



Executive Summary of the 2006 Stock Assessment Workshop (8th SAW) for the New Jersey Delaware Bay Oyster Beds

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Status of the Stock

Figure 1 summarizes the condition of the oyster stock throughout the New Jersey waters of Delaware Bay and by bay region in comparison to the 1989-2005 period. This period is chosen because the advent of Dermo as a major influence on population dynamics began in 1989/1990 and evidence indicates a substantive change in population dynamics as a consequence. In particular, average mortality rates are up, the frequency of epizootics is up, the average abundance is down, and the average recruitment rate is down with respect to the 1953-1988 time period.

The stock at the end of 2005 presents a mixture of positive and negative indicators that approximately balance. Oyster abundance declined slightly in 2005 to the lowest level since the onset of Dermo disease circa 1989 and to one of the lowest levels in the 1953 to 2005 record (Figure 2). Declines were concentrated on the medium-mortality beds upbay of Shell Rock. Elsewhere, abundance increased and this increase approximately balanced the reduction in abundance on the medium-mortality beds that was anticipated at SAW-7. The expansion of the stock from its consolidation on the medium-mortality beds that has occurred over the last few years through range contraction is a positive sign, although it exposes the stock to a higher level of natural mortality if Dermo disease intensity rises.

Spawning stock biomass is still low bay-wide, but rose in 2005. Increases were noted in all bay regions upbay of and including Shell Rock, reaching or exceeding median levels for the 1990-2005 time period (Figure 3). SSB remained stable on the high-mortality beds. Increases in SSB coincided with increases in condition index, that reached historical highs bay-wide in 2005.

Recruitment remains low bay-wide and particularly low on the medium-mortality beds (Figure 4). Recruitment rose above 50 spat per bushel only on Upper Arnolds, Arnolds, and Bennies Sand. As a consequence of the former two, an above-average recruitment event occurred on the low-mortality beds in comparison to most years since 1991. Evidence exists that low spat abundance is associated with low adult abundance, although the explanation for this trend is controversial. The trend implies, however, that high recruitment may be less likely under current conditions of low abundance. The number of spat per >20-mm oyster was 0.340; insufficient to sustain the present population. The ratio of spat to oysters has been lower than the 2-year replacement level over five of the last 6 years and below that anticipated from the broodstock-recruitment relationship, suggesting that low adult abundance is not a sufficient explanation for the low recruitment of the last few years. The origin of this trend is lower recruitment in comparison to standing stock upbay of Shell Rock. Shell Rock and the high-mortality beds have been recruiting at a level at or exceeding the 2-year replacement level for most of the decade.

Inadequate recruitment upbay of Shell Rock has resulted in a population size

frequency deficient in the smaller oyster size classes, particularly on the medium-mortality beds. This year, however, surplus production is expected to permit an increase in market-size abundance bay-wide, given average mortality rates, in the absence of fishing. Surplus production is anticipated to be negative on the medium-mortality beds in 2006, but the reduction in abundance of market-size individuals anticipated should be much smaller than observed in 2005. Positive surplus production will occur in all other bay regions, with a substantial increase in market-size abundance on Shell Rock and downbay, barring a higher than average rate of natural mortality and not counting removals by the fishery. This continues the trend of positive surplus production on these downbay beds, due to high growth rates and relatively good recruitment in an otherwise low-recruitment time period.

Dermo disease continued to be low in 2005 and natural mortality rates were well below average. Natural mortality, bay-wide, was 12% of the stock in 2005, a relatively typical non-epizootic mortality rate (Figure 5). Natural mortality was unusually high on the low-mortality beds. A rising trend in Dermo disease prevalence may presage increased rates of natural mortality in 2006, given facilitative environmental conditions.

The 2005 harvest removed 0.9% of the stock and 1.9% of the spawning stock biomass, with most of the harvest coming from Shell Rock, Nantuxent Point, Hawk's Nest, Bennies, and Cohansey. Fishery exploitation levels since 1989 appear to be very low (<2% of abundance per year). Recent improvements in collection of fishery-dependent data indicate that exploitation in terms of biomass has been $\leq 4\%$ in the last few years. Low exploitation rates indicate that the fishery does not have a significant effect on the stock and that fishing mortality is not responsible for the current conditions of low abundance.

Overall, the conditions on the medium-mortality beds upbay of Shell Rock continue to be disadvantageous, whereas the remaining bay regions appear to have improved since 2004. Specific target and threshold abundances and spawning stock biomasses were defined for the first time in this SAW. In 2005, for the low-mortality beds, abundance fell below the abundance target set at the median abundance for that bay region during the 1989-2005 time period, and just below the threshold value of abundance, set at half that value (Figure 6). SSB fell above the equivalently-derived SSB target value (Figure 6). For the medium-mortality beds, 2005 abundance values fell below the threshold value; however, SSB fell above the target (Figure 6). Shell Rock abundance fell below the threshold value for this bed and SSB fell near target. Abundance on the high-mortality beds also fell below the abundance threshold, while SSB fell near the target (Figure 6). The fact that all bay regions fell at or below their abundance thresholds indicates that actions to enhance abundance are needed. These are ongoing. A recruitment enhancement program begun in 2005 increased recruitment on Shell Rock and Bennies Sand by

about 50%. A pilot program in 2003 has about doubled market-size abundance on Bennies Sand.

2006 Management Goals

Evidence indicates that the oyster stock varies in its population dynamics within bay regions and, as a consequence, management goals must be established separately for each region. Two alternatives are provided for setting management goals in each bay region. Since 1998, a constant-abundance reference point has been used successfully for Shell Rock and the high-mortality beds. Under this reference point, fishing allocation is determined by the surplus production of the population in each region. The use of a natural mortality rate above the 50th percentile, such as the 75th percentile, incorporates into this reference point a rebuilding plan than can be expected to increase market-size abundance in most years and which guards against a high level of overfishing in epizootic years. An alternate, exploitation-based reference point also is provided. The exploitation reference point recognizes that the fishery has been successfully prosecuted at relatively low exploitation levels since 1995 and that this record permits the promulgation of an exploitation-based reference point based on the median exploitation rate, defined in terms of the fraction of abundance removed, for each bay region for the years 1996-2005. The exploitation reference point, in particular, provides alternatives for bay regions where transplant options are more likely to be chosen.

Shell Rock and the high-mortality beds have provided most of the fished animals since 1995 because market quality is consistently high. The SARC recognizes the need to manage these beds conservatively. The constant-abundance approach using a projection of surplus production has proven itself in this area and contains adequate precaution. Harvest levels at variance to those suggested by surplus production projections should be considered carefully. Given the importance of Shell Rock in maintaining both the industry and oyster population, the SARC recommends that Shell Rock be independently and more conservatively managed than the high-mortality beds.

The low-mortality beds are best used to replace abundance downbay in support of fishery removals when low recruitment downbay makes transplantation of this upbay resource useful. The present low-abundance period represents such a time. Transplanting options and an exploitation reference point are needed to manage these beds under this circumstance. Transplantation scenarios should be devised to minimize the distance downbay that the animals are moved to permit increased survival of the many juvenile-size animals.

The medium-mortality beds contributed the bulk of the stock supporting the fishery over the 1996-2005 direct-market period, albeit indirectly through transplant to replace animals fished from the beds farther downbay. These beds must be

included in the fishery; otherwise the pressure on the downbay beds will be too high. A complex array of options exists to manage these beds. Direct-marketing has proven effective in some years and it is inherently a preferred option as it retains juveniles on these beds where survival is high. Direct-marketing should be encouraged as the management option of choice. Alternatively, market-size animals transplanted downbay might be marketed after a 6-week period to increase market quality. Culling machines can successfully concentrate the larger animals when properly operated, making this a viable option.

Allocation projections based on the constant-abundance reference point

<u>Bay Region</u>	<u>Natural Mortality Percentile (market-equivalent bushels)</u>	<u>Allocation</u>
High-Mortality	75 th	1,461
	67 th	13,476
	50 th	21,880
Shell Rock	75 th	13,606
Medium-Mortality	75 th	0
Low-Mortality	75 th	9,227

Note that the surplus-production option assumes efficient culling of market-size individuals or direct-marketing. Inefficient culling for transplant requires the use of the exploitation reference point presented subsequently, as the constant-abundance reference point assumes removals of market-size animals only. The SARC recommends consideration of a range of harvest levels for the high-mortality beds based on projections using a range of natural mortality probabilities.

Allocation projections based on the abundance-based exploitation reference point

<u>Bay Region</u>	<u>Percentile</u>	<u>Exploitation Rate</u>	<u>Number of Animals Removed</u>	<u>Efficient Cull or Direct-market Bushels</u>	<u>Population Oysters/Bu</u>	<u>Deck-load Transplant Bushels</u>	<u>Deck-load Marketable Bushel Equivalents</u>
High-Mortality	40 th	.03675	4,216,860	15,735			
	50 th	.03964	4,548,470	16,972			
	60 th	.04396	5,044,170	18,822			
Shell Rock	40 th	.05391	2,657,810	9,917			
	50 th	.05556	2,739,150	10,221			
	60 th	.05600	2,760,850	10,301			
Medium -Mortality	40 th	.00806	3,536,180	13,195	179	19,755	6,757
	50 th	.01551	6,804,740	25,391	179	38,015	13,003
	60 th	.01855	8,138,480	30,368	179	45,466	15,551
Low-Mortality	50 th	.00034	84,013	313	182	461	28
	60 th	.00176	434,888	1,623	182	2,389	147
	75 th	.01507	3,723,730	13,895	182	20,460	1,258

Note that transplanting options are not provided for Shell Rock and the high-mortality beds assuming that these regions will be used exclusively for direct marketing. Note that transplant options will require transplant before the allocation derived therefrom can be set. Note that allocation values obtained from downbay transplants of oysters from the medium-mortality and low-mortality beds will likely fall in between the 'Efficient Cull' column and the 'Deck-load' column for the medium-mortality and low-mortality beds, depending on culling efficiency.

The following chart splits the medium-mortality beds into two groups based on the expectation that direct-marketing is most feasible on Cohansey, Ship John and Sea Breeze.

<u>Bay Region</u>	<u>Percentile</u>	<u>Exploitation Rate</u>	<u>Number of Animals Removed</u>	<u>Efficient Cull or Direct-market Bushels</u>	<u>Population Oysters/Bu</u>	<u>Deck-load Transplant Bushels</u>	<u>Deck-load Marketable Bushel Equivalents</u>
Cohansey, Ship	40 th	.00806	2,713,006	10,123	179	15,156	5,679
John, Sea	50 th	.01551	5,220,550	19,480	179	29,165	10,929
Breeze	60 th	.01855	6,243,950	23,299	179	34,882	13,070
Middle, Upper	40 th	.00806	823,174	3,072	179	4,599	1,078
Middle	50 th	.01551	1,584,190	5,911	179	8,850	2,074
	60 th	.01855	1,894,530	7,069	179	10,584	2,481

Caveats Apropos to Risk for 2007 Fishery Yield

Management options for 2006 provided in the preceding tables permit a relatively wide range of possible 2006 fishery allocations. Increasing Dermo disease and continued uncertainty in recruitment, plus the fact that the shell-planting program will not provide an increase in harvestable resource for 2007 suggests that moderation in setting 2006 allocation goals may be desirable. Specific observations include the following.

1. Consideration should be given to managing the high-mortality beds under the constant abundance reference point with a percentile no lower than the 67th to protect this area against an epizootic. Coincidence of a higher fishing rate with an epizootic would likely result in a significant reduction in the 2007 quota and epizootic mortality rates are possible in 2006.
2. Since 1998, the fishery has rarely exceeded 1.5% of the stock and this has lent stability to the resource and minimized year-to-year variations in allocation. A 1.5% exploitation in 2006 equates to an allocation of 47,793 bu. The surplus production value assuming a median mortality rate (the 50th percentile) for the bay equates to a harvestable quota of 45,640 bushels, very near the 1.5% value. Given anticipated above average mortality in 2006, a quota significantly exceeding the range of 45,000 to 47,000 substantially increases the risk of a quota reduction in 2007.
3. Although the exploitation rate for the low-mortality beds does not realize a significant addition to the 2006 quota, it is important to move animals downbay

from Arnolds/Upper Arnolds to the Shell Rock area to mitigate the effect of the 2006 fishery in this area of the bay. This should be done prior to the season opening and will provide animals necessary to support the fishery in 2007.

4. A drop of SSB below SSB threshold levels while abundance remains at the levels expected to be present at the end of 2006 will likely result in a bay-wide closure. A quota set at 1.5% of the stock will likely remove 3-4% of SSB. That is, the fishery can move SSB closer to the SSB threshold value much more rapidly than it can modify abundance. The tenuous status of abundance in all four bay regions at the end of 2005 argues for conservative management in 2006 to minimize the chance of a decline in SSB and a concomitant bay closure in coming years.

Figure 1. Summary status of the stock for 2005. Green (+) indicates variables judged to be above average. Red (-) indicates variables judged to be below average. Average, indicated by a '0', is defined as within the central 40% of the range of conditions. Judgments concerning trend, e.g., improving, are relative to the previous one or two years. Spatial extent refers to the dispersion of the stock across the salinity gradient.

	Whole Stock		Low Mortality		Medium Mortality		High Mortality	
Spawning stock biomass	-	improving	0	improving	0	improving	0	stable
Abundance	-	stable	-	improving	-	degrading	-	improving
Recruit abundance (spat)	-	stable	+	improving	-	stable	0	stable
Juvenile Abundance (1-2.5 in)	-	degrading	0	improving	-	degrading	0	degrading
CPUE	0	stable						
Growth	+	?						
Dermo infection intensity	+	degrading	+	stable	+	degrading	+	degrading
Condition index	+	improving	+	improving	+	improving		improving
Spat / adult	0	stable	+	improving	-	stable	-	stable
Spatial extent	-	improving						
Natural mortality	+	stable	-	stable	+	degrading	+	degrading
Surplus production @ median mortality	+	improving	+	improving	-	stable	0	stable
Surplus production @ 75-percentile of mortality	-	degrading	+	improving	-	degrading	0	stable

Figure 2. Time series of abundance by bed region. High-mortality: Beadons, Nantuxent Point, Strawberry, Hog Shoal, Vexton, Hawk's Nest, New Beds, Egg Island, Ledge, Bennies, Bennies Sand; medium-mortality less Shell Rock: Ship John, Cohansey, Sea Breeze, Middle, Upper Middle; low mortality: Arnolds, Upper Arnolds, Round Island.

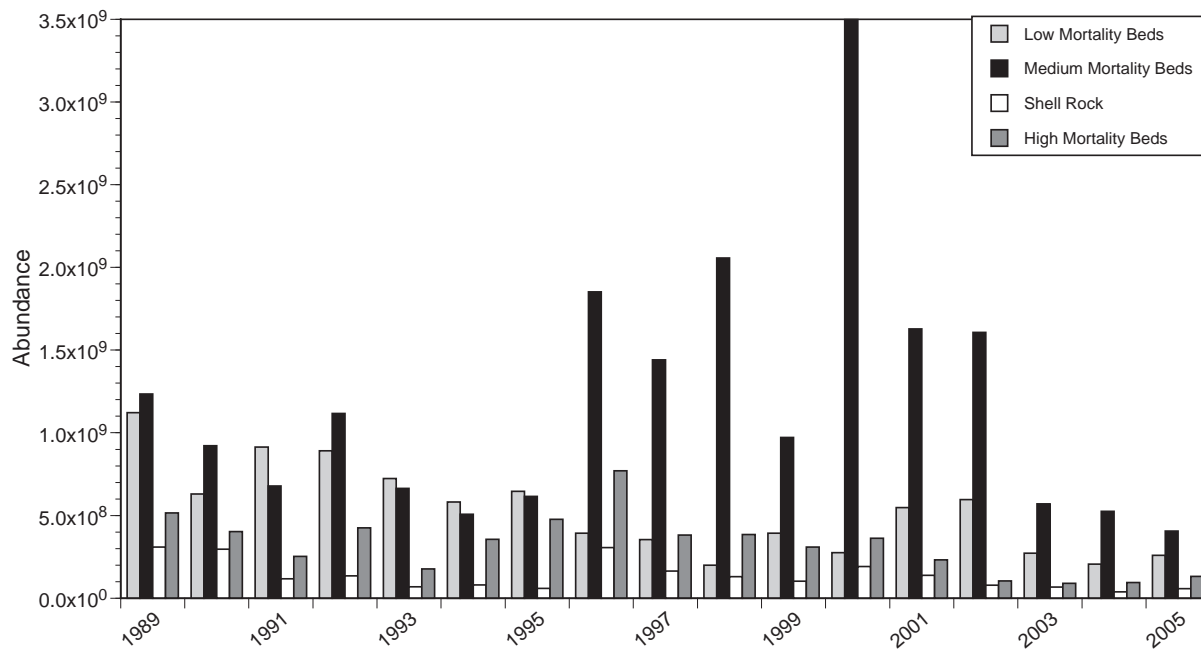


Figure 3. Time series of spawning stock biomass by bed region. Bed distributions by region are given in Figure 1.

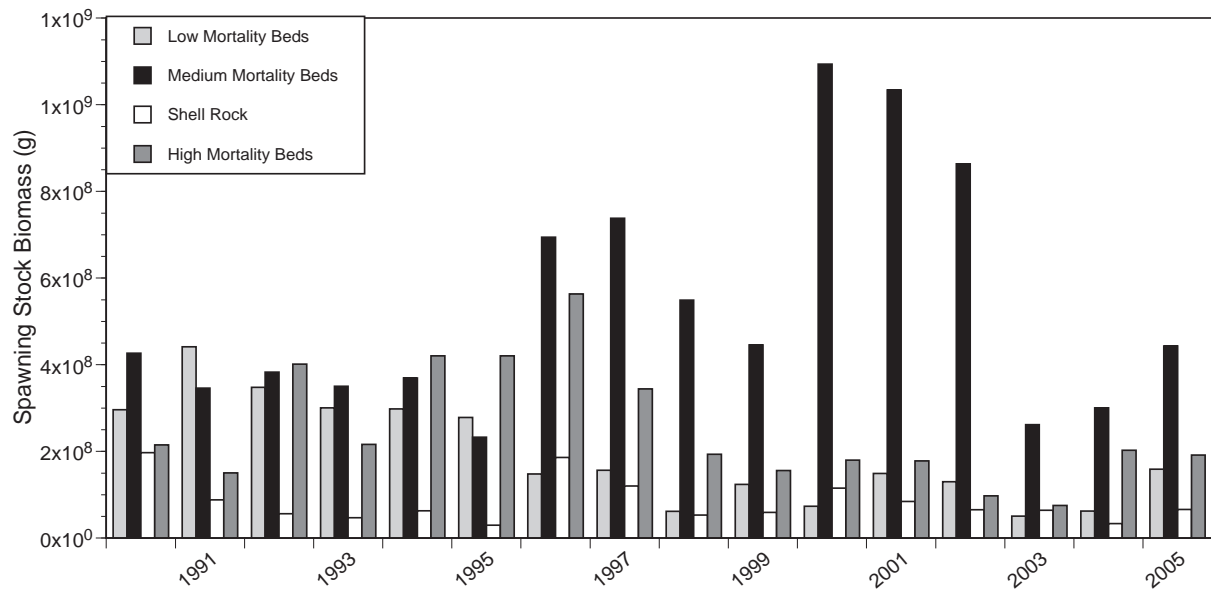


Figure 4. The number of spat recruiting per >20-mm oyster per year on the high- and medium-quality strata. Solid line marks a ratio of 1 spat per adult oyster.

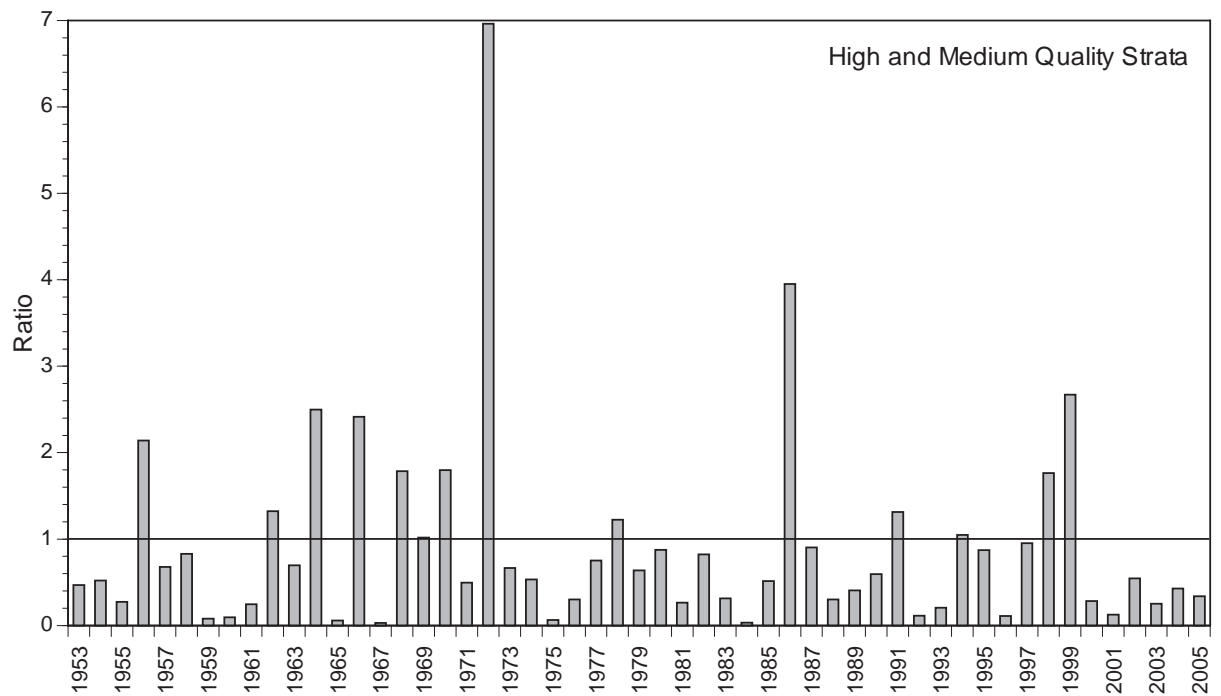


Figure 5. Mean and 2005 box-count mortality on New Jersey Delaware Bay oyster beds, rendered as the percent of beginning year abundance that died. Error bars are 95% confidence intervals.

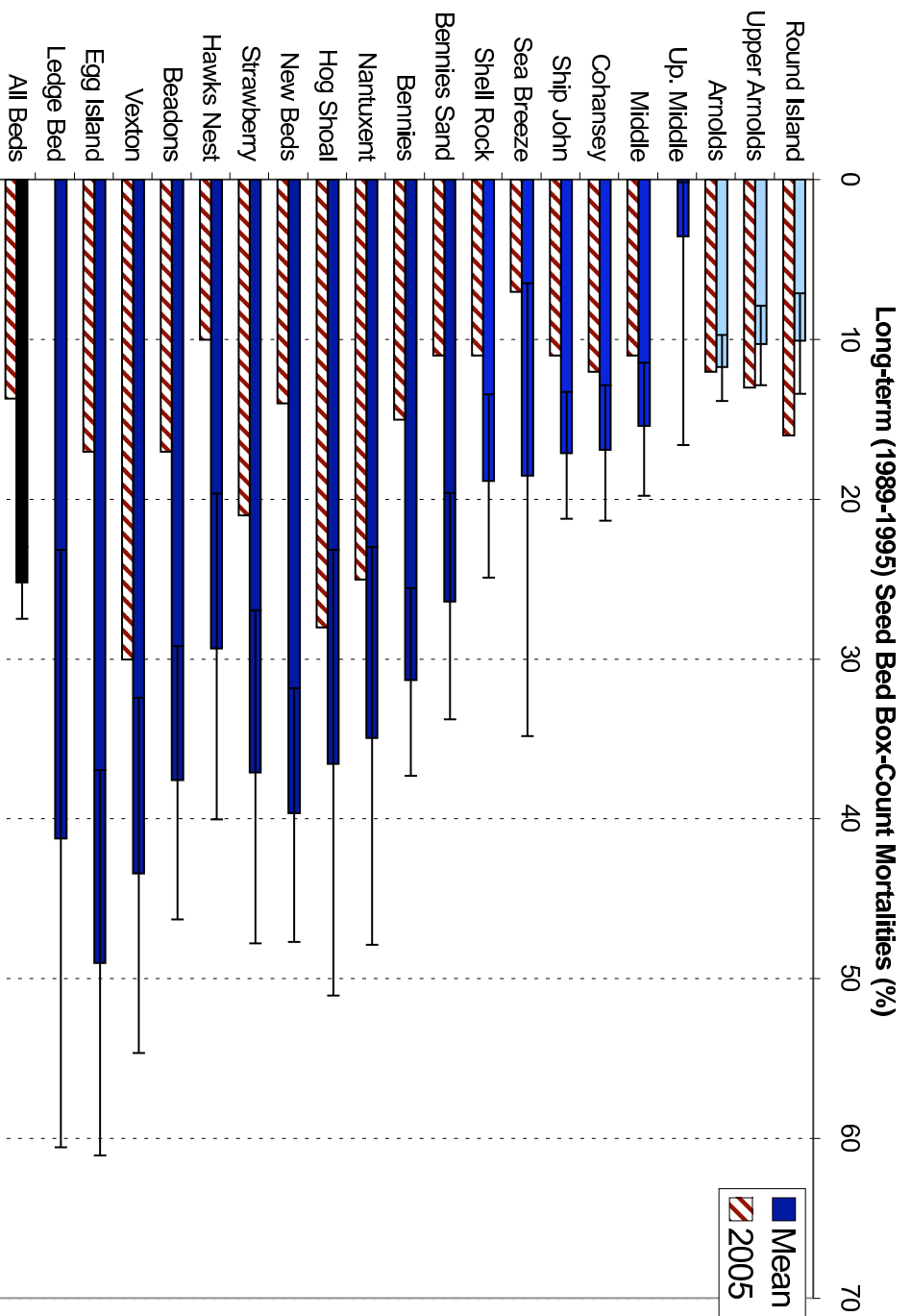


Figure 6. Position of the oyster stock in 2005 with respect to biomass and abundance targets and thresholds. The target is taken as the median of abundance or biomass during the 1989-2005 time period. The threshold is taken as half these values.

