Report of the
2003 Stock Assessment Workshop
for the
New Jersey Delaware Bay Oyster Seed Beds

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Executive Summary 2003 Stock Assessment Workshop

The stock assessment workshop utilized data from the historical record, the 2002 seed bed random sampling program, dredge efficiency studies and a model to develop harvest allocations for the 2003 oyster season. The data and support documentation is provided in the following document.

Status of the Stock:

Oysters- Baywide oyster abundance remained about the same a last year. Market size (>3") oyster abundance has been maintained on the Market beds mostly by transplantation, and there is a continuing trend toward decreased submarket (2.5 to 2.99") oyster abundance on these beds. Due to poor spat sets and relatively good growth the percentage of oysters > 2.5" has increased dramatically in the past year. Few small oysters remain on to replenish the larger individuals.

Numbers of oyster in all size classes on beds below Bennies Sand have continued to deteriorate.

Oyster meat (Condition Index) declined somewhat this year. The slight decrease in condition in the Upper regions of the bay continues.

Spat set was low throughout the bay for the third year in a row. The trend toward declining recruitment on beds in the Central portion of the bay is of continuing concern. In addition, the low spat counts and elevated Dermo mortality suggest that lower market and submarket oyster abundance can be expected in 2004 and 2005, and perhaps 2006.

Box count mortality (natural mortality) was higher than last year in the Central and Lower seed bed area. Mortality became greater the farther down bay one progressed.

Dermo levels were much higher than last year. Average bay wide weighted prevalence was at near record levels and was especially high in parts of the Upper Central area. As with mortality, percentage of oysters infected and the intensity of the infection became greater the farther down bay one progressed.

Harvest came mostly (>81%) from Shell Rock, Bennies, Bennies Sand, Hog Shoal and New Beds. The industry harvested nearly 68,000 bushels nearly the same as last year.

Catch per unit effort (CPUE) increased slightly for single dredge boats and has been nearly stable for the past two years.

Transplants came from Ship John and Cohansey, but did not meet the 70,000 bu. goal set by the Delaware Bay Shellfish Council or the 140,000 recommendation of the SAW. The industry transplanted slightly more than 28,000 bu. These were planted on Bennies.

Management Advice:

For model purposes direct Market beds are all beds below Ship John except Nantuxent and Beadons.

The Market beds are divided into high-mortality and medium-mortality beds.

High mortality beds are: Bennies, Bennies Sand, New Beds, Hog Shoal, Strawberry, Hawk's Nest, Vexton, Egg Island and Ledge.

Medium mortality bed is: Shell Rock.

Allocations from the Market beds are modeled for two fishing seasons: A continuous season (April 1 to November 15) without bed closure and Closure of the high-mortality beds on August 31.

The majority of oysters available for direct market are on Shell Rock. Consideration should be given to supplementing the direct market allocation from Ship John. Oysters from the latter bed are usually not marketable due to poor meat quality.

Area management (the opening and closing specific beds or groups of beds to harvest) will increase the numbers of marketable oysters by permitting better allocation of fishing effort

1. With area management and without a transplant, 22,000 bushels are available for harvest.

2. With area management and with a June transplant, between 39,000 to 45,000 bushels are available for harvest.

3. An additional allotment is available on Ship John. This could be used for direct market or transplant..

If transplantation is to take place the following should be considered:

1.Transplant Upper and Upper Central (except Shell Rock) oysters to Bennies or Bennies Sand in June. Fall transplants should come from Ship John.

2. Monitoring of the transplant program to provide Numbers of oysters per bushel is essential.

3. Two transplants are needed: the first in June to augment 2003 harvests and one in August/September (Ship John if no direct market or Low mortality beds) to provide oysters for 2004.

An early season transplant in mid-June to early July is recommended. This will permit a simultaneous bed harvest closure to guard against a *Vibrio* outbreak.

Based on the old 40% rule all beds below Shell Rock would be closed this year.

Without a fall transplant the direct market allocation in 2004 is likely to be near zero.

There is no reason to change the 10^0C rule to close the fall harvest.

An annual cultch management program to replace those shells being removed from the seed beds is essential for long term resource viability.

2003 Stock Assessment Workshop for the New Jersey Delaware Bay Oyster Seed Beds

Introduction

The natural oyster seed beds of the New Jersey portion of Delaware Bay (Figure 1) have been surveyed yearly, in the fall and/or winter, since the middle 1950's. Since 1989, this period has been concentrated into about one week in the latter part of October to early November, and has been conducted using a stratified random sampling method. Each bed is divided into a series of 25-acre grids. These grids fall into one of three strata. The strata consist of test, bed proper and bed margins. The test area typifies the highest quality areas of the bed (a high abundance of oysters 75% or more of the time). The bed proper is those sites at which oysters are abundant 25-75% of the time and the bed margin is areas that have an abundance of oysters less than 25% of the time. The survey consists of about 100 samples covering the primary and most of the minor seedbeds. Each sample represents a composite of 3 one-third bushels from three one-minute tows within each grid. The current survey instrument is a standard 1.27 m commercial oyster dredge on a typical large Delaware Bay dredge boat, *Howard Sockwell.*

Sample analysis includes measurement of the total volume of material obtained in each measured dredge haul; the volume of live oysters, boxes, and cultch; the number of spat, yearlings, and older oysters per composite bushel; the size of live oysters >20mm from the composite bushel; and the intensity of Dermo and MSX infections in oysters from selected beds. The data are normalized to a 37 quart bushel, because this approximates the size of a US Standard Bushel. Until 1999, the principal data used in management was based on the proportion of live oysters in the composite bushel, although spat set also entered the decision-making process. Samples continue to be collected and analyzed in the same way; however two projects have since been undertaken: dredge tow lengths were measured and recorded every 5 seconds by GPS navigation during the survey and separate dredge calibration studies were made. These new data were integrated into the regular sampling results to estimate the total numbers of oysters per square meter and the numbers of oysters in different size classes present on each bed. This improvement was added to the survey, at the recommendation of the Oyster Industry Science Steering Committee, because of concerns about management of the direct-market program on the seedbeds that was initiated in 1995. Prior to that time, the seed beds had been used principally as a source of seed for transplanting to leased grounds and the semi-quantitative survey worked well. A third major alteration, again as a recommendation of the Oyster Industry Science Steering Committee, took place this year. We altered the sampling on a number of beds to better reflect their current utilization, and to provide more accurate estimates of oyster abundance on frequently used beds. The old and new sampling regimens are provided (Table 1).

From 1953 to1992, the bay-wide mean number of oysters per bushel was about 100, with a bay-wide average maximum of a little over 600. The highest numbers were on the upper beds and the lowest, on the lower beds (Table 2).

During the past decade (1989 to 2002), the bay-wide overall mean of 145 oysters/bu. has varied little, and the changes, with the exception of the extremes (1989 and 1994) have not been statistically significant (Figure 2). The 1953-92 bay-wide mean spat/bu. was about 51, with an average bay wide maximum of 2100 (Table 2). In the last decade the bay-wide overall average has been 98 spat/bu., about twice the earlier figure. The mean spat count for the fifty-year period is 58 spat/bu.. The maximum seed removed from the seedbeds by the industry during the past thirteen years was in 1991 when nearly 300,000 bushels were transplanted to leased grounds. This is typical of the MSX period from the 1970's to the early 1980's, when 300,000 to 450,000 bu. per year were transplanted to the lower bay leased grounds (Figure 3). Since the direct landing of oysters from the seedbeds was instituted in 1996, the greatest landing occurred in 1998 (136,000 bu.). The average yearly landing since 1996 has been slightly more than 78,000 bu.

Status of Stock and Fishery

Seed Bed Sampling

Oyster

Sampling in 2002 was conducted from October 28 to October 30 using donated time on the oyster dredge boat *Howard Sockwell* with Sam Elias as captain. Samples were collected from the standard random stratified grid system on each of the major seedbeds and a subset of the minor beds. The numbers of samples were modified somewhat on a few beds (Table 1), and the allocation of beds to be sampled annually and biannually was altered to better reflect current oyster seedbed use. An additional category "transplant" was added to assure that oysters transplanted from Upper or Upper Central beds to Central beds are explicitly accounted for in the allocation of oysters to be harvested.

Because oysters are being sampled along a salinity gradient that reflects spat set, predation, disease and growth, combining the data into bay-wide statistics results in high variances. During the past decade the seed bed region has experienced a nearly a two fold fluctuation in the number of oysters per bushel, but, with the exception of the highest and lowest values, no statistical differences (Figure 4). The bay-wide average number of 145 oysters/bu. in 2002 was statistically the same as for the present decade, but about 50% higher than the long term average of 100 oysters/bu. Based on the "old rule" that, if a bed has most grids with <40% oyster, it should be closed, in 2003 all beds below Shell Rock should be closed to harvest activities.

Beds in the Upper and Upper Central segments of the bay continue to support high oyster abundance (Table 3). Most of these beds (except Upper Middle, Sea Breeze, and for the first time-Shell Rock) have > 150 oysters/bu. With the exception of Shell Rock and Sea Breeze, all beds in the Upper and Upper Central Region had more than half the grids sampled containing >40% oyster. Round Island, which experienced little or no fishing, did not have one grid with > 40% last year, but this year 5 of the 6 grids sampled had a higher percentage of oyster than all of the grids last year. Grids with high percentage of oyster also increased on Middle and Cohansey, but declined on Shell Rock.

Last year, oyster abundance on beds in the Central and Lower segments of the bay fell into two groups; those that had retained high to moderate levels (>40%) of oysters (the inshore beds - Nantuxent Point, Hog Shoal, Vexton and Hawks Nest) and the remainder (Table 3). In 2002 only one grid below Shell Rock had > 40% oyster, and only Bennies Sand had > 40 oysters bu.$^{-1}$. The sole grid with >40% oyster was on Bennies, and that abundance was caused by oysters being transplanted to the grid. The percentage of the number of oysters in the >2.5 inch categories was >55% on all beds in the Central and Lower areas. The general trend for this increase in percentage of large oysters is continuing. During the past decade the percentage >2.5" has been in the 15 to 20% range on all of these beds. The recent increase in this percentage is primarily due to low recruitment and **not** because more large oysters are present. Last year, Beadons was notable because it had deteriorated to the point that it resembled New Beds with low abundance, high Dermo and a high percentage of oysters >2.5". This year **all** inshore beds had low abundance, high Dermo and a high percentage of oysters >2.5".

The important areas for the oyster industry are the beds in the Upper Central and Central region. Examination of the trends on the individual seedbeds indicates that these two regions have substantially different processes controlling oyster abundance (Figure 5). The average numbers of oysters on the Upper Central beds for the 1989 to 2002 period was statistically greater than for the Central beds (Figure 5). The spat set was not statistically different over the period (Figure 5); thus some factor or factors affected post-set survival differentially. This phenomenon is a continuation of the historical trend of differentiation between the bed groups and the factors that most affect post set survival are predation and disease.

In 2002 total oysters per bushel on the Upper Central beds remained about the same while total oysters on the heavily fished Market beds appear to have declined about 50% (83 to 40), but due to the typically high variances the value is statistically insignificant from last year (Figure 6). Numbers of submarket oysters > 2.5" have increased Upper Central region increased in the past year. This reflects the good growth of the past few years. On the Market beds the number of submarket oysters declined slightly (Figure 7). The percentage of the <u>number</u> of oysters/bu. > 3" and > 2.5" has greatly increased the Upper Central and Market areas of the bay (Figure 8). Unfortunately, this reflects the poor spat set of the last few years. Shell Rock is of particular importance because this bed produced >45% of the direct market landings this past year. While there are still appreciable numbers of oysters on this bed, and it was one of the few beds with reasonable spat set this year, the total numbers of oysters are declining and the percentage >2.5" is 50%. This suggests that the good growth of the past year, coupled heavy fishing pressure, may result in declining numbers of oysters on this bed in the next few years.

With Shell Rock of the Upper Central region, the Central region supplied the majority of market oysters this past year. The numbers of market size (> 3") oysters on the beds supplying the most market oysters: Shell Rock, New Beds, Hog Shoal, Bennies, and Bennies Sand, remained about the same as last year (Table 4, Figure 9). The percentage of total oysters in the > 2.5" size class is 50% or more on all beds below Shell Rock and New Beds and continues to increase on all beds except those in the Upper portion of the bay (Table 3). As noted before this is not because of an increase in the abundance of oysters, but is due to the relatively good growth and poor spat sets of the last few years. The inshore beds in the Central region of the bay, New

Beds and Bennies Sand received transplanted oysters from the Upper and Upper Central Regions last year. These were probably an important factor supporting the harvest from these beds. Only about half as many oysters were transplanted in 2002 when compared to last year. All these transplants were placed on Bennies bed.

Oyster Condition

On a bay-wide basis, condition index dropped slightly this year (Figure 10), and the drop appeared to be similar in all areas of the bay. Data from the Lower area are not available this year because too few oysters were collected.

Spat Set

Spat set in 2002 was an improvement over 2001, but it was still relatively poor (Table 3, Figure 11) and continues the poor setting for the third consecutive year. The bay wide 2002 spat counts (mean = 28/bu.) were well below the long term mean of 51 spat/bu., and far below the 98 spat/bu. decade long mean. Spat set was 100/bu. or higher on only two beds – Sea Breeze and Shell Rock. The Upper region spat set was 58 and 48/bu. on Round Island and Arnolds, respectively. Sets of this level in the Upper region typically result in good recruitment, because of low predation. Typically, some of the inshore beds of the Central Region (Nantuxent, Hog Shoal, Strawberry, Hawks Nest, Beadons and Vexton) receive a good set, but this did not materialize this year. Only Beadons received >50 spat/bu. On a longer-term perspective, spat settlement for the period of 1997 to 1999 was at the upper end of the 12-year range (Figure 4). This is also a period when the mean spat fall was nearly double the nearly 40 year long term average and the past three years have been at or below the long term average. It is this 1997-1999 spat set that has been supporting the current harvests, and is why, with the lack of substantial set in the past three years, the percentage of large oysters is increasing.

Mortality and Disease

Since the onset of the Dermo (*Perkinsus marinus*) epizootic in 1990, average mortality on the seed beds, as assessed by box counts during the fall survey, has fallen into 3 major groups: Upper, Upper Central and Central/Lower, with the lowest values on the Upper beds. Over the previous two years, however, mortality in the two upper regions had been similar and about 25% of those in the Central/Lower region (Table 3, Figure 12). This year mortality reverted back to the prior 3 group pattern. In the Upper region oyster mortality remained about same as in 2000, and 2001, but mortality in the Upper Central appears to have at least doubled in 2002. Mortality greatly increased in the Central region, and was >55% on all beds below Hog Shoal. Bennies and Bennies Sand experienced somewhat less mortality, but it was still elevated over that of last year. The low percent mortality on Shell Rock may reflect the heavy harvest pressure on the bed. Continued dredging breaks up the boxes and lowers the estimated mortality.

Prevalence of *P. marinus* reversed a modest downward trend that began 3-4 years ago, and detectable infections exceeded 90% on all beds below and including Middle (Table 3, Fig. 13). An average >45% of oysters had detectable infections in the Upper region. The Weighted Prevalence, which includes infection intensity, showed a clear differentiation between the Upper bay and farther down bay direction, averaging 0.6, 2.9, and 3.4 (out of 5.0) from the Upper to Upper Central to Central beds (Fig. 14). The Lower bay was only sampled on Ledge bed and its Weighted Prevalence was 2.4. It is noteworthy that both *P. marinus* infection levels and mortality were higher than last year. This probably reflects the higher salinity throughout the bay due to the drought this past summer.

Samples were collected in May 2002 to test a model, developed two years ago, which suggested that May prevalence could predict *P. marinus*-caused mortality over the summer and fall (Figure 15). Predicted mortality was compared with observed box count mortality at the end of October (Table 4). This year the model failed to predict the extensive mortality on the direct market beds its usefulness will need to be reevaluated.

MSX, *Haplosporidium nelsoni*, disease prevalence continued to be insignificant in 2002.

Harvest and Transplant

Harvest

Based on a provision of a 70,000 bu. fall transplant program from Upper Central bay beds to Central bay beds, a prorated SAW 2002 recommended harvest limit of about 54,000 bu. Beds were harvested almost continually from April 1, to November 15, 2002. The 33 weeks of fishing this year is the same as last year, 20 in 2000, 26.5 in 1999, 30 in 1998, 17 in 1996, and 25 in 1997. Harvest was from 16 beds and totaled 68,038 bushels. Five beds accounted for slightly over 80% of harvest (Bennies (5.8%), Bennies Sand (9.3%), New Beds (11.8%), Shell Rock (43.6%) and Hog Shoal (11.8%))(Table 5). Total catch for the 2002 season was 68,038 bu.

(Figure 3). Thirty-five boats participated in the fishery and worked for a total of 1,099 boat days. After dropping for 4 consecutive years, the catch per boat day for dual dredge boats remained about the same as last year. The catch per boat day for single dredge boats rebounded this year to a level similar to that of 1999 and 2000. This stabilization may reflect allocations or the high percentage of marketable or nearly marketable oysters on most of the market beds It is equally plausible that a few low or high harvest reports by participants could greatly affect these CPUE data sets. The first year of the direct market fishery had an average catch per boat day of 104 and 37 bushels for dual and single dredge boats, respectively, but was only a partial year (Figure 15).

We also examined the actual bed harvest from 2002 with the estimate of the oysters available made in 2001 (Table 6). On those beds where intensive harvest took place (Fraction covered > 5) there is reasonably good correspondence between the available bushels and those actually harvested (Table 6).

Transplant

Transplantation from up bay and high mortality beds to replace those being harvested was recommended by the 2001 and 2002 SAW. The Delaware Bay Shellfish Council (DBSC) passed a resolution for a transplant to be implemented in a late summer/ fall transplant. For 2001 this amount was 52,195 bu. (Table 7). The 2002 SAW recommended increased transplants (either 189,395 bu. in spring or 140,940 bu. in fall), to support harvest in 2002 and 2003. The DBSC allocated 70,000 bu. for a fall transplant in 2002. In spite of the recommendations, and the smaller allocation, only 28,616 bushels of oysters and material were moved from other seedbeds to the market beds in 2002 (Table 6). Between 1997 and 2001, about 206,500 bu. of material was moved from Upper Central and inshore Central beds to New Beds (parts of grids 24, 25. 38, and 39) and Bennies Sand (11)(Table 7). Although transplant culling concentrates larger oysters somewhat (about 1.459 times), transplants of this type involve oysters of all sizes, and not just those in the market and submarket categories. In 2002 all oysters were transplanted in October and November and were placed on Bennies (Table 8). These oysters came from two beds Cohansey (6,200 bu.) and Ship John (22,416 bu.). Many of these oysters came from the Outside Light grid and the area where the two beds meet, and thus the allocation of the source to one bed or the other may not be exact. Of the grids sampled in 2002 only grid 110 and a small fraction (ca. 25%) of Bennies grid 121 received transplants (Table 8). It is readily apparent that the sample from grid 110, designated as transplant sample grid, is substantially different from the remainder of the Bennies samples. There is a slight indication that the sample from grid 121 was also affected, but this was included in the bed average, while the sample from 110 was not.

Other Studies

One other study was initiated this year. This was to estimate the effectiveness and the impact of using the suction dredge on the seedbeds. The final sampling of this study is not scheduled until May of 2003 so the report will not be available until summer.

Management Advice

2003 Direct-Market Allocation from Direct-Market Beds

Projections were made based on the management plan developed by the 2nd SAW. Under this plan, the goal for managing the direct-market beds is to achieve no net reduction in the number of market-size oysters at the end of the year. That is, the number at the end of the year should equal the number at the beginning of the year. In essence, this allocates to the fishery a number of oysters equivalent to the number expected to grow into market size during the year. This goal has been met reasonably successfully in 2000-2002 (Figures 17-20, quantitative time series).

The following beds were considered direct-market beds: Shell Rock, Bennies, Bennies Sand, New Beds, Hog Shoal, Strawberry, Hawk's Nest, Vexton, Ledge, and Egg Island. The potential use of Ship John to enhance the direct-market program will be considered in the transplant section.

Estimates of abundance on the direct-market beds were obtained from the 2002 survey and were based solely on the high quality, test, and transplant grids (Table 3). Low quality areas were not included. A few beds were not sampled in 2002. Data for these beds from 2001 were used. The correction for dredge efficiency used the size-class dependent dredge efficiencies and the differential in dredge efficiency between upper and lower beds formulated by the 3rd SAW. These were 9.6, 14.5, 14.4 and 30, 38.9, 64.9 for upper and lower beds, by juveniles, submarket and market oysters respectively. Market-size oysters were defined as those ≥75 mm, based on selectivity data developed during Summer and Fall 2001 (4th SAW). Conversion of numbers to market bushels used an updated value of 345 oysters per bushel from data developed during the Fall of 2001 (4th SAW).

The numerical model used by the 3rd and 4th SAWs was applied to this assessment. The model includes recruitment to the fishery, natural mortality, and fishing mortality. Mortality is introduced into the model as a time-varying function that permits the rate of natural and fishing mortality to vary during the year and independently of each other. The model requires input of the number of market and submarket-size oysters, the periods of mortality, and the anticipated rate of natural mortality. The model then estimates the amount of fishing mortality necessary to balance abundance over the year. From that, the model provides an estimate of harvest consistent with the management goal set forth earlier.

Direct-market calculations were made using the assumption that natural mortality was lower on Shell Rock than on the other direct-market beds. Based on recommendations from the 3rd SAW, natural mortality rate was set at the 75th percentile of observed yearly mortality rates since 1989 (in 2002 the observed mortality was at the 90th percentile). These percentiles were updated using the entire 1989-2002 time series (Figure 21). The 75th percentiles of natural mortality were 0.486/yr. for the high-mortality beds and 0.266/yr. for Shell Rock. Growth rates, obtained from field observations in 2001, were used to estimate the smallest oyster expected to recruit to the fishery in 2003. This size boundary was set at 65 mm for the high-mortality beds and 68 mm for Shell Rock.

Two fishing options were investigated: (1) a continuous season (April 1-November 15) without bed closure and (2) a season assuming closure of the high-mortality beds on August 31 (earlier closure if the allocation has been reached). As predicted by the 4th SAW, only a minimal allocation is available this year from natural production on the direct-market beds. Option 2 conforms to the principles of area management defined by the 3rd SAW and which are re-recommended in this document, in that the number of bushels taken from the high-mortality beds is restricted to be no higher than the allocation for those beds. The necessity of limiting fishing downbay, so that oysters from Shell Rock are harvested, continues to be important since Shell Rock contains a large fraction of the total oysters available for harvest.

Allocation Options -- Direct-Market from the Direct-Market Beds

Option 1. Continuous Season (April 1to November 15)

High-Mortality Beds	5,670 bushels
Medium-Mortality Beds (Shell Rock)	13,626 bushels
Total	19,296 bushels

Option 2. Area Management Scenario (April 1 to Closing Date)

		Latest Closing Date
High-Mortality Beds	8,307 bushels	August 31
Medium-Mortality Beds (Shell Rock)	13,626 bushels	November 15
Total	21,933 bushels	

The difference in these estimates is due to the relative timing of fishing and natural mortality. In Option 2, most of the oysters on the high-mortality beds are harvested prior to the end of August when Dermo mortality reaches its peak. As a consequence, some oysters can be harvested that would otherwise die naturally. In the continuous season option, these same oysters die from Dermo and are lost to the fishery.

Examination of the origin of available oysters in these simulations reveals that much of the high-mortality bed allocation came from oysters transplanted downbay in 2002.

Recommended 2003 Transplant Program

Transplant beds were divided into three groups based on their natural mortality rates as recommended by the 3rd SAW. These were (1) low mortality beds: Round Island, Upper Arnolds and Arnolds; (2) medium mortality beds: Upper Middle, Middle, Cohansey, Sea Breeze, and Ship John; (3) high mortality beds: Nantuxent Point and Beadons.

Evaluation of the 2002 transplant program revealed that the transplants were enriched in the larger animals by an average of 1.459 (Figure 22). This concentration factor was consistent across a number of transplant events. Counts taken during the transplant program showed that the number of submarket + market oysters per bushel transplanted was 121 per bushel.

Several options for determining the volume that might be transplanted downbay were investigated. The following facts are pertinent to this decision.

1. Estimates comparing food requirements to food availability using a carrying capacity model suggest that oysters on beds such as Cohansey, Ship John, and Middle are food limited (Figure 23). Reduction in abundance might be expected to enhance oyster growth rates on these beds. Present weighted market-size abundance (# markets + # $^{submarkets}/_{2}$) on these beds is near the 90th percentile of the 1989-2002 time series (Figure 24).
2. Typical ages for oysters from the Ship John-Cohansey area are 4-6 yr. Thus, the market-size replacement rate on these beds, on average, is something like 20% of the market-size animals per year.
3. Median yearly mortality rates are 0.198 (Cohansey area) and 0.115 (Arnolds area). Setting a transplant rate at something less than the natural mortality rate is probably within the replacement capacity of these beds.

The SARC concludes that a 10% removal rate from these beds to support a transplant program is a reasonable goal. Transplant could occur early or late in 2003, depending on the management goal. Augmentation of the 2003 direct-market allocation could be achieved by an early season transplant.

In addition, the SARC recommends using Ship John as a direct-market bed following closure of the beds farther downbay. The long-term viability of the fishery depends on the combination of direct-marketing from these beds -- this is the least intrusive option biologically -- with transplant. A minority of individuals suggested that because Ship John and Cohansey oyster meats rarely are of acceptable market quality, that these beds be used only as a source of transplant oysters. The SARC notes that more oysters are available for transplant than can be transplanted with available cultch fund resources. More funds could become available if tags for the 2003 harvest program are sold in the spring. In either case, a mixed transplant-direct market option is available. If a mixed option is used, transplant from Ship John should be delayed until Fall to permit the direct-marketing option to be implemented. However, some use of Ship John oysters must occur in 2003; as a consequence, a Fall transplant is essential if Ship John is held in abeyance during the Spring transplant and if direct-marketing is not successful.

The SARC emphasizes the desirability of limiting the amount of cultch and juvenile oysters transplanted downbay. Limiting the volume of cultch and juvenile oysters transplanted downbay requires: (1) targeting abundance highs; (2) enforcing a minimum concentration factor (market and submarket oysters should be enhanced in the deck load relative to what is brought into the hopper by a factor of about 1.5); and (3) encouraging direct-market fishing wherever sufficient market quality exists. In addition, the SARC strongly recommends that any transplant to augment the 2003 season should include a 6-week bed closure on the bed where the oysters are planted to permit an increase in oyster condition.

The timing of transplant depends on a number of considerations.

1. A Fall transplant should be conducted to provide oysters for 2004. *Without such a transplant, the direct-market allocation in 2004 is likely to be near zero.* The Fall transplant should be taken from Ship John if the direct-market program is not fully implemented. Otherwise, some portion of the transplanted animals should be taken from the low-mortality beds.
2. An early season transplant should target the larger animals on Cohansey, Middle, and Sea Breeze to augment the 2003 direct-market program. If Ship John is not to be used as as direct market bed, it should be utilized as a source for transplant oysters. The SARC recommends that this transplant occur in mid-June to early July to permit a simultaneous bed closure to guard against a *Vibrio* outbreak. The SARC notes that illnesses were recorded in 2001 and 2002 from oysters harvested in late June.
3. The rate of natural mortality increases incrementally downbay as salinity increases. The transplanted oysters should be moved as short a distance downbay as possible to reduce the increment in mortality rate, but provide the necessary increase in market quality. Based on 2002 stock abundance, Bennies Sand and Bennies are preferable destinations. Because the survey now explicitly contains transplant grids as a stratum, the SARC strongly urges NJDEP to avoid using small portions of grids and to designate areas for transplanting using the grid system by buoying off destination grids to enhance coverage within a limited number of grids. This will permit increased accuracy in estimating the 2004 allocation.

4. Because the volume of transplant is estimated from a quantitative stock abundance value converted to bushels by conversions that are not necessarily fixed, any transplant must be monitored to permit determination of the total number of submarket and market-size animals moved downbay.
5. Because of the uncertainty concerning the number of oysters present on Nantuxent Point bed, (not sampled this year), the SARC recommends that the high-mortality transplant beds not be included in the transplant options in 2003.
6. Finally, the SARC notes that a direct-market calculation cannot be made using the "no net loss of market-size oysters" reference point this year for the medium mortality beds. The present submarket-size abundance cannot support anticipated natural mortality in the market size class due to the large numbers of large oysters present on the beds. The SARC recommends using a market-size abundance reduction scenario to reduce abundance from the 90th to the 75th percentile of the abundance time series for these beds, if direct-marketing is implemented.

Transplant and Mixed Transplant/Direct-Market Options

June Transplant + Ship John Direct-Market Mixed Option

The transplant calculations assume that the volume moved downbay will contain about 120 submarket + market oysters per bushel and that the animals come from the medium-mortality beds: Ship John (see previous proviso), Cohansey, Middle, Upper Middle, and Sea Breeze. Monitoring of the transplant program must occur to verify this bushel conversion estimate. The direct-market allocation estimates utilize: (1) the 75th percentile of natural mortality rate and (2) the 75th percentile of the 1989-2002 abundance time series as the target end-of-year market-size abundance. The transplant estimates use the 10% rule. The direct-market calculations assume 345 oysters per bushel as used in all direct-market estimates.

Option 1: Assume Cost of $1/bu for transplant and $65,000 Budget

	Direct-Market	Transplant
Medium-Mortality Beds (emphasizing Ship John)	56,626	
Medium-Mortality Beds (Cohansey/Middle/Sea Breeze)		65,000

Option 2: Assume Cost of 75¢/bu for transplant and $65,000 Budget

	Direct-Market	Transplant
Medium-Mortality Beds (emphasizing Ship John)	49,029	
Medium-Mortality Beds (Cohansey/Middle/Sea Breeze)		86,666

September Transplant

The transplant calculations assume that the volume moved downbay will contain about 120 submarket + market oysters per bushel and that the animals come from the low-mortality and medium-mortality beds. The bushel conversion estimate is extremely uncertain for the low-mortality beds. *It is likely that this oyster-per-bushel value cannot be achieved and that the volume that should be transplanted exceeds this estimate.* Monitoring of the program must occur to verify this bushel conversion estimate. The transplant estimates use the 10% rule. Estimates for the medium-mortality beds cannot be made until the volume transplanted in June is known and the volume of direct-market bushels taken can be estimated. Accordingly, the following estimate is a minimal value based solely on the low-mortality beds.

	Transplant
Low-Mortality Beds	27,056
Medium-Mortality Beds	??

Impact of 2003 Transplant Program on Direct-Market Allocation

Any allocation that includes the transplant of oysters downbay must take into account the insufficient supply of oysters on the direct-market beds to sustain the entire allocation prior to transplant. Early season direct-market allocations for transplanted oysters are converted into direct-market equivalents using the ratio of 121 oysters per bushel in the transplant to 345 oysters per bushel in a direct-market bushel. The estimate includes the loss of animals due to natural mortality.

Projections were based on a continuous fishing season beginning 6-weeks after transplant, about August 1 assuming a June 15 transplant, and continuing through November 15. Projections are based on the assumption that all marketable oysters are allocated to the 2003 fishery. The mortality rates for the high-mortality beds were used. The estimates do not include oysters direct-marketed off Ship John.

Direct Market Allocation (Area Management Option 2 + June Transplant)

	Transplant Option 1	Transplant Option 2
High-Mortality Beds, Area Management (Option 2)	8,307	8,307
Medium-Mortality Beds (Shell Rock), Area Management (Option 2)	13,626	13,626
Direct-Market of Transplants (Transplant Options 1 and 2)	17,127	22,894
Total	39,060	44,827
Ship John Augmentation	??	??

Recommendations for Area Management -- Review

A significant fraction of the oysters available for harvest are on Shell Rock. Some mechanism should be included in the management plan to assure that the high-mortality beds are not overfished and Shell Rock underfished.

Any allocation that includes the transplant of oysters downbay must take into account the insufficient supply of oysters on the direct-market beds to sustain the entire allocation prior to transplant. Particular care should be taken to prevent overfishing on Shell Rock and beds not receiving transplants once fishing on the transplants commences.

All transplant scenarios should take into account the approximate six week interval required to increase meat yield following transplant. Accordingly, any transplants should be closed to fishing for minimally six weeks post-transplant.

Any early season transplant should occur in mid-June to mid-July to reduce the risk of a *Vibrio* outbreak.

A decision not to transplant off Ship John in June to retain oysters for direct-market should be revisited in September. It is essential to effectively include Ship John in the management program either as a transplant or direct-market bed.

A Fall transplant should include the low-mortality beds. A June transplant should not.

Stock/Management Summary

Industry Harvest

a. Most oysters were harvested from the high-mortality direct-market beds. Area management is required to assure some harvest on Shell Rock.

b. The majority of oysters came from Shell Rock, Bennies Sand, Hog Shoal, New Beds and Bennies.

c. Total dredging impact was estimated. Five beds were covered by dredging more than once during 2002: Bennies Sand, Hog Shoal, Shell Rock, New Beds, and Vexton.

Estimates of Abundance

a. Estimates of abundance include the high quality, test and transplanted areas only. Low quality areas have not been included.

b. The correction for dredge efficiency used the size-class dependent dredge efficiencies and the differential in dredge efficiency between upper and lower beds.

c. Market-size oysters were defined as those ≥76.2 mm. Submarket-size oysters were defined according to the three growth rate groupings: 73.2 mm (low growth), 68.1 mm (medium growth), 65.0 mm (high growth).

d. Estimates of abundance have used an updated value of 345 to convert market-size and submarket-size abundance to market-bushel equivalents.

e. If a bed was not sampled in 2002, the value for 2001 was used.

Trends in Abundance.

a. Spat set was low for the third year in a row, bay wide. Only two beds exceed the recent decade bay-wide average of 98 spat $bu.^{-1}$. Shell Rock and Sea Breeze.

b. Bay wide oyster abundance used all information but the transplant grid and remained essentially unchanged from 2001.

c. Abundance in 2002 on the direct-market beds declined from 2001, although total market-size abundance was essentially unchanged. Total weighted abundance (markets + (submarkets/2)) fell to about the 25th percentile level for the 1989 to 2002 time series, primarily due to the continued decline in submarket abundance. No grid below Shell Rock had >40% oyster (except for those grids that received transplants).

d. Abundance in 2002 on the transplant beds, exclusive of Beadons and Nantuxent Point, remained at near record highs for the 1989-2002 period, and was near the 90th percentile for the time series.

e. Because of the three years of poor sets, only a very limited number of juvenile oysters remain on most direct-market beds. Numbers of small oysters/bu. on **all** the inshore beds declined to a very low number. The numbers of submarkets has also declined, as predicted in 2001. The numbers of juveniles is now so low that natural production, on the direct-market beds in 2003, will not sustain a fishery in 2004. Closure of the direct-market beds in 2004 can be anticipated without augmentation of oyster abundance through a significant transplant program.

f. The overabundance of market-size animals (relative to the submarket-size animals) is not sustainable under normal natural mortality rates in the Cohansey-Ship John area. The abundance can be expected to decline naturally in 2003.

g. Modeling of food availability identifies Ship John, Cohansey and Middle as the three beds where oyster abundance probably impairs production.

Mortality Trends

a. Natural mortality rate reached a decadal high on the high mortality beds in 2002. The use of the 75th percentile mortality rate in allocation projections at the 4th SAW very likely caused overfishing on these beds in 2002.

b. Attempts to use early season Dermo prevalence to predict seasonal mortality were unsuccessful. In 2002, mortality on the high-mortality beds far exceeded predictions from long-term trends in prevalence.

c. Natural mortality rate on the medium-mortality beds was nearly average (50th percentile) levels for the 1990-2002 time series.

d. Natural mortality rate on the low-mortality beds was below average (near the 25th percentile) levels for the 1990-2002 time series.

Projections 2004 and 2005: Direct-Market Beds

A limited and rapidly decreasing number of juvenile oysters remain on the direct-market beds. For Bennies, Hawk's Nest, Hog Shoal, New Beds, Strawberry and Vexton the supply of young is so meager that, if high disease mortality rates continue into 2003, natural production may not sustain the oyster population. Other than a few direct-market beds, such as Beadons, and Bennies Sand the young oysters may be enough to sustain the population, but offer little prospect for continued harvests. Only on Sea Breeze and Shell Rock, was the set sufficient, if it has average survival, sufficient to replenish the oyster stocks. There was only a small transplant in 2002. This will not provide much relief to the only beds with modest numbers of market oysters – Shell Rock and Bennies Sand. As a result, the 2004 and 2005 direct-market allocation is likely to be small without additional transplants in 2003 and beyond.

2003 Science Advice

Based the management discussion and the anticipated program needs in the near future, the SARC recommended consideration of the following science studies. The items were **not** given a priority status.

1. Continue the Dermo monitoring program with monthly samples from May to early fall.

2. Continue development of the aging techniques to determine the age structure of oyster populations on transplant source beds.

3. Conduct new dredge efficiency studies to be sure that changing conditions have not affected the base efficiency. These programs should be focused at the beds that haven't been heavily worked (Cohansey and Ship John) in the past few years.

4. Use statistical techniques to evaluate variability of the dredge efficiency so some estimate of variance can be made.

5. Develop a broodstock-recruitment relationship for oysters.

6. Develop a program to evaluate annual growth variability.

7. Evaluate culling options for both the suction dredge and conventional systems to increase the efficiency of transplanting.

8. Use risk assessment techniques to evaluate various transplant scenarios.

9. Consider bringing in a resource economist to evaluate the management techniques and ways of improving economic benefits to the industry and state.

10. Include spatial structure in the modeling to include calculations at the bed scale and then sum the results rather than summing into regions before analysis.

11. Develop a cultch planting/seed production/seed movement program.

12. Evaluate whether recording additional information such as depth of water, bottom conditions and length of chain out should be incorporated into basic data collection procedures.

13. Evaluate the possible effect on the survey data integrity that would result form use of another boat and/or captain.

14. Examine other methods of data analysis for survey data: Specifically – distribution patterns of raw base data, precision of abundance estimates (coefficients of variation) trend analysis of abundance, and uncertainty elements of model output.

Figure Legends

Figure 1. Delaware Bay Seed Beds. Division of the beds in groupings based on salinity and biological characteristics.

Figure 2. Delaware Bay Seed Beds. Annual bay wide average number of oysters per 37 quart bushel. Error bars are the 95% confidence intervals.

Figure 3. Delaware Bay Seed Beds. Annual seed bed harvest.

Figure 4. Delaware Bay Seed Beds. Average annual bay wide oyster and spat abundance (37 qt. Bushel) and Dermo weighted prevalence with 95% Least Significant Difference confidence intervals. Underlined values are not significantly different. Mean = average of annual values. Years are arrayed across the top.

Figure 5. Delaware Bay Seed Beds. Average annual seedbed region oyster and spat abundance (37 qt. Bushel) for Upper Central and Central seedbeds. Upper Central = Upper Middle, Middle, Ship John, Cohansey, Shell Rock. Central= Bennies, Bennies Sand, Nantuxent, Hog Shoal, New Beds, Strawberry, Hawk's Nest, Beadons, Vexton. Underlined values are not significantly different according to 95% Least Significant Difference confidence intervals. Mean = average of annual values. * = means that are significantly different.

Figure 6. Delaware Bay Seed Beds. Total oysters per 37 qt. Bushel from Upper Central (less Shell Rock) and Market beds.= Shell Rock, Bennies, Bennies Sand, New Beds, Hog Shoal, Strawberry, Hawk's Nest, Vexton, Egg Island and New Beds. Error bars are the 95% confidence intervals.

Figure 7. Delaware Bay Seed Beds. Oyster per 37 qt. bushel by market (>3") and submarket (2.5 to 2.99") size classes from Upper Central (less Shell Rock) and Market beds. Market beds.= Shell Rock, Bennies, Bennies Sand, New Beds, Hog Shoal, Strawberry, Hawk's Nest, Vexton, Egg Island and New Beds. Error bars are the 95% confidence intervals.

Figure 8. Delaware Bay Seed Beds. Percent of total oysters in the 2.5" to 3" (submarket) and >3" (market) categories for the Upper Central (less Shell Rock) and Market beds. Market beds.= Shell Rock, Bennies, Bennies Sand, New Beds, Hog Shoal, Strawberry, Hawk's Nest, Vexton, Egg Island and New Beds.

Figure 9. Delaware Bay Seed Beds. Oyster per 37 qt. bushel by market (>3") and submarket (2.5 to 2.99") size classes from Market beds. Market beds = Shell Rock, Bennies, Bennies Sand, New Beds, Hog Shoal, Strawberry, Hawk's Nest, Vexton, Egg Island and Ledge. Error bars are the 95% confidence intervals.

Figure 10. Delaware Bay Seed Beds. Annual average condition index (dry meat weight (g)/hinge to lip dimension (mm)) by seed bed group. Upper = Round Island, Arnolds, Upper Arnolds. Upper Central = Upper Middle, Middle, Ship John, Cohansey, Shell Rock. Central= Bennies, Bennies Sand, Nantuxent, Hog Shoal, New Beds, Strawberry, Hawk's Nest, Beadons, Vexton. Lower = Egg Island, Ledge. Error bars are the 95% confidence intervals. Interval is missing from Lower because only one bed is sampled in alternate years.

Figure 11. Delaware Bay Seed Beds. Annual bay wide average spat counts per 37 quart bushel. Error bars are the 95% confidence intervals.

Figure 12. Delaware Bay Seed Beds. Annual percentage mortality for the past decade by region. Error bars are the 95% confidence intervals.

Figure 13. Delaware Bay Seed Beds. Prevalence of Dermo (*Perkinsus marinus*) by bed group for the past decade. Error bars are the 95% confidence intervals.

Figure 14. Delaware Bay Seed Beds. Weighted prevalence of Dermo (*Perkinsus marinus)* by bed group for the past decade. Error bars are the 95% confidence intervals.

Figure 15. May Dermo (*Perkinsus marinus*) prevalence in relation to fall total box count mortality. The regression line was based on all data but 2002. Note that the predictive model did not work for 2002.

Figure 16. Catch per boat day for Delaware Bay Market Beds. The program began in 1996 with a fall harvest only.

Figure 17. Total number of oysters on Low, Medium and High mortality seed beds – 1999 to 2001.

Figure 18. Total number of oysters by size class – juvenile = <2.5", submarket = 2.5 to 3", market = 3", on individual Low mortality seed beds 1999 to 2002.

Figure 19. Total number of oysters by size class – juvenile = <2.5", submarket = 2.5 to 3", market = 3", on individual Medium mortality seed beds 1999 to 2002.

Figure 20. Total number of oysters by size class – juvenile = <2.5", submarket = 2.5 to 3", market = 3", on individual High mortality seed beds 1999 to 2002.

Figure 21. Percentage mortality for High, Medium and Low mortality beds. Percentiles base on box count mortality form 1989 to 2002. High = record high mortality for the period. 2002 = data for current year.

Figure 22. Estimates of selectivity by size class of oysters transplanted from Cohansey seedbed in 2002. Selectivity = ratio of the number of oysters of different sizes in the deck load (post culling) /number of oysters of different sizes in the hopper (prior to culling). All data are normalized to a bushel of 1000 oysters.

Figure 23. Carrying capacity model outputs for selected Delaware Bay seed beds. The numbers represent the estimated fraction reduction in filtration due to competition for food by high densities of oysters.

Figure 24. Weighted market size abundance (market + (submarket/2)) in terms of oysters per 37 qt. U.S. Standard bushel. Data are presented for the High, and Medium mortality beds. Percentiles are based on abundance from 1989 to 2002. High = record high abundance for the time period. 2002 = data for current year.

Table 1. Revised sampling scheme for Delaware Bay Seed Beds.

1989-2001		2002-	
Arnolds	6	Arnolds	6
Beadons	10	Beadons	10
Bennnies	12	Bennnies	12
Bennies Sand	5	Bennies Sand	5
Cohansey	5	Cohansey	7
Egg Island	10	Middle	9
Middle	9	New	9
New	9	Shell Rock	7
Round Island	6	Ship John	5
Shell Rock	7	Transplant*	2
Ship John	5	Hawks Nest	4
		Strawberry	4
		Vexton	5
		Hog Shoal	4
Total	**84**		**89**
Even Years		**Even Years**	
Hawks Nest	6	Ledge	5
Ledge	8	Upper Middle	2
Strawberry	6	Round Island	5
Upper Mid	2	Seabreeze	3
Total	**22**		**15**
Odd Years		**Odd Years**	
Hog Shoal	6	Nantuxent	6
Nantuxent	6	Upper Arnolds	2
Upper Arn	2	Egg Island	8
Vexton	7		
OL	1		
Total	**22**		**16**

* Transplant = Samples from areas to which oysters were transplanted

Table 2. Long term (1956- 1992) average and average maximum numbers of oysters and spat per bushel for the New Jersey Delaware Bay seed beds. Upper = Round Island, Arnolds and Upper Arnolds. Upper Central = Upper Middle, Middle, Cohansey, Ship John and Shell Rock. Central = Bennies Sand, Bennies, Nantuxent, Hog Shoal, Strawberry, Hawk's Nest, Beadons and Vexton. Lower = Ledge and Egg Island..

	Oyster	**Spat**
Bay Average	102	51
Upper	345	100
Upper Central	151	75
Central	66	35
Lower	30	20

Table 3. Results of a random sampling of the Delaware Bay seed beds

Attached is a summary of the 2002 seedbed sampling data with similar data for 2000 and 2001. All data were collected between October 28 and October 30, 2002 using a boat and captain donated by Bivalve Packing. This information is provided based on a stratified random sampling of grids from the seedbeds. The strata (groups) from which the samples were selected are: Test area, general bed, and marginal areas. One sample was taken from one of the test area strata, and no more than two samples were taken from the marginal strata of the beds. The remainder of the samples were from the general bed. All data were adjusted to a 37-quart bushel. A significant change took place in the beds sampled this year (see Table 1).

The data format is the same as in the past years, with the exception of the addition of a Size series which was initiated last year (see below). Data are displayed from the farthest up bay beds to those down bay. The test area is a small area of grids that has been sampled consistently as representative of the better areas of the bed. The test area sample is indicated by an *. The column called Bushels/haul to the left of the Percent Oyster 2002 indicates the **average** number of bushels brought up by the 3 dredge hauls from each grid. This year we have relied on the calibrated the hopper to estimate the numbers of bushels of oysters brought up in the three dredge hauls. For a discussion of this method see the year 2000 report.

For each bed the percentage of oysters for each sample is presented, with rankings from highest to lowest. Percentage of oyster is based on volume of oyster in the sample divided by the total volume of the shell, oyster and debris in the sample. Those samples that have over 40% oyster are underlined. Oysters per bushel and spat per bushel are based on actual counts adjusted to 37 quarts. Notable this year is the first sample in Bennies. It is italicized and all other sampled grids are shifted down one space. The italicized grid was added as a "Transplant" sample. It is NOT included in the averages for the subsequent information on Bennies.

Because of the emphasis on the direct marketing of oyster from the seedbeds we have continued the Size columns. These columns indicate the number of oysters greater than 2.5" and the percentage of oysters that are greater than 2.5". This is based on the measurements of oysters (Table 3), and can be utilized in conjunction with that table. It is not the same as the percent oyster in the preceding columns. This former number is the percent of the bushel of material brought on board that was oyster.

The Percentage Mortality figure is based on the number of boxes that were counted in the samples. Due to the influence of Dermo on the industry we have continued the set of columns for Percentage Mortality and data on Percent Prevalence and Weighted Prevalence of Dermo. Prevalence is the percentage of oysters with detectable infections. Weighted Prevalence is the average infection intensity (scored from 0 to 5) of all infected and uninfected oysters.

Summary of the 2002 Random Sampling of the Seed Beds

Table 3. Delaware Bay Seed Bed data for 2002.

Bed		Bushels/ Haul	Percent			Oysters/Bushel			Yearling/Bushel			Spat/ Bushel			Percent Mortality			Dermo Percent Prevalence			Dermo Weighted Prevalence			Size No./bu. >2.5 in.			Size %oysters >2.5 in.		
			2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000
		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Round Island		5.7	**60.4**	36.0	48.2																								
Round Island		4.5	**57.1**	35.0	44.4																								
Round Island		3.3	**51.1**	31.3	27.5	**371**	192	231	--	11	24	**58**	7	13	**6**	7	6	**40**	20	20	**0.48**	0.1	0.1	**14**	12	26	**4**	6	11
Round Island	*	2	**50.7**	29.0	21.4																								
Round Island		1.8	**38.9**	6.3	16.9																								
Round Island		1.6	**27.0**	2.6	9.6																								
Up. Arnolds		--	--	41.4	--																								
Up. Arnolds		--	--	19.7	--	--	218	--	--	0.6	--	--	13	--	--	9	--	--	20	--	--	0.15	--	--	12	--	--	6	--
Up. Arnolds		--	--		--																								
Arnolds	*	8.7	**65.0**	67.6	47.6																								
Arnolds		5.7	**59.8**	64.0	35.5																								
Arnolds		1.8	**50.0**	58.0	32.8	**383**	245	222	--	7	2	**48**	35	16	**9**	9	8	**33**	40	60	**0.73**	0.7	1.2	**34**	16	33	**9**	7	12
Arnolds		4.2	**47.8**	44.6	25.7																								
Arnolds		3	**45.1**	40.5	20.2																								
Arnolds		0.3	**8.9**	0.0	0.0																								
Up. Middle		2.8	**15.6**	--	16.7																								
Up. Middle		0	**0.0**	--	0.0	**58**	--	25	--	--	0	**0**	--	0	**15**	--	0	**70**	--	--	**1.6**	--	--	**6**	--	--	**10**	--	--
Middle		1.3	**88.7**	67.8	60.1																								
Middle		8	**72.0**	46.7	50.2																								
Middle	*	5.8	**62.1**	37.3	45.2																								
Middle		0.7	**52.2**	33.2	40.6																								
Middle		0.4	**45.8**	17.1	20.4	**237**	133	214	--	3	17	**31**	5	47	**14**	9	10	**90**	33	77	**2.2**	0.27	1.9	**72**	17	23	**30**	16	11
Middle		3.5	**40.0**	5.4	14.0																								
Middle		1.7	**2.1**	3.1	13.8																								
Middle		0.1	**0.0**	0.0	5.3																								
Middle		--	--	0.0	0.0																								
Cohansey	*	8.2	**68.7**	81.5	87.7																								
Cohansey		2.8	**47.7**	45.5	79.8																								
Cohansey		8.5	**41.9**	9.6	76.5																								
Cohansey		2.6	**41.2**	0.8	75.3	**163**	149	541	--	3	59	**42**	3	56	**20**	8	6	**100**	79	87	**3.1**	1.61	1.7	**50**	25	74	**31**	17	14
Cohansey		3	**33.4**	0.0	56.5																								
Cohansey		0.1	**6.8**	--	--																								
Cohansey		0.1	**3.9**	--	--																								
Ship John		3	**81.8**	78.7	60.8																								
Ship John		4	**74.2**	77.3	54.8																								
Ship John		8	**63.2**	58.8	54.0	**225**	220	316	--	20	14	**57**	38	156	**22**	8	10	**100**	95	100	**2.8**	2.33	2.8	**100**	42	39	**44**	19	12
Ship John	*	2.4	**46.2**	46.9	44.5																								
Ship John		0.4	**14.6**	12.4	15.9																								

Summary of the 2002 Random Sampling of the Seed Beds

Table 3. Delaware Bay Seed Bed data for 2002.

Bed		Bushels/ Haul	Percent			Oysters/Bushel			Yearling/Bushel			Spat/ Bushel			Percent Mortality			Dermo Percent Prevalence			Dermo Weighted Prevalence			Size No./bu. >2.5 in.			Size %oysters >2.5 in.		
			2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000
		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Seabreeze		8.7	**29**	37.5	--																										
Seabreeze	*	1.7	**22.4**	16.6	--	**71**	91	--	--	0	--	**105**	7	--	**43**	15	--	**100**	70	--	**4.6**	1.15	--	**20**	25	--	**28**	27	--
Seabreeze		0.4	**2.6**	0.18	--																										
Shell Rock	*	3.7	**69.4**	66.7	59.4																								
Shell Rock		2.7	**40.0**	62.7	57.3																								
Shell Rock		2.8	**30.3**	62.2	45.0																								
Shell Rock		3	**27.4**	54.6	40.5	**141**	184	213	--	45	34	**212**	32	130	**20**	11	11	**100**	100	83	**3.27**	2.48	1.8	**70**	60	40	**50**	33	19
Shell Rock		4	**23.3**	45.0	40.5																								
Shell Rock		0.2	**19.8**	43.0	20.3																								
Shell Rock			--	26.6	19.5																								
Bennies Sand		0.6	**32.5**	31.3	46.9																								
Bennies Sand		2.3	**28.8**	31.0	45.2																								
Bennies Sand		3	**28.2**	19.1	17.1	**98**	89	133	--	0	15	**67**	4	22	**40**	16	18	**90**	90	90	**3.13**	2.05	2.3	**61**	39	41	**62**	44	31
Bennies Sand	*	4.2	**23.5**	15.2	15.5																								
Bennies		*10.7*	*65.6*																										
Bennies		1.8	**28.2**	27.3	29.7																								
Bennies		1.3	**18.4**	19.1	25.3																								
Bennies		3.3	**15.5**	18.6	22.0																								
Bennies		1.8	**15.4**	15.6	20.8																								
Bennies		1.8	**11.6**	13.8	14.3																								
Bennies		1.6	**4.0**	5.5	7.2	**16**	20	38	--	1	2	**4**	3	10	**39**	43	35	**90**	75	100	**2.76**	1.23	4	**13**	13	23	**81**	66	61
Bennies	*	9.7	**2.9**	5.0	6.9																								
Bennies		0.6	**1.5**	4.2	6.6																								
Bennies		0.7	**0.8**	3.1	4.4																								
Bennies		5.3	**0.6**	2.8	4.3																								
Bennies		1.8	**0.3**	1.4	3.5																								
Bennies		1.8	**0.0**	0.4	3.0																								
Nantuxent Pt		--	--	73.4	--																								
Nantuxent Pt		--	--	54.4	--																								
Nantuxent Pt		--	--	53.5	--	--	149	--	--	11	--	--	25	--	--	31	--	--	90	95	--	3	3.5	--	25	--	--	17	--
Nantuxent Pt		--	--	27.3	--																								
Nantuxent Pt		--	--	24.2	--																								
Nantuxent Pt		--	--	0.3	--																								
Hog Shoal		6	**21.5**	60.1	--																								
Hog Shoal		3.7	**6.1**	40.0	--																								
Hog Shoal	*	6.2	**4.4**	38.5	--	**27**	108	--	--	5	--	**32**	13	--	**62**	38	--	**100**	100	--	**3.45**	2.95	--	**20**	45	--	**74**	34	--
Hog Shoal		1.8	**3.6**	35.0	--																								
Hog Shoal		--	--	27.6	--																								
Hog Shoal		--	--	1.0	--																								

Summary of the 2002 Random Sampling of the Seed Beds

Table 3. Delaware Bay Seed Bed data for 2002.

Bed		Bushels/ Haul	Percent			Oysters/Bushel			Yearling/Bushel			Spat/ Bushel			Percent Mortality			Dermo Percent Prevalence			Dermo Weighted Prevalence			Size No./bu. >2.5 in.			Size %oysters >2.5 in.		
			2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000	2002	2001	2000
		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
New Beds		5.2	**17.5**	13.1	17.2																								
New Beds		2.7	**10.7**	9.7	12.8																								
New Beds		0.5	**8.9**	8.6	7.0																								
New Beds	*	2.7	**6.5**	7.0	4.5																								
New Beds		4.8	**5.5**	4.1	3.2	**12**	12	13	--	2	1	**5**	2	4	**59**	47	51	**93**	95	100	**2.64**	1.65	3.5	**10**	8	9	**83**	70	69
New Beds		0.2	**3.7**	3.2	1.3																								
New Beds		1.8	**2.7**	0.9	1.1																								
New Beds		0.3	**1.9**	0.3	0.4																								
New Beds		2.9	**0.0**	0.0	0.0																								
Strawberry	*	4.3	**13.1**	23.9	23.9																								
Strawberry		1.5	**0.9**	1.8	17.6																								
Strawberry		2.7	**0.3**	--	5.9	**8**	39*	28	--	0*	2	**4**	10*	15	**59**	51*	47	**90**	--	--	**2.9**	--	--	**5**	18	14	**63**	47	50
Strawberry		4	**0.0**	--	3.7																								
Strawberry		--	--	--	1.8																								
Strawberry		--	--	--	0.73																								
Hawks Nest		4.2	**13.3**	56.9	73.6																								
Hawks Nest	*	6.5	**8.6**	36.6	54.2																								
Hawks Nest		2.8	**1.4**	--	42.7																								
Hawks Nest		1.8	**0.5**	--	34.9	**16**	203*	219	--	11*	33	**4**	46*	318	**61**	28*	18	**100**	--	100	**3.5**	--	3.3	**9**	38	43	**56**	19	20
Hawks Nest		--	--	--	24.3																								
Hawks Nest		--	--	--	5.2																								
Beadons		1.5	**23.1**	30.8	22.5																								
Beadons		2.8	**17.4**	11.7	20.8																								
Beadons		2.7	**6.0**	11.4	17.9																								
Beadons		2.7	**4.5**	9.4	15.3																								
Beadons		2.7	**3.3**	7.3	11.6	**18**	25	46	--	7	11	**53**	11	43	**62**	52	31	**100**	100	95	**4.25**	3.85	3.7	**10**	14	9	**56**	56	20
Beadons		0.7	**2.2**	6.3	10.9																								
Beadons		1.7	**1.5**	5.2	10.9																								
Beadons		4.2	**1.5**	3.4	6.4																								
Beadons		4	**0.8**	3.0	4.4																								
Beadons	*	5	**0.0**	1.8	2.4																								
Vexton		2.5	**31.2**	47.2	--																								
Vexton		4.2	**16.7**	35.0	--																								
Vexton		4.7	**11.2**	25.2	--																								
Vexton		3.8	**11.0**	21.2	--																								
Vexton		4.7	**1.1**	8.8	--	**26**	66	--		5	--	**30**	22	--	**64**	28	--	**100**	80	--	4.9	1.7	--	**16**	25	--	**62**	38	--
Vexton		--	--	2.0	--																								
Vexton		--	--	0.3	--																								

Summary of the 2002 Random Sampling of the Seed Beds

Table 3. Delaware Bay Seed Bed data for 2002.

																							Dermo				Dermo				Size				Size		
Bed		Bushels/	Percent				Oysters/Bushel				Yearling/Bushel				Spat/ Bushel				Percent Mortality				Percent Prevalence				Weighted Prevalence				No./bu. >2.5 in.				%oysters >2.5 in.		
		Haul																																			
			2002	2001	2000		2002	2001	2000		2002	2001	2000		2002	2001	2000		2002	2001	2000		2002	2001	2000		2002	2001	2000		2002	2001	2000		2002	2001	2000
		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Egg Island		--	--	3.0	0.80																																
Egg Island		--	--	2.13	0.71																																
Egg Island		--	--	0.88	0.48																																
Egg Island		--	--	0.35	0.33																																
Egg Island		--	--	0.34	0.32		--	2	0.8		--	0	0		--	1	0.4		--	77	73		--	71	100		--	2.21	3.6		--	1	0.6		--	75	75
Egg Island		--	--	0	0																																
Egg Island		--	--	0	0																																
Egg Island		--	--	0	0																																
Egg Island		--	--	0	0																																
Egg Island		--	--	0	0																																
Ledge		4.3	**4.9**	--	3.8																																
Ledge		9.2	**1.3**	--	2.6																																
Ledge		1.2	**0.6**	--	1.3																																
Ledge	*	1	**0**	--	0.39		**1.1**	1	3		--	--	0.1		**0**	--	0.4		**59**	--	62		**100**	--	70		**2.4**	--	1.9		**1**	--	3		**100**	--	100
Ledge		0.5	**0**	--	0																																
Ledge		--	--	--	0																																
Ledge		--	--	--	0																																
Ledge		--	--	--	0																																

Table 4. Oyster Seed Beds Size Frequency 2002

	Round Is	Arnold	Up Mid	Middle	Cohan	Ship Jn	Seabrz	Shell Rk	Ben Snd	Bennie	Hog Shl	New Beds	Straw	Hawks N	Beadon	Vexton	Ledge
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
15	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
20	23	8	0	2	1	1	1	3	0	0	1	0	0	0	0	1	0.0
25	37	12	1	6	2	1	3	2	0	0	0	0	0	0	0	1	0.0
30	65	32	5	9	4	4	6	2	1	0	0	0	0	1	0	0	0.0
35	65	52	7	17	7	7	5	3	1	0	0	0	0	1	1	1	0.0
40	56	56	15	20	14	9	6	4	2	0	1	0	1	1	1	0	0.0
45	50	67	10	20	17	18	7	7	5	0	1	0	0	2	2	1	0.0
50	24	61	8	33	23	22	8	10	6	0	0	0	1	1	1	2	0.0
55	21	33	2	29	25	34	8	16	11	1	1	1	0	0	1	3	0.0
60	8	27	4	28	19	29	7	22	12	1	3	1	0	2	1	2	0.0
65	7	20	2	26	17	31	5	19	17	1	3	1	1	2	2	2	0.0
70	4	8	4	18	13	25	5	18	15	2	4	1	1	0	2	4	0.0
75	**1**	**5**	**0**	**13**	**8**	**19**	**3**	**14**	**11**	**2**	**5**	**1**	**1**	**2**	**3**	**2**	**0.0**
80	**1**	**1**	**0**	**8**	**4**	**11**	**3**	**10**	**10**	**2**	**3**	**2**	**1**	**2**	**1**	**2**	**0.2**
85	**0**	**0**	**0**	**5**	**4**	**6**	**2**	**5**	**4**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**0.4**
90	**0**	**0**	**0**	**2**	**2**	**4**	**1**	**3**	**2**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**0.0**
95	**0**	**0**	**0**	**0**	**1**	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**0**	**0**	**1**	**1**	**0.2**
100	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0.2**
105	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0**
110	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0.0**
115	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0**
120	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0**
Total/Bu.	371	383	58	237	163	225	71	141	98	16	27	12	8	16	18	26	1
No. Measured	1171	885	80	890	1662	731	204	718	388	180	92	83	26	64	178	167	5
Greater than 3"	**3**	**6**	**0**	**28**	**20**	**44**	**11**	**33**	**29**	**10**	**13**	**7**	**3**	**7**	**6**	**10**	**1**
> 3" 2001	3	5		6	8	16	13	24	15	8	23	5	9	15	8	11	
> 3" 2000	8		10	10	34	17		18	19	13			7	7	20	4	
Greater than 2.5"	**14**	**34**	**6**	**72**	**50**	**100**	**20**	**70**	**61**	**13**	**20**	**10**	**5**	**9**	**10**	**16**	**1**
> 2.5" 2001	12	16		17	25	42	25	60	39	13	45	8	18	38	14	25	
> 2.5" 2000	26		26	23	74	39		40	41	23			9	14	43	9	

Table 5. Seed bed harvest (bu.)of market oysters and bushels of oysters transplanted in 2002. All transplants were moved between September 26 and Oct 22, 2002. All were placed on Bennies bed. No records are available for the source of the Replanted oysters (4,935 bu.).

Bed	Bushels Harvested	Percent	Bushels Transplanted
Arnolds	675	1.0	
Middle	475	0.7	
Cohansey	85	0.1	6,200
Ship John	528	0.8	22,416
Shell Rock	29,685	43.6	
Bennies	3,958	5.8	
Bennies Sand	6,312	9.3	
Nantuxent	76	0.1	
Hog Shoal	7,533	11.1	
New Beds	8,032	11.8	
Hawks Nest	2,196	3.2	
Beadons	557	0.8	
Vexton	2,680	3.9	
Ledge	163	0.2	
Egg Island	48	0.1	
Replanted to Leases + Other	5,035	7.4	
Total	**68,038**		**28,616**

Table 6. Industry bottom coverage and catch per unit effort (CPUE). Total coverage = estimated (est.) bottom area covered by oyster dredges in 2002. Fraction of bottom area swept by oyster dredges in 2002. Bu. = bushel. Hectare = 2.47 acres. * = High quality areas only, Submarket+Market oysters. ** = No "special/test area" sampled in 2001.

	Total Coverage (m^2)	**Fraction Covered**	**2002 Harvest (Bu.)**	**2001 Est. Availability (Bu.)***	**CPUE (Bu./hectare)**
Bed					
Round Island					
Upper Arnolds					
Arnolds	190,820	0.10	550	30,255	29
Upper Middle					
Middle	318,033	0.09	925	39,496	29
Ship John	699,627	0.24	528	86,472	89
Cohansey	657,007	0.2	3,122	40,628	48
Seabreeze					
Shell Rock	24,959,756	7.21	29,818	23,784	12
Bennies Sand	5,792,257	7.12	6,312	9,834	11
Bennies	3,979,862	0.71	3,958	12,338	10
New Beds	9,020,872	1.58	8,032	10,992	9
Nantuxent	100,645	0.05	152	18,577	15
Hog Shoal	6,290,638	6.87	7,533	14,507	12
Strawberry					
Hawk's Nest	1,818,021	0.94	2,196	29,560	12
Beadons	556,362	0.23	821	6,906	15
Vexton	2,289,834	1.61	2,680	18,292	12
Egg Island	63,607	0.02	48	**488	8
Ledge	190,820	0.10	163	1,236	9

Table 7. Source beds and volumes (bu.) for transplanted oysters.

Year	Arnolds	Middle	Cohansey	Ship John	Nantuxent	Beadons	Total
1997		30,000					30,000
1998			6,000	6,000			12,000
1999		14,650	40,200	17,350			72,200
2000		24,210	4,146	6,572	225	4,900	40,053
2001	6,500	6,395	18,400	14,650	6,250		52,195
2002			6,200	22,416			28,616

Table 8. Bennies Transplant Area Sampling, 2002. Most transplanted oysters were placed on grids 110 (total coverage) and 122. Approximately 25% of the transplant was placed on grid 121. Total bushels transplanted = 28,616. Below, grid system indicating those grids sampled (Bold) and approximate area of transplant.

Grid Number	**Oysters m^{-2}**		
	Juvenile	**Submarket**	**Market**
110	50.46	22.25	7.27
121	0.74	0.29	0.52
124	0	0.13	0.08
125	0.13	0.03	0.12
131	0	0	0.02
102	0.08	0.26	0.49

Bennies Grids

95	96	97	98	99	100	101	**102**
108	109	**110**	111	112	113	114	115
120	**121**	122	123	**124**	**125**	126	127
130	**131**	132	133	134	135	136	

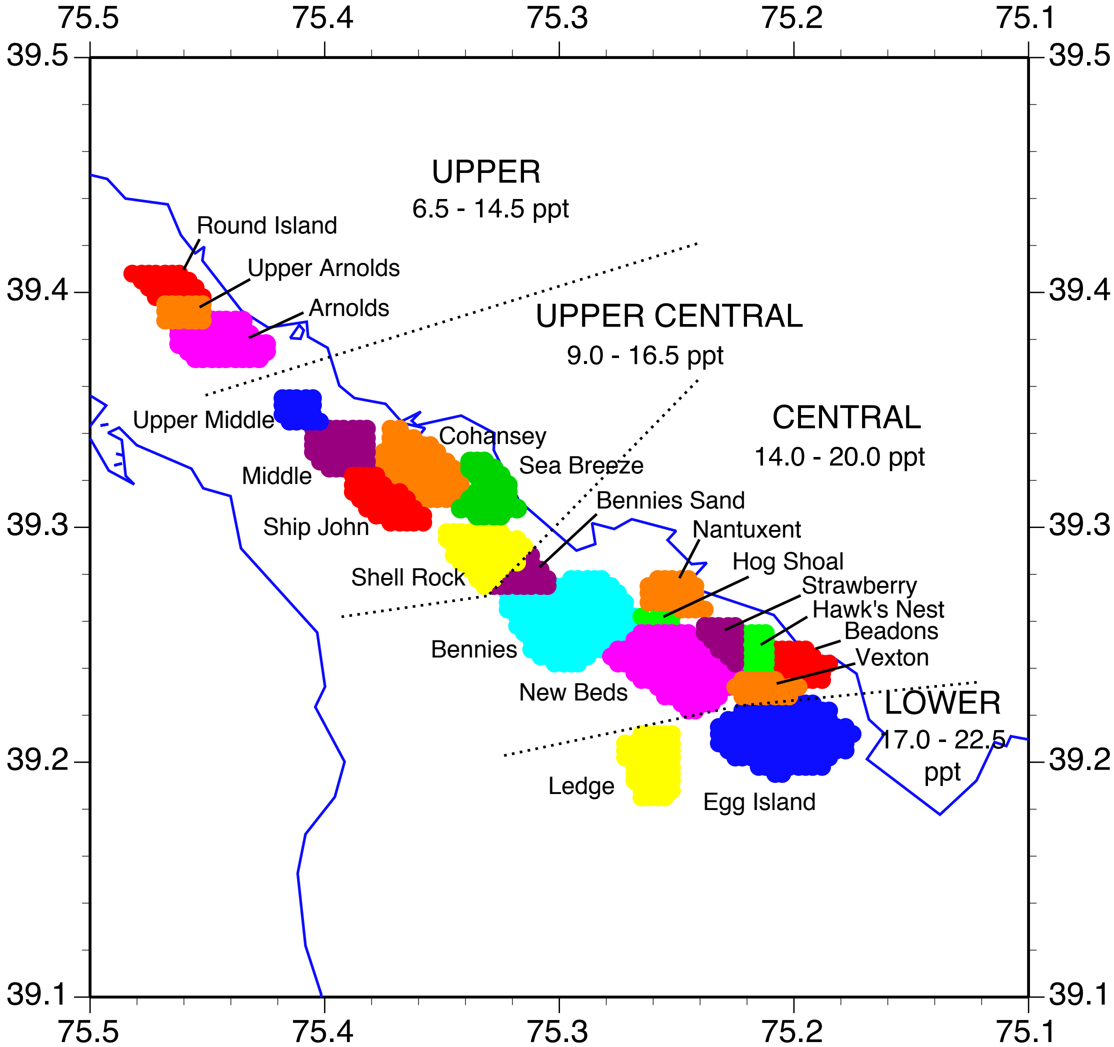
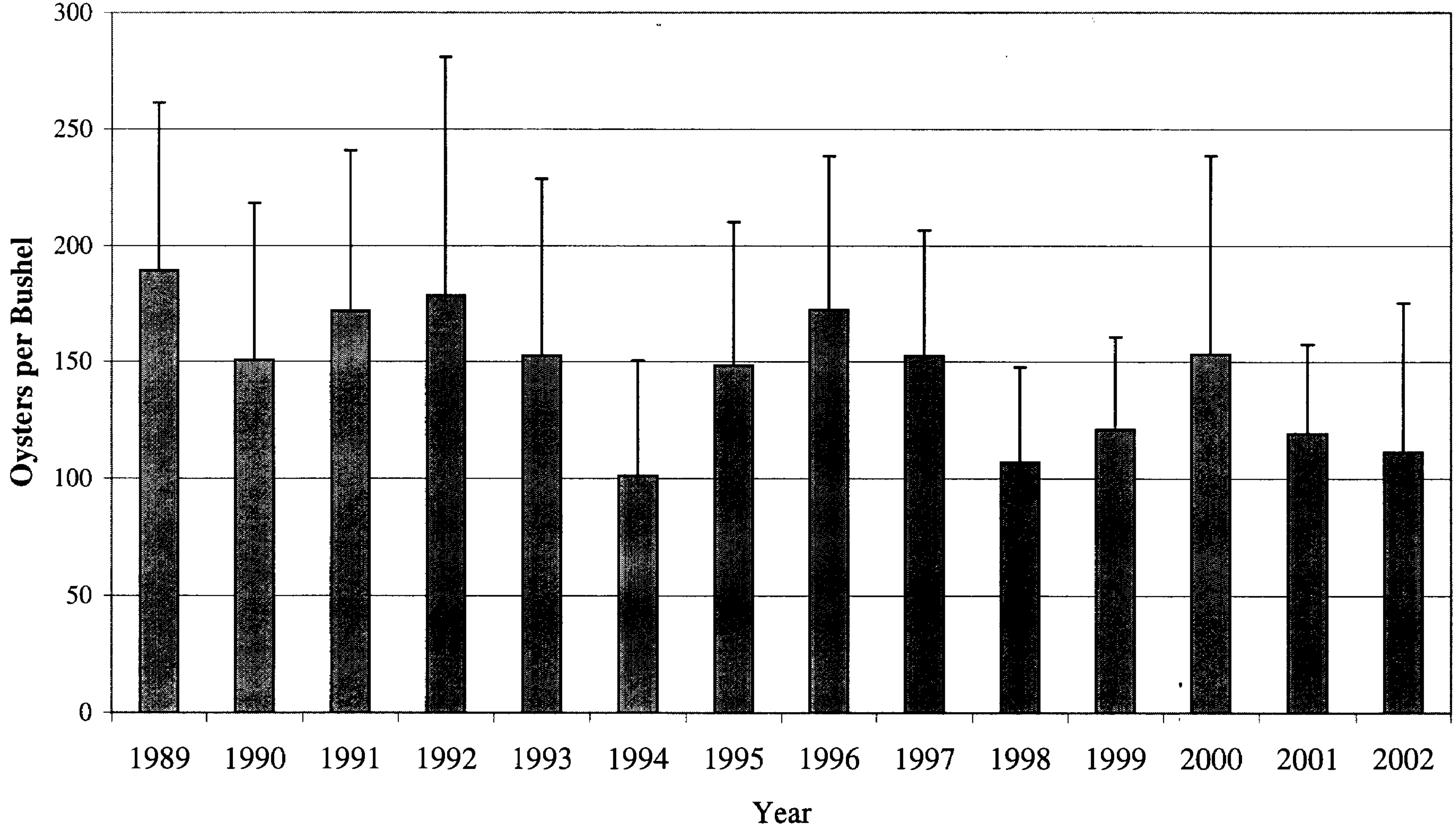
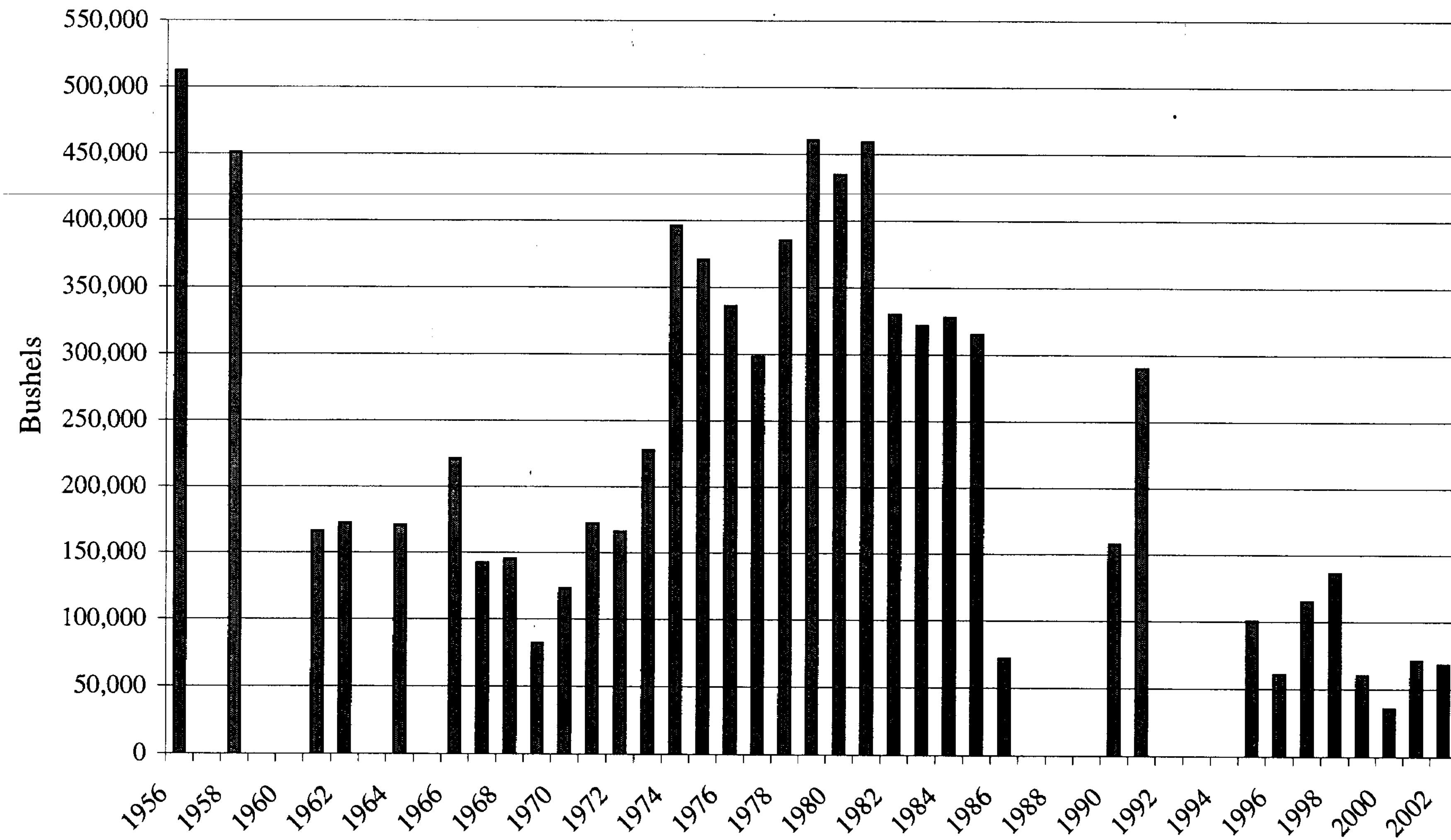

75.5
75.4
75.3
75.2
75.1
39.5
39.4
39.3
39.2
39.1
UPPER
6.5 - 14.5 ppt
UPPER CENTRAL
9.0 - 16.5 ppt
CENTRAL
14.0 - 20.0 ppt
LOWER
17.0 - 22.5 ppt
Round Island
Upper Arnolds
Arnolds
Upper Middle
Middle
Cohansey
Sea Breeze
Ship John
Shell Rock
Bennies Sand
Nantuxent
Hog Shoal
Strawberry
Hawk's Nest
Beadons
Vexton
Bennies
New Beds
Ledge
Egg Island

Figure 1

Average Delaware Bay Oyster Abundance



Seed Bed Harvest



Delaware Bay Seed Beds

Year	1989	1992	1996	1991	2000	1993	1997	1990	1995	1999	2001	2002	1998	1994	Mean
Oysters	189	178	172	172	153	153	152	151	148	121	119	110	107	101	145

Year	1991	1999	1997	1998	1995	1994	1990	1989	2000	1993	2002	1992	1996	2001	Mean
Spat	268	191	151	128	127	124	112	69	55	44	43	25	22	14	98

Year	1993	2002	1994	1999	1998	2000	1992	1995	1996	2001	1991	1997	Mean
Dermo WP	2.99	2.87	2.67	2.63	2.56	2.45	2.18	1.84	1.81	1.71	1.2	1.12	2.22

Upper Central Beds

Year	2000	1996	1997	1992	1990	1991	1989	1998	1993	2002	2001	1999	1994	1995	Mean
Oysters	321	309	265	244	225	222	214	193	190	167	155	153	143	138	207*

Central Beds

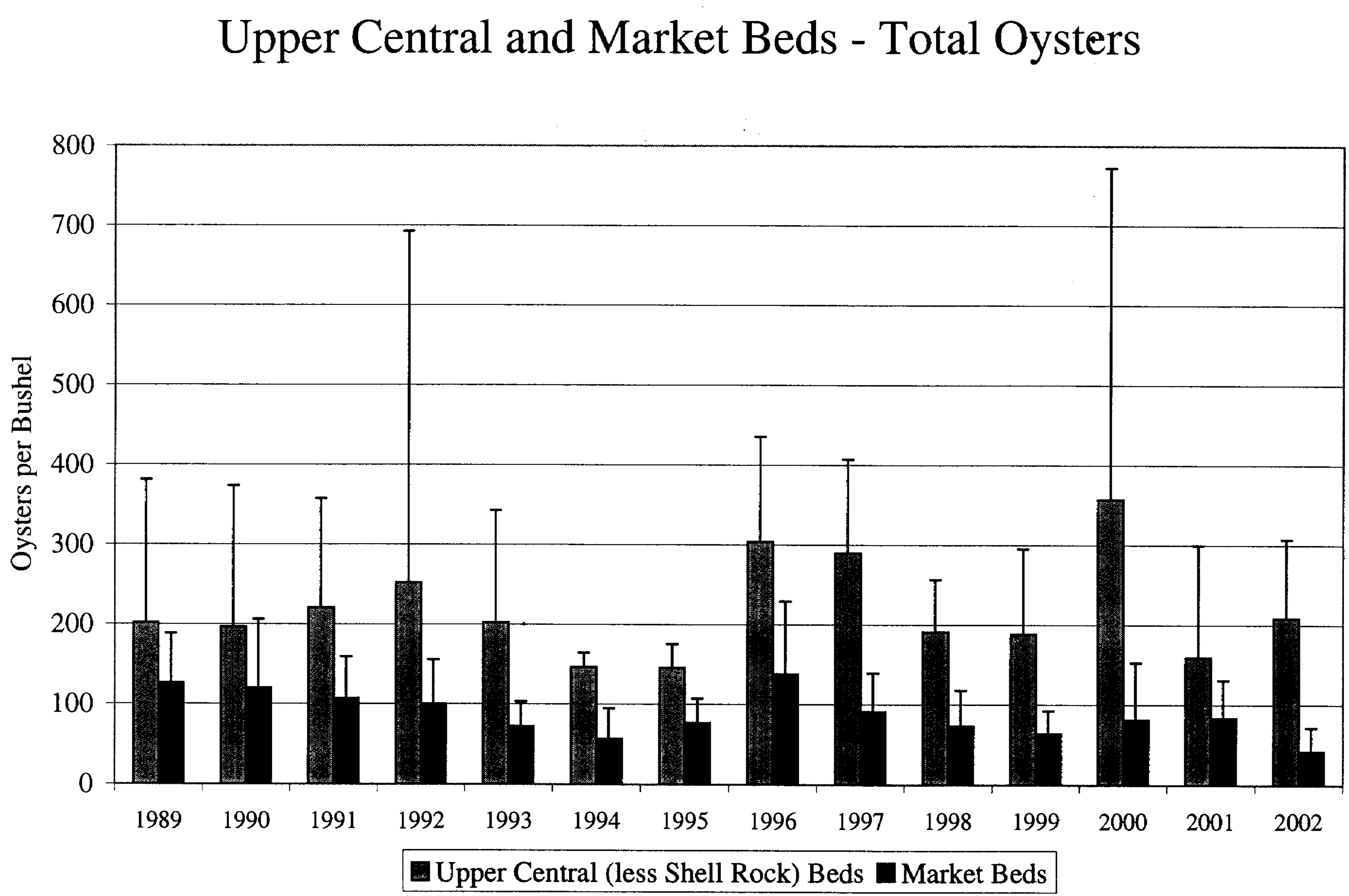
Year	1996	1989	1995	1990	1997	1992	1991	1998	2000	1999	2001	1993	1994	2002	Mean
Oysters	153	105	95	91	91	91	84	80	80	78	67	55	52	28	82*

Upper Central Beds

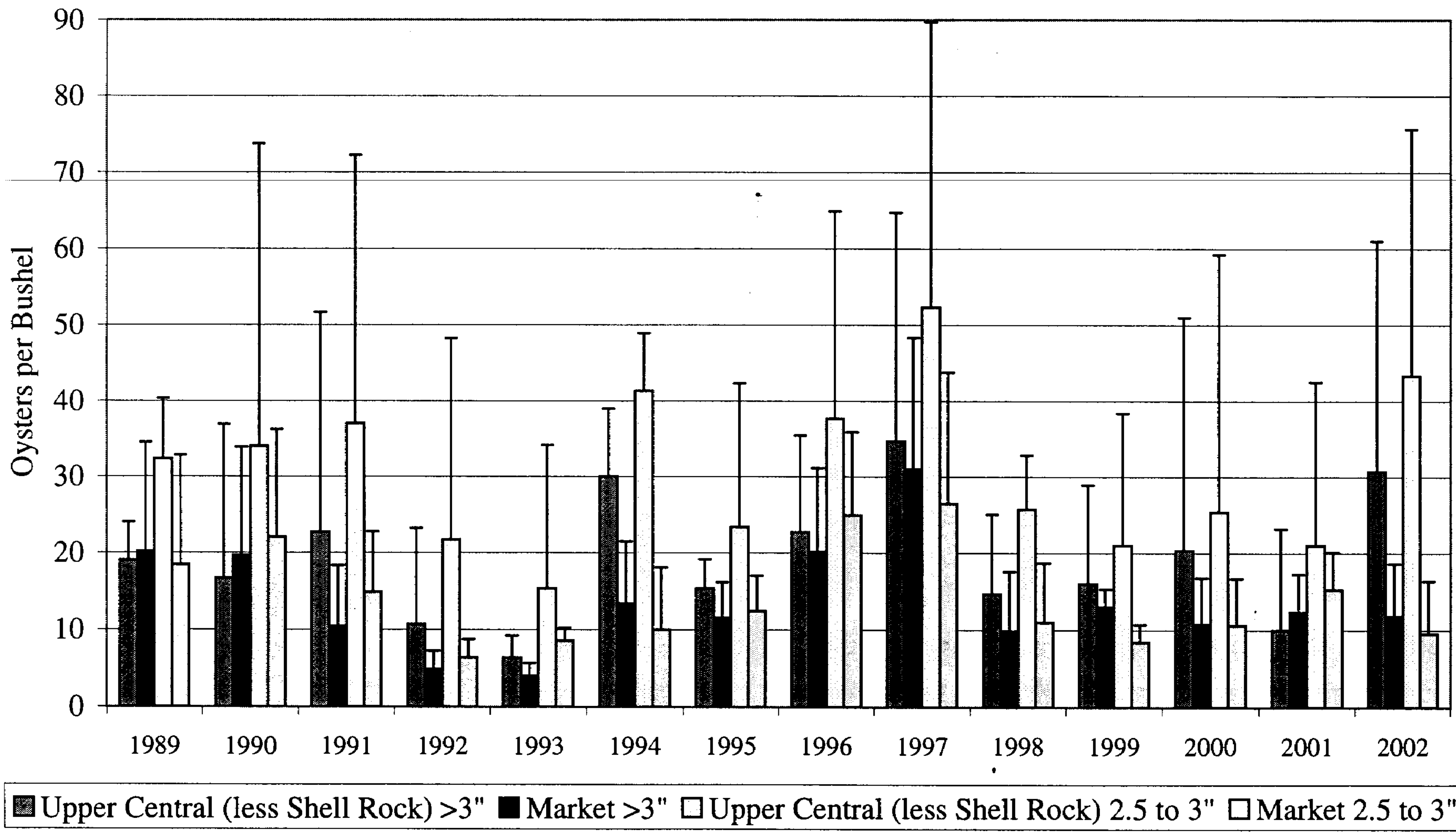
Year	1991	1999	1998	1995	1994	1990	1997	2000	2002	1989	1993	1996	1992	2001	Mean
Spat	307	291	209	179	164	126	113	97	75	70	60	36	31	17	127

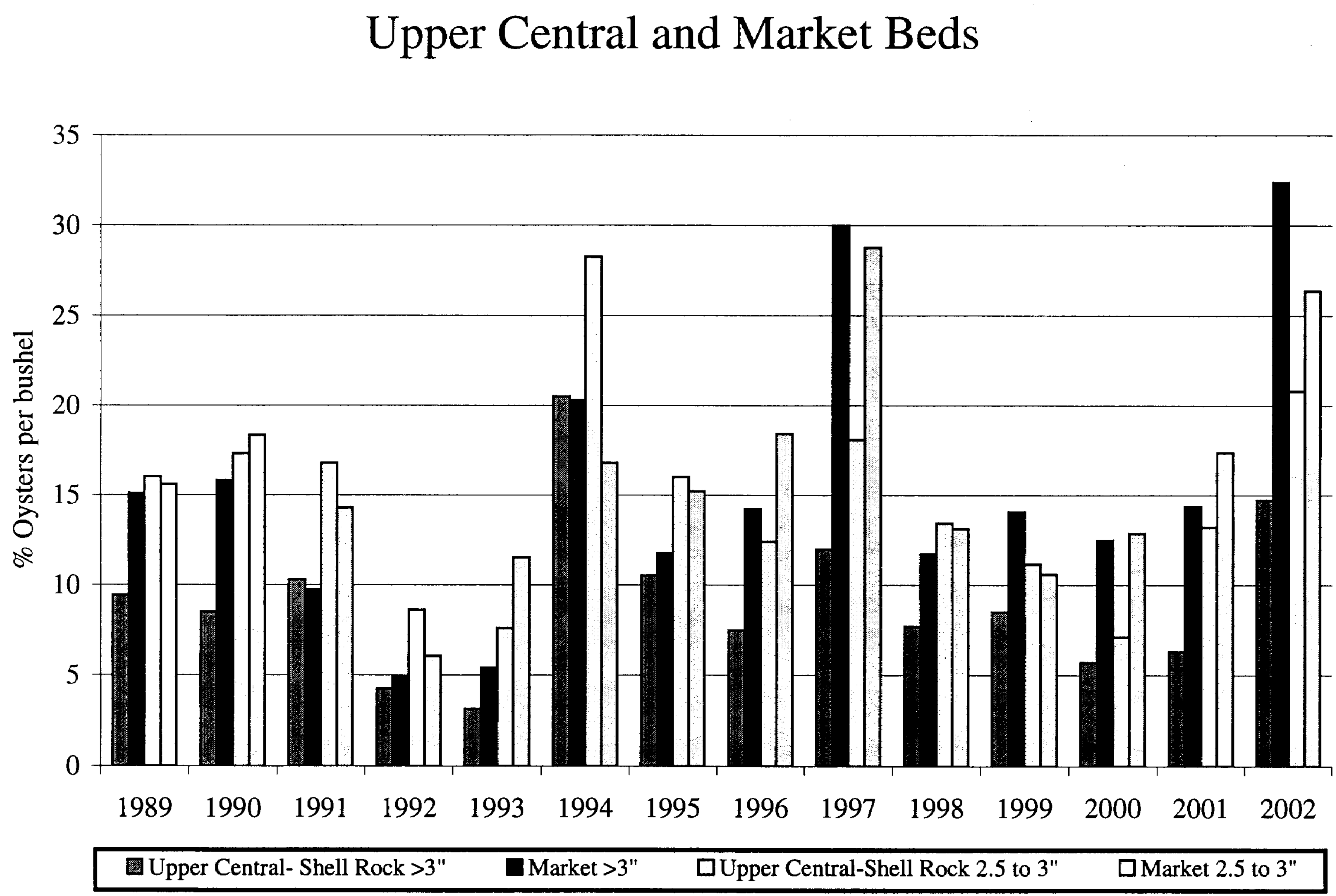
Central Beds HSD

Year	1991	1997	1999	1994	1998	1995	1990	1989	2000	1993	2002	1992	1996	2001	Mean
Spat	273	221	166	166	146	137	107	70	69	46	30	21	16	11	106

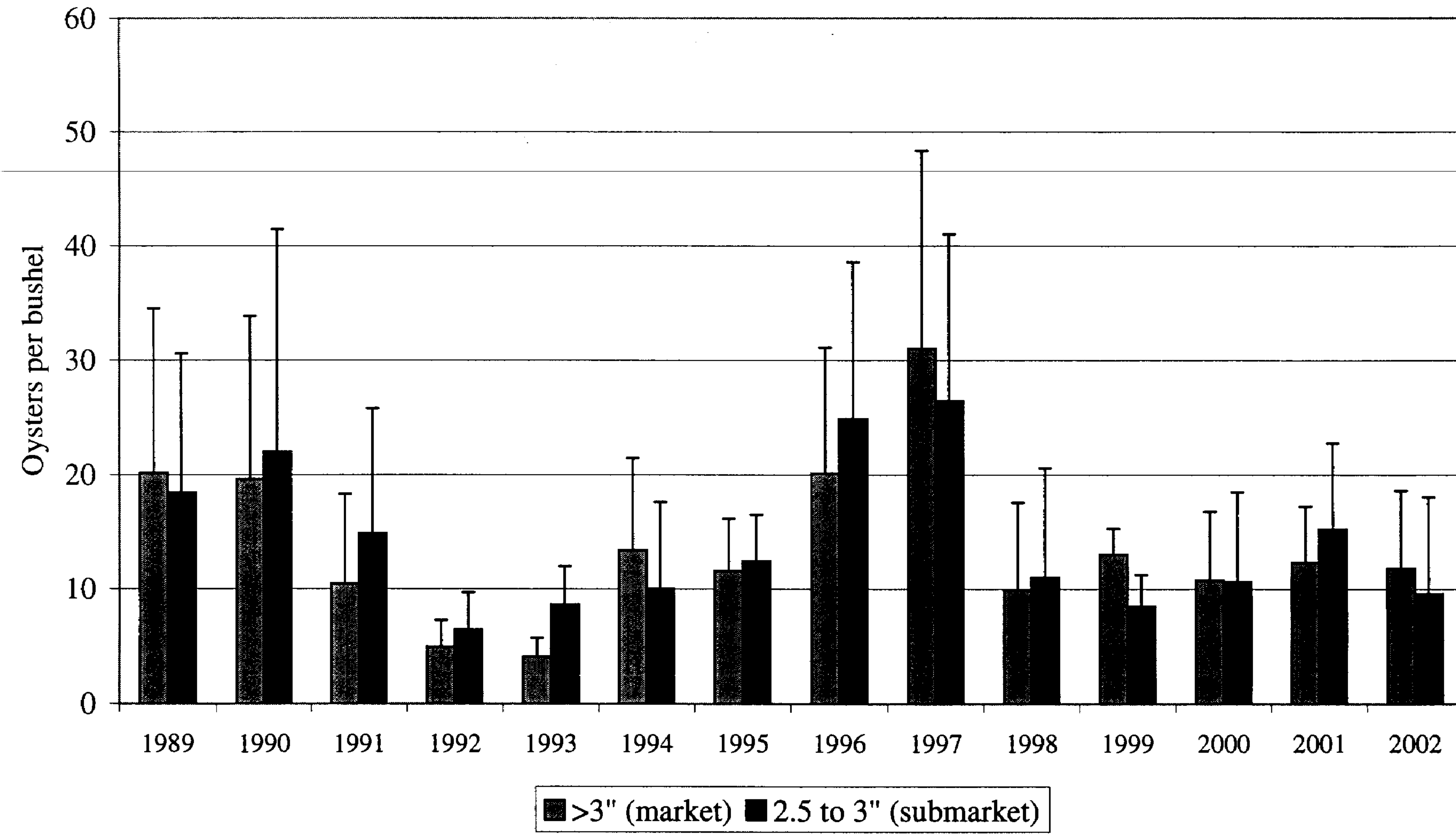

Upper Central and Market Beds - Total Oysters
Oysters per Bushel
800
700
600
500
400
300
200
100
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Upper Central (less Shell Rock) Beds
Market Beds

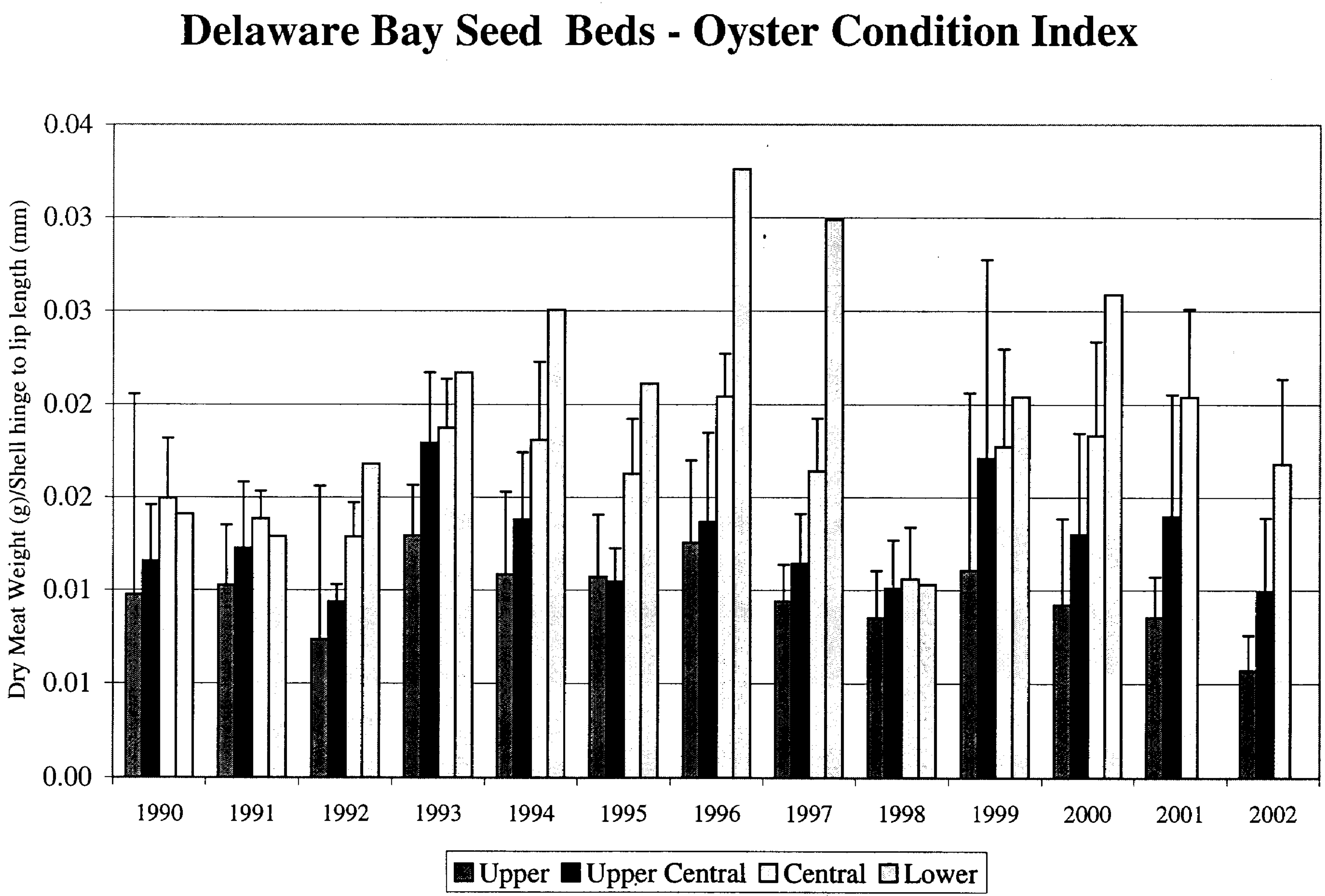
Upper Central and Market Beds - Oysters by Size

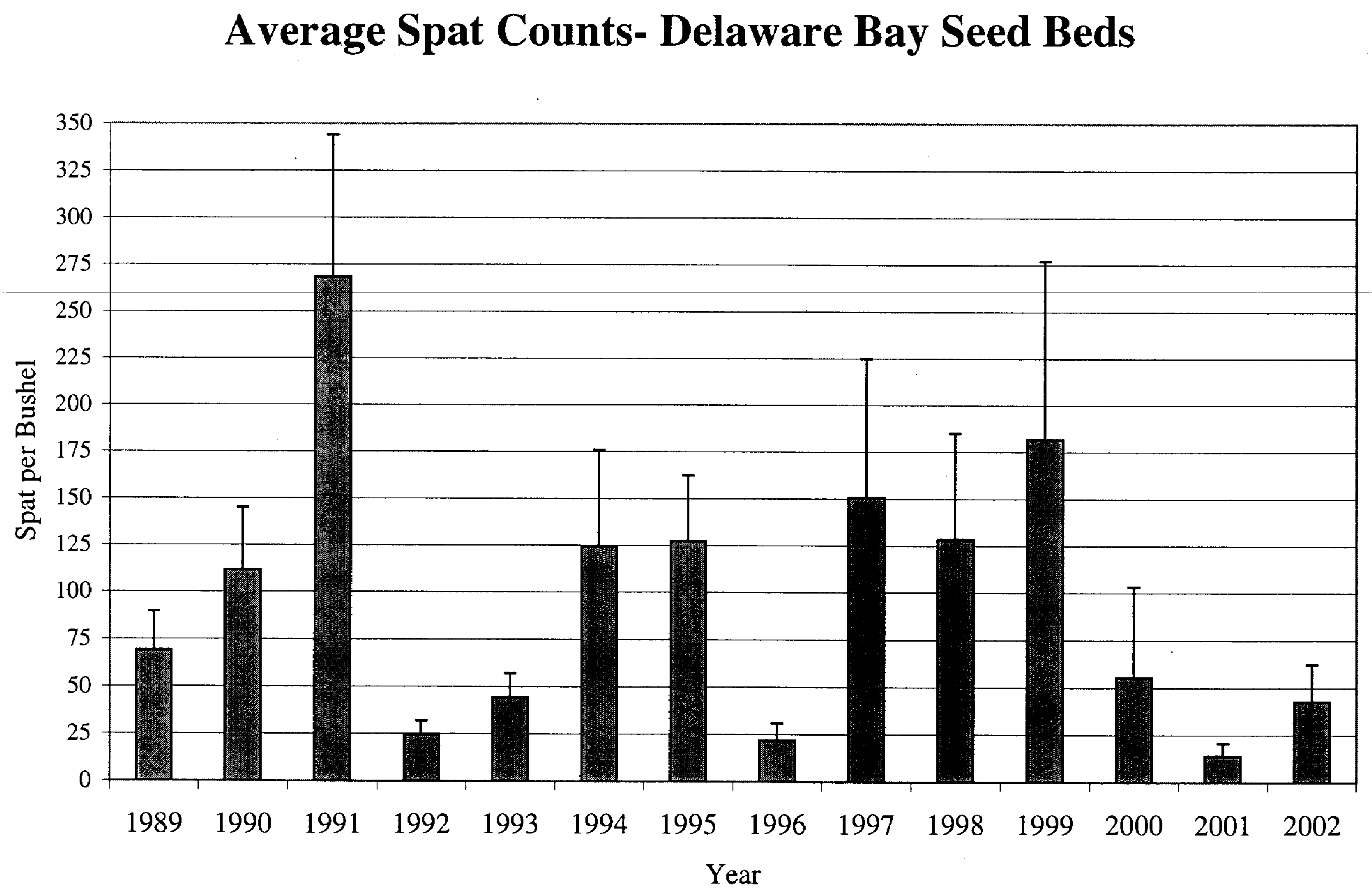



Upper Central and Market Beds
35
30
25
20
15
10
5
0
% Oysters per bushel
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Upper Central- Shell Rock >3"
Market >3"
Upper Central-Shell Rock 2.5 to 3"
Market 2.5 to 3"

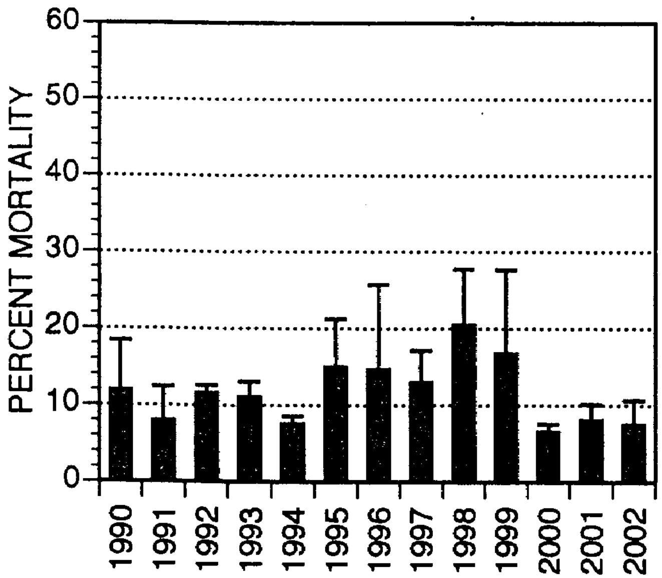
Market Beds - Oysters per Bushel by Size



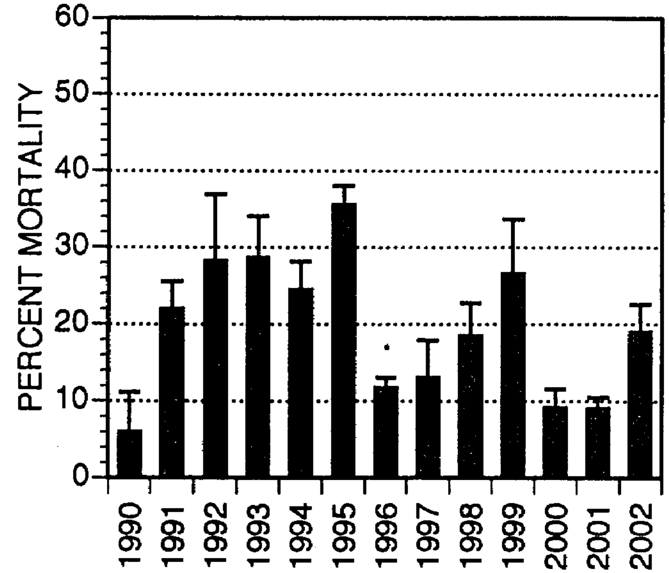

Delaware Bay Seed Beds - Oyster Condition Index
Dry Meat Weight (g)/Shell hinge to lip length (mm)
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Upper
Upper Central
Central
Lower


Average Spat Counts- Delaware Bay Seed Beds
Spat per Bushel
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Year

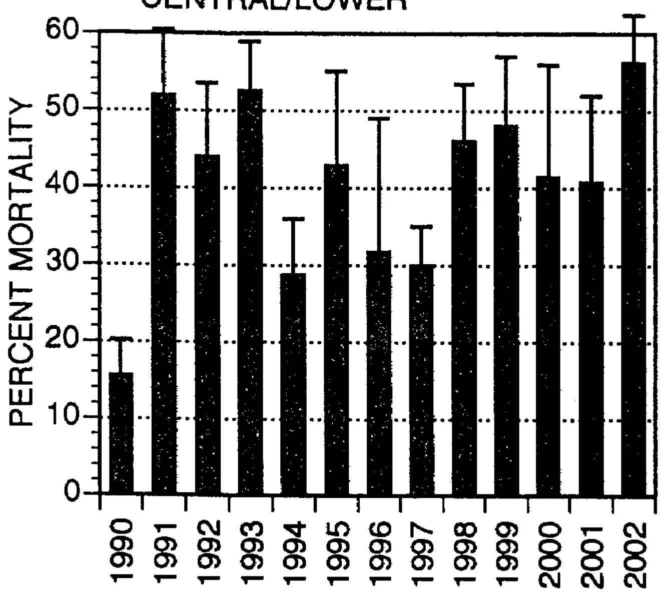
UPPER



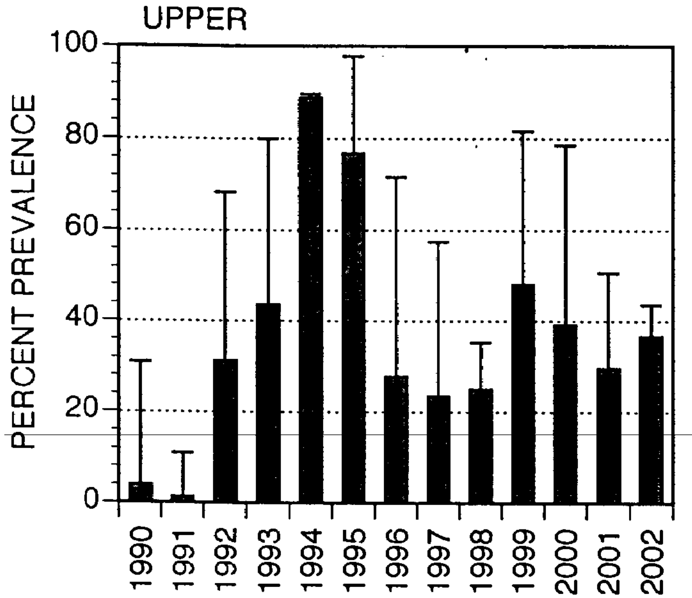
UPPER CENTRAL

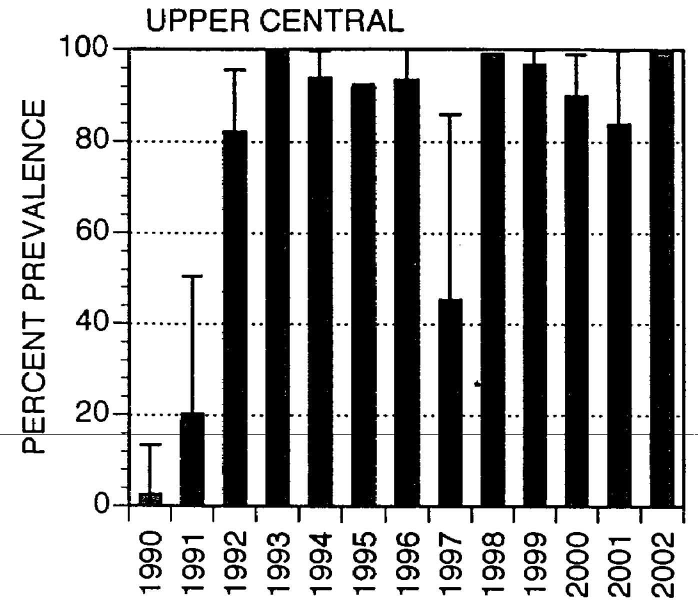


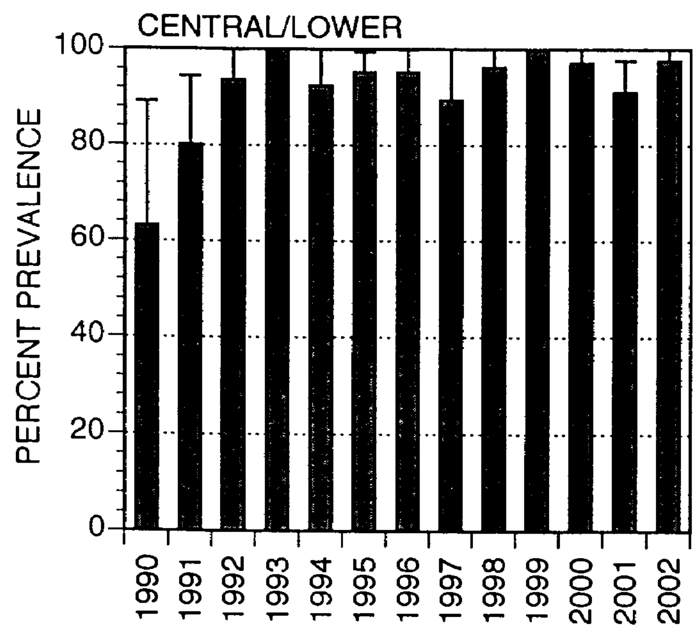
CENTRAL/LOWER



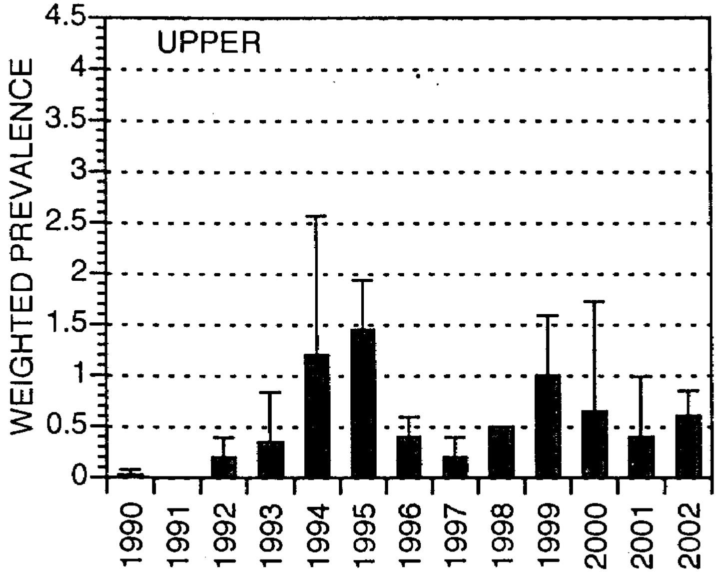
Area	Mean	sem	95%CI
Upper	11.3	0.7	1.3
Up Central	18.5	0.9	1.7
Central/Lower	40.9	3.2	6.3

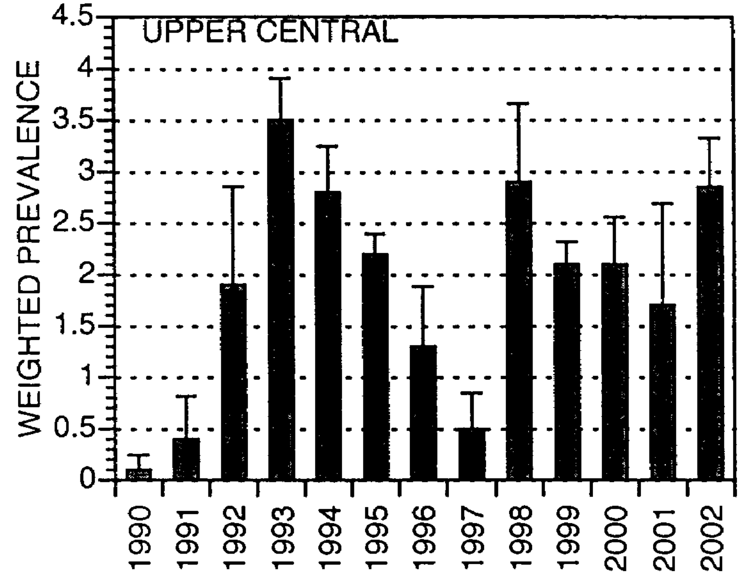


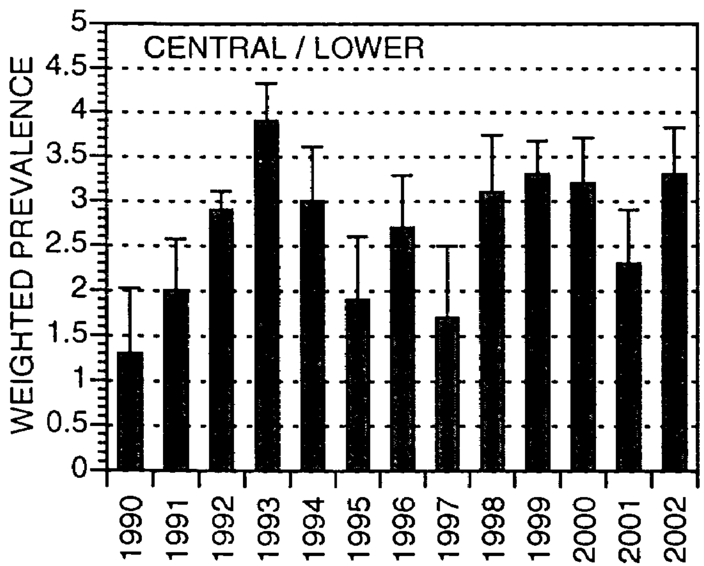




Area	Mean	sem	95%CI
Upper	34.5	9.9	19.6
Up Central	80.5	6.2	11.2
Central/Lower	93.1	1.9	3.4







Area	Mean	sem	95% CI
Upper	0.5	0.2	0.4
Up Central	1.9	0.1	0.2
Central/Lower	2.8	0.1	0.2

May *Perkinsus marinus* Prevalence vs Fall Box Count Mortality

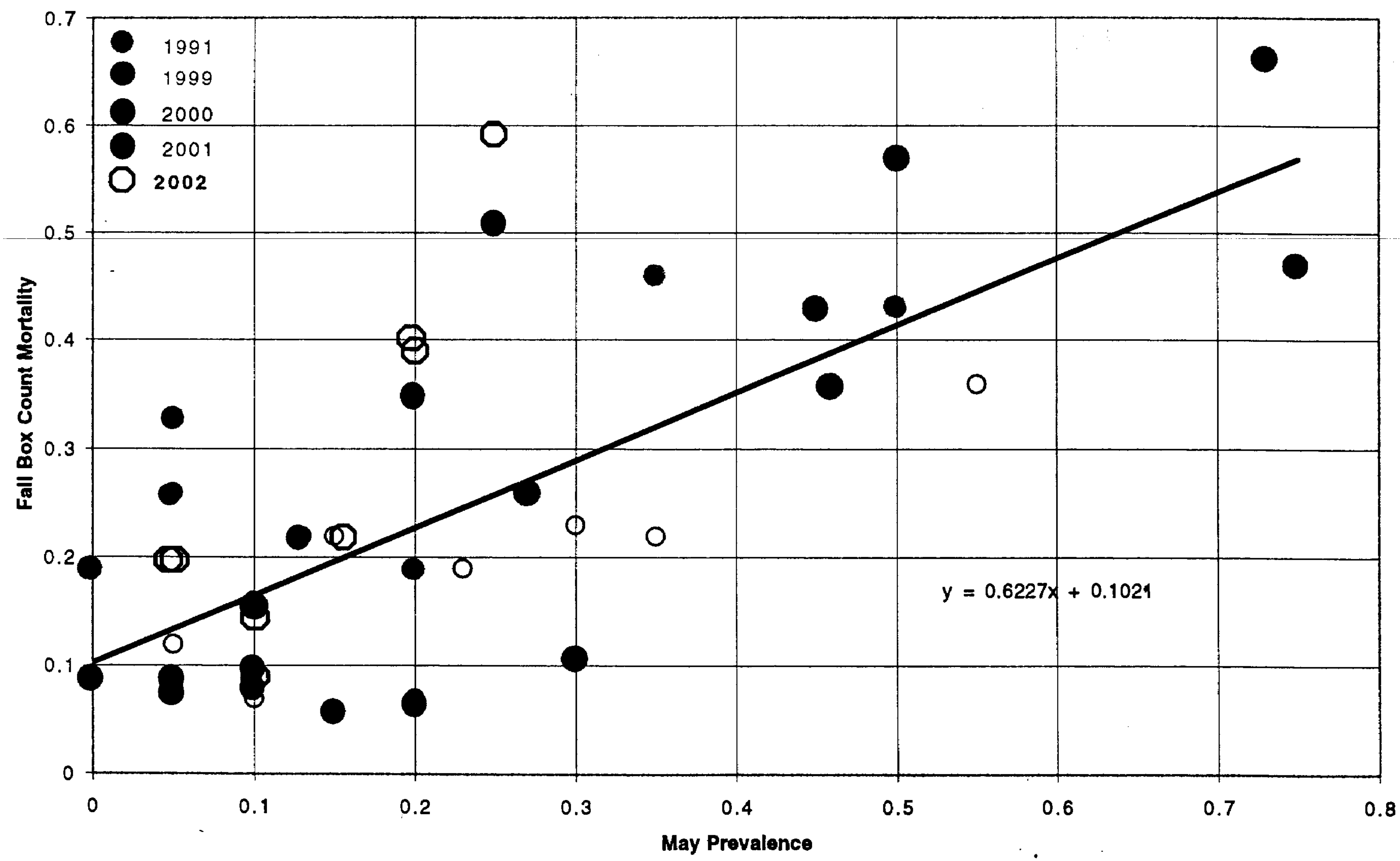
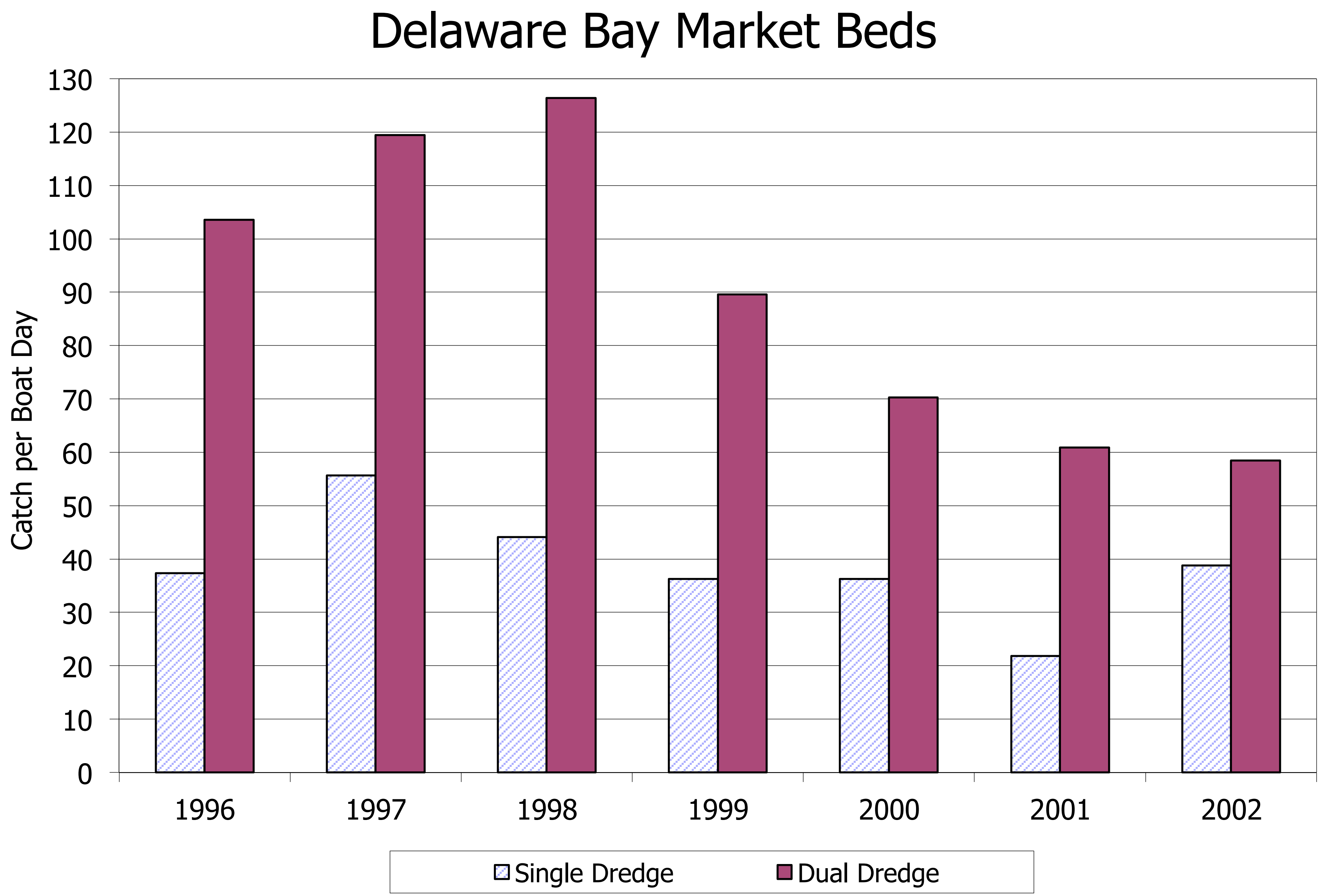
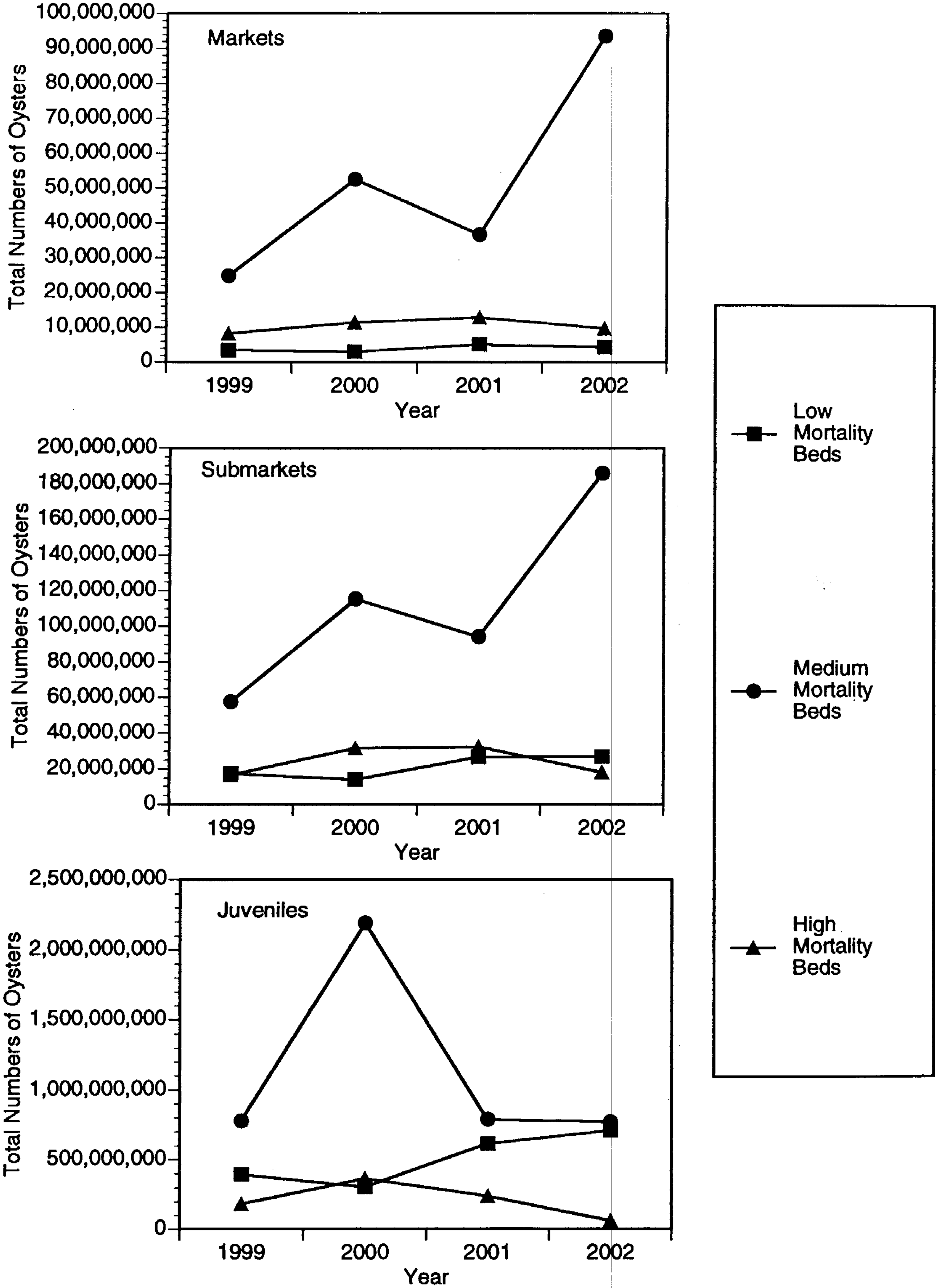
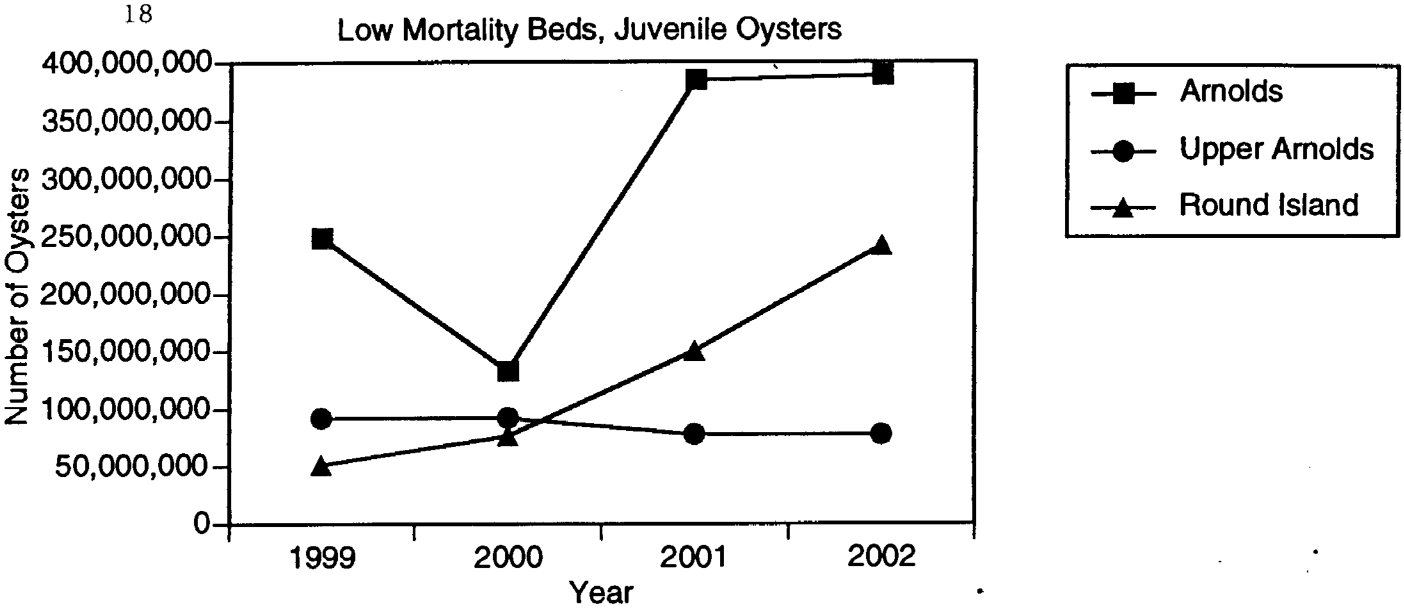


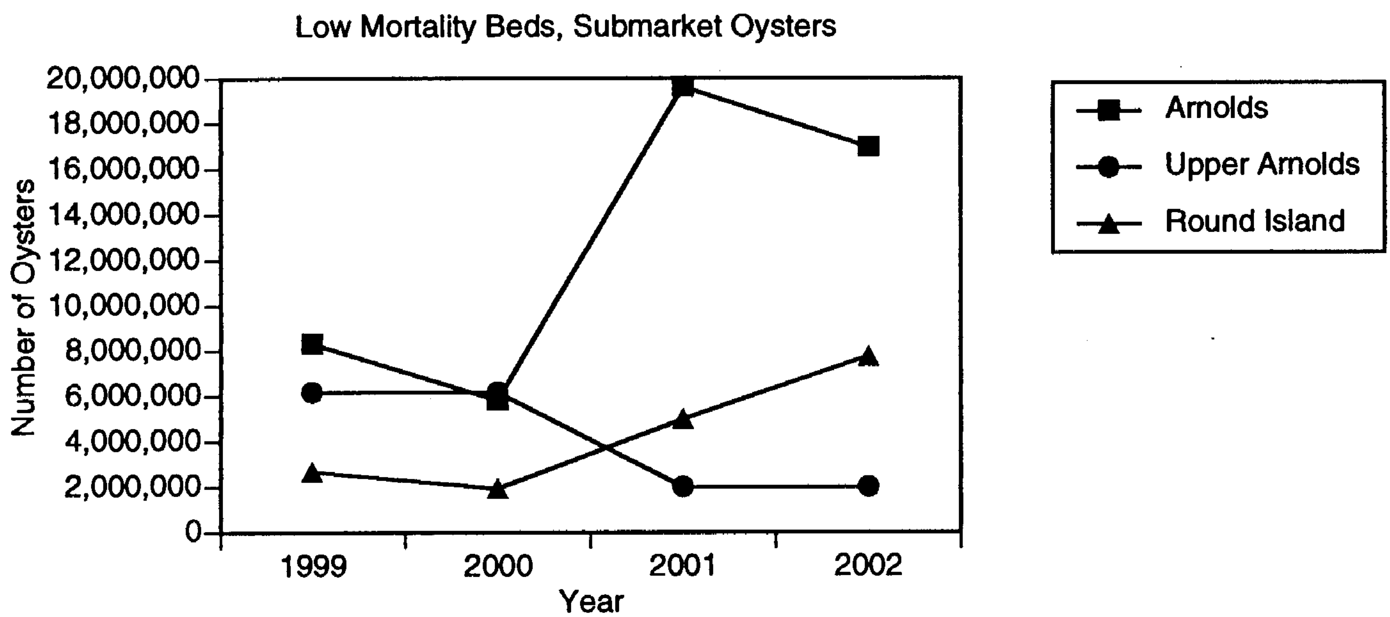
Figure 16

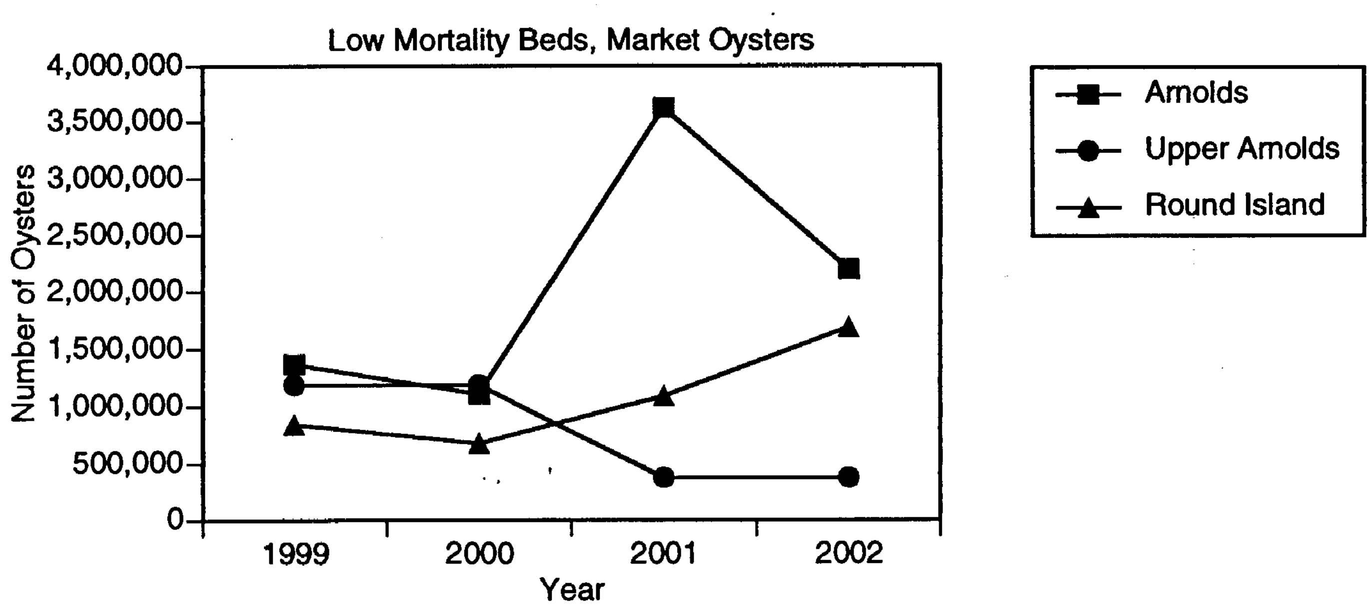


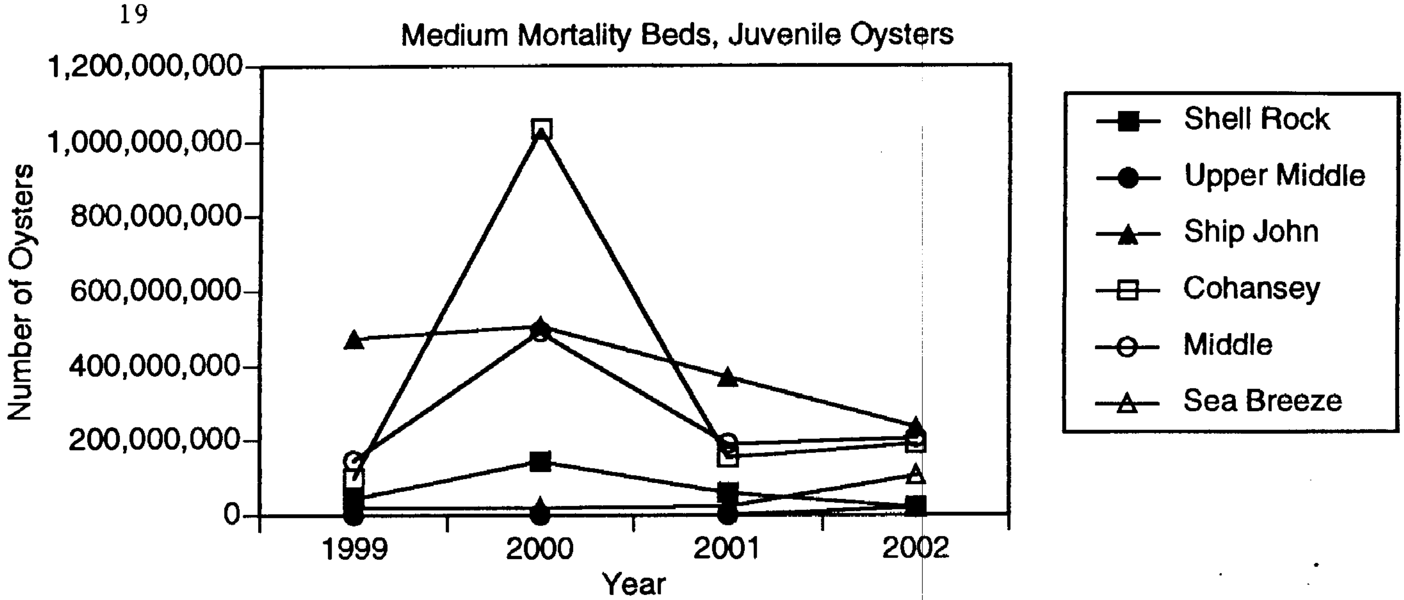
Delaware Bay Market Beds
Catch per Boat Day
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1996
1997
1998
1999
2000
2001
2002
Single Dredge
Dual Dredge

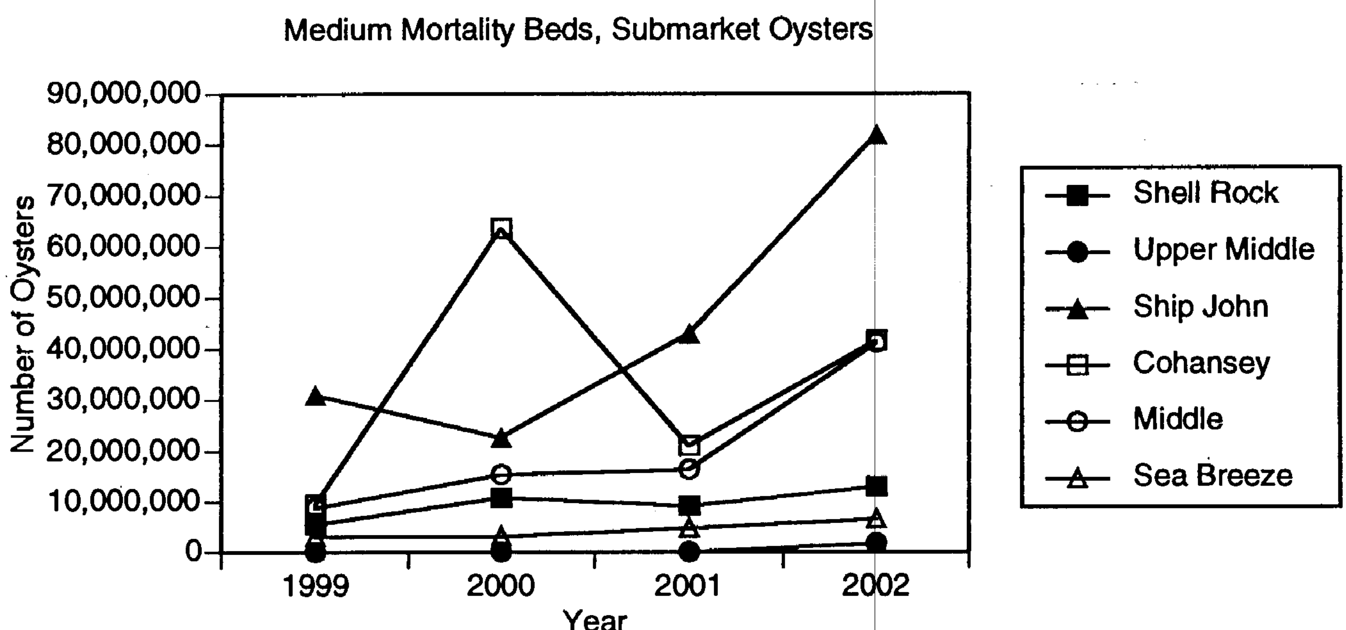

Markets
Total Numbers of Oysters
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1999
2000
2001
2002
Year
Submarkets
Total Numbers of Oysters
200,000,000
180,000,000
160,000,000
140,000,000
120,000,000
100,000,000
80,000,000
60,000,000
40,000,000
20,000,000
0
1999
2000
2001
2002
Year
Juveniles
Total Numbers of Oysters
2,500,000,000
2,000,000,000
1,500,000,000
1,000,000,000
500,000,000
0
1999
2000
2001
2002
Year
Low Mortality Beds
Medium Mortality Beds
High Mortality Beds

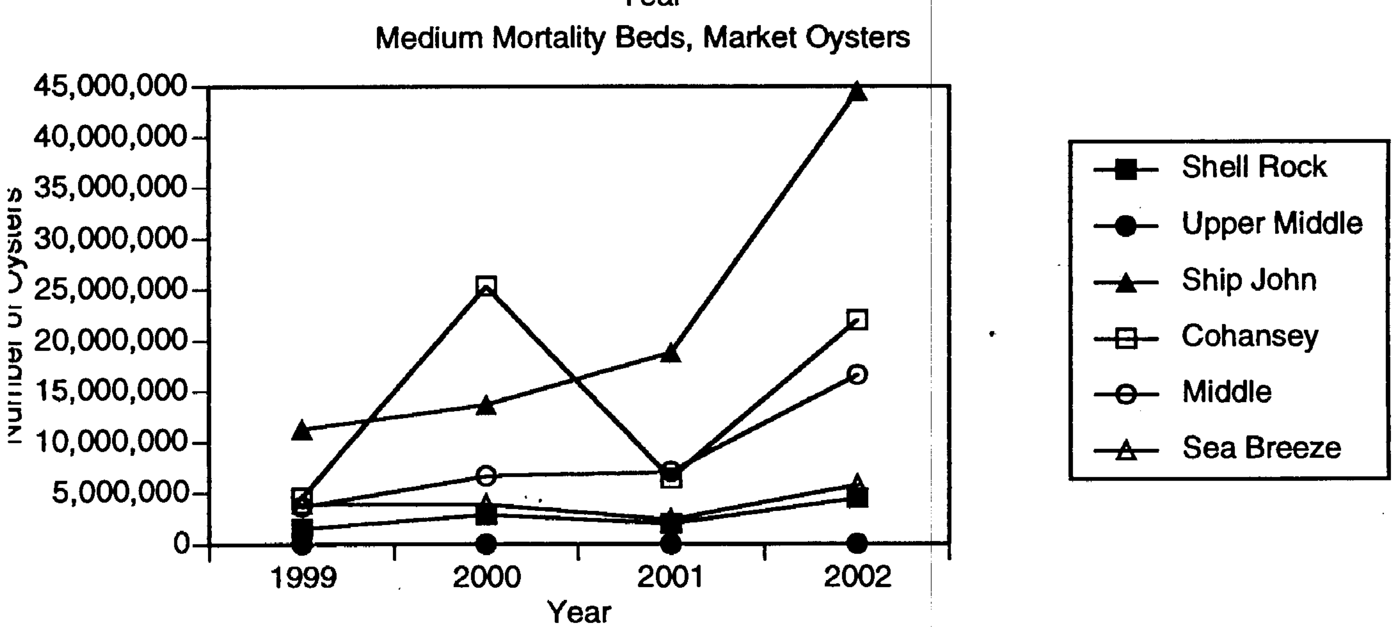

Low Mortality Beds, Juvenile Oysters
400,000,000
350,000,000
300,000,000
250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
0
Number of Oysters
1999
2000
2001
2002
Year
Arnolds
Upper Arnolds
Round Island

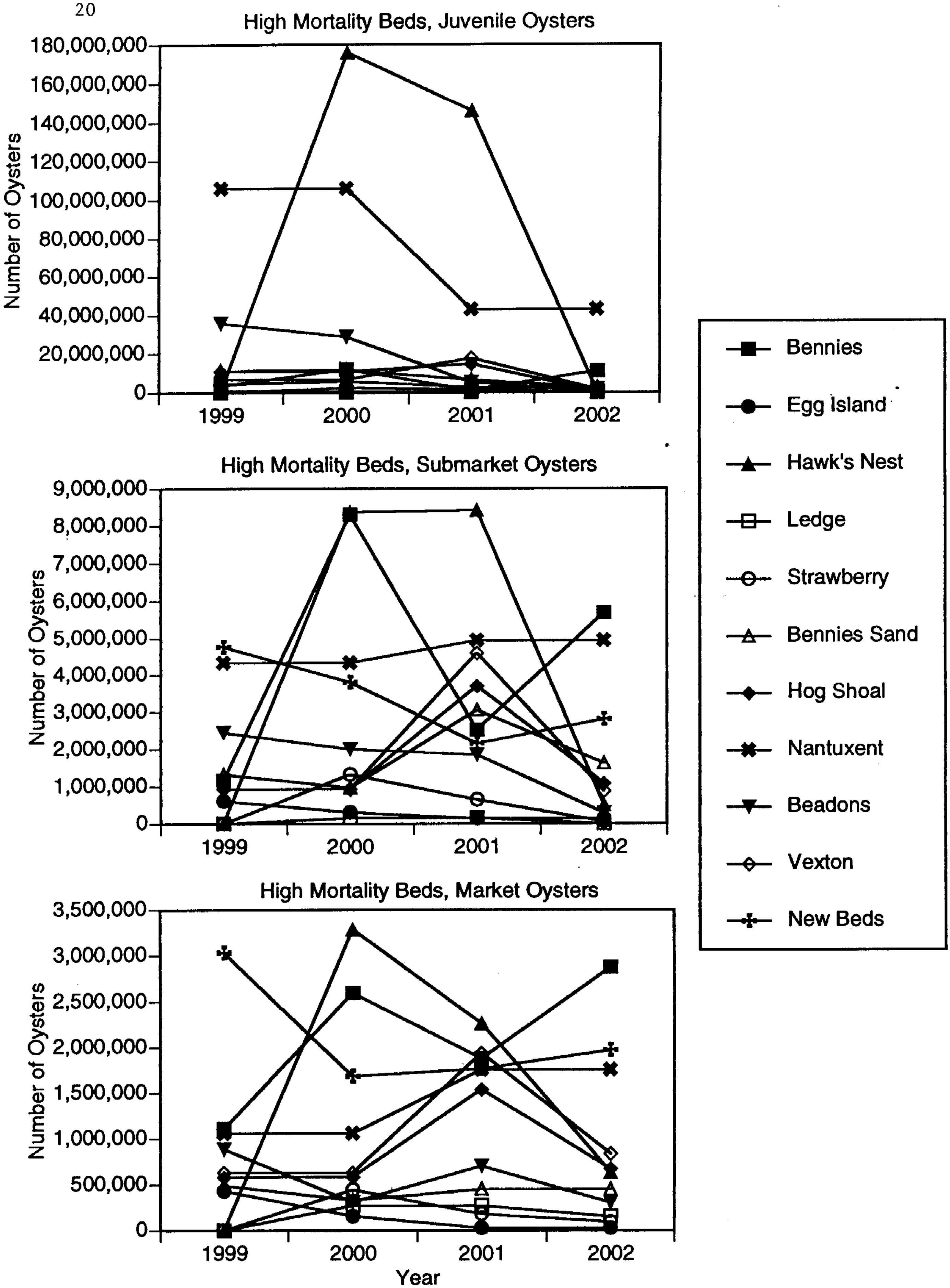

Low Mortality Beds, Submarket Oysters
20,000,000
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
Number of Oysters
1999
2000
2001
2002
Year
Arnolds
Upper Arnolds
Round Island

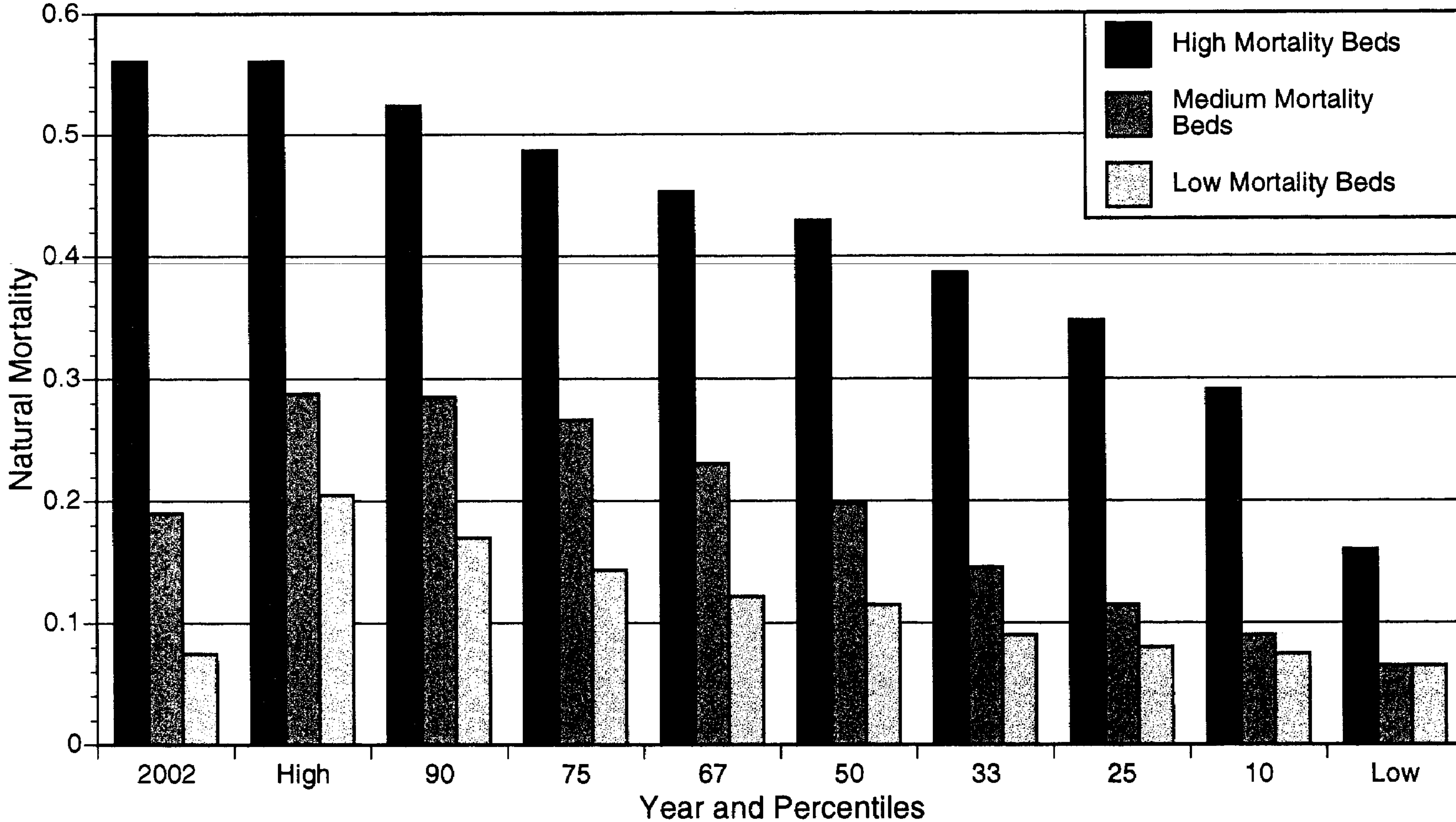

Low Mortality Beds, Market Oysters
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Number of Oysters
1999
2000
2001
2002
Year
Arnolds
Upper Arnolds
Round Island


Medium Mortality Beds, Juvenile Oysters
Number of Oysters
1,200,000,000
1,000,000,000
800,000,000
600,000,000
400,000,000
200,000,000
0
1999
2000
2001
2002
Year
Shell Rock
Upper Middle
Ship John
Cohansey
Middle
Sea Breeze


Medium Mortality Beds, Submarket Oysters
Number of Oysters
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1999
2000
2001
2002
Year
Shell Rock
Upper Middle
Ship John
Cohansey
Middle
Sea Breeze

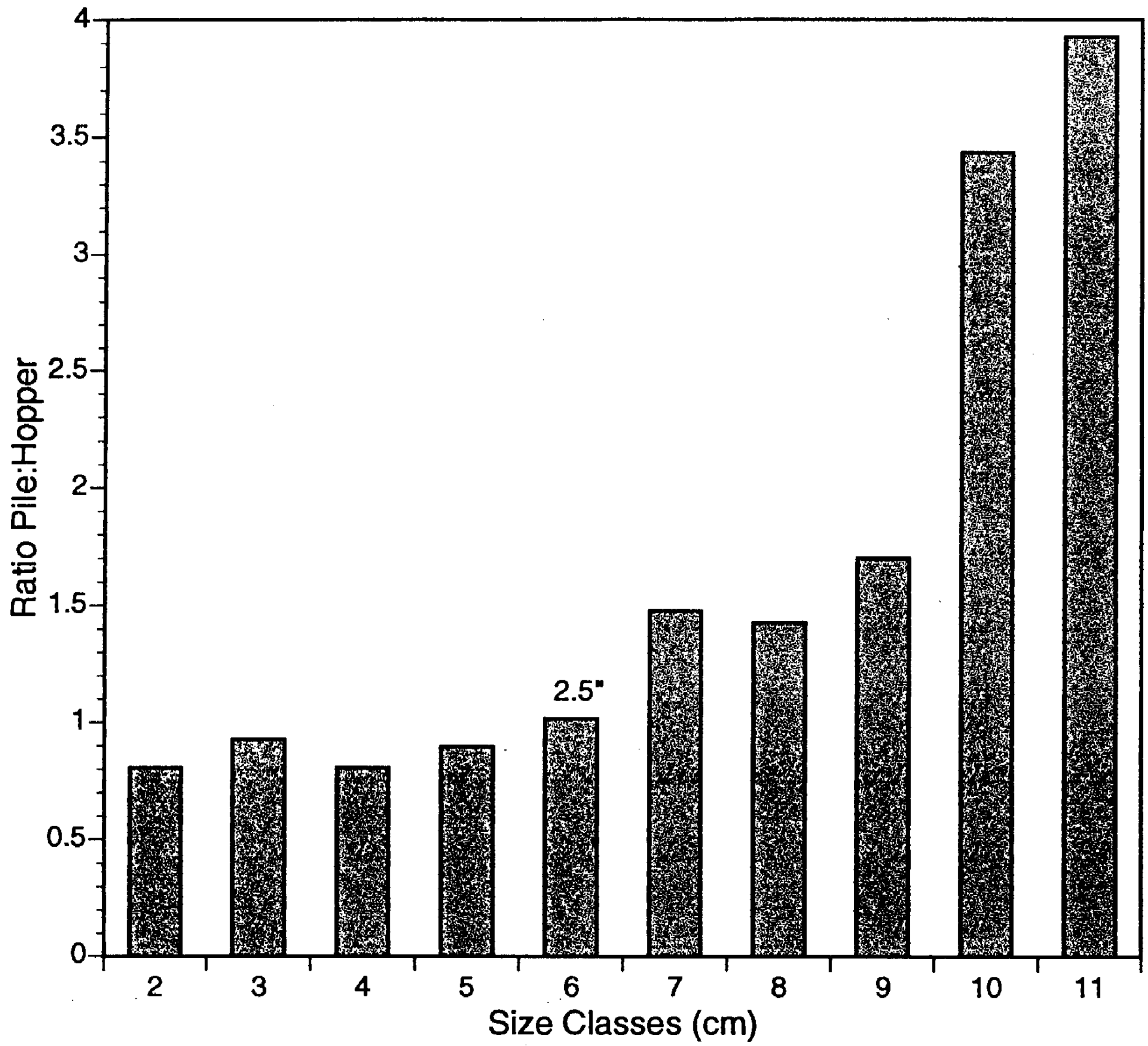

Medium Mortality Beds, Market Oysters
45,000,000
40,000,000
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
1999
2000
2001
2002
Year
Shell Rock
Upper Middle
Ship John
Cohansey
Middle
Sea Breeze

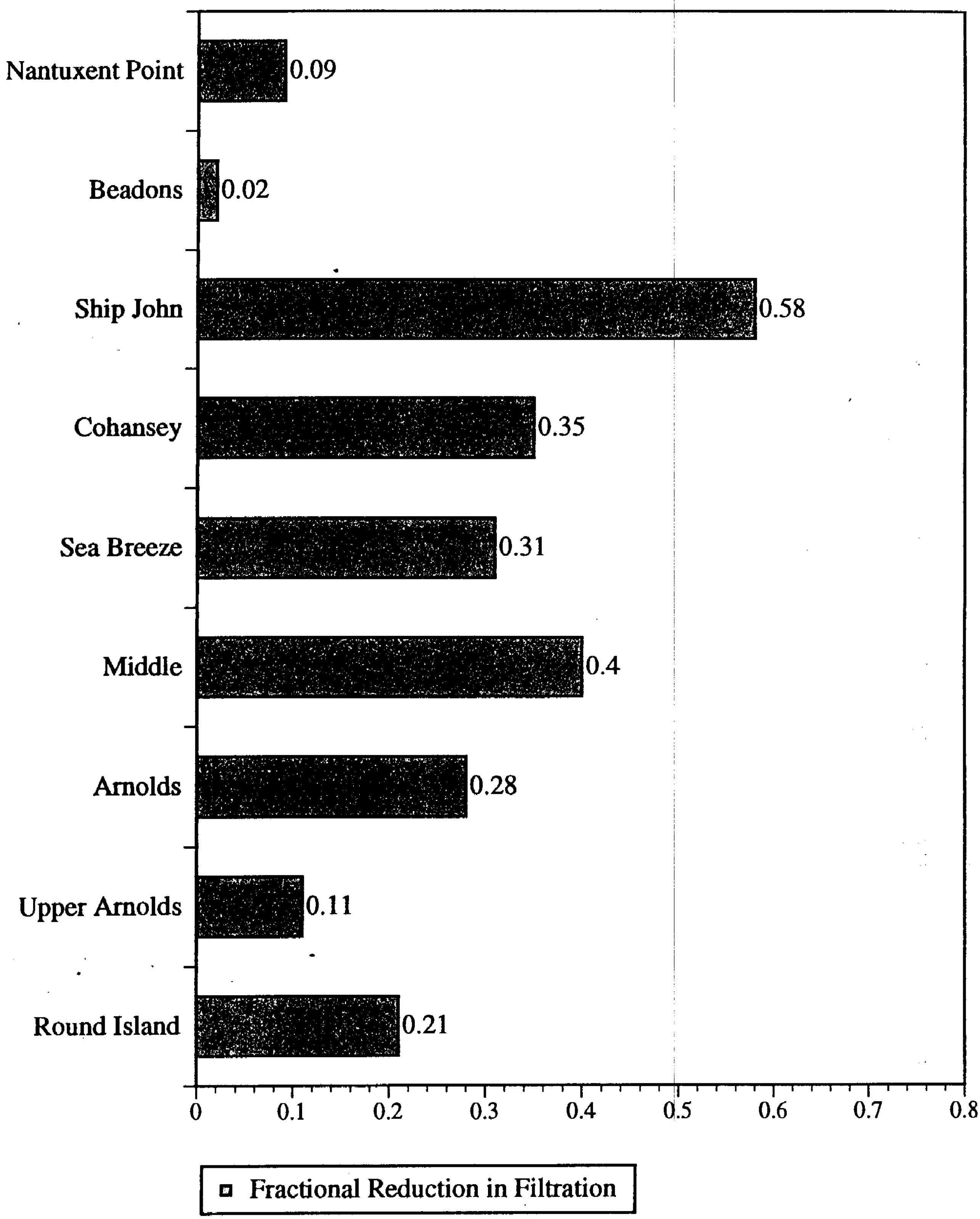

High Mortality Beds, Juvenile Oysters
Number of Oysters
180,000,000
160,000,000
140,000,000
120,000,000
100,000,000
80,000,000
60,000,000
40,000,000
20,000,000
0
1999
2000
2001
2002
High Mortality Beds, Submarket Oysters
Number of Oysters
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
1999
2000
2001
2002
High Mortality Beds, Market Oysters
Number of Oysters
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
1999
2000
2001
2002
Year
Bennies
Egg Island
Hawk's Nest
Ledge
Strawberry
Bennies Sand
Hog Shoal
Nantuxent
Beadons
Vexton
New Beds

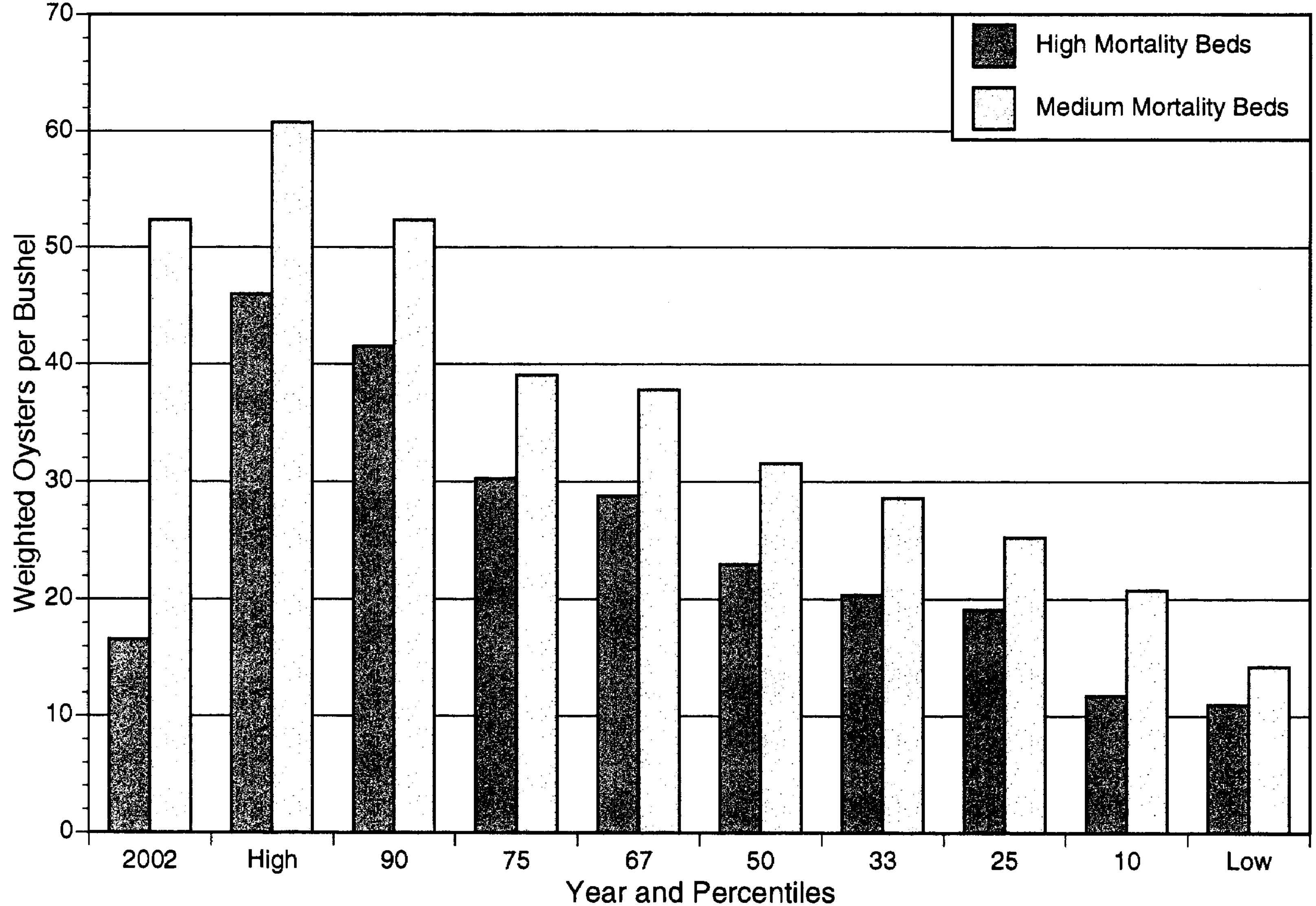


High Mortality Beds
Medium Mortality Beds
Low Mortality Beds
Natural Mortality
0.6
0.5
0.4
0.3
0.2
0.1
0
2002
High
90
75
67
50
33
25
10
Low
Year and Percentiles

Selectivity of oysters transplanted from Cohansey grid 23 in June 2002.
Normalized to 1000 oysters per bushel




Nantuxent Point
0.09
Beadons
0.02
Ship John
0.58
Cohansey
0.35
Sea Breeze
0.31
Middle
0.4
Arnolds
0.28
Upper Arnolds
0.11
Round Island
0.21
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Fractional Reduction in Filtration



High Mortality Beds
Medium Mortality Beds
Weighted Oysters per Bushel
0
10
20
30
40
50
60
70
2002
High
90
75
67
50
33
25
10
Low
Year and Percentiles