from which total haul volumes are measured: tall and square for the *Sockwell*, shorter and more rectangular in bow-stern direction for the *Paynter* hoppers.

The experiment was performed on Shell Rock grid 2, an area with plentiful oysters. A buoy was placed in the center of the grid and 100 paired tows were taken around it using survey protocol of 1-min bottom time. Each tow was measured using GPS and total haul was recorded.

A subsample of approximately $^1/_3$ bushel was taken from each haul. Halfway through the experiment, the captains switched boats such that for tows 1 through 50, Captain 1 was on the *Sockwell* and Captain 2 was on the *Paynter*: tows 51-100 had Captain 2 on the *Sockwell* and Captain 1 on the *Paynter*. The *Paynter* began the experiment using the port-side dredge and the *Sockwell* began with the starboard dredge in order for the boats to remain as close as possible in the bottom covered. The captains switched dredge side at tows 22 and 75 such that each boat:captain pair performed a comparable number of tows with the dredge on each side of the vessel. Subsamples were taken back to the lab and evaluated for proportion of oysters vs cultch, boxes, and debris. Oysters and boxes were counted and measured. Oysters per m^2 were calculated by multiplying subsample numbers up to total haul volume and dividing by swept area (distance x dredge width).

The parameter chosen to evaluate any difference between the boats was oysters per m^2 estimated from each. The paired tow data allow for a direct comparison of oyster density estimated for each boat under common conditions. Controlling for captains by switching them midway through the study balanced out differences between them, resulting in no significant difference in estimated oyster density being observed between the two vessels (Wilcoxon paired rank test, $p=0.90$, Figure 7). The data evaluated here indicate that the substitution of the *F/V Peter Paynter* for the *F/V Howard W. Sockwell*, if necessary, would not impact the NJ Delaware Bay oyster stock assessment results. Although, the experiment was not designed to test for them, the SARC discussed captain differences and the potentially confounding effect of tide, ultimately suggesting that randomizing boats and captains could minimize any effects on survey results.

Application of Updated Catchability Coefficients

Evaluation of dredge efficiency data collected in September 2013 was completed and used to update abundance estimates with more accurate catchability coefficients (q) defined here and in previous reports as the reciprocal of dredge efficiency (see Gear Efficiency Corrections). The two major changes were (1) the determination that temporal variability was not a factor, allowing catchability coefficients to be applied uniformly across the entire time series, and (2) the refinement of the spatial pattern in dredge efficiency (Table 3). These changes have no effect on harvest data or quotas but they improve the accuracy of abundance estimates. Notably, they reduced estimates of abundance on the Very Low Mortality region suggesting that it was being fished at higher exploitation rates than previously thought. This was countered by increases in abundance estimates on Shell Rock, partially corroborating fishing reports that there were more oysters on Shell Rock than previously estimated.

Exploitation Rate Flexibility

As explained earlier (Historic Overview, The Fishery), the exploitation rates used in the NJ oyster stock assessment have been based on percentiles from the 1996-2006 exploitation records. 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. Initially, 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 since the direct market fishery began in 1996 to 2005, the latest data year at that time. To provide flexibility in management, the SARC recommended using the 50^{th} percentile of exploitation as a base but to allow increasing exploitation to the 60^{th} percentile rate when the population was expanding or to reduce it to the 40^{th} percentile rate if the population was decreasing or appeared unstable, e.g., during periods of increased disease mortality.

The basic approach and time period 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 are removed proportionately in deckloading transplants and one using a knife-edge assumption that size classes ≥ 2.5" were removed proportionately for direct market by pickers on the boat crews. Fishing activity during the 1996-2006 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 sparse for the Transplant regions that it was decided that they should share the same set of exploitation rates.

Because the regional exploitation rates were based on a relatively short time series, the percentiles did not always transition linearly, sometimes offering little difference between percentiles and sometimes spanning a large range (Figure 8). For example, the change from the 40^{th} to 50^{th} percentile in the High Mortality region spans a much larger range of exploitation than that of the 25^{th} to 40^{th} percentiles whereas Shell Rock's 40^{th} and 50^{th} percentiles are almost identical at 3.28 and 3.31%, respectively. Consequently, if market-size oyster abundance was low on Shell Rock and other parameters were not promising, the choice for conservative exploitation was constrained to fishing below the 40^{th} percentile. To overcome a problem in the Transplant regions, the 2009 SARC made an adjustment to the original set of exploitation percentiles in order to smooth a temporally biased change in exploitation rates at the 50^{th} percentile that separated as high and low. The 50^{th} and 60^{th} percentile values from the original data were averaged. That average was used as the 50^{th} percentile and the previous 50^{th} percentile was used as the 40^{th}. To address the problem of a narrow range of low exploitation rates on the MMM (the 100^{th} percentile exploitation rate on the MMM was below the 10^{th} percentile exploitation rate on nearby Shell Rock) the SARC had regularly recommended an 'experimental' fishery at the 100^{th} percentile rate of exploitation on the MMM (Figure 8).

The 2015 SARC specified a desire to have more regular changes between exploitation rates within each region; however, it did not suggest that the basic quota range of the 1996-2006 exploitation time period's 40^{th} to 60^{th} percentiles should be changed.[1] The 2016 SARC examined realized fishing exploitation rates since the adoption of the 1996-2006 baseline time period i.e., 2007 to 2015 (Figures 9a and b) and concluded that the median of the realized exploitation rates from 2007-2015 should be used as an exploitation target going forward and that it should be bounded by the range of realized rates from that period (Figures 9a and b). The fishery will thus continue to operate within the original bounds of the 1996-2006 time period. Rates on the quota tables provided later in this report are labeled as follows: 50^{th}, the 2007-2015 exploitation median; Min, the 2007-2015 exploitation minimum; and Max, the 2007-2015 exploitation maximum. A lower level of exploitation, halfway between the minimum and zero called SubMin, is also provided in case the population in a particular region is experiencing low abundance but not so low that closure is recommended. Further, the 2016 SARC agreed on the option to vary from the median of the 2007-2015 exploitation by percentage increments for flexibility. These percentages may be as fine or as coarse as desired. Due to its 3-year time series of exploitation, the VLM options are labeled simply Min, Mid, and Max on the table later in this report.

Sources of Error Within the Assessment

To generate the annual estimates of abundance for each region, high and medium quality grids are chosen randomly from each bed in the region and sampled to generate a relative estimate the oysters/m^2 on each grid. Catchability coefficients estimated by dredge efficiency experiments (see Gear Efficiency Corrections) are applied to the relative density estimates to calculate corrected-density estimates for each grid. The corrected-density estimates for all grids within a stratum on a given bed are then averaged to generate a strata-specific density estimate for each bed. These strata-specific estimates of density are then multiplied by the area of each stratum to generate the total abundance of oysters in each stratum on each bed. Strata-specific abundances are summed across beds and beds are summed across regions to generate the annual estimate of abundance in a region.

Given the approach detailed above, there are two potential sources of error associated with the annual abundance estimates in each region. First, there is variability in oyster density within each stratum, hereafter referred to as the survey error. Second, there is variability in the estimate of the catchability coefficient being applied to the relative oyster density measured on each grid, herein referred to as the dredge efficiency error. We used 1,000 bootstrap simulations to estimate each source of error separately. For the survey error estimates, the catchability coefficients were fixed and grids were sampled randomly with replacement, within each stratum, to generate a new set of stratum-specific estimates of density for each new simulation. For the dredge efficiency error estimates, for each new simulation, the abundance on each grid was fixed

[1] It should be reiterated that the data in this report has been reconstituted using updated catchability coefficients that do not vary through time (see previous section and Table 3) but the suite of exploitation rate percentiles upon which the system is based represent abundances and exploitation fractions calculated using temporally-varying catchability coefficients.

at that observed on the survey, and the catchability coefficients applied to each abundance estimate were drawn at random with replacement, from a list of 69 estimates generated from experiments conducted from 1999-2013. For both sources of error, the error bars on the abundance estimates represent the 10th and 90th percentiles of the simulated distributions.

Market abundance for three years (2012-2014) was used to evaluate each source of error separately. Relative to survey error, the survey error bars overlap in all three years evaluated for the Very Low Mortality region only (Figure 10). For all other regions, the survey error bars do not overlap among all years. Relative to dredge efficiency error, with the exception of the Low Mortality region between 2013 and 2014, the error bars overlap in all years and on all regions. For all regions except Very Low Mortality (VLM), error due to dredge efficiency is larger than survey error. This is because there is less variation amongst the catchability coefficients specific to the VLM region. The SARC expressed concerns that it may not be appropriate to separate these two sources of error and that additional methods to estimate error should continue to be investigated to better understand the accuracy of survey estimates when comparing the significance of change over time.

Spat-to-Oyster Transition Size

While the numbers of spat are counted and used as a parameter to evaluate the status of the regional stocks in the NJ Delaware Bay oyster stock assessment, they do not enter the estimates of oyster abundance nor are they included when determining exploitation rates. A cutoff size of 20mm, the approximate average size of young of the year oysters in the NJ resource, is used to describe a settled 'spat' as opposed to an 'oyster' (see Stock Assessment Design, Analytical Approach). Commonly, spat of unknown age are delineated from older oysters by morphology. If the growing edges of small oysters are flat to their substrate and smooth, they are considered spat. If the edges are lifting off their substrate and the oyster is starting to have a cupped lower valve and/or ridges ('growth lines') forming on the upper valve, it is considered to be older than a spat. Differing evaluations can result amongst people due to inexperience and the size/morphology differences of young oysters over the extensive salinity and growth range from upbay to downbay in the Delaware Bay.

Evaluation of the size at which an oyster is no longer considered a spat was conducted based on morphology of individual oysters. Experienced technicians measured shell height and defined each individual as spat or oyster. Measurements included in this analysis were made monthly throughout two seasons, 2014 and 2015 for various beds throughout the Bay. The total dataset includes 2344 observations of small oyster length and spat category. A test of the sensitivity of these observations to technician bias was performed for the previous (2014) assessment and demonstrated that observer did not significantly affect the size at which the spat-to-oyster transition is defined. For the remainder of this discussion, the influence of observer is not included and the spat-to-older-oyster size will be referred to as 'the transition size'. Logistic regression was used to estimate the size at which an oyster no longer appears to be a spat (the response variable, oyster code) with oyster size, year, month and bed region as explanatory variables. Stepwise AIC (Akaike, 1974) was used to select the best model to explain variation in the spat to oyster transition. The best fit model is as follows:

$$\text{OysterCode} \sim \text{Size} + \text{Bed} + \text{Month}$$

Year was not included in the best-fit model, and logistic fit among years did not significantly differ when holding month constant as shown in Figure 11a. The influence of bed region on the size at morphological transition, holding month constant, is shown in Figure 11b. The transition size tends to increase with increasing salinity (moving from upbay regions to downbay regions), with the exception of the Medium Mortality Market region which groups with more upbay regions. The influence of month on the transition size is shown in Figure 11c with May and November having the largest transition size and all other months shifting from spat to oyster at approximately 25mm. During the Fall assessment period (October–November), the size of transition from spat to oyster is generally larger than the 20mm cutoff that is currently employed. Figure 11d shows the transition sizes for each bed region in 2014 and 2015. In general, the transition size increases as one moves downbay with approximately two groups of regions: one upbay (VLM, LM, MMM) with an average morphological transition size of ~22mm; the other downbay (MMT, SR, HM) with an average transition size of ~30mm.

Since at least the 2010 SAW, Science Advice from the SARC has included the need to ‘reconfigure the recruitment index’ and ‘develop an improved spat cut-off size’. The 2016 SARC advised that analyses be continued to investigate the effect of regionally differential spat cutoff sizes on the estimates of spat and oyster abundance in the assessment (see Science Advice).

Control rules

The quota for the NJ Delaware Bay oyster fishery is derived annually by recommendations from the SARC, decisions made by the NJ Shellfisheries Council (Delaware Bay Section), and the acceptance of those decisions by the NJDEP (Table 1). The total quota is the sum of the exploitation decisions for the three direct market regions (plus additional quota as a result of transplants from the non-market regions to direct market regions) allocated across the number of oyster licenses held. It is a simple abundance-based calculation. For each region, the fall survey market-size oyster abundance is multiplied by a chosen exploitation rate and divided by the average number of oysters per market bushel derived from a port-sampling program (in the Transplant regions, total oyster abundance is used, not market-size abundance). This protocol began in 2007 as result of previous years of SARC and Oyster Industry Science Steering Committee recommendations and assessment evolution.

Exploitation rates based on percentiles of 1996-2006 exploitation records (direct market, Dermo disease era) were used by the SARC to establish options from 2007-2015. The recommendations usually given to the Council by the SARC were based on the median and loosely bounded by the 40th and 60th percentile rates with occasional decreases and increases in exploitation rate percentile as discussed earlier in the preceding Exploitation Rate Flexibility section. The 2016 SARC recommendations are based on the median of realized exploitation from the 2007-2015 period (that used the 1996-2006 percentiles). Flexibility is now bounded by the minimum and maximum values of exploitation from the later period and a lower value between zero and the minimum. Percentage changes from the median supply further flexibility for quota option recommendations.

Information available to the SARC to make recommendations includes: the status of the stock report details, an estimate of current abundance relative to biological reference point targets/thresholds for each region, regional summaries, and a stoplight diagram representing the overall condition by region. The latter includes abundance indicators, spat settlement success (recruitment potential for following year) and trends in oyster disease (specifically Dermo disease) which has been the leading cause of oyster mortality since about 1990, far outweighing fishing mortality.

The 2015 SARC requested explanation and elaboration of control rules describing how to move among different exploitation rates based on the status of the stock. The 2016 SARC provides the following:

Control Rules. Control rules have been implicitly applied at every SAW though never explicitly articulated nor provided as guidance for SARC members. Here we articulate the basic process used to manage the New Jersey Delaware Bay Oyster Fishery. They are updated with the new exploitation targets, flexibility and bounds.

1. *Area Management*: Harvest and management activities are set by region to help ensure that no area receives more harvest pressure than it can sustain.

2. *Baseline Abundance Targets*: Target abundances and thresholds for each region are set by the median and half the median from the time series between 1989 and 2005, inclusive. Targets and thresholds of market-size oysters (>2.5”) and SSB are set the same way but using the period 1990-2005. Both periods represent the current disease regime (the Dermo era) and include high and low recruitment, growth, disease and mortality.

3. *Additional Population Indicators*: Trends in abundance, recruitment, disease, mortality and other factors are summarized (region trends panels and stoplight table) to develop expectations of population change in the coming year(s) in order to inform harvest and management decisions.

4. *Exploitation Targets*: The 2016 SARC updated the exploitation targets for each region as the median rates realized between 1997 and 2015 as explained above.

5. *Exploitation rate flexibility*: The range of rates employed between 1997 and 2015 provides bounds that can be used to assist in balancing harvest and management goals if necessary. Movements away from the median value require justification based upon the status of the stock, its position relative to targets and thresholds, anticipated changes to the stock, or management activities (transplanting from upper regions to lower). Because the bounds are not equally distributed about the median nor will movement from the median to a bound always be necessary, movement away from the median should be in percentage points of the median, generally in increments of 10% for simplicity. Strong justification is required for movement beyond bounds that have proven sustainable for the fishery.

6. *Management Tools*: Transplanting oysters from upbay regions to Direct Market regions (aka the Intermediate Transplant Program) and shellplanting (either directly or via replanting) are used to make market size animals accessible to the fishery or to enhance or to rebuild abundance in a given region. Transplants may be used to justify increased rates of exploitation on recipient Direct Market regions. No more than half of any transplant from the MMT should come from Middle bed; the remainder should come from Upper Middle and/or Sea Breeze in any proportion. Transplants from the LM should alternate in sequence between Arnolds and Upper Arnolds/Round Island.

Stock Assessment Design

Sampling Methodology

As discussed earlier, 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 oyster densities that cumulatively contain 2% of a bed's 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. 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 a bed's stock are designated as the `Medium Quality' stratum and the rest that cumulatively account for the upper 50% 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. The 18th SARC (2016) revised this schedule to resurvey Shell Rock in 2016 rather than in 2022 when it would otherwise have been due. To accommodate the change, other shifts occurred to maintain the original premise of the schedule: 1) to resurvey beds every decade and 2) when multiple beds are scheduled, they are in separate regions in case of differential change throughout the resource (Table 2).

Gear Efficiency Corrections

Densities of oysters, boxes, and cultch from each survey sample are calculated based on the area swept by the dredge, the total haul from which the sample was taken, and the

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.

appropriate catchability coefficients (q) to correct for dredge efficiency[1]. Work from 1999 to 2003 to establish these coefficients for the oyster beds in Delaware Bay is described in Powell et al. 2002, 2007. Briefly, the differences between bottom samples from parallel transects of measured tows by a commercial dredge from the *F/V Howard W. Sockwell* and quadrat samples collected by divers presumed to be 100% efficient were calculated. Analyses of these data 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. Concerns about the effect that natural bay bottom changes over time might have on dredge efficiency led to different q-values applied to the time series of survey results (Table 3). The 1998-2000 survey results used average q-values from dredge efficiency projects of that timeframe. Surveys from 2001-2004 used q-values that also included results from the 2003 dredge calibration project in their average. These were also applied to surveys prior to 1998. Surveys from 2004-2014 used only the 2003 average q-values.

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. Further details can be found in Ashton-Alcox et al. 2014. Spatial and temporal analyses of these data in 2014 compared the 2013 patent tong experiments to the 1999, 2000, and 2003 dredge-diver experiments described above (Ashton-Alcox et al. 2015). Previous analysis of a subset of these data suggested the efficiency of the sampling gear might have been changing over time in some regions (Powell et al. 2007). To account for these changes, separate sets of catchability coefficients were applied to different parts of the time series (Table 3). However, an updated analysis that includes data collected from all years shows no statistically significant temporal trend in gear efficiency (Ashton-Alcox et al. 2015). Thus, data from all experiment years may be averaged together within bed groups, a point on which the 2015 SARC indicated agreement. The spatial analyses show that the original Upbay dredge efficiency bed group should be further divided for a total of three groups. This is due to 2013 dredge-tong comparisons on beds farther upbay than Arnolds, the previous most upbay site used for efficiency experiments. The third group contains data from Round Island and Hope Creek (Figure 1). Additionally, results indicate that Shell Rock should be included with the Upbay group of beds rather than the Downbay group.

For the data presented at the 18th SAW, all years of efficiency data are averaged as discussed above into three groups: Downbay (encompassing all beds downbay of Shell Rock), Upbay (Shell Rock to Upper Arnolds), and Far Upbay (Round Island to Hope Creek). The catchability coefficients (q) for these groups are listed in Table 3. To clarify, the Far Upbay

[1] The catchability coefficient (q) as defined in Powell et al. (2002) is the reciprocal of dredge efficiency *e*: q =*1/e*.

group q applies to the following beds: Round Island, Hope Creek, Fishing Creek and Liston Range, ie. Round Island and the VLM. Upper Arnolds and Arnolds remain with the Upbay group.

The entire time-series has been reconstructed using a single set of catchability coefficients as detailed above.[1] This change has results in an abundance shift along the entire time series equivalent to the shift from previously-calculated to newly-calculated catchability coefficients. Similarly, previously-calculated exploitation rates have shifted equivalently as have the target and threshold biological reference points for each regions. When interpreting how these changes influence the stock assessment and management of the resource, it is important to consider the following three points: 1) Our understanding of how heavily the stock in any region has been exploited has changed; 2) Our understanding of where the stock is in any region, relative to the reference points has not changed; and 3) Potential harvest to be fished from any region remains fixed because the original set of exploitation rates is based on the reference period of 1996 to 2006 (see Ashton-Alcox et al. 2015).

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 $\geq$ 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 $\geq$ 35 mm are considered to be adults. Calculations of spawning stock biomass (SSB) are based on the $\geq$ 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 sometimes divided into individuals $\geq$ 76 mm (3") and individuals $\geq$ 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

[1] All estimates throughout the survey time series have been updated to reflect the updates in catchability coefficients. Because of this, data for all years in this document will follow comparable trends to earlier reports but the scales will not match.

harvested oysters are ≥ 63.5 mm (2.5”) and historical use of the 76-mm (3”) boundary to define a market oyster. In this report, market-size oysters are considered to be those ≥ 63.5 mm (2.5”).

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 within a bed’s dredge efficiency group (Powell et al. 2008a). 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. Prior to this report, the dredge efficiency choices included those calculated for three oyster size classes (< 2.5”, 2.5-3”, and >3”). Because of the tendency of oysters of different sizes to clump together, this system of choice resulted in biases such that the survey point estimate did not usually fall near the 50th percentile of the simulated surveys (see Ashton-Alcox et al. 2015, Figure 27). For the results presented in this report, there is an ‘all-size’ suite of oyster efficiency estimates from which the random pulls are drawn.

2015 Spring Resurvey

For the current assessment, the strata for two beds, Arnolds in the Low Mortality region and Strawberry in the High Mortality region, were updated based on a Spring 2015 resurvey of each grid on the beds. Arnolds has 99 grids but 70-75% of them fall into its low quality stratum (low oyster density). Strawberry has only 29 grids with 40-50% of them in its low quality stratum. 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 12).

After the 2015 restratification, Arnolds retained six high quality (high oyster density) grids in a similar location as before (Figure 13). Five grids, mostly in the center of the bed, moved from the low to the high quality. Arnolds was previously restratified in June-August 2007. At that time, average oyster density on the high quality stratum was 151 m^{-2} and that of the medium quality grids was 35 m^{-2} with a total range of 7-225 m^{-2} (Table 4). In spring 2015, the range of oyster densities in the medium to high quality strata was smaller (6-138 oysters m^{-2}) but 10 grids moved up in stratum designation while only 5 moved down. The resulting average density for the 2015 high quality stratum was 113 m^{-2} and for the medium quality stratum was 27 m^{-2}. The overall decrease in oysters on Arnolds from 2007 to 2015 was about 19% based on these two stratification surveys. Possible explanation for the decrease in density lies in the mortality rates experienced by the Low Mortality region (LM) of which Arnolds is the primary bed, in years prior to each resurvey. The average annual mortality on the LM from 2000 until the 2007 survey was 8% while the mortality rate from 2008 up to the 2015 survey was 13%.

Arnolds is the most productive bed in its region and gets used as an intermediate transplant donor with the ongoing SARC recommendation to use it only in alternate years.

Strawberry gained 1 high quality grid in 2015 and lost 4 medium quality grids (Figure 13). Its bed footprint changed more than that of Arnolds with the medium and high quality strata grids now spread around the margin of the bed outline. Strawberry contains many fewer oysters than Arnolds does so the range of densities on which its stratification is based is considerably smaller. This bed was previously restratified in May 2006 when its medium quality stratum had oyster densities as low as 0.2 m^{-2} and its high quality stratum had densities as high as 7 m^{-2}. In the spring of 2015, densities in the high quality stratum of Strawberry topped out at only 3 oysters m^{-2} (Table 4). Overall, the number of oysters on the high and medium strata for Strawberry fell by nearly 40% from the 2006 to the 2015 resurvey and the average density of oysters on the high quality stratum was halved. Strawberry is a small part of the High Mortality region and has been subject to similar high rates of mortality as the rest of the region. This bed has not received any transplants or shellplants over the years and has been fished minimally and sporadically since 1996 when the Direct Market fishing program went into effect.

2015 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 for the enhanced stratum (Table 5). Sampling for the 2015 assessment survey was conducted October 16th and 22nd, and on November 5th and 23rd using the oyster dredge boat *F/V Howard W. Sockwell* with Lemmy Robbins as captain. Total sampling effort in 2015 was 168 grids (Figure 14). The Enhanced stratum consisted of 12 selectively sampled grids that included 2 grids that received intermediate transplants in 2015, 3 grids that received shellplants in 2015, 4 grids that received shellplants in 2014, and 3 grids that received shellplants in 2013 (Table 5). 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. Any effect of a transplant or shellplant on oyster density in a grid gets assessed in the next resurvey of that bed.

Status of the Stock in 2015[1]

Whole Stock

The total acreage of the surveyed oyster beds includes the area of the High, Medium, and Enhanced strata on each bed (Figure 1). This can change somewhat each year due to strata reassignments of resurveyed grids and the inclusion of grids in the Enhanced stratum. Each grid is approximately 25 acres. In 2015, the total area of the beds was 15,790 acres (63,898,256 m^2).

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[1] All estimates of stock have been updated to reflect the updates in catchability coefficients throughout the time series (see Gear Efficiency Applications earlier in this report). Because of this, data, figures, and tables in this document will not match those of earlier reports.

Whole stock oyster abundance in 2015 was 1.55 billion oysters at an average density of 24 oysters m^{-2}. Abundance and density were somewhat less than in 2014 (1.72 billion oysters; 27 oysters m^{-2}) but within the range for recent years (Figure 2). Of the 2015 total abundance of oysters >0.8", 677 million or 44% were market-size (>2.5"); an increase from 2014 when the fraction of market-size oysters was 33%. Since the inclusion of the VLM in 2007 to the total oyster area, the fraction of market-size oysters has ranged from 25-46% and averages 36%. Two biological factors ultimately influence the fraction of market oysters: mortality rate and spat recruitment. In 2015, box-count mortality was 13%, the lowest level in the time series that includes the VLM and the third year of decreasing mortality rates. This results in increased survival of oysters into market size-class. Spat recruitment was very low in 2014 (95.5 million) and only a little higher in 2015 (113 million) leading to fewer small oysters, thus increasing the fraction of market-size oysters in the total.

Due to the short time series of the VLM, it is necessary to exclude this region to make time-series comparisons of the 'whole stock' data so the remainder of this section does not include the VLM.[1] Oyster abundance in 2015 was at the 14th percentile of the long-term time series (1953-2015) and at the 21st percentile during the Dermo era from 1990-2015 (Table 6). Abundance remains in the range of recent years and above the lows of 2003-2005 when abundance hovered around 1.0 billion oysters (Figure 2). Natural mortality has generally far outweighed fishing mortality in the Delaware Bay since the 1990s (Figure 4a and b). The 2015 box-count mortality is at the 56th percentile for the 63-yr time series and at the 25th for the Dermo-era time series reflecting the decrease in mortality described in the previous paragraph (Table 6). Unfortunately, spat abundance, although higher than the extreme low of 2014, was again low in 2015 at the 23rd percentile of the longterm time series and the 37th percentile since 1990 (Table 6). It is hoped that continued high survival of the older oysters will balance out the lack of high recruitment (Figure 5b). The lower mortality rates and recruitment of the past few years have likely led to the sharp increase in spawning stock biomass (SSB) in 2015 (Figure 15) and the third-year increase in the abundance of market-size oysters (Figure 16). This size group has been relatively stable since 2008 when the current fishery management scheme went into effect. SSB was at the 79th percentile of the 1990-2015 time series and market-size abundance was at the 80th (Table 6).

Stock by regions[1][2][3]

Upper 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 density for all grids sampled on the VLM in the Fall 2015 survey (Figure 14) was 31 oysters m^{-2} with a

[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.

range of 0.22 to 58 oysters m^{-2} (see Appendix C). For the second consecutive year, the number of oysters on the VLM increased in 2015 (Figure 17a). The VLM in 2015 was 1,337 acres and contained 160 million oysters comprising 10% of the total stock. This is the highest abundance and fraction of stock for the VLM since its time series began in 2007. In 2015, box-count mortality on the VLM was 4.5% (Figure 18a) and this region has had two large spat sets in 2013 and 2015, the latter accounting for 27% of all spat recruited to all regions (Figure 19a). As a result, numbers of small oysters (0.8"-2.5") rose in 2014 and 2015 to 142 million, well over the previous highest number in 2007 (Figure 19b). The number of market-size oysters (>2.5") has also risen since its low of 8 million after the freshwater mortality event of 2011 to 18 million in 2015 although not quite as fast as the small oyster numbers, probably due to the slower upbay growth rates (Figure 19c). Prior to that event, market-size oysters ranged from 29-39 million on the VLM from 2007- 2010.

In 2015, the LM covered 1,679 acres and contained 226 million oysters comprising 15% of the total stock (Figures 3 and 17a). This is the lowest abundance on the LM since 2004 and is reflected by very low percentiles for both the long-term and the Dermo era time series: the 7th and the 14th, respectively (Table 6). The drop in abundance is due to decreases in numbers of oysters both larger and smaller than 2.5" but mostly in the smaller size class, a result of the poor 2014 spat set (Figure 19a-c). The average density for grids sampled in 2015 on the LM dropped from 47 oysters m^{-2} on grids sampled in 2014 to 43 oysters m^{-2} in the 2015 samples (Figure 14, Appendix C). The range of densities in 2015 was 0.30 to 203 oysters m^{-2}. On a brighter note, like the VLM, the LM is at its lowest level of mortality since 2007 at 6.6% (Figure 18a). Box-count mortality is at the 14th percentile for on the LM for the 1990-2015 time series (Table 6). Although not nearly as high as that of the VLM, spat abundance on the LM in 2015 was respectable at 119 million; the 64th percentile of the 1990-2015 time series and the 41st percentile of the 63-yr time series (Figure 19a, Table 6). Market-size oyster abundance is at the 48th percentile for the 1990-2015 time series. Continued low mortality rates in this region will benefit the survival of recruits and older oysters.

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). At 1,576 acres, the area of the MMT is similar to that of the LM while the acreage of the MMM is larger (2443 acres; Figure 3). The MMM holds the largest fraction of the stock (30%) while the MMT contains the second-largest fraction (17%). The average oyster density of non-enhanced (by shellplant or transplant) grids sampled on the MMT for the Fall 2015 survey was 47 m^{-2} with a range of 4 to 197 m^{-2}; an increase from the 2014 non-enhanced average density of 36 oysters m^{-2} (Figure 14, Appendix C). The average oyster density on the non-enhanced (by shellplant or transplant) sampled grids for the larger MMM region in 2015 was nearly the same as that of the MMT, 50 oysters m^{-2} with a range from 17 to 102 m^{-2}. Abundance on the MMT increased in both 2013 and 2014; by 2015, it was up to 265 million oysters, the same abundance as in 2012 (Figure 17b). Abundance was at the 37th percentile in the MMT for the 1990-2015 time series (Table 6). Numbers of both small and market-sized oysters have increased on the MMT (Figure 20b and c). The 2015 abundance of market-size oysters on the MMT is the third-highest value and at the 92nd percentile for the 1990-2015 time series (Table 6). Since 1990, the MMM has usually had the highest oyster abundance of all six regions with the MMT tracking its trends but at lower abundance (Figure 17b). The 2015 total abundance on the MMM was 466 million oysters, a decrease from 2014 and the 44th percentile for the 1990-2015 time series (Figure 17b, Table 6). Small oyster abundance on the MMM decreased by about 100,000 from 2014 to 2015, probably due to the low 2014 recruitment event while the number of market-size oysters increased for the second year to 234 million which is the 76th percentile for the 1990-2015 time series (Figure 20a-c, Table 6). Spat recruitment was not abysmal for either the MMT or the MMM but was below the median for each region in both time series (Table 6). As in the uppermost regions, mortality rates decreased for the second consecutive year in the Medium Mortality regions to 14% in the MMT (the 37th percentile) and to 16% in the MMM (the 40th percentile) providing some assurance of survival for older oysters (Figure 18b, Table 6).

Lower Regions (Shell Rock and High Mortality)

Shell Rock (SR) is the smallest region at 1209 acres (Figure 3) but has contained more oysters than the High Mortality (HM) region which is the largest (> 6 times larger than SR at 7,546 acres) in nearly all years since 2000 (Figure 17c). In 2015, the smaller SR region held 13% of the stock while the very large HM contained 15% of the oyster stock. Average density of non-enhanced sampled grids in 2015 on Shell Rock was 45 oysters m^{-2} with a range of 8 to 84 oysters m^{-2}; much lower than in 2014 when the average, non-enhanced oyster density for sampled grids was 68 m^{-2} (Figure 14, Appendix C). This represents a 34% decrease in average density for SR. Large portions of the HM have low densities of oysters compared to the other regions: in 2015, oyster densities on sampled grids averaged 9 m^{-2} and ranged from 0 to 61 m^{-2} on the HM (Figure 14, Appendix C). The Oyster Metrics Workgroup from the Chesapeake Bay in Maryland (2011) mentioned the following in their report when describing a successful reef: A mean oyster density of 50 m^{-2} over 30% of the bottom is comparable to the mean density of 10-15 oysters m^{-2} in Maryland 100 years ago over 100% of a bar. Using those criteria, Shell Rock would qualify as a very successful reef and 4 of 11 HM beds (Bennies Sand, Bennies, Nantuxent, and Hog Shoal) would at least partly satisfy the criteria while the remainder would not. All other surveyed beds in the Delaware Bay, NJ system would meet or exceed the criteria.

Since 2012, the SR and HM regions have contained similar numbers of oysters despite the large difference in acreage; in 2015, total abundances on these regions were 208 million and 227 million, respectively (Figure 17c). This represented more of an abundance decrease for the SR than the HM. Total abundance on SR was at the 28th percentile for the 1953-2015 time series and at the 25th for the 1990-2015 time series (Table 6). On the HM, these percentiles were the 25th and the 40th. The number of market-size oysters which had been increasing on the SR in recent years, leveled off at 132 million in 2015, still fairly high and the 80th percentile for the 1990-2015 time series (Figure 21c, Table 6). The number of market-sized oysters has been increasing on the HM also and was 112 million in 2015, also the 80th percentile for that region (Figure 21c, Table 6). Mortality increased on both regions, more so on the HM, reversing a 3yr trend and the opposite direction from the other four regions (Figure 18c). The 2015 final mortality estimate was similar for SR and HM; 19% and 18% respectively. This was just under the 1990-2015 median for SR at the 48th percentile and at the 21st percentile on HM (Table 6). Somewhat unusually, in 2015, Shell Rock had the lowest spat set of all the regions surveyed and the percentiles for spat abundance were the 17th for the 1953-2015 time series and only the 10th for the 1990-2015 time series (Figure 21a, Table 6). This was the third lowest set on Shell Rock since 1990, the lowest being last year, 2014. The percentiles for spat abundance on HM were somewhat better at the 20th and 21st percentiles for the 63-yr and the 26-yr time series, respectively (Table 6).

Primary Influences on the Oyster Stock: Habitat, Recruitment, Disease

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. As described in the Historical Overview, Dermo disease became prevalent in the Delaware Bay ca. 1990 and has effectively doubled natural mortality rates since then (Powell et al. 2008b). 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. 2012b). 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 2015 (Table 7). Half-lives ranged generally between 4 and 10 years for most beds, with a 2015 median of 8.38 years. Six beds had higher values and five had undefined negative values. 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.

The shell budget was updated using the 1998-2015 time series based on 2015 half-life estimates (Table 7). 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. Since 1998 is the first year that full survey data are available, 1999 is the first year an estimate can be made. Figure 22 illustrates the relationship between abundance (future mortality), shellplanting, and the shell budget. The years from 1996 to approximately 2000 were years of higher oyster abundance (Figure 22a). Assuming an average Delaware Bay oyster life span of approximately 5 yrs, one might expect shell loss to gradually decrease between about 2000 to 2005 as the oysters die and are added to the budget. When shell is planted in the Delaware Bay, the budget should indicate a decrease in shell loss (Figure 22b). 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 estimate falls around the zero line in 2008 indicating a balanced shell budget. Since then, there has been annual shell planting but at a reduced level and in general, oyster abundance has decreased leading to fewer oyster available to die and be added into the shell budget. As a result, shell loss seems to be gradually increasing again.

Shellplanting

As has been implied in the previous section, shellplanting is an important management activity to maintain the oyster beds and has been practiced with varying regularity and intensity throughout the survey time series with the volumes of shell planted 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 using the commercial dredge. Planted shell will continue to recruit spat in years subsequent to the initial planting.

In 2015, there were three direct unspatted plants of clamshell in three separate regions that were sampled in the Fall Survey: Cohansey 56 in the MMM, Shell Rock 52, and Bennies 110 in the HM (Table 8). Bennies 110 is a grid that has been used for many years as a oyster disease monitoring grid. The highest set on a planted grid by far occurred on the Cohansey grid, just upbay of Ship John and Shell Rock. The density of spat on the Cohansey grid was 25 m^{-2} whereas the average spat density on sampled non-planted grids on Cohansey was 16 m^{-2}, ranging from 9 to 26 m^{-2} (see Appendix C). The Shell Rock planted grid on the other hand, had 10 spat m^{-2} compared to an average of 12 m^{-2} for non-planted grids with a range from 2 to 33 m^{-2}. In fact, Shell Rock as a whole had the lowest spat abundance of all regions for the third year in a row (Figure 21a). This is unusual since Shell Rock, the smallest region, has often had the highest spat set of the six regions since 1990. The shellplanted Bennies grid did not out-perform the non-planted grids in spat recruitment in 2015. The density of spat on the planted grid equaled the average density on un-enhanced grids: 2 m^{-2} with a range of 0 to 4 spat m^{-2}. Bennies is in the HM region where 2015 total spat abundance was approximately the same as the very low abundance of 2014 (Figure 21a).

Four grids that received shellplant in 2014 were sampled again in 2015 to evaluate a second year of recruitment to planted shell (Table 9). All these shellplants continued to recruit spat in 2015 although Shell Rock, again, had the fewest. Ship John is in the MMM with Cohansey and like Cohansey had the highest recruitment to its shellplant. Spat density on the Ship John shellplant was 99 m^{-2} compared to an average of 21 m^{-2}, ranging from 5 to 51 spat m^{-2}, for non-planted Ship John grids (see Appendix C). At 10 spat m^{-2}, the recruitment to the 2014 Nantuxent shellplant did not appear to outperform the non-enhanced grids sampled in 2015 that had an average spat density of 26 m^{-2} with a range of 9 to 45 spat m^{-2}. The two grids on Middle that received spatted shell as part of a mitigation program in 2013 and 2014, had an average spat density in 2015 similar to that of other Middle grids sampled, 28 and 30 m^{-2} respectively.

Within-grid comparisons of spat recruiting to clamshell versus spat recruiting to native shell (including oysters, boxes, loose oyster shell) from the same survey sample, indicate that in six of the seven planted grids, spat recruited preferentially to clam shell (Table 10). This is generally true with shellplants and is thought to perhaps be due to the newly planted shell having less epibiont coverage than older native cultch. In most cases, the 2nd year plants recruit spat less heavily than 1st year plants (eg. prior SAW reports and Ashton-Alcox et al. 2009). The HM and the MMM region each received shellplants in 2014 and in 2015. The ratio of spat recruiting to shellplant versus spat recruiting to native shell in the same grid was higher in the 2015-planted grid in both cases: Bennies was 5.71 vs. Nantuxent 1.84 and Cohansey was 13.08 vs. Ship John 1.67 (Table 10). From 2003 to 2015, the fraction of recruits on planted shell as a portion of all recruitment in a region has ranged from 1% to much higher percentages within regions (Table 11). In 2015, shellplants contributed 2% of all recruitment in the large HM region, 1% in the small SR region, and 7% in the MMM. 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. For example, the 2015 Cohansey shellplant in the MMM (Table 8) was on one grid (~25 acres). That grid is 1% of the area for the MMM yet the spat resulting from that planting made up 7% of the total spat abundance on the MMM for 2015 (Table 11). Figure 23 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 2015 was 2%.

Projections of potential numbers of market-sized oysters (>63.5 mm, 2.5") that might result from the 2015 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 2015, the estimate is three years to market-size oyster. The median of the regional 'juvenile' (first year post-spat) mortality rate from the 1990-2015 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 265, the number of oysters in a bushel going to market. This number is a longterm average determined annually by a port sampling 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 (Ashton-Alcox et al. 2015). 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. While spat are not included in oyster abundance or biomass estimates in the stock assessment, where the cutoff is placed affects both. Further, spat abundance enters deliberations when establishing quota allocations for an upcoming season. Finally, quota allocations for transplant regions are currently based on the abundance of all oysters >20 mm. For these reasons, 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.

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 of the 2015 SAW report (Ashton-Alcox et al. 2015), 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 (Table 12), a practice that likely helped ensure enhanced spat settlement even if recruitment was spatially patchy among the regions. Further analyses are needed to explore the specific relationship between shell (habitat), salinity, oyster recruitment, and adult abundance.

Disease and Mortality

Oyster mortality on the Delaware Bay oyster beds is caused by a variety of factors including predation, siltation, freshets, disease and fishing. Since the appearance of *Haplosporidium nelsoni* (the agent of MSX disease) in 1957, disease mortality has been the primary concern (Powell et al. 2008b). Following a severe and widespread MSX epizootic in 1986, the Delaware Bay population as a whole appears to have developed significant resistance to MSX disease (Ford and Bushek 2012). Nevertheless, routine monitoring continues to detect the MSX parasite in Delaware Bay and naïve oysters quickly succumb to the disease indicating that virulence remains high. MSX was again present in 2015 but levels declined and do not appear to be impacting the native population (Figure 24).

Since the establishment of Dermo disease in 1990, average oyster mortality on NJ oyster beds has effectively doubled. Since 1999, Dermo disease and mortality are tracked monthly from April to October along a transect from Hope Creek to New Beds that also includes Arnolds, Cohansey, Shell Rock and Bennies (Figure 1). The fall assessment survey provides a more comprehensive spatial snapshot of Dermo disease during or near peak prevalence and intensity that can be directly correlated to mortality data collected contemporaneously. Many studies have indicated that Dermo is largely controlled by temperature and salinity so those parameters are tracked closely.

Monthly samples in 2015 revealed that Dermo disease was slightly below average and mortalities were even lower (Figure 25a and b). Data obtained from USGS stream gages during 2015 indicated a sustained pulse of fresh water following melting of ice and winter snow pack along with a rainy spring (Figure 26). A second large pulse resulted from a wet June peaking in early July. Increased runoff lowers salinity and decreases residence time potentially flushing free-living pathogens down bay. These conditions led to an unusual spatial pattern in which disease peaked in mid sections of the Bay (Figure 27a and b). Although mortality still showed the upbay to downbay increase, values in the middle region of the beds were closer to long-term means than either the upper or lower region (Figure 27c). A similar pattern was observed the past two years and its stability suggests that changes in disease dynamics may be occurring across the Bay (Ashton-Alcox et al. 2015). In particular, reductions in disease on the lower bay beds are associated with reductions in mortality (Figure 18c, HM region). It is unclear whether or not this observation is a density-dependent response to reductions in oyster abundance on the lower beds, evidence of the development of resistance by oysters under heavier disease pressure in the lower bay, or a result of changing environmental conditions. Plotting the longterm patterns of Dermo weighted prevalence (WP, Figure 27b) against mortality (Figure 27c) reveals a threshold infection intensity (WP) of about 1.5, which is equivalent to just over 10,000 cells per gram (Figure 28). Above this threshold, the risk of mortality increases exponentially.

Many factors such as temperature, salinity and recruitment are known to influence Dermo disease (Villalba et al. 2004) but the confluence of these factors is difficult to predict. Moreover, while there is some understanding of how these factors influence spatial and seasonal variations in Dermo disease, it is less clear how they interact to influence inter-annual variation. Lagged correlations between river flow and WP produce a significant negative correlation (Bushek et al. 2012). As discussed by Bushek et al. (2012), the apparent cycling may be driven by larger regional climate patterns such as the North Atlantic Oscillation, but a longer time reference is needed to provide better support for this hypothesis. For the purposes of the current assessment, Dermo levels are trending down in all regions except the Medium Mortality Market beds.

Mortality is also trending down in all regions as might be expected, curiously even on the Medium Mortality Market beds. This latter situation is unique and may be related to the timing of freshets and fall sampling more than anything else. Regardless, the current Dermo disease prognosis appears to be relatively good going into the winter of 2015-16.

Oyster Fishery

Direct Market Harvest

The quota for the direct market harvest is decided at the March council meeting each year with any additional quota accruing from spring intermediate transplant program allotted at the June council meeting. The total quota is divided by the number of licenses held. The 2015 direct market harvest occurred from April 6th 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 20 vessels including 8 single (reduced from 15 in 2014)- and 12 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 2015 was 87,430 bushels, 10,520 bushels more than in 2014 and the third highest harvest since 1998 (Table 13, Figure 29)[2]. This harvest was the result of both the initial quota allocation of 75,428 bushels from the three direct market regions: MMM, 26,520 bu; Shell Rock, 21,926 bu; and HM, 26,982 bu with an additional 13,233 bushel allocation resulting from intermediate transplants (see Intermediate Transplant section below). The final 2015 harvest was 1,231 bushels below the allocation. Of the 14 beds opened to the 2015 Direct Market harvest, 8 were fished with 35% of the catch from the MMM, 34% from SR, and 31% from the HM. The proportions of the harvest by bed are similar to what they have been 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) for both single and dual-dredge boats is standardized to an 8-hour day and has steadily increased since 2012 (Figure 30a). The SARC discussed the utility of CPUE since the fishery is not managed on it. The suggestion was made to calculate CPUE using hour instead of 8-h day as the unit for effort although that would require more careful tracking of the boats, something that may be difficult to accurately obtain. Since CPUE does not enter the assessment process, no specific recommendation was made. The Science Advice will contain a suggestion to investigate the measurement of CPUE and the relationship of CPUE to size structure of the population being fished. Continued license consolidation now

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1 http://www.nj.gov/dep/bmw/Reports/2015vibrioplan.pdf

2 Harvest data provided by the New Jersey Department of Environmental Protection.

allows one boat to harvest quota for up to six licenses; each license represents an individual allocation. The number of boats doing the harvesting has concurrently decreased (described at the beginning of this section) from 74 in 2009 to 20 in 2015.

There has been a general increase in CPUE since the 2001-2002 low point of the direct market time series. The CPUE calculated for 2015 is the highest since the inception of the direct market program with single-dredge boats averaging 108 bushels per 8-h day and two-dredge boats averaging 171 bushels per 8-h day. Figure 30b shows CPUE on the beds where harvest occurred in 2015. In 2015, CPUE was again highest on Shell Rock at 152 and 215 bushels per day for single and dual dredge boats, respectively. Ship John in the MMM and New Beds in the HM also had high CPUE. 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 4 of the 8 beds fished during the 2015 direct market (Table 13). The highest fraction for 2015 (1.73) occurred on Shell Rock and was lower than the highest 2014 value (Ship John, 2.34; Ashton-Alcox et al. 2015). Powell et al. (2001b) 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 2015, the average number of oysters per 37-qt bushel harvested was 276 including small but non-targeted oysters (Figure 31). This number is lower than that of 2014 (310 per bushel) and is due primarily to a smaller fraction (13%) of non-targeted oysters in 2015 compared to 18% for 2014. In general, 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 265 oysters bu^{-1} in 2015, the average of 12 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 32 illustrates the 2015 size frequency of marketed oysters compared to the average size frequency for the years since port sampling began (2004) until 2014. In 2015 the proportion of larger oysters was somewhat larger than the average of the previous 11 years but not excessively so. This may reflect the lower proportion of small oysters and higher proportion of large oysters in the MMM, SR, and HM region stocks in 2015 (see Appendix B.4-6). Anecdotal input from oystermen suggests that the proportion of large oyster discards has risen in recent years: the market does not want the largest oysters and increased survival has resulted in higher proportions of the largest oysters. Thus, the 2015 size frequency in Figure 32 does not reflect the population size frequency as much as the targeted oyster size frequency.

Intermediate Transplant[1]

The three most upbay regions of the New Jersey Delaware Bay oyster resource are considered 'intermediate transplant' regions from which oysters may be moved downbay to annually-specified grids in chosen direct market regions in an NJDEP-HSRL monitored program that usually occurs in late April and/or early May. 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 May 2015, the intermediate transplant program moved 10,200 bushels of culled material from Upper Arnolds in the LM down to a grid on Ship John in the MMM and 10,800 bushels off Sea Breeze in the MMT plus 5,550 bushels off Middle in the MMT to a grid on Shell Rock (Tables 13-14). Nearly 9 million oysters were moved (Table 14) reflecting the target numbers associated with exploitation decisions made for each of these regions after the 2015 SAW.

Boats deckloading oysters for transplant use automatic cullers as the only sorting device because of the large volumes to be moved. Ideally, the cullers will remove most cultch from the deckloaded volume of material and onsite NJDEP transplant monitoring will instruct boats to change location if cultch fractions exceed much more than 20% of the deckload volume. Boxes are not included in the calculation of cultch fraction because they are generally the same size as oysters or are attached to oysters and thus, will not be culled. In most cases, boxes make up no more than 10% of the transplant volume. In 2015, the overall cultch fractions were 33% from the Upper Arnolds transplant, 31% from Middle, and 25% from Sea Breeze (Table 14).

Exploitation rates in the Transplant regions are based on all sizes of oysters because the proportion of oysters smaller than market size that get moved can be high, particularly from the Low Mortality region where oysters do not grow as large or as fast as those further downbay. Although the premise of these transplants is to move market sized oysters to the direct market regions in order to add them to the current year's quota allocation, a 2011 study of the intermediate transplant program (Ashton-Alcox et al. 2013) found the proportion of small oysters < 2.5" (63.5mm) in the transplant to be as high as 60%. The proportion of small oysters moved in the 2015 transplant program ranged from 42% on Sea Breeze, the transplant bed furthest downbay where growth rates are faster, to 72% on Upper Arnolds, the most upbay bed in the 2015 transplant program (Table 14). These small oysters did not enter into the calculations for the quota increase in the receiver regions although they are included in the assessment survey of those regions. Oysters ≥2.5" contained in the transplant were converted to market bushel equivalents using the number of market oysters per bushel (266) derived from the port sampling longterm mean of 2004 to 2014 (Ashton-Alcox et al. 2015) and were added to the quota for the

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[1] Intermediate transplant memoranda in Appendix D.

receiving regions in June 2015. The 2015 intermediate transplant program increased the quota by 13,233 bushels (Table 14).

Exploitation and Fishing Mortality

Table 15 compares the proposed plan for the 2015 direct market harvest to what was achieved by the fishery by the end of the season. The exploitation percentiles and their associated bushels listed were the result of the SARC recommendations for a range of exploitation options and the choices made by the Council at its post-SAW meeting in March 2015. As explained earlier, the basis for the exploitation rate percentiles used for the 2015 fishery is the 1996-2006 exploitation record from the early part of the direct market era (see Historical Overview and 2015 Science Advice Progress). The 2015 quota for the direct market regions associated with the chosen exploitation percentiles was based on the 2014 abundance. For each of the three market regions, the chosen exploitation rate is multiplied by the 2014 abundance of market-size oysters and divided by the number of oysters per bushel as determined from the 2014 port sampling program. The sum of the annual regional quotas is divided by the number of active licenses (approximately 75) to determine individual allocations. Additional quota from any intermediate transplants is determined based on the number of market-size oysters moved and gets allocated after the oysters were moved to the direct market regions and held there for about 6 weeks. In 2015, the direct market fishery harvested fewer bushels than were allocated in the MMM and SR but harvested slightly more than were allocated in the HM (Table 15). The overall difference was an under-harvest of 1,231 bushels.

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 6). 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. The total harvest in 2015 was 87,430 bushels (Table 15) or approximately 24 million oysters using the value of 276 harvested oysters per bushel from Figure 31. This number of oysters represents a fishing mortality of 1.5% of all oysters in five regions, excluding those from the VLM, in 2015 and is just over the average of 1.4% since the current quota system began (Figure 33a). The fraction of market-sized oysters fished in 2015 was 3.7% of all market-size oysters, again excluding the VLM, and at the higher end of the market-size fishing mortality since 2007 (Figure 33b).

Regional fishing mortality is shown in Figure 34 as both percentage of all oysters and percentage of market-size (≥2.5”) oysters. The numbers reflect the addition of oysters in regions that received transplant so that some years may have negative values if more oysters were added in the transplant than were removed by the fishery. By vote of the Shellfish Council, the VLM was closed in 2015 for the fourth year to allow continued recovery from the extreme freshwater mortality it suffered in 2011 despite the SARC supporting a low level of exploitation in that region. Exploitation for transplant purposes was conducted on the Low Mortality (LM) region in 2015 and the rates of fishing mortality on all oysters and market oysters (1.5% and 1.8% respectively) reflect the 2015 SARC advice to use the lower percentile exploitation option for the LM. The MMT was also used for 2015 transplanting and the percentage of fishing mortality for both total and market-size oysters was nearly identical to the previous two years: 2.1% for all oysters and 2.8% for market-size oysters. Fishing mortality on all oysters in the MMM decreased for the third year in a row to 0.7% but remained approximately the same for market-size oysters at 3.1% in 2015. The MMM received transplants in 2014 and 2015 from the LM to help maintain abundance and provide market oysters. Shell Rock received transplants in 2013, 2014, and 2015 for the same reasons and fishing mortality on this region stayed about the same in 2015 (1.2% of all oysters and 3.7% of the market-size) as it was in 2014. The HM has not received transplant since 2013 and was harvested at its 60th percentile of exploitation for 2013 and its 75th percentile for 2014 and 2015. The fishing mortality on all oysters in the HM has risen since 2012 from a negative value to 3.3% in 2015. The market-size oyster fishing mortality was 6.5% in 2012 and 2013 and rose to 8% in 2014 and 2015.

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 disease-induced 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. 2008b). 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, SARCs 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 (2.306 billion and 401 million) that are listed in Table 16 (with the thresholds at half those values 1.153 billion and 200 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 debated the validity or relevance of using the surplus production model to identify whole stock reference points and have 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 2015 total abundance was 1.393 billion oysters (excluding the VLM) of which 659 million were market-size. The 2015 point-estimate of 1.39 billion falls significantly below the whole-stock reference point of 2.3 billion (Figure 35a) as it has at least since 2009 (Powell et al. 2010). This point-estimate is just over the 50th percentile of the survey uncertainty envelope and the whole-stock abundance threshold of 1.2 billion falls below the 10th percentile confidence limit so the survey may be considered to be statistically over the whole-stock abundance threshold. In contrast to total abundance, market abundance across the entire stock sits significantly above the stock performance target of 401 million oysters as it has in recent years (Figure 35b). The whole stock market-sized abundance estimate of 659 million oysters, like the total abundance point-estimate is just over the 50th percentile of survey uncertainty. 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. As described earlier in this report (Stock Assessment Design, Analytical Approach), the gear efficiency portion of the confidence percentile calculations in Figure 35 used a set of catchability coefficients based on catchability of all sizes of oysters as opposed to size-class separated catchability coefficients as in previous reports.

Regional[1]

In 2006, the SARC set specific targets and thresholds for total abundance, market-size abundance, and spawning stock biomass based on the 1989-2005 (total) and 1990-2005 (market-size, SSB) time periods under the assumption that this time period likely represents the entire scope of oyster population dynamics in the present climate and disease regime (Table 16). For each region, the median abundance and SSB values from these time periods were set as targets

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[1] Confidence limit graphics in Appendix E.

with values half these levels set as threshold levels. 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 (Powell et al. 2012a). With the application of new catchability coefficients in this current report, using the LM as the basis to set targets for the VLM has been deemed insufficient as explained below.

In 2015, total abundance was reasonably above threshold in the central regions: MMT, MMM, and SR and close to or at threshold in the upmost (LM) and downmost (HM) regions (Figure 36). In two regions (VLM, MMT), the 2015 abundances represent a 2-yr trend of increase from low 2013 values; in two regions (MMM, HM), the 2015 abundance remained much the same as 2014; and in two regions (LM, SR), there were fairly substantial decreases in abundance. Throughout the lower regions (MMT and below), the 2015 SSB estimates were considerably above the SSB targets. In most cases, this represented a substantial increase over 2014 aside from SR where SSB remained the same from 2014 to 2015 despite the decrease in total oyster abundance. This indicates increased growth and/or survival of the smaller sizes in the population since SR has not had good spat recruitment for at least two years. Although SSB remained just below target for the LM, the 2015 value was much higher than that of 2014. Nearly identical relationships for regional estimates of abundance vs SSB exist for abundance vs market-size oysters in 5 out of the 6 regions in 2015 (Figure 37). The only difference is in the LM region where market-size oyster abundance is just above its target whereas SSB in the LM region is just below its target.

The VLM targets were created based on the assumption that conditions on the VLM are equivalent to those on the LM but the 2012 SAW report stated that the VLM targets may be biased low. The 2010 market abundance on the VLM, pre-flood, tended to support that as it was an order of magnitude above the then-target value where the post-freshwater mortality market abundances hovered (see Figure 30 in Ashton-Alcox et al. 2015). The dredge efficiency study of 2013 showed that conditions on the VLM and LM are probably not equivalent given the much lower catchability coefficients found on Hope Creek in the VLM as compared to those on Arnolds in the LM. Therefore, the 2016 SARC recommended discarding the previous VLM targets and thresholds and advised the derivation of new reference points for this region as a science recommendation.

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 `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 a 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 Powell et al. 2012a). 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 useful metric used to evaluate stock sustainability for the NJ Delaware Bay oyster stock has been the trend in market-size abundance (Figure 16). 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 varies widely based on recruitment and disease dynamics from year to year. These factors can similarly impact SSB, as does 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 1990-2015 time series, excluding the VLM, shows that the abundance of market-size oysters has remained relatively stable since 1990, fluctuating around a median of 5.02×10^8 and has been higher since 2005 with a median abundance of 5.62×10^8 oysters (Figure 16). 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 epizootics when there are 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 2015 is above the market size abundance target of 4×10^8 as it has been since 2005 (Figure 16, Figure 35b), 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 below 2% in the period of direct marketing, 1997-2014 (Figure 33a) 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 supports the notion 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, i.e., market abundance has not been reduced below thresholds in any bed region, an indication that the stock is not experiencing overfishing.

Finally, Powell et al. (2012b) 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 1953-2015 time series both as a percentage of all oysters and as a percentage of market-size oysters (Figures 4b and 33). 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), the 2015 fishing mortality fraction of 1.5% provides additional support that overfishing is not occurring.

Summary of Stock Status

Table 17 is a 'stoplight' table summarizing the 2015 status of the oyster stock by region relative to the 1990-2015 time period or the previous five years. Parameters of the regional stocks are designated as improving (green), neutral (beige), or degrading (orange). Parameters include total abundance, market-size abundance, spawning stock biomass, spat recruitment abundance, natural mortality, and Dermo disease. Metrics include percentile ranks (40^{th} - 60^{th} percentiles are considered neutral), comparison to the previous 5-yr median, comparison to biological reference points, comparison to general mortality rates in the absence of disease, or comparison to Dermo levels known to cause mortalities. The 2016 SARC requested an additional metric under the heading of Recruitment (Table 17): the 3-year (2013-2015) mean spat recruitment abundance is assigned a percentile rank in the 1990-2015 time series of spat abundance that is judged like the other percentile ranks regarding its color e.g. the color is beige if the percentile ranking is between the 40^{th} - 60^{th}.

In 2015, all parameters except total oyster abundance improved somewhat over 2014 (see Table 17 in Ashton-Alcox et al. 2015). No region even reached the median total abundance for the 1990-2015 time series although the MMM and HM were closest. Most were between the target and threshold abundance but were closer to the threshold. The VLM has been increasing in abundance since the 2011 freshwater mortality event so it is above the 5-year median in 2015. Most regions are on the high side of all market-size abundance and SSB metrics although the two upper regions, VLM and LM are not. The LM is just below its market-size and SSB medians for the 1990-2015 time series. Although not as bad as 2014, spat recruitment in most regions, particularly the downbay direct market regions, was poor: all 2015 spat abundances were below median values except for the LM (the VLM time series is too short for this comparison) and Shell Rock was lowest at the 10^{th} percentile. When the percentile rank of the 3-year average recruitment is compared to the 1990-2015 time series (the 2007-2015 time series for VLM), the ranks change somewhat but all regions downbay of the LM, especially Shell Rock (at the 17^{th}

percentile for this metric), are still below the median value. Mortality levels were generally good (low) although Shell Rock was nearly at its median for the 1990-2015 time series for the second year and was above the 5-yr. The HM continues to have lower mortality rates than earlier in its time series and Dermo disease is lower than it has been.

Appendix B contains graphics of parameters from 2007 to 2015 on a regional basis. Starting at the most upbay region, VLM (Appendix B.1) suffered high mortalities (>45%) in 2011 due to freshwater but has moved in a positive direction for abundance in 2014 and 2015 due primarily to the increase in small oysters. This is accompanied by the virtual disappearance of Dermo disease and a concurrent decrease in mortality. Added to the hopeful outlook is a good 2015 spat set. There have been no transplants from this region since 2011.

Although Dermo disease has been low since 2011 in the LM (Appendix B.2) and mortality dropped to about 7% in 2015, abundance decreased in 2015 and is at its lowest level since 2004 (not included in Appendix B.2). This appears to be due to the decrease in the number of small oysters, probably resulting from low spat set in 2014 and the growth of previous small oysters into the market-size class. Lack of a reasonable spat set in 2014 did not replenish the small oyster size class in 2015 and the spat set in 2015 was above the 2014 low but was among the 6 low years since 2007. Dermo rates and annual mortality were high prior to 2011 but both have decreased since then. Fishing mortality (transplanting) on the LM has been approximately 1-2% annually since 2008 but prior to that, transplants from the LM were sporadic.

The MMT (Appendix B.3) has experienced an increase in total abundance due to increases in both oyster size classes in 2015. Although spat set was dismal in 2014, it was moderate in 2012, 2013, and 2015 supplying the smaller size class of oysters to the total abundance. Dermo and mortality have both been lower on the MMT in 2014 and 2015 as compared to 2012 and 2013, leading to increased survival of the larger oysters. Fishing mortality (transplanting) has been steady at approximately 2% since 2011 on the MMT.

The MMM is a direct market region (Appendix B.4) and numbers of oysters in both size classes have been holding fairly steady recently. The 2014 low spat set led to a decrease in the 2015 small oyster size class; the 2015 spat set was not much better than that of 2014. Curiously, although Dermo disease has been inching upward since 2011, there has been a concurrent decrease in natural mortality from 25% in 2012 gradually down to about 15% in 2015. Fishing mortality has also decreased and in 2015 was about half the level (~0.07%) as it was in 2013 (~1.5%).

Numbers of small oysters decreased precipitously on Shell Rock in 2012 (Appendix B.5) and have not increased much since then due to low spat recruitment. High spat recruitment in 2010 likely led to the higher numbers of small oysters in both 2010 and 2011. Throughout the time span shown on these graphs, the abundance of market-size oysters has remained steady. Shell Rock is a frequent recipient of both shell for spat recruitment and transplanted oysters from upbay, some of which led to the negative value for fishing mortality in 2013. Dermo and mortality levels are lower in 2014 and 2015 as compared to 2012 and 2013 but not spectacularly so and mortality due to fishing decreased from its high rate of ~1.7% in 2014 to about 1.2% in 2015.

Oyster abundance in the HM (Appendix B.6) has been remained relatively higher since 2012 and steady since 2013 thanks in part to a very high spat set in 2012. This led to an increase in the number of small oysters in 2013 that has been declining ever since because spat sets have been lower and because the region has not received any transplants since 2013. Meanwhile, Dermo levels have been declining and the abundance of market-size oysters has been increasing as the smaller oysters grow and survive. This region is also a frequent recipient of shell for spat recruitment. Evidence of the effect of transplants can be seen in fishing mortality that was near 0 in 2010 and 2011, negative in 2012 and has inched up to over 3% in 2015.

Management Advice

Shellplanting efforts should continue and be expanded when possible. While market-size oyster abundance is above target levels in all regions, total abundance was near thresholds in the LM and HM, and it has decreased in most regions between 2014 and 2015 (Figure 36, Table 17). Recruitment was low in all Direct Market regions in 2015 auguring continued decreases of the <2.5" oyster category in 2016. To help ameliorate this, a shell-planting program to enhance recruitment must continue with the aim of planting 250,000 bushels or more annually. Sources to expand planting efforts should be sought wherever possible. Because anticipated shellplanting funds will come from the industry tax in 2016, the SARC recommends that the Council and the NJDEP should make the decisions about shellplanting programs.

Harvest Recommendations

Direct Market *(Table 18, new exploitation rates reflect 2016 SARC decision)*

Overall, the 2016 SARC felt that Direct Market harvest at the 2007-2015 exploitation rate median could safely be taken from all three regions without requiring transplants. The SARC cautions that future abundance may decline if recruitment conditions do not improve.

The **Medium Mortality Market** (MMM) region has had relatively steady abundances of market-size and smaller oysters, possibly helped by the receipt of transplants. It is experiencing a reduction in mortality despite increases in Dermo. Low recruitment in 2014 and 2015 suggests that this situation may not last. Therefore, the SARC felt no compelling reason to increase harvest above the 2007-2015 exploitation rate median of 3% of market-sized oysters. Harvest at the rate of 3.7%, the upper bound of the 2007-2015 exploitation, can be considered only if the MMM receives a transplant.

Anecdotal reports from those working on **Shell Rock** in 2015 indicate that it yielded more oysters in less time than usual. Fall survey data did not indicate higher total abundances but did indicate stability in market-size abundance, possibly helped by transplants from Sea Breeze and Middle in 2015 that contained 58% and 40% market-size oysters respectively (Table 14). The abundance of oysters <2.5" on Shell Rock declined to numbers well below market abundance in 2015 causing concern for the future. There is pressure to increase fishing rates on Shell Rock but its current status suggests caution. Harvest at the 2007-2015 market-size exploitation rate median of 3.7% was acceptable to the SARC. Any increase in exploitation rate up to 4.9% (the upper bound of the range of exploitation rates from 2007-2015) would require a transplant to this region.

Total abundance in the **High Mortality** region (HM) was stable between 2014 and 2015 with a decrease in small oyster abundance and an increase in market oyster abundance. Two years of poor recruitment may continue that pattern and lead to lower total abundance although Dermo and mortality rates were concurrently generally lower. The SARC felt this region could sustain a harvest rate 15% over the 2007-2015 median exploitation rate without requiring a transplant. This would bring the harvest rate from 0.075 for market oysters at the median rate to 0.086 on the HM. The SARC felt that transplants should go to Shell Rock and the MMM before considering any for the HM.

Intermediate Transplant *(Table 19 new exploitation rates reflect 2016 SARC decision)*

All transplants must be done with the use of mechanical cullers. Abundance in all three transplant regions is relatively steady or improving with fewer decreases in the <2.5" size class than downbay. Disease and mortality have been low for two years and may remain that way.

There is a short time series for abundance (2007→) for the **Very Low Mortality** region (VLM) and it has only been used for transplant exploitation in three of those years (2009-2011). Additionally, the three years of exploitation were contained in a narrow range between 3.7 and 4.3% of all sizes of oysters. As such, it is a difficult region to evaluate although abundance has been increasing and spat set has been good in recent years. The freshwater mortality of 2011 indicates that the VLM may be an ephemeral resource, however thus the SARC felt that exploitation of this region should be conservative and limited to periods of improving abundance. The 2016 SARC recommends that the VLM may be reopened for transplant donation not to exceed 2.8% of its total abundance. Some SARC members indicated that exploitation below this level is immaterial.

As is true for SR and MMM, the **Low Mortality** (LM) region declined in abundance although market abundance remains above target level. Spat recruitment has been better in the LM than in the SR and MMM and mortality decreased in the LM in 2015. Due to the decrease in abundance, however, the SARC does not recommend any transplant exploitation above the

2007-2015 median of 1.8%. As has been regular practice in the LM, transplants should alternate annually between Arnolds and Upper Arnolds/Round Island. A 2016 transplant would come from Arnolds. Locations to receive transplants will be determined by the NJDEP staff in conjunction with the Shellfish Council.

The **Medium Mortality Transplant** region (MMT) has improved in both market-size and smaller oyster abundance over three years thanks to reasonable spat sets in two of them and lower Dermo and mortality levels in 2014 and 2015. Abundance has not yet returned to pre-2011 levels. The SARC recommended that a 2016 transplant may be taken from the MMT at the 2007-2015 exploitation median of 2% of total abundance. As has been regular practice on the MMT, no more than half the total transplant should come from Middle bed with the rest from a combination of Upper Middle and Sea Breeze. Locations to receive transplants will be determined by the NJDEP staff in conjunction with the Shellfish Council.

2016 Science Advice

Continue standard monitoring and assessment programs

Annual Fall Survey – this is the basis for the entire assessment

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. Due to concerns expressed about possible changes in oyster distribution on Shell Rock in the last two years, the SARC recommended that the existing Resurvey schedule be reorganized such that Shell Rock is completely resurveyed in 2016 (see Table 2)

Monthly 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 management activities.

Port Sampling Program - provides estimates required for accurate size-related landings information and abundance-to-bushel conversions in the stock assessment.

Monitor how refinement of the quota setting methodology affects harvests, management, and sustainability of the fishery.

Continue to collect gear efficiency estimates particularly in the downbay and far upbay regions.

Continue to explore sources of error associated with the assessment. Compare how each source of error (e.g., dredge efficiency vs. survey sampling error) is contributing to the overall assessment error. Incorporate error bars into estimates of stock parameters. Determine if calculations are correct and then determine their utility in the assessment.

Fit discrete models of population dynamics to estimate how the available range of exploitation rates might affect the population next year. Test with existing data from prior years.

Complete the analysis of spat-to-oyster transition sizes and determine how this may affect the assessment and if so how to incorporate findings. Simulate a range of transition sizes to estimate how they influence estimates of spat and juvenile abundance

In addition to the shell budget, investigate the value of plotting shell resource abundance over time.

Standardize the measurement of CPUE to account for changes in fishing day, license consolidation and investigate the relationship of CPUE to size structure of the population being fished.

Investigate the abundance and port sampling time series size frequencies to split out oysters 2.5” to 3.5” and those >3.5 “, we already have the 2.5”-3” class.

Plot exploitation as a function of abundance.

Develop appropriate abundance, market abundance, and SSB targets and threshold for the VLM.

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Table 1. Groups and their responsibilities for managing the oyster stock and fishery of Delaware Bay, NJ.

Group	Members	Duties
Rutgers Haskin Shellfish Research Laboratory (HSRL)	HSRL faculty and staff	Design/analyze stock assessment. Execute surveys with industry and NJDEP assistance. Address science needs. Host and facilitate SAW. Prepare SAW report.
Oyster Industry Science Steering Committee	HSRL Shellfish Council NJDEP	Prioritize science agenda and management strategies. Nominate SARC membership.
Stock Assessment Review Committee (SARC)	Academics; RU & other. Managers; NJDEP & other. Industry	Peer review of assessment. Recommend harvest rates & area management by region. Provide science advice.
New Jersey Shellfisheries Council (Delaware Bay Section)	Industry	Select harvest rate & area mgmt. activities from SARC recommendations. Plan/approve disbursement of industry imposed harvest taxes.
New Jersey Department of Environmental Protection (NJDEP)	Biologists Managers Statisticians Enforcement Administrators	Approve decisions impacting public oyster resource. Lead/coordinate mgmt activities. Monitor harvest and enforce regulations. Collect, maintain & disperse industry imposed harvest taxes.

Table 2. Resurvey history and schedule for NJ Delaware Bay oyster beds and number of grids on each bed. The intent is to resurvey each bed at least once per decade and when multiple beds are scheduled, they should not be in the same region. One grid is 0.2" latitude x 0.2" longitude (approximately 25 acres, 101,175 m^2 or 10.1 hectares). Asterisk* = partial resurvey only. Years separated by hyphen indicate that resurvey took 2 years to complete.

Bed	# Grids	2005-2008	2009-2015	2016→
Cohansey	83	2005*	2009	2019
Bennies Sand	49	2005-2006	2009	2019
Ship John	68	2005*	2010	2020
Fishing Creek	67	2007-2008	--	2020
Beadons	38	2006	2011	2021
Middle	51	2005*	2011	2021
Vexton	47	2006	2011	2021
Upper Middle	84	2007	--	2022
Nantuxent	68	2005*, 2006	2010	2022
Upper Arnolds	29	2007	2013	2023
New Beds	112	2007	2013	2023
Bennies	171	2005*, 2006	2014	2024
Arnolds	99	2007	2015	2025
Strawberry	29	2006	2015	2025
Shell Rock	93	2005*, 2008	2012	**2016**
Hog Shoal	23	2005*, 2006	**--**	**2016**
Liston Range	32	2007-2008	**--**	**2016**
Hawk's Nest	28	2006	--	2017
Hope Creek	97	2007-2008	--	2017
Sea Breeze	48	2005*	2012	2018
Round Island	73	2007	--	2018

Table 3. Original catchability coefficient (q) assignments to years and bed groups in the time series (black) and newly-averaged values and bed group assignments for the whole time series moving forward (red) for **(a)** oysters, **(b)** boxes, and **(c)** cultch. Standard deviations are provided for the new oyster values. Note the different values for Round Island and Upper Arnolds/Arnolds within the Low Mortality region and the move of Shell Rock to the upper bed group.

a. Oyster

Region	Previous q Values				NEW
	1953-1997	**1998-2000**	**2001-2004**	**2005-2014**	**1953-->**
Very Low Mortality	--	--	--	7.30	2.41 ±0.56
Low Mortality - *Round Island*	8.22	9.40	8.22	7.30	2.41 ±0.56
Upper Arnolds, Arnolds	8.22	9.40	8.22	7.30	8.26 ±6.99
Medium Mortality Transplant	8.22	9.40	8.22	7.30	8.26 ±6.99
Medium Mortality Market	8.22	9.40	8.22	7.30	8.26 ±6.99
Shell Rock	2.96	2.83	2.96	3.11	8.26 ±6.99
High Mortality	2.96	2.83	2.96	3.11	2.82 ±2.44

b. Box

Region	Previous q Values				NEW
	1953-1997	**1998-2000**	**2001-2004**	**2005-2014**	**1953-->**
Very Low Mortality	--	--	--	10.87	6.82
Low Mortality - *Round Island*	11.12	11.47	11.12	10.87	6.82
Upper Arnolds, Arnolds	11.12	11.47	11.12	10.87	12.69
Medium Mortality Transplant	11.12	11.47	11.12	10.87	12.69
Medium Mortality Market	11.12	11.47	11.12	10.87	12.69
Shell Rock	5.67	6.50	5.67	4.64	12.69
High Mortality	5.67	6.50	5.67	4.64	5.10

c. Cultch

Region	Previous q Values				NEW
	1953-1997	**1998-2000**	**2001-2004**	**2005-2014**	**1953-->**
Very Low Mortality	--	--	--	13.71	9.11
Low Mortality - *Round Island*	17.11	21.49	17.11	13.71	9.11
Upper Arnolds, Arnolds	17.11	21.49	17.11	13.71	25.79
Medium Mortality Transplant	17.11	21.49	17.11	13.71	25.79
Medium Mortality Market	17.11	21.49	17.11	13.71	25.79
Shell Rock	8.97	9.55	8.97	8.14	25.79
High Mortality	8.97	9.55	8.97	8.14	8.46

Table 4. Comparison of average and median oyster densities (oysters m^{-2}) on the medium and high quality strata for **(a)** Arnolds and **(b)** Strawberry from their 2006-2007 resurveys and the 2015 resurvey.

a.

Arnolds	**High Quality Stratum**		**Medium Quality Stratum**	
	2007	**2015**	**2007**	**2015**
Mean oys per m^2	151.14	113.09	35.05	27.01
Median oys per m^2	143.94	115.36	27.34	17.83

b.

Strawberry	**High Quality Stratum**		**Medium Quality Stratum**	
	2006	**2015**	**2006**	**2015**
Mean oys per m^2	5.70	2.57	0.57	0.47
Median oys per m^2	5.70	2.69	0.52	0.19

Table 5. Sampling scheme for the Fall 2015 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 (T) or shellplant (S) in the current survey year or received 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	Enhanced Details
Very Low Mortality	Hope Creek	4	4	0		
	Fishing Creek	2	3	0		
	Liston Range	2	4	0		
Low Mortality	Round Island	2	3	0		
	UpperArnolds	3	4	0		
	Arnolds	3	4	0		
Medium Mort. Transplant	Upper Middle	1	3	0		
	Middle	3	4	0	2	2013-14 S
	Sea Breeze	3	4	0		
Medium Mort. Mkt.	Cohansey	5	5	0	1	2015 S
	Ship John	6	5	0	2	2014 S, 2015 T
Shell Rock	Shell Rock	4	6	0	5	2013-2015 S, 2015 T
High Mortality	Bennies Sand	3	6	0		
	Bennies	5	9	0	1	2015 S
	Nantuxent Pt.	3	3	0	1	2014 S
	Hog Shoal	3	3	0		
	Strawberry	2	3	0		
	Hawk's Nest	2	3	0		
	New Beds	4	5	0		
	Beadons	2	3	0		
	Vexton	2	2	0		
	Egg Island	1	5	0		
	Ledge	0	0	0		
Total		65	91	0	12	

Grand Total: 168

Table 6. Percentile positions for the 26-year time series (1990 – 2015) 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. Recruitment values do not include the enhancements from shell planting. There is currently insufficient data to calculate percentiles for the Very Low Mortality region. Percentiles for the 63-year time series (1953 – 2015) can be found in Appendix A.

1990 – 2015	Oyster Abundance	Market >2.5" Abundance	Spat Abundance	Spawning Stock Biomass	Box-Count Mortality
Very Low Mortality	-	-	-	-	-
Low Mortality	0.135	0.480	0.635	0.442	0.135
Medium Mortality Transplant	0.365	0.920	0.404	0.788	0.365
Medium Mortality Market	0.442	0.760	0.365	0.827	0.404
Shell Rock	0.250	0.800	0.096	0.788	0.481
High Mortality	0.404	0.800	0.212	0.788	0.212
Baywide	0.212	0.800	0.365	0.788	0.250

Table 7. Average half-lives in years for surficial oyster shell on Delaware Bay oyster beds for 1999–2015 time series. Beds arranged in upbay to downbay order. --, unable to determine.

Location	1999 - 2015
Hope Creek	--
Fishing Creek	--
Liston Range	--
Round Island	19.44
Upper Arnolds	8.92
Arnolds	10.96
Upper Middle	--
Middle	32.85
Sea Breeze	28.69
Cohansey	30.47
Ship John	6.12
Shell Rock	6.02
Bennies Sand	7.43
Bennies	9.17
Nantuxent Pt.	4.16
Hog Shoal	6.12
Strawberry	7.27
Hawk's Nest	7.79
New Beds	--
Beadons	7.09
Vexton	7.84
Egg Island	15.72
Ledge	77.59

Table 8. Summary of shell planting activities for 2015. Direct (unspatted) plants occurred on Cohansey, Shell Rock, and Bennies. Spat per bushel estimates are from the clamshell volumes in Fall 2015 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 1990-2015 time series for the Medium Mortality Market region (Cohansey), Shell Rock, and the High Mortality region (Bennies). Calculation of years to market size used von Bertalanffy parameters (see Kraeuter et al., 2007) for each region. Because none of these sites has previously received shellplant, the 20-mm size cutoff was not used to determine recruits; all oyster set on the clamshell was considered spat.

	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
Cohansey 56	direct	38,539	374	14,403,829	0.273	1	0.181	2	6,680,871
Shell Rock 52	direct	47,913	6	268,746	0.507	1	0.188	2	82,675
Bennies 110	direct	43,038	46	1,961,019	0.492	1	0.242	2	514,038

Table 9. Summary of 2015 spat recruitment on 2014 shell plants. Spat per bushel estimates are from the clamshell volumes in Fall 2015 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 1990–2015 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 each region. Spat recruits to these shellplants were determined using the 20-mm size cutoff.

	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	32,709	84	2,759,331	0.277	1	0.151	2	2,288,661
Ship John 33	direct	52,740	151	7,988,799	0.273	1	0.181	2	3,705,413
Shell Rock 31	direct	55,394	35	1,952,523	0.507	1	0.188	2	600,659
Nantuxent 23	direct	42,704	151	6,433,053	0.492	1	0.242	2	1,686,284

Table 10. Spat recruitment on planted shell compared to recruitment on native shell in 2015. The ratio of spat per bushel of planted shell to spat per bushel of native shell is shown in the last column.

Site	Year Planted	2015 Spat per bu. Planted Shell	2015 Spat per bu. Native Shell	Plant:Native
Bennies 110	2015	46	8	5.71
Cohansey 56	2015	374	29	13.08
Shell Rock 52	2015	6	17	0.33
Nantuxent 23	2014	151	82	1.84
Shell Rock 31	2014	35	17	2.07
Ship John 33	2014	151	91	1.67
Middle 27-28	2013-2014	84	46	1.82

Table 11. Shellplants as fractions of regions' area and as fraction of regions' spat recruitment. Comparison is from the first year of a shellplant. Subsequent years may produce additional spat. Details of 2014 and 2015 shellplants are shown in Tables 8 and 9; 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	0.18	0.82
7,546 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
	2015	0.0033	0.02	0.98
Shell Rock	2005	0.0533	0.28	0.72
1,209 acres	2006	0.0635	0.25	0.75
	2009	0.0212	0.13	0.87
	2010	0.0212	0.13	0.87
	2011	0.0212	0.24	0.76
	2013	0.0423	0.06	0.94
	2014	0.0212	0.03	0.97
	2015	0.0207	0.01	0.99
Med. Mort. Mkt.	2007	0.0512	0.03	0.97
2,443 acres	2008	0.0102	0.09	0.91
	2012	0.0205	0.01	0.99
	2014	0.0102	0.04	0.96
	2015	0.0102	0.07	0.93
Med. Mort. Trans.	2007	0.0159	0.07	0.93
1,576 acres	2011	0.0083	0.01	0.99
	2013	0.0083	0.01	0.99
	2014	0.0083	0.02	0.98
Very Low Mort.	2012	0.0093	0.03	0.97
1,337acres				

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
2015	43,038	47,913	38,539				129,490

Table 13. Harvest and transplant data for 2015. 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. The number of transplant bushels is not the same as the number of bushels allocated to the quota from the transplant (see Table 14).

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				10,200	0.38
	Arnolds	761					
MMT	Upper Middle	236					
	Middle	814				5,550	0.21
	Sea Breeze	525				10,800	0.41
MMM	Cohansey	1234	1.01	10,669	0.122		
	Ship John	1208	1.37	19,837	0.227		
SR	Shell Rock	1209	1.73	29,629	0.339		
HM	Bennies Sand	788	0.69	6,301	0.072		
	Bennies	1577	0.75	10,712	0.123		
	Nantuxent Pt.	631	1.21	5,267	0.060		
	Hog Shoal	447	0.04	103	0.001		
	Strawberry	368					
	Hawk's Nest	500					
	New Beds	1236	0.31	4,912	0.056		
	Beadons	210					
	Vexton	316					
	Egg Island	1000					
	Ledge	474					
	Total	15,790	0.89	87,430	1.000	26,550	1.00

Table 14. Intermediate transplant data. Transplants were conducted in May 2015 from the Low Mortality region (Upper Arnolds) and the Medium Mortality Transplant region (Middle, Sea Breeze). Estimates of numbers of oysters moved reflect daily samples taken from each boat and measured deckloads throughout the transplant. Market-Equivalent bushels used the number of oysters moved that were ≥2.5” (63.5mm) and the Fall 2014 port-sampling result of 265 market oysters per bushel. The fraction of oysters <2.5” did not enter into additional quota allocations for 2015. The fraction of cultch includes shell only, not boxes.

Donor	Receiver	Bushels Moved	Total # Oysters	Fraction Oysters < 2.5”	Fraction Cultch	Number ≥2.5”	Mkt-Equiv. Bu (≥2.5”)
Upper Arnolds	Ship John	10,200	4,474,515	0.72	0.33	1,247,128	4688
Middle	Shell Rock	5,550	1,726,335	0.60	0.31	682,813	2567
Sea Breeze	Shell Rock	10,800	2,748,912	0.42	0.25	1,590,121	5978
Total		26,550	8,949,762			3,520,062	13,233

Table 15. Comparison of the proposed plan for the 2015 fishery to the achieved harvest in 2015. The direct market harvest regions are Medium Mortality Market, Shell Rock, and High Mortality. Percentiles are associated with region-specific exploitation rates based on catch data from 1996-2006. They reflect the harvest of market-size oysters from market-size abundance. Numbers of market-size oysters associated with the percentile are converted to bushels. Oysters moved from transplant regions to market regions result in additional quota to the region. Note that the 2016 SARC has refined the range of exploitation for the 2016 harvest and allowed for more flexible options within each region's range.

Direct Market Region	Chosen Exploit. Percentile	Chosen (bu)	Additional Allocation (bu)	Total Allocation (bu)	Achieved Final Harvest (bu)	Achieved Minus Allocated (bu)
MMM	100th	26,520	4,688	31,208	30,506	-702
SR	60th	21,926	8,545	30,471	29,629	-842
HM	75th	26,982	--	26,982	27,295	313
	Total	75,428	13,233	88,661	87,430	-1,231

Table 16. Region-specific stock performance targets and thresholds. The targets are the median of abundance for 1989–2005, the median of spawning stock biomass (SSB) for 1990-2005, and the median of market-sized (≥ 2.5”) abundance for 1990–2005. The threshold is taken as half of each target value. Note: these values represent the updated time-series using temporally-consistent and newly-grouped catchability coefficients. They will not match previously reported targets and thresholds. Because of this, the reference points previously used for the VLM region are no longer appropriate and will be re-evaluated.

	Very Low Mortality	Low Mortality	Medium Mortality Transplant	Medium Mortality Market	Shell Rock	High Mortality
Abundance						
Target	-	391,877,696	414,560,096	747,234,944	313,595,904	438,391,488
Threshold	-	195,938,848	207,280,048	373,617,472	156,797,952	219,195,744
SSB						
Target	-	153,189,760	173,661,088	324,680,512	169,225,344	250,026,400
Threshold	-	76,594,880	86,830,544	162,340,256	84,612,672	125,013,200
≥ 2.5” Abundance						
Target	-	42,075,297	46,566,027	175,051,502	72,910,219	64,446,071
Threshold	-	21,037,649	23,283,014	87,525,751	36,455,110	32,223,036

Table 17. Summary status of the stock for 2015. Green indicates variables judged to have improved relative to the 1990–2015 time period, the 2010–2014 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 1990–2015 time period. The percentile rank of the 3-year average recruitment (2013-2015) is compared to the 1990-2015 recruitment. Mortality rates for 2015 are judged against general rates in the absence of disease and Dermo weighted prevalence is compared to rates known to cause mortality. All values shown represent the updated time-series using temporally-consistent and newly-grouped catchability coefficients. Because of this, the reference points previously used for the Very Low Mortality region are no longer appropriate and will be re-evaluated.

2015 Metrics	Transplant Very Low Mortality	Transplant Low Mortality	Transplant Medium Mortality	Market Medium Mortality	Market Shell Rock	Market High Mortality
Total Abundance						
Percentile		0.135	0.365	0.442	0.250	
versus 10-14 Median	Above	Below	Below	Below	Below	Below
versus Target-Thresh		Between	Between	Between	Between	Between
≤2.5" Abundance						
Percentile		.12	.56	.20	.08	.36
versus 10-14 Median	Above	Below	Above	Below	Below	Below
≥2.5" Abundance						
Percentile		0.480	0.920	0.760	0.800	0.800
versus 10-14 Median	Above	Below	Above	Above	Above	Above
versus Target-Thresh		Above	Above	Above	Above	Above
Recruitment						
Percentile		0.635	0.404	0.365	0.096	0.212
2015 versus 10-14 Median	Above	Above	Below	Below	Below	Below
3-yr Mean Percentile	0.654	0.705	0.366	0.401	0.171	0.462
Mortality						
Percentile		0.135	0.365	0.404	0.481	0.212
versus 10-14 Median	Below	Below	Below	Below	Above	Below
Rate	0.0448	0.06554	0.13936	0.16004	0.18772	0.18079
Dermo						
Percentile	0.250	0.360	0.478	0.720	0.320	0.080
versus 10-14 Median	Below	Below	Above	Above	Below	Below
Weighted Prevalence	0.01	0.28	1.68	2.33	1.78	1.33

Table 18. Direct Market quota projections for 2016. Numbers to be removed are based on the abundance of ≥2.5” oysters in each region and realized exploitation rates from 2007-2015. Projections use the average oysters per marketed bushel (265) derived from the 2004-2015 port-sampling program. Arrows indicate highest SARC-recommended option in each region. Lower exploitation rates are implicitly acceptable to the SARC; higher rates are not. Shaded percentiles require that Intermediate Transplant must occur.

Region		Exploitation Category	Rate	Number of Oysters Removed	Direct Market Bushels
Medium		SubMin	.0090	2,109,351	7,960
Mortality		Min	.0180	4,209,349	15,884
Market	→	50th (med)	.0303	7,085,737	26,739
		+10%	.0333	7,794,310	29,492
		+20%	.0364	8,502,884	32,086
	→	Max	.0370	8,652,550	32,651
Shell		SubMin	.0117	1,551,582	5,855
Rock		Min	.0234	3,105,819	11,720
	→	50th (med)	.0370	4,910,910	18,532
		+10%	.0407	5,402,001	20,385
		+20%	.0444	5,893,092	22,238
	→	Max	.0488	6,477,093	24,442
High		SubMin	.0240	2,689,113	10,148
Mortality		Min	.0481	5,379,345	20,299
		50th (med)	.0749	8,376,568	31,610
		+5%	.0786	8,795,397	33,190
		+10%	.0824	9,214,225	34,771
	→	+15%	.0861	9,633,054	36,351
		Max	.0982	10,982,363	41,443

Table 19. Projections for intermediate transplanting in 2016. Exploitation rate and numbers to remove are based on all sizes of oysters and realized exploitation rates from 2007-2015. The estimated number of bushels to move is derived from the mean of the number of oysters per bushel by region from the 2015 transplant program or other as noted.[1] Cullers are used for transplants. Market equivalent bushels are based on the fraction of oysters ≥2.5” converted to bushels using the average 265 oysters/bu derived from the 2004-2015 port-sampling program. Arrows indicate highest SARC-recommended option in each region. Lower exploitation rates are implicitly acceptable to the SARC; higher rates are not.

Region	Category	Exploit. Rate	Number of Oys Removed	Deckload Oys / bu	Trans. bu	Mkt.Equiv. bu
Very Low	SubMin	.0186	2,988,192	480	6,225	1,263
Mortality[1]	→ ½ SubMin-Min	.0280	4,482,287	480	9,338	1,894
	Min	.0373	5,976,383	480	12,451	2,526
	Mid	.0386	6,192,802	480	12,902	2,617
	Max	.0432	6,923,819	480	14,425	2,926
Low	SubMin	.0038	856,176	439	1,950	879
Mortality[1]	Min	.0076	1,712,353	439	3,901	1,758
	-20%	.0140	3,165,367	439	7,210	3,249
	-10%	.0158	3,561,038	439	8,112	3,655
	→ 50^{th}(med)	.0175	3,956,709	439	9,013	4,061
	Max	.0226	5,105,431	439	11,630	5,240
Medium	SubMin	.0051	1,362,493	274	4,973	2,314
Mortality	Min	.0103	2,724,985	274	9,945	4,627
Transplant[1]	-30%	.0139	3,694,370	274	13,483	6,273
	-25%	.0149	3,958,253	274	14,446	6,722
	-20%	.0159	4,222,137	274	15,409	7,170
	-15%	.0169	4,486,020	274	16,372	7,618
	-10%	.0179	4,749,904	274	17,335	8,066
	-5%	.0189	5,013,787	274	18,298	8,514
	→ 50^{th} (med)	.0199	5,277,671	274	19,262	8,962
	Max	.0246	6,512,927	274	23,770	11,060

[1] Very Low Mortality region deckload oys/bu is an estimate based on 2010 transplant when total abundance for this region was similar to 2015 abundance. Low and Medium Mortality region oysters/bu taken from 2015 intermediate transplant samples; actual numbers for 2016 may not be similar.

Figure 1. The natural oyster beds of Delaware Bay, NJ with 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. From upbay to downbay, the regions are: Very Low Mortality (dark green), Low Mortality (red), Medium Mortality Transplant (light green), Medium Mortality Market (light blue), Shell Rock (orange), High Mortality (dark blue). Bold black outlines indicate complete footprint of each bed including grids in the High, Medium, and Low oyster density strata. Grids in High and Medium density strata are indicated in dark and light shades respectively with the caveat that strata designations are within-bed, not within-region. Low quality grids are blank spaces within the bed outline. Strata designation is described in the text. Each grid is 0.2" latitude x 0.2" longitude; approximately 25 acres (101,175 m^2 or 10.1 hectares).

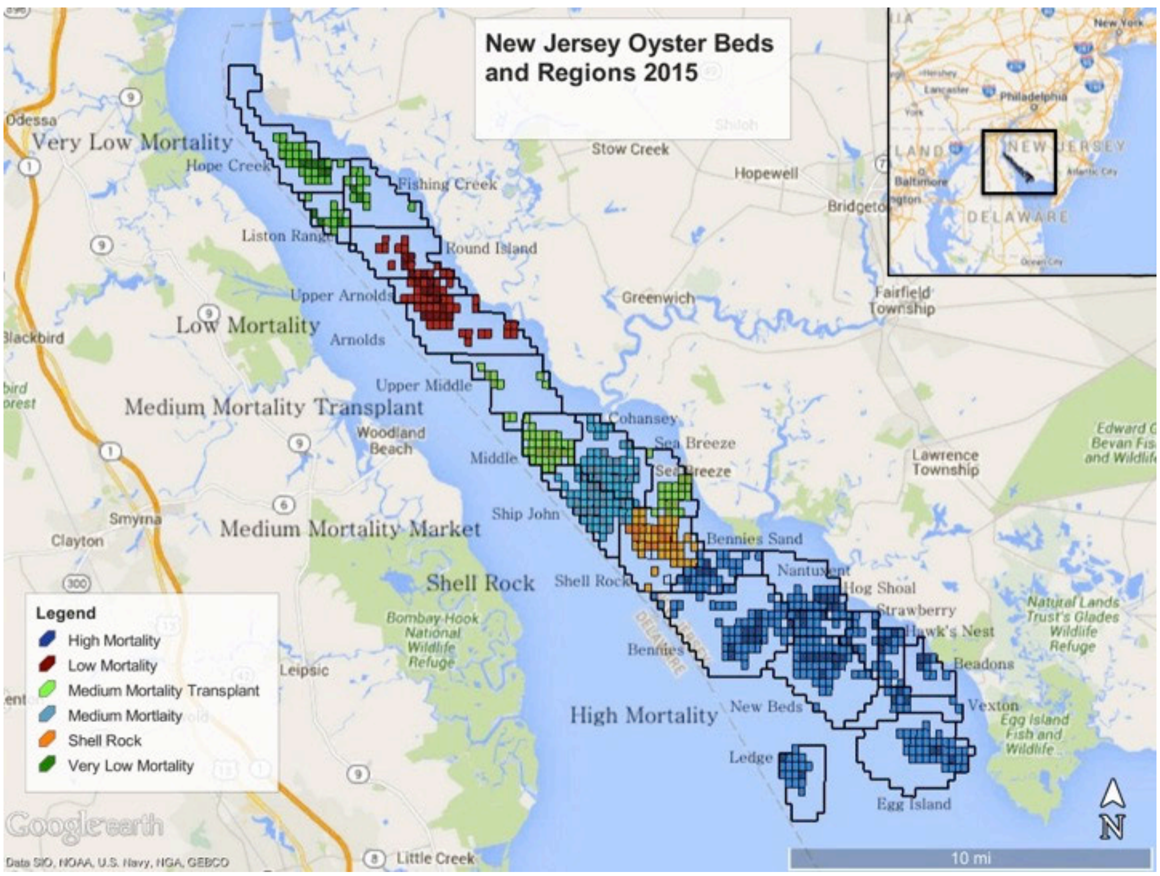


Figure 2. Abundance of oysters on the oyster beds of Delaware Bay, NJ for the entire time series of stock surveys (1953–2015). Until 2007, the three most upbay beds that comprise the Very Low Mortality Region (see Figure 1) were not included in the annual surveys and therefore they are not included in most of the whole stock analyses.

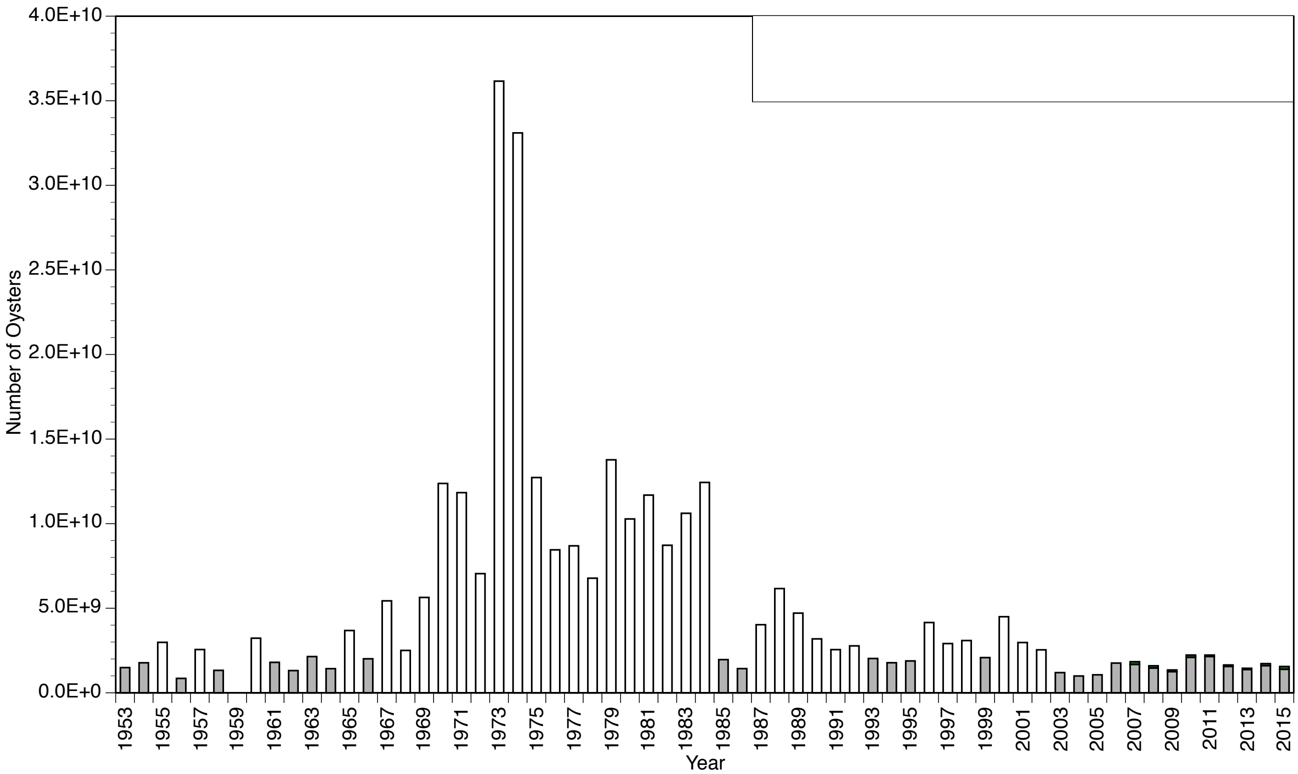


Figure 3. Acreage of the six bed regions in 2015, excluding low quality strata. Relative acreage of each region shown in pie chart. Acreage includes only the high and medium quality strata footprint for each bed from the 2015 surveys. From upbay to downbay: Very Low Mortality (VLM), Low Mortality (LM), Medium Mortality Transplant (MMT), Medium Mortality Market (MMM), Shell Rock (SR), High Mortality Market (HM). Total Acreage: 15,790 acres (63,899,863 m^2 or 6,390 hectares).

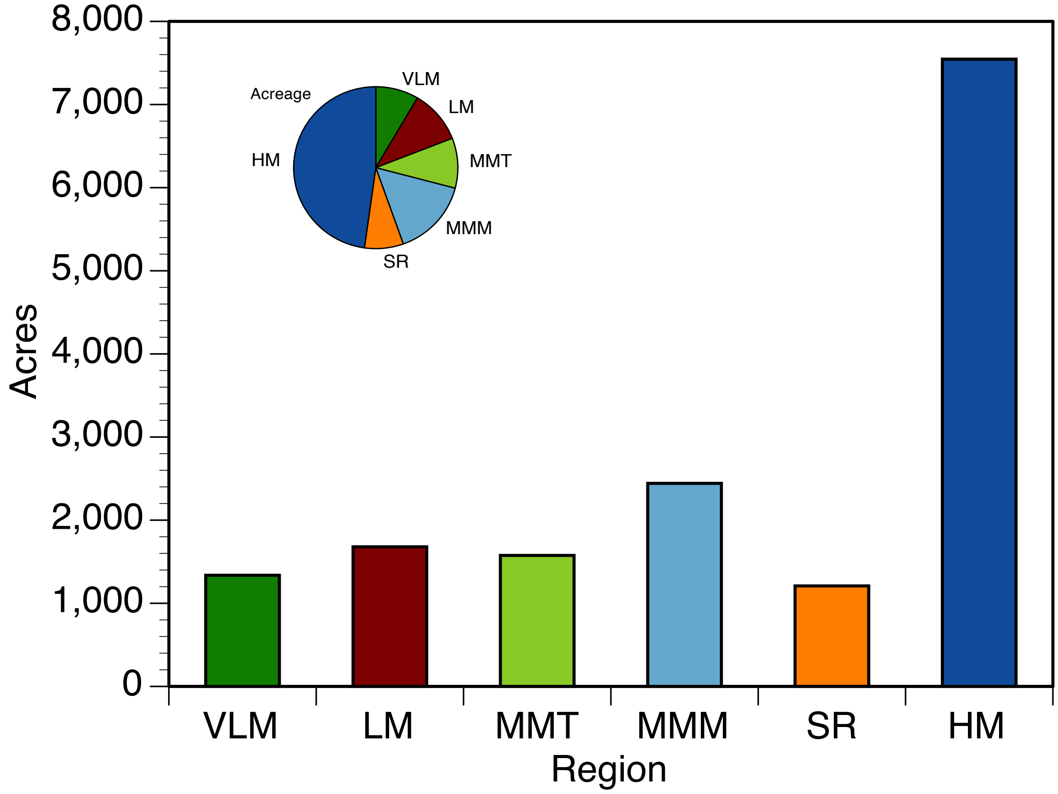
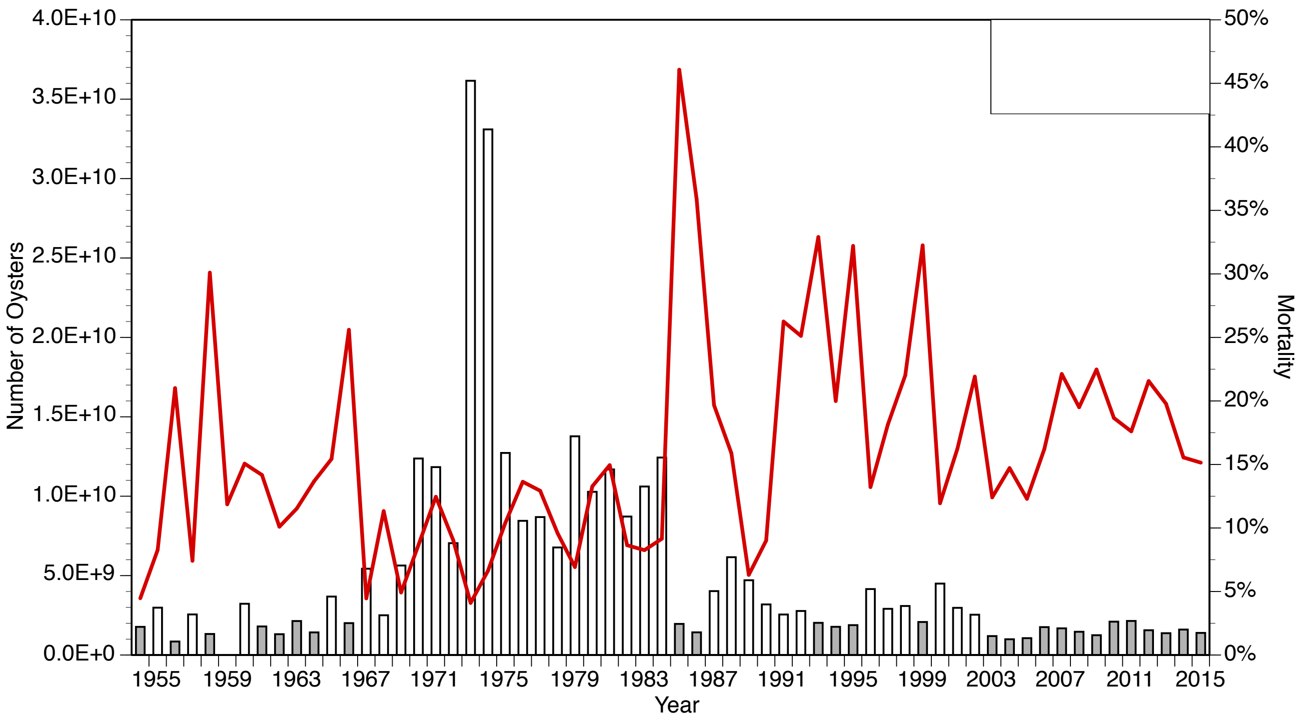


Figure 4. Total abundance of oysters compared to box-count mortality rate on righthand axis (**a**) and fishing mortality on righthand axis (**b**). Time series of 1953–2015 stock surveys excludes the Very Low Mortality region.

(a)



(b)

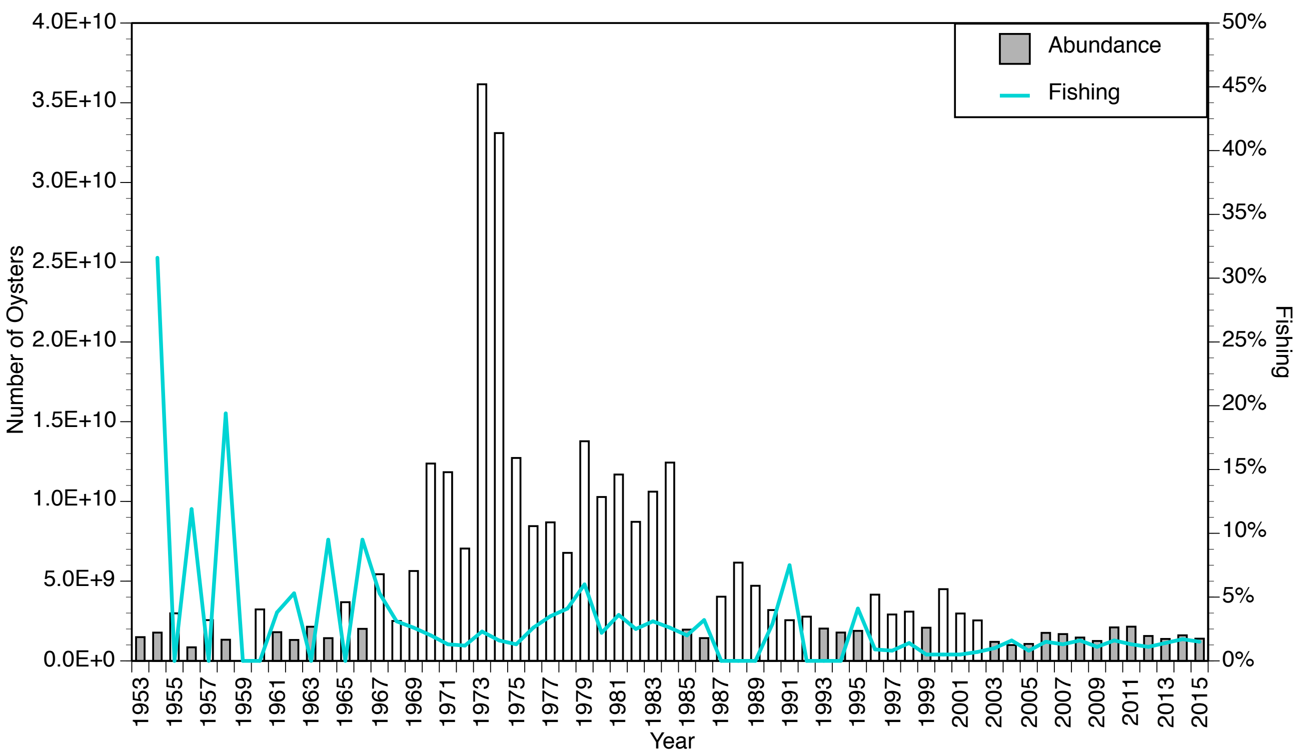
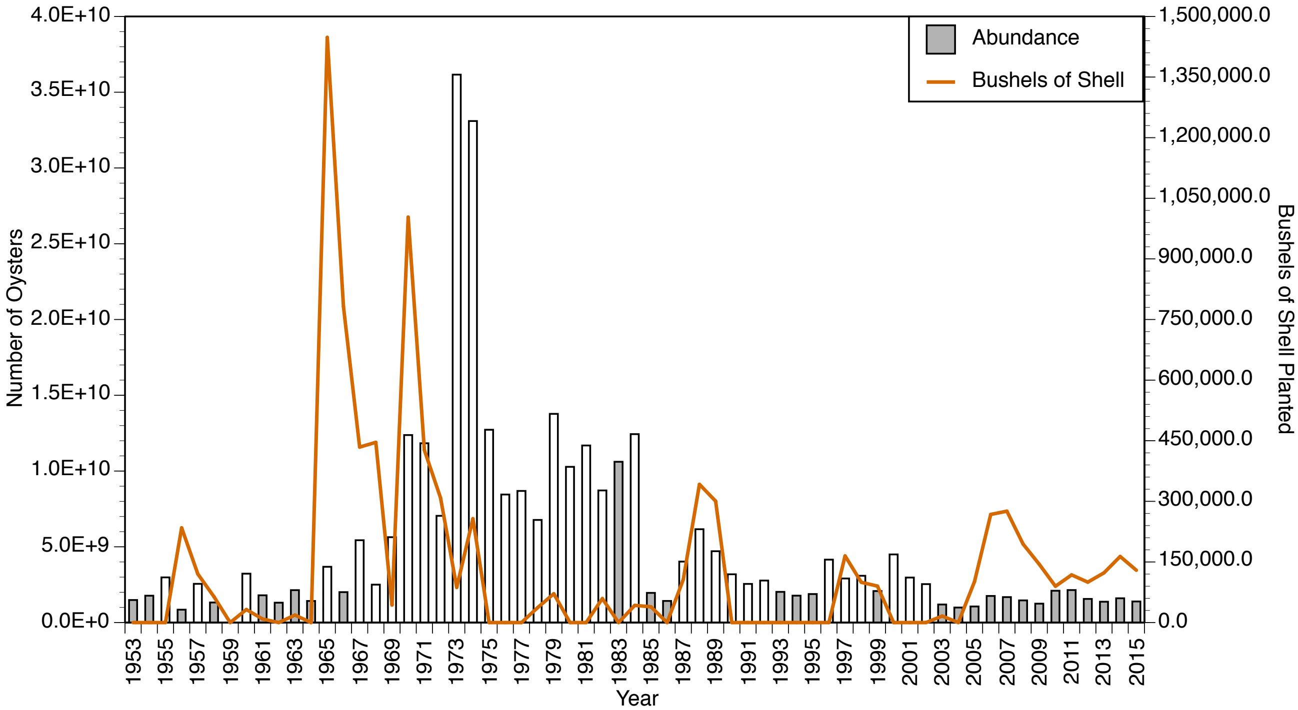


Figure 5. Total abundance of oysters compared to bushels of shell planted for spat recruitment on righthand axis (**a**) and number of spat from the stock assessment time series on righthand axis (**b**). Time series of 1953–2015 stock surveys excludes the Very Low Mortality region.

(a)



(b)

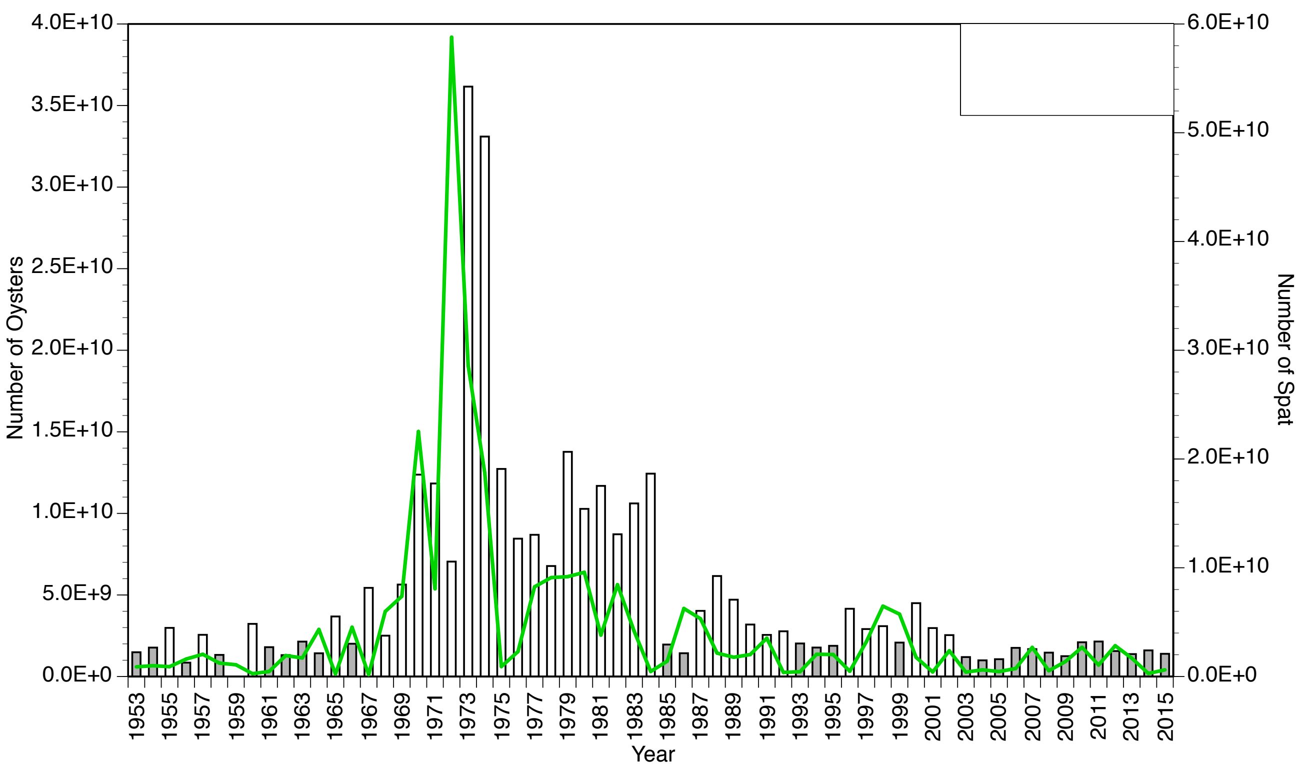


Figure 6. Number of oysters harvested from the natural oyster beds of Delaware Bay, NJ from 1953–2015. Prior to 1996, the bay-season fishery removed oysters from the natural beds and transplanted them downbay to leased grounds. The direct-market fishery began in 1996. In 1997, an intermediate transplant program began. Zeros represent years of fishery closure.

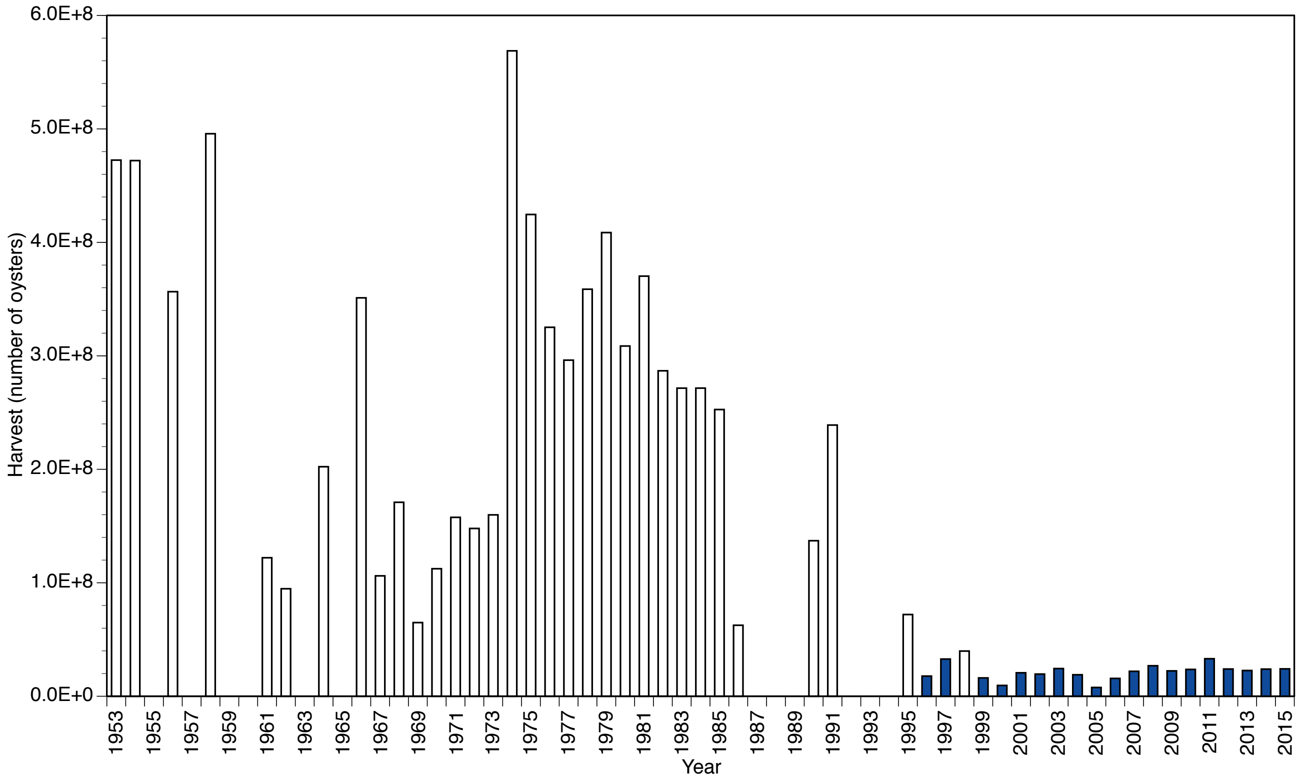


Figure 7. Estimates of oyster density from 100 paired tows made by the *F/V* Peter Payner and the *F/V* Howard W. Sockwell on Shell Rock, grid 2.

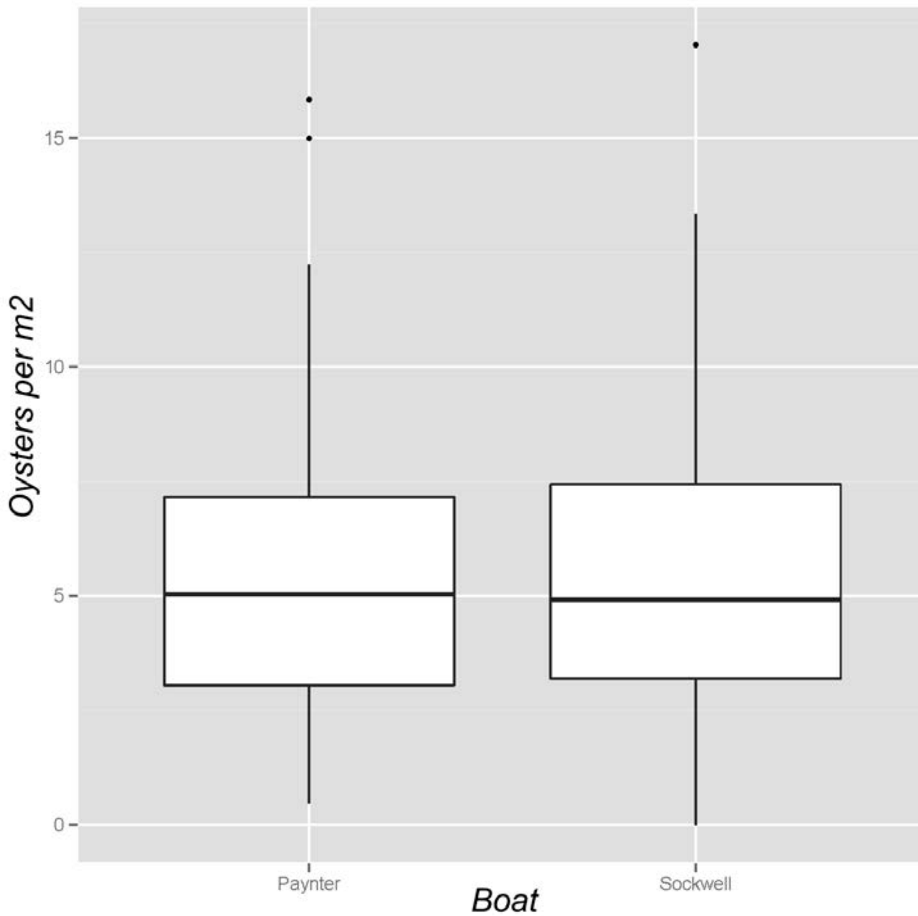


Figure 8. Exploitation percentiles and their associated rates for each region. Rates are based on the percentiles derived from the 1996-2006 fishing record for each region. The same base data is used for each transplant region (VLM, LM, MMT) due to sparse exploitation of those regions during the time series.

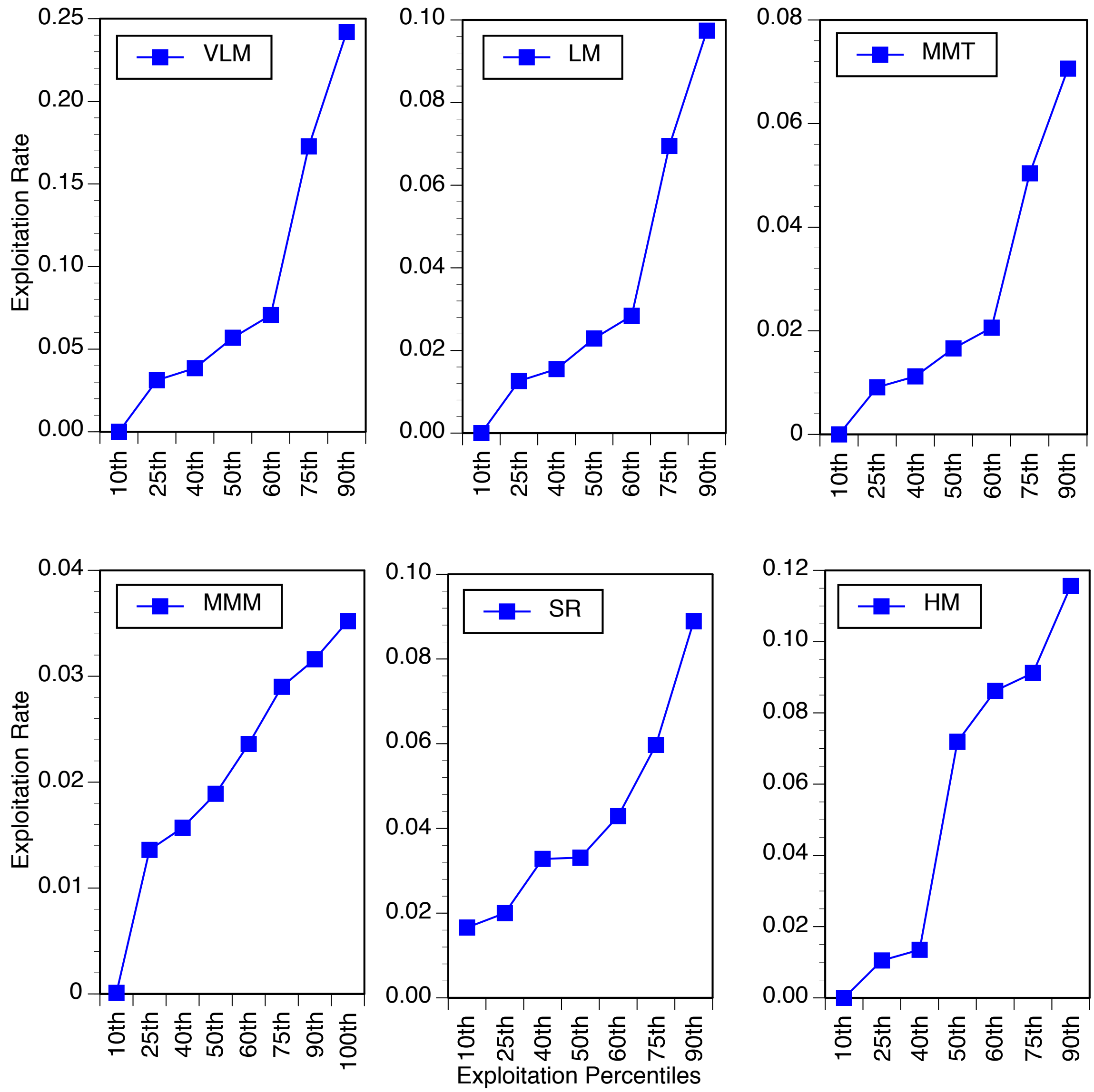


Figure 9a. Realized exploitation fractions of the >2.5" oyster stock on the Direct Market regions in Delaware Bay NJ for two time periods: 1996-2006 and 2007-2015. Values use the current, temporally-consistent dredge efficiencies. The 1996-2006 median (dashed line) is based on a time series of abundance and fishing exploitation calculated with temporally-varying dredge efficiencies (Table 3) and was used as the exploitation target for the later time period. The 2007-2015 median (dotted line) is based on the realized exploitation values shown with shading showing the range.

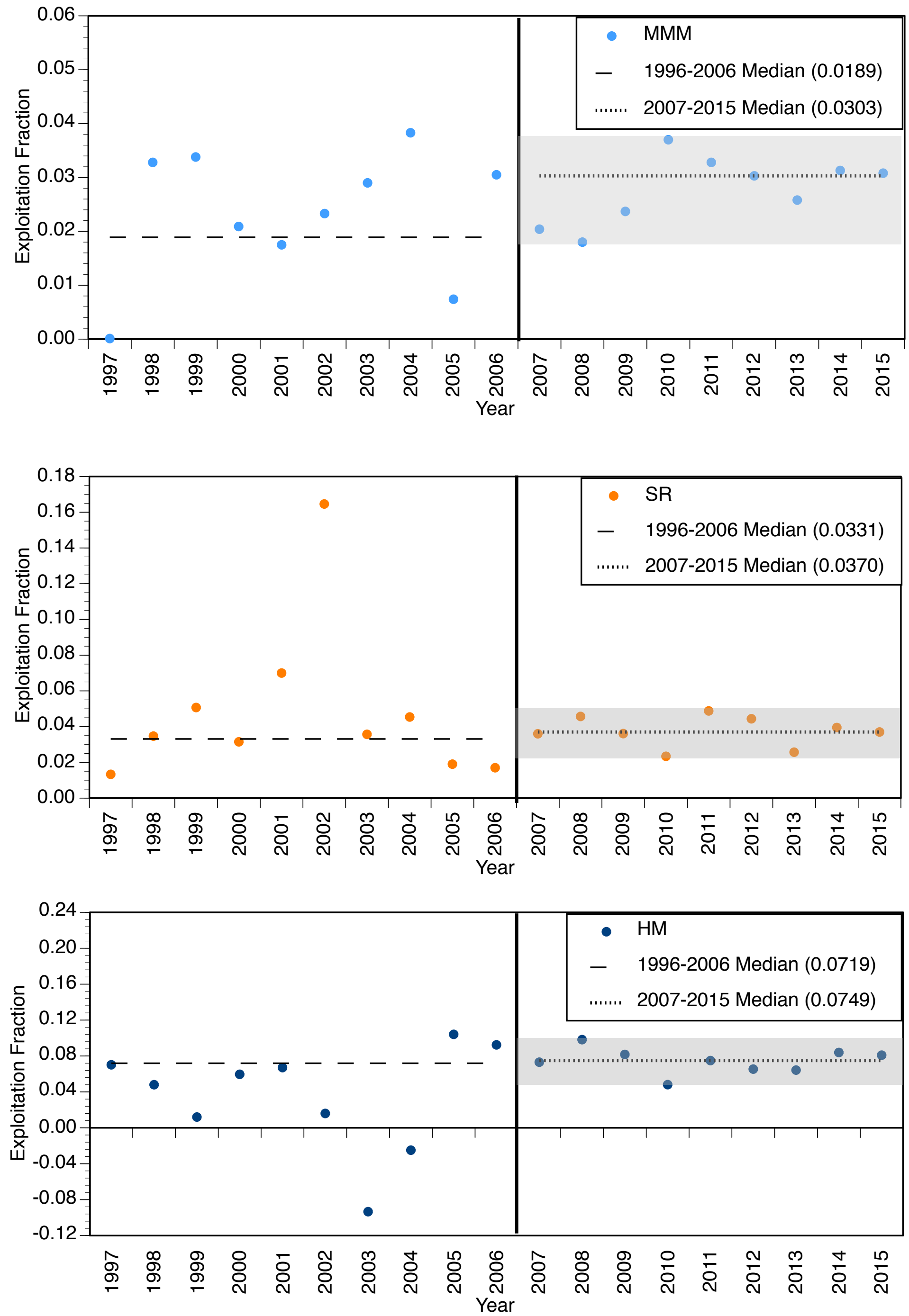


Figure 9b. Realized exploitation fractions of the whole oyster stock, excluding spat, on the Transplant regions in Delaware Bay NJ for two time periods: 1996-2006 and 2007-2015. Values use the current, temporally-consistent dredge efficiencies. The 1996-2006 MMT median (dashed line) was used for all Transplant regions and is based on a time series of abundance and fishing exploitation calculated with temporally-varying dredge efficiencies (Table 3). It was used as the exploitation target for the later time period. The 2007-2015 median (dotted line) is based on the realized exploitation for each region with shading showing the range. The VLM abundance time series began in 2007 and the region has only 3 years of exploitation.

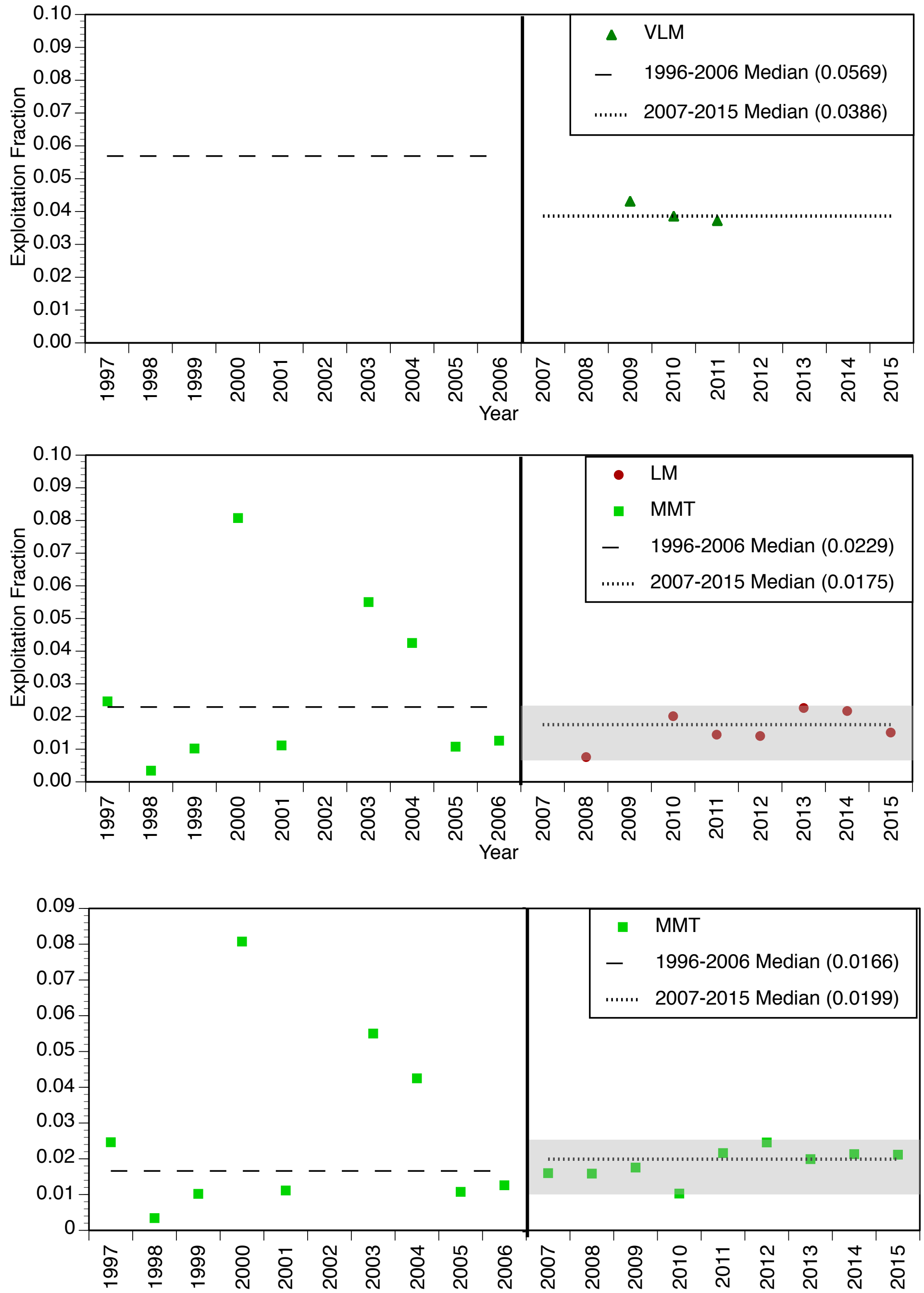


Figure 10. Delaware Bay market oyster abundance estimated from the annual stock assessment survey by region and year. Error bars represent the 10th and 90th percentiles of 1,000 bootstrap survey (black) and catchability (red) error simulations.

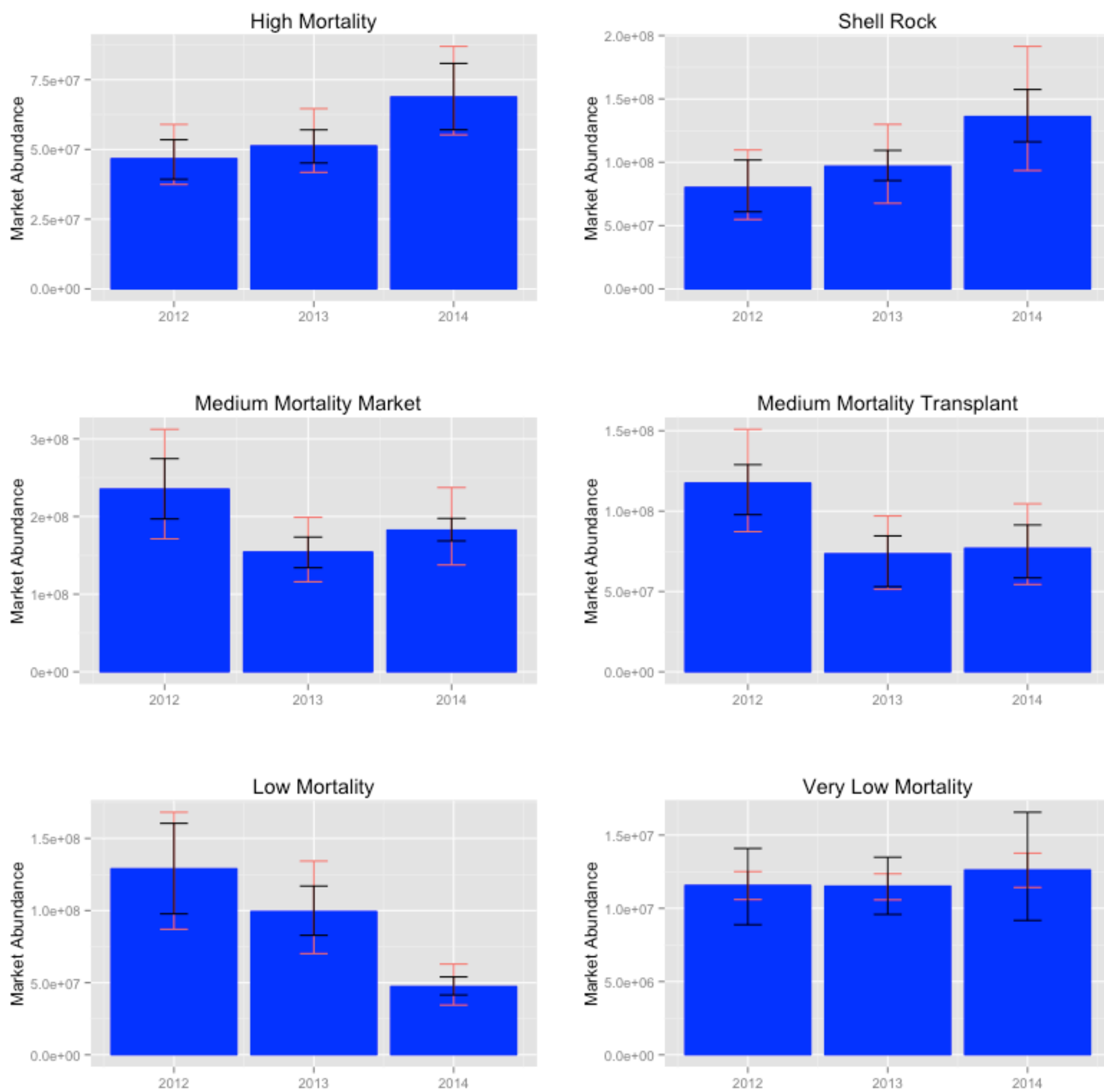
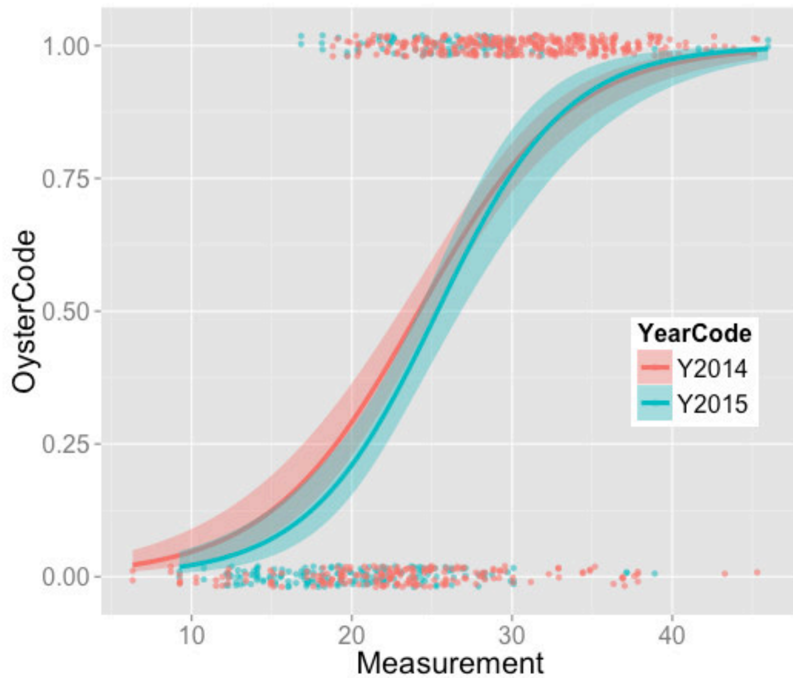
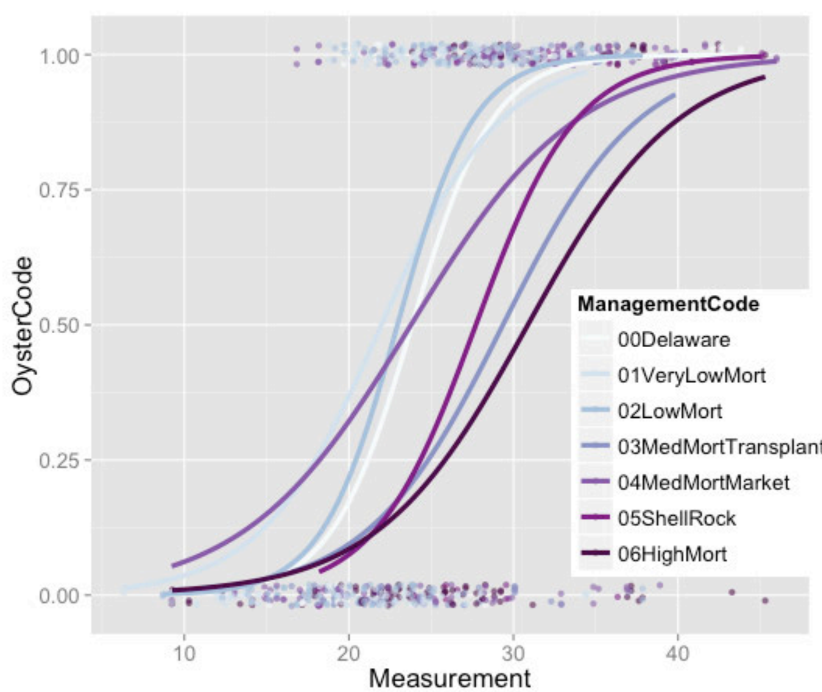


Figure 11. Logistic curve fits using 95% confidence band and observations from September and October only, for **(a)** each year and **(b)** each region. **(c)** Logistic curve fits for each month including all regions, **(d)** Shell height at which logistic regression models predict 50% probability of morphological transition from spat to oyster.

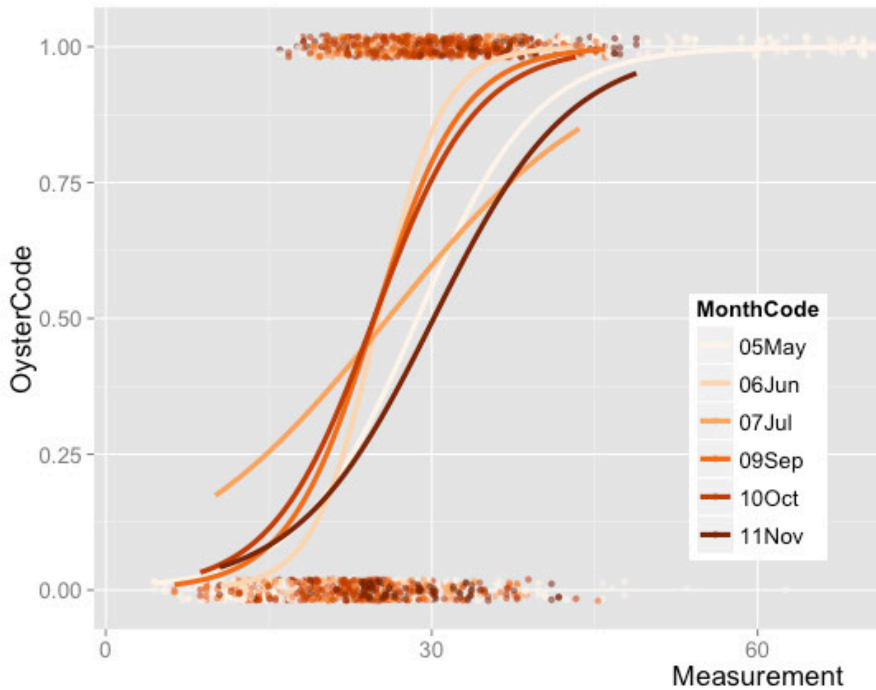
(a)



(b)

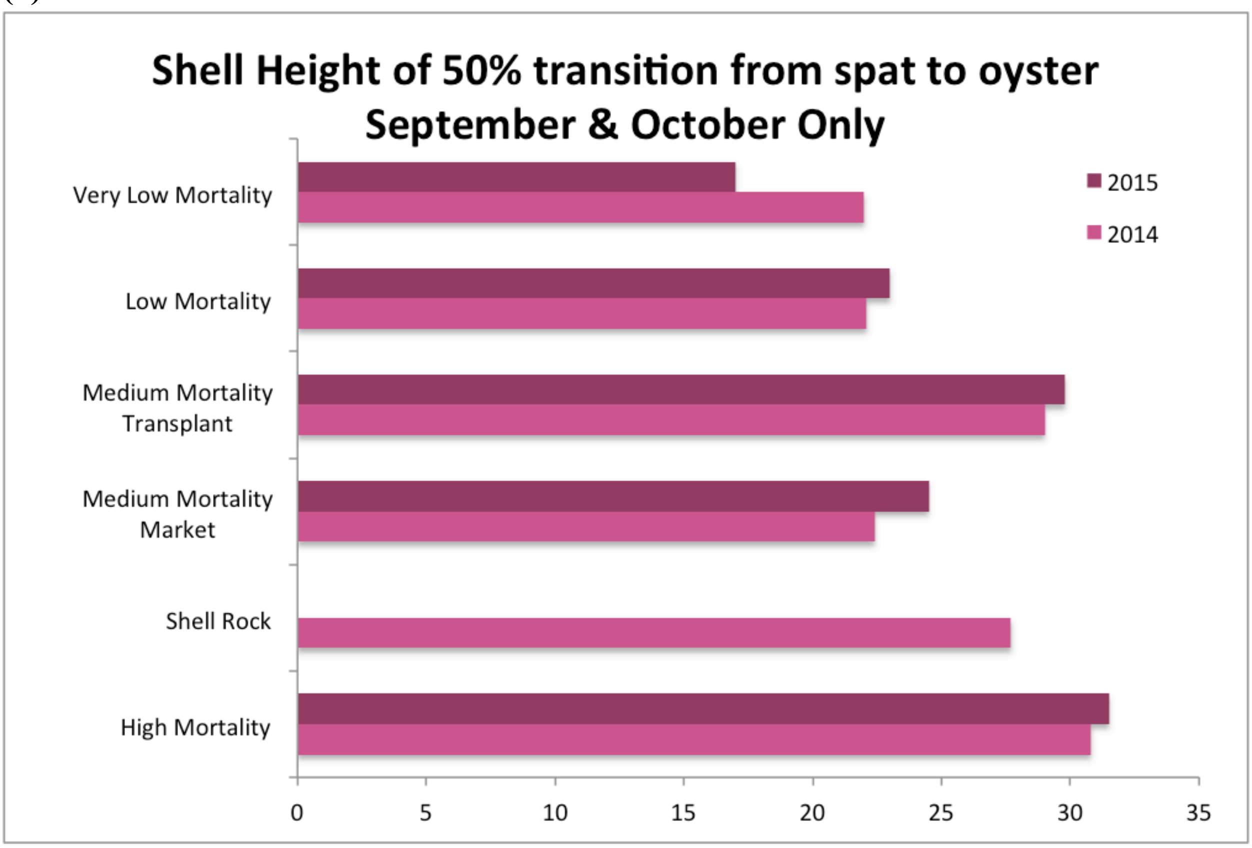


(c)



1.00
0.75
0.50
0.25
0.00
OysterCode
0
30
60
Measurement
MonthCode
05May
06Jun
07Jul
09Sep
10Oct
11Nov

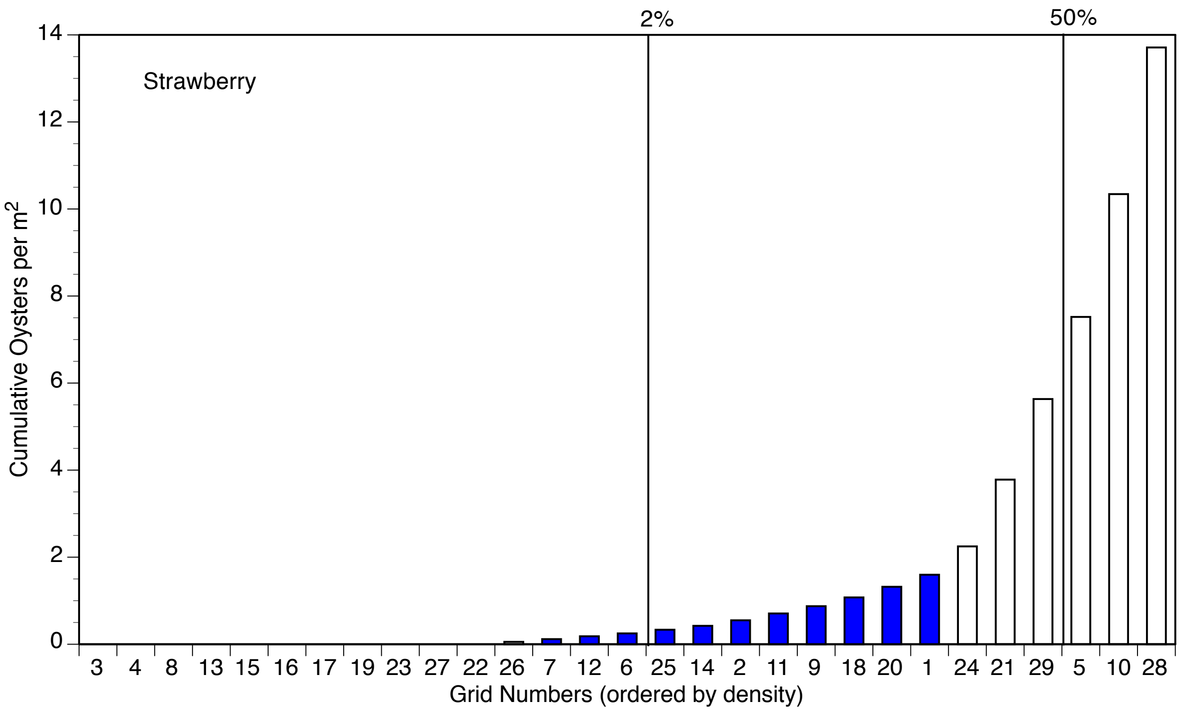
(d)



Shell Height of 50% transition from spat to oyster
September & October Only
Very Low Mortality
Low Mortality
Medium Mortality Transplant
Medium Mortality Market
Shell Rock
High Mortality
2015
2014
0
5
10
15
20
25
30
35

Figure 12. Relationship between cumulative oyster abundance and density for grids ordered by increasing abundance on **(a)** Strawberry and **(b)** Arnolds for the Spring 2015 resurvey. This resurvey covered all navigable grids associated with Strawberry and Arnolds. 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.

(a)



(b)

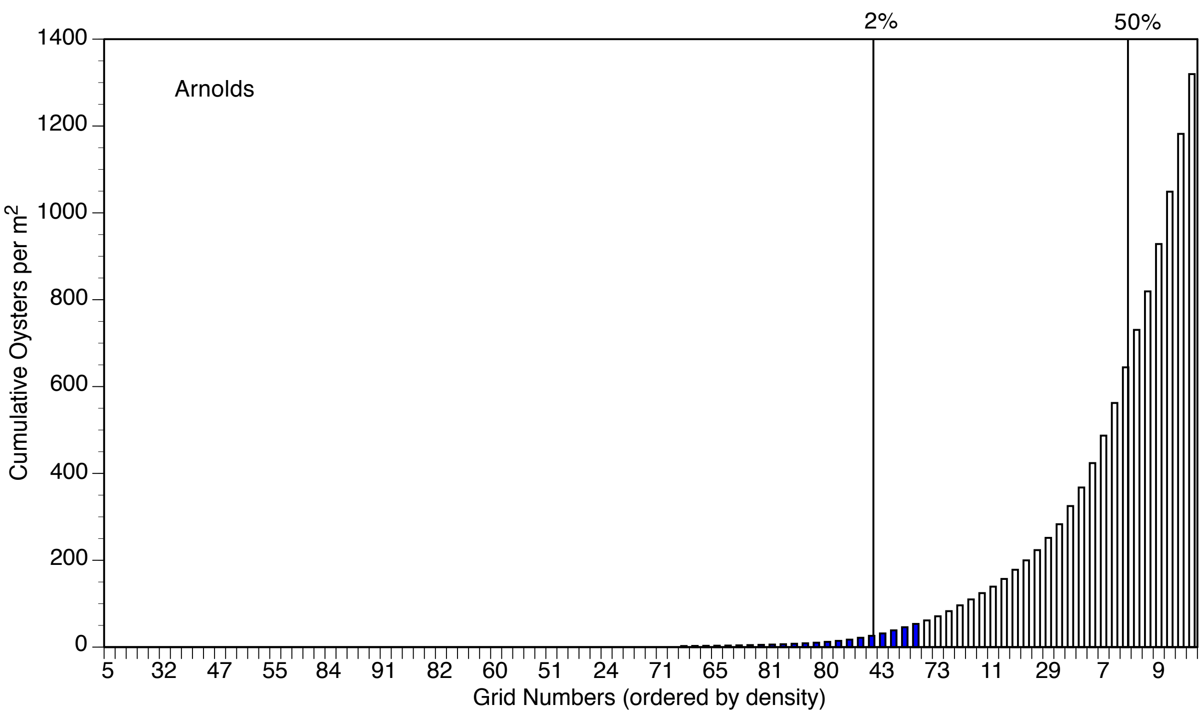


Figure 13. Distribution of grids on Arnolds and Strawberry before and after the Spring 2015 resurvey. Arnolds was last resurveyed in 2007; Strawberry was last resurveyed in 2006. The 2015 resurvey program covered all navigable grids associated with Arnolds and Strawberry. Grids are shaded according to stratification by oyster density within bed. Grids assigned to the High density stratum are shaded darkly, those assigned to the Medium density stratum are shaded an intermediate color, and Low density grids are not shaded. After the 2015 restratification: Arnolds (99 grids) has 6 High, 23 Medium, and 70 Low; Strawberry (29 grids) has 3 High, 11 Medium, and 15 Low.

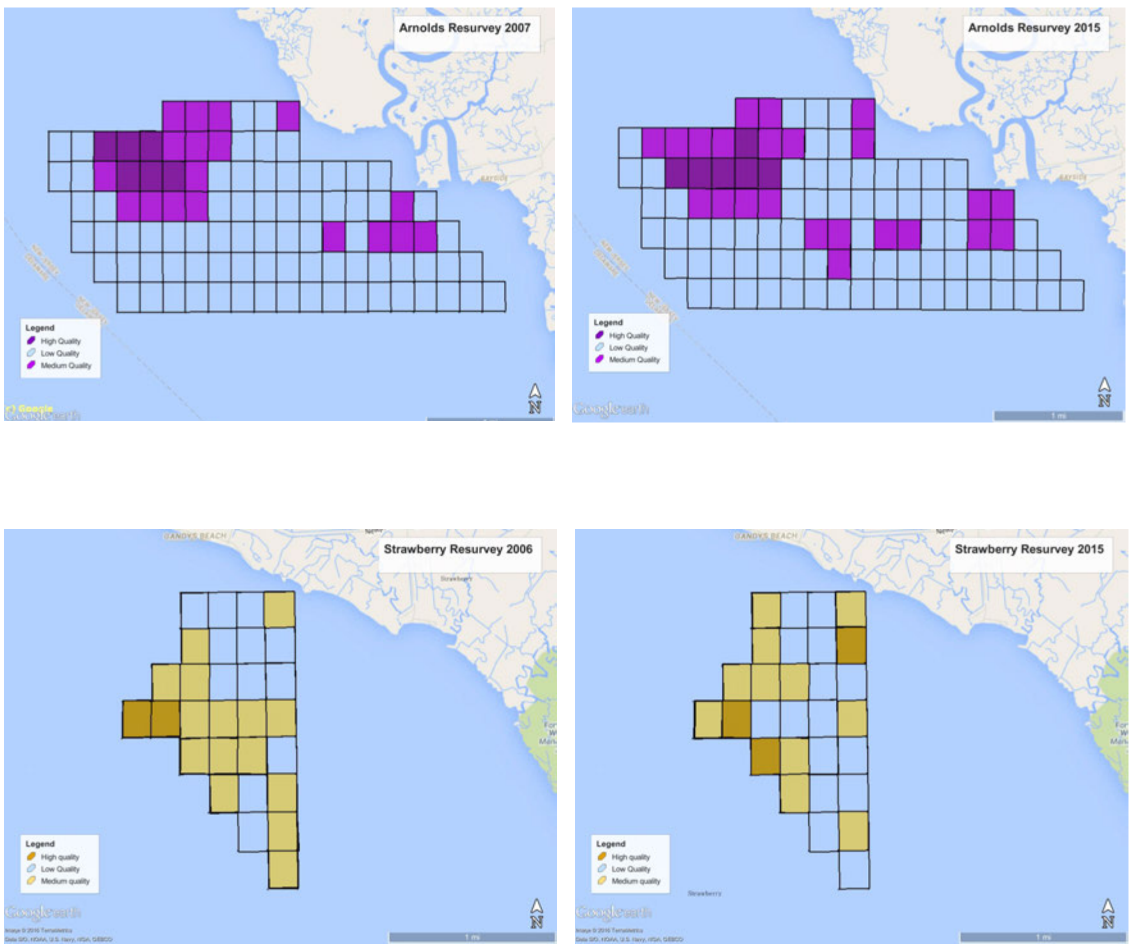


Figure 14. Map of the 2015 oyster stock assessment survey 'Random Sampling'. The sites for the 2015 stock assessment survey are indicated by white dots. Red and black dots are sites sampled in the enhanced stratrum: red are transplants, black are shellplants. Bed colors reflect their assigned region: 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) density 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. Total 2015 oyster resource acreage (minus Low stratum) is 15,790 acres (63,898,256 m^2 or 6,390 hectares).

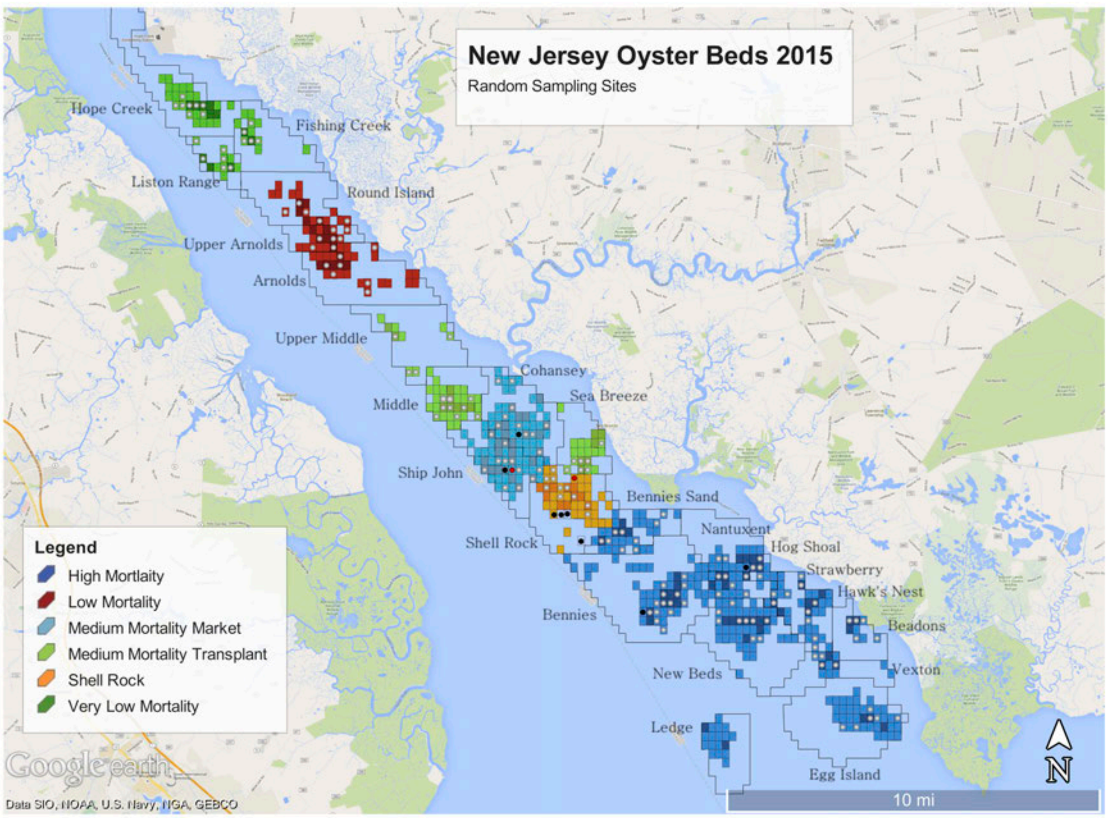


Figure 15. Total abundance of oysters >20mm on the oyster beds of Delaware Bay, NJ for the 1990–2015 time series (bars). Purple line overlay is the spawning stock biomass (SSB) which is based on oysters >35mm (right y-axis). VLM is not included in either set of data.

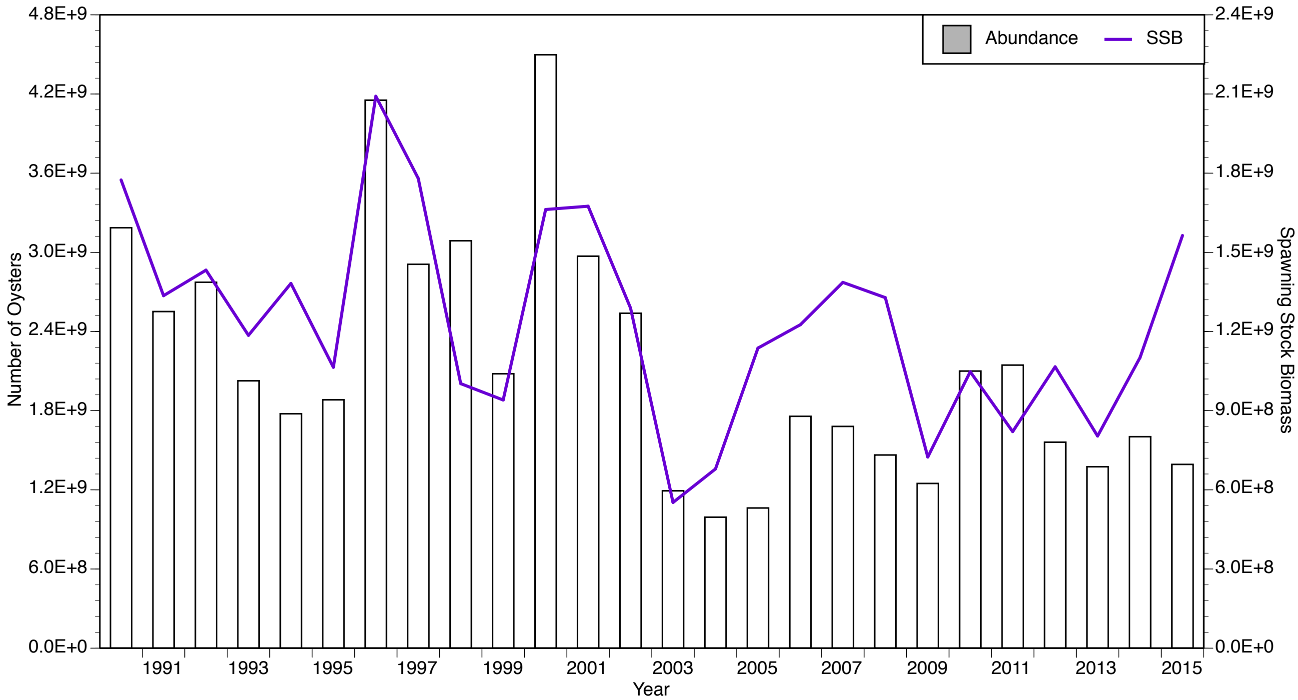


Figure 16. Number of market-size oysters (> 2.5 inches) for the 1990–2015 time series. Green line is the median value for the time series, 5.02 x 10^8 market-size oysters. Data from the Very Low Mortality Region is not included.

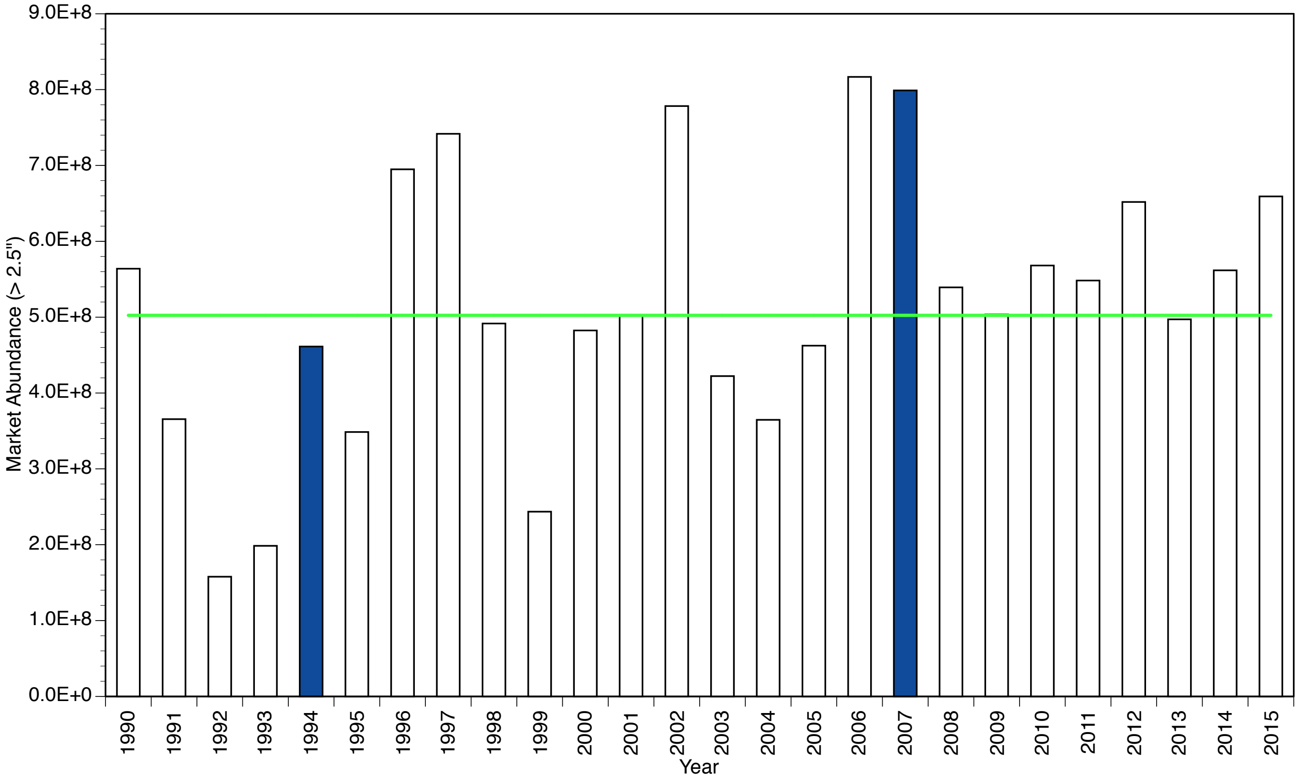


Figure 17. Oyster abundance for the 1990–2015 survey time series in: **(a)** the upper regions (VLM, LM); **(b)** the central regions (MMT, MMM); and **(c)** the lower regions (SR, HM). Regions are color-coded as in Figure 1.

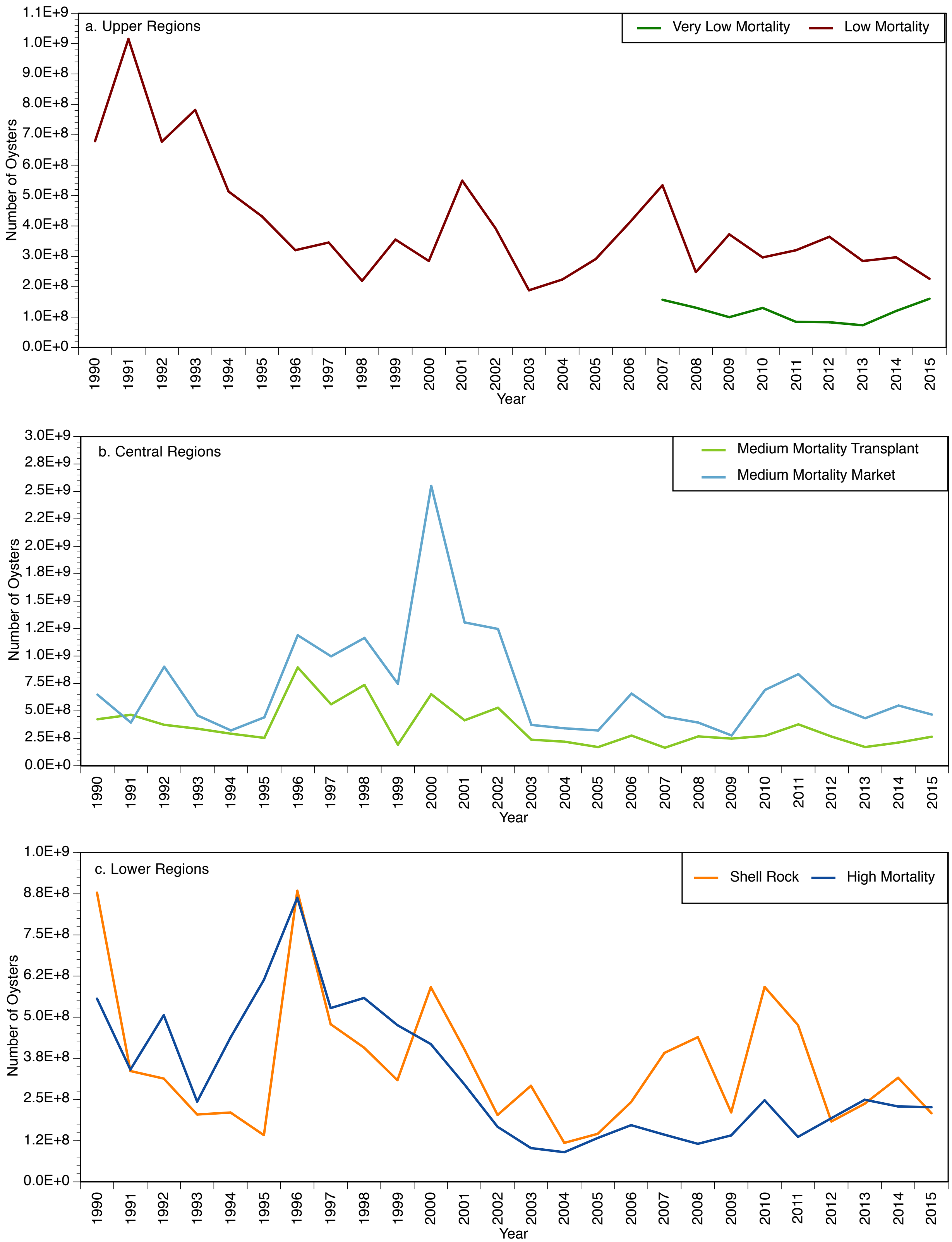


Figure 18. Box-count mortality rate for the 1990–2015 survey time series in: **(a)** the upper regions (VLM, LM); **(b)** the central regions (MMT, MMM); and **(c)** the lower regions (SR, HM). Regions are color-coded as in Figure 1.

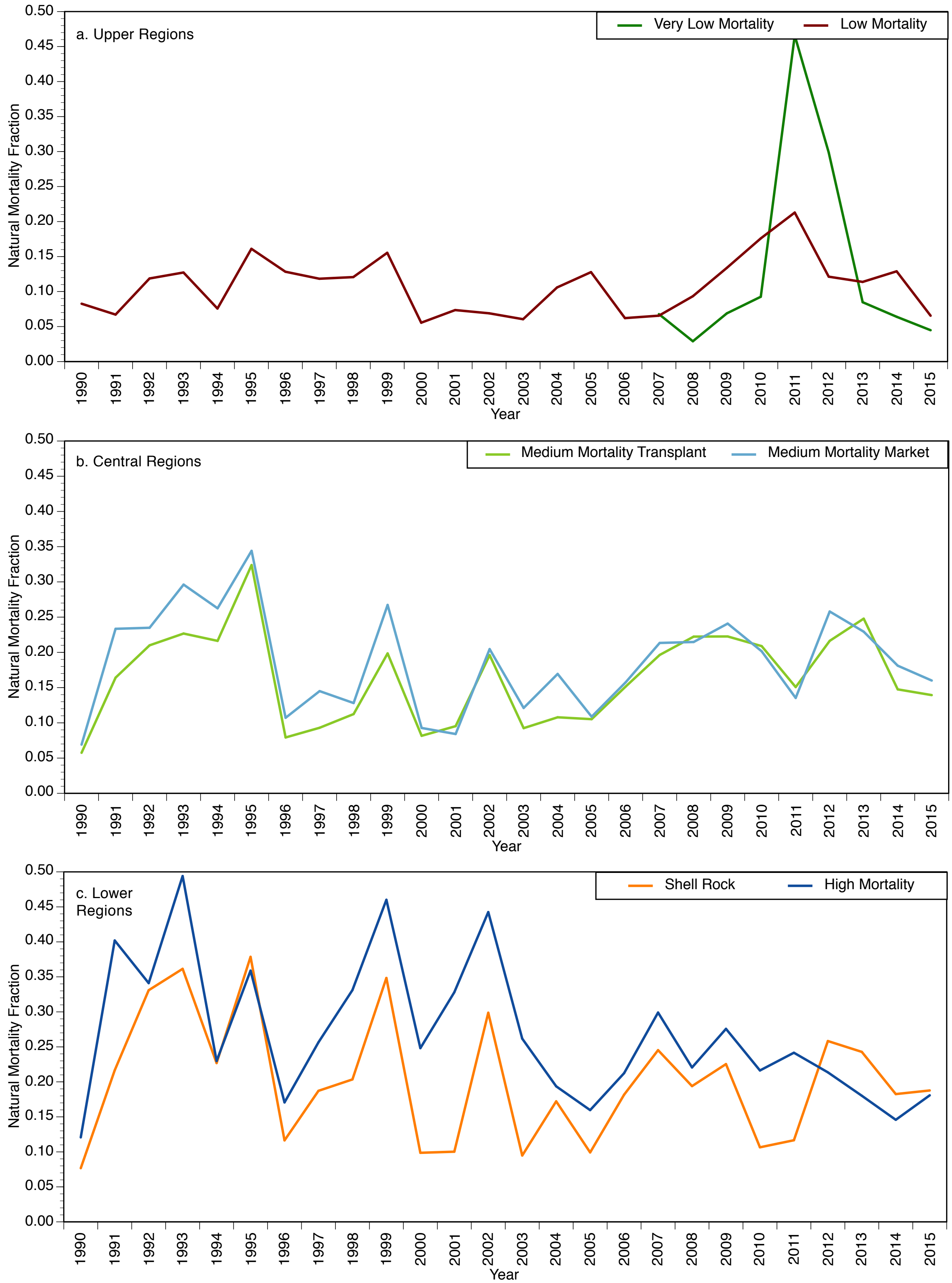


Figure 19. Abundance by size classes in the Upper Regions (VLM, LM) for the 1990–2015 survey time series. (**a**) abundance of spat (< 0.8"); (**b**) abundance of small oysters (0.8"–2.5"); (**c**) abundance of market-size oysters (> 2.5").

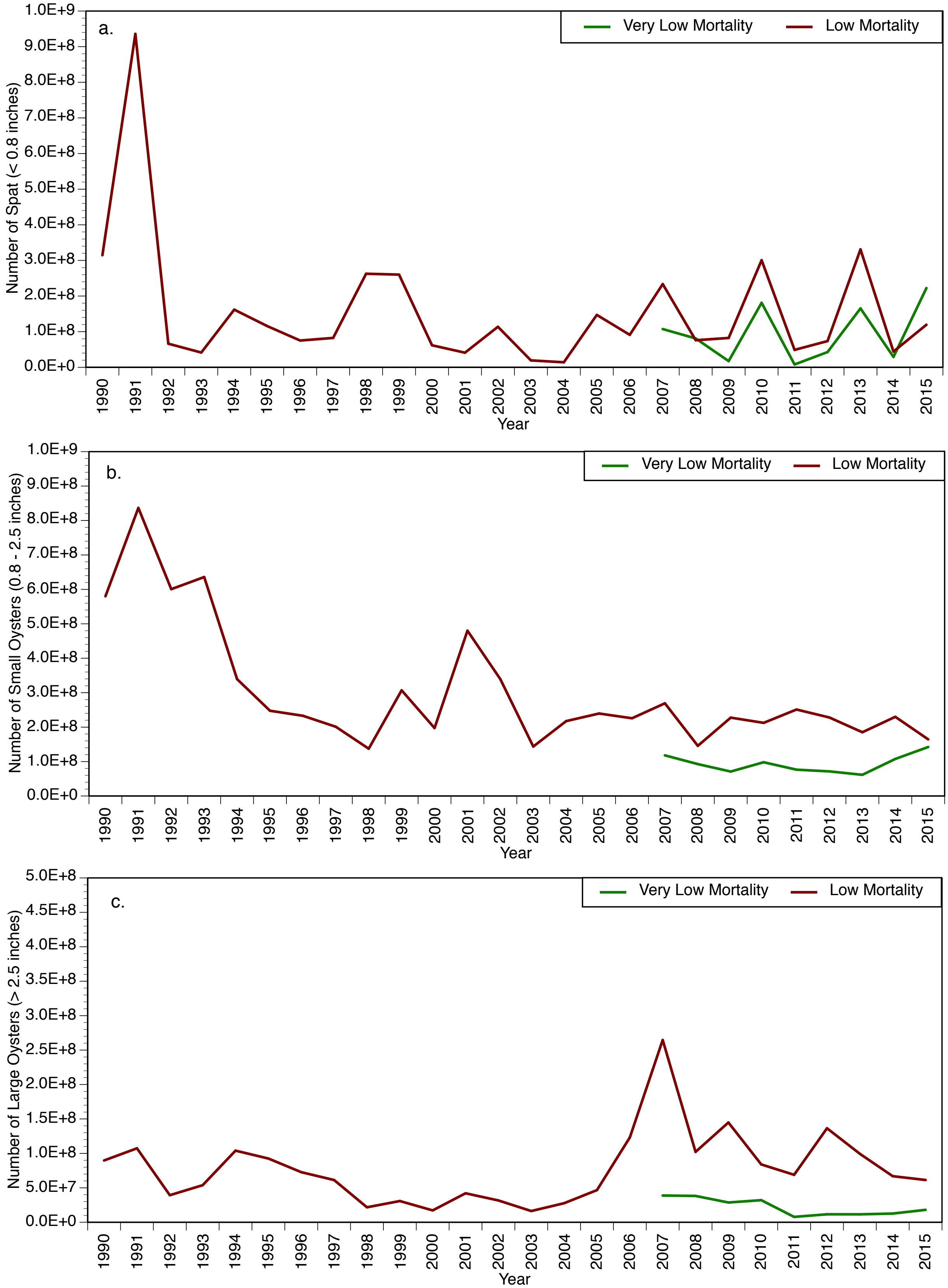


Figure 20. Abundance by size classes in the Central Regions (MMT, MMM) for the 1990–2015 survey time series. (**a**) abundance of spat (< 0.8”); (**b**) abundance of small oysters (0.8”–2.5”); (**c**) abundance of market-size oysters (> 2.5”).

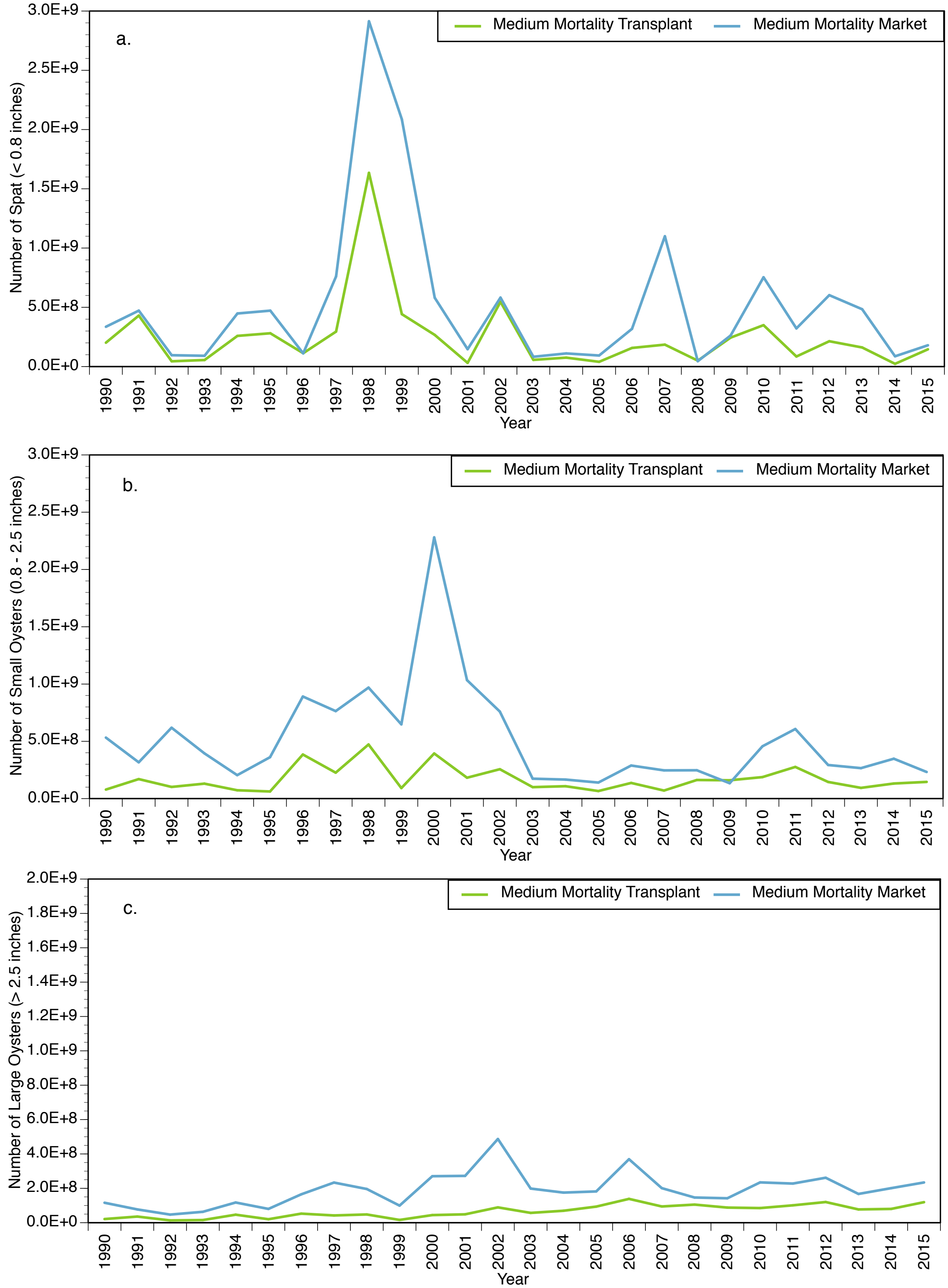


Figure 21. Abundance by size classes in the Lower Regions (SR, HM) for the 1990–2015 survey time series. (**a**) abundance of spat (< 0.8”); (**b**) abundance of small oysters (0.8”–2.5”); (**c**) abundance of market-size oysters (> 2.5”).

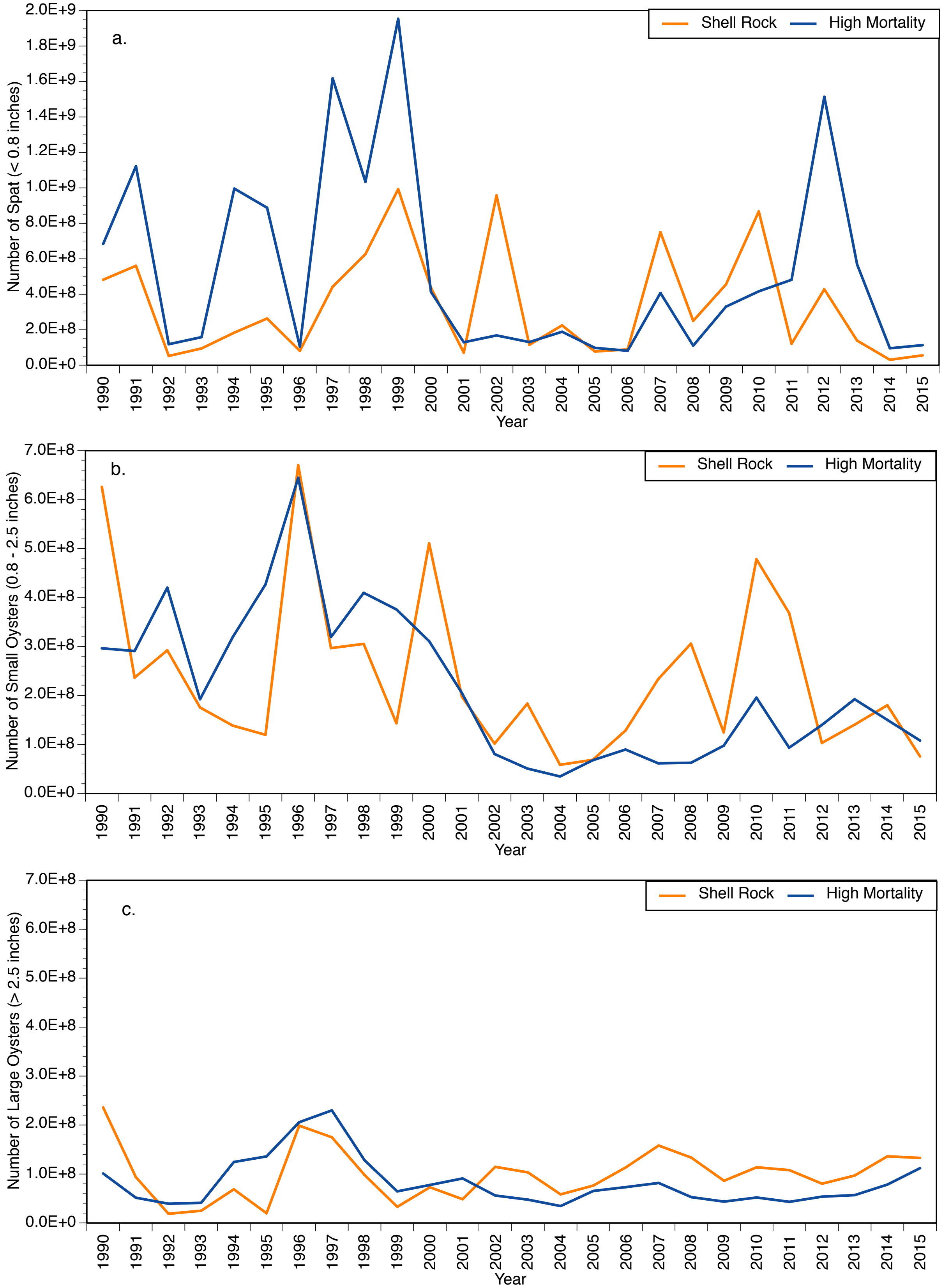


Figure 22. (a) Total abundance of oysters from 1990 – 2015. (b) Upper panel: bushels of shell planted from 1997 – 2015. Lower panel: Estimated number of bushels of shell lost from New Jersey oyster bed. Shell budget is calculated using updated half-lives estimated in this assessment.

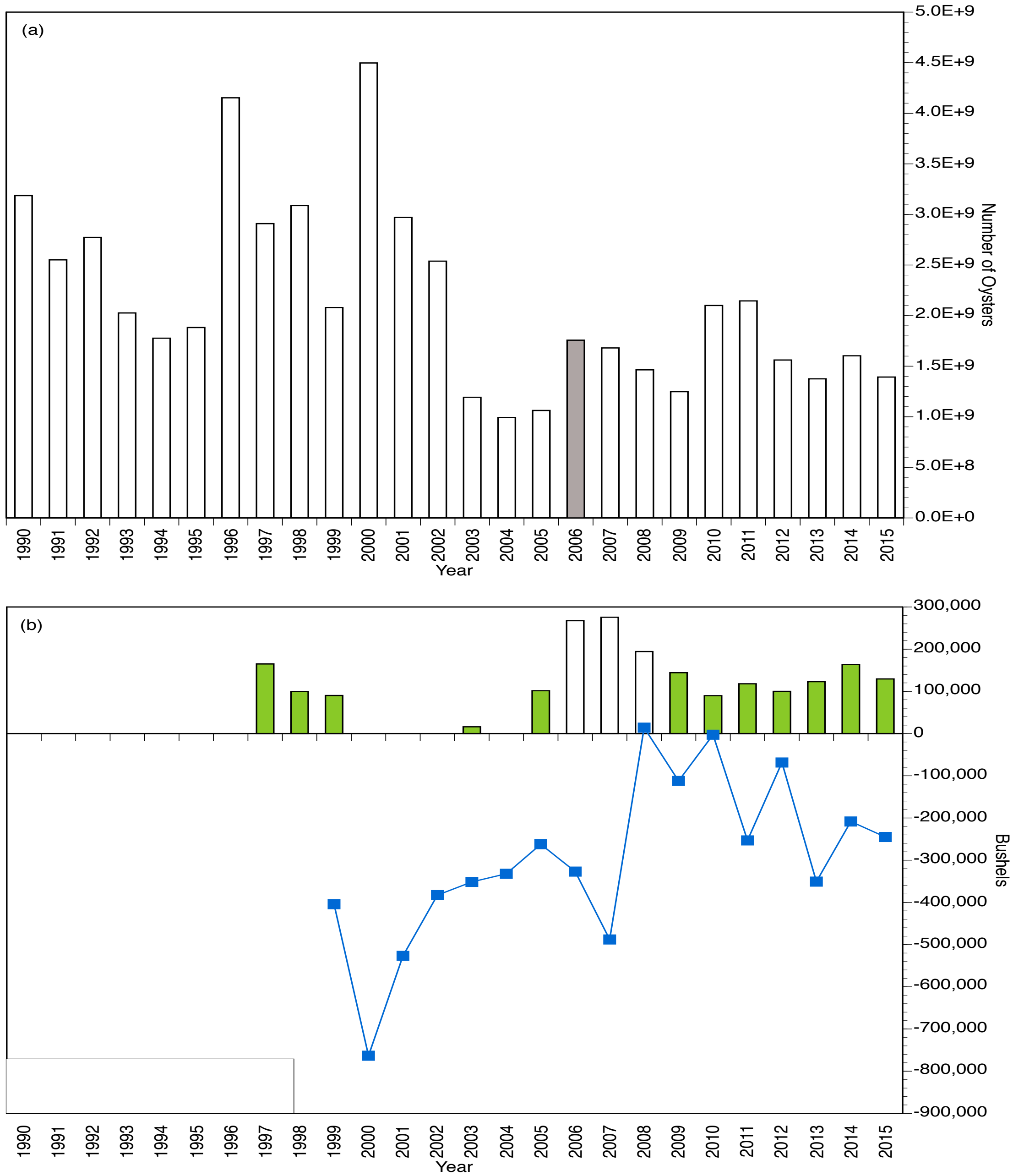


Figure 23. Spat recruitment to native shell (cultch), dark green; and to planted clam shell, light green. Recruitment to clam shell was counted for the first year of shell plant only. Clam shell will continue to attract recruits at a lower rate in subsequent years. Details on shellplanting can be found in Tables 8-12 and in previous SAW documents.

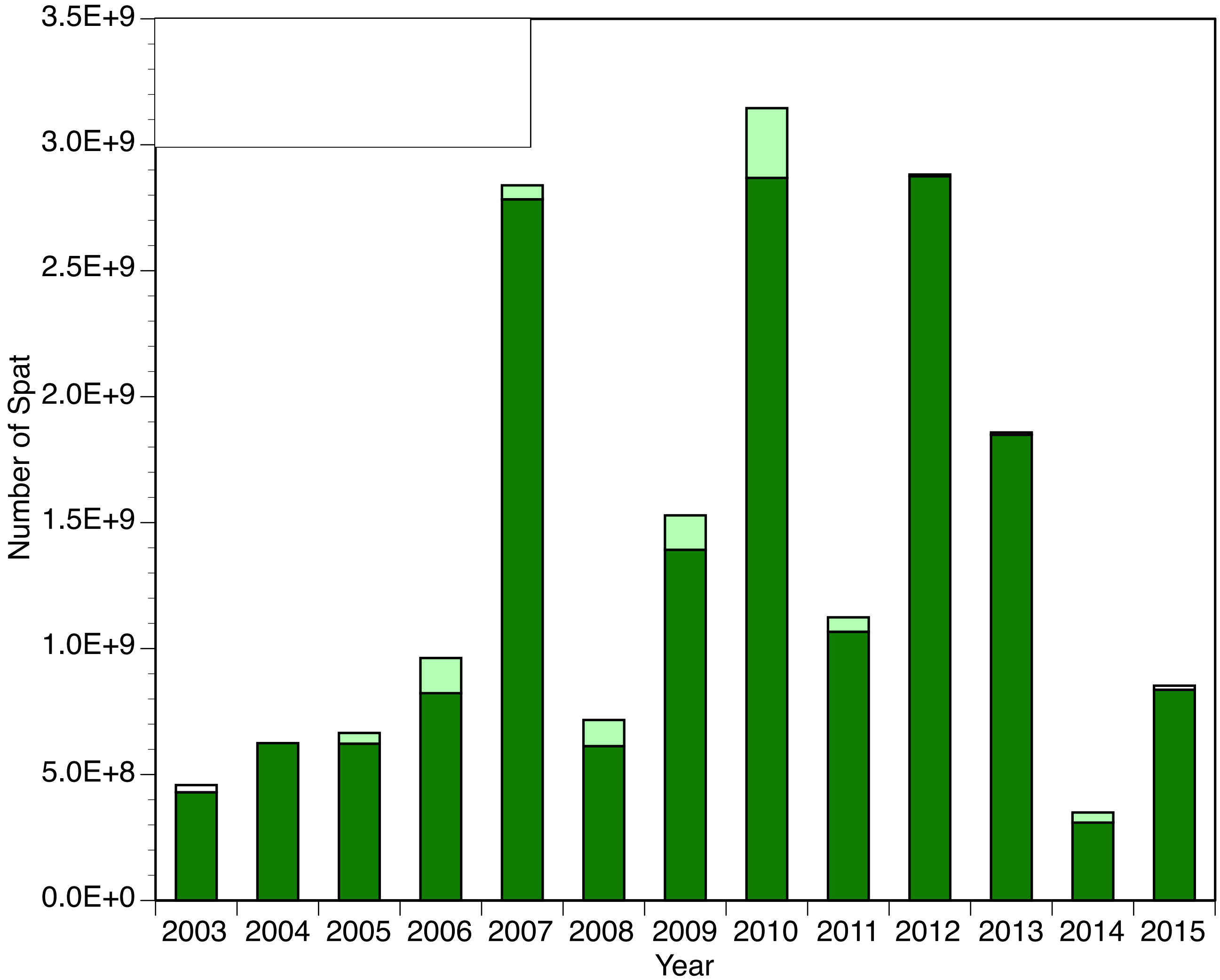


Figure 24. Annual Fall MSX disease prevalence on New Jersey Delaware Bay oyster beds from 1988 to present.

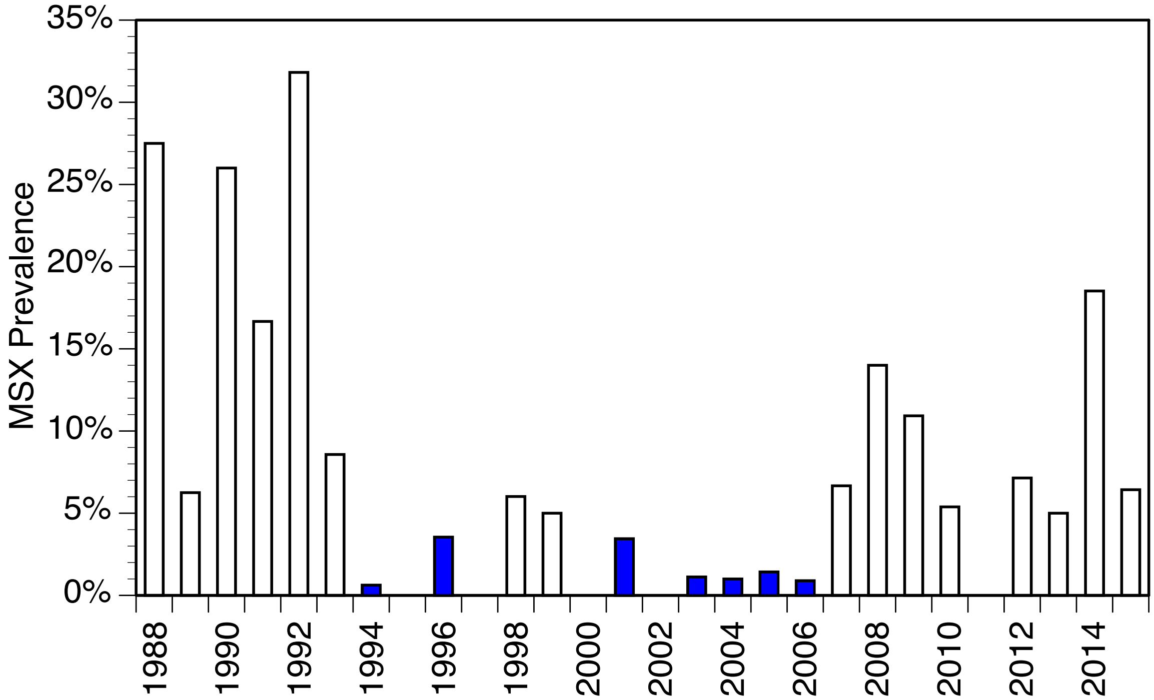
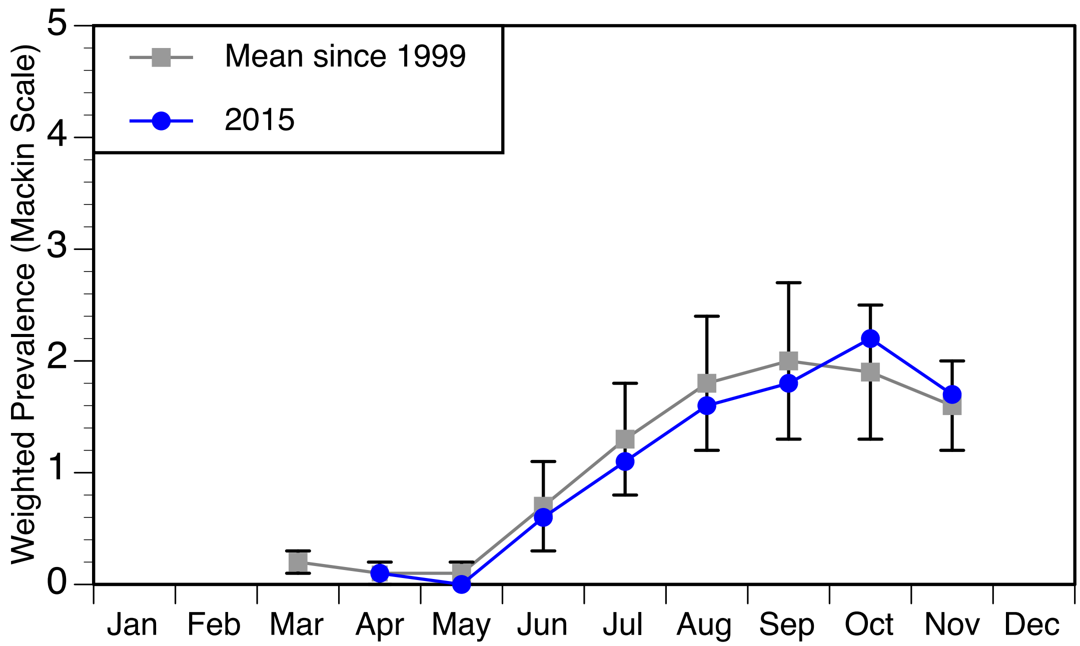


Figure 25. Means of 2015 Monthly Monitoring Program for six primary beds compared to long-term seasonal patterns. **(a)** Dermo disease intensity measured as weighted prevalence. **(b)** Mortality measured by summing the appearance of new boxes over time. New boxes are oysters that have died since the prior sampling event. Error bars represent one standard deviation.

a.



b.

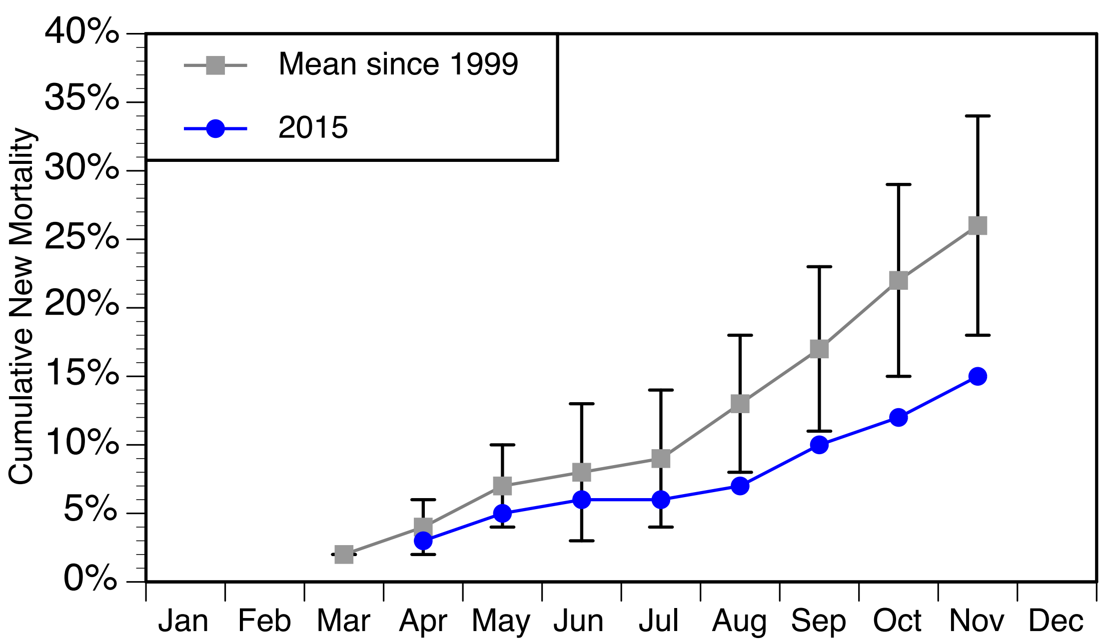


Figure 26. USGS discharge from Delaware River at Trenton and Schuylkill River at Philadelphia with water temperature from Trenton. These two sources provide the majority of freshwater to the Delaware Bay. In 2015, ice formed over the Delaware from mid-January to late February preventing accurate measurements. A large sustained pulse of fresh water resulted from the melting of the ice and winter snow pack. A wet June brought lots of water in early July.

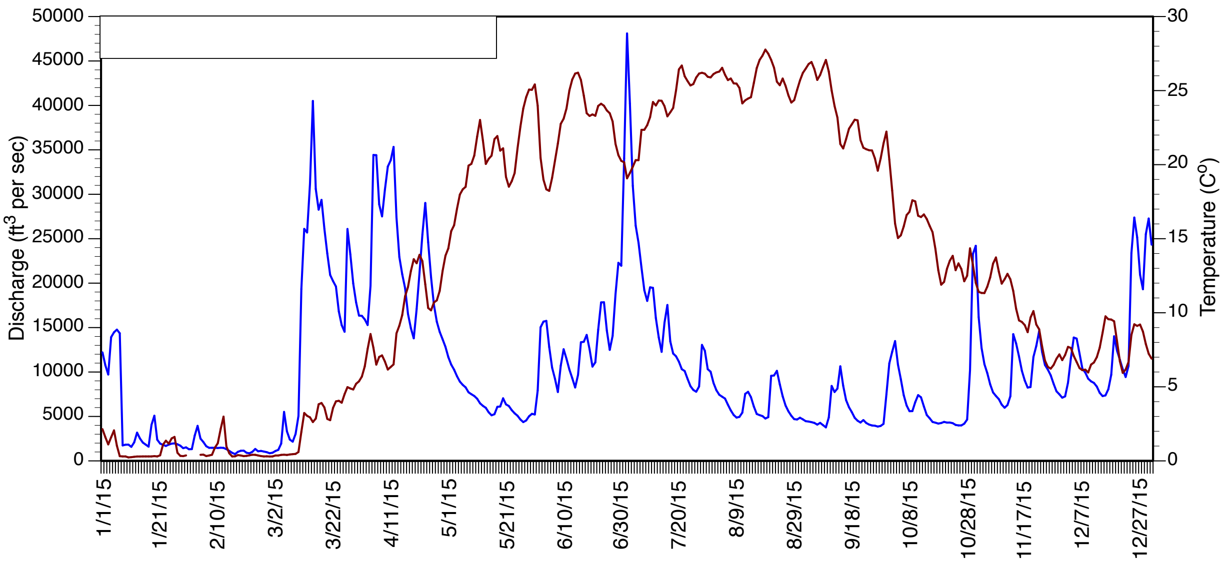


Figure 27. Long-term spatial patterns of: **(a)** Dermo prevalence, **(b)** Dermo weighted prevalence and **(c)** natural mortality across the oyster beds. Beds are listed from upbay to downbay left to right. All three metrics increase from upper to lower bay regions. Not all beds were sampled every year. Ledge Bed was not sampled in 2015. Error bars represent 95% confidence intervals.

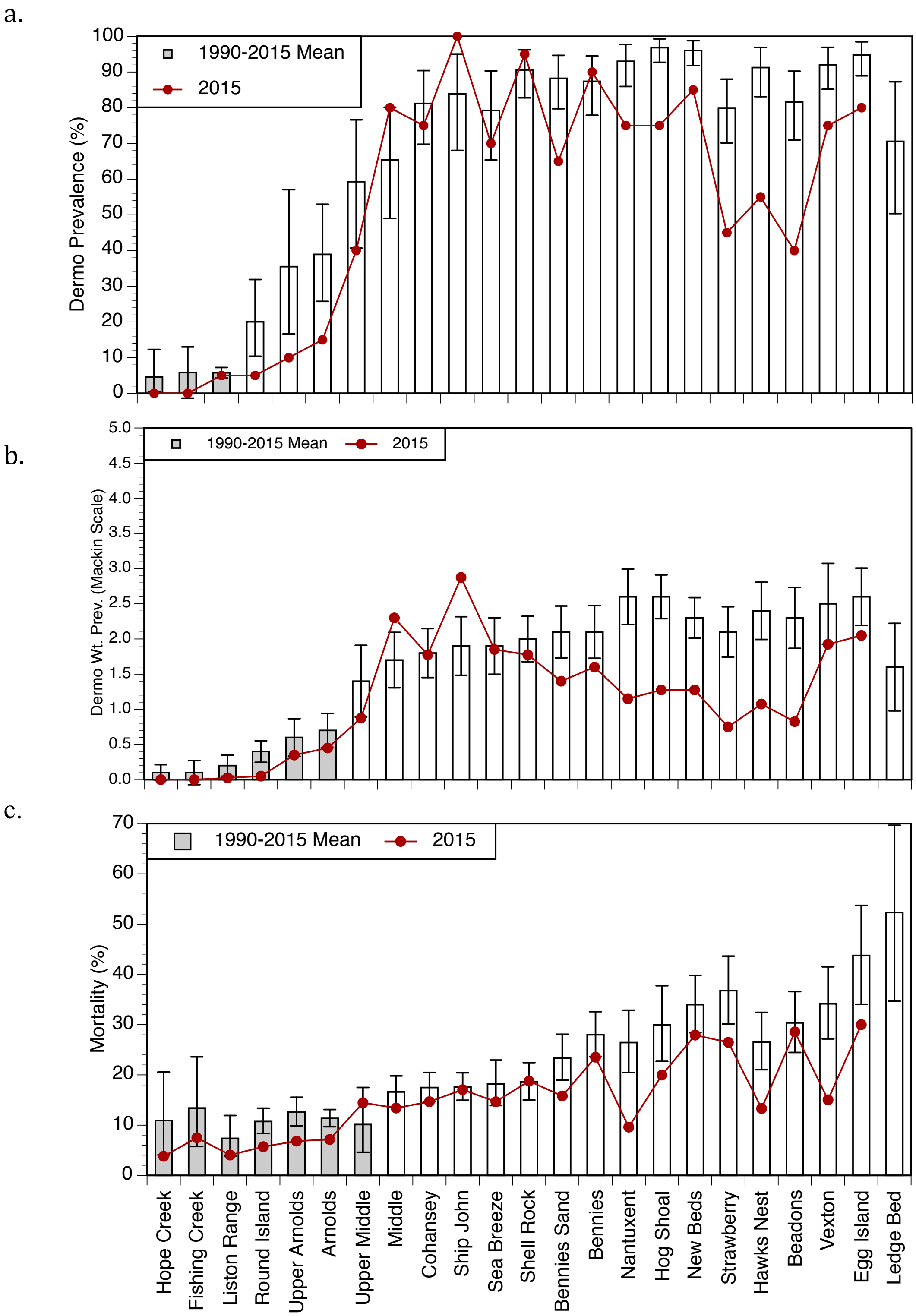


Figure 28. Average Fall box-count mortality (from Figure 27c) as a function of average Dermo infection intensity (from Figure 27b) converted to cells per gram of tissue (Choi et. al. 1989). Parasite density beyond 10,000 cells per gram of tissue (an intensity of ~1.5 on the Mackin Scale) results in an exponential increase in mortality. Regions cluster into groups: High Mortality (HM), Medium Mortality (SR MMM, MMT), Low Mortality (VLM, LM). Data span the Dermo era from 1990-2015 except on VLM where the time series begins in 2007.

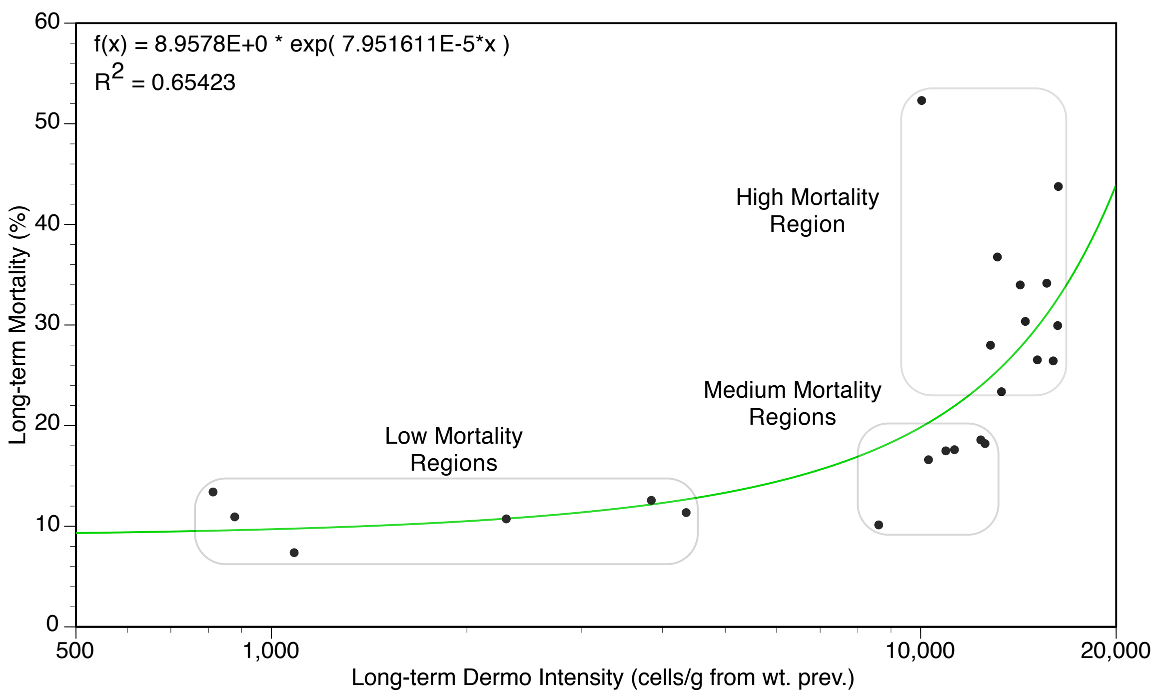


Figure 29. Number of bushels harvested from the natural oyster beds of Delaware Bay since the inception of the direct-market program in 1996. Average harvest = 76,085 bushels; median harvest = 77,525 bushels.

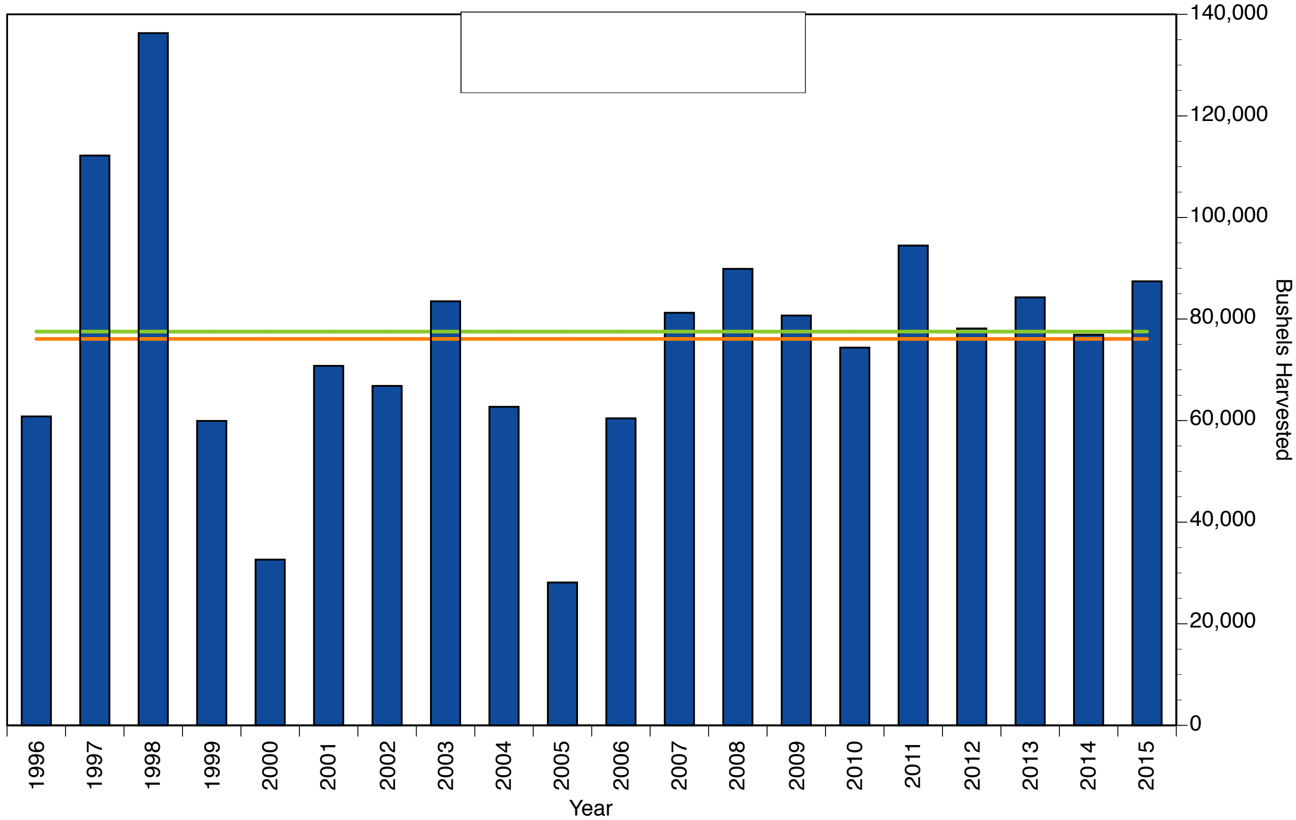
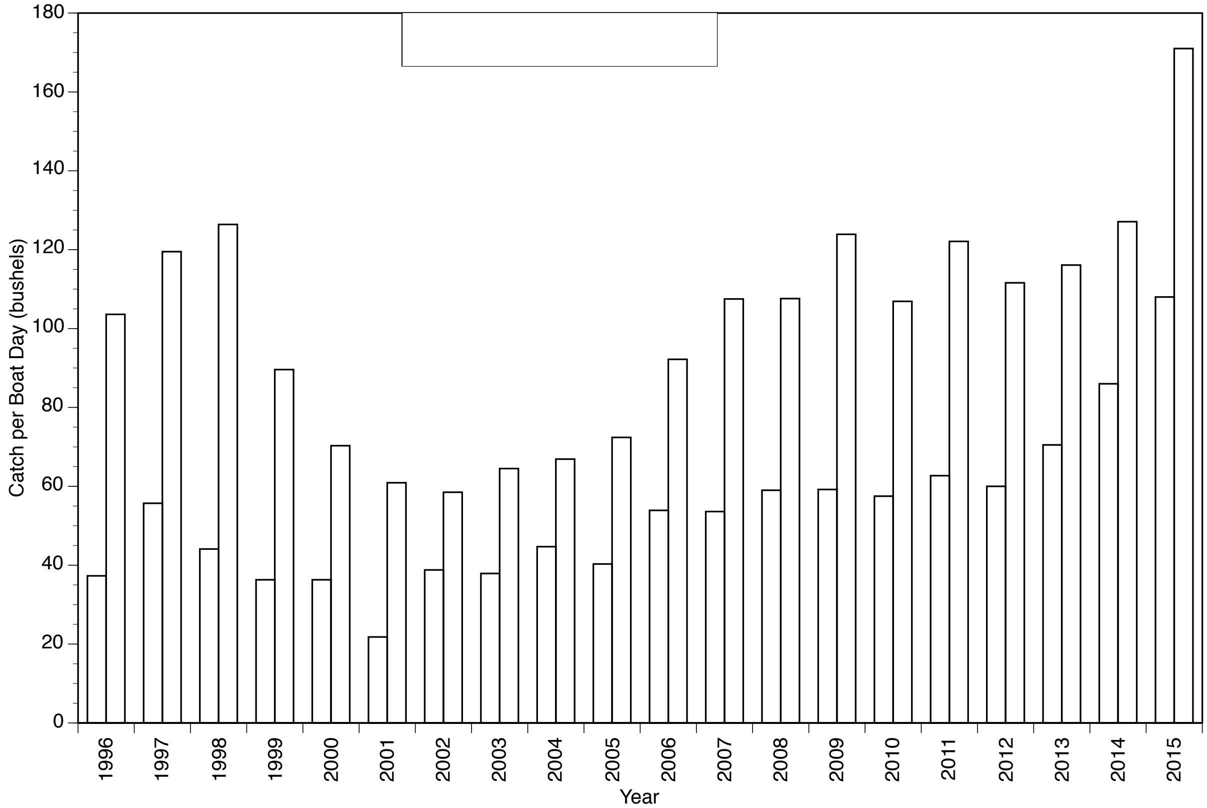


Figure 30. Catch per unit effort (cpue) standardized to 8-h days by one- and two-dredge boats. Consolidation of licenses in recent years has allowed one boat to fish multiple licenses so number of boats has decreased. The total quota is divided by the number of licenses. (a) cpue each year since direct marketing began on all harvested beds. (b) cpue in boat-days on the beds fished in 2015.

(a)



(b)

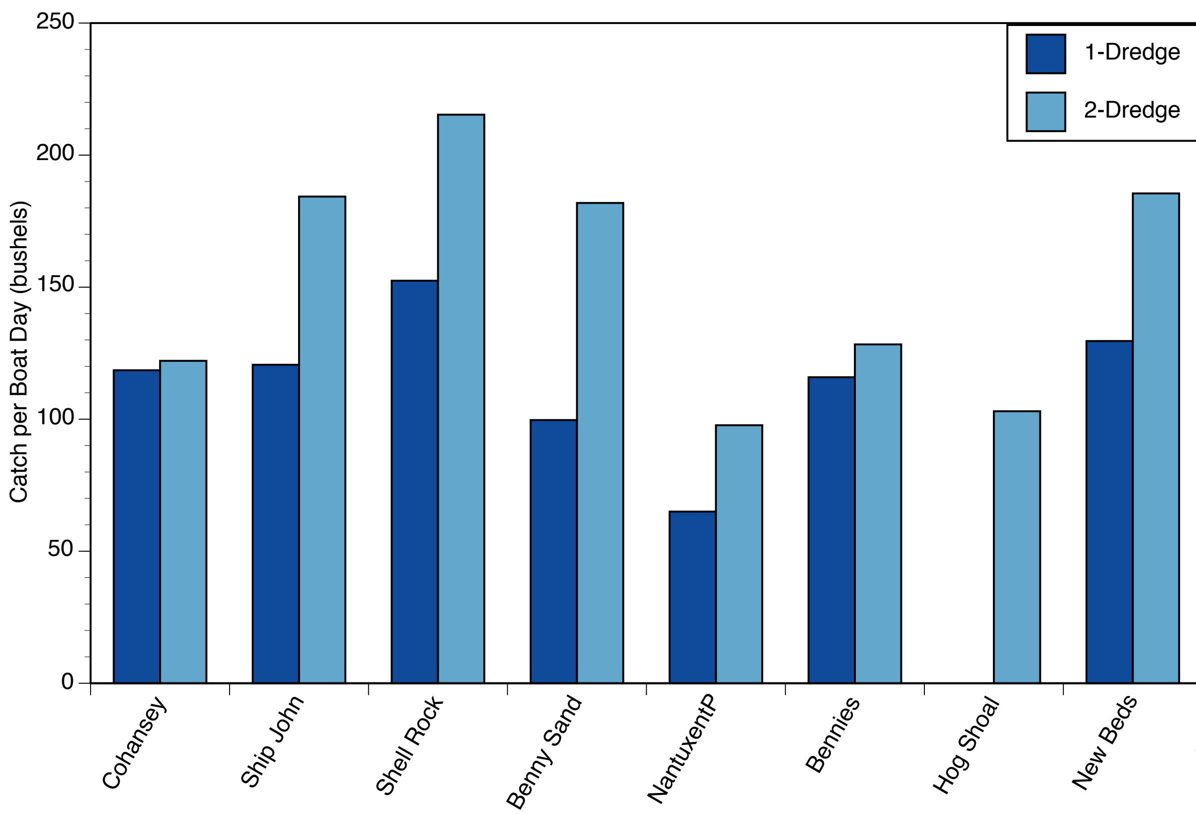


Figure 31. Landed oysters per bushel in three groups: market-size (≥2.5”), smaller attached oysters, and smaller unattached oysters. The 2015 number of oysters per marketed bushel averaged 276. The long-term mean of all oysters (265) is shown as an orange line.

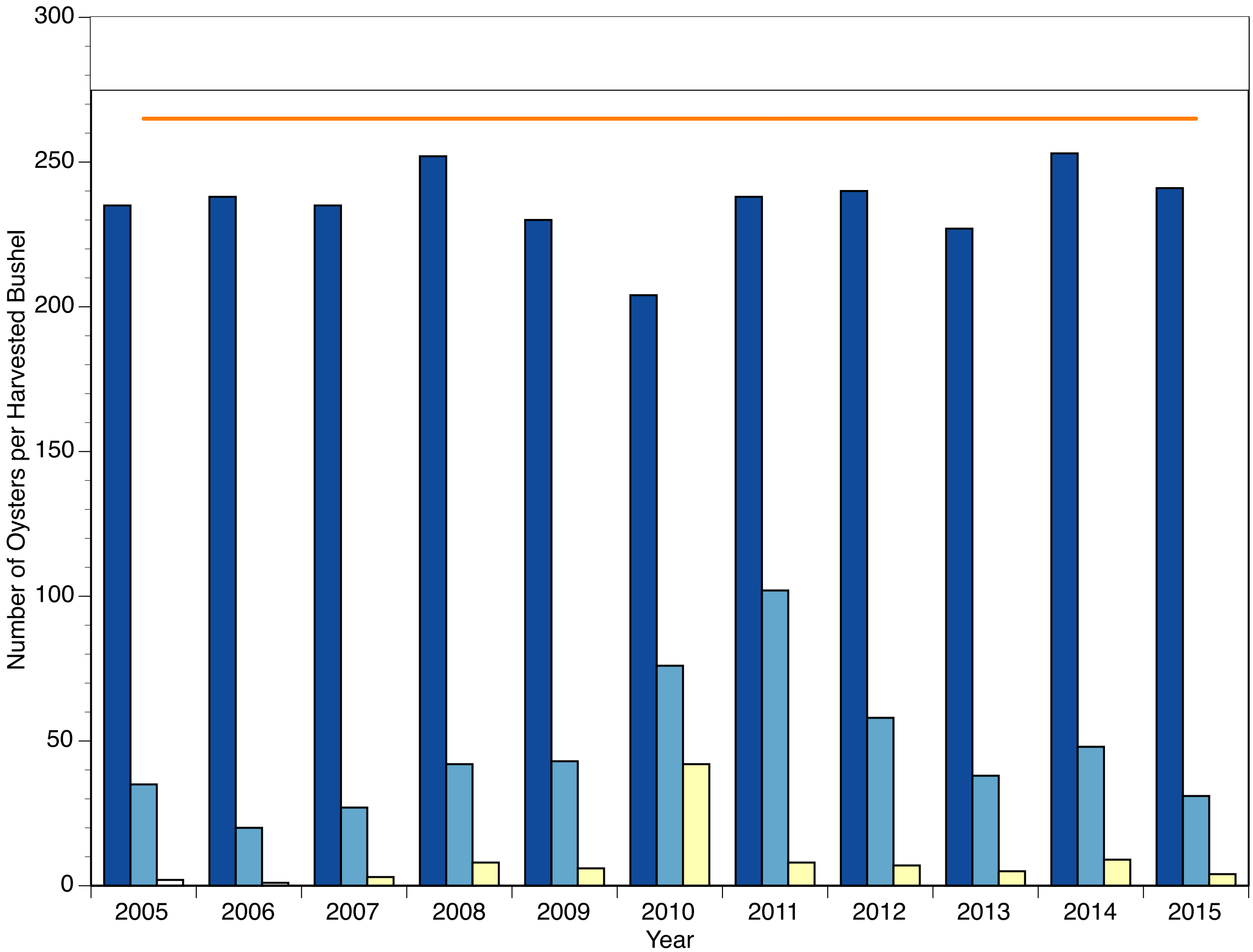


Figure 32. Size frequency of oysters landed in 2015 compared to the mean size frequency from the previous 11 years. Size class values are the lower bounds of the size class.

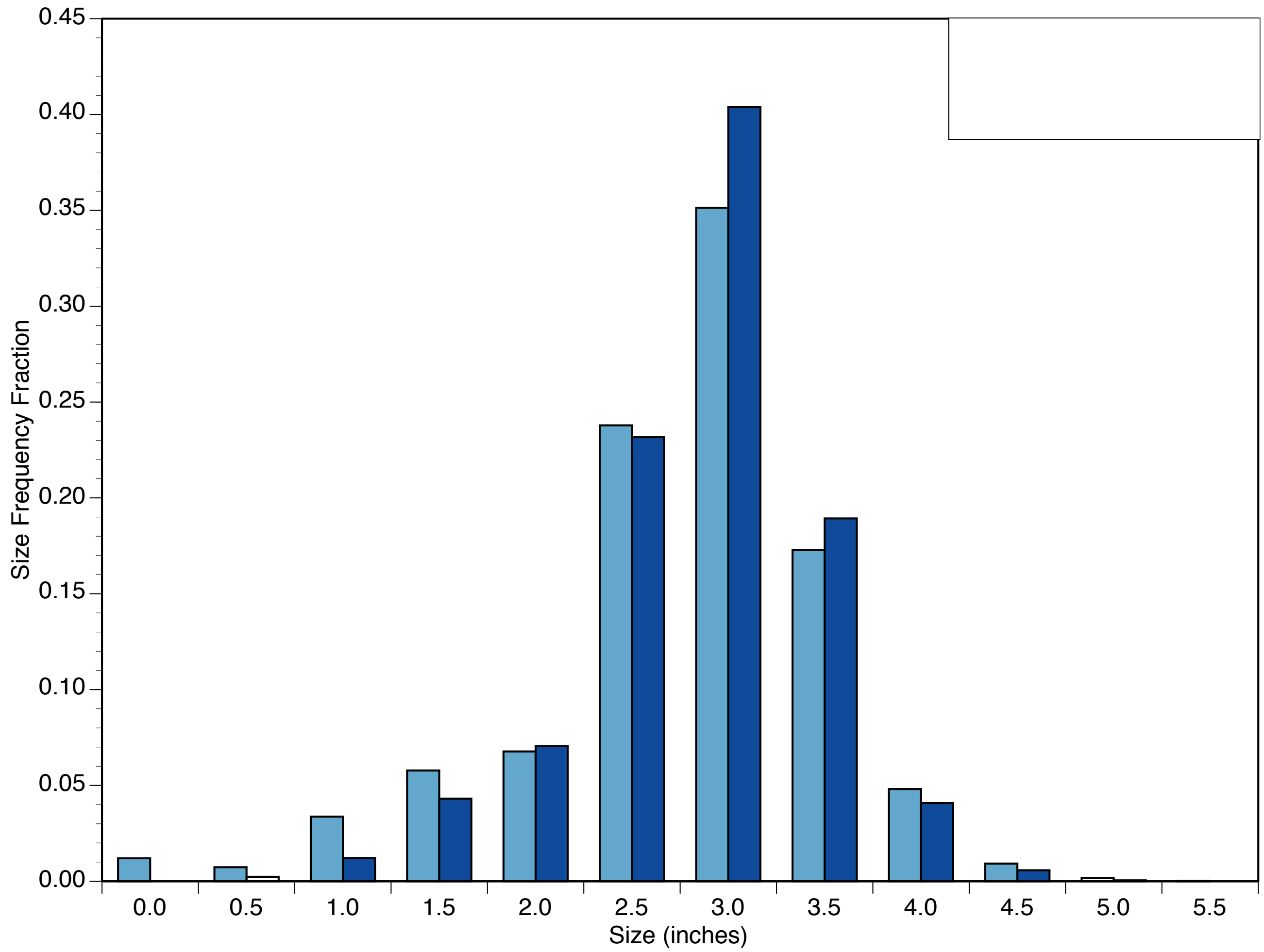
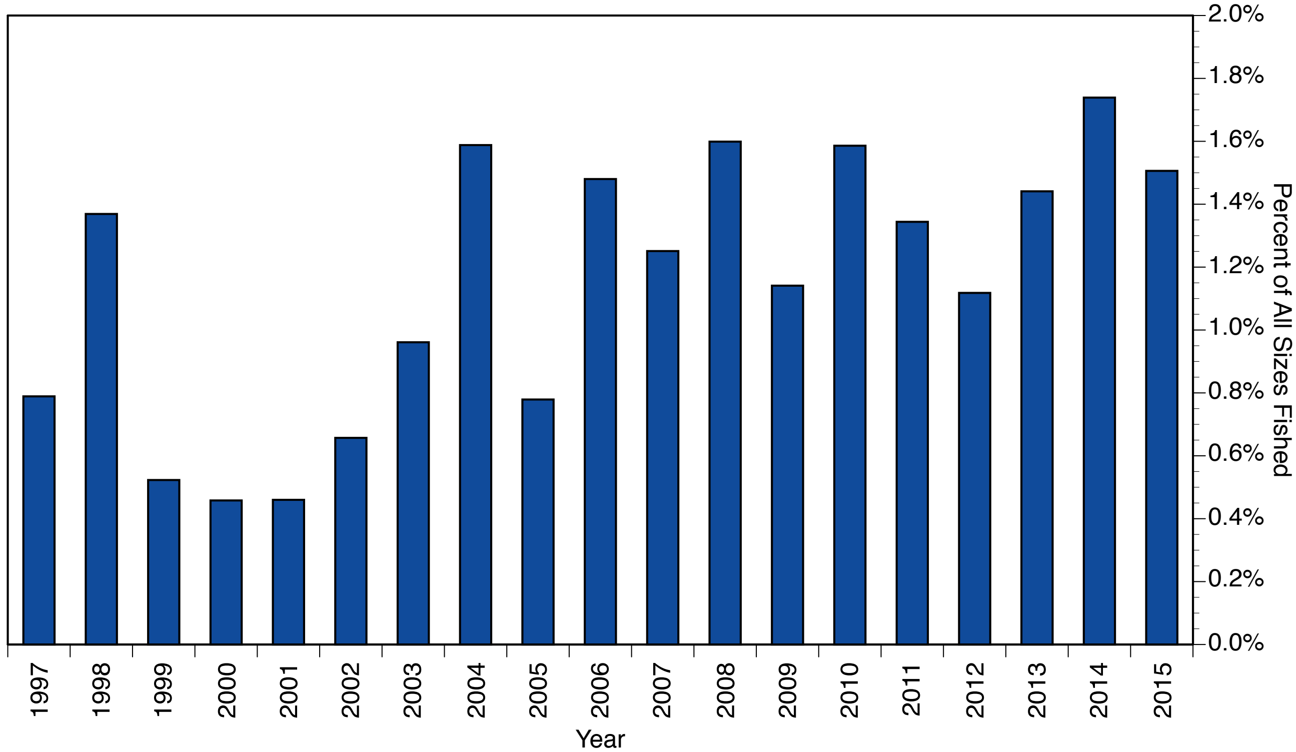


Figure 33. Fishing mortality for the 1997–2015 time period excluding the VLM as a percentage of: (a) oyster abundance and (b) market-sized oyster abundance (>2.5").

(a)



(b)

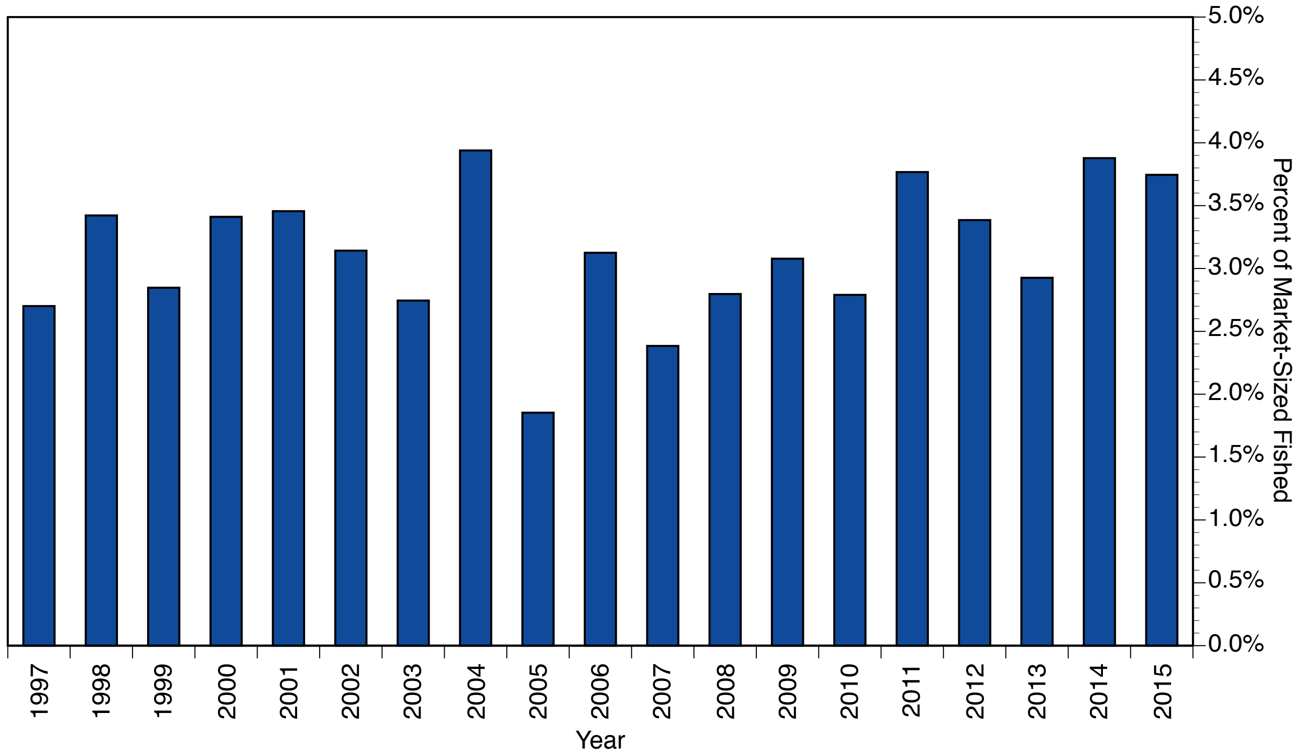


Figure 34. Fishing mortality percentages by region during the Direct Market time series (1997-2015). Percentages reflect transplant removals from the Very Low Mortality, Low Mortality, and Medium Mortality Transplant regions and transplant additions plus direct market harvest from the Medium Mortality 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.

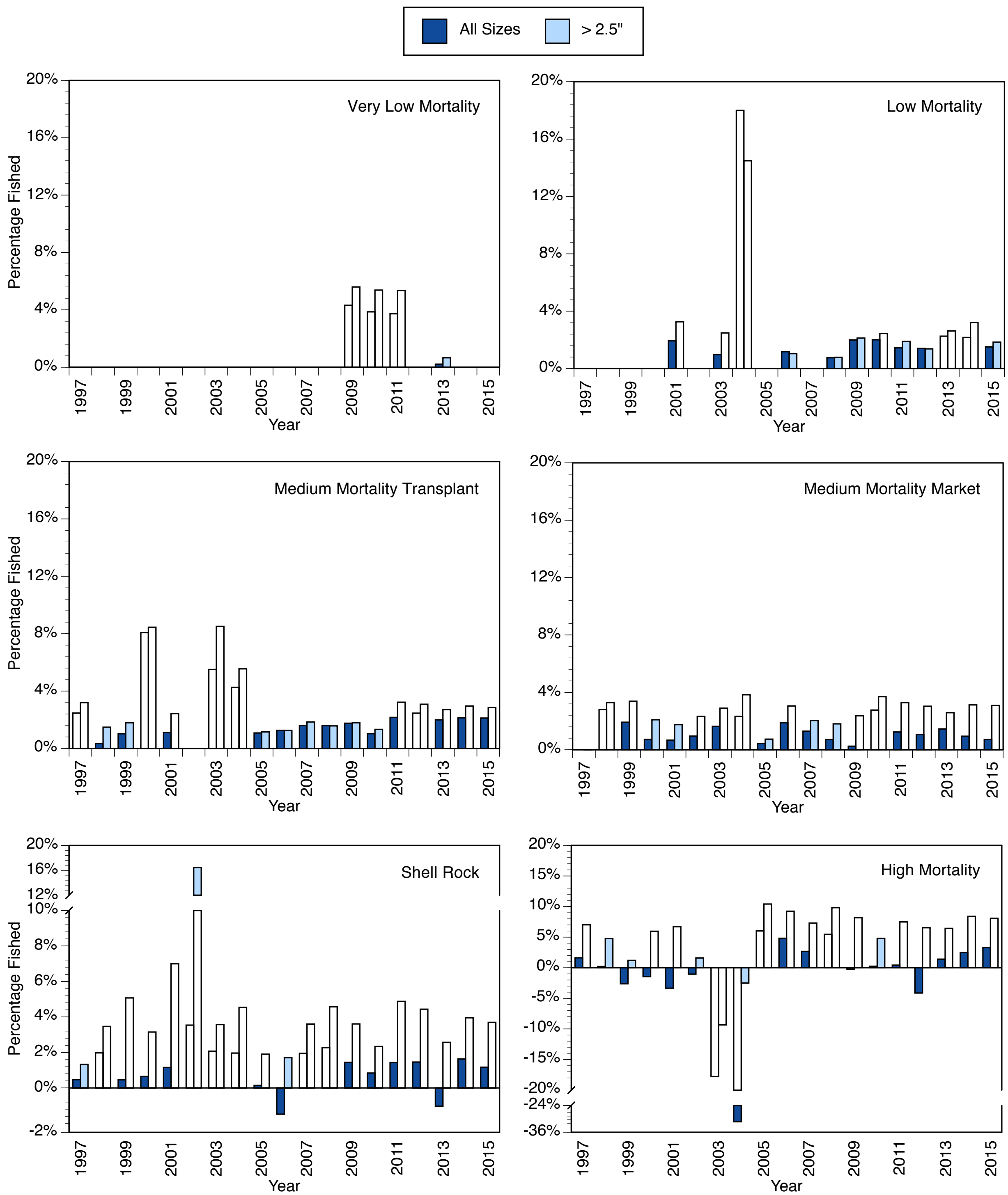


Figure 35. 2015 total abundance **(a)** and market-sized abundance **(b)** whole-stock estimates within confidence percentiles for the 2015 survey taking into account between-sample variation and uncertainty in dredge efficiency updated to use all-oyster catchability coefficients rather than size-based catchability coefficients (see Analytical Approach in this report). Whole stock reference points are included for comparison. 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.

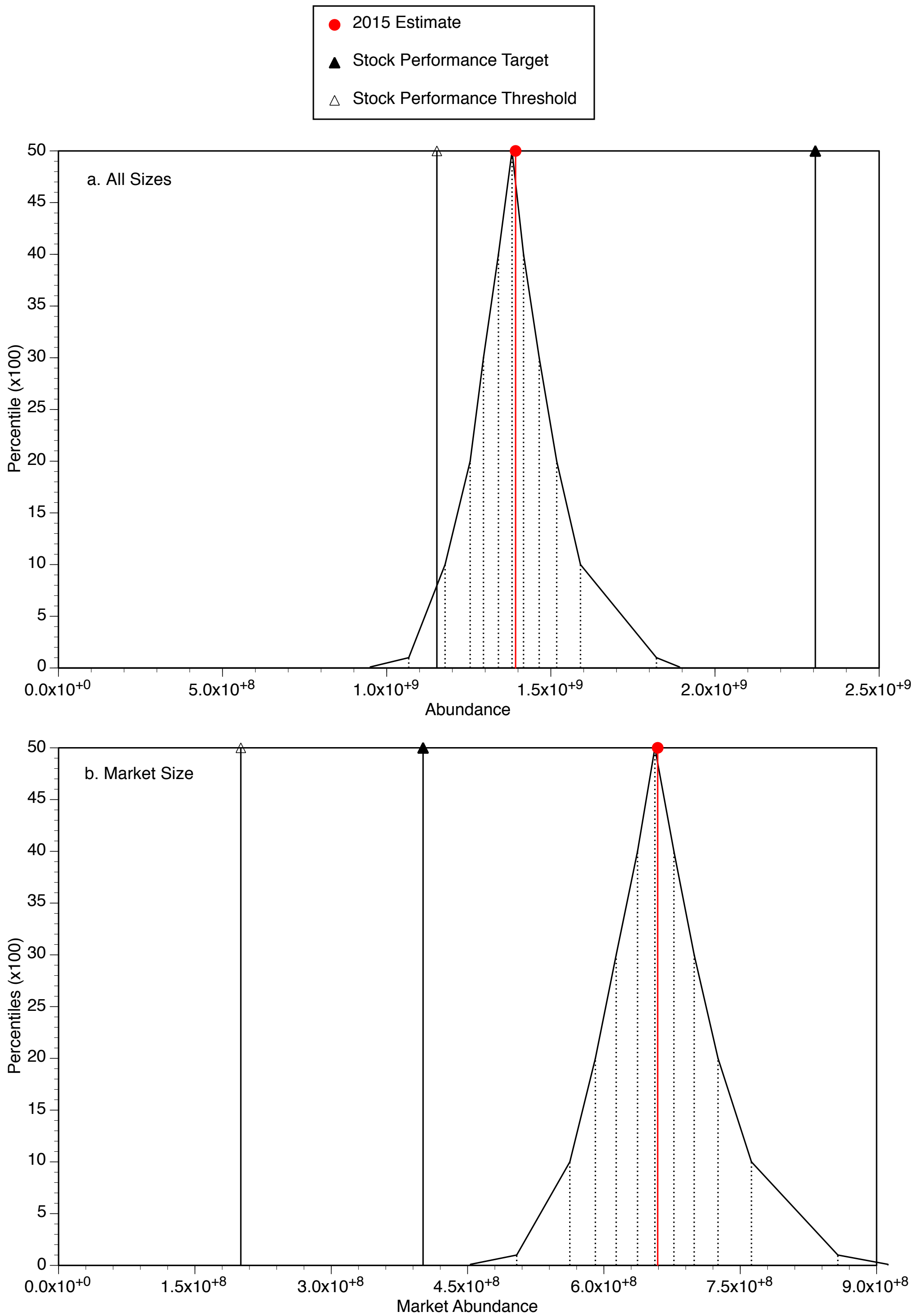


Figure 36. Positions of the oyster stock in 2010–2015 with respect to regional abundance and biomass targets and thresholds. The target is taken as the median of abundance or biomass from the 1989–2005 (1990–2005) time period. The threshold is taken as half these values. Reference points are updated to reflect new catchability coefficient values and their derivation is described in this report. The reference points previously used for the VLM are no longer appropriate and will be re-evaluated.

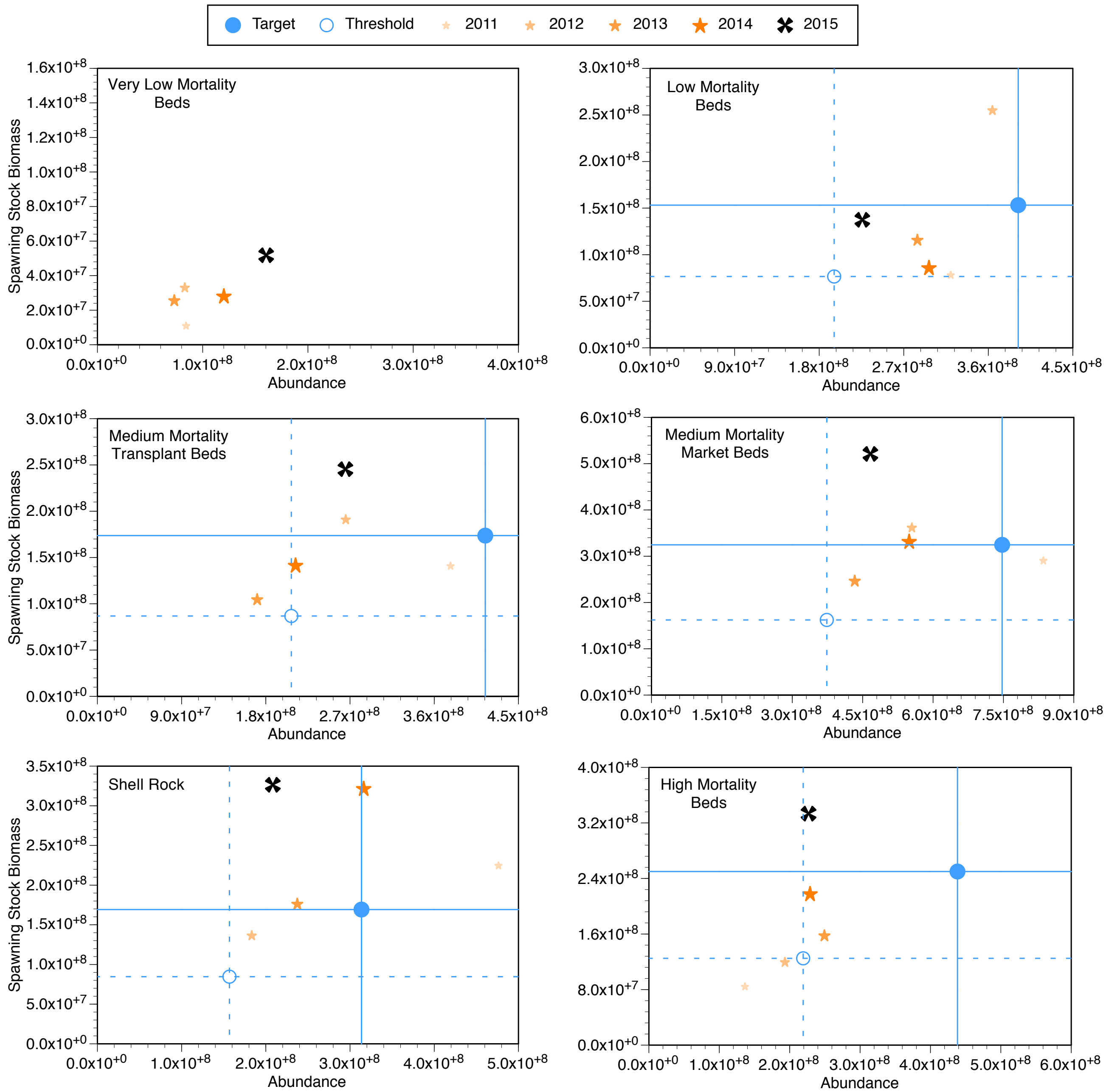
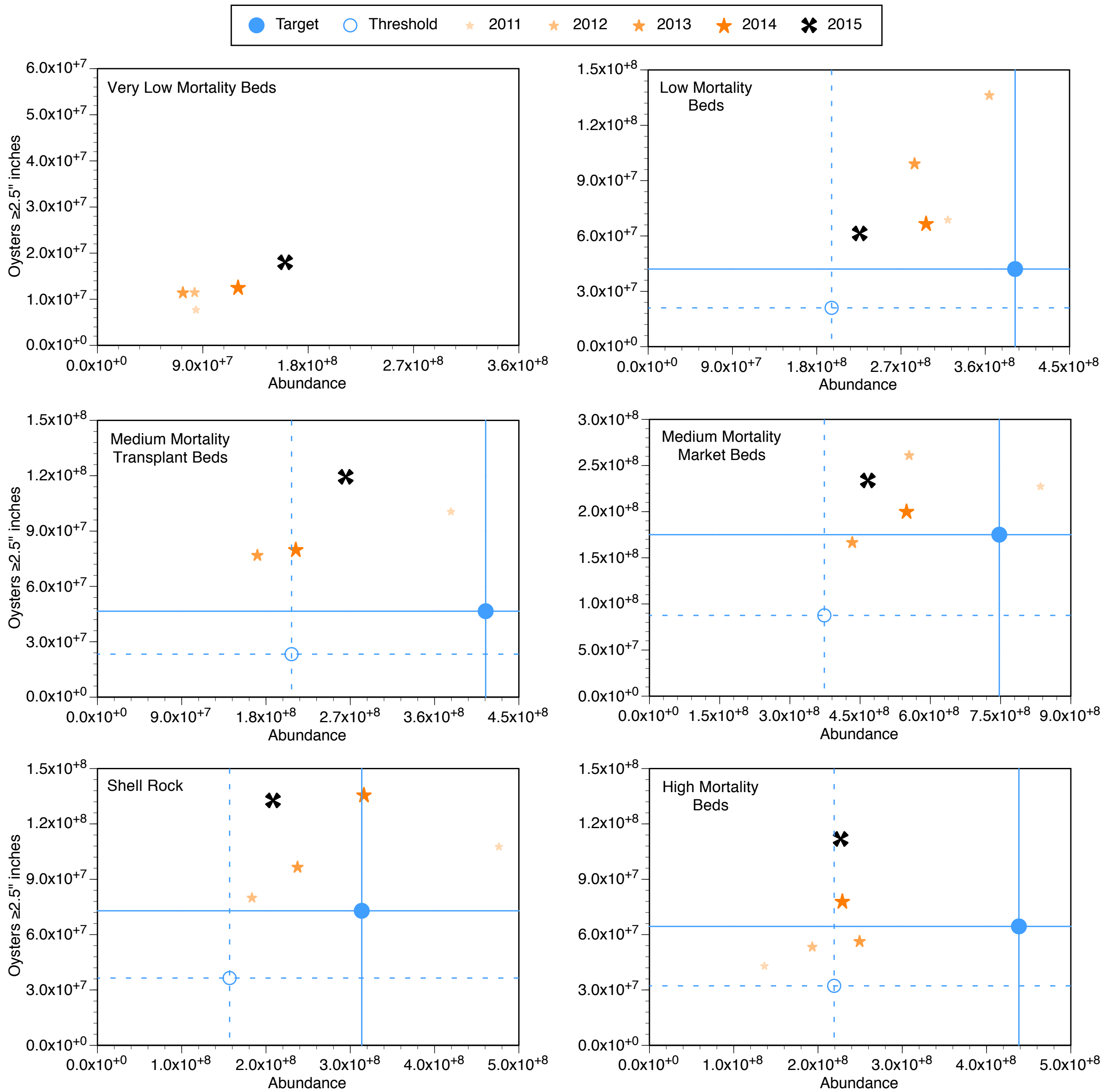


Figure 37. Position of the oyster stock in 2010–2015 with respect to regional abundance and market abundance (> 2.5”) targets and thresholds. The target is taken as the median of abundance or biomass from the 1989–2005 (1990–2005) time period. The threshold is taken as half these values. Reference points are updated to reflect new catchability coefficient values and their derivation is described in this report. The reference points previously used for the VLM are no longer appropriate and will be re-evaluated.



Appendix A.1.1.

Oyster abundance percentiles by region for time series 1953 to 2015. A series of 19 percentile rankings are listed with their associated values and years. The specific 2015 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
0.01	188146624	2003	83505968	1954	133347448	1956	26446584	1966	70609376	1958
0.05	223700160	2004	99238416	1956	183269568	1954	40437220	1963	102509488	2003
0.075	225904032	2015	164479664	2007	266421504	1962	88314440	1962	133158280	2005
0.1	247801632	2008	167121600	1958	273047040	1955	100462672	1956	136463744	2011
0.175	296315776	2010	211773392	2014	341242944	2004	145852928	2005	158428128	1964
0.25	355159744	1999	237771552	2003	393779584	1991	203083840	2002	226855520	2015
0.333	409420288	2006	265401040	2012	457992320	1959	215947104	1957	247774336	2010
0.375	462866368	1986	275256448	2006	486386368	1961	249282112	1985	273462784	1986
0.4	513350656	1994	292227296	1994	495207104	1966	250623552	1960	296903456	2001
0.5	679089408	1990	433659904	1955	658064512	2006	391652864	2007	418730400	1988
0.6	977048192	1968	515284032	1987	902673856	1992	476265920	2011	506168544	1992
0.625	1015315072	1991	522474112	1988	937948864	1965	478759936	1997	518696896	1954
0.667	1216428032	1989	560042304	1997	1165114240	1998	603986624	1953	558553920	1998
0.75	1534448896	1977	676591488	1980	1343717376	1982	959588928	1981	986874240	1960
0.825	1759764992	1983	1070379264	1971	2117523712	1970	1155372672	1971	2170004736	1976
0.9	2935392000	1982	1318795776	1984	2411669504	1983	1763810176	1983	3443166208	1983
0.925	3042920448	1984	1545844480	1977	2550822656	2000	1764919168	1976	3514286848	1979
0.95	3816468736	1969	1738814976	1981	3638521600	1975	1962986496	1979	4454327808	1980
0.99	4638983168	1981	4446481408	1974	8394828800	1974	2699857920	1984	14419853312	1974
2015 Value:	225904032	0.071	265076384	0.31	466485568	0.375	208314288	0.278	226855520	0.246

Appendix A.1.2.

Box-count mortality fraction percentiles by region for time series 1953 to 2015. A series of 19 percentile rankings are listed with their associated values and years. The specific 2015 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 Market Transplant		Medium Mortality Market		Shell Rock		High Mortality	
Percentile	Value	Year	Value	Year	Value	Year	Value	Year	Value	Year
0.01	0.02015	1969	0.0388	1973	0.04148	1973	0.02566	1973	0.0304	1954
0.05	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
0.1	0.05053	1979	0.06718	1969	0.06908	1990	0.05047	1974	0.05923	1989
0.175	0.0605	2003	0.07806	1964	0.08389	1984	0.06178	1972	0.09688	1969
0.25	0.06556	2007	0.08212	1977	0.09174	1982	0.06899	1971	0.10878	1968
0.333	0.07357	2001	0.0929	1962	0.10716	1996	0.08974	1977	0.12069	1990
0.375	0.07649	1967	0.09528	2001	0.10952	1953	0.09478	2003	0.1349	1980
0.4	0.07716	1980	0.09618	1988	0.10975	1964	0.09869	2000	0.14457	1963
0.5	0.10012	1977	0.11634	1983	0.12808	1998	0.1167	1960	0.17763	1987
0.6	0.11384	1962	0.15073	2011	0.16004	2015	0.18256	2014	0.21242	2006
0.625	0.11683	1983	0.15112	1965	0.16678	1966	0.18721	1997	0.21362	2012
0.667	0.12066	1998	0.15374	1972	0.17171	1976	0.20348	1998	0.22055	2008
0.75	0.12834	1996	0.16726	1959	0.20465	2002	0.22699	1963	0.25654	1997
0.825	0.1554	1999	0.20887	2010	0.23492	1992	0.29877	2002	0.32799	2001
0.9	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	0.3698	1986	0.40197	1991
0.95	0.21286	2011	0.30899	1986	0.34412	1995	0.37861	1995	0.46011	1999
0.99	0.26397	1985	0.34611	1958	0.45355	1958	0.48086	1958	0.49404	1993
2015 Value:	0.06554	0.23	0.13936	0.532	0.16004	0.595	0.18772	0.627	0.18079	0.532

Appendix A.1.3.

Spat abundance percentiles by region for time series 1953 to 2015. A series of 19 percentile rankings are listed with their associated values and years. The specific 2015 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
0.01	6333816.5	1984	23093696	2014	.	1967	4605387.5	1965	23748702	1967
0.05	14083137	2004	31122898	2001	48534808	1960	23145720	1962	62806244	1963
0.075	24880106	1967	40091896	2005	74083680	1984	30515622	2014	72903192	1956
0.1	26818624	1965	41617620	1967	82737920	2003	42820056	1959	81395376	2006
0.175	46648752	1953	68642088	1961	96014672	1992	55626148	2015	105425488	1996
0.25	75127984	1996	97215760	1958	146489072	2001	80942648	1996	129302976	2001
0.333	91136816	2006	145636704	2015	206651872	1975	121193680	2011	181565088	1957
0.375	113754272	2002	185140928	2007	307102528	1985	148552320	1957	251242752	1984
0.4	115737616	1995	188979840	1959	318352672	2006	169654464	1953	264238080	1975
0.5	260206560	1999	258999008	1994	448024352	1994	263318752	1995	416641536	2010
0.6	357406752	1955	364378592	1976	579703680	1957	415485472	1954	583010048	1958
0.625	383572960	1956	400069216	1963	580947264	2000	428249216	2012	589182592	1985
0.667	572411328	1957	430370048	1991	602631616	2012	455612992	2009	684034048	1990
0.75	932318016	1962	563485184	1957	949019328	1966	750414080	2007	1122550656	1991
0.825	1381483264	1987	725248960	1978	1619488384	1982	957817216	2002	1618010368	1997
0.9	2638539520	1980	993972032	1986	2086584576	1999	1770790912	1974	2654484736	1978
0.925	2937662976	1974	1271248768	1982	2913591808	1998	1866195072	1977	3432518144	1979
0.95	3338800640	1969	1634833536	1998	3702969344	1974	2340961024	1982	7516831744	1974
0.99	5593945600	1973	6409227264	1973	6631005184	1973	2523629568	1970	12548471808	1970
2015 Value:	119495024	0.405	145636704	0.325	179844768	0.278	55626148	0.167	113167648	0.198

Appendix A.2.1.

Oyster abundance percentiles by region for time series 1990 to 2015. A series of 19 percentile rankings are listed with their associated values and years. The specific 2015 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
0.01	188146624	2003	164479664	2007	276226816	2009	118273056	2004	89990688	2004
0.05	188146624	2003	164479664	2007	276226816	2009	118273056	2004	89990688	2004
0.075	219267584	1998	170442320	2005	321760000	2005	141664160	1995	102509488	2003
0.1	223700160	2004	170753888	2013	322111360	1994	145852928	2005	115430248	2008
0.175	247801632	2008	211773392	2014	372326464	2003	203083840	2002	136463744	2011
0.25	284678368	2000	237771552	2003	393779584	1991	208314288	2015	143180608	2007
0.333	296315776	2010	254142528	1995	441452672	1995	210770288	2009	172121440	2006
0.375	296810560	2014	265076384	2015	447398976	2007	237353056	2013	193216800	2012
0.4	296810560	2014	265076384	2015	447398976	2007	237353056	2013	193216800	2012
0.5	345433408	1997	272756928	2010	549132160	2014	308705920	1999	243472176	1993
0.6	372427136	2009	337801856	1993	658064512	2006	336587840	1991	296903456	2001
0.625	372427136	2009	337801856	1993	658064512	2006	336587840	1991	296903456	2001
0.667	391877696	2002	373223040	1992	691196416	2010	391652864	2007	340859008	1991
0.75	513350656	1994	424013120	1990	902673856	1992	439337120	2008	475871232	1999
0.825	533791808	2007	464617344	1991	997140096	1997	476265920	2011	506168544	1992
0.9	677346368	1992	560042304	1997	1189617536	1996	591178624	2000	556456192	1990
0.925	679089408	1990	652267392	2000	1246804864	2002	592071232	2010	558553920	1998
0.95	782048128	1993	737089792	1998	1306350080	2001	878491392	1990	613422656	1995
0.99	1015315072	1991	896213632	1996	2550822656	2000	884210816	1996	862921984	1996
2015 Value:	225904032	0.135	265076384	0.365	466485568	0.442	208314288	0.25	226855520	0.404

Appendix A.2.2.

Box-Count mortality percentiles by region for time series 1990 to 2015.A series of 19 percentile rankings are listed with their associated values and years. The specific 2015 mortality fraction and percentile are listed at the bottom of the table. Very Low Mortality region not included due to short time series.

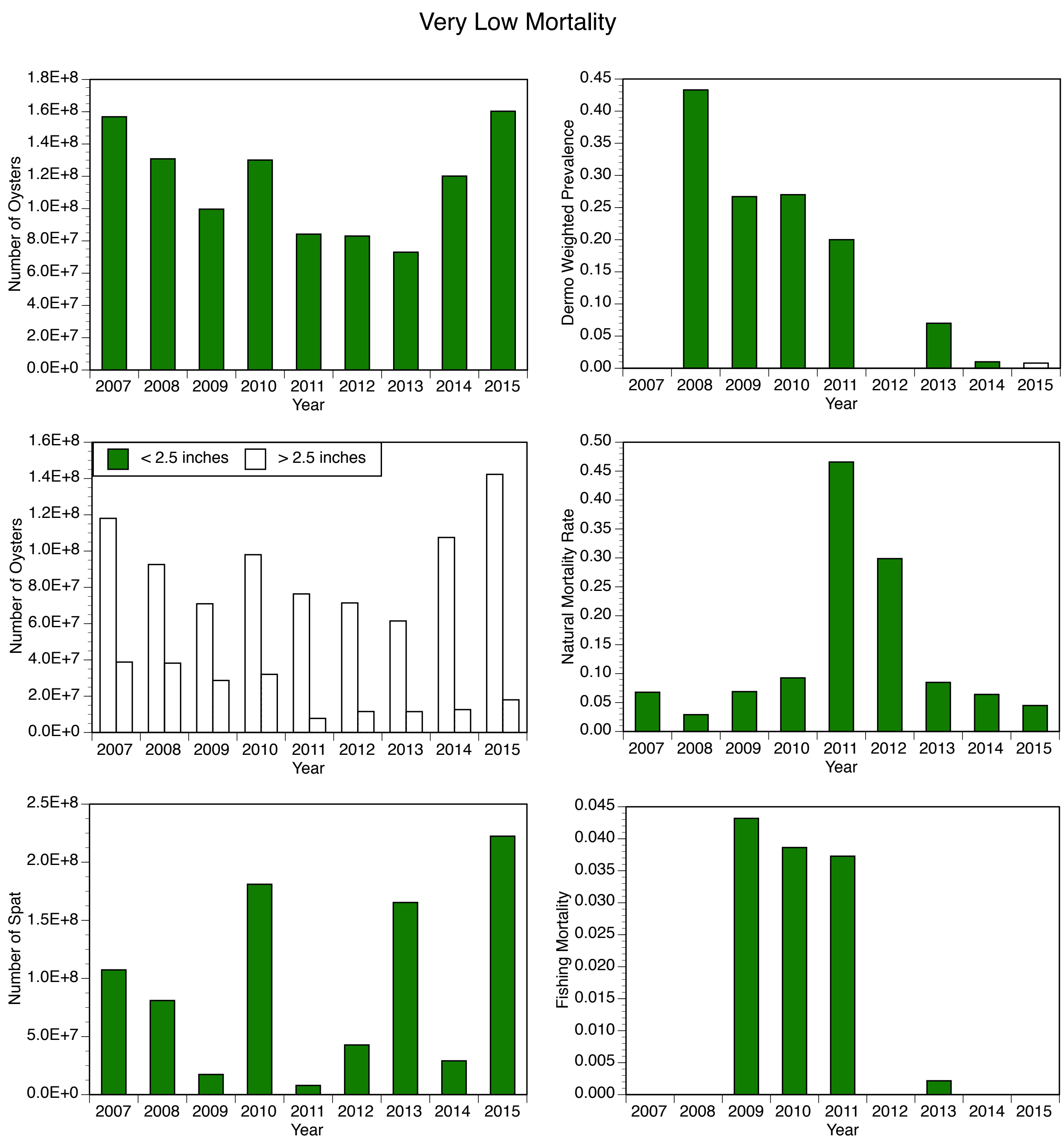
	Low Mortality		Medium Market Transplant		Medium Mortality Market		Shell Rock		High Mortality	
Percentile	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**
0.01	0.05551	2000	0.0575	1990	0.06908	1990	0.0767	1990	0.12069	1990
0.05	0.05551	2000	0.0575	1990	0.06908	1990	0.0767	1990	0.12069	1990
0.075	0.0605	2003	0.07924	1996	0.08414	2001	0.09478	2003	0.1458	2014
0.1	0.06208	2006	0.0816	2000	0.09274	2000	0.09869	2000	0.15964	2005
0.175	0.06556	2007	0.09299	1997	0.10869	2005	0.10025	2001	0.18018	2013
0.25	0.06895	2002	0.1052	2005	0.12808	1998	0.1164	1996	0.19363	2004
0.333	0.07574	1994	0.11242	1998	0.14503	1997	0.17219	2004	0.21362	2012
0.375	0.08264	1990	0.13936	2015	0.15751	2006	0.1817	2006	0.21629	2010
0.4	0.08264	1990	0.13936	2015	0.15751	2006	0.1817	2006	0.21629	2010
0.5	0.11379	2013	0.15148	2006	0.18113	2014	0.18772	2015	0.24163	2011
0.6	0.12066	1998	0.19632	2007	0.21339	2007	0.21657	1991	0.26176	2003
0.625	0.12066	1998	0.19632	2007	0.21339	2007	0.21657	1991	0.26176	2003
0.667	0.12126	2012	0.19854	1999	0.21474	2008	0.22539	2009	0.27575	2009
0.75	0.12834	1996	0.21632	1994	0.23492	1992	0.2453	2007	0.3311	1998
0.825	0.12893	2014	0.21633	2012	0.24085	2009	0.25834	2012	0.34105	1992
0.9	0.1554	1999	0.22259	2009	0.26253	1994	0.33091	1992	0.40197	1991
0.925	0.16109	1995	0.22673	1993	0.26732	1999	0.34845	1999	0.44257	2002
0.95	0.17597	2010	0.24787	2013	0.29622	1993	0.36147	1993	0.46011	1999
0.99	0.21286	2011	0.32394	1995	0.34412	1995	0.37861	1995	0.49404	1993
2015 Value:	0.06554	0.135	0.13936	0.365	0.16004	0.404	0.18772	0.481	0.18079	0.212

Appendix A.2.3.

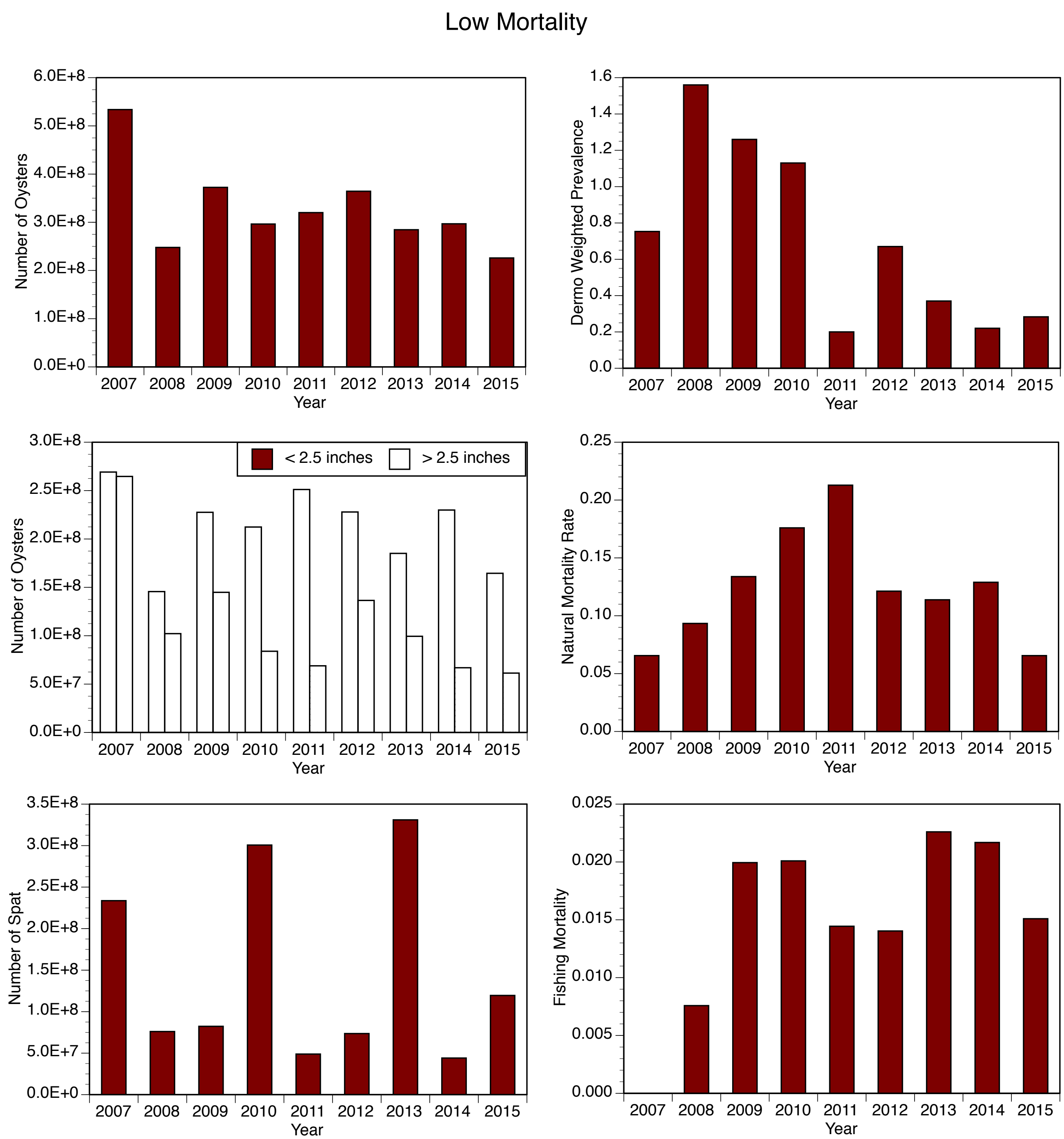
Spat abundance percentiles by region for time series 1990 to 2015. A series of 19 percentile rankings are listed with their associated values and years. The specific 2015 abundance and percentile are listed at the bottom of the table. Very Low Mortality region not included due to short time series.

	Low Mortality		Medium Market Transplant		Medium Mortality Market		Shell Rock		High Mortality	
Percentile	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**	**Value**	**Year**
0.01	14083137	2004	23093696	2014	45299616	2008	30515622	2014	81395376	2006
0.05	14083137	2004	23093696	2014	45299616	2008	30515622	2014	81395376	2006
0.075	19418498	2003	31122898	2001	82737920	2003	52128692	1992	95493184	2014
0.1	40992476	2001	40091896	2005	86778824	2014	55626148	2015	97781496	2005
0.175	44109368	2014	50158556	2008	93363584	2005	77211640	2005	110184936	2008
0.25	61874824	2000	56356680	2003	110848936	2004	89092624	2006	118348792	1992
0.333	73598896	2012	84934808	2011	146489072	2001	114865792	2003	130487440	2003
0.375	75127984	1996	112689656	1996	179844768	2015	121193680	2011	158191392	1993
0.4	75127984	1996	112689656	1996	179844768	2015	121193680	2011	158191392	1993
0.5	82435072	1997	161197248	2013	322078112	2011	224714720	2004	330150176	2009
0.6	115737616	1995	213788848	2012	471906624	1995	428249216	2012	416641536	2010
0.625	115737616	1995	213788848	2012	471906624	1995	428249216	2012	416641536	2010
0.667	119495024	2015	244443680	2009	472144160	1991	436437920	2000	481662880	2011
0.75	233658288	2007	281019104	1995	582054592	2002	481982784	1990	888077632	1995
0.825	260206560	1999	295318112	1997	602631616	2012	560660160	1991	996042752	1994
0.9	300650624	2010	430370048	1991	760809920	1997	750414080	2007	1122550656	1991
0.925	314637184	1990	442342496	1999	1099550592	2007	867099136	2010	1513959168	2012
0.95	330993632	2013	546450880	2002	2086584576	1999	957817216	2002	1618010368	1997
0.99	935990720	1991	1634833536	1998	2913591808	1998	992921856	1999	1953821056	1999
2015 Value:	119495024	0.635	145636704	0.404	179844768	0.365	55626148	0.096	113167648	0.212

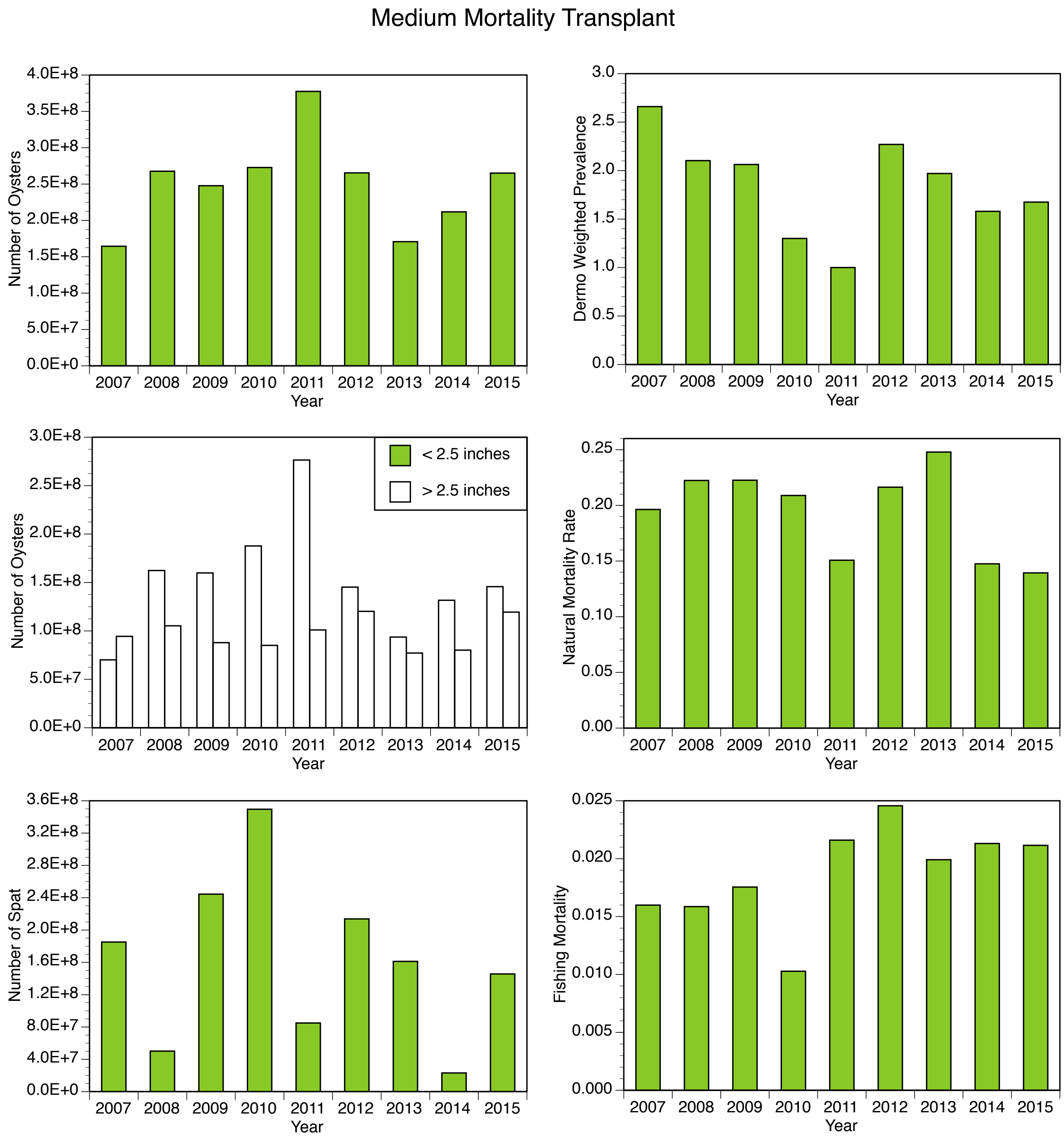
Appendix B.1. Region Trends. Nine-year time series summary for the Very Low Mortality region. Left panels show total abundance (excluding spat), abundance by size class (excluding spat), and spat abundance (oysters < 20 mm). Right panels show Dermo levels, natural mortality rate and fishing mortality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



Appendix B.2. Region Trends. Nine-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.

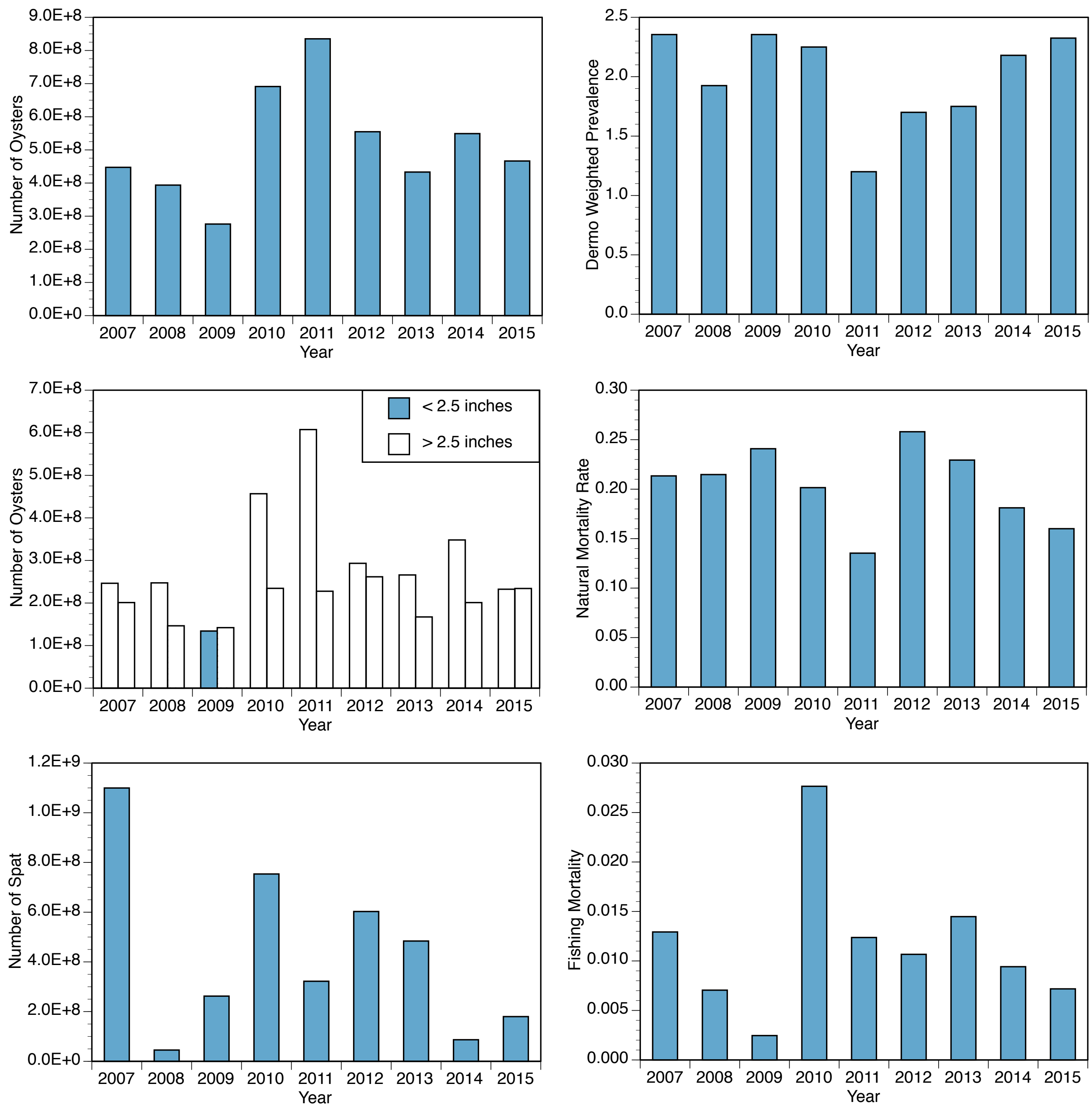


Appendix B.3. Region Trends. Nine-year time series summary for the Medium Mortality Transplant region. Left panels show total abundance (excluding spat), abundance by size class (excluding spat), and spat abundance (oysters < 20 mm). Right panels show Dermo levels, natural mortality rate and fishing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

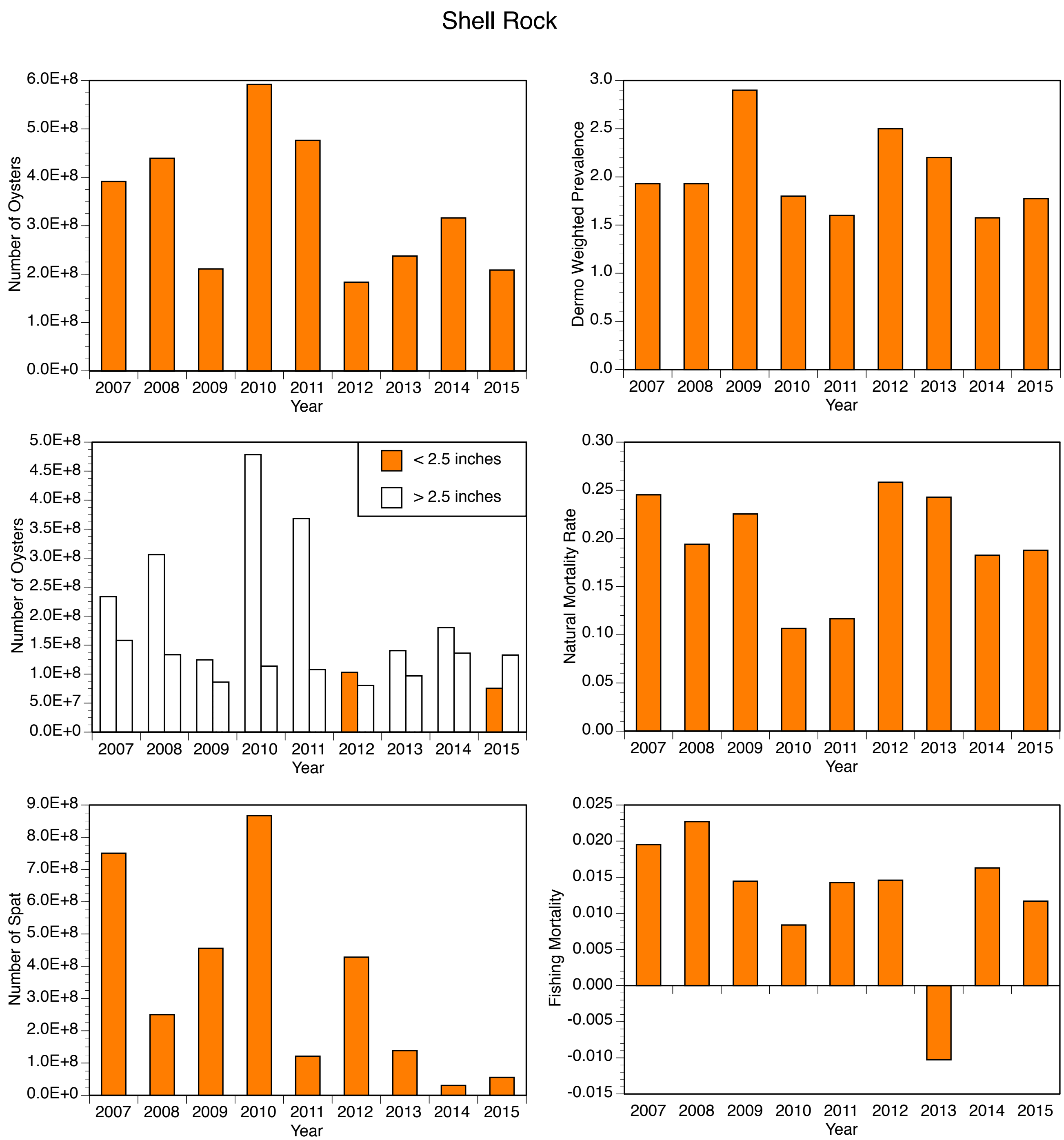


Appendix B.4. Region Trends. Nine-year time series summary for the Medium Mortality Market region. Left panels show total abundance (excluding spat), abundance by size class (excluding spat), and spat abundance (oysters < 20 mm). Right panels show Dermo levels, natural mortality rate and fishing mortality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

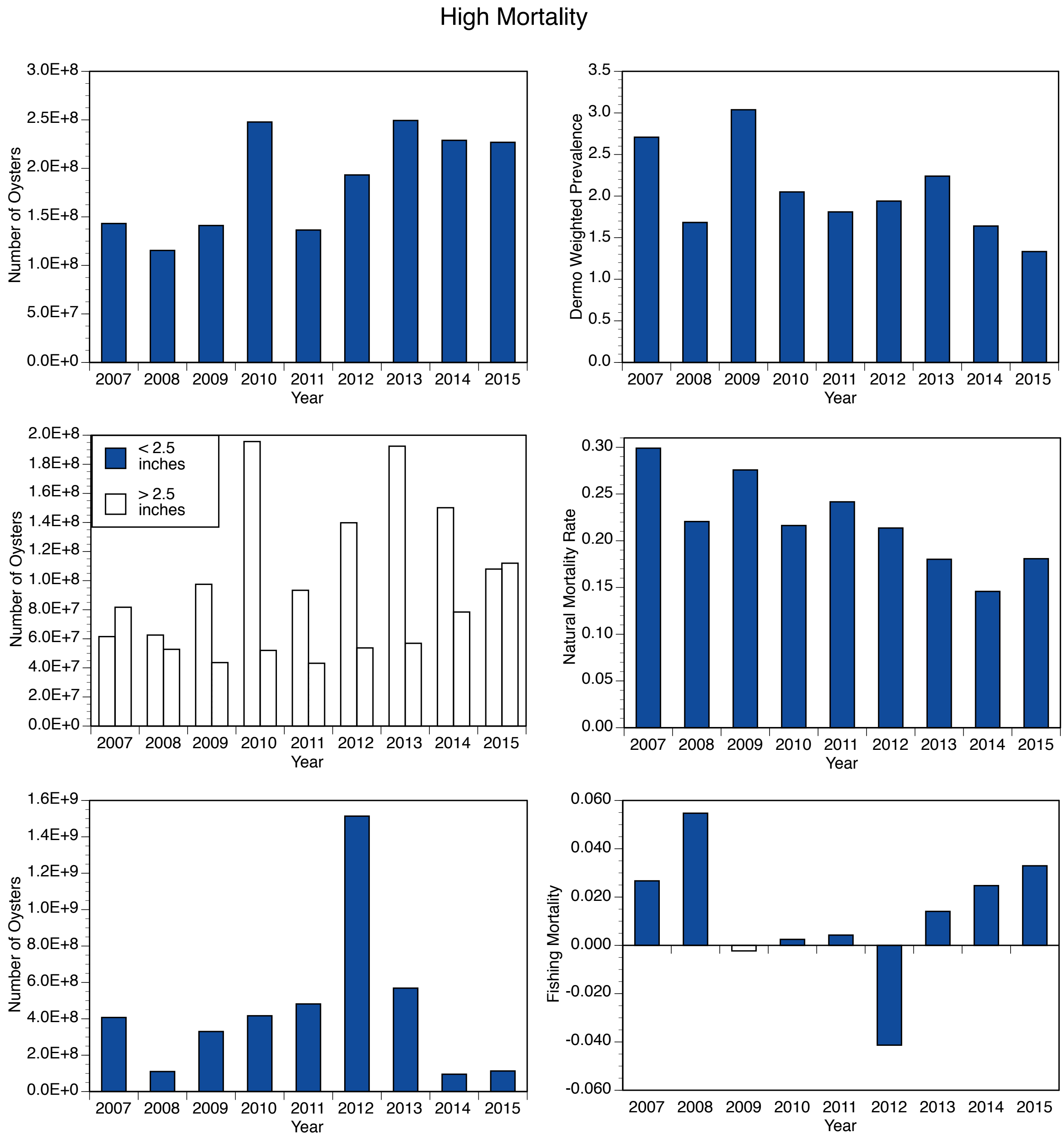
Medium Mortality Market



Appendix B.5. Region Trends. Nine-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. Nine-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.



Appendix C. Density data by sampled grid from Fall surveys (stock assessment) and Spring resurveys (bed stratification) for 2011 - 2015. 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 was sampled in both Spring and Fall, the Fall survey data is used. Regions: HM=High Mortality, SR=Shell Rock, MMM=Medium Mortality Market, MMT=Medium Mortality Transplant, LM=Low Mortality, VLM=Very Low Mortality. 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) approximately 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. NOTE: The density data in this appendix reflect the changes wrought by the new temporally-consistent catchability coefficients and the new bed groupings to which the coefficients are applied (see Gear Efficiency Corrections in this report).

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2011	Nov-11	VLM	Hope Creek	**64**	1	74.214	4.252	11.313
2011	Nov-11	VLM	Hope Creek	**61**	1	74.035	3.524	8.524
2011	Nov-11	VLM	Hope Creek	**76**	1	71.339	2.693	9.896
2011	Nov-11	VLM	Hope Creek	**84**	2	55.171	2.852	3.855
2011	Nov-11	VLM	Hope Creek	**55**	2	50.199	3.709	8.256
2011	Nov-11	VLM	Hope Creek	**46**	2	0.193	0	0.043
2011	Nov-11	VLM	Fishing Creek	**4**	2	93.301	2.292	11.087
2011	Nov-11	VLM	Fishing Creek	**5**	2	33.564	1.626	7.780
2011	Nov-11	VLM	Fishing Creek	**16**	1	19.069	0.970	5.907
2011	Nov-11	VLM	Fishing Creek	**8**	2	7.088	0	1.479
2011	Nov-11	VLM	Hope Creek	**63**	1	74.649	2.774	14.159
2011	Nov-11	VLM	Liston Range	**24**	1	133.080	15.513	11.861
2011	Nov-11	VLM	Liston Range	**17**	2	44.264	3.056	2.092
2011	Nov-11	VLM	Liston Range	**23**	2	18.554	1.187	1.849
2011	Nov-11	VLM	Liston Range	**25**	2	10.655	1.391	0.668
2011	Nov-11	VLM	Liston Range	**21**	1	8.155	0.480	0.588
2011	Nov-11	VLM	Liston Range	**22**	2	5.917	0.185	1.417
2011	Nov-11	LM	Round Island	**26**	1	176.458	12.402	11.587
2011	Nov-11	LM	Round Island	**25**	2	91.746	8.030	7.986
2011	Nov-11	LM	Round Island	**12**	1	84.908	7.469	11.885
2011	Nov-11	LM	Round Island	**5**	2	32.335	2.216	2.859
2011	Nov-11	LM	Round Island	**4**	2	0.188	0	0.342
2011	Nov-11	LM	Upper Arnolds	**8**	2	89.482	7.929	12.056
2011	Nov-11	LM	Upper Arnolds	**18**	1	81.248	8.002	8.531
2011	Nov-11	LM	Upper Arnolds	**5**	1	79.395	5.459	4.657
2011	Nov-11	LM	Upper Arnolds	**13**	2	32.666	5.599	11.357
2011	Nov-11	LM	Upper Arnolds	**21**	2	13.556	1.744	0.995
2011	Nov-11	LM	Arnolds	**7**	1	159.254	16.182	7.756
2011	Nov-11	LM	Arnolds	**16**	1	140.622	13.129	6.821
2011	Nov-11	LM	Arnolds	**17**	1	123.645	8.963	4.877
2011	Nov-11	LM	Arnolds	**19**	2	46.482	5.316	13.309
2011	Nov-11	LM	Arnolds	**72**	2	25.012	5.229	12.178
2011	Nov-11	LM	Arnolds	**26**	2	8.337	1.266	1.183
2011	Nov-11	MMT	Upper Middle	**48**	1	110.174	8.294	15.230
2011	Nov-11	MMT	Upper Middle	**36**	2	10.906	0.913	3.338
2011	Nov-11	MMT	Upper Middle	**56**	2	2.175	0	1.455
2011	Nov-11	MMT	Upper Middle	**49**	2	1.428	0.224	2.660
2011	Oct-11	MMT	Middle	**28**	1	154.080	53.344	9.220
2011	Oct-11	MMT	Middle	**35**	1	70.432	16.733	2.200
2011	Oct-11	MMT	Middle	**21**	2	64.541	6.747	14.126
2011	Oct-11	MMT	Middle	**38**	1	41.771	6.816	10.944
2011	Oct-11	MMT	Middle	**41**	2	26.019	6.373	4.938

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2011	Oct-11	MMT	Middle	**51**	2	18.485	3.759	5.238
2011	Oct-11	MMT	Middle	**1**	2	16.566	2.807	9.043
2011	Nov-11	MMT	Middle	**26**	4	13.250	1.186	3.442
2011	Oct-11	MMT	Sea Breeze	**18**	1	169.619	60.415	20.315
2011	Jun-12	MMT	Sea Breeze	30	2	145.397	12.191	10.617
2011	Jun-12	MMT	Sea Breeze	14	2	139.575	5.713	8.444
2011	Oct-11	MMT	Sea Breeze	**15**	2	133.638	28.530	5.207
2011	May-12	MMT	Sea Breeze	36	2	125.190	10.742	3.651
2011	Jun-12	MMT	Sea Breeze	31	2	120.096	5.715	10.120
2011	Jun-12	MMT	Sea Breeze	19	1	118.331	13.933	25.978
2011	Jun-12	MMT	Sea Breeze	17	2	117.015	6.507	8.108
2011	Jun-12	MMT	Sea Breeze	20	2	114.719	5.105	4.549
2011	Jun-12	MMT	Sea Breeze	22	1	114.454	4.480	6.513
2011	Jun-12	MMT	Sea Breeze	23	3	72.585	6.235	4.809
2011	Oct-11	MMT	Sea Breeze	**13**	2	59.732	14.269	12.577
2011	Oct-11	MMT	Sea Breeze	**24**	1	47.544	5.604	6.407
2011	Jun-12	MMT	Sea Breeze	25	2	39.887	2.920	4.413
2011	May-12	MMT	Sea Breeze	37	2	32.934	2.312	4.830
2011	Jun-12	MMT	Sea Breeze	39	3	17.449	0	3.157
2011	Oct-11	MMT	Sea Breeze	**16**	1	16.896	4.117	8.894
2011	May-12	MMT	Sea Breeze	38	2	13.366	3.310	3.382
2011	May-12	MMT	Sea Breeze	46	3	12.781	1.737	1.131
2011	Jun-12	MMT	Sea Breeze	26	2	8.742	0.990	7.569
2011	Jun-12	MMT	Sea Breeze	29	2	8.045	0.226	3.188
2011	May-12	MMT	Sea Breeze	48	3	5.161	0	5.460
2011	Jun-12	MMT	Sea Breeze	33	3	4.226	0.661	6.500
2011	Jun-12	MMT	Sea Breeze	34	3	4.202	0	6.903
2011	Jun-12	MMT	Sea Breeze	32	3	3.460	0	1.123
2011	Jun-12	MMT	Sea Breeze	12	3	2.696	0.241	2.691
2011	May-12	MMT	Sea Breeze	47	3	2.111	0	2.422
2011	Jun-12	MMT	Sea Breeze	1	3	1.649	0	2.549
2011	May-12	MMT	Sea Breeze	35	2	1.210	0.186	0.760
2011	Jun-12	MMT	Sea Breeze	27	3	1.154	0.210	1.015
2011	Jun-12	MMT	Sea Breeze	3	3	0.907	0	0.930
2011	Jun-12	MMT	Sea Breeze	2	2	0.679	0.064	0.523
2011	Jun-12	MMT	Sea Breeze	28	3	0.672	0.180	1.271
2011	Jun-12	MMT	Sea Breeze	45	3	0.647	0.128	1.322
2011	Jun-12	MMT	Sea Breeze	11	3	0.431	0	4.760
2011	Jun-12	MMT	Sea Breeze	43	2	0.339	0	1.365
2011	Jun-12	MMT	Sea Breeze	21	3	0.268	0.045	0.957
2011	Jun-12	MMT	Sea Breeze	6	3	0.250	0.134	0.703
2011	Jun-12	MMT	Sea Breeze	8	3	0.225	0	1.733

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2011	Jun-12	MMT	Sea Breeze	9	3	0.187	0	1.621
2011	Jun-12	MMT	Sea Breeze	5	3	0.168	0	0.473
2011	Jun-12	MMT	Sea Breeze	42	3	0.162	0	1.068
2011	Jun-12	MMT	Sea Breeze	44	3	0.107	0	0.354
2011	Jun-12	MMT	Sea Breeze	10	1	0.075	0	2.131
2011	Jun-12	MMT	Sea Breeze	4	3	0	0	0.046
2011	Jun-12	MMT	Sea Breeze	7	3	0	0.093	0.329
2011	Jun-12	MMT	Sea Breeze	40	3	0	0	0.096
2011	May-12	MMT	Sea Breeze	41	3	0	0	0
2011	Oct-11	MMM	Cohansey	**54**	1	146.294	19.646	5.494
2011	Oct-11	MMM	Cohansey	**50**	1	144.916	18.249	6.931
2011	Oct-11	MMM	Cohansey	**46**	2	110.118	7.850	8.353
2011	Oct-11	MMM	Cohansey	**36**	1	101.892	14.872	7.066
2011	Oct-11	MMM	Cohansey	**44**	1	79.182	7.168	3.096
2011	Oct-11	MMM	Cohansey	**43**	1	54.653	4.214	4.390
2011	Oct-11	MMM	Cohansey	**66**	2	46.404	4.355	9.822
2011	Oct-11	MMM	Cohansey	**3**	2	38.506	12.034	7.645
2011	Oct-11	MMM	Cohansey	**65**	4	33.733	2.068	2.313
2011	Oct-11	MMM	Cohansey	**33**	2	27.524	2.957	7.240
2011	Oct-11	MMM	Cohansey	**8**	2	22.161	4.697	9.192
2011	Oct-11	MMM	Ship John	**25**	1	192.446	77.909	9.862
2011	Oct-11	MMM	Ship John	**18**	2	181.692	48.234	12.677
2011	Oct-11	MMM	Ship John	**31**	1	147.975	61.533	6.073
2011	Oct-11	MMM	Ship John	**33**	1	132.608	59.434	6.584
2011	Oct-11	MMM	Ship John	**15**	1	113.926	17.575	9.631
2011	Oct-11	MMM	Ship John	**42**	1	110.921	51.300	3.668
2011	Oct-11	MMM	Ship John	**16**	1	88.536	26.017	6.494
2011	Oct-11	MMM	Ship John	**8**	2	68.736	13.428	9.425
2011	Oct-11	MMM	Ship John	**30**	2	54.911	4.351	3.019
2011	Oct-11	MMM	Ship John	**57**	2	11.956	51.044	16.093
2011	Oct-11	MMM	Ship John	**52**	2	7.665	8.253	12.435
2011	May-12	SR	Shell Rock	24	1	111.636	14.641	3.445
2011	Oct-11	SR	Shell Rock	**15**	2	110.931	24.029	7.265
2011	Oct-11	SR	Shell Rock	**23**	4	106.490	44.320	9.706
2011	May-12	SR	Shell Rock	20	1	99.509	14.193	3.427
2011	Oct-11	SR	Shell Rock	**14**	1	92.056	43.696	5.122
2011	Oct-11	SR	Shell Rock	**19**	1	84.175	34.667	5.817
2011	Oct-11	SR	Shell Rock	**21**	4	81.486	10.875	2.640
2011	May-12	SR	Shell Rock	13	2	75.668	7.595	2.150
2011	May-12	SR	Shell Rock	5	2	70.792	5.384	2.029
2011	May-12	SR	Shell Rock	2	2	68.733	3.589	1.787
2011	Oct-11	SR	Shell Rock	9	1	67.893	7.188	3.320

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2011	May-12	SR	Shell Rock	4	2	59.868	3.355	1.401
2011	May-12	SR	Shell Rock	62	2	52.689	3.999	4.886
2011	May-12	SR	Shell Rock	12	1	48.533	2.815	0.809
2011	May-12	SR	Shell Rock	22	2	45.646	3.175	0.822
2011	May-12	SR	Shell Rock	58	2	44.730	2.930	3.951
2011	Oct-11	SR	Shell Rock	**11**	4	44.558	10.545	2.209
2011	May-12	SR	Shell Rock	17	2	43.603	8.999	1.723
2011	May-12	SR	Shell Rock	10	1	33.172	1.292	0.750
2011	Oct-11	SR	Shell Rock	**1**	2	29.702	5.092	3.006
2011	May-12	SR	Shell Rock	43	1	28.010	14.484	2.933
2011	May-12	SR	Shell Rock	55	3	27.753	2.149	5.854
2011	May-12	SR	Shell Rock	59	3	25.353	1.664	2.646
2011	May-12	SR	Shell Rock	6	2	24.140	2.627	2.089
2011	May-12	SR	Shell Rock	3	2	23.058	1.188	0.929
2011	May-12	SR	Shell Rock	25	2	20.048	2.655	0.262
2011	May-12	SR	Shell Rock	85	2	19.687	7.270	1.728
2011	Oct-11	SR	Shell Rock	**27**	2	15.041	8.748	4.868
2011	May-12	SR	Shell Rock	90	2	13.979	1.363	1.032
2011	May-12	SR	Shell Rock	56	2	11.733	1.684	3.102
2011	May-12	SR	Shell Rock	7	2	9.550	0.841	1.436
2011	May-12	SR	Shell Rock	46	2	8.761	14.226	3.609
2011	May-12	SR	Shell Rock	34	2	7.826	1.679	0.401
2011	May-12	SR	Shell Rock	33	2	7.465	0.667	0.316
2011	May-12	SR	Shell Rock	68	2	6.974	2.929	0.998
2011	May-12	SR	Shell Rock	35	1	6.284	1.104	0.232
2011	May-12	SR	Shell Rock	29	2	6.046	7.632	2.313
2011	May-12	SR	Shell Rock	91	3	5.359	0.204	0.395
2011	May-12	SR	Shell Rock	45	2	4.813	1.109	1.406
2011	May-12	SR	Shell Rock	44	2	4.528	2.593	0.854
2011	May-12	SR	Shell Rock	63	3	3.397	0	3.374
2011	Oct-11	SR	Shell Rock	**42**	2	3.221	3.887	5.012
2011	May-12	SR	Shell Rock	31	2	2.729	1.062	0.482
2011	May-12	SR	Shell Rock	40	3	2.624	3.098	1.844
2011	May-12	SR	Shell Rock	38	1	2.251	4.132	0.961
2011	May-12	SR	Shell Rock	75	2	2.237	4.183	1.701
2011	May-12	SR	Shell Rock	79	2	2.149	9.335	5.558
2011	May-12	SR	Shell Rock	16	3	1.971	0.275	0.108
2011	May-12	SR	Shell Rock	18	3	1.606	0.200	1.108
2011	May-12	SR	Shell Rock	30	2	1.527	1.749	0.815
2011	May-12	SR	Shell Rock	71	3	1.102	1.209	1.175
2011	May-12	SR	Shell Rock	50	3	0.720	0.233	0.410
2011	May-12	SR	Shell Rock	67	3	0.635	0.606	0.875

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2011	May-12	SR	Shell Rock	36	3	0.534	0.055	0.179
2011	May-12	SR	Shell Rock	60	3	0.476	0.130	0.250
2011	May-12	SR	Shell Rock	65	2	0.458	0.141	1.388
2011	May-12	SR	Shell Rock	37	3	0.435	0.117	0.174
2011	May-12	SR	Shell Rock	57	3	0.419	0.027	0.231
2011	May-12	SR	Shell Rock	49	3	0.376	0.186	0.665
2011	May-12	SR	Shell Rock	61	3	0.319	0.083	0.154
2011	May-12	SR	Shell Rock	28	3	0.269	0.076	0.122
2011	May-12	SR	Shell Rock	41	2	0.266	0.603	0.522
2011	May-12	SR	Shell Rock	88	3	0.211	0.039	0.303
2011	May-12	SR	Shell Rock	51	3	0.165	0.086	2.710
2011	May-12	SR	Shell Rock	52	2	0.149	0.390	6.725
2011	May-12	SR	Shell Rock	93	3	0.145	0.058	0.200
2011	May-12	SR	Shell Rock	64	3	0.140	0.147	0.924
2011	May-12	SR	Shell Rock	39	3	0.127	0.111	0.525
2011	May-12	SR	Shell Rock	81	3	0.118	0.143	2.017
2011	May-12	SR	Shell Rock	26	3	0.113	0.023	0.121
2011	May-12	SR	Shell Rock	53	3	0.111	0.110	0.991
2011	May-12	SR	Shell Rock	54	3	0.097	0	1.113
2011	May-12	SR	Shell Rock	8	3	0.086	0.224	0.528
2011	May-12	SR	Shell Rock	48	3	0.068	0	0.270
2011	May-12	SR	Shell Rock	86	3	0.068	0.035	0.387
2011	May-12	SR	Shell Rock	69	3	0.043	0.085	0.251
2011	May-12	SR	Shell Rock	72	3	0.023	0	0.355
2011	May-12	SR	Shell Rock	47	3	0.013	0.033	0.103
2011	May-12	SR	Shell Rock	76	3	0.013	0	0.063
2011	May-12	SR	Shell Rock	73	3	0.012	0.045	0.114
2011	May-12	SR	Shell Rock	66	3	0	0	3.383
2011	May-12	SR	Shell Rock	70	3	0	0	0.230
2011	May-12	SR	Shell Rock	74	3	0	0	0
2011	May-12	SR	Shell Rock	77	3	0	0	0.278
2011	May-12	SR	Shell Rock	78	3	0	0	1.587
2011	May-12	SR	Shell Rock	80	3	0	0	0.157
2011	May-12	SR	Shell Rock	82	3	0	0	0.492
2011	May-12	SR	Shell Rock	83	3	0	0.200	1.444
2011	May-12	SR	Shell Rock	84	3	0	0	1.249
2011	May-12	SR	Shell Rock	87	3	0	0.062	1.425
2011	May-12	SR	Shell Rock	92	3	0	0	0
2011	Oct-11	HM	Benny Sand	**4**	4	103.464	55.304	1.959
2011	Oct-11	HM	Benny Sand	**8**	1	50.597	74.081	9.669
2011	Oct-11	HM	Benny Sand	**15**	4	24.327	38.586	5.669
2011	Oct-11	HM	Benny Sand	**9**	1	17.355	21.481	1.646

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2011	Oct-11	HM	Benny Sand	**7**	1	13.517	31.010	4.461
2011	Oct-11	HM	Benny Sand	**14**	2	12.399	26.034	8.735
2011	Oct-11	HM	Benny Sand	**1**	2	10.477	10.820	4.569
2011	Oct-11	HM	Benny Sand	**11**	4	6.263	39.837	7.678
2011	Oct-11	HM	Benny Sand	**13**	2	4.316	51.299	13.995
2011	Oct-11	HM	Benny Sand	**27**	2	3.318	3.074	3.568
2011	Oct-11	HM	Benny Sand	**22**	2	2.907	8.189	4.068
2011	Oct-11	HM	Benny Sand	**26**	2	1.878	4.533	2.735
2011	Oct-11	HM	Bennies	**71**	4	18.036	63.974	10.591
2011	Oct-11	HM	Bennies	**70**	4	8.841	39.556	7.033
2011	Oct-11	HM	Bennies	**86**	1	5.722	50.374	5.898
2011	Oct-11	HM	Bennies	**123**	1	2.799	7.339	6.536
2011	Oct-11	HM	Bennies	**102**	4	1.827	14.123	5.742
2011	Oct-11	HM	Bennies	**148**	2	1.505	5.730	8.010
2011	Oct-11	HM	Bennies	**7**	2	0.821	2.091	0.916
2011	Oct-11	HM	Bennies	**107**	2	0.731	4.591	10.216
2011	Oct-11	HM	Bennies	**84**	2	0.642	5.169	10.090
2011	Oct-11	HM	Bennies	**133**	2	0.128	0.668	4.272
2011	Oct-11	HM	Bennies	**114**	2	0.125	1.308	9.349
2011	Oct-11	HM	Bennies	**97**	1	0.121	4.122	11.202
2011	Oct-11	HM	Bennies	**64**	2	0	0.332	5.022
2011	Oct-11	HM	Bennies	**96**	2	0	1.572	12.262
2011	Oct-11	HM	Bennies	**127**	2	0	0.137	0.686
2011	Oct-11	HM	NantuxentP	**24**	4	80.689	77.841	9.562
2011	Oct-11	HM	NantuxentP	**18**	1	44.482	26.589	9.293
2011	Oct-11	HM	NantuxentP	**16**	1	40.012	9.772	1.408
2011	Oct-11	HM	NantuxentP	**15**	1	23.151	65.238	5.304
2011	Oct-11	HM	NantuxentP	**26**	2	3.780	1.682	0.499
2011	Oct-11	HM	NantuxentP	**13**	2	1.843	5.704	3.026
2011	Oct-11	HM	NantuxentP	**29**	2	0.540	2.364	3.429
2011	Oct-11	HM	New Beds	**26**	1	8.887	61.856	10.710
2011	Oct-11	HM	New Beds	**17**	1	6.839	59.220	10.196
2011	Oct-11	HM	New Beds	**41**	2	5.306	21.864	4.820
2011	Oct-11	HM	New Beds	**53**	2	3.494	36.041	10.741
2011	Oct-11	HM	New Beds	**39**	2	2.659	25.398	6.217
2011	Oct-11	HM	New Beds	**28**	2	1.998	7.591	4.229
2011	Oct-11	HM	New Beds	**68**	2	1.018	0.899	1.297
2011	Oct-11	HM	New Beds	**55**	2	0.923	3.960	4.765
2011	Oct-11	HM	New Beds	**43**	2	0.676	2.780	5.764
2011	Oct-11	HM	Hog Shoal	**1**	1	21.796	45.861	10.847
2011	Oct-11	HM	Hog Shoal	**13**	1	18.847	29.647	7.191
2011	Oct-11	HM	Hog Shoal	**12**	2	16.964	22.944	2.694

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2011	Oct-11	HM	Hog Shoal	**2**	2	5.117	5.639	3.455
2011	Oct-11	HM	Hog Shoal	**4**	1	2.866	7.534	4.458
2011	Oct-11	HM	Hog Shoal	**20**	2	1.350	17.353	6.715
2011	Oct-11	HM	Strawberry	**9**	2	3.321	19.068	10.872
2011	Oct-11	HM	Strawberry	**29**	1	1.217	13.064	12.456
2011	Oct-11	HM	Strawberry	**24**	2	0.924	0.316	0.156
2011	Oct-11	HM	Strawberry	**20**	2	0.260	0.733	1.058
2011	Oct-11	HM	Hawk's Nest	**25**	2	25.916	12.477	2.064
2011	Oct-11	HM	Hawk's Nest	**2**	1	13.938	33.484	2.951
2011	Oct-11	HM	Hawk's Nest	**1**	1	10.322	14.133	2.220
2011	Oct-11	HM	Hawk's Nest	**9**	2	3.261	3.101	3.028
2011	Oct-11	HM	Hawk's Nest	**19**	2	0.139	2.358	4.577
2011	Oct-11	HM	Beadons	**3**	1	26.855	119.763	10.094
2011	Oct-11	HM	Beadons	**4**	1	16.255	79.724	4.640
2011	Oct-11	HM	Beadons	**9**	2	2.232	7.945	0.271
2011	Oct-11	HM	Beadons	**5**	2	1.444	6.174	1.279
2011	Oct-11	HM	Beadons	**15**	2	0.432	1.681	0.173
2011	Oct-11	HM	Vexton	**4**	1	12.688	43.540	5.723
2011	Oct-11	HM	Vexton	**9**	1	11.496	92.935	16.673
2011	Oct-11	HM	Vexton	**5**	2	3.497	38.677	14.991
2011	Oct-11	HM	Vexton	**33**	2	0	0.081	0.268
2011	Oct-11	HM	Egg Island	**44**	2	1.653	10.506	11.562
2011	Oct-11	HM	Egg Island	**62**	1	0.360	0.628	10.707
2011	Oct-11	HM	Egg Island	**101**	2	0.315	0.275	4.909
2011	Oct-11	HM	Egg Island	**82**	2	0.155	1.213	14.836
2011	Oct-11	HM	Egg Island	**59**	2	0	0.801	6.186
2011	Oct-11	HM	Egg Island	**85**	2	0	0.096	1.882
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	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	VLM	Liston Range	**18**	2	100.675	16.916	5.798

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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	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
2012	Oct-12	LM	Arnolds	**17**	1	100.883	11.959	6.095

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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	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	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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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	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
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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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	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
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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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
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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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	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	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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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
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	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	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	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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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
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	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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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	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	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
2013	Nov-13	HM	Benny Sand	**3**	2	6.272	5.239	1.237

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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
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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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
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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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
2013	May-14	HM	Bennies	81	2	0	0	12.627

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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	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	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	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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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
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	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	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	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	May-15	LM	Arnolds	17	1	162.995	36.581	24.183
2014	May-15	LM	Arnolds	15	2	158.155	12.038	7.943
2014	May-15	LM	Arnolds	16	1	151.307	13.362	15.078

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2014	May-15	LM	Arnolds	3	2	0.387	0.026	0.382
2014	Oct-14	LM	Arnolds	**3**	2	0.342	0.023	0.183
2014	May-15	LM	Arnolds	65	3	0.296	0	0.071
2014	May-15	LM	Arnolds	52	3	0.294	0	1.080
2014	May-15	LM	Arnolds	95	3	0.269	0	3.586
2014	May-15	LM	Arnolds	58	3	0.269	0.279	0.149
2014	May-15	LM	Arnolds	38	3	0.255	0.159	0.395
2014	May-15	LM	Arnolds	71	2	0.254	0	1.054
2014	May-15	LM	Arnolds	78	3	0.225	0	0.707
2014	May-15	LM	Arnolds	89	3	0.190	0	0.152
2014	May-15	LM	Arnolds	34	3	0.168	0	0.070
2014	May-15	LM	Arnolds	90	3	0.165	0	0.436
2014	May-15	LM	Arnolds	24	3	0.150	0	0.007
2014	May-15	LM	Arnolds	92	3	0.142	0	1.287
2014	May-15	LM	Arnolds	25	3	0.137	0	0.177
2014	May-15	LM	Arnolds	30	3	0.136	0	0.272
2014	May-15	LM	Arnolds	74	3	0.117	0	0.063
2014	May-15	LM	Arnolds	51	3	0.105	0	0.156
2014	May-15	LM	Arnolds	70	3	0.086	0	0.100
2014	May-15	LM	Arnolds	83	3	0.084	0	0.068
2014	May-15	LM	Arnolds	76	3	0.076	0	0.250
2014	May-15	LM	Arnolds	99	3	0.060	0	0.023
2014	May-15	LM	Arnolds	60	3	0.054	0	0.140
2014	May-15	LM	Arnolds	73	2	0.051	0	0.268
2014	May-15	LM	Arnolds	4	3	0.050	0.079	0.070
2014	Oct-14	LM	Arnolds	**73**	2	0.045	0	0.130
2014	May-15	LM	Arnolds	62	3	0.038	0	0.063
2014	May-15	LM	Arnolds	64	3	0.031	0	0.027
2014	May-15	LM	Arnolds	5	3	0.031	0	0.093
2014	May-15	LM	Arnolds	98	3	0.030	0	0.354
2014	May-15	LM	Arnolds	82	3	0.030	0	0.031
2014	May-15	LM	Arnolds	39	3	0.027	0	0.051
2014	May-15	LM	Arnolds	84	3	0	0	0
2014	May-15	LM	Arnolds	48	3	0	0	0.009
2014	May-15	LM	Arnolds	49	3	0	0	0
2014	May-15	LM	Arnolds	86	3	0	0	0.019
2014	May-15	LM	Arnolds	36	3	0	0	0
2014	May-15	LM	Arnolds	37	3	0	0	0
2014	May-15	LM	Arnolds	23	3	0	0	0.017
2014	May-15	LM	Arnolds	47	3	0	0	0.058
2014	May-15	LM	Arnolds	50	3	0	0	0
2014	May-15	LM	Arnolds	88	3	0	0	0

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2014	Oct-14	LM	Arnolds	**17**	1	144.051	24.477	11.692
2014	May-15	LM	Arnolds	9	2	124.222	9.163	13.445
2014	May-15	LM	Arnolds	18	1	106.047	22.302	40.675
2014	May-15	LM	Arnolds	19	2	100.182	5.464	19.219
2014	May-15	LM	Arnolds	8	1	93.589	9.192	14.800
2014	May-15	LM	Arnolds	7	1	88.699	17.943	6.981
2014	Oct-14	LM	Arnolds	**7**	1	78.390	13.254	3.491
2014	May-15	LM	Arnolds	6	1	69.643	6.214	4.931
2014	Oct-14	LM	Arnolds	**6**	1	61.552	4.782	2.396
2014	May-15	LM	Arnolds	42	3	48.670	3.097	21.486
2014	May-15	LM	Arnolds	28	2	47.923	1.726	3.881
2014	May-15	LM	Arnolds	72	2	35.796	2.325	9.537
2014	May-15	LM	Arnolds	29	2	32.169	2.428	26.238
2014	May-15	LM	Arnolds	59	3	26.823	1.110	6.093
2014	May-15	LM	Arnolds	26	2	24.583	0.603	4.024
2014	May-15	LM	Arnolds	1	2	24.121	1.420	1.312
2014	May-15	LM	Arnolds	67	2	20.719	0	6.187
2014	May-15	LM	Arnolds	45	3	17.563	0.192	4.126
2014	May-15	LM	Arnolds	11	2	17.002	1.211	7.672
2014	May-15	LM	Arnolds	27	2	15.651	0.660	1.247
2014	May-15	LM	Arnolds	68	3	15.287	0.191	10.778
2014	May-15	LM	Arnolds	56	3	13.416	0.731	4.575
2014	May-15	LM	Arnolds	10	2	13.132	1.295	1.045
2014	Oct-14	LM	Arnolds	**10**	2	11.606	0.891	0.514
2014	May-15	LM	Arnolds	57	2	9.200	0.044	0.755
2014	May-15	LM	Arnolds	46	2	8.673	0.589	4.625
2014	May-15	LM	Arnolds	2	2	8.412	0.359	1.742
2014	May-15	LM	Arnolds	53	3	8.077	0.682	5.176
2014	May-15	LM	Arnolds	43	3	6.278	0.149	5.467
2014	May-15	LM	Arnolds	66	3	5.110	0.134	1.963
2014	May-15	LM	Arnolds	79	3	3.227	0.129	5.340
2014	May-15	LM	Arnolds	77	3	2.569	0	3.537
2014	May-15	LM	Arnolds	80	3	2.215	0	3.892
2014	May-15	LM	Arnolds	40	3	1.529	0.162	0.673
2014	May-15	LM	Arnolds	96	3	1.244	0	11.748
2014	May-15	LM	Arnolds	31	3	1.202	0	0.547
2014	May-15	LM	Arnolds	14	3	0.902	0.036	0.453
2014	May-15	LM	Arnolds	81	3	0.756	0	1.139
2014	May-15	LM	Arnolds	13	3	0.755	0.032	0.650
2014	May-15	LM	Arnolds	41	3	0.643	0	0.673
2014	May-15	LM	Arnolds	44	3	0.537	0	0.682
2014	May-15	LM	Arnolds	20	3	0.388	0	0.282

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2014	May-15	LM	Arnolds	93	3	0	0	0.178
2014	May-15	LM	Arnolds	61	3	0	0	0.212
2014	May-15	LM	Arnolds	85	3	0	0	0.004
2014	May-15	LM	Arnolds	63	3	0	0	0
2014	May-15	LM	Arnolds	91	3	0	0	0.028
2014	May-15	LM	Arnolds	21	3	0	0	5.005
2014	May-15	LM	Arnolds	33	3	0	0	0.029
2014	May-15	LM	Arnolds	75	3	0	0	0.007
2014	May-15	LM	Arnolds	22	3	0	0	0.051
2014	May-15	LM	Arnolds	69	3	0	0	0.002
2014	May-15	LM	Arnolds	97	3	0	0	0.021
2014	May-15	LM	Arnolds	94	3	0	0	0.075
2014	May-15	LM	Arnolds	87	3	0	0	0.060
2014	May-15	LM	Arnolds	32	3	0	0	0.086
2014	May-15	LM	Arnolds	55	3	0	0	1.239
2014	May-15	LM	Arnolds	54	3	0	0	1.712
2014	May-15	LM	Arnolds	12	3	0	0	0.246
2014	May-15	LM	Arnolds	35	3	0	0	0.010
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	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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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	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
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	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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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
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	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	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	May-15	HM	Strawberry	28	3	3.642	0.130	1.101
2014	May-15	HM	Strawberry	10	2	3.050	0	10.829
2014	Oct-14	HM	Strawberry	**5**	1	2.897	0.505	7.793
2014	May-15	HM	Strawberry	5	1	2.627	0.525	9.180

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2014	May-15	HM	Strawberry	29	1	1.996	0.143	8.333
2014	May-15	HM	Strawberry	21	3	1.657	0	3.396
2014	May-15	HM	Strawberry	24	2	0.700	0.215	0.293
2014	May-15	HM	Strawberry	20	2	0.263	0	3.379
2014	May-15	HM	Strawberry	9	2	0.181	0	6.113
2014	May-15	HM	Strawberry	11	2	0.170	0	2.799
2014	May-15	HM	Strawberry	2	3	0.137	0	5.077
2014	Oct-14	HM	Strawberry	**7**	2	0.132	0.025	0.270
2014	May-15	HM	Strawberry	7	2	0.119	0.026	0.318
2014	Oct-14	HM	Strawberry	**1**	2	0.118	0	0.737
2014	May-15	HM	Strawberry	1	2	0.107	0	0.867
2014	May-15	HM	Strawberry	14	2	0.097	0	0.213
2014	May-15	HM	Strawberry	25	2	0.090	0	1.509
2014	May-15	HM	Strawberry	6	2	0.071	0.107	1.503
2014	May-15	HM	Strawberry	12	2	0.071	0	3.219
2014	May-15	HM	Strawberry	26	3	0.048	0.143	1.677
2014	May-15	HM	Strawberry	22	3	0.012	0	0.009
2014	Oct-14	HM	Strawberry	**18**	2	0	0	8.255
2014	May-15	HM	Strawberry	16	2	0	0	12.378
2014	May-15	HM	Strawberry	19	2	0	0	14.728
2014	May-15	HM	Strawberry	8	2	0	0	4.076
2014	May-15	HM	Strawberry	18	2	0	0	9.720
2014	May-15	HM	Strawberry	17	3	0	0	0.384
2014	May-15	HM	Strawberry	23	3	0	0	0.008
2014	May-15	HM	Strawberry	4	3	0	0	0.352
2014	May-15	HM	Strawberry	27	3	0	0	0.037
2014	May-15	HM	Strawberry	3	3	0	0	1.265
2014	May-15	HM	Strawberry	13	3	0	0	8.092
2014	May-15	HM	Strawberry	15	3	0	0	9.993
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

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
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
2015	Oct-15	VLM	Hope Creek	**63**	1	72.931	113.729	6.936
2015	Oct-15	VLM	Hope Creek	**61**	1	51.865	76.478	6.313
2015	Oct-15	VLM	Hope Creek	**62**	1	51.357	86.755	3.492
2015	Oct-15	VLM	Hope Creek	**74**	2	42.479	70.801	7.148
2015	Oct-15	VLM	Hope Creek	**72**	2	33.237	40.670	5.417
2015	Oct-15	VLM	Hope Creek	**53**	2	31.212	62.352	7.708
2015	Oct-15	VLM	Hope Creek	**60**	2	22.906	21.998	5.419
2015	Oct-15	VLM	Hope Creek	**59**	1	0.222	0.106	0.062
2015	Oct-15	VLM	Fishing Creek	**25**	1	38.010	28.001	6.230
2015	Oct-15	VLM	Fishing Creek	**10**	2	19.689	12.705	3.324
2015	Oct-15	VLM	Fishing Creek	**24**	2	16.684	7.587	3.396
2015	Oct-15	VLM	Fishing Creek	**16**	1	5.904	6.127	3.634
2015	Oct-15	VLM	Fishing Creek	**26**	2	4.520	2.425	1.407
2015	Oct-15	VLM	Liston Range	**12**	2	58.475	109.532	7.575
2015	Oct-15	VLM	Liston Range	**14**	1	46.138	40.458	3.002
2015	Oct-15	VLM	Liston Range	**24**	1	41.118	57.159	4.084
2015	Oct-15	VLM	Liston Range	**17**	2	34.066	36.120	2.404
2015	Oct-15	VLM	Liston Range	**23**	2	11.367	16.590	1.966
2015	Oct-15	VLM	Liston Range	**2**	2	0.762	1.097	0.447
2015	Oct-15	LM	Round Island	**11**	1	22.891	12.780	4.613
2015	Oct-15	LM	Round Island	**18**	2	21.303	9.996	4.867
2015	Oct-15	LM	Round Island	**26**	1	11.565	5.254	1.000
2015	Oct-15	LM	Round Island	**73**	2	0.039	0.007	0.026
2015	Oct-15	LM	Round Island	**15**	2	0.029	0.049	0.001
2015	Oct-15	LM	Upper Arnolds	**10**	1	203.272	107.736	17.301
2015	Oct-15	LM	Upper Arnolds	**18**	1	118.674	52.544	12.132
2015	Oct-15	LM	Upper Arnolds	**12**	1	70.906	26.548	7.807
2015	Oct-15	LM	Upper Arnolds	**22**	2	17.494	9.672	7.339
2015	Oct-15	LM	Upper Arnolds	**6**	2	9.872	2.228	0.762
2015	Oct-15	LM	Upper Arnolds	**15**	2	2.358	0.566	0.155
2015	Oct-15	LM	Upper Arnolds	**25**	2	0.297	0.094	0.042
2015	Oct-15	LM	Arnolds	**18**	1	132.879	53.356	26.171
2015	Oct-15	LM	Arnolds	**57**	2	74.770	69.853	6.247
2015	Oct-15	LM	Arnolds	**16**	1	50.586	14.318	1.557
2015	Oct-15	LM	Arnolds	**9**	1	45.635	9.460	27.689
2015	Oct-15	LM	Arnolds	**27**	2	30.457	11.356	3.576

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2015	Oct-15	LM	Arnolds	**53**	2	1.731	0.831	1.438
2015	Oct-15	LM	Arnolds	**43**	2	1.246	0.427	1.347
2015	Oct-15	MMT	Upper Middle	**63**	2	34.894	14.432	13.056
2015	Oct-15	MMT	Upper Middle	**58**	1	32.790	6.843	17.048
2015	Oct-15	MMT	Upper Middle	**71**	2	27.050	24.025	28.328
2015	Oct-15	MMT	Upper Middle	**64**	2	4.237	3.724	10.492
2015	Oct-15	MMT	Middle	**34**	1	197.061	103.275	34.672
2015	Oct-15	MMT	Middle	**28**	4	108.510	40.663	14.975
2015	Oct-15	MMT	Middle	**35**	1	82.045	38.265	13.995
2015	Oct-15	MMT	Middle	**27**	4	66.135	16.103	9.337
2015	Oct-15	MMT	Middle	**37**	1	65.349	11.899	31.390
2015	Oct-15	MMT	Middle	**42**	2	49.364	8.258	25.129
2015	Oct-15	MMT	Middle	**31**	2	43.355	18.646	24.636
2015	Oct-15	MMT	Middle	**49**	2	17.046	22.241	10.150
2015	Oct-15	MMT	Middle	**45**	2	6.728	5.925	9.467
2015	Oct-15	MMT	Sea Breeze	**30**	1	71.214	81.652	12.871
2015	Oct-15	MMT	Sea Breeze	**31**	1	53.328	25.240	8.370
2015	Oct-15	MMT	Sea Breeze	**20**	2	46.992	47.119	13.31
2015	Oct-15	MMT	Sea Breeze	**37**	2	41.630	30.985	7.466
2015	Oct-15	MMT	Sea Breeze	**29**	2	30.420	13.045	4.889
2015	Oct-15	MMT	Sea Breeze	**36**	1	28.621	19.620	4.605
2015	Oct-15	MMT	Sea Breeze	**46**	2	5.071	1.655	3.307
2015	Oct-15	MMM	Cohansey	**50**	1	71.449	19.338	19.027
2015	Oct-15	MMM	Cohansey	**25**	1	65.269	26.200	19.531
2015	Oct-15	MMM	Cohansey	**46**	2	62.249	14.736	31.137
2015	Oct-15	MMM	Cohansey	**43**	1	57.785	10.063	14.192
2015	Oct-15	MMM	Cohansey	**56**	4	52.813	25.241	21.243
2015	Oct-15	MMM	Cohansey	**58**	2	49.970	11.180	27.254
2015	Oct-15	MMM	Cohansey	**3**	2	35.735	22.377	31.756
2015	Oct-15	MMM	Cohansey	**34**	2	35.341	12.974	16.651
2015	Oct-15	MMM	Cohansey	**5**	2	32.939	21.314	24.827
2015	Oct-15	MMM	Cohansey	**57**	1	30.200	14.197	19.131
2015	Oct-15	MMM	Cohansey	**72**	1	22.031	9.492	13.158
2015	Oct-15	MMM	Ship John	**42**	1	101.818	51.134	29.852
2015	Oct-15	MMM	Ship John	**33**	4	89.509	99.246	20.255
2015	Oct-15	MMM	Ship John	**9**	1	80.238	20.502	19.028
2015	Oct-15	MMM	Ship John	**16**	1	78.067	35.291	15.540
2015	Oct-15	MMM	Ship John	**28**	2	70.890	12.762	10.135
2015	Oct-15	MMM	Ship John	**34**	4	58.695	3.696	9.767
2015	Oct-15	MMM	Ship John	**35**	2	54.660	21.342	13.523
2015	Oct-15	MMM	Ship John	**29**	1	43.411	10.356	13.670
2015	Oct-15	MMM	Ship John	**27**	2	40.754	10.803	9.840

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2015	Oct-15	MMM	Ship John	**53**	1	37.923	4.924	10.434
2015	Oct-15	MMM	Ship John	**58**	1	32.092	32.196	22.302
2015	Oct-15	MMM	Ship John	**51**	2	25.607	5.643	11.450
2015	Oct-15	MMM	Ship John	**56**	2	16.966	24.711	19.595
2015	Nov-15	SR	Shell Rock	**34**	2	84.070	33.234	18.942
2015	Nov-15	SR	Shell Rock	**1**	1	67.726	19.275	17.975
2015	Nov-15	SR	Shell Rock	**31**	4	66.399	15.221	12.398
2015	Nov-15	SR	Shell Rock	**24**	1	59.719	13.161	7.608
2015	Nov-15	SR	Shell Rock	**30**	4	52.622	10.757	7.175
2015	Nov-15	SR	Shell Rock	**29**	4	52.503	24.508	14.465
2015	Nov-15	SR	Shell Rock	**58**	2	50.674	8.093	16.683
2015	Nov-15	SR	Shell Rock	**11**	2	48.683	7.858	11.710
2015	Nov-15	SR	Shell Rock	**13**	1	46.677	10.916	10.871
2015	Nov-15	SR	Shell Rock	**4**	1	45.040	11.127	9.079
2015	Nov-15	SR	Shell Rock	**3**	2	29.945	7.836	9.224
2015	Nov-15	SR	Shell Rock	**89**	4	24.520	12.807	9.964
2015	Nov-15	SR	Shell Rock	**52**	4	10.419	1.609	6.317
2015	Nov-15	SR	Shell Rock	**56**	2	8.854	2.606	6.240
2015	Nov-15	SR	Shell Rock	**59**	2	7.762	2.057	4.232
2015	Nov-15	HM	Benny Sand	**7**	1	39.823	10.246	5.059
2015	Nov-15	HM	Benny Sand	**12**	2	27.013	9.351	4.204
2015	Nov-15	HM	Benny Sand	**11**	1	24.441	6.504	3.099
2015	Nov-15	HM	Benny Sand	**8**	1	21.890	7.831	2.845
2015	Nov-15	HM	Benny Sand	**16**	2	13.066	4.007	1.596
2015	Nov-15	HM	Benny Sand	**22**	2	12.649	2.197	3.193
2015	Nov-15	HM	Benny Sand	**24**	2	11.046	3.104	5.094
2015	Nov-15	HM	Benny Sand	**30**	2	0.622	0.276	1.334
2015	Nov-15	HM	Benny Sand	**37**	2	0.424	0.296	2.600
2015	Nov-15	HM	Bennies	**87**	1	24.554	2.443	2.678
2015	Nov-15	HM	Bennies	**101**	1	20.472	1.851	3.456
2015	Nov-15	HM	Bennies	**85**	1	20.264	4.342	3.200
2015	Nov-15	HM	Bennies	**124**	2	16.216	2.232	7.759
2015	Nov-15	HM	Bennies	**100**	1	15.862	2.102	3.640
2015	Nov-15	HM	Bennies	**99**	2	10.631	4.019	7.385
2015	Nov-15	HM	Bennies	**110**	4	9.639	2.048	8.554
2015	Nov-15	HM	Bennies	**111**	1	8.281	0.728	6.243
2015	Nov-15	HM	Bennies	**114**	2	6.507	2.563	6.080
2015	Nov-15	HM	Bennies	**69**	2	3.162	0.386	2.014
2015	Nov-15	HM	Bennies	**57**	2	3.143	0	5.422
2015	Nov-15	HM	Bennies	**135**	2	3.138	0.222	1.462
2015	Nov-15	HM	Bennies	**72**	2	1.945	0.432	0.789
2015	Nov-15	HM	Bennies	**103**	2	1.858	0.381	1.102

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2015	Nov-15	HM	Bennies	**112**	2	0.917	0	5.523
2015	Nov-15	HM	Nantuxent	**24**	1	60.649	39.142	4.332
2015	Nov-15	HM	Nantuxent	**28**	2	45.568	44.915	4.797
2015	Nov-15	HM	Nantuxent	**25**	1	36.837	27.844	4.214
2015	Nov-15	HM	Nantuxent	**23**	4	30.123	9.961	2.079
2015	Nov-15	HM	Nantuxent	**13**	2	17.802	18.576	4.803
2015	Nov-15	HM	Nantuxent	**18**	1	16.259	8.586	2.952
2015	Nov-15	HM	Nantuxent	**12**	2	13.165	17.499	2.342
2015	Nov-15	HM	New Beds	**28**	1	14.221	1.551	7.653
2015	Nov-15	HM	New Beds	**3**	2	14.153	1.726	9.058
2015	Nov-15	HM	New Beds	**25**	1	10.638	2.228	6.861
2015	Nov-15	HM	New Beds	**24**	1	7.937	1.323	7.820
2015	Nov-15	HM	New Beds	**26**	1	7.003	1.433	14.545
2015	Nov-15	HM	New Beds	**21**	2	4.325	0.721	6.680
2015	Nov-15	HM	New Beds	**9**	2	2.578	0	10.402
2015	Nov-15	HM	New Beds	**54**	2	1.127	0.282	6.726
2015	Nov-15	HM	New Beds	**55**	2	0.062	0	4.326
2015	Nov-15	HM	Hog Shoal	**13**	1	20.119	10.992	4.286
2015	Nov-15	HM	Hog Shoal	**1**	1	14.409	15.944	6.233
2015	Nov-15	HM	Hog Shoal	**4**	1	11.272	10.589	7.972
2015	Nov-15	HM	Hog Shoal	**6**	2	10.947	5.859	3.611
2015	Nov-15	HM	Hog Shoal	**19**	2	10.426	2.919	7.658
2015	Nov-15	HM	Hog Shoal	**11**	2	3.189	1.928	1.424
2015	Nov-15	HM	Strawberry	**24**	2	3.446	2.185	0.479
2015	Nov-15	HM	Strawberry	**28**	1	1.135	0.619	1.418
2015	Nov-15	HM	Strawberry	**2**	2	0.652	0.652	3.288
2015	Nov-15	HM	Strawberry	**5**	1	0.414	0	2.234
2015	Nov-15	HM	Strawberry	**20**	2	0.207	0	2.201
2015	Nov-15	HM	Hawk's Nest	**2**	1	18.205	39.153	4.996
2015	Nov-15	HM	Hawk's Nest	**5**	1	0.785	0	6.994
2015	Nov-15	HM	Hawk's Nest	**18**	2	0.157	0	5.425
2015	Nov-15	HM	Hawk's Nest	**9**	2	0.044	0	1.605
2015	Nov-15	HM	Hawk's Nest	**22**	2	0.027	0.164	1.161
2015	Nov-15	HM	Beadons	**3**	1	0.568	0	3.756
2015	Nov-15	HM	Beadons	**4**	1	0.439	0.110	2.172
2015	Nov-15	HM	Beadons	**5**	2	0.119	0.017	0.711
2015	Nov-15	HM	Beadons	**18**	2	0.102	0.031	0.476
2015	Nov-15	HM	Beadons	**15**	2	0.093	0	0.749
2015	Nov-15	HM	Vexton	**9**	1	2.224	1.271	3.892
2015	Nov-15	HM	Vexton	**3**	2	1.772	1.233	5.357
2015	Nov-15	HM	Vexton	**11**	1	0.453	0.187	1.220
2015	Nov-15	HM	Vexton	**2**	2	0.183	0	3.044

Data Year	Collection Date	Region	Bed	Grid	Stratum	Oyster/m2	Spat/m2	Cultch/m2
2015	Nov-15	HM	Egg Island	**63**	1	0.763	0	10.088
2015	Nov-15	HM	Egg Island	**77**	2	0.135	0	2.998
2015	Nov-15	HM	Egg Island	**64**	2	0.081	0	4.503
2015	Nov-15	HM	Egg Island	**46**	2	0.056	0	3.253
2015	Nov-15	HM	Egg Island	**67**	2	0	0	2.030
2015	Nov-15	HM	Egg Island	**79**	2	0	0	2.895

Appendix D.1. Intermediate Transplant memorandum for the May 2015 transplant from Upper Arnolds in the LM to Ship John in the MMM. The 10,200 bushels of material moved included enough market-size oysters to increase the 2015 MMM quota by 4,688 bushels. The smaller oysters and cultch remain to enhance the MMM in future years. See report text for further details.

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

HASKIN SHELLFISH RESEARCH LABORATORY
Department Of Marine And Coastal Sciences - New Jersey Agricultural Experiment Station
6959 Miller Avenue, Port Norris, NJ 08349-3617

REPLY TO:
Kathryn A. Ashton-Alcox or David Bushek
(856) 785-0074; fax (856) 785-1544
kathryn@hsrl.rutgers.edu
bushek@hsrl.rutgers.edu

May 20, 2015

MEMORANDUM
TO: Jason Hearon, Craig Tomlin
FROM: Kathryn Alcox
Haskin Shellfish Research Laboratory

SUBJECT: Intermediate Transplant – Low Mortality Region

An intermediate transplant from Upper Arnolds in the Low Mortality region was conducted from May 12-15, 2015. The goal for this transplant was to move 3,598,514 oysters: the 1.3% (40th percentile) exploitation rate for the Low Mortality region listed in Table 4 of the 17th SAW Executive Summary. The SARC advised that the transplant occur on Upper Arnolds and/or Round Island but not Arnolds. The total of 10,200 bushels of culled material removed from the Low Mortality region by three boats was put on Ship John grid 34.

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 351 to 560 with an average of 439. The percent cultch (not including boxes) in this transplant ranged from 17 to 49% with an average of 33%.

The 1.3% exploitation rate maximum of 3,598,514 oysters in 9,627 bushels was overshot with 4,474,515 oysters moved (125% of the goal) in 10,200 bushels in 9 boat-days. For comparison, the 50th percentile rate of 1.9% is 5,326,934 oysters in 13,384 bushels (Table 4, 17th SAW Executive Summary). This included 3,227,387 small oysters that are not included in the quota increase calculations and 1,247,128 larger oysters that are included in those calculations.

Using the conversion of 266 market-size oysters per bushel, this part of the transplant can increase the quota by up to 4,688 bushels.

OYSTERS PER BU	BOAT 1	BOAT 2	BOAT 3
5/12/15	560	357	351
5/14/15	414	448	397
5/15/15	453	560	408

PERCENT CULTCH	BOAT 1	BOAT 2	BOAT 3
5/12/15	28%	49%	36%
5/14/15	23%	39%	23%
5/15/15	42%	17%	40%

PERCENT BOXES	BOAT 1	BOAT 2	BOAT 3
5/12/15	6%	5%	6%
5/14/15	6%	6%	4%
5/15/15	6%	7%	3%

Appendix D.2. Intermediate Transplant memorandum for the May 2015 transplant from Sea Breeze and Middle in the MMT to Shell Rock (SR). The 16,350 bushels of material moved included enough market-size oysters to increase the 2015 SR quota by 8,545 bushels. The smaller oysters and cultch remain to enhance Shell Rock in future years. See report text for further details.

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

HASKIN SHELLFISH RESEARCH LABORATORY
Department Of Marine And Coastal Sciences - New Jersey Agricultural Experiment Station
6959 Miller Avenue, Port Norris, NJ 08349-3617

REPLY TO:
Kathryn A. Ashton-Alcox or David Bushek
(856) 785-0074; fax (856) 785-1544
kathryn@hsrl.rutgers.edu
bushek@hsrl.rutgers.edu

May 12, 2015

MEMORANDUM
TO: Jason Hearon, Craig Tomlin
FROM: Kathryn Alcox
Haskin Shellfish Research Laboratory

SUBJECT: Intermediate Transplant – Medium Mortality Region

An intermediate transplant from Sea Breeze and Middle beds in the Medium Mortality Transplant region was conducted from May 4-11, 2015. The goal for this transplant was to move 4,360,643 oysters: the 2.3% (60th percentile) exploitation rate for the Medium Mortality Transplant beds listed in Table 4 of the 17th SAW Executive Summary. The SARC advised that the transplant start on Sea Breeze and that no more than half the amount be taken from Middle bed. There were a total of 16,350 bushels of culled material removed from the Medium Mortality Transplant region by three boats as follows:

10,800 bushels from Sea Breeze to Shell Rock 89
5,550 bushels from Middle to Shell Rock 89

Deck samples with one exception, 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 349 with an average of 274. The percent cultch (not including boxes) in this transplant ranged from 9 to 46% with an average of 25%.

The 2.3% exploitation rate maximum of 4,360,643 oysters was slightly overshot with approximately 4,443,494 moved (102% of the goal) in 15 boat-days. This included 2,202,311 small oysters that are not included in the quota increase calculations and 2,272,934 larger oysters that are included in those calculations. Using the conversion of 266 market-size oysters per bushel, this part of the transplant can increase the quota by up to 8,545 bushels.

OYSTERS PER BU	BOAT 1	BOAT 2	BOAT 3
5/4/15	260	258	--
5/5/15	291	249	--
5/6/15	209	290	299
5/7/15	228	201	261
5/8/15	349	311	329
5/11/15	307	no samp.	--

PERCENT CULTCH	BOAT 1	BOAT 2	BOAT 3
5/4/15	31%	19%	--
5/5/15	19%	9%	--
5/6/15	27%	9%	29%
5/7/15	46%	34%	30%
5/8/15	28%	31%	35%
5/11/15	28%	no samp.	--

PERCENT BOXES	BOAT 1	BOAT 2	BOAT 3
5/4/15	5%	1%	--
5/5/15	9%	3%	--
5/6/15	8%	2%	12%
5/7/15	6%	3%	7%
5/8/15	7%	10%	4%
5/11/15	6%	no samp.	--

Appendix E.1. 2015 regional total abundance estimates within confidence percentiles for the 2015 survey taking into account between-sample variation and uncertainty in dredge efficiency updated to use all-oyster catchability coefficients rather than size-based catchability coefficients (see Analytical Approach in this report). Reference points are included for comparison except for the VLM. 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.

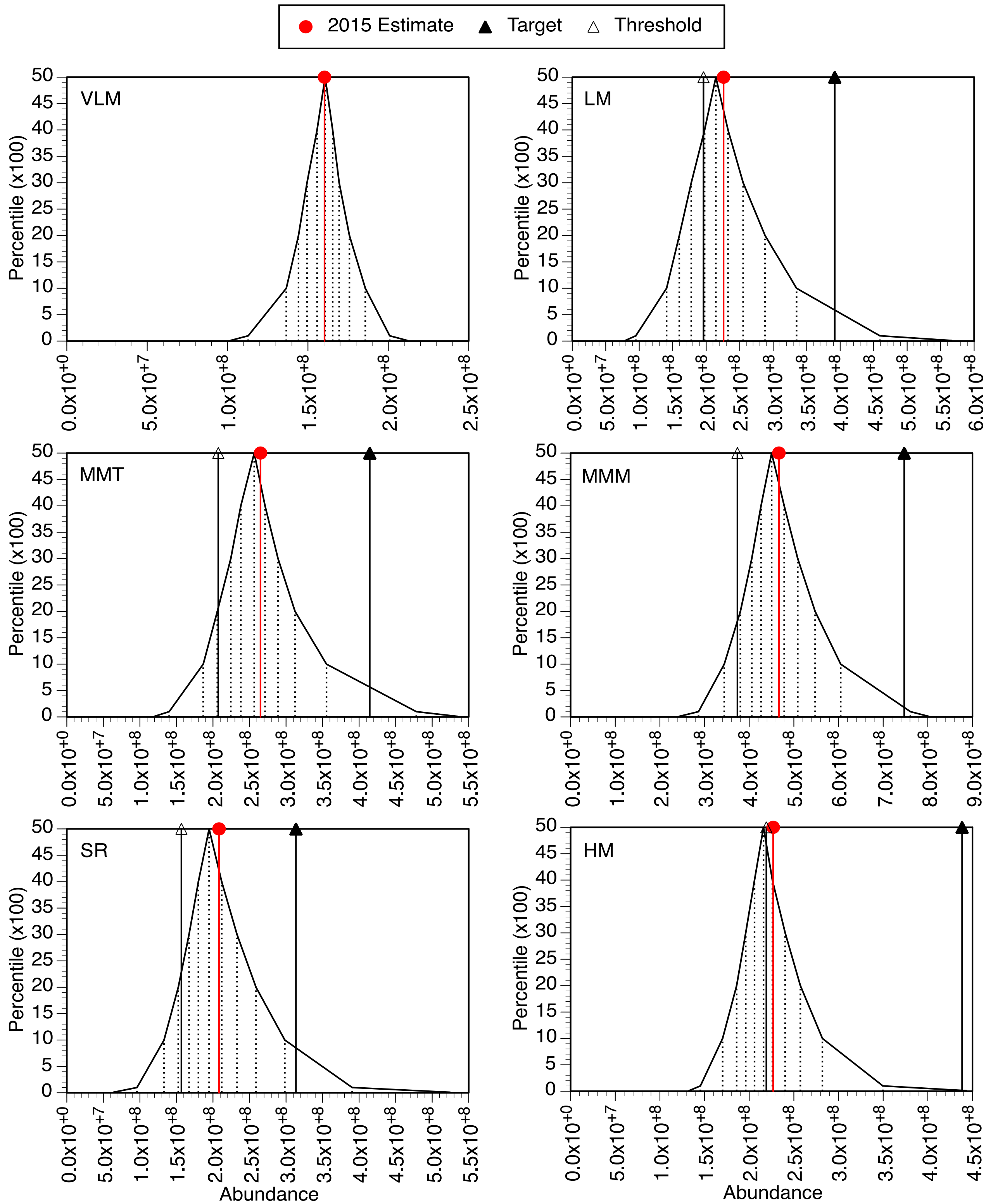


Figure E.2. 2015 regional market-size abundance estimates within confidence percentiles for the 2015 survey taking into account between-sample variation and uncertainty in dredge efficiency updated to use all-oyster catchability coefficients rather than size-based catchability coefficients (see Analytical Approach in this report). Reference points are included for comparison except for the VLM. 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.