Considerations for Shell Use in Oyster Rehabilitation

Assessing the Effectiveness of Options

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Abstract

Oyster shell from processing plants (*aka* shucking house shell or green shell), represents a by-product that remains after the meat has been removed from the animal and has historically been used in attempting to enhance natural recruitment and support commercial production. Since the early 1980s, declining oyster production, loss of most processing plants and currently unavailable mined fossil shell deposits have contributed to a severe lack of material with which to rebuild the resource and fishery. Recent success of hatchery-produced seed for public and private fisheries has increased demand for whole shell and made it a valuable resource. This paper compares three uses of shucking house shell for the production of seed and market oysters. We provide calculations for comparisons based on a standard unit of 1,000 bushels of processing plant-derived shell for all comparisons unless noted otherwise.

Background

Calculations for comparisons in this report are complex and include more assumptions than those in our companion publication analyzing power dredging. We quantify the loss of shell volume or mortality of spat and oysters based upon data derived from years of large-scale spat production and follow-up monitoring of hatchery reared seed for restoration projects in Maryland.

Shucking house shell contains mud, sand, shell bits, and other unsuitable material within its volume which are not usable as setting substrate regardless of the technique used. Experience with processing these shells at the Horn Point Oyster Hatchery has shown that approximately 20% of the shell volume is comprised of these 'fines' which are removed prior to hatchery setting by pre-washing. This material is, therefore, not available for the setting process, either in tanks or the environment.

Loss of shell volume also occurs due to inconsistent bottom and difficulty in deploying shell uniformly over an area. This loss affects all techniques at one or more points during deployment and grow-out. Loss of either shell or spat on shell during various phases of these techniques have been grouped and listed as "post deployment loss". Explanations of the causes of loss and descriptions of how estimates were obtained are discussed under the individual techniques.

Technique One: Wild Seed Production

This method is one of the oldest used to enhance oyster populations and relies on natural spat left in place for ultimate harvest. Shell is purchased, either by the State or private planters, transported to a chosen site and deployed. Naturally occurring larvae from spawning oysters attach to these shells at the onset of metamorphosis and the resulting seed is left in place to grow to harvestable size. Shell is moved only once during this method and losses due to unsuitable bottom or uneven deployment (*i.e.,* post-deployment loss) are factored into the calculations only one time.

Technique Two: Wild Seed Production for Transplant

Similar to Technique One except seed oysters are removed and transplanted to alternate sites to grow to market size after spat attach. In this method the shell and spat are moved twice; therefore losses of shell or spat due to unsuitable bottom or uneven deployment are greater than in Technique One. No studies could be found to provide actual survival data for re-deployed spat. Oyster programs from other North American areas were queried in attempting to obtain a "best estimate" for survival. Commercial shellfish businesses in Virginia, Massachusetts, Washington, and New Brunswick, Canada were polled with similar results. Estimates of seed survival after deployment losses ranged from 10% to 25% and were similar to data on hatchery seed survival obtained by Maryland scientists monitoring plantings.

Oysters experience mortality during grow-out from predation, disease, and other factors. Data from hatchery seed showed that natural mortality in most healthy oyster populations in Chesapeake Bay is 10-15% annually. Estimates from other regions compare well with this data and show similar losses. Oyster survival predictions from Technique Two are approximately 20% while hatchery seed survival has been calculated at approximately 24%. Estimates for spat survival from Technique One are poor at best. However, using data from survival of newly settled hatchery seed (30%) and applying the same annual mortality used in both other techniques (10%) yields overall survival from settlement to market for Technique One as approximately 24%. Given the wide range of conditions under which these techniques have been used, the overall survival for oyster spat is remarkably similar.

It is apparent that more extensive studies are required to understand the factors contributing to overall mortality and resultant survival. However, estimates that include such a wide range of locations and techniques are so similar that it is highly probable that they are reasonably accurate and can be used to evaluate and compare these techniques in Maryland.

Technique Three: Hatchery Produced Seed

In producing hatchery seed, shell is purchased and transported to a storage site to remain for a minimum of one year to ensure that all organic matter attached to it has decomposed. After aging the shell is washed, graded, and containerized. Hatchery larvae are introduced into a tank of water which is gently aerated to circulate the larvae until setting occurs. The resulting spat are transported to a site for grow-out to harvest. For more than a decade hatchery seed have been monitored and data collected on their survival. Spat placed on suitable bottom exhibits approximately 70% mortality during the first year after deployment. The data are used to estimate survival for calculations in this paper. Studies have shown the importance of proper bottom characteristics for robust survival. Planting spat on poorly prepared or unsuitable bottoms will result in significant losses regardless of the technique used.

Uniform deployment of shell in large quantities is not easy to accomplish. Homogeneity of bottom is rare at most sites. Since shell deployment is also variable, estimates are based upon data from other studies or examples from other restoration or production areas. Additional experimentation providing more accurate data will allow increased accuracy of comparisons.

Production of spat and market oysters

Each technique has the potential to produce oyster spat and market oysters but variables exist that influence their effectiveness. Techniques One and Two totally rely upon natural recruitment for spat production. Once deployed, this new shell will behave similarly to shell already in place on bottom at each site. Temporal and spatial variation in recruitment will affect these shells as shown in the authors' power dredging analysis. Therefore, hatchery seed is generally more reliable. After post-deployment mortality is considered, hatchery produced seed approximates densities found in Maryland's best seed producing regions during the 1960's, which period is considered to have been the most productive for natural recruitment. Spat from natural recruitment are close to one year old; therefore the initial mortality experienced with young hatchery seed allows us to make meaningful comparisons.

Table 1 compares the estimated production of spat from three techniques utilizing shucking house shell under a variety of natural recruitment levels. Hatchery seed production is based upon data from the Horn Point Oyster Hatchery during the period 2011-2013.

Natural Recruitment (spat/bushel)	Technique 1 No Re-deployment	Technique 2 Re-deployment	Technique 3 Hatchery
2	2	0.6	7,069
10	12	3	7,069
100	118	29	7,069
500	589	145	7,069
1000	1,178	291	7,069

Table 1. Bushels of oysters produced from 1,000 bushels of shucking house shell using three techniques.

Table 1 demonstrates that an efficient hatchery can utilize shell more effectively than natural systems with natural recruitment similar to Maryland's Chesapeake Bay. An important component needed for meaningful comparison of techniques is their cost to benefit ratio. Some costs, like the purchase price of shell, are fairly constant across techniques while others like hatchery costs are only applicable to a single option. For comparison, total shell costs are estimated to be $5.50 per bushel. This includes the purchase price of shell and the accumulated costs associated with transportation to the initial site. These are estimated to be similar throughout all techniques.

Technique Two requires additional transport to a final deployment site, which has been estimated at $2 per bushel[1]. Hatchery costs are estimated based upon experience at the Horn Point Hatchery during 2011-2013. Estimates for production of market oysters from an initial input of 1,000 bushels of shucking house shell are:

[1] Based on DNR and industry prices in 2012 and 2013.

- Technique One = $5,500
- Technique Two = $7,500
- Technique Three = $30,900

These estimates will become more accurate as better studies are undertaken; however, by utilizing these estimates, it is now possible to calculate an estimated cost for a bushel of market oysters produced by each technique. Table 2 illustrates production costs per bushel for market oysters by each technique throughout a range of recruitment variables.

Spatfall level	Technique 1 No Re-deployment	Technique 2 Re-deployment	Technique 3 HATCHERY
10 spat/bushel	$375.00	$2,166.67	$4.37
100 spat/bushel	$38.14	$224.13	$4.37
500 spat/bushel	$7.64	$44.83	$4.37
1000 spat/bushel	$4.69	$22.34	$4.37

Table 2. Cost per bushel of market oysters using three techniques under variable natural recruitment levels with a starting unit of 1,000 bushels of shucking house shell.

Conclusions

These comparisons demonstrate that the most cost-effective and productive use for shucking house shell is through hatchery seed production. This technique results in increased levels of spat and market oysters through more consistent and reliable supply of seed and, ultimately, market product. It has a higher production cost for spat on shell; however, the increased efficiency of a hatchery compensates for this. Natural recruitment needs to approach 1,000 spat per bushel in order to become as cost effective as hatchery seed production. It would also have to be: a) regular by year and location and, b) predictable throughout annual variations in weather patterns, especially rainfall which affects salinity. Natural recruitment of spat of this magnitude and under those criteria is not possible in Maryland.

These comparisons have focused on the production of market oysters but they similarly apply to restoration projects for habitat enhancement. The current shortage of whole oyster shell and demonstrated differences in cost effectiveness for its use contraindicates using techniques that fail to incorporate scientific and economic factors into allocation of this valuable but limited resource.

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.