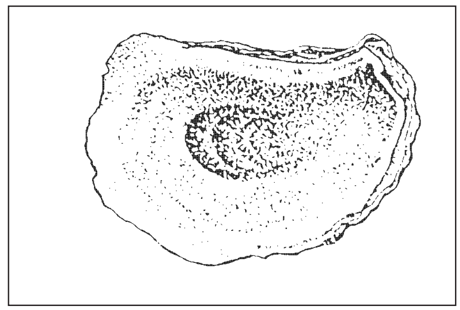
CASE STUDY 1

Oyster Restoration in Chesapeake Bay

Background

Since the mid-1800s the Chesapeake Bay has been a major producer of oysters to an extended market reaching as far away as California and England. During the 56-year period after 1834 when the business of packing oysters for shipment to the interior was established in Baltimore, Maryland, the average annual harvest from the Bay was 7 million bushels per year, or 392 million bushels for the period. This massive yield from both the Maryland and Virginia portions of the Bay was almost entirely the result of natural production, that is, there was little farming of oysters.

Sometime after the turn of the century, Maryland's oyster harvests dropped below that of Virginia. This change in comparative productivity may have resulted from several factors: development of widespread private leasing of Bay bottom grounds in Virginia while in Maryland public grounds remained the primary source of harvesting; growth of power dredging in Virginia, which was highly restricted in Maryland; overfishing of public beds in Maryland; and increasing destruction of oyster reefs and their consequent smothering by siltation. In the early 1900s, Virginia became the largest producer of oysters in the Chesapeake Region and on the entire Atlantic seaboard.[1]



Situation

The near-decimation of oysters in the Chesapeake Bay by protozoan diseases has stirred interest in importing a disease-resistant species of oyster for restoration of the fishery. Historical differences between the Maryland and Virginia oyster industries, however, complicate the problem of restoration. Competing interests between the commercial fisheries of both states as well as considerations of the role oysters play in the Bay's ecological health must be taken into account.

[1] Hargis, W.J. and D.S. Haven. 1988. The Imperilled Oyster Industry of Virginia. Special Report No. 290 in Applied Marine Science and Ocean Engineering. Virginia Sea Grant Marine Advisory Services.

In 1954, Chesapeake harvests rose dramatically in response to a 15 percent increase in ex-vessel price, which was itself the result of a decrease in mid-Atlantic harvests. However, this boom did not last for long. In 1959, the protozoan pathogen *Haplosporidium nelsoni* (MSX) invaded the Chesapeake Bay and, soon after, *Perkinsus marinus* (Dermo) — both have been responsible for catastrophically killing most of the oysters in high-salinity regions of the Bay. In Virginia, leaseholders, or private growers, hold a majority of their leased bottoms in the high salinity areas affected by MSX and Dermo — public grounds are in the lower-salinity waters. Unlike Maryland watermen, who have depended for their harvests primarily on publicly open grounds, Virginia's private industry has been virtually decimated.

In spite of the MSX invasion in the Bay, oyster production in Maryland in the 1960s increased for a short period. A major reason for that increase was the discovery of pre-historic fossil shell sources and the development of a dredge to extract the shell for use as a substrate to "catch" natural oyster seed. Subsequent employment of these resources by the State of Maryland was commonly referred to as the "repletion program."[2]

Prior to the repletion program, state legislation had required processors to make 10 percent of their shucked shell available for purchase by the state in order to ensure the availability of substrate for future oyster production. The legislation also provided funds for state shell-planting activities. The discovery of additional shell sources provided a cheap alternative to freshly shucked shell and yielded significant production increases. Maryland's oyster production doubled from around 1.5 million bushels to some 3 million annually. The increase in importance of the repletion program relative to natural oyster set helped transform the oyster fishery from traditional natural resource gathering into a "put-and-take" state fishery.[3] Watermen were temporarily relieved of the constraints of nature alone and no longer solely dependent on the "recycling" of processed oyster shell.

The use of relatively inexpensive dredged shell also changed the philosophy of oyster management in Maryland from maintenance of a collapsing industry to revitalization, through repletion, of a potentially valuable one. The state switched from its regulatory role of oyster manager to a champion of production growth. Although production began to wane in the late 1960s and has continued to do so, until about 1981 Maryland oyster production remained over 2 million bushels. During this time there was concern that the market could not absorb, at an acceptable price, more than about 2.5 million bushels. In this new scenario, the market, not nature, became the constraining element.

Since the 1980s oyster production has been suffering from the reappearance of MSX and, especially, Dermo. Maryland's harvest has declined from over 2.5 million bushels during the 1980-

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[2] The nature of oyster reproduction is such that young larvae require a hard substrate on which to attach; oyster shell provides such a material. However, if the harvested shell is not replaced in the Bay by a suitable substrate, there is a strong likelihood that the future availability of oysters will be reduced.

[3] Lipton, D.W., E.F. Lavan, and I.E. Strand. 1992. Economics of Molluscan Introductions and Transfers: The Chesapeake Bay Dilemma. Joumal of Shellfish Research 11(2):511-519.

1982 season to under 250 thousand bushels in the early 1990s. As a result of the decline in supply, ex-vessel prices have risen.[4] In spite of the increased ex-vessel prices, the effect of the loss of production on the income of the Chesapeake watermen has been significant. Unlike past battles with MSX and Dermo disease, this most recent outbreak has not been relieved by the repletion program. Lipton, Laval and Strand explain that the sporadic nature of the protozoan infections have made it difficult to develop a comprehensive strategy for oyster repletion.

Proposal to Revitalize Oyster Production

In contrast to the steep decline of oyster landings in Chesapeake Bay, oyster production on the west coast of the United States grew between 1982 and 1988 by 600 thousand pounds. The source of this production increase is hatchery production of the introduced species *Crassostrea gigas* (originally from Japan). Because of evidence that C. *gigas* is more resistant to MSX and Dermo, there has been strong interest in introducing this species into the Chesapeake Bay to test its hardiness. Virginia growers, in particular, are interested in introducing such a non-native species of oyster into their waters in an effort to revive their leased grounds and their processing industry. Maryland watermen, who harvest public grounds, have generally opposed introductions even though public grounds are not nearly as productive as they once were. In the meantime, harvesters in both Maryland and Virginia have turned to alternative resources — in Maryland, to softshell clams; in Virginia, to hardshell clams; in both states, to more intensive fishing effort for blue crabs, beginning earlier in the season and lasting later. Other watermen have left commercial fishing entirely.

The decision on whether or not to introduce C. *gigas* or some other non-native oyster into the Chesapeake Bay is not as straightforward as it may appear. Several factors must be considered including the costs and benefits of such an action. The net benefits to the different groups affected by the introduction must be estimated. These benefits may be economic or ecological in nature. Other significant considerations in the decision process are the uncertainties involved.

Benefits of an Introduction

Among the expected benefits from the introduction of C. *gigas*. are those to commercial harvesters and consumers. From the Virginia industry's perspective, the argument in favor of introducing a non-native species is based on the expected economic benefits, for instance, increases in income levels and employment, as well as in increases in producer surplus or economic rent.

The measurement of producer surplus is assessed as the revenue net of costs. In this case, culturing, processing, and harvesting costs are taken into account as well as the opportunity cost of a

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[4] Harvest prices are strongly influenced by the supply of the oyster yields. When both Maryland and Virginia harvests were low prior to 1960, real prices, the actual prices adjusted for the general level of inflation, were high. The tremendous increase in Maryland's production in 1966 caused real prices to drop by as much as 40%.

producer's labor — what he or she could earn in the next best employment opportunity.

As Lipton, Lavan and Strand point out, if the introduction of *C. gigas* is for the purpose of restoring a public fishery, the net benefit to producers will also depend on how the resource is managed. If an open access management regime is maintained, then net benefits to producers will be less than if a bottom leasing program or limited entry program on public grounds is instituted. Simply replacing one species with another does not necessarily eliminate the human-induced factors that caused the decline of the native species.

Consumers of oysters may also benefit from the introduction of *C. gigas* or some other non-native molluscan into the Chesapeake Bay implying further increases in social welfare. Increases in consumer surplus may occur with expected increases in the quantity of oysters available and decreases in price. Consumer welfare measures are assessed based on the demand for the introduced oyster. It is questionable, however, to what extent consumers are aware of or care about the oyster species they consume. It is entirely possible that the introduction of *C. gigas* into the Chesapeake will have negative net benefits: one reason is the negative publicity surrounding the health and safety aspects of eating molluscan shellfish. Consumer demand for the product may be highly inelastic so that a slight increase in the available quantity will be accompanied by a large decline in price.

In addition to market-oriented benefits from oyster introduction, there are potentially significant ecological functions and services that oysters may enhance, ultimately leading to long-term benefits to society. Historically, the oyster was the dominant benthic organism in the Chesapeake Bay: according to many ecologists, as reef-forming organisms, oysters played a major role in ecosystem dynamics.[5] Restoration of the oyster is seen therefore as highly desirable from an environmental perspective. The oyster's filter feeding functions could serve to filter the Bay's large amounts of algae, which could perhaps help reverse eutrophication of the Chesapeake ecosystem. Related improvements in water quality might ultimately provide ecosystem benefits in terms of improved fisheries, aesthetics and recreation and could lead to avoided costs of sewage treatment or depuration facilities.

Costs of a Species Introduction

The costs of introducing *C. gigas* or any other non-native mollusc into the Chesapeake Bay include direct costs such as the actual costs of performing the introduction, monitoring, and maintenance. In addition, there are costs associated with the introduction in the form of research dollars. That is, before an introduction is implemented, research must be conducted to determine the impact and probability of success of such an action.

Another critical cost is the risk of environmental injury resulting from species introductions. The history of molluscan introductions demonstrates that they can ferry in unintended or nuisance species that could potentially outcompete or displace a desirable native species. There are numer-

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[5] Newell, R.I.E. 1988. Ecological changes in Chesapeake Bay: Are they the result of overharvesting the American Oyster, *Crassotra virginica? In* Understanding the Estuary: Advances in Chesapeake Bay Research Consortium. Newell estimated that prior to major harvesting (pre-1870) of oyster beds, oysters filtered the entire water column in 3.3 days, while in 1988, the turnover time would have been 325 days. He further estimated that the pre-1870 populations may have been capable of removing 23-41 percent of the 1982 phytoplankton carbon production, but by 1988, they could remove only 0.4 percent.

ous examples in terrestrial and aquatic environments.[6] In addition, the introduction of a non-native species such as *C. gigas* could have unforeseen, detrimental ecological impacts.

The magnitude of the risks involved in introducing a non-native species into the Chesapeake Bay is as yet undetermined. However, it is clear that an introduction poses fewer risks for Virginia's oyster fishing industry than for Maryland's. Unlike Maryland's oyster fishery, which though much diminished is still viable, Virginia's oyster industry is failing. Thus, Virginia's industry does not risk the devastation of native species with the unintended, negative ecological consequences of an introduction. An introduction in Maryland's waters, on the other hand, puts the native *Crassostrea virginica* potentially at risk.

Dealing with Risk and Uncertainty

Compounding the debate over *C. gigas* introduction into the Chesapeake Bay is the natural ecological connection between the industries of the two states. It is likely that introductions in Virginia waters will eventually affect Maryland waters. The decimated state of Virginia's fishing industry compels its oyster producers and managers to pursue the introduction or transfer of a molluscan species in an effort to save the industry. The less urgent circumstances surrounding Maryland's industry impels its producers and managers to act more cautiously. These contrasting agendas inhibit consensus among the two states as to the appropriate course of action. The use of economics in the decision process could enhance the possibility of a resolution; towards this end, the uncertainties of an introduction can be considered within the benefit-cost framework.

Two principle methods of doing a benefit-cost analysis are through *expected net benefits* and *game-theoretic* approaches. In the expected net benefits approach, the distributions about the costs and benefits are used and the value of net benefits are calculated. Conceptually, the procedure is straightforward. However, the distributions about net benefits are not easy to ascertain, particularly when considering future events. As a result, a higher discount rate is often used with more risky selections.[7]

Game theory[8] can also be applied to the uncertainty involved in the decision on whether or not to allow an introduction. The game theory method is based on the two choices presented — to allow or not to allow an introduction. The approach offers the option of taking either a conservative or a more risky position with regard to possible damages from unintended negative consequences or environmental costs. The conservative position utilizes the minimax principle in which the strategy that minimizes the maximum possible losses is chosen.[9] The more risky position

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[6] Rosenfield, A. and R. Mann. 1992. Dispersal of Living Organisms into Aquatic Ecosystems. Maryland Sea Grant College, College Park, Maryland.

[7] Lipton, D.W., E.F. Lavan, and I.E. Strand. 1992. Economics of Molluscan Introductions and Transfers: The Chesapeake Bay Dilemma. Joumal of Shellfish Research 11(2):517.

[8] Bishop, R.C. 1978. Endangered Species and Uncertainity: The Economics of a Safe Minimum Standard. American Journal of Economics 60(10):10-19.

[9] Ciriacy-Wantrup, S.V. 1968. Resource Conservation: Economics and Policies. Berkeley and Los Angeles: University of California Division Agricultural Sciences.

makes use of probability distributions of net benefits and compares the expected value of the introduction and no-introduction scenarios, choosing the action with the greater expected value. Clearly for each strategy, measures of the consequences of introductions and damages must be made. This procedure must determine how the stream of net benefits should be discounted over time and the characteristics of the uncertainty of these measurements.

Exercise

The debate over the introduction of C. *gigas* or some other non-native oyster into Chesapeake Bay waters is highly political and full of uncertainties. Watermen are unwilling to abandon an industry that has been a fundamental element of the region's economy and culture for over a century. Virginia watermen, in particular, see molluscan introductions as a means to revitalize the failing industry. However, the uncertainty of the effects of an introduction clouds the issue. Another complication is the fact that the decision will have effects that cross jurisdictional boundaries.

The decision whether or not to allow an introduction is not isolated to the specific, individual oyster beds within the two states of Maryland and Virginia. The Chesapeake Bay ecosystem is not confined, of course, by political boundaries. Any decision that is made must take a multi-jurisdictional approach that transcends artificial divisions.

Suppose that you are a member of a Chesapeake Bay economic development council. You are tasked with developing recommendations on a Bay wide oyster development plan. Consider the role of environmental valuation in your analysis. Using the following questions as a guide, outline the study you would request of a local economist.

1. What values associated with oyster resources and services should be analyzed?

2. What techniques would you recommend in order to determine the values of these resources and services?

3. What are the limitations to the existing methodologies in this case?

4. What additional information do you need in order to determine the expected net economic benefits of a C. *gigas* introduction plan?

5. What discount rate would you recommend in a benefit-cost analysis of a C. *gigas* introduction plan?

6. Suppose that new technological developments offer alternative methods of oyster enhancement (e.g., bio-technological or bio-engineering of a native species immune to MSX or Dermo). What role can environmental valuation play in assessing these alternatives?