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Impact of Diseases on the Chesapeake Bay Oyster Industry

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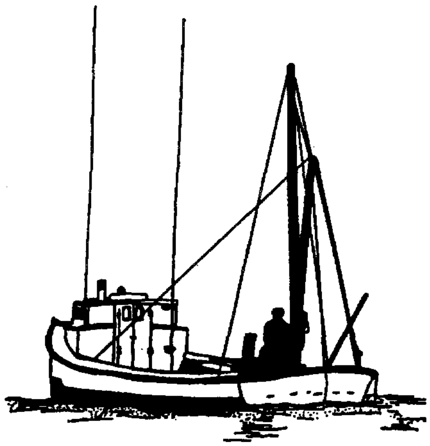

CHESAPEAKE BAY OYSTER INDUSTRY*

Submitted by
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Present Status of the Industry

Oysters harvested in the Chesapeake Bay originate from two different sectors of the industry. The natural oyster rocks were set aside in the public trust and are called public oyster grounds. Anyone with a license can harvest oysters from these grounds during the commercial oyster season. In addition, private individuals can lease what are often barren grounds from the states and transplant small "seed" oysters to their grounds to grow them to market size. This private sector represents a very small proportion of the industry in Maryland, but a significant proportion of the Virginia industry. Until recently, the James River has been the major source of seed oysters for private planters in Virginia. This river yields large quantities of small oysters, but they grow slowly because of low salinity in that portion of the river. Many private grounds have traditionally been located in high salinity waters where improved growth of transplanted seed oysters occurs.

Two oyster diseases, *Haplosporidium nelsoni*, popularly called MSX, and *Perkinsus marinus*, popularly called Dermo, cause serious annual mortality along the Atlantic and Gulf coasts of the U.S. MSX causes oyster mortality from Massachusetts to Chesapeake Bay, and an organism similar to MSX has been reported as far south as Georgia. *Perkinsus* causes mortality throughout Chesapeake Bay, south along the Atlantic coast, and in the Gulf of Mexico. In addition, *Haplosporidium costale*, popularly called SSO, causes annual mortality of about 20% in oysters growing in seaside bays of the middle Atlantic states.

MSX and *Perkinsus* have decimated oyster populations in Chesapeake Bay in recent years and the industry in both Virginia and Maryland is presently in crisis. Public beds have been depleted and fewer private beds are planted because of the presence of diseases. MSX first appeared in the Virginia portion of Chesapeake Bay in 1959 and within a few years the annual Virginia harvest decreased from an average of about 3.5 million bushels to less than 1 million bushels (see Figure 1). The industry in Virginia has never recovered. Mortality was high on public oyster grounds, but hardest hit were the private planters who had been producing about 85% of the annual harvest (see Figure 1).

The distribution and abundance of both diseases appear to be controlled by salinity. In years with normal rainfall, MSX is restricted to the lower Bay and the lower portions of tributaries south of the Rappahannock River. *Perkinsus* is present throughout most of the Bay and its tributaries wherever oysters occur, except in the upper-most portions of the major river systems. Both diseases require salinity of about 15 ppt to produce infections in oysters. [Parts per thousand is a measure of salt content in water. Oceanic water is about 35 ppt; fresh water is 0 ppt]. When salinity in the Bay increases because of low rainfall over the watershed, diseases move up the Bay and deeper into its tributaries - areas that were previously disease-free.

There have been three prolonged droughts in Chesapeake Bay during the period 1960 to 1987. During each multi-year drought, MSX invaded upper Virginia and many Maryland tributaries and caused extensive mortalities. The 1963 to 1967 drought was the longest, but not the most severe; not until 1965 did MSX invade Maryland from its endemic area in Virginia. The second and third prolonged droughts occurred from 1980 to 1982 and from 1985 to 1987.

* Prepared by Dr. Eugene Burreson, oyster pathologist, VIMS.

Thus, there have been six drought years during the eight years of the 1980's and the resulting increase in oyster disease distribution and abundance has been dramatic. MSX invaded deep into the Maryland portion of the Bay in 1982 and again in 1987. Both MSX and *Perkinsus* are presently at record high levels of intensity and have invaded deeper into Virginia and Maryland tributaries than ever before. During 1986 and 1987, estimated overall mortality on public beds in Virginia was between 70% and 90%, the highest values ever recorded in 28 years of continuous monitoring. Estimated overall mortality for public beds in Maryland was between 30% and 50% for both years, also the highest values ever recorded. During 1987, there were only two locations in Maryland that did not have one of the two diseases, and in Virginia, for the first time in history, both diseases invaded and caused serious mortality in the upper James River seed area, a region usually protected by low salinity. Based upon monthly samples collected during 1988, both diseases are still abundant in the James River seed area and began causing oyster mortality when the water temperature increased in late May.

During the 1986/87 and 1987/88 oyster seasons the James River seed area was the focus for the harvest of market oysters in Virginia because of increasing mortality of oysters on other public beds. During the 1986/87 season 68.4% of the market oysters harvested from public beds came from the James River, and during the 1987/88 season 91.0% of the oysters came from the James River. Thus, the impact of diseases has caused a change in market oyster production in Virginia from the traditional harvest areas to the James River seed area. This change has resulted in an increased harvest during 1986 and 1987 (Figure 1), but the oysters from the James River are small and quality is poor. Unfortunately, the use of the James River as a source of market oysters has effectively denied private planters an economical source of seed oysters.

The cumulative effects of the six drought years of the 1980's have decimated the oyster industry in the Chesapeake Bay. Virginia's industry has been depressed since MSX first appeared in the Bay in 1959, and Maryland's landings are now also at record low levels. Bay-wide harvest has been declining steadily since 1981 except for a slight increase in 1984 resulting from a wet year in 1983 (see Figure 2). Preliminary data based upon 75% of the 1987/88 oyster season in Virginia indicates that total harvest will be about one-half of the 1986/87 harvest.

There is no reason to be optimistic about the near future. Because of the recent drought, the diseases have killed a large proportion of remaining oysters in typically low-salinity areas of Virginia and much of Maryland. With many broodstocks destroyed, most growing areas lack the means to rapidly restore populations and it will take years to replenish stocks to a harvestable level. Harvesting in the upper James River seed area, where oysters have survived the diseases, compounds the problem and there is concern that this area may also be subject to broodstock depletion. As stated, the weather plays a major role in the distribution and severity of both diseases. Another dry year in 1988 will allow diseases to invade deeper into the James River and into Maryland, and further depletion of broodstocks will occur. On the other hand, a wet year will markedly decrease the activity of MSX in many areas of the Bay and will reduce the impact of *Perkinsus* as well. It is well documented that salinities of 10 ppt or less will cause MSX to be eliminated from oysters within 10 days. The relatively wet winter-spring of 1988 has caused a reduction in MSX activity in Virginia tributaries of the Potomac River, Great Wicomico River and portions of the Rappahannock River. The lower James River and Hampton Roads/Mobjack Bay area, however, have not escaped the grip of MSX, with high levels of infection still present. Unfortunately, low salinity does not eliminate *Perkinsus* from oysters already infected, but it does greatly reduce mortality. It will undoubtedly require several consecutive wet or normal years, assuming sufficient setting occurs, before oyster stocks can recover to any measurable degree.

Ongoing Research and Monitoring Programs

Currently, efforts by scientists to find solutions to the disease problem center mainly around monitoring for the presence of the disease organisms, epidemiological studies, and development of an improved source of seed.

Disease Monitoring Program. The monitoring programs conducted by the Virginia Institute of Marine Science and Maryland Department of Natural Resources provide critical information on annual distribution and prevalence of both diseases on selected public and private oyster beds throughout the Bay, and allow scientists to gain added insight into the relationship between salinity and disease parameters. Information from the monitoring programs are utilized by private planters to determine sources of disease-free seed oysters, and to determine when and where to plant oysters, and when to harvest. The management agencies in Virginia and Maryland utilize data from the monitoring programs in their repletion efforts and in their general management strategy.

Remote Setting Program. The purpose of a remote setting program is to perfect the methodology that will allow private planters to augment the natural oyster set in the Bay by producing larvae in oyster hatcheries and setting the larvae on shell in large tanks. The shell is then placed in the Bay, preferably in disease-free areas, until oysters have grown to market size. For example, the VIMS oyster hatchery is producing 500,000,000 late stage larvae per year for private planters and our advisory personnel are assisting with setting and grow-out techniques. When methods are perfected it is anticipated that private entrepreneurs will adopt the techniques to assure a constant source of seed oysters. Similar efforts are under way in Maryland.

Future Research Priorities

Monitoring programs are vital to management agencies, but measures to mitigate the effects of oyster diseases can only be realized through research. Important studies are underway at several universities, but progress has been slow because of a lack of manpower due to limited funding. Many critical research topics have no funding. We suggest that future research efforts should be encouraged and should focus on the following four basic areas of endeavor.

Disease-Resistant Oysters. Oysters that are slightly more resistant to MSX than native oysters have been developed through selective breeding in the laboratory. It has been demonstrated that these oysters have greater survival than native oysters when exposed to MSX. If strains are improved and raised in sufficient quantities, the use of resistant oysters in hatchery and remote setting programs has the potential to increase harvests in areas where MSX is endemic. Resistant oysters may allow reutilization of the traditional private beds in high salinity portions of the Bay and greatly increase the acreage available for private planting.

VIMS and Rutgers University have small programs to assess disease resistance in hatchery-reared and remote-set larvae from various broodstocks. A planned program at the University of Maryland is stalled by a lack of funding. Increased funding would allow such programs in the U.S. to be expanded for rapid assay of existing oyster strains and for continuing development of new strains.

Disease Response to Environmental Fluctuations. It is well documented that MSX is eliminated rapidly in salinity below 10 ppt. However, it is not clear how long it takes for elimination of *Perkinsus* under similar conditions, and we cannot predict when oyster beds infected with this parasite will be disease-free after salinity returns to normal. It is important to be able to predict the rate of regression of the diseases and acquire a greater understanding of how, and how fast, MSX and *Perkinsus* invade areas as salinity increases during drought conditions. In fact, during 1987 *Perkinsus* spread much more rapidly and caused much greater mortality than expected from experience in past years; there is no obvious explanation for this dramatic change. It is apparent that research on *Perkinsus* has been neglected since the appearance of MSX and a renewed emphasis on this disease is mandatory.

MSX Life Cycle. Research on MSX has been severely hindered because basic aspects of the life cycle of the parasite are not known. The sources of infection are unknown and speculation persists that another organism carries stages of MSX. Because the infective stage is unknown, it is impossible to infect oysters in the laboratory and this has prevented study of MSX under controlled conditions. Thus, experiments to examine a wide variety of topics have been impossible to conduct and this has limited the development of potential mitigating measures. Elucidation of the life cycle of MSX would also enhance predictive capabilities. It is clear that the disease responds to changes in salinity, but it is not known whether salinity acts directly on the parasite or on some other organism that harbors stages of the parasite. If the life cycle were known we would have a much better basis for predicting distribution of the disease in relation to salinity.

Research at VIMS and Rutgers University has demonstrated that recent immunological and biotechnological advances in the diagnosis of human and veterinary diseases can be adapted for use with oyster diseases. The sensitivity and specificity of these techniques, such as enzyme immunoassays and DNA probes, make them ideally suited for use in life cycle research and this approach must now receive a high priority.

Alternate Species. The combined effect of MSX and *Perkinsus* has reduced stocks of native oysters (*Crassostrea virginica*) in the Chesapeake Bay to an all time low level. The prospects for relief in the low salinity portions of the Bay are good when salinities return to normal because there are areas of low salinity that can serve as "sanctuaries" from disease. However, the future for much of the industry is not favorable because salinity in much of the Bay and its tributaries is sufficiently high to ensure permanent residence of both MSX and *Perkinsus*. Elsewhere in the world, fisheries devastated by disease have been revitalized by the introduction of alternate species; however, such actions can have serious ecological consequences if effected in an inappropriate manner.

The rapid development of oyster hatchery technology, wherein animals spawn in closed systems and their progeny are cultured through the delicate larval stages, combined with advances in biotechnology, offer the option to culture sterile hybrids of *C. virginica* with other closely related oyster species that may have greater natural resistance to disease than does the endemic *C. virginica.* The option for utilization of reproductively sterile oysters suitable for culture on the abandoned and unused oyster grounds in the high salinity portion of the Bay is worthy of consideration at this time to supplement, not replace, the present oyster fishery.

IN SUMMARY, the revitalization of the oyster industry is a pressing, urgent need. The seriousness of the problems facing the industry dictates a multifaceted research approach including extensive disease monitoring to support management, research on development of resistant oysters for private industry, research into fundamental aspects of epidemiology for both MSX and *Perkinsus*, research on the life cycle of MSX, and the consideration of sterile, disease-resistant hybrids or alternate species for high salinity areas where both diseases are permanently resident.

Figure 1
ANNUAL VIRGINIA MARKET-OYSTER PRODUCTION

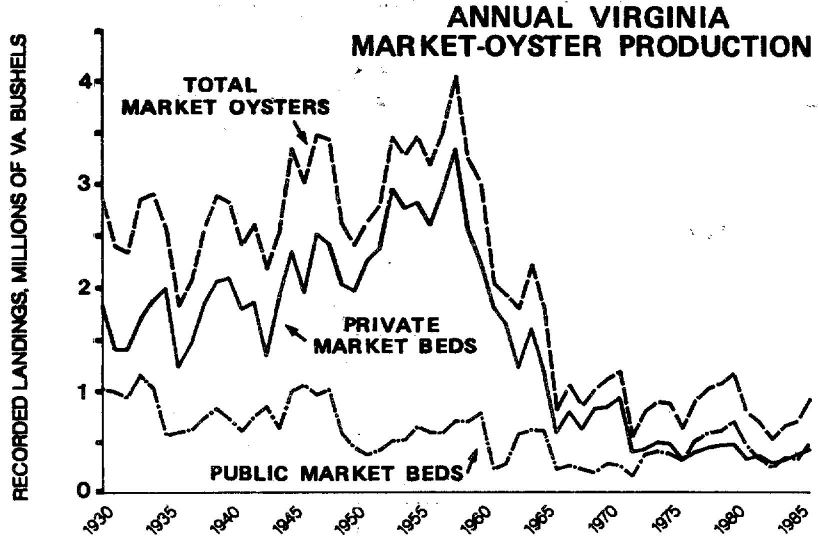

Figure 2
ANNUAL CHESAPEAKE BAY OYSTER PRODUCTION