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REHABILITATION OF THE TROUBLED OYSTER INDUSTRY OF THE LOWER CHESAPEAKE BAY

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ABSTRACT After 1885 Virginia's lower Chesapeake Bay system produced more oysters per year than any other area in the United States and remained predominant until 1960. Since then she has surrendered supremacy as annual harvests of her troubled oyster industry have steadily declined. Numerous factors were responsible for the tremendous productivity of the lower Bay's oyster beds; a number have been involved in its decline. Natural events, such as the catastrophic epizootics of the early 1960's, continuing disease and predation, increased salinities of drought years and great freshets of tropical storms have contributed significantly to the reduction. Pollution and other man-related alterations have been involved also. Additionally, high costs of money and operations, risk-reduction efforts, loss of competitive position and markets, and, in some problem areas, lack of certain important scientific knowledge have contributed. Persistent overfishing by public harvesters, lack of application of best-management practices and recent technological advances, reduction of planting efforts by private growers, and resistance to remedial improvements by industry and public managers are the *major factors* causing the continuing decline! Nevertheless, restoration of oyster production in Virginia (and Maryland) waters can be accomplished by applying a combination of currently available scientific knowledge and technological skills and by making or enabling sociological, economic and political improvements.

KEY WORDS: Oyster industry, biological restoration, economic rehabilitation, Virginia, lower Chesapeake Bay.

INTRODUCTION

Since Colonial times the Chesapeake estuarine system has produced the most recorded annual harvests of United States oysters, reaching a high of some 20 million bushels around 1880. During the mid-1800's Maryland's upper Bay and its tributaries annually yielded around 4.9 million bushels of the Atlantic oyster, *Crassostrea virginica*, while Virginia's waters gave up some 2.1 million—less than half (Brooks 1891 and 1905). After 1885, annual catches of the lower Chesapeake surpassed those of the upper Bay and remained predominant until 1960. Since then, Virginia's lower Bay has surrendered its national supremacy and production throughout the entire Chesapeake region has diminished.

The oyster industry of Virginia, long a mainstay of the commercial fisheries supported by the biological resources of the lower Chesapeake, has shown signs of distress since the 1920's. During the decade of the '20's reduced harvests and widely publicized, pollution-related public health problems drove state and federal agencies to investigate the causes of distress. Research programs and organizations, such as cooperative state-federal oyster fishery research programs on the James River, Virginia and at Yorktown, Virginia and the Chesapeake Biological Laboratory at Solomons, Maryland were established for this purpose. Considerable research and engineering development effort has been directed at the oyster fishery in the Chesapeake region and elsewhere since and certain management efforts

aimed at increasing production have ensued. As an example of the magnitude of the research and development effort, some 260 related, selected documents have been examined in the course of our studies (Haven *et al.* 1978a and 1978b and Hargis and Haven in press). There are others.

In 1970-71 the present authors undertook an exhaustive study of the Virginia oyster industry which resulted in publication of a monograph (Haven *et al.* 1978a) and an executive summary based upon it (Haven *et al.* 1978b). From these studies remedial recommendations were made to industry, the General Assembly of Virginia and the Virginia State agencies responsible for management of the fisheries and the marine environment. After publication of the main report (Haven *et al.* 1978a), some of the recommendations were adopted partially or wholly, but not enough of them. The key ones have been ignored! The Virginia oyster industry remains seriously troubled.

In 1986 we decided to again review basic conditions of the oyster resources and industry of the lower Chesapeake. The resulting report by Hargis and Haven (in press) is the foundation of this presentation. During this research we learned that several primary problems, the bases of industry's difficulties, have not been effectively addressed in the period since our earlier comprehensive studies. Production of oysters from Virginia's bottoms continues its long-term downward trend.

FINDINGS

Virginia's oyster industry consists of two main elements, the public and private oyster fisheries (Quittmeyer, 1957; Haven *et al.* 1987a and 1987b). Public harvesters are essentially hunters or gatherers, taking seed and market oysters from state (publicly-owned) oyster-growing areas

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within a constitutionally adopted boundary in each tidal estuary and coastal lagoon in Virginia and from the mainstem of Chesapeake Bay—the Baylor Survey Grounds (Figure 1). The private sector consists of oyster planters who, using their own funds, rear and harvest seed and/or market oysters (mostly the latter) on bottoms leased to them by the state. It also includes the oyster shuckers; first-level processors; and, packers and repackers who purchase oysters from public and private harvesters (or from secondary suppliers) for shucking or packing (or both) and for processing to advanced stages for sale and shipment. Shippers, wholesalers and retailers also handle oysters. Some integrated organizations grow, shuck, process, market and ship them.

When all of these elements are considered, the Commonwealth's oyster industry is quite complex (Figure 2). The basic complexity and interwoven nature of various segments of the industry and the economic, social, political and natural factors affecting them at each level complicates effective understanding and management. Indeed, this premise is supported by the results of our review of the

current condition of the oyster industry, its problems and promise (Hargis and Haven, in press).

Historically, the oyster industry of Virginia has passed through six phases as follows:

Phase I, the longest (1600 to about 1850), began almost 400 years ago with the establishment of the Virginia Colony. In early Colonial days many oyster reefs extended upward into the water column and were threats to navigation like coral reefs of some tropical waters today. Many were awash at low tide. Surfacing reefs and many submerged ones have long since disappeared. Many now exist only as "reef-shells" buried under a layer of natural and anthropogenic sedimentary overburden. Harvesting of oysters for food, shell and lime; channel dredging; continuing high rates of natural and man-affected sedimentation; sea level increases; and, subsidence have all been involved, with the first most important in the majority of places;

Phase II, beginning around the mid-1800's was characterized by increasing demand for oysters as food and to a lesser extent for building and agricultural materials re-

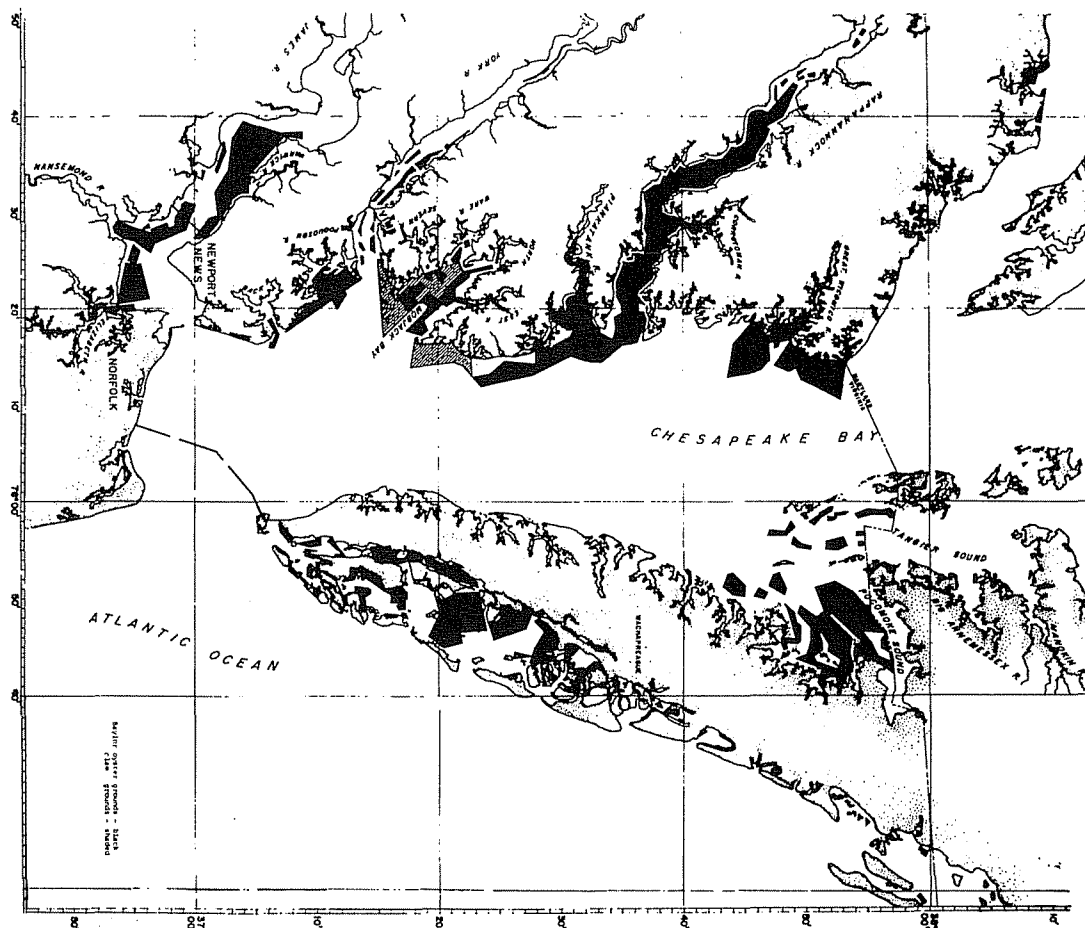


Figure 1. Map of Tidewater Virginia showing public oyster ground and public clam ground. The public oyster ground (Baylor Bottoms—Baylor, 1894) are in black; public clam bottoms are hatched. (From charts on file at Virginia Marine Resources Commission in Newport News, VA).

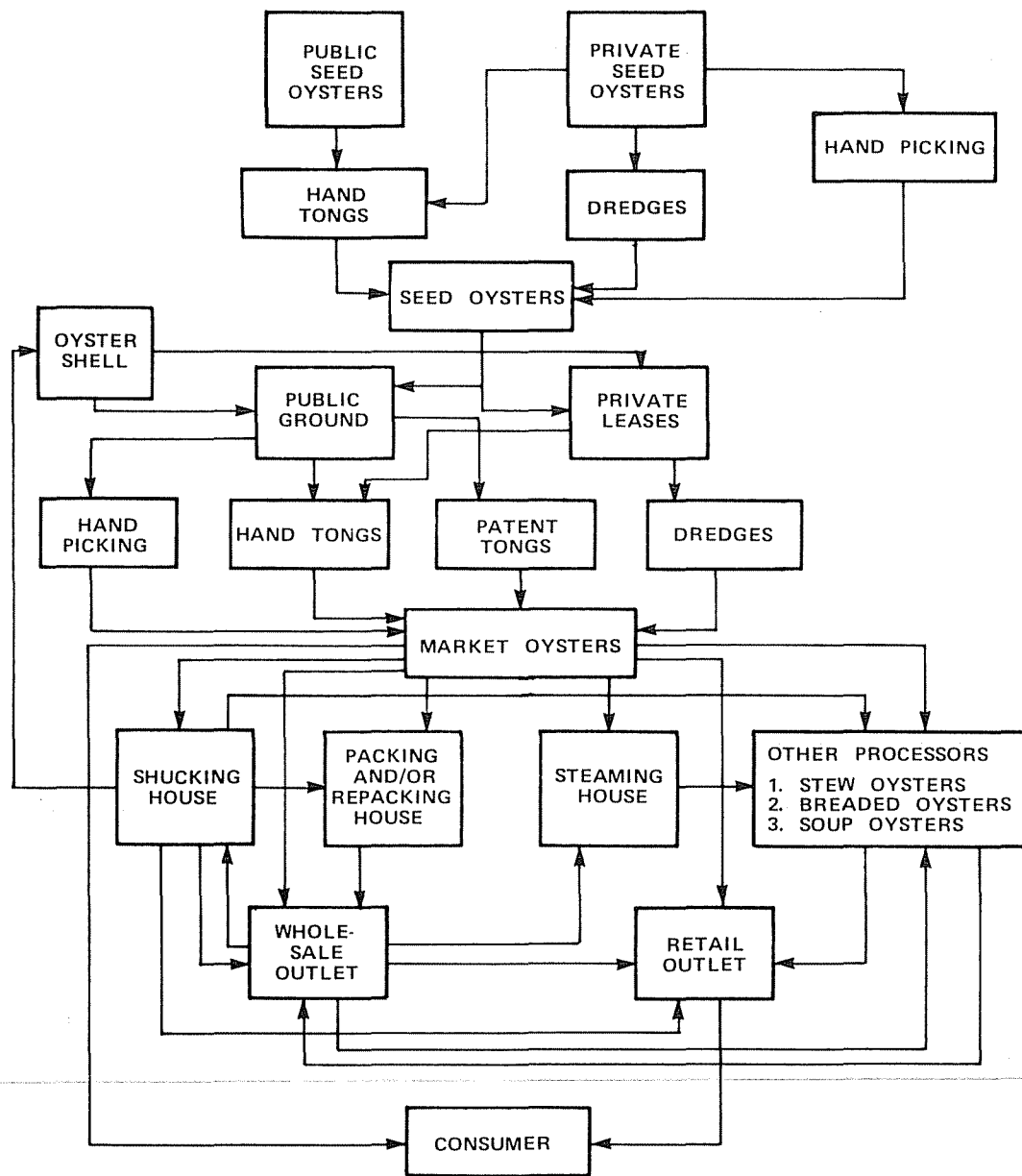


Figure 2. Key elements in the harvesting, processing and distribution of seed and market oysters in Virginia.

sulting from population growth. During this period, market oyster production grew until it reached 6.8 million bushels by 1880 (Table 1);

Phase III lasted from 1894 to 1912 when annual harvests ranged from some 5 to 7.5 million bushels (Table 1). This era can be called the "high water", or peak phase;

Phase IV was characterized by indications of overfishing by the public watermen, and annual harvests from public oyster beds gradually declined during 1913 to 1932. Economic recession prior to and after World War I, the war itself, and overharvesting, may have affected yields or records, or both. In 1925, 4.4 million bushels were taken (Table 1). By 1931–32 annual market-oyster production had declined to 2.4 million bushels (Table 2). [Official

record-keeping attained some degree of completeness, continuity, precision, and accuracy only after 1930]. Certainly subsistence oyster fishing for home consumption and local sale occurred during the Great Depression period, but most of those harvests were probably not reported;

Phase V began after 1932 and was characterized by relatively stable landings that reached about 4.0 million bushels for public beds and private leases in the 1958–59 harvesting season [November of one year to the end of October ensuing (Table 2)]. Much of this increase was due to privately financed and managed production from leased bottoms; harvests from public bottoms continued to decline (Table 2 and Figure 3);

Phase VI, extending from 1959–60 to the present (al-

TABLE 1.
Recorded Oyster Landings in Virginia from 1880 to 1925 for
Certain Years^a

| Year | Bushels | Pounds of Meats |
|------|-----------|-----------------|
| 1880 | 6,837,320 | 47,861,240 |
| 1888 | 3,664,433 | 25,651,031 |
| 1890 | 6,074,025 | 42,518,175 |
| 1891 | 6,162,086 | 43,134,602 |
| 1897 | 7,023,848 | 49,166,936 |
| 1901 | 6,067,669 | 42,473,683 |
| 1904 | 7,612,289 | 53,286,023 |
| 1908 | 5,075,000 | 35,525,000 |
| 1912 | 6,206,098 | 43,442,686 |
| 1920 | 3,963,569 | 27,744,983 |
| 1925 | 4,356,416 | 30,494,912 |

^a From Table 16, Haven, Hargis and Kendall (1978a, as modified from Corson, 1930).

most 30 years) was initiated by the suddenly appearing epidemic (epizootic) resulting from the oyster disease known as MSX caused by the protozoan *Haplosporidium nelsoni*. Oysters on the public and private beds in the higher salinity portions of Virginia's Chesapeake system were most severely affected. Harvests from both decreased but the reduction in production from leased ground was catastrophic. Current harvests continue on a downward trend on both types of bottoms (Table 2 and Figure 3).

Operating elements of industry have declined almost 17% (Table 3). In the 1975–1985 decade the shucker-packer segment declined by 36% and shell-stock shippers by 13%. In contrast, repackers and reshippers increased almost 12%.

A major aspect of the recent decline is that while statewide production decreased drastically (by about half) during the period from 1959 to 1964, the reduction in landings was not merely in high salinity, high disease incidence areas, but also in moderate to low disease areas where MSX was not a problem. Following this, statewide total production continued its downward trend and by the 1984–85 season private and public ground production had slipped to only 658,679 Virginia bushels. While the harvests from private, leased beds exceeded those from Baylor (public) bottoms by factors as high as 5–6 times in the 1950's and early 1960's, their comparative positions had all but shifted by harvest year 1977–78. During that year yields from public grounds exceeded those from private leases (512,687 vs. 394,692 Virginia bushels, respectively) for the first time since 1930–31 as they have for 7 of the last 10 harvesting seasons included in Table 2.

For the last 28 years Virginia bottoms have been unable to produce sufficient market oysters to meet the demands of local packers and repackers. Oysters grown elsewhere have filled ever-increasing shares of this need. Oysters, primarily from Maryland (Potomac and Upper Bay waters) in

the beginning, then New Jersey, the south Atlantic, and the Gulf of Mexico; and, now from the West Coast, have been imported to supply the Virginia industry. It is reported that the Pacific oyster, *Crassostrea gigas*, is now being processed or repacked by some Virginia packers and sold in local supermarkets as "fresh oysters". The slight growth in repackers and reshippers is the only reversal of the overall downward trend in numbers of oyster-handling organizations (Table 3). This probably reflects the increased importance of imports to the Virginia oyster industry while the reduction in the shuckers-packers and shell-stock shippers organizations reflects the declining availability of locally grown oysters.

The factors responsible for the 28-year decline in oyster production from Virginia waters are many and intertwined. Continuing overfishing of public oyster beds, catastrophic epizootics, fresh-water kills, lowered levels of brood-stock, reduced setting and continuous predator pressure are definite causes. Declining environmental quality is strongly suspected as a contributor in certain heavily populated and industrialized areas, such as the lower James River. Economic elements have contributed to rising production costs. These include increasing costs of money (during the last 20 years), availability of higher economic yields at less risk in other investment areas, generally stagnant dockside prices, consumer resistance and competition from harvesters and growers outside of the State. Failure of the public sector to adjust to modern production methods, and inadequate public and private management have also contributed.

With so many factors operating it is difficult to separate or rank them objectively. First, all facets are not equally understood and for some further study and analysis is needed; secondly, some can never be evaluated separately because of their intertwined nature. Yet clarification is possible!

Overfishing has been identified as the single most important factor affecting yields from publicly owned and "managed" Baylor Survey Grounds (Haven *et al.* 1978a and 1978b; Hargis and Haven, in press). Oystermen have consistently taken more market oysters from public bottoms than were replaced under prevailing conditions and management practices since the early 1900's. When more market-sized oysters consistently are taken than nature and management can replace, overfishing is the inescapable conclusion (Tables 1 and 2 and Figure 3)!

Reduction of planting by private, oyster-growing leaseholders in the wake of the MSX epizootic clearly was responsible for most of the drastic decrease in total oyster production since 1959–60 (see Table 2 and Figure 3). Persistent low-levels of oyster production from leased beds continues because investments in new plantings are withheld. The disease outbreaks of late 1986 and 1987, an extremely dry period that resulted in salinity increases in the Bay waters and caused spreading, disease-related mortali-

TABLE 2.

Virginia Market Oyster Production from Public and Private Bottoms, and Total Landings, in Virginia bushels for the Harvest Years 1930-31 through 1986-87^{a,b}

| | Public ^a | Private ^b | Total |
|---------|---------------------|----------------------|-----------|
| 1930-31 | 1,017,641 | 1,830,836 | 2,848,477 |
| 31-32 | 991,335 | 1,404,952 | 2,396,287 |
| 32-33 | 934,537 | 1,402,231 | 2,336,768 |
| 33-34 | 1,155,640 | 1,689,860 | 2,845,500 |
| 1934-35 | 1,028,023 | 1,871,116 | 2,899,139 |
| 35-36 | 565,824 | 1,993,418 | 2,559,242 |
| 36-37 | 598,345 | 1,230,304 | 1,828,649 |
| 37-38 | 619,407 | 1,459,308 | 2,078,715 |
| 38-39 | 733,871 | 1,834,298 | 2,568,169 |
| 1939-40 | 824,383 | 2,059,271 | 2,883,654 |
| 40-41 | 726,241 | 2,092,864 | 2,819,105 |
| 41-42 | 606,498 | 1,797,363 | 2,403,861 |
| 42-43 | 749,410 | 1,857,321 | 2,606,731 |
| 43-44 | 845,721 | 1,338,603 | 2,184,324 |
| 1944-45 | 634,179 | 1,906,500 | 2,540,679 |
| 45-46 | 997,843 | 2,346,535 | 3,334,378 |
| 46-47 | 1,060,147 | 1,953,155 | 3,013,302 |
| 47-48 | 962,284 | 2,517,992 | 3,480,276 |
| 48-49 | 1,015,035 | 2,423,447 | 3,438,482 |
| 1949-50 | 586,412 | 2,034,097 | 2,620,509 |
| 50-51 | 444,4741,969,207 | 2,413,681 | |
| 51-52 | 374,013 | 2,259,970 | 2,633,983 |
| 52-53 | 419,063 | 2,372,742 | 2,791,805 |
| 53-54 | 510,333 | 2,951,485 | 3,461,818 |
| 1954-55 | 517,178 | 2,766,137 | 3,283,315 |
| 55-56 | 650,333 | 2,820,314 | 3,470,647 |
| 56-57 | 592,181 | 2,601,353 | 3,193,534 |
| 57-58 | 586,304 | 2,926,750 | 3,513,054 |
| 58-59 | 703,915 | 3,347,170 | 4,051,085 |
| 1959-60 | 699,420 | 2,553,275 | 3,252,695 |
| 60-61 | 781,783 | 2,237,736 | 3,019,519 |
| 61-62 | 227,921 | 1,815,001 | 2,042,922 |
| 62-63 | 278,830 | 1,652,880 | 1,931,710 |
| 63-64 | 576,857 | 1,223,549 | 1,800,406 |
| 1964-65 | 615,864 | 1,605,759 | 2,221,623 |
| 65-66 | 605,982 | 1,188,633 | 1,794,615 |
| 66-67 | 226,855 | 587,105 | 813,960 |
| 67-68 | 262,996 | 790,483 | 1,053,479 |
| 68-69 | 227,577 | 621,463 | 849,040 |
| 1969-70 | 192,187 | 818,943 | 1,011,130 |
| 70-71 | 281,001 | 836,014 | 1,117,015 |
| 71-72 | 260,241 | 928,404 | 1,188,645 |
| 72-73 | 157,890 | 394,121 | 552,011 |
| 73-74 | 374,522 | 424,277 | 798,799 |
| 1974-75 | 403,737 | 491,860 | 895,597 |
| 75-76 | 397,209 | 475,159 | 872,368 |
| 76-77 | 312,539 | 320,711 | 633,250 |
| 77-78 | 512,687 | 394,692 | 907,379 |
| 78-79 | 590,533 | 441,082 | 1,031,615 |
| 1979-80 | 608,880 | 465,896 | 1,074,776 |
| 80-81 | 704,848 | 472,465 | 1,177,313 |
| 81-82 | 464,280 | 326,809 | 791,089 |
| 82-83 | 329,492 | 361,792 | 691,284 |

| | Public ^a | Private ^b | Total |
|---------|------------------------|----------------------|------------------------|
| 83-84 | 241,517 | 285,777 | 527,294 |
| 1984-85 | 341,757 | 316,922 | 658,679 |
| 85-86 | 328,338 | 386,665 | 715,003 |
| 86-87 | 273,811 ^c | 265,695 ^c | 539,506 ^c |
| | (476,050) ^c | | (741,745) ^c |

^a Public Harvests: Landing data for 1930-31 to 1962-63 and 1975-76 through 1976-77 are from NMFS *Fisheries Statistics of the U.S.* Essentially, they are the same as shown in Table 13 (Haven, Hargis, Kendall 1978a).

Data for 1965-66 to 1976-77 were obtained from the annual summaries of the VMRC. They are mostly the same as shown in Table 12 (Haven, Hargis and Kendall 1978a).

Data for 1977-78 to 1986-87 were calculated from current Virginia Landings (VMRC Newport News, Virginia).

^b Private Harvests: Landings data for 1930-31 to 1962-63 were from NMFS (*Fisheries Statistics of the U.S.*). They are the same as shown in Table 13 (Haven, Hargis and Kendall 1978a) and are the best available despite certain shortcomings.

For 1965-66 to 1974-75 they were obtained from the annual summaries of the VMRC, Newport News, VA.

Landing data for 1975-76 to 1976-77 were calculated from Va. Landings NMFS (on the basis of pounds landed).

Data for 1977-78 to 1985-86 were calculated from Va. Landings VMRC, Newport News.

^c During the 1986-87 harvest year the James River seed bed area became the major source of market oysters (called "clean culls" there) and Virginia Landings showed that a total of 476,050 Va. bu. had been taken from public bottoms in Virginia. This figure is shown in parentheses for emphasis! This was a marked increase (147,712 Va. bu., or some 45%) over the 1985-86 market oyster harvest of 328,338 Va. bu. from public rocks. However, VMRC records for 1986-87 (*i.e.* VMRC computer files on 2.4.88) show that many of the publicly taken market oysters for that harvest year (some 202,239 Va. bu., or 42.5%) had come from the James River, mostly from the traditional seed beds. Since harvest of large quantities of market oysters from these beds was unprecedented, any comparison of the market oyster yields of 1986-87 (and 1987-88, when finally in) with earlier harvests must take this into account to be as accurate and realistic as possible!

Actually, the market yield datum for the 1986-87 harvest most comparable with those of previous years was 273,811 Va. bu. (*i.e.* the first number presented in the table for harvest year 1986-87) since the clean cull (market) harvesting from the James River seed beds had not begun in earnest before 1986-87 (though up until the Kepone incident of late 1975 small oysters for use in preparation of soup, stew and chowder, called "soups", which may have been recorded as market-oysters or clean-culls, had been taken from some beds in the lower James). Compared with the 1985-86 yield of 328,338 Va. bu. of market oysters from public bottoms this represents a reduction of some 54,527, or 16.65.

Total non-James market oysters production of 539,506 Va. bu. represents the *second lowest yield of record* since the 1930-31 harvest year when more-or-less "careful" recording of harvest first began, 57 years previously. It exceeded only slightly (12,212) the 1984-84 harvest of 527,294 Va. bu., which was the lowest! Compared with the total of 715,003 from 1985-86 this is a decrease of 175,497, or 24.5%—nearly a quarter. This remarkable reduction, related mostly to the inroads of disease, previous over-harvesting and transfer of most of the hand-tonging harvesting effort to the James River seed beds continues the dismal story of decline of yields from the non-James public bottoms.

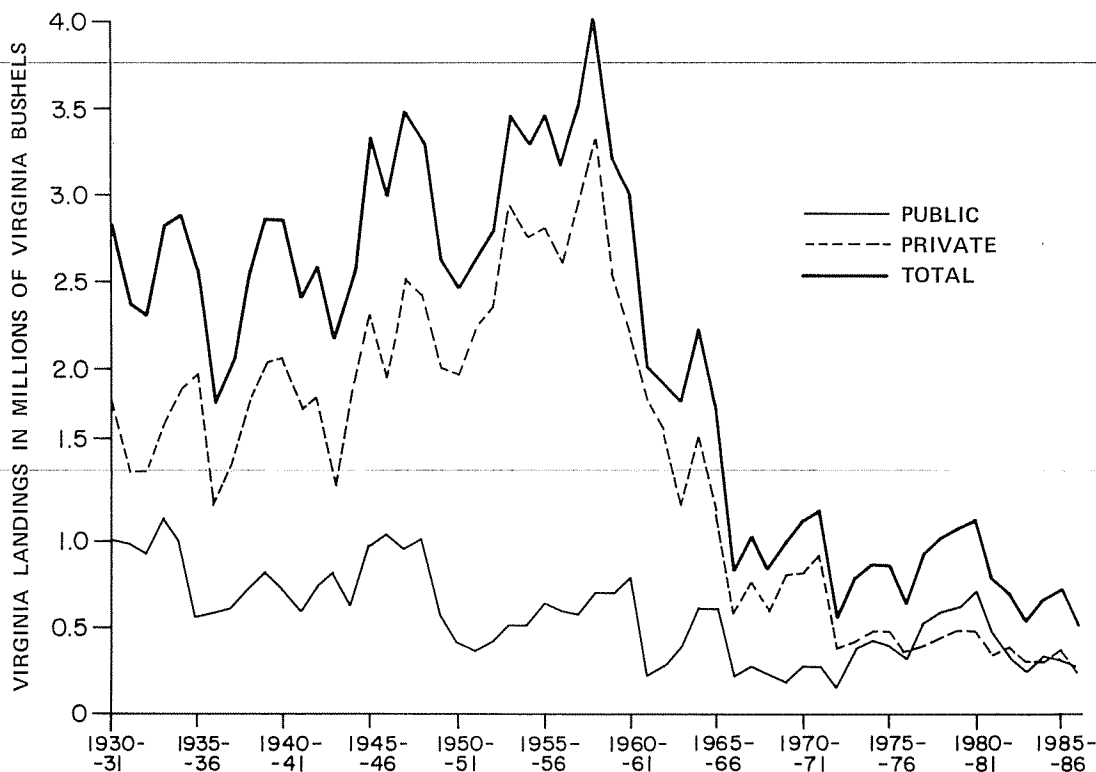


Figure 3. Annual reported market-oyster harvests from public and private beds of the lower Chesapeake Bay from the 1930-31 through the 1986-87 harvest years.

ties (even in Maryland's upper Bay according to George Krantz, personal communication), have further damaged oyster production by private growers almost everywhere and on non-James River public bottoms.

RECOMMENDATIONS FOR RESTORATION

Despite these serious difficulties, we are firmly convinced that marked improvement in production of market and seed oysters within a reasonable period (5-10 years) is possible and that every effort should be made toward revitalizing the private and public sectors of the industry! The Commonwealth will benefit.

Sufficient scientific and technological knowledge is now available for reversal of the long-term decline in market and seed oyster production even though more is

needed to restore the fishery to pre-1920 levels of production and to enable industry to cope with changing environmental and economic conditions. Critical management recommendations are:

A. To increase oyster production from Virginia waters:

1. By the private sector (at its own and not public expense)—

Of the some 243,000 acres of Baylor Survey Grounds, most of which are of much better oyster-producing potential than those acreages now available for leasing, only a small fraction (*i.e.* less than 10%) is "managed" by the State in its repletion programs. The rest are largely unproductive or only marginally productive. Leases to private growers of some of the acreage with higher producing potential would reduce the risks of losses and increase possible yields. Opportunities for higher production than the historical 1:1 seed to market oyster yield (the norm as we have discovered) would help encourage oyster planters to make greater investments in plantings for market oysters. Hence, to speed revitalization of private oyster production, we recommend strongly that a reasonable portion of the better quality unused public oyster grounds with potential for higher yields be identified by the state and opened up to carefully-controlled leasing.

2. By the public sector—

State managers must immediately establish appropriate

TABLE 3.

Numbers of oyster-handling businesses in Virginia in 1975 and 1985 by permit category

| | 1975 | 1985 |
|----------------------|------|------|
| Shuckers-Packers | 83 | 53 |
| Repackers | 46 | 51 |
| Reshippers | 0 | 1 |
| Shell-Stock Shippers | 54 | 47 |
| Total | 183 | 152 |

regulations and undertake enforcement measures necessary to reduce harvests from public bottom. The goal should be to balance harvesting pressure with the recruitment capabilities of the grounds, providing continuing yields without stock depletion.

To increase market oyster yields as harvesting pressures and natural productivity are equalized, public bottoms must be actively and forcefully cultivated. In general, more effective applications of suitable cultch materials are required for more and better quality substrate to increase spatfalls. Shell (or other suitable cultch) must be planted at places where and when maximum sets are expected to occur, not where local political pressures are strongest or when shell is cheapest. Unproductive shell plantings are a waste of effort and money and accomplish nothing of lasting value. Seed should be planted regularly on those areas where local spatfall is usually inadequate but growth and survival are suitable.

Further, a better system insuring effective closure of grounds to harvesting while production is being rejuvenated is also important. Generally, present practice by VMRC managers allows harvest even before remedial measures become effective.

B. Improvement in seed supply is vital to increasing the market oyster production by private and public sectors. This can be done by:

1. Improving seed yields from public seed bottoms in the James River by more effective application of traditional cultch for spatfall, *i.e.* planting the cultch at favorable times and places and in desirable amounts. Further, existing cultch may be improved by "turning" or other "resurfacing" methods. Suitable alternate cultches such as surf-clam, ocean scallop, ocean quahog and hard clam shells could be useful.
2. Closure of seed oyster producing areas to all competing uses except seed production until the beds recover and become self-sustaining and while demand for seed remains unmet. The present practice of allowing market oyster production from vital James River seed areas should be discontinued until a sound long-range management plan is in place.
3. Developing and maintaining other areas (*i.e.* the Piankatank and Great Wicomico Rivers) as supplemental and backup seed sources, using the same management techniques outlined above.
4. Making suitable acreages of the public bottoms in the James River seed area, the Piankatank and the Great Wicomico available to private growers as sites for seed production.

[Seed and market leases should be carefully identified and apportioned, controlled and monitored by the Virginia Marine Resources Commission (VMRC), the public fisheries management

agency, as should its own public market and seed-growing acreages.]

5. Continuing production-level hatchery operations to enhance natural seed production and provide backup support should wild seed production falter and, especially, to produce rehabilitative brood-stock and seed with desirable disease-resistance and growing capabilities.

These recommendations, if followed, should enable the public and private sectors of Virginia's oyster industry to increase productivity. Nothing should be allowed to deter or delay their adoption or continuation! More detailed recommendations aimed at bringing about this objective are provided in Hargis and Haven (in Press). In the meantime, our extensive monograph (Haven *et al.* 1978a) and the shorter Executive Summary (Haven *et al.* 1978b) are available in many institutional libraries.

Making the assumption that long-term rainfall and salinity patterns, and hence disease-levels, will return to the Bay watershed, we are convinced that seed and market oyster production from the lower Chesapeake Bay can be increased to early 1950 levels within five to ten years by adoption of essential public and private management measures based upon current scientific knowledge and seed and market oyster-producing technology. Several other remedial measures are necessary to increase production even more and ensure growing and improved yields over the long-term:

1. Though there are other factors such as currently high levels of disease, which we assume will subside as weather and salinity patterns return to normal, the major limitations to improving seed and market oyster production in Virginia in both the short and long-term future are economic, sociological and political understanding and engineering.

Overharvesting by fishermen, resistance to more efficient and effective management measures and the *lack of will, purpose or incentive* by public legislative and executive resource and environmental managers to effectively control the oyster fishery, the resources on which it is based and the environment on which the resource depends are the major factors responsible for the continuing decline of Virginia's oyster resources and its industry (as they are elsewhere). Since these factors are so important, sociological and economic research would seem paramount! Accordingly, we place a high priority on soundly conceived and conducted sociological, sociopolitical and socioeconomic studies directed to more effective public and private management of the fisheries, the environment and the oyster resources. They should be done and acted upon quickly.

2. Development of more thorough and useful understanding of the environmental factors (natural and

man-influenced) responsible for low levels of larval setting (i.e. low setting) and high spat mortality and the converse—adequate or high setting and survival of seed and market oysters. These include more careful studies of environmental and physiological requirements of larvae, spat and adults, the lethal and sublethal effects of contaminants and the factors affecting setting and survival.

3. Developing more effective techniques of accommodating to, avoiding, preventing or treating the diseases affecting larval, juvenile and market oysters. Major diseases in Chesapeake Bay and Seaside of Virginia are MSX caused by (*Haplosporidium nelsoni*), SSO (*H. costalis*) and "Dermo" (*Perkinsus marinus*).
4. Improving the technology for acquiring new supplies of cultch and in using existing supplies more effectively. Research should include searches for untapped stocks of reef-shelf near growing areas, use of ocean quahog, sea scallop, surf clam, hard clam and other natural cultch and promising artificial cultch. Cultch existing on the beds can be enhanced by proper manipulation to reduce fouling at setting time. Survival of spat can be improved by proper seed management.
5. Understanding, accommodating to and/or controlling predation from oyster drills (*Urosalpinx cinerea* and *Eupleura caudata*), blue crabs (*Callinectes sapidus*), cow-nosed rays (*Rhinoptera bonasus*), oyster leeches (*Stylochus ellipticus*) and others in the Chesapeake and on Seaside. These predators remain actual or potential deterrents to an increase of oyster yields to maximum levels, are sources of biological and economic losses and, as oyster production is restored, will certainly increase their tolls.
6. We have recommended increased support of experimental seed oyster hatcheries and controlled stock-improvement research already underway at VIMS. The State should also encourage industry to participate in this activity through its own research and development programs and by continuing to provide effective advisory service programs. Industry should be encouraged to modernize in this and other ways.

CONCLUSION

In summary, after reaching a peak of 7.6 million recorded bushels in 1904, market oyster production in Virginia's Bayside (lower Chesapeake and its tributaries) and Seaside waters has steadily declined to current levels of less than 1 million Virginia bushels. While diminishing environmental quality may have been a factor in this 80-year decline and must be attended, other factors (such as still poorly understood outbreaks of MSX, SSO, and Dermo, predators, natural catastrophes, adverse economics and

continuing poor oyster-production statistics) have also taken their toll. Most of these problems have been recognized widely for some time and, under normal climatological, hydrographic and economic conditions, can be dealt with.

The largest single factor responsible for the continuing downward trend is *overharvesting!* The Virginia oyster industry has been living off of the principal of its oyster producing potential and not the interest for almost a century! The State and the industry, especially the public sector of industry, have been unwilling or unable to recognize this fact, or—if it has been recognized, able to effectively ignore it. Many have continued to resist adoption of more effective management measures, again and again, for whatever short-sighted reasons they have advanced for short-term financial or political gain.

As always, overharvesting is relative. Prevention of continued decimation of oyster stocks (existing principal) requires a reduction of harvesting effort (withdrawals of interest) to maintain present stock levels and allow addition of new stocks (new principal). No person, government, institution or industry can continue to deplete principal without eventually running out of it, and destroying the possibility of future interest yields (harvests). Yet we are doing precisely that. The handwriting is on the wall. Put simply, if public and private oyster-producing efforts continue as they are, Virginia's position as a significant producer of oysters will decline even further!

To increase yields, more stringent and effective management measures for the public oyster beds are needed—now! If they are not brought about quickly, public and private oyster production will continue to decline to some lower, less valuable but sustainable level and a large portion of the oyster industry based upon Virginia-grown oysters will disappear as some has already. But it need not do so! Production from Virginia bottoms can be increased significantly within the next 5 to 10 years if the essential management steps recommended above are taken quickly and effectively!

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