Delaware Bay Oyster Seedbed
Mortality and Disease Report for 2004

Submitted by

David Bushek
Haskin Shellfish Research Laboratory
Rutgers, The State University of New Jersey

February 7, 2005

Oyster mortality on the seedbeds is caused from a variety of factors including predation, siltation, and freshets, but since the appearance of *Haplosporidium nelsoni* (the agent of MSX disease) and *Perkinsus marinus* (the agent of dermo disease), disease mortality has been of particular concern. Fortunately, MSX disease has not been problematic for native oysters in Delaware Bay for several years, particularly on the seedbeds. Hence, aside from reporting that MSX continues to be rare and infections are generally light when detected, MSX data is not presented nor discussed in this report. During the past 15 years, dermo disease has remained a pernicious threat to oyster production on the seedbeds and is the focus of this report. The report also examines oyster growth.

Since the appearance of dermo disease in 1990, average mortality on the seedbeds, as assessed by total box counts during the fall survey, has fallen into 3 major groups: Upper, Upper Central and Central/Lower regions (Figure 1). Salinity increases from Upper to Lower regions and each region receives fresh water inputs from different tributaries along the Jersey Shore. The inputs and the geomorphological configuration of the coves influence salinity, circulation and flushing, which in turn influences the spatial and temporal prevalence and intensity of dermo disease on the seedbeds and ultimately oyster mortality.

To develop a better understanding of disease patterns and processes, five beds were routinely monitored monthly from spring through fall for mortality, disease and growth. In 2004, the NJDEP clamshell transplant on Bennies Sand was also monitored along with a July 2004 transplant of oysters from Middle to New Beds. Samples are collected from the NJDEP RV Zephyrus with assistance from NJDEP. During the fall seedbed stock assessment, samples of 20 oysters from every bed sampled (generally two grids per bed) were processed for dermo prevalence and intensity. An additional 20 oysters were collected from transplant grids for comparison. Mortality estimates were calculated as the number of boxes and gapers divided by the total boxes, gapers and live oysters (excluding spat). Dermo is diagnosed using the standard RFTM tissue assay with rectal and mantle tissues. The percent of oysters in the sample with detectable infections is termed the prevalence. Infection intensity is scored along the "Mackin scale" from zero (= pathogen not detected) to five (= heavily infected) and then averaged among all oysters in the sample to calculate a weighted prevalence. These data have been collected over a period of years to provide insight into year-to-year variation and long-term cycling.

Figures 2 through 8 present mortality, dermo prevalence and dermo infection intensity (= weighted prevalence) data from fall random sampling surveys since the appearance of dermo in

1990 (the mortality figures also include 1989 data). In general, mortality and disease increase with salinity from upper to lower seedbeds. Figures 2 through 4 show the mean bed values since 1989 or 1990 (solid bars) along with the current 2004 values (hatched bars). Beds are listed from upper to lower regions on the x-axis. The bars at the bottom of each plot show the grand means for all beds. The patterns for each parameter (mortality, dermo prevalence and dermo weighted prevalence) are strikingly similar, highlighting the general relationship between dermo disease and mortality. Note that the long-term means for beds within the same region are shaded similarly to illustrate that beds within regions tend to experience similar levels of disease and mortality. The relationship between fall dermo disease and mortality is depicted in Figure 5 where a highly significant at regression ($p < 0.001$) of mortality on weighted prevalence explains approximately 42% of the variation in mortality among beds since 1990. Note that the y-intercept is just above 10% indicating that a mortality rate of at least 10% is expected in the absence of dermo disease. That number is likely to be conservative because box count mortality estimates can only measure mortality of those animals that leave intact boxes behind and younger oysters that are less likely to die of disease are also less likely to leave behind intact boxes.

In 2004, oyster mortality and the prevalence and intensity of dermo were generally well below long-term means on all beds (Table 1, Figures 2-4). In fact, as depicted in Figures 6-8, 2004 values approached the lowest values recorded since 1990. Temperature and salinity are the two dominant factors controlling dermo disease, but they typically only explain about 50% of the variation observed. Seasonal patterns are highly correlated with seasonal temperatures and bay-wide spatial patterns typically correlate with salinity. Year-to-year fluctuations are generally correlated with local climate changes, but smaller scale patterns remain difficult to predict. In 2003 and 2004, summer water temperatures were cooler than normal (Figure 13) and watershed runoff was reportedly higher than normal. The increased flow of freshwater probably decreased disease transmission while cooler temperatures likely reduced proliferation rates within infected oysters. This combination helped reduce dermo prevalence and intensities across the seedbeds, which can then be ascribed to the reduced mortalities. The cooler temperatures also delayed oyster spawning with many oysters in spawning condition through July and a late set occurring in August. If similar conditions prevail in 2005, then dermo levels and mortality are likely to remain low. Climatic conditions, however, are often cyclical on various time scales. An examination of figures 6-8 indicates that there may be a several year cycle of mortality, dermo prevalence, and dermo intensity. If so, disease prevalence and intensity would be expected to increase in the next year or two. **Fall dermo and mortality measurements should continue to further develop our understanding of inter-annual variation.**

A notable exception to the patterns just described was the higher than average mortality on the upper seedbeds (Figure 6). This mortality cannot be attributed to dermo disease because dermo was virtually absent on these beds (Figures 3-4, 7-8). Closer inspection of the data revealed a spike in mortality in the May 24, 2004 sample, suggesting a possible connection to excessive spring runoff and subsequent freshwater kill. However, salinity measurements during collections in March, April and May were not unusually low (Figure 13). While intervening salinity levels could have been much lower, **the mortality may have resulted from disturbances associated with the April 2004 transplants from Arnolds and Upper Arnolds to Bennies Sand**. Excess sedimentation was noted during the May sampling and this may have been related to the suction boat. Moreover, bottom salinity following the passing of Hurricane Ivan in mid-September was 0.5 ppt on Arnolds bed and was not associated with any mortality despite relatively warm water temperatures (22ºC). **The fate of oysters remaining on a bed after others have been transplanted should be examined more closely along with the fate of the transplanted oysters.**

Although not considered in depth last year, May prevalence data may be a threshold predictor of fall mortalities. Figure 9 shows a regression of fall mortality on May dermo prevalence for all data collected since 1991 in which both measures were made on the same bed. The regression is significant and explains 53% of the variation. Note that the data fall into two major clusters: one cluster bounded by 30% prevalence and 30% mortality in the lower left quadrant of the scatterplot and the other above these values in the upper right quadrant. Within either of these clusters there appears to be no relationship, suggesting a possible threshold at about 30%. That is, once May dermo prevalence exceeds 30%, fall mortality will probably exceed 30%. This relationship could be tested in the coming year if a greater number of beds that will be sampled in the fall are sampled for dermo in May. If the relationship holds, summer management could be actively planned around May dermo levels. One possibility would be to focus harvesting first on those beds with 30% or higher dermo prevalence. Before doing so, however, the relationship between dermo prevalence and *Vibrio parahaemolyticus* should be determined. If dermo and *V. parahaemolyticus* are positively correlated, then the summer management strategy would be to avoid those beds during summer to protect consumers. **A direct effort should be conducted to validate the May dermo – fall mortality relationship as well as the relationship between dermo and Vibrio.**

The five beds examined monthly from March to October 2004 were (Arnolds, Cohansey, Shell Rock, Bennies and New Beds). These beds span the salinity gradient across the seedbeds. The surfclam shell transplant performed by NJDEP was also monitored along with a New Beds transplant site that received oysters from Middle bed. These samples were collected from the NJDEP vessel Zephyrus with an oyster dredge that measures 0.81 m across and holds approximately 3 bushels of material when full. The collections provide insight into seasonal disease and mortality processes and also alert the NJDEP and the industry to changes that may affect management strategies. From these samples, the size (shell height, hinge to bill) of 100 randomly selected individuals was also measured. Figure 10 shows that size remained relatively constant during most of 2004 until an apparent growth spurt at the end of the year. The exception to this was the surfclam shell transplant on Bennies. These oysters grew at a relatively constant rate of nearly 5 mm per month from April to September. The surfclam transplant oysters were all from a 2003 cohort that was easily identifiable because they were all attached to surfclam shells that are not naturally present on the bed. A comparison of mean seedbed oyster size between 2003 and 2004 is shown in the lower panel and indicates an increase in mean size of about 5 mm. This difference most likely reflects the poor recruitment that occurred in 2003. Seasonal growth is not easily observed because there is no way to measure oysters of equivalent age from sample to sample. **There is a continuing need to generate growth data to improve standing stock projections.**

In 2004, monthly estimates of mortality generally fell between 5 and 20% (Figure 11). As in past years, mortality on New Beds was substantially higher than elsewhere. The spike in mortality on Arnolds was discussed above and highlights the importance of monthly sampling in order to relate mortality events with specific events. High overwintering mortalities were evident on the clamshell transplant, but mortality of those oysters quickly fell to expected levels for the remainder of the year. Overall, monthly estimates of mortality as measure by box counts were lower in 2004 than 2003.

Dermo prevalence and intensity was erratic in 2004 compared to most years (e.g., 2003) in which levels intensify in early summer and the level of intensification corresponds to the location of the bed along the salinity gradient. That is, beds further down bay generally experience higher prevalence and intensity of dermo than beds further up bay (Figure 12). Because 2004 dermo levels were lower, mortality related to dermo was reduced during 2004.

The monthly data provides critical insight into processes affecting oyster survival on the seedbeds and should be continued. Spatial resolution during the fall sampling is minimally adequate over the seedbeds, but could be improved substantially if additional support were provided. A more gaping hole is the near lack of disease and mortality data available from down bay on the leased grounds and on the tongers beds. These areas continue to hold potential for production and are widely recognized as producing a much higher quality oyster. Directed efforts should be designed and supported to examine disease and mortality patterns in these portions of the bay.

Table 1. Comparisons of 2004 mortalities, dermo prevalence and dermo weighted prevalence with long-term averages by seedbed region. Numbers are means ±95% confidence interval.

	Percent Mortality		**Prevalence**		**Weighted Prevalence**	
Region	**2004**	**long-term**	**2004**	**long-term**	**2004**	**long-term**
Upper	15 (4)	11 (2)	1 (9)	31 (17)	0.02 (0.3)	0.4 (0.3)
Upper-Central	8 (8)	16 (3)	36 (14)	75 (10)	0.8 (0.4)	1.5 (0.5)
Central-Lower	26 (5)	36 (3)	56 (13)	92 (3)	1.3 (0.4)	2.6 (0.2)
All regions	**18 (6)**	**26 (2)**	**42 (15)**	**81 (5)**	**1.0 (0.3)**	**2.0 (0.4)**

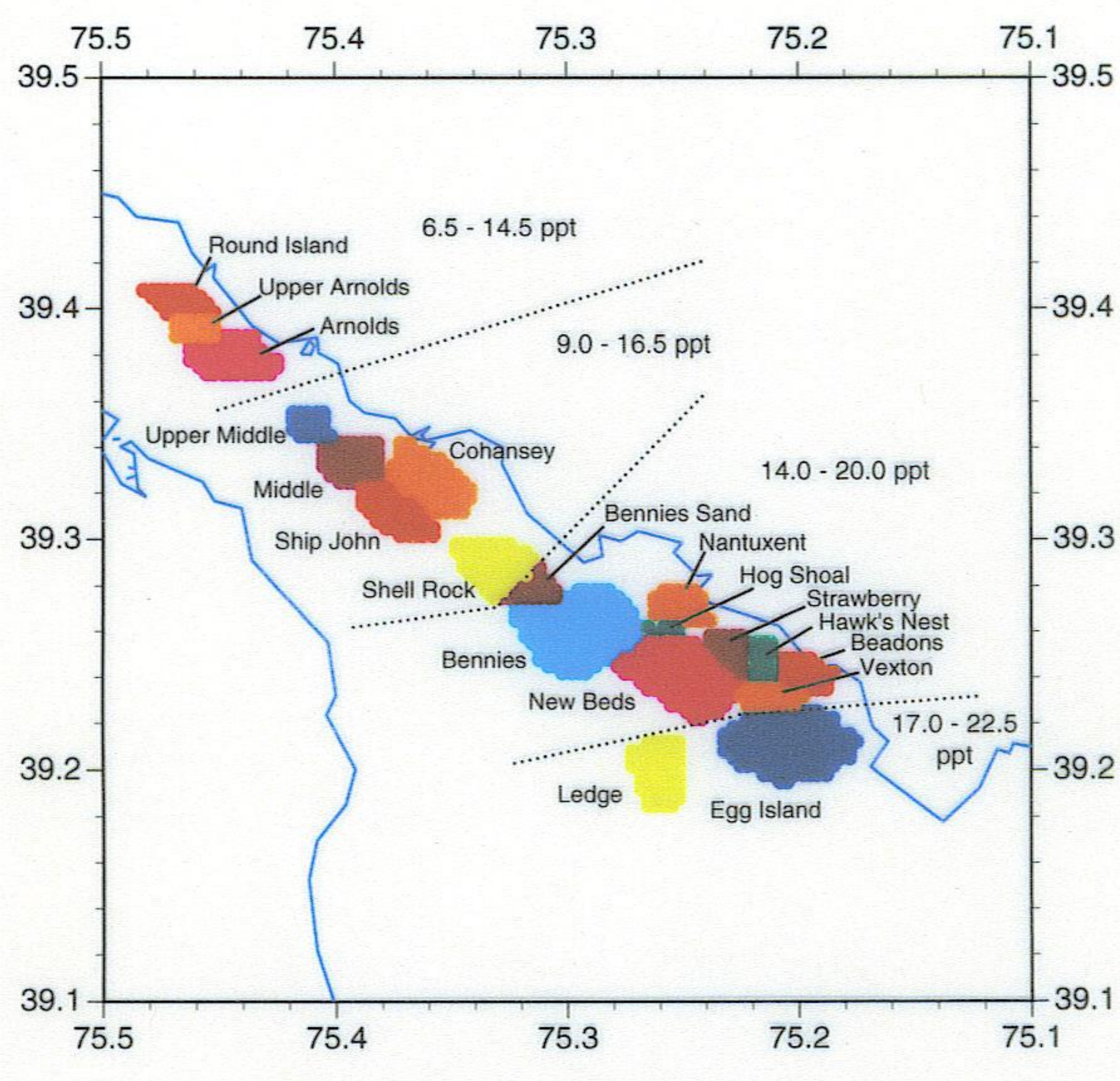


Figure 1. Delaware Bay New Jersey Natural Oyster Seedbeds. Dotted lines separate beds that tend to have similar characteristics. Salinity regimes for each region are indicated in parts per thousand.

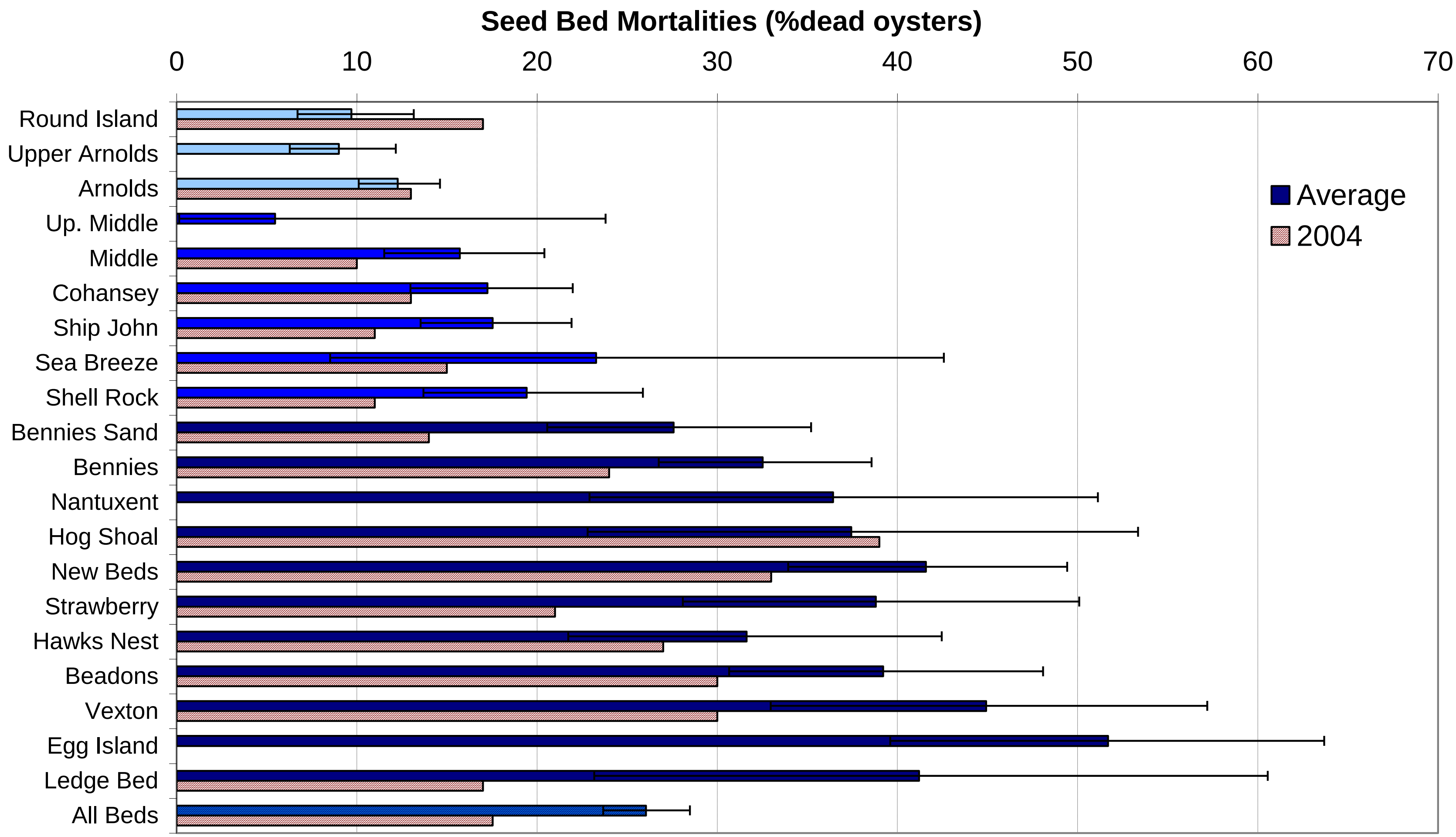


Figure 2. Comparison of average fall mortality of oysters on seedbeds since 1989 with 2004 mortality measurement. Not all seedbeds are sampled every year. With the exception of Round Island and Hog shoal, mortality on all beds was lower than the 16 year average.

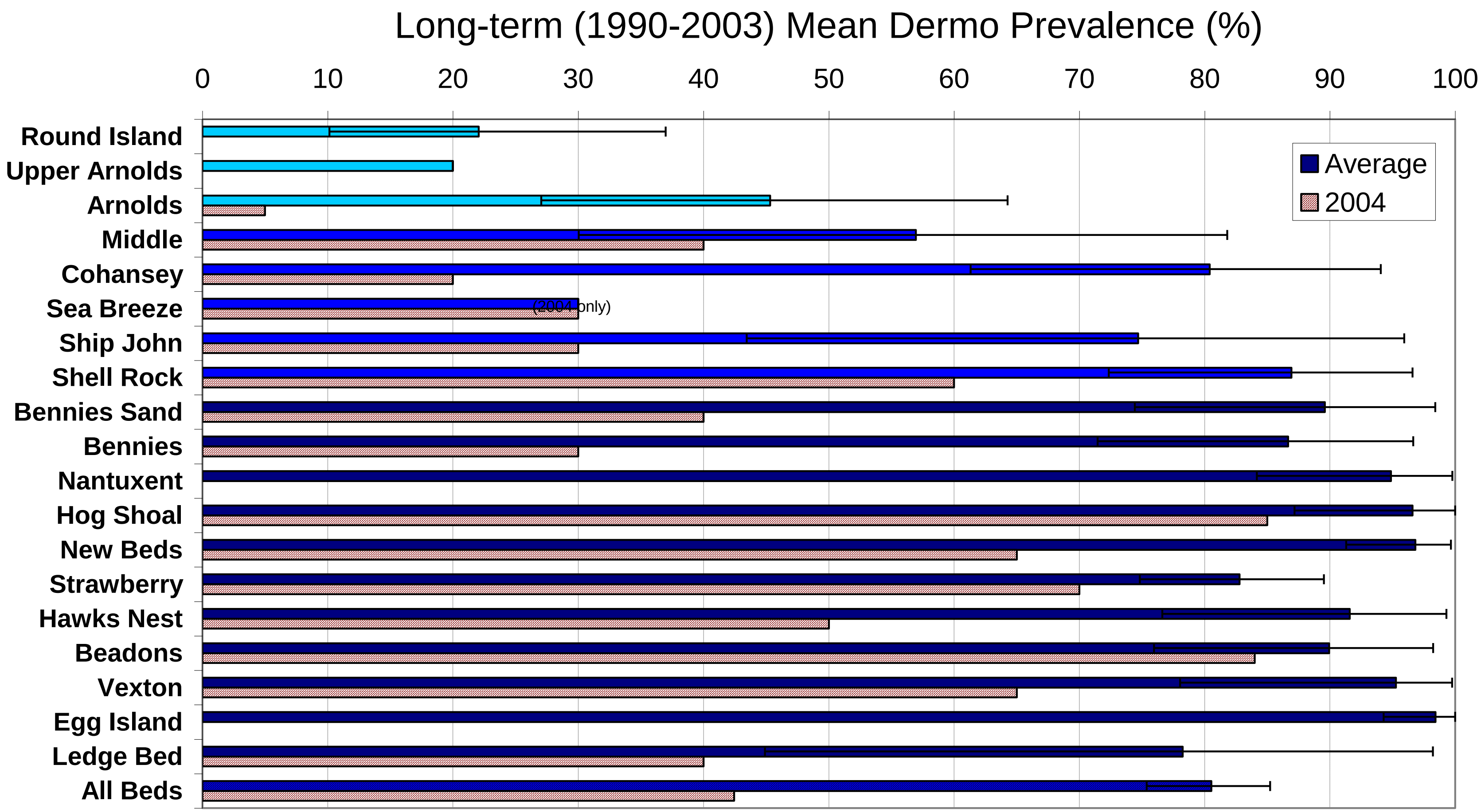


Figure 3. Comparison of average fall prevalence of *Perkinsus marinus* (dermo) in oysters on seedbeds since 1990 with 2004 prevalences. Not all beds are sampled every year – no dermo was present on Round Island in 2004. Prevalences in 2004 were lower than 15 year averages on all beds sampled.

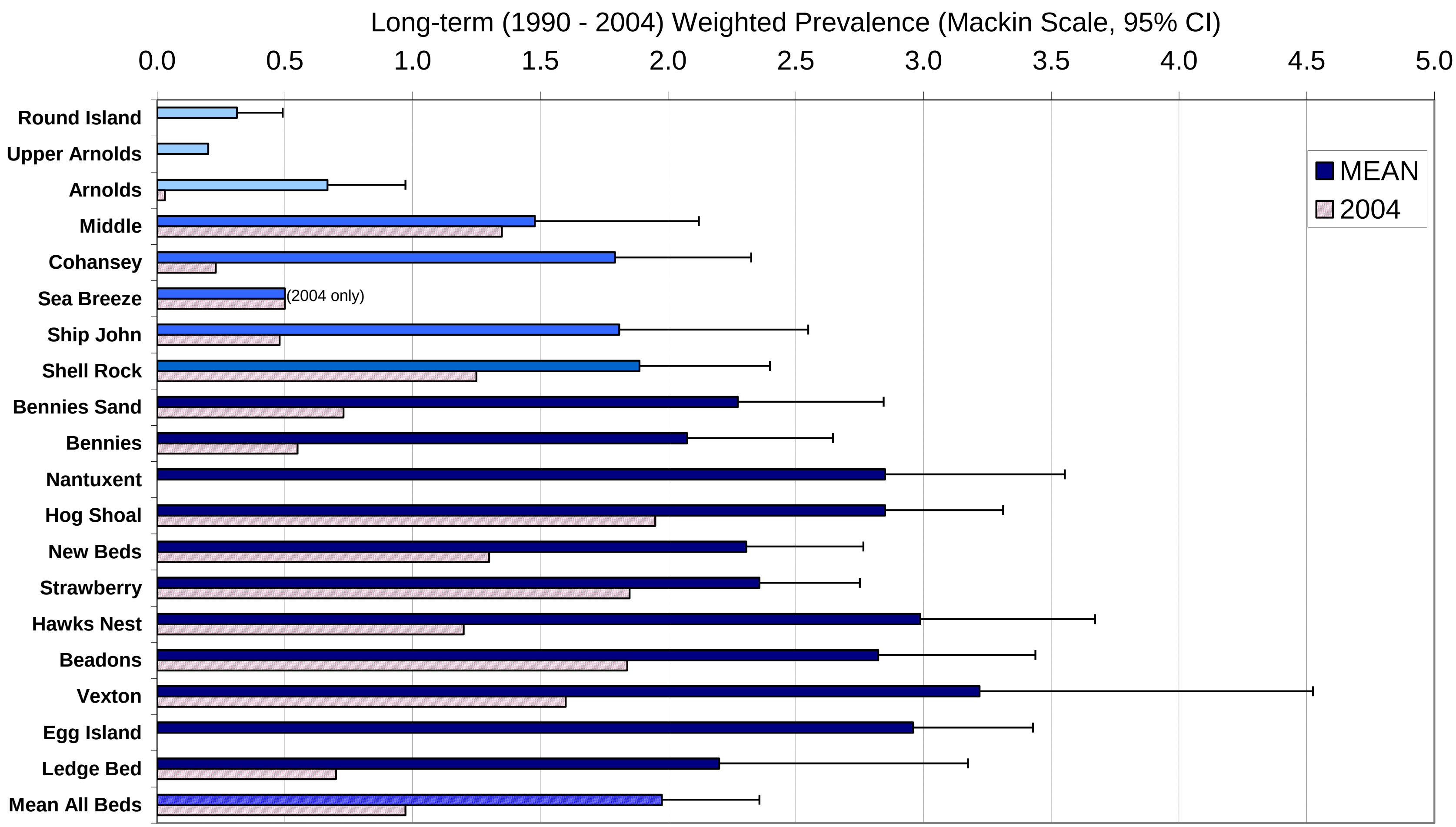


Figure 4. Comparison of average fall dermo infection intensities (weighted prevalence) in oysters on seedbeds since 1990 with 2004 levels. Not all beds are sampled every year – No dermo was present on Round Island in 2004. Infection intensities in fall 2004 were lower than 15 year averages on all beds sampled.

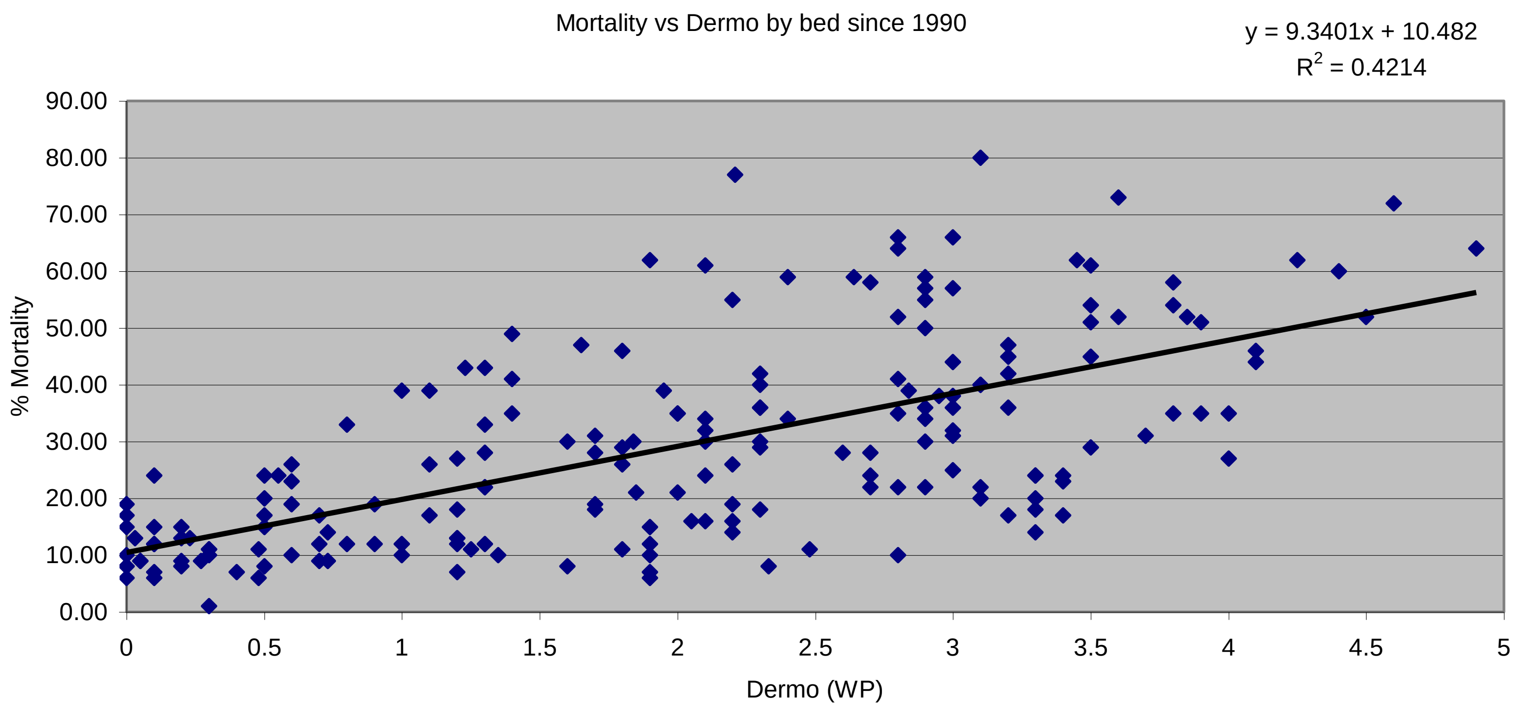
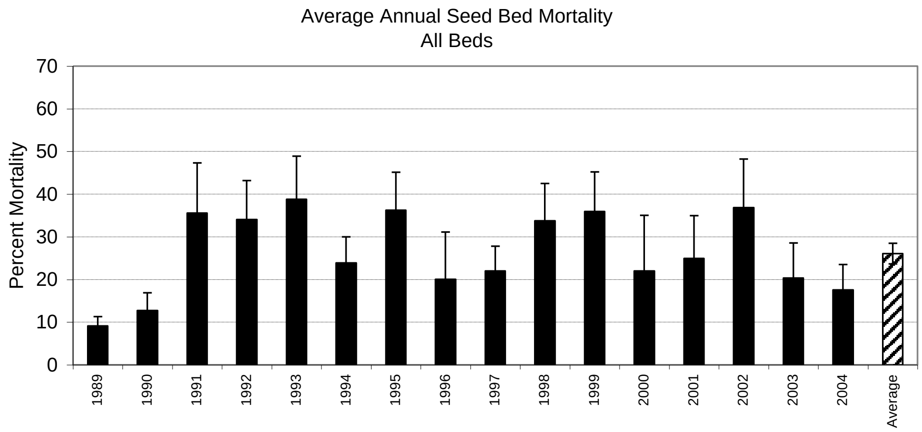
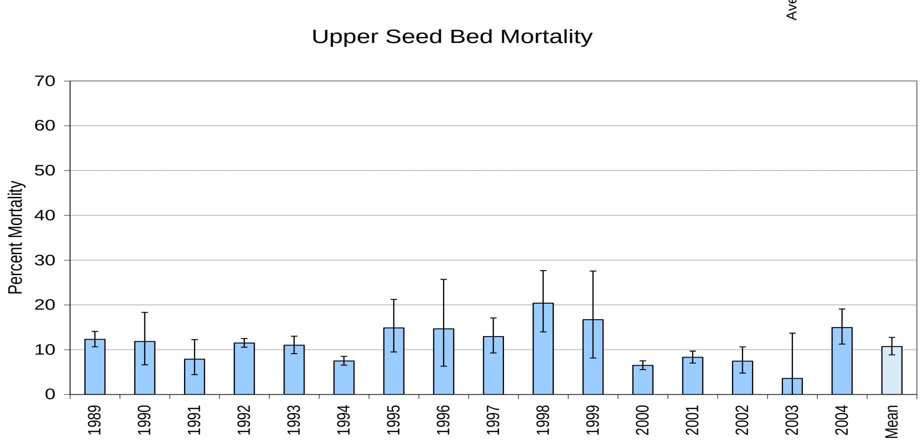
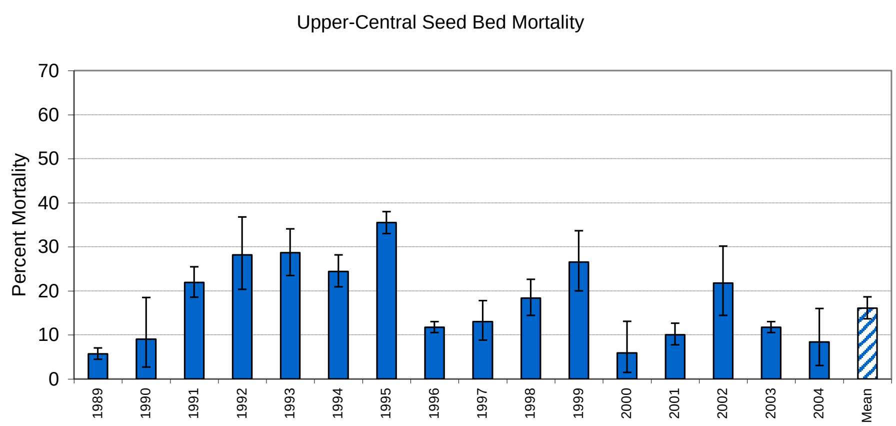


Figure 5. Relationship between percent mortality on a bed and the intensity of dermo infections on seedbeds since 1990.







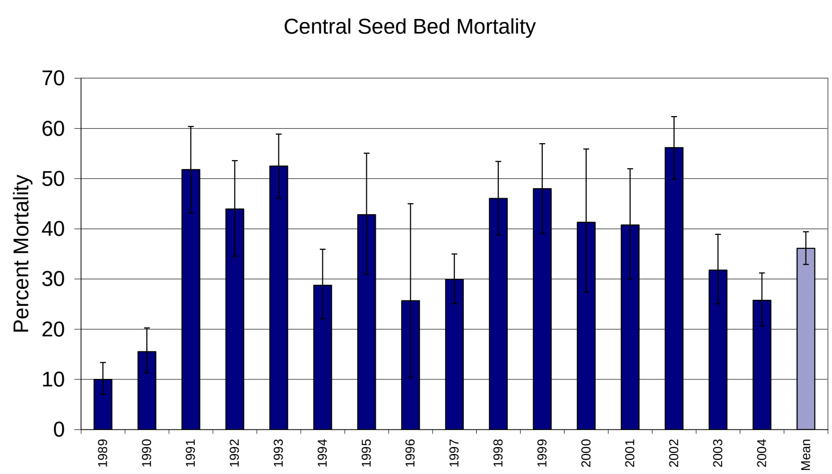


Figure 6. Annual mortality of oysters on seedbeds.

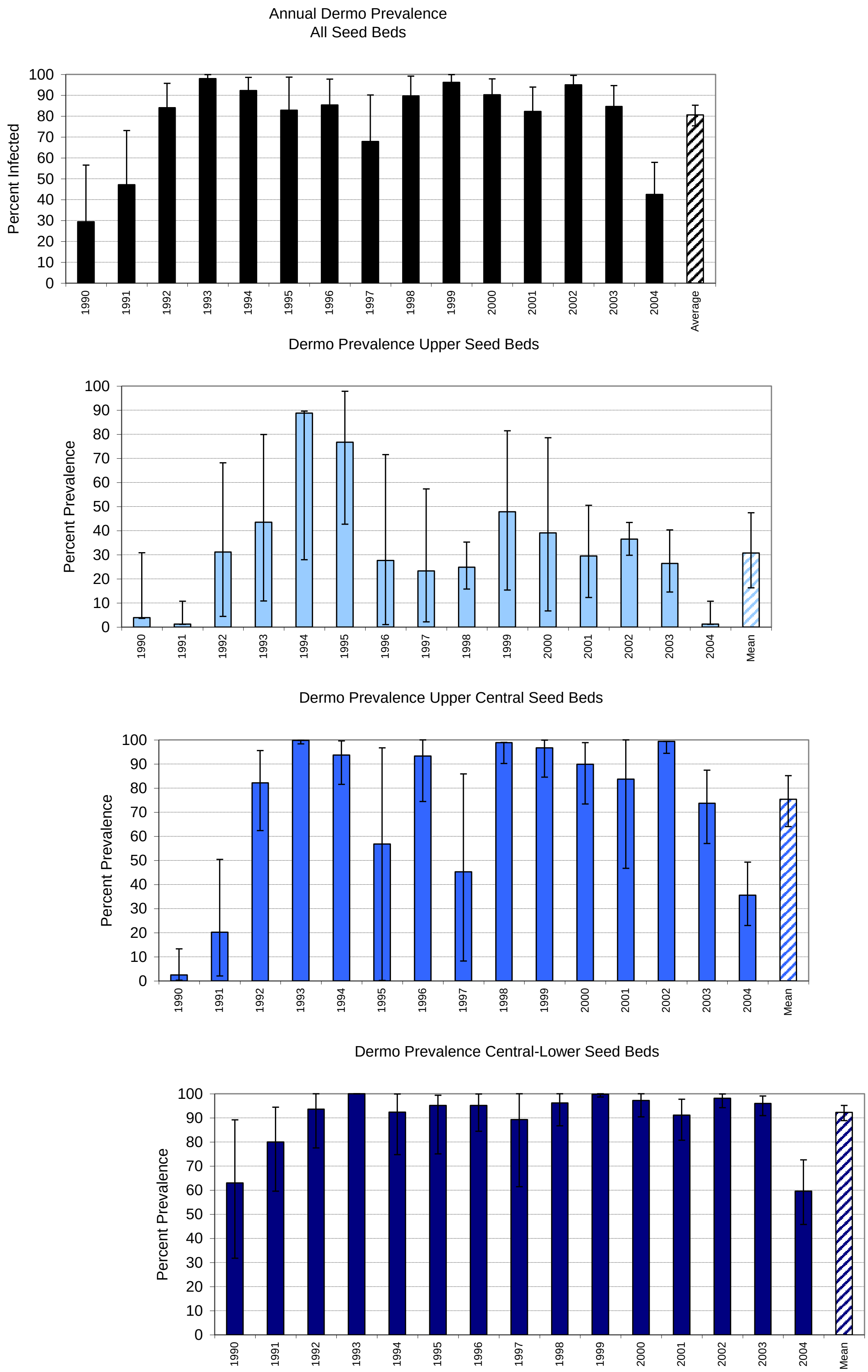
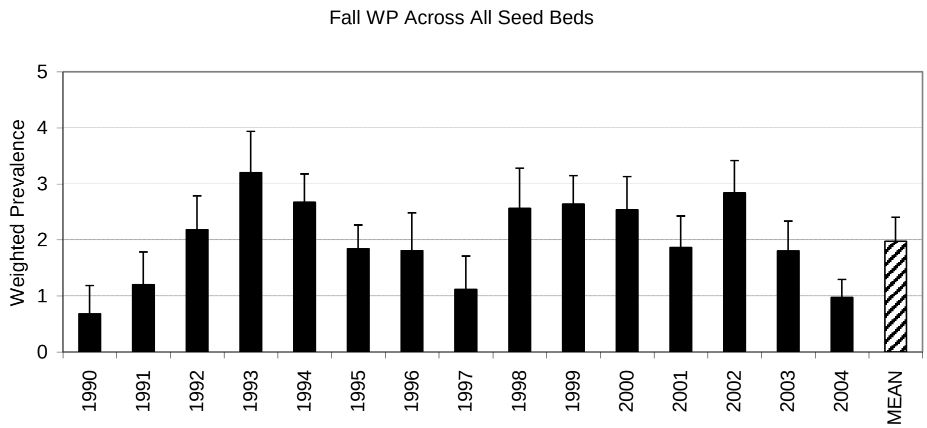
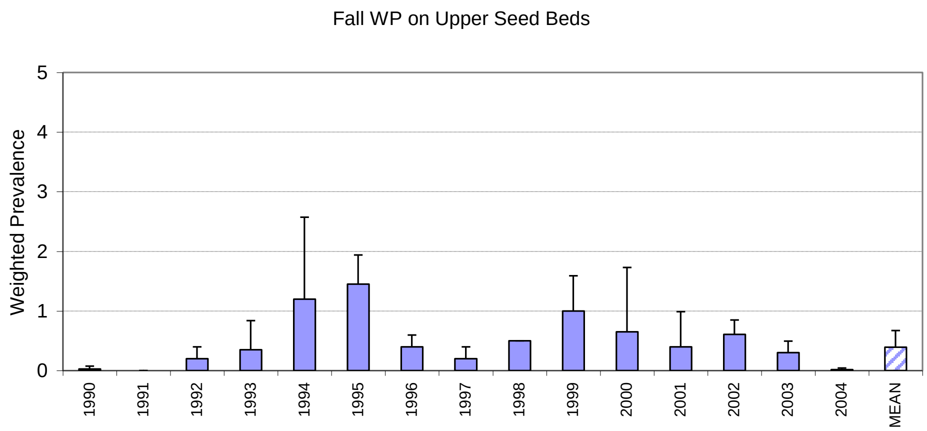
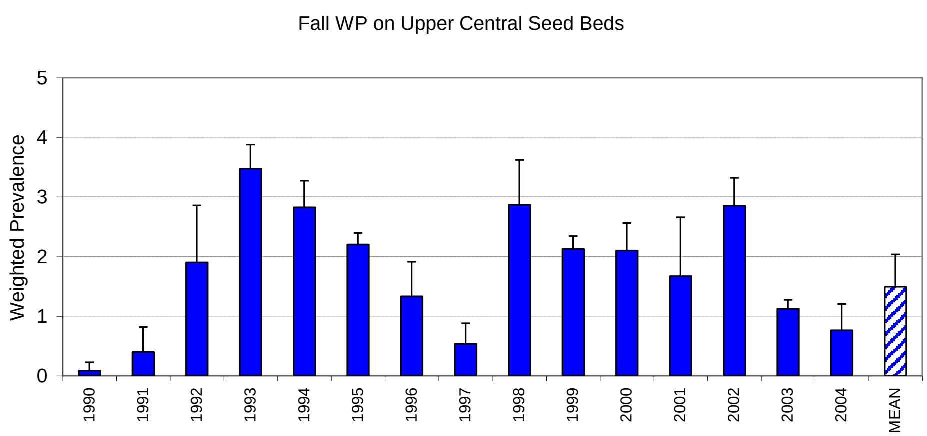


Figure 7. Annual mean dermo prevalence in seedbed oysters.







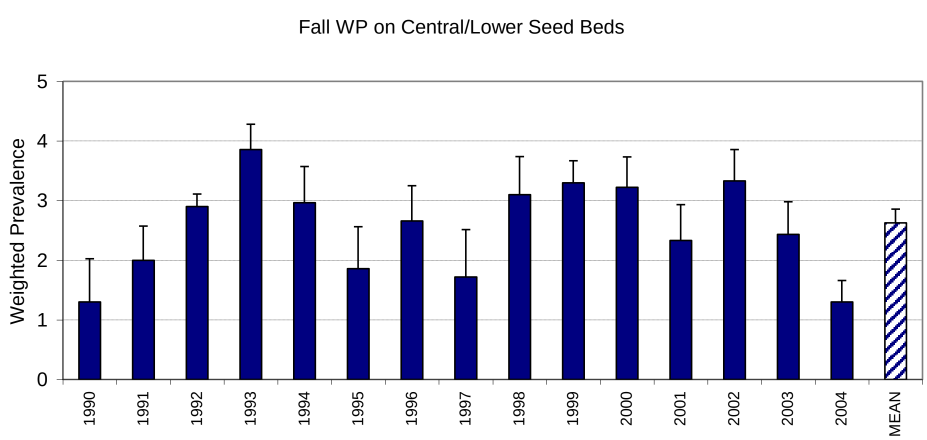


Figure 8. Annual mean dermo infection intensity in seedbed oysters.

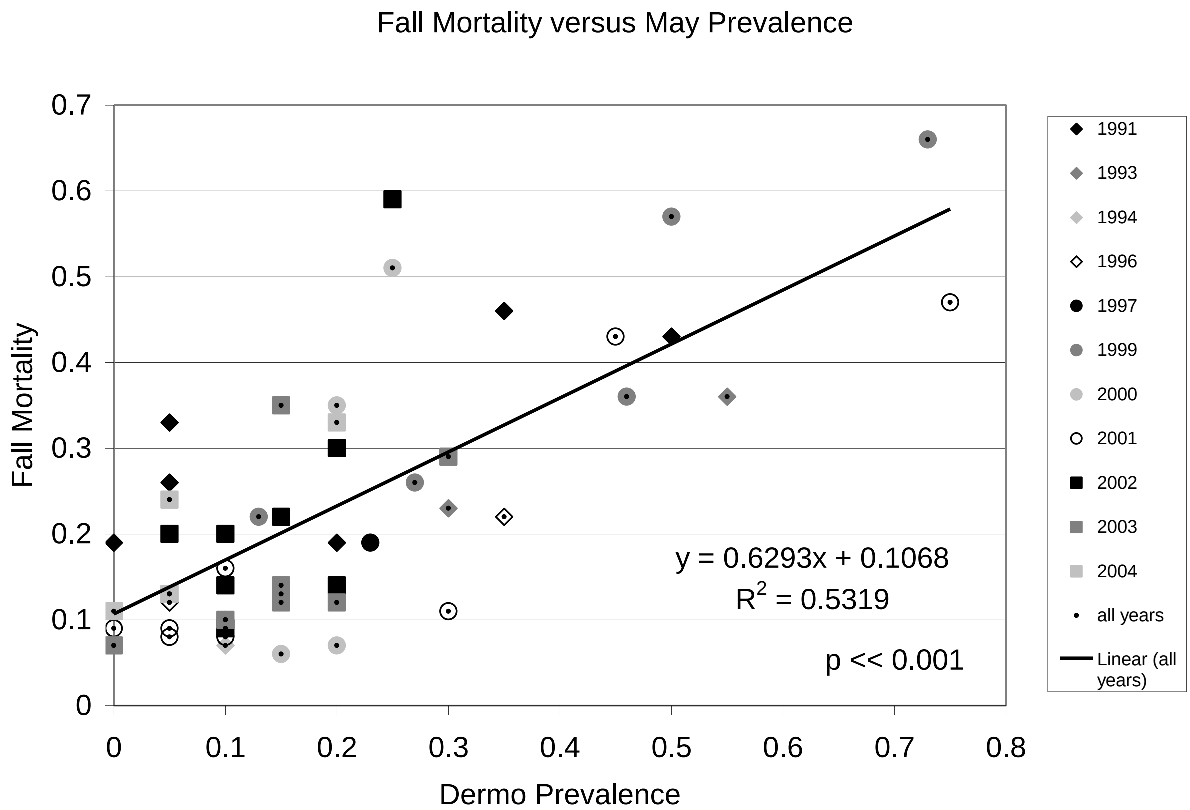
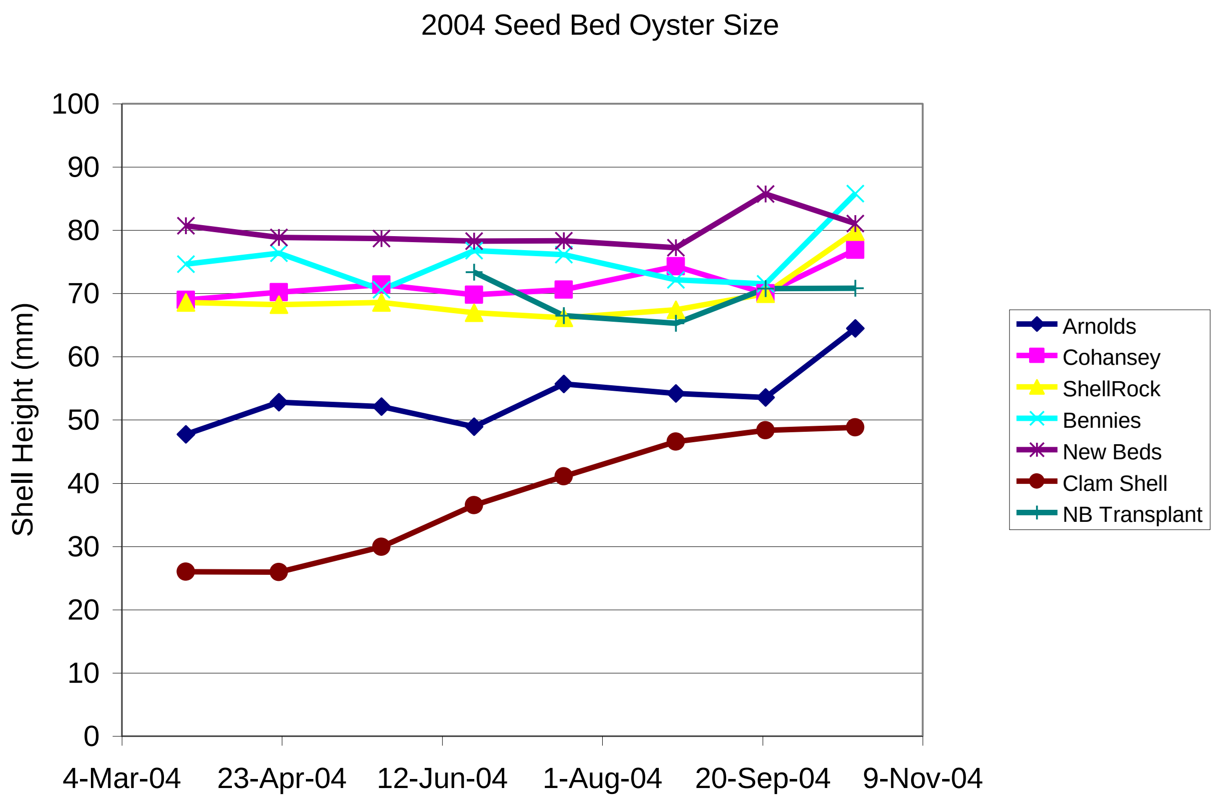


Figure 9. Plot of fall mortality rates on beds against corresponding May dermo prevalence.



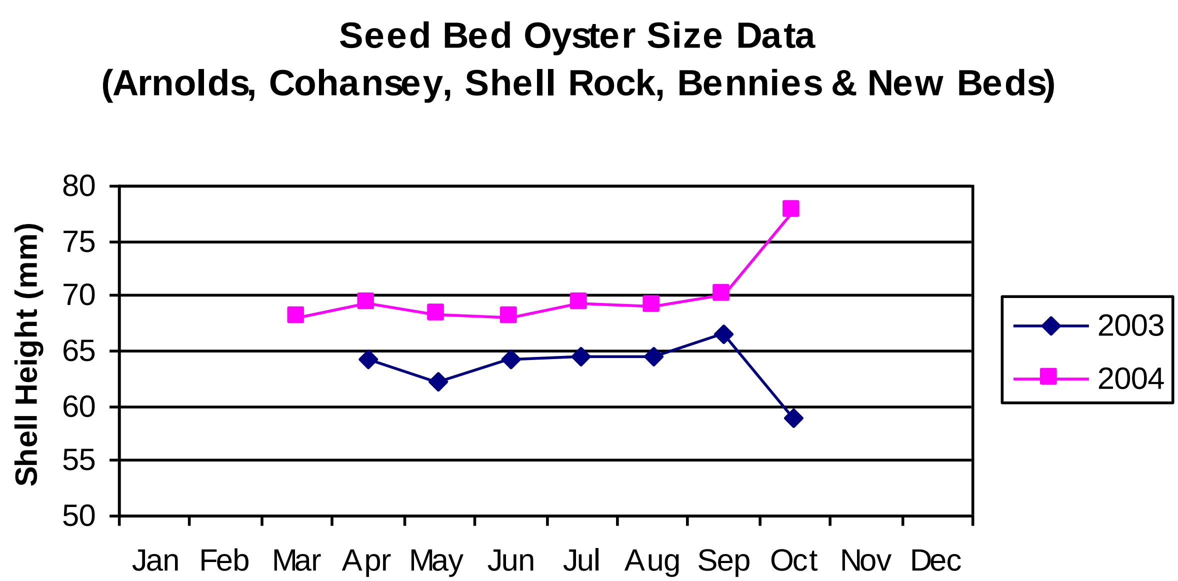
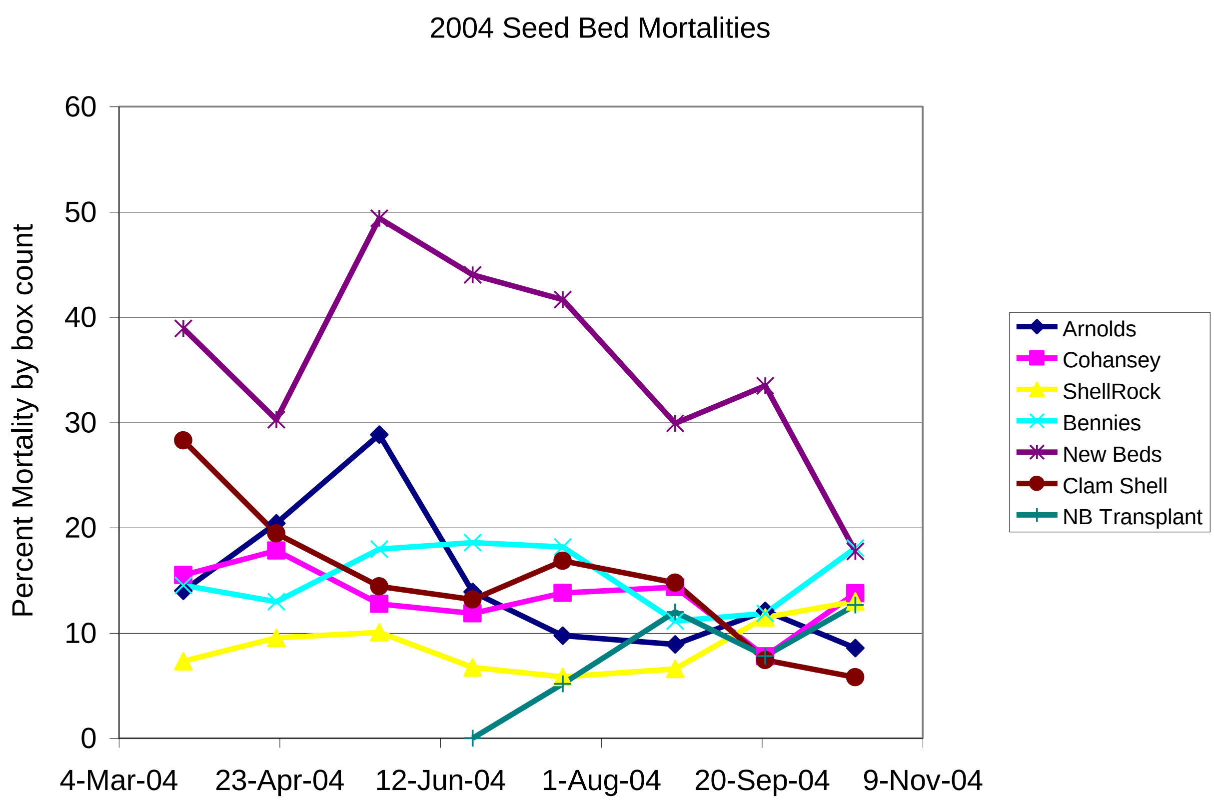


Figure 10. Changes in mean oyster shell height on selected seedbeds during 2004. Lower panel compares mean values from 2004 with means from 2003.



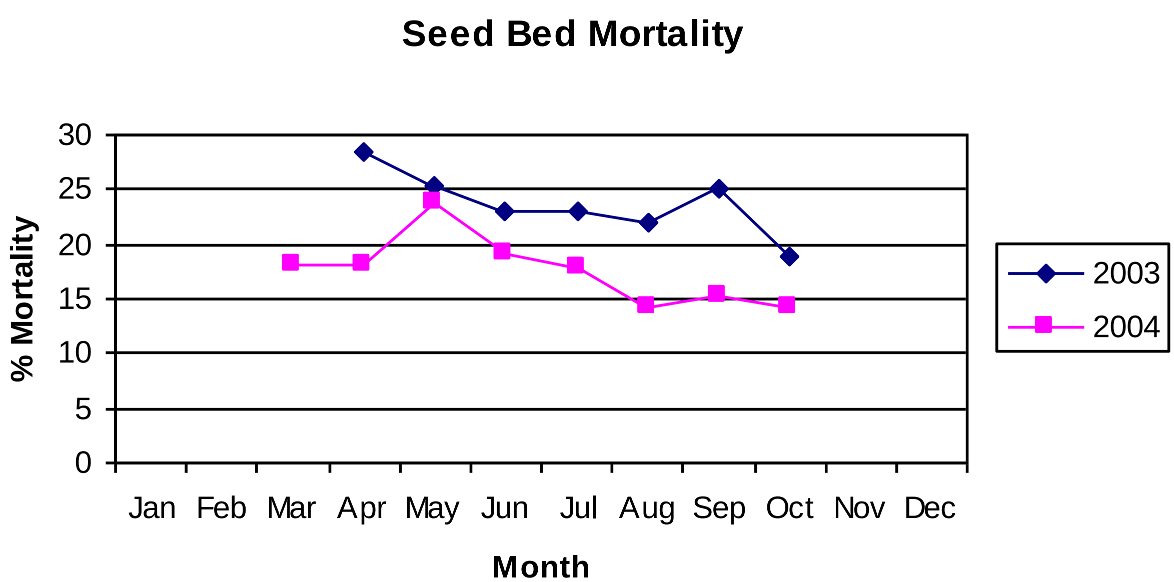


Figure 11. Changes in oyster mortality, measured by box count, on selected seedbeds during 2004. Lower panel compares mean values from 2004 with means from 2003.

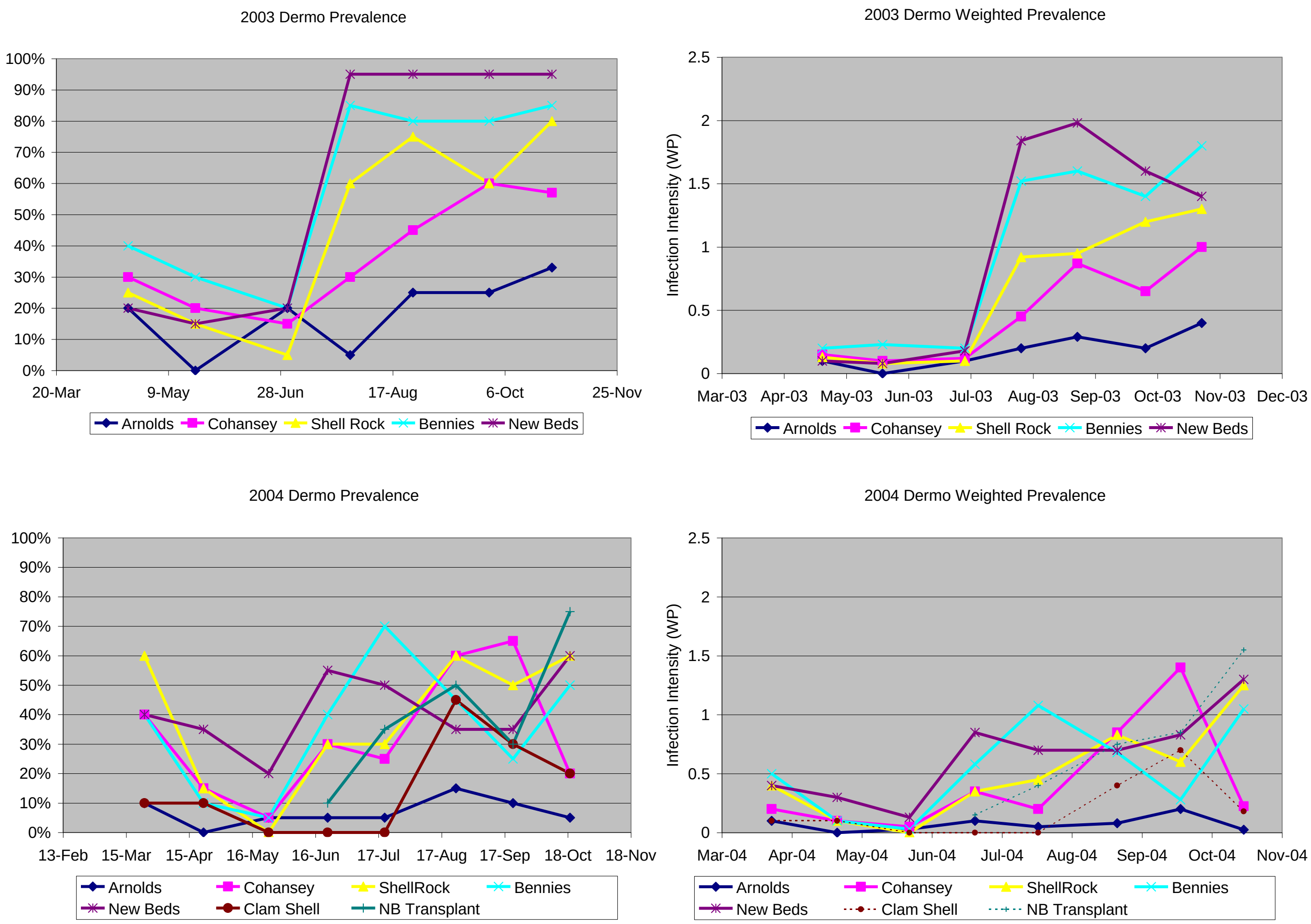


Figure 12. Comparison of seasonal changes in dermo prevalence (left panels) and dermo intensity (right panels) during 2003 (upper panels) and 2004 (lower panels).

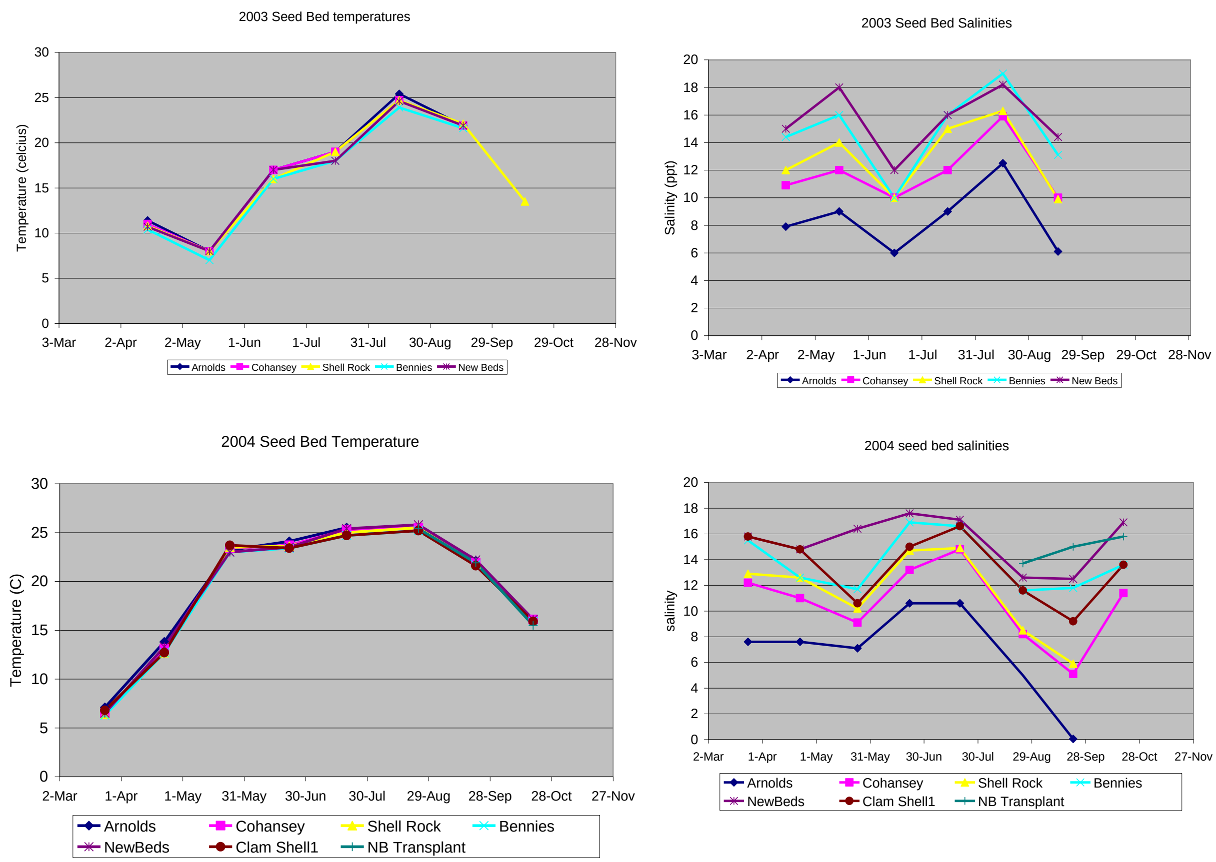


Figure 13. Comparison of seasonal changes in temperture (left panels) and salinity (right panels) during 2003 (upper panels) and 2004 (lower panels).