Predicting Oyster Production

A Comparison of Natural Recruitment and Aquaculture

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Abstract

The Chesapeake Bay oyster resource and fishery have shown wide temporal population fluctuations generating controversy regarding restoration methods. Disagreements stem from lack of accurate and defensible data upon which to base decisions. Power dredging using metal scrapes towed by powered harvest vessels - is favored by many in commercial oyster harvesters as a beneficial practice with the claim that its expansion throughout the Bay would lead to increased biomass and public harvest. This opinion is disputed by scientific and environmental communities that point to differences between bottom renovation and ultimate recruitment. This has created problems for managers who must consider multiple factors in regulating fisheries. To understand the effect of dredging on populations, data from scientific studies were analyzed and used to predict the likely outcome of dredging activities. This paper evaluates the cost-effectiveness and predicted production that derives from restoration options. It deals with power dredging and reliance on natural recruitment to rebuild biomass in comparison to contemporary aquaculture techniques.

Data and Assumptions

Maryland has a long-term data set demonstrating spatial and temporal variation in natural spat production. Data from these surveys has been used for computations in this document. One weakness in spat production data is that they are qualitative and do not allow the total number of new oysters recruited into the population to be accurately calculated. These qualitative data are in the form of spat per bushel of shell found during sampling cruises. To estimate the size of a new year-class of oysters on a reef, two numbers are required. The first is the number of oysters found in a unit of reef substrate (*e.g.*, bushels) and second is the total volume of reef substrate. A few surveys have attempted to determine the amount of shell on a reef but these do not cover all oyster production areas of the Bay nor provide the data required to determine the spatial extent of shell on a discrete reef site. Additional studies that refine these data will allow more substantial analyses. A sole study was found that provided data on available shell after bagless dredging as a management technique. It indicated that the practice actually decreased the amount of suitable shell an average of 22% (8-29%).

To compare the effects of power dredging on recruitment and production the following assumptions have been made based on prior studies. The number of bushels of shell in an acre-inch (n= 2,200) has previously been calculated and the number of adult oysters in a market bushel (n= 275) has been agreed upon as a constant derived from research projects and these have been used in several calculations. Another factor required for comparisons is the survival of newly recruited oysters to harvestable size. Data generated from restoration projects in Maryland has been compared with information provided by experts in other regions to generate and verify the estimates used in this document.

For natural oyster recruitment to occur, three criteria must be met:

1. Competent oyster larvae at the correct developmental stage must exist in the water column
2. Water quality at the setting location must be conducive for settlement and larval survival
3. Suitable substrate must exist for larval oysters to attach and metamorphose into spat

If any component is lacking, significant oyster settlement will not occur.

Estimating Spat Production and Resulting Harvests

It is critical to know how much shell is available for larvae to set on. Data show a range of 0 - 3,238 bushels of available shell per acre. For these calculations we have chosen the mean of 1,500 bushels of available shell per acre. With 1,500 bushels per acre of available shell at a site, the amount of shell and expected natural spatfall are used to predict the actual number of oysters likely to be produced.

Using survey data from 2000 thru 2012, it is possible to predict total oyster production for different regions of the Bay. Table 1 compares three areas with different recruitment histories to calculate natural spat production and potential harvest. The Bay-wide average and two scenarios using hatchery seed are also shown. These are compared with hatchery plantings of 1 million and 2 million spat/acre[1]. Note: Current practices for deployment of hatchery seed are a minimum of 1 million/acre for oyster leases and up to 4 million/acre for sanctuaries.

Region	Estimated Spatfall (spat/bushel)	Number of Spat Produced per Acre	Number of Bushels Produced per Acre
Upper Bay (above Bay Bridge)	0.15	225	0.66
Average of the Top 10 Best Regions	223	334,500	985
Average of the Top 5 Best Regions	335	502,500	1,480
Bay-Wide Average	42	63,000	186
Hatchery Seed planted at 1 Million/acre	10,000	1,000,000	884
Hatchery Seed planted at 2 million/acre	10,000	2,000,000	1,767

Table 1. Comparison of spatfall by region to aquaculture production with an estimation of spat production and potential resultant harvest.

[1] Current practices for deployment of hatchery seed are a minimum of 1 million/acre for leases and up to 4 million/acre for sanctuaries

These comparisons make clear that, in certain circumstances, natural recruitment can provide significant increases in biomass. In extreme circumstances this compares favorably with hatchery-based production. The principal difficulties lie in selecting the site and choosing the proper year for that to occur. An examination of natural recruitment calculations illustrates the high variability that normally exists in the Maryland portion of the Chesapeake Bay.

	Upper Bay	Top 5 Regions	Top 10 Regions	Bay-wide Average
Predicted spatfall in spat/bu of shell	0.15	335	223	42
Percent of years where average is > 100 spat/bu (%)	0	62%	38%	0
Percent of years where average is > 250 spat/bu (%)	0	31%	31%	0
Percent of years where average is > 500 spat/bu (%)	0	0	0	0

Table 2. Annual variation in natural spatfall in Maryland from 2000 through 2012.

Table 2 illustrates the risk of relying upon natural recruitment for restoration in areas other than the top five. Individual oyster bars sometimes experience recruitment higher than the values noted here. These values average all samples within a given region for that year. Since these are averages, some sites will be expected to have higher recruitment while some will remain lower. Variation between sites within a region adds further risk and uncertainty to the success of any individual restoration project and questions the wisdom of applying this approach with any expectation of predictable success.

Conclusions

From these comparisons, it is clear that there are regions of the Maryland portion of the Chesapeake Bay that will not benefit from dredging alone. In those areas, natural recruitment should not be considered as a reasonable solution to population enhancement. While remaining difficult to predict exact numbers of oysters to be produced under either of these scenarios due to bar-to-bar variation within regions of the Bay, it is clear that the unpredictability of natural spatfall and resulting harvests will, in most regions and years, provide poor benefit to cost for the required expenditure of public funds. These data clearly indicate that there are regions where dredging or other bottom preparation activities should be avoided if the principal objective is to increase oyster biomass through the application of cost-effective methods.

This exercise does not incorporate some potential multi-year benefits that may accrue from oyster restoration activities. The numbers generated in this exercise assume that all shell or oysters will be harvested from a given site. This is not a safe assumption due to the inefficiency of harvest equipment and methods currently in use. For example, when estimating harvest numbers for an acre of oyster bottom there will be oysters left after harvesting has reduced the density of oysters on the bottom below what is deemed a profitable level. Additionally, those oysters and the shell that remains *in situ* will serve as cultch for future larval oysters to potentially attach. However, the same calculations used in this document apply when attempting to calculate actual numbers of spat and market oysters although at a rate reduced by the volume of the material removed.

The number of years that it takes to largely eliminate any positive influences by management activities will vary by site. However, given the dismal record of regular natural recruitment in many regions of Chesapeake Bay, there are still extensive regions where natural recruitment alone is not likely to result in any significant increase in oysters.