THE OYSTER INDUSTRY OF VIRGINIA: ITS STATUS, PROBLEMS AND PROMISE

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Gloucester Point, Virginia 23062

Being a short presentation of an exhaustive, multi-volume work on the history and current condition of the oyster industry of the Commonwealth by the same authors

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FOREWORD

The Virginia Institute of Marine Science has recently completed a comprehensive study of Virginia's oyster industry from 1931 to 1976. The prime objectives of this study were to examine the history and current status of the oyster industry of Virginia which was once the largest in the world. We also intended to investigate the catastrophic decline in oyster landings since 1960, determine possible causes and suggest remedial measures.

This complete report detailing this study is very long (116 tables and figures and over 1000 pages) since it must present all of the references used, all of the analyses, and all of the findings which are the bases for the extensive recommendations. Since the full report is too lengthly for rapid perusal, a condensed version is given in the following pages. It includes portions of the Preface and Introduction, a review of oyster culture and the Summary and Recommendation chapter from the original report.

The complete report is available for review of details if that is required. The bibliography of the full report is reproduced in this brief version in case verification is required.

PREFACE

Since the beginning of governmentally-supported research into the fishery resources and the environments on which they depend, the primary objectives of that research have been to improve management of those resources and the productivity and profitability of the fisheries' industries dependent thereon. Though modern efforts at fishery science by the Commonwealth of Virginia may be said to date back to the hiring of Dr. Victor Loosanoff by the old Virginia Fisheries Commission in the early thirties, organized scientific efforts at improving the oyster fisheries of the Chesapeake Bay may be traced at least to the activities of Dr. W. K. Brooks, a marine scientist who served as a Maryland oyster commissioner in 1883. Also active in the period was Lt. Francis Winslow of the U.S. Navy, on loan to the U.S. Coast and Geodetic Survey, who studied oyster production in Tangier Sound.

Technical efforts in Virginia directed at increasing oyster yields may be traced to the delineation of those grounds most suitable to public culture of oysters in the late 1800's by Lt. J. B. Baylor of the U.S. Coast and Geodetic Survey, i.e., the Baylor Survey.[1] Virginia had asked the federal government for help. The U.S. Coast and Geodetic Survey responded.

Organized research into the biological resources and the fisheries of the Maryland portions of the Chesapeake Bay had been undertaken much earlier by various groups such as the old U.S. Commission of Fisheries and persons such as W. K. Brooks of Johns Hopkins, and later the Chesapeake Biological Laboratories, also of Maryland. The U.S. Fish and Wildlife Service, with participation from the Commonwealth of Virginia, including the College of William and Mary, established a laboratory at Yorktown, Virginia, to study the effects of estuarine pollution and diseases on oysters in the York River and the lower Chesapeake in the thirties. In 1940 this latter organization was physically replaced by the Virginia Institute of Marine Science (then the Virginia Fisheries Laboratory) which has continued the work on oysters and on other aspects of estuarine biology.

Though these are probably not the earliest beginnings of attempts at application of fishery science and technology to

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[1]In his report to the Governor of Virginia of 1893, Lt. Baylor urged, among other things, encouragement of the leasing and private planting activity. Thus, the man whose name is synonymous with the public grounds and public oyster fishery was convinced even as he reported the results of his survey that "the future of the oyster industry of Virginia...must rest on its planting interests" (Baylor, 1894).

the oyster fishery, and this account is certainly not detailed, they will serve adequately for purposes of this preface to indicate that the effort to improve or preserve the oyster fisheries of the upper and lower Chesapeake by scientific and technical means has been underway for sometime. Interestingly, early marine biologists recommended improvements which are still being urged, but which have not as yet been adopted. These voices from the past should be heard and heeded.

It is only fair to point out for most of this period investment of money, facilities and manpower in these scientific endeavors was extremely sparse. Only in the last ten to fifteen years have investments in research been significant in Virginia. This is far too short a period to allow development of an understanding of the complex natural and economic problems involved in the many fisheries important to the lower Chesapeake. Much remains to be learned.

In carrying out such research one must be concerned not only with the complex nature of the species involved but also of the fisheries' activities which depend upon them. Especially important is an understanding of the impacts upon these fisheries by environmental factors and by other users. It is a difficult and many-faceted business not to be easily or quickly fathomed. Much is as yet unknown.

Despite the shortages and gaps in our knowledge more detailed scientific understanding and technical capabilities have been developed than put into use. There are many reasons for this lack of transfer and application of knowledge and manipulative capability into improved management and increased yields and economic benefits. Some of these are: 1) archaic practices and attitudes within industry itself; 2) economic and political conflict between segments of industry, and between the fisheries and other users and uses; 3) lack of firm and consistent purpose and practice by industry and by the State toward achievement of realistic and improved management; and 4) continuation of legal restrictions and economic practices which actually mitigate against and prevent improvements in the fisheries. Destruction or debilitation of estuarine and marine environments by man-made and natural changes (some of which may or may not be induced or aggravated by the activities of society) have materially affected yields, generally by reducing them. Then, too, overfishing has taken its own toll of the stocks.

Perhaps part of the failure in achieving control over the fishery resources and of the industry based thereon is due to the lack of comprehensive analyses of the problems of the fisheries' industries and of existing knowledge related to fisheries' stocks, environmental conditions, socioeconomic aspects and of fishery technology. Convinced of the necessity for such analyses, the administration and staff of the Virginia Institute services in the Commonwealth and in the Chesapeake Region. Too, we expect to receive guidance in the planning and scheduling of fishery-related research activities. We fervently hope and expect that this series of "white papers" or working documents on the fisheries of Virginia will contribute materially to attainment of these objectives.

As an aid in understanding the complexity of Virginia's oyster industry and its problems, a general review of the catastrophic decline in Virginia landings follows in the next section.

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SECTION I. THE CATASTROPHIC DECLINE IN LANDINGS OF OYSTERS FROM VIRGINIA'S WATERS

Virginia was the most important producer of the American oyster, *Crassostrea virginica*, in the nation in the early part of this century and even until the 1950's. Middens from prehistoric periods demonstrate wide use of oysters by American Indians. Similar shell piles attest continued consumption in pre- and post-Revolutionary periods. Civilians and soldiers from all periods of military history until World War I have left remains of meals and feasts containing millions of shells around the shores of the Bay. Large masses of buried shells have been found in the rubbish piles and dumps of the many permanent and temporary encampments and fortifications around Tidewater, Virginia, dating from McClellan's Peninsula campaign and the long occupation of Eastern Virginia by Southerners and Yankees alike. Many thousands, sometimes hundreds of thousands, of men were involved often for fairly long periods of time. They and the inhabitants ate a lot of oysters.

During the mid-1800's millions of bushels from Chesapeake Bay were consumed locally each year or sold to distant markets in New England and even as far away as California and England (Brooks, 1891). By the early 1900's production had decreased somewhat as the natural oyster beds became depleted to the point where annual production was down to a reported 4 to 7 million bushels. Though a decline, this amount was large by national, even worldwide, standards and Virginia out-produced all other East Coast states.

According to the early records this level was maintained up until 1925 when there began a drastic decrease in landings and in 1931 only 2,848,477 bushels were harvested. This was a reduction of from two-thirds to one-half--not an insignificant drop! Probably, the Depression years (low demand) were responsible for a major portion of this early decline, but this needs investigation since other factors may have been involved.

After 1931, production slowly increased to 3.5 million bushels in 1954. Following this a record decline took place and in 1975 Virginia produced only 895,597 bushels. One of the principal reasons for the recent decline was the disease produced by the oyster pathogen, Minchinia nelsoni (MSX), which appeared in the Chesapeake Bay population in 1960 and killed large numbers of oysters in high salinity areas. As we will see, other causes have contributed to the decline and for the continuance of low production.

To determine the reasons for this diminishment and the persistence of lowered productivity we have conducted a detailed study of the Virginia oyster industry for the period 1931 to 1975. This period has been chosen because sufficiently reliable and comprehensive information exists in the literature concerning the fishery to support such an analysis.[2] This report will examine the major problems facing the industry. Emphasis will be placed on determining the reason or reasons for recent major reductions in oyster production and the persistent lack of recovery.

Information for this study has been obtained from published materials, unpublished data and manuscripts, historical and legal records, tax data on file at the Virginia Marine Resources Commission, records from several private oyster producers, and from interviews with oyster growers, dealers, inspectors, planters, packers and processors. The geographical area emphasized in the study is the lower Chesapeake Bay and its tributaries and the Seaside of the Eastern Shore, but pertinent material is included for Maryland.

A review of available information shows little is known in detail about the Virginia oyster industry as a whole.

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[2]Even now (1976-77) adequate data on production are lacking but sufficient information exists to allow our current analytical efforts and support their conclusions.

Many persons have generalized knowledge; a few know many or most details of specific portions of the industry. Almost no one has details of all segments: Many papers and articles on individual aspects have been published, but little of this information has been recorded and treated as a comprehensive whole. It is our purpose to do so.

A quotation from a recent report from the Marine Resources Study Commission dated 27 November 1967, describes the present situation:

> The planting and harvesting of oysters is taken for granted by oystermen and natives of Tidewater, Virginia in the same manner as citizens of rural areas consider farming; it is a livelihood and a way of life. With the exception of those persons having direct contact with the oyster industry or a personal knowledge from having resided in the Tidewater area, few persons have a comprehensive knowledge of the mechanics or the complexity of this phase of Virginia's economy.

For analysis, the factors and phases of the oyster industry, both public and private, have been divided into several categories. These are: oyster production on public and leased areas, the condition of the public rocks, economics of the industry, possible methods of management, predators and diseases, pollution, oyster culture, laws and recommendations.

Tropical Storm Agnes hit Virginia on June 21, 22 and 23 of 1972 and dropped unprecedented quantities of water on the major water sheds emptying into the tributaries of the Chesapeake Bay. As a direct result of this storm many millions of dollars worth of oysters were killed. Losses of oysters were estimated as follows: James - 10%; York - 2%; Rappahannock - 50%; Potomac Tributaries (Virginia) - 70%. No attempt is made to analyze the impact of Agnes on the economy of the State in this paper since this information has been summarized elsewhere (Haven et al, 1976). It is sufficient here to point out that it caused more than eight million dollars worth of damage. Even so, it only accelerated, but did not otherwise change, the long-term trends established here.

The following section describes oyster culture as it is practiced in Virginia, how the industry operates, where oysters are cultured, and ecological aspects influencing growth and survival.

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SECTION II. OYSTER CULTURE IN VIRGINIA - PAST AND PRESENT

To provide a framework against which later details may be considered, it is necessary to begin with a general discussion of where and how oysters are grown, methods of harvest processing techniques, diseases and other aspects.

Value and Magnitude of the Resource

Values of oysters as landed in Virginia as well as value of the shucked or processed oyster are summarized yearly by the National Marine Fisheries Service (NMFS), formerly the United States Bureau of Commercial Fisheries (USBCF). According to statistical data for the period 1880 to 1925, Virginia was producing enormous quantities of oysters, ranging annually from 4 to 7 million bushels. According to Dr. W. K. Brooks (1891) the records of C. S. Maltby, who evaluated oyster production for the whole Bay in 1865, indicated that dredging yielded 3,663,125 bushels in Maryland and 1,083,209 bushels in Virginia while tongers harvested 1,216,375 bushels in Maryland and 981,791 bushe in Virginia or 4,879,500 bushels for Maryland and 2,065,000 for Virginia. Thus, the entire Bay was recorded as having produced 6,954,500 bushels of oysters in 1865. Ten years later, in 1875, the annual production had increased to 17,000,000 bushels and it continued to increase "year after year up to the last few years" (Brooks, op. cit.). If Maltby's and Brooks' statistics are accurate, and we see no reason to challenge them, oyster production in the Bay may have reached 20,000,000 bushels or more per year in the period between 1875 and 1885.[3]

Based upon these figures Dr. Brooks calculated that during the fifty-six year period after 1834, when the business of packing oysters for shipment to the interior was established in Maryland, the average annual production from the Bay was 7,000,000 bushels per year, or 392,000,000 bushels for the period. This massive harvest was almost entirely wild, natural or unaided production. Sometime during or after this period, Maryland's oyster production dropped below that of Virginia. This reduction may have been due to the development of the private leasing system in Virginia in the late 1800's, or to overfishing and/or increasing destruction of the public bottoms in Maryland or all three. The early 1900's saw Virginia become and remain the largest producer of oysters in the Chesapeake Region and on the entire Atlantic seaboard. From 1931 to 1960 annual production decreased but was still high and Virginia

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[3]We must remember that "oyster bushels" as measures are not now the same in volume between Maryland and Virginia--perhaps they were then! Since these are the only data available for the period before 1880 and "bushels" may have been "bushels" in those days before the sophistication of official measurements was introduced, we assume equality. In any case, the official Virginia bushel is the largest of the two now. If it was also then, any error would tend toward conservatism, i.e., there would be a conservative bias against Virginia's figures.

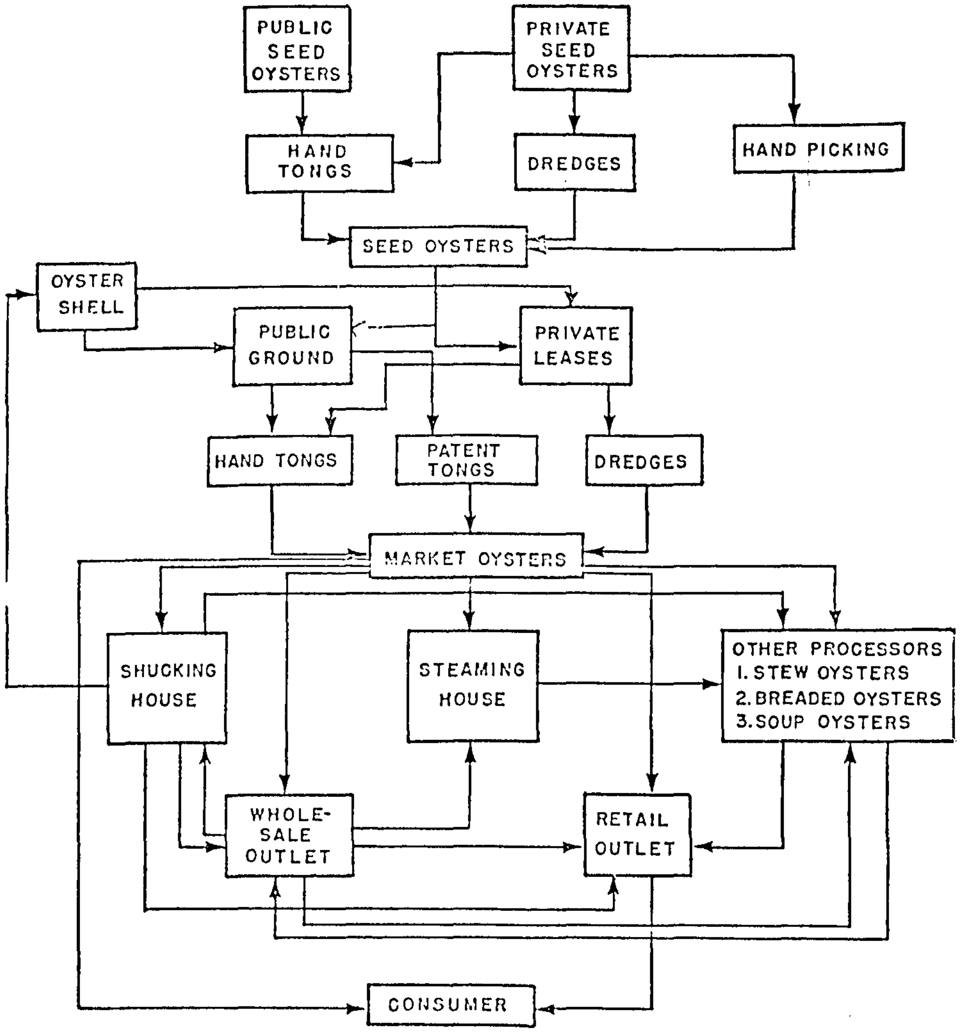
remained foremost producer on the East Coast. The average annual production in this period from the State ranged from about 1.3 to 3.5 million bushels.

Beginning around 1959 the Virginia industry began to suffer a serious decline with the initial cause being the oyster disease MSX. The latest complete NMFS data available for the 1974-75 season show a significant reduction in quantity to slightly less than 1 million bushels landed in that year. This catch was worth about 3.7 million dollars at dockside. The value of the processed meats from the oysters (shucked, raw, steamed or breaded) was over 12 million dollars. Despite a recent decline in landings the oyster industry remains a multi-million dollar business activity significantly contributing to the economy of the State.

Most persons are unfamiliar with the details of the Virginia oyster industry. Many regard it as a simple business of harvesting Nature's bounty or planting some seed oysters and dredging up marketable oysters after a few years. Actually, the oyster industry is complex, and all of its many parts are interrelated. As a consequence, something which influences one part will ultimately influence the many other aspects and the economic repercussions may be widespread. An outline showing the industry in all of its organizational and operational complexities is shown in Figure 1.

Figure 1

Stages in the harvesting, processing and distribution of seed and market oysters in Virginia.


PUBLIC SEED OYSTERS
PRIVATE SEED OYSTERS
HAND TONGS
DREDGES
HAND PICKING
SEED OYSTERS
OYSTER SHELL
PUBLIC GROUND
PRIVATE LEASES
HAND TONGS
PATENT TONGS
DREDGES
MARKET OYSTERS
SHUCKING HOUSE
STEAMING HOUSE
OTHER PROCESSORS
1. STEW OYSTERS
2. BREADED OYSTERS
3. SOUP OYSTERS
WHOLE-SALE OUTLET
RETAIL OUTLET
CONSUMER

Natural History

The American oyster, *Crassostrea virginica*, occurs along the Atlantic and Gulf Coasts of North America. This mollusc has always been a desirable and nutritious seafood from early times, when it was consumed by Indians, and later by colonists (at first somewhat reluctantly by many), until the present. Middens and refuse pits and shell piles of all ages and stages of human habitation attest to this statement.

The oyster is a suspension feeder which extracts and retains particulate matter suspended in the water drawn into its shell from the outside upon its gills. To bring in food and other essential materials water is pumped through these gills by the action of small cilia. The quantity of water pumped is large for mature oysters and may amount to as much as 15 liters (3.9 gallons) per hour. In a 24-hour period the volume pumped and strained by a bed bearing thousands of oysters would be tremendous. Material retained by the gills is transported by ciliary action to the mouth and then to the oyster's stomach where absorption of nutrients takes place. Waste products which have passed through the gut are voided as feces. Materials which have been brought into the shell cavity but not into the gut which have been selected out or rejected and segregated from the flow that passes into the "mouth," are then agglomerated by mucus on the gills and discharged as pseudofeces in the form of loosely compacted flocs or strings. Rejected in this fashion are large amounts of silt and other presumably undesirable particles. This adaptation enables the oyster to survive in many coastal and estuarine waters whose turbidity and silt burdens are extremely high. Turbid waters are characteristic of the shallow bays and estuaries in which oysters do best.

Though sex may reverse in individuals, the sexes at any one time in oysters are separate. Hence, individuals of both sexes must be available so that a suitable mixture of sperm and eggs results at spawning time. Spawning may occur during an extensive period from late June to October. However, most spawning in Virginia waters takes place during July, August and September. The eggs are released into the water from the female and then fertilized by sperm released by males. Fertilization and the early stages of blastulation and gastrulation occur in the waters nearby. In less than a day oyster larvae are able to use their cilia to propel themselves about in the water column. The larvae swim freely for about 8 to 22 days before attaching (setting) on some hard object such as an oyster shell. Embryonic shells begin to develop even before the larvae attach.

After setting or attaching, the oysters are called spat. Growth thereafter is rapid: a length of 1 to 1-1/2 inches may be reached by the end of the first summer. At this early stage the small oysters are known as "seed." As they reach 1-1/2 to 2-1/2 inches they may be harvested and purchased by companies for use in making soup. Oysters for the soup and chowder trade, or "soups" as they are called, have occupied an increasing percentage of the market in recent years. So-called "traditional market oysters," from 3 inches on up, are sold to the shucking or raw-bar market.

According to available data each estuary has a characteristic pattern of setting both in timing and quantity of set. Furthermore, geographical patterns of setting are unique. On the Seaside of the Eastern Shore, the set of oysters has always been high, with 10 to 30 spat attaching to a shell 3 to 4 inches long during a season. Furthermore, there does not seem to have been a long-term or consistent decline in intensity of set in recent years on Seaside. In fact, often too many spat have attached themselves rather than too few. Overly heavy sets often result in large numbers of oysters (from 3 to 10, perhaps more) being attached to each other in a single cluster or clump at maturity. This makes them difficult to separate and "shuck" (or open) and oysters are not "well-shaped."

On the Bayside of the Eastern Shore, the set of oysters generally is much lower than on Seaside and, in many regions, such as Pocomoke Sound, too few small oysters attach to maintain the productivity of natural oyster rocks. This low set on Bayside does not seem to be a recent development, for the limited records available suggest little change in setting intensity in the area over the past 20 years.

On the Western Shore of the main portion of the Bay proper and in the York, James, Rappahannock, Great Wicomico, Piankatank, Corrotoman and other primary and secondary tributaries, the set of oysters varies over wide limits.

Historically, the James River has been the best setting area in the State. However, in recent years there has been a serious decline in its productivity of seed and soup-sized oysters. The Piankatank and the Great Wicomico are also systems in which setting is often good.

Where Oysters Grow--Public and Private Grounds

The business of packing Bay oysters for shipment into the interior, which ushered in an era of increasing demand, seems to have developed earliest in Baltimore around 1834 (Brooks, op. cit.). If this time is correct, demand developed rapidly. As early as the mid-1800's the vast natural oyster beds of Virginia were being heavily exploited. Yields were as high as 6 to 7 million bushels annually. Oysters were being shipped in boats to New England for use as seed and "bedding" (overboard storage in the water for later recovery and consumption). Great quantities were also consumed locally or packed for shipment to California and England (Ingersoll, 1881). Large numbers went inland.

Records indicate the Indians, the colonists and succeeding generations of Tidewater inhabitants, used oysters and oyster shells for food and construction of buildings and roads in tremendous amounts. The middens of Indians and trash dumps of the Revolution and Civil War military activities contain millions of bushels of shells and many of the older roads and driveways of the Chesapeake Bay country were paved with oyster shells. In addition, until very recently, oysters were harvested just for lime-burning or road construction. The meats were wasted.

Depletion of many of the natural rocks in the late 1880's led to the establishment of regulations by public fisheries' agencies and in 1894 large acreages of the best natural oyster bottom in the Commonwealth were set aside by legislative action for public use. These areas became known as the Baylor Survey Grounds.

Most areas of bottom, below mean low water, outside the Baylor Survey Grounds, are also under State jurisdiction. Some of the non-Baylor grounds are leased to private oyster growers, some are designated as public clam grounds; others are unassigned. At present all publicly-owned "bottoms" in Chesapeake Bay below mean low water are administered by the Virginia Marine Resources Commission.

Baylor Survey Grounds

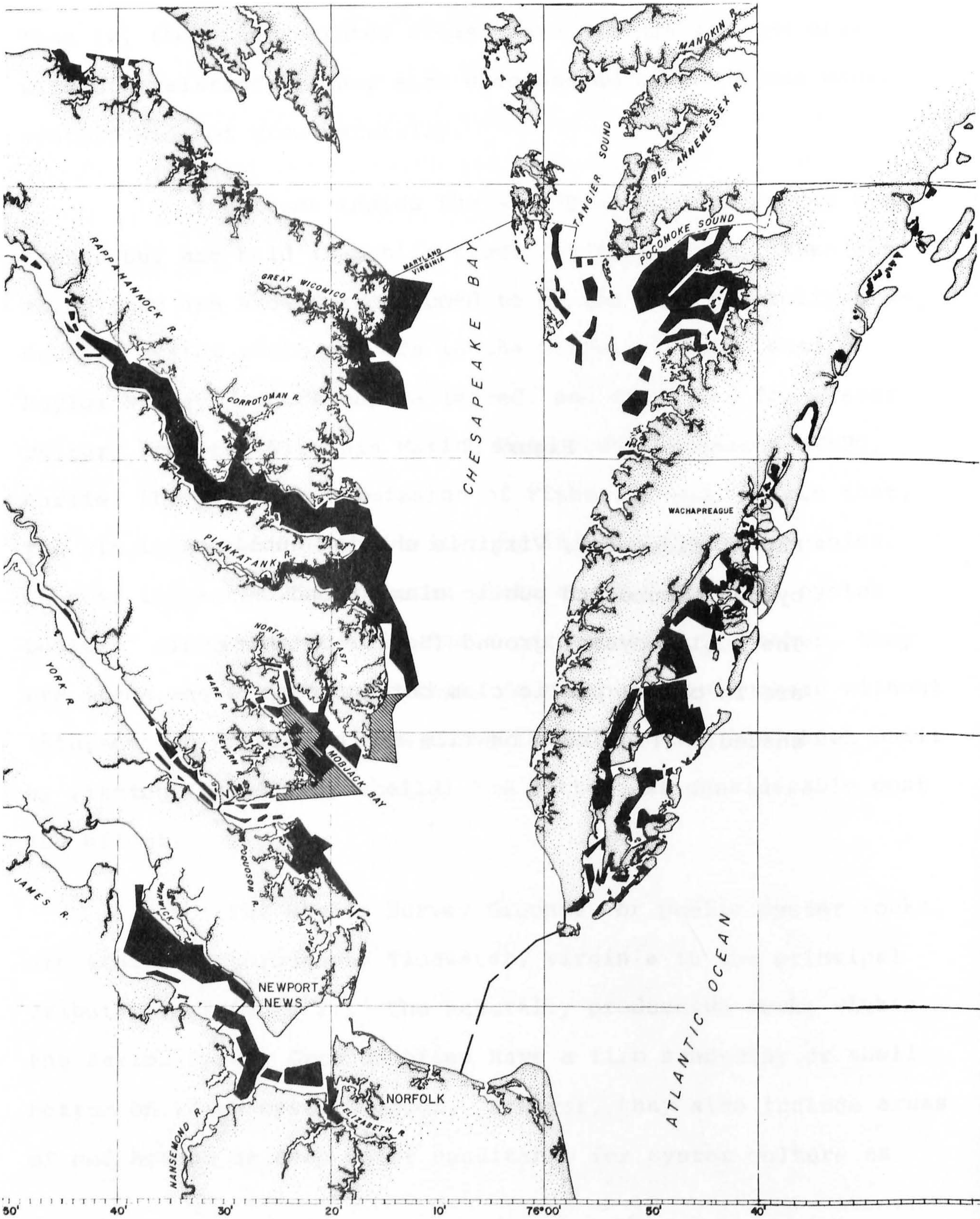
When completed in 1896, the survey of Lt. Baylor, USN, who worked for the Coast and Geodetic Survey in Virginia, included most of the natural oyster producing regions in Virginia. That is, they incorporated areas where oysters set and grew without assistance. They also encompassed barren areas where oysters did not grow naturally.

Bottoms inside the Survey boundaries cannot be leased but are held in public trust for public use. When set aside they are known or presumed to be the best naturally productive oyster rocks or beds in the State. Bottoms outside Baylor Survey Grounds may be leased, and many are, for oyster culture from the Virginia Marine Resources Commission (VMRC, earlier the Virginia Commission of Fisheries and, before that, the Virginia Board of Fisheries) by individuals or companies. In most instances these leased plots are not "natural oyster bottoms" since they are not "self perpetuating." Rather, they are areas where oysters normally do not occur in numbers without intervention of man. Often these leased bottoms have been built by firming (usually by shells) the bottoms at considerable cost and effort.

The Baylor Survey Grounds, or public oyster rocks, are scattered throughout Tidewater, Virginia in the principal tributaries (Figure 2). The naturally productive rocks within the Baylor Survey Grounds often have a firm sand-clay or shell bottom on which oysters occur. However, they also include areas of mud bottom or deep water unsuitable for oyster culture as

Figure 2

Map of Tidewater, Virginia showing public oyster ground and public clam ground. The public oyster ground (Baylor Bottoms) are in black; public clam bottoms are shaded. (From maps on file at the VMRC.)



RAPPAHANNOCK R.
GREAT WICOMICO R.
MARYLAND
VIRGINIA
CORROTOMAN R.
CHESAPEAKE BAY
PIANKATANK R.
NORTH
EAST R.
WARE R.
SEVERN
MOBJACK BAY
YORK R.
POQUOSON R.
JAMES R.
WARWICK R.
NEWPORT NEWS
NORFOLK
NANSEMOND R.
ELIZABETH R.
TANGIER SOUND
BIG ANNEMESSEX R.
MANOKIN R.
POCOMOKE SOUND
WACHAPREAGUE
ATLANTIC OCEAN
50'
40'
30'
20'
10'
76°00'
50'
40'

currently practiced. In some cases, deeper waters cannot be used regardless of methods because of other factors. The size of a "rock" may range from a few square feet to a thousand acres or more. They occur from the intertidal zone to depths of around 25 feet. Most, if not all, surviving bars and some only recently depleted, are designated by names known to all watermen which have been passed down for many generations (Figures 3, 4 and 5).

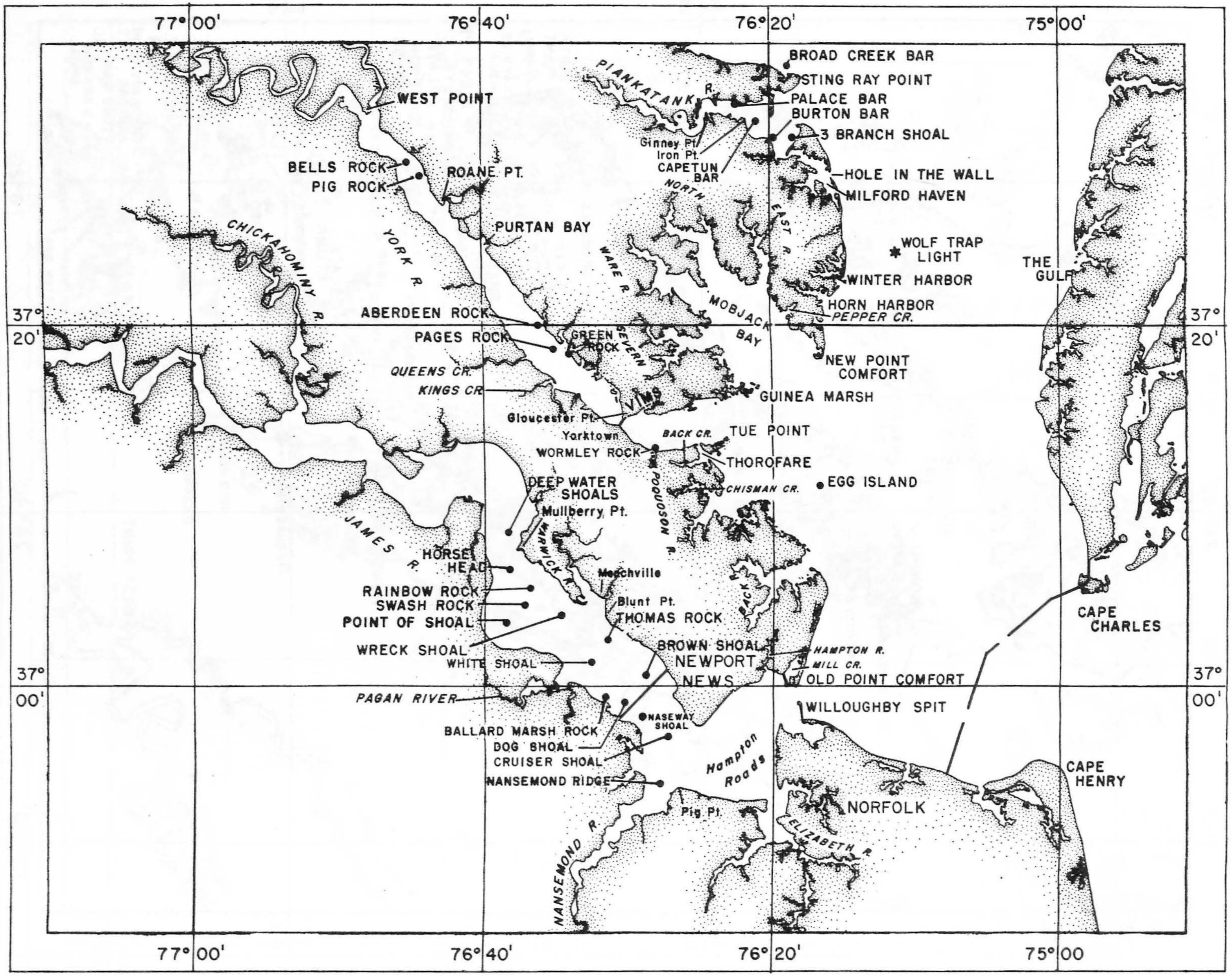
The size at which oysters may be harvested from public rocks in Virginia is specified by law. The purpose of these size restrictions is to prevent unnecessary destruction of undersized individuals and to allow them to grow to market size as conceived in the days before processed soups and chowders became popular and began to demand small oysters for processing. Oysters may be harvested only when they reach 3 inches, except in certain low-salinity regions where growth is slow and the legal size is 2-1/2 inches, or in seed areas. Certain public bottoms, such as those in the James River and parts of the Great Wicomico and Piankatank rivers, are designated as seed areas and oysters from recently-set spat up to those of the largest size may be harvested.

Opening or Closing Public Rocks

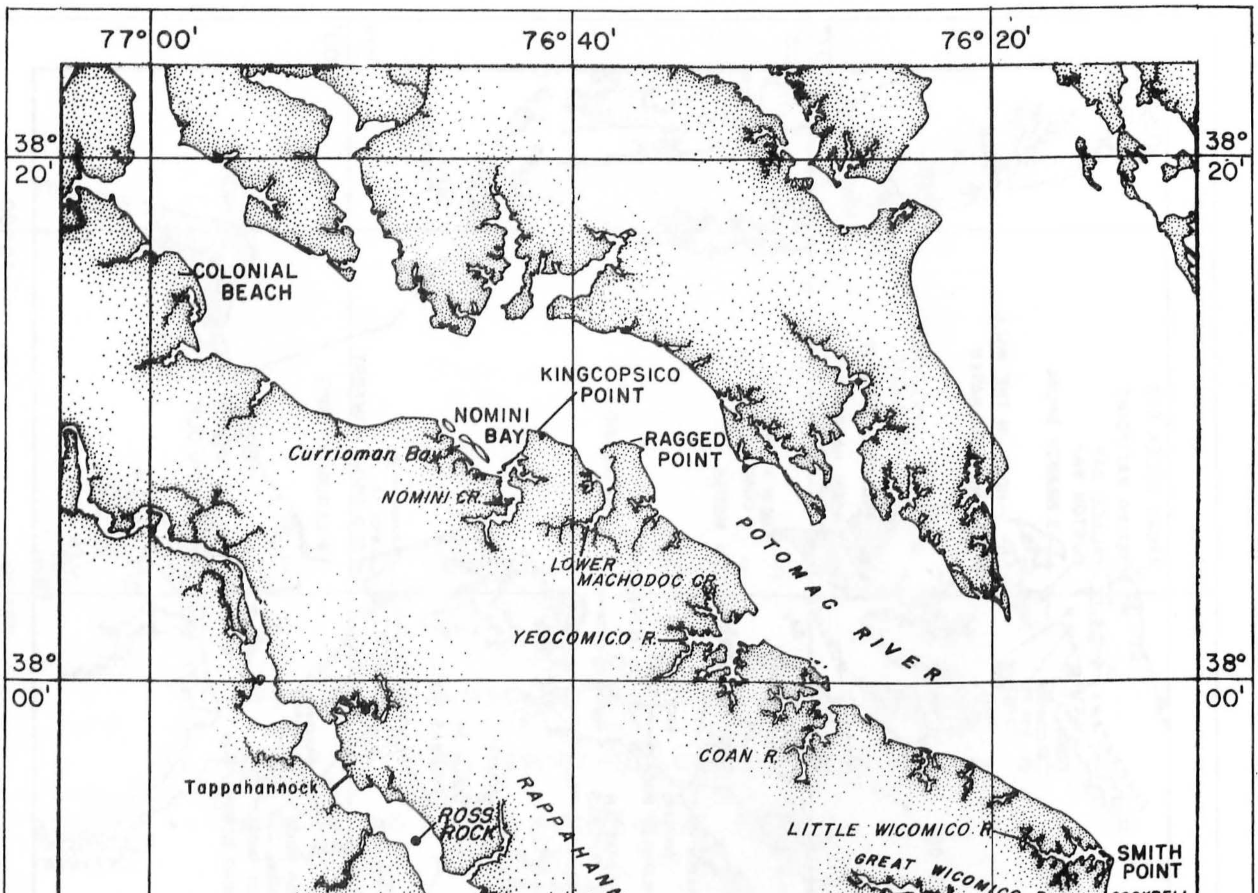
There are laws regulating the catching of oysters in Virginia. However, with the exception of the Great Wicomico and Piankatank rivers, these laws are seldom used to maximum advantage.

Figures 3, 4 and 5

Maps of Tidewater, Virginia showing names of oyster rocks, geographical points, towns and bodies of water mentioned in this report.



77° 00'
76° 40'
76° 20'
75° 00'
37° 20'
37° 00'
BROAD CREEK BAR
STING RAY POINT
PALACE BAR
BURTON BAR
3 BRANCH SHOAL
HOLE IN THE WALL
MILFORD HAVEN
WOLF TRAP LIGHT
WINTER HARBOR
HORN HARBOR
PEPPER CR.
NEW POINT COMFORT
GUINEA MARSH
TUE POINT
THOROFARE
EGG ISLAND
CHISMAN CR.
BACK CR.
THE GULF
CAPE CHARLES
CAPE HENRY
PIANKATANK R.
Ginney Pt.
Iron Pt.
CAPETUN BAR
NORTH R.
EAST R.
WARE R.
MOBJACK BAY
SEVERN R.
WEST POINT
BELLS ROCK
PIG ROCK
ROANE PT.
PURTAN BAY
YORK R.
CHICKAHOMINY R.
ABERDEEN ROCK
PAGES ROCK
GREEN ROCK
QUEENS CR.
KINGS CR.
VIMS
Gloucester Pt.
Yorktown
WORMLEY ROCK
POQUOSON R.
DEEP WATER SHOALS
Mullberry Pt.
JAMES R.
WARWICK R.
HORSE HEAD
RAINBOW ROCK
SWASH ROCK
POINT OF SHOAL
WRECK SHOAL
WHITE SHOAL
Blunt Pt.
THOMAS ROCK
BROWN SHOAL
BACK R.
NEWPORT NEWS
HAMPTON R.
MILL CR.
OLD POINT COMFORT
WILLOUGHBY SPIT
PAGAN RIVER
BALLARD MARSH ROCK
DOG SHOAL
CRUISER SHOAL
NASEWAY SHOAL
NANSEMOND RIDGE
Hampton Roads
Pig Pt.
NORFOLK
ELIZABETH R.
NANSEMOND R.
75° 00



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76° 40'
76° 20'
38° 20'
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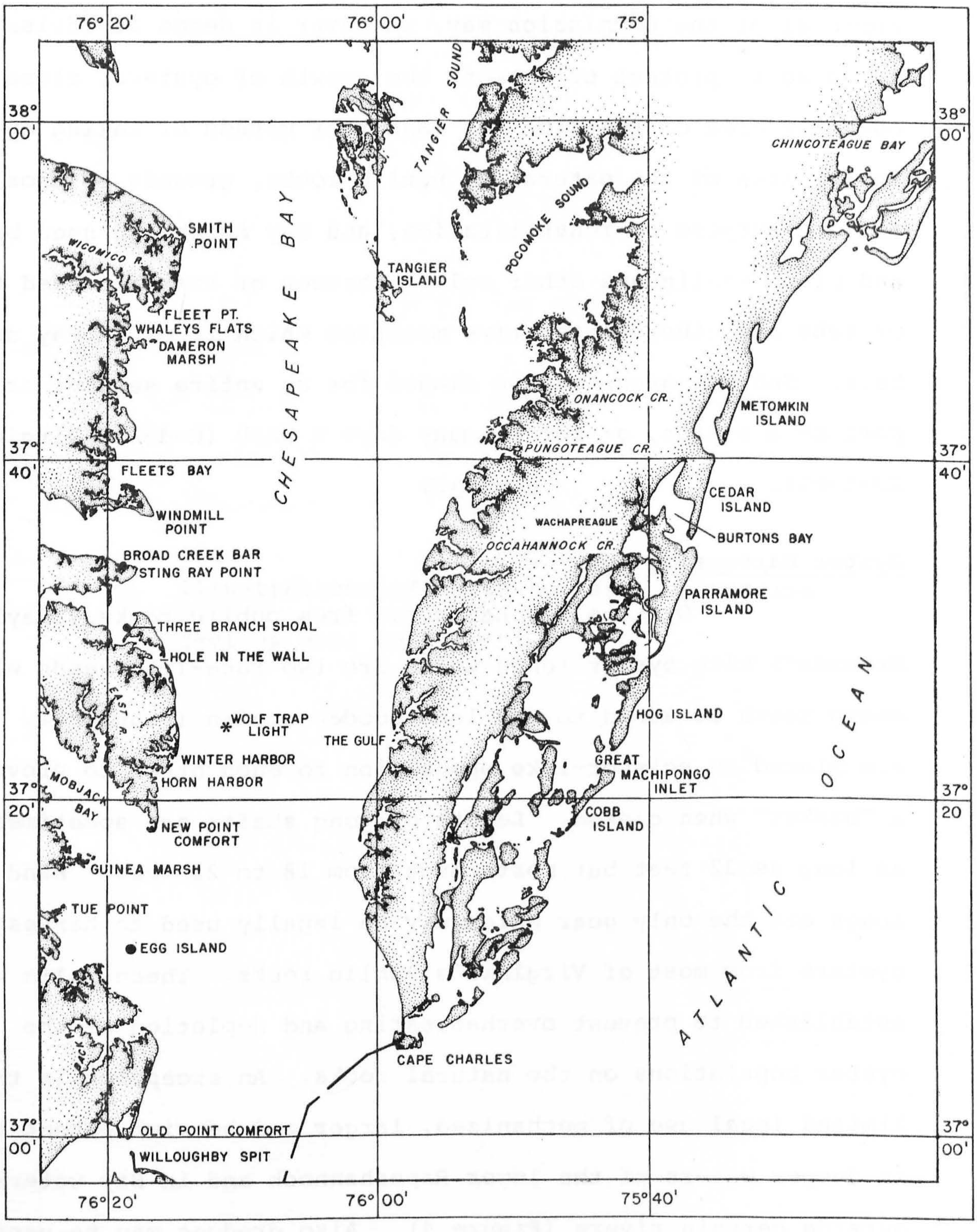
37° 40'
COLONIAL BEACH
KINGCOPSICO POINT
NOMINI BAY
Currioman Bay
NOMINI CR.
RAGGED POINT
LOWER MACHODOC CR.
POTOMAC RIVER
YEOCOMICO R.
COAN R.
Tappahannock
ROSS ROCK
RAPPAHANNOCK R.
LITTLE WICOMICO R.
GREAT WICOMICO R.
SMITH POINT
COCKRELL CR.
HAYNIES BAR
SHELL BAR
SANDY POINT
FLEET PT.
Cranes Cr.
Mill Cr.
WHALEYS FLATS
DAMERON MARSH
BOWLERS ROCK
MORATTICO BAR
Monaskon Bluff
CORROTOMAN R.
MATTAPONI R.
PUNCH BOWL
Smokey Pt.
Dividing Cr.
BLACK STUMP
Corrotoman Pt.
Indian Cr.
Rogues Hole
FLEETS BAY
Dymer Cr.
Urbanna
DRUMMING GROUND
HOG HOUSE BAR
WINDMILL POINT
Greys Pt.
Parrots Is.
PAMUNKEY R.
TOWLES BAR
BROAD CREEK BAR
Sting ray Point
PIANKATANK R.
PALACE BAR
BURTONS BAR
WEST POINT
Ginny Point
Iron Point
CAPETUN BAR
3 BRANCH SHOAL
YORK R.


76° 20'
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CHINCOTEAGUE BAY
TANGIER SOUND
POCOMOKE SOUND
CHESAPEAKE BAY
SMITH POINT
WICOMICO R.
TANGIER ISLAND
FLEET PT.
WHALEYS FLATS
DAMERON MARSH
ONANCOCK CR.
METOMKIN ISLAND
PUNGOTEAGUE CR.
FLEETS BAY
CEDAR ISLAND
WINDMILL POINT
WACHAPREAGUE
BURTONS BAY
OCCAHANNOCK CR.
BROAD CREEK BAR
STING RAY POINT
PARRAMORE ISLAND
THREE BRANCH SHOAL
HOLE IN THE WALL
EAST R.
WOLF TRAP LIGHT
THE GULF
HOG ISLAND
ATLANTIC OCEAN
WINTER HARBOR
HORN HARBOR
GREAT MACHIPONGO INLET
MOBJACK BAY
NEW POINT COMFORT
COBB ISLAND
GUINEA MARSH
TUE POINT
EGG ISLAND
CAPE CHARLES
OLD POINT COMFORT
WILLOUGHBY SPIT

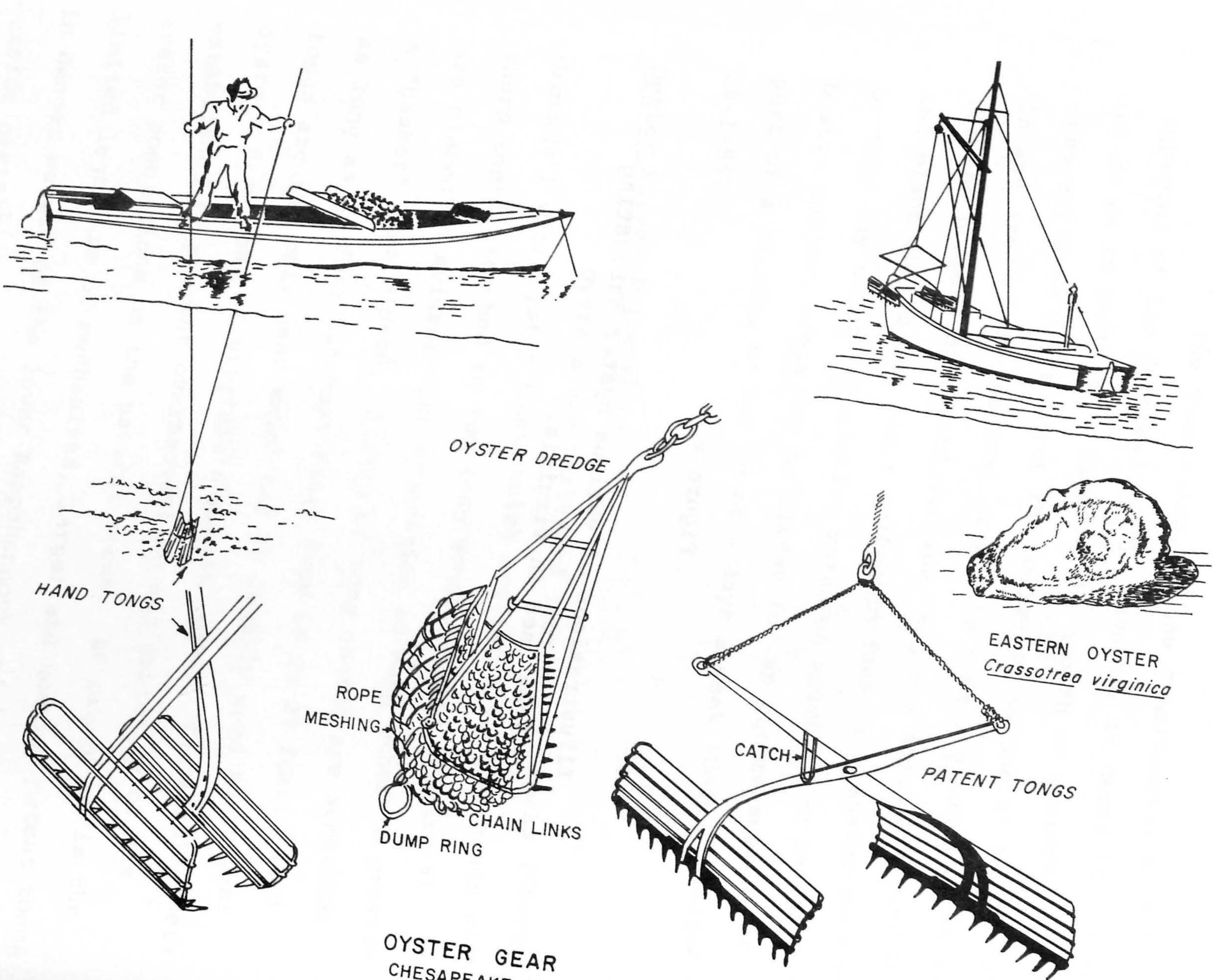
The Commission, or the Commissioner with the approval of the Commission may, whenever it deems it advisable to do so to protect or promote the growth of oysters, close or open any area or restrict the manner or method of taking oysters in any area of the natural or public rocks, grounds or shoals for the purpose of rehabilitation, and may establish seed beds and plant shells and other cultch thereon or transfer seed thereto or take any other restorative measures which it or he may deem best. Subject areas may be closed for an entire season, or part of a season, or for so many days a week (Code of Virginia 28-1-85).

Oyster Harvesting Devices

Oysters are harvested from public rocks ("Baylor Grounds") with oyster tongs which are two rake-like heads with sharp teeth attached to two long wooden shafts (Figure 6). They are placed in scissor-like opposition to each other to provide a "basket" when closed. Length of tong shafts are sometimes as long as 32 feet but most range from 18 to 22 feet. Hand tongs are the only gear which may be legally used to harvest oysters from most of Virginia's public rocks. These rules were established to prevent overharvesting and depletion of the oyster populations on the natural rocks. An exception is the limited legal use of mechanized, larger and heavier patent tongs in deeper waters of the lower Rappahannock and in Bay waters outside certain rivers (Figure 4). Also dredges may be used during certain seasons in two or three areas in Tangier Sound.

Figure 6

Illustrations of various oyster harvesting devices used in Virginia.



OYSTER GEAR
CHESAPEAKE BAY

Oyster tongers operate from shallow draft boats 20 to 45 feet long, usually possessing a cabin forward and a large open cockpit aft where the oysters harvested by the tonger are heaped. The boats have a wide washboard on which hand tongers may stand while harvesting. Free-board is generally 2 to 4 feet. The crew generally consists of two or three men. One man "culls" the catch, while one or two men "tong." If market oysters are being caught, culling consists of returning to the water, as prescribed by law, all oysters less than legal size. Empty shell must also be returned. When a waterman is working in a seed area the minimum size limit does not apply. However, all shell which does not bear visible small oysters must be culled from the catch and returned to the water. This rule is intended to slow or eliminate the destruction of the rocks caused extensively in the past by removal of the shell substrate so important to continued productivity.

In general, catch of market oysters per boat will range from 10 to 30 bushels daily. Seed catch is usually higher and daily catches may range from about 20 to as high as 50 to 100 bushels per boat. Where possible, market oysters are sold (by the bushel) the same day they are harvested to the owner of the shucking house or to a packer who specializes in the sale of unshucked or "raw-bar" oysters.

Seed oysters for planting on leased bottoms are handled in a different way. At the end of a work period, usually a day, the tonger generally sells his catch to the operator of a "buy-boat." Buy-boats may be 60 to 80 feet long and may be capable of carrying a deck load of several thousand bushels of seed which the operator purchases from a number of tong boats. In all cases, the quantity sold to the buy-boat is measured by the bushel (the Virginia oyster bushel), and there is occasionally controversy between the buyer and seller as to whether the bushel measure is properly filled.

In recent years the practice of selling seed or market oysters to truckers instead of buy-boats has become quite common. In this process the tonger transports his oysters to a dock where they are off-loaded onto a conveyor belt which empties into a truck. There is little effort to remember or denote the precise locations at which the seed was originally harvested; hence, records of production from specific oyster rocks are virtually non-existent. Thus, efforts at evaluating the effects of specific repletion efforts are nearly impossible.

For various reasons transactions between the tonger and buyer have usually been in cash. Up to October 1975 this aspect made it difficult to obtain valid statistics on price, volume or source of seed. However, a recent regulation by the VMRC has changed this aspect and price and other economic aspects may now be determined.[4]

Recently part-time and sport or avocation tongers who frequently use outboard-powered boats of lesser substance and sea-keeping qualities than those of fulltime watermen have become fairly common. The catches of the casual or avocational groups are unrecorded and unknown to anyone save themselves.

Season of Harvest

The season when oysters may be taken from public rocks is regulated. In the James River oysters may be taken from sunrise to sunset from 1 October to 1 June, and on the Seaside of the Eastern Shore from 1 November to 1 April. In all other regions of Virginia oysters may be harvested from 1 October to 1 June.

Private Grounds

Private leases used to produce oysters as a business venture are scattered throughout Virginia, generally occupying marginal (in terms of natural production or unaided potential) areas between the Baylor Survey Grounds and shore, or bottoms in deeper, high-salinity waters which are or were not considered to be "natural" oyster bottoms when the original Baylor Survey

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[4]Since October 1975 the tonger must sign a VMRC Buyer's Slip if cash is paid.

was made. These areas, in most instances, do not receive significant natural sets but must be planted with seed, if they are to produce oysters. Frequently the bottoms are unsatisfactory (too soft) for oyster culture without stabilization. Should this be the case, "shelling" with up to 10,000 bushels of oyster shells per acre is required. This provides a substrate on which larvae may set or a firm foundation for a later planting of seed oysters. In the past and until 1963 and 1964, private grounds produced 3 or 4 times as many oysters per acre as did the public grounds. Today (1975-1976) production from the two areas is about equal.

The primary basis for the private oyster industry in Virginia are the productive public seed rocks in the James River. Other lesser public seed sources, however, exist on public "rocks" in the Great Wicomico and Piankatank rivers. Without these important seed sources the private oyster growing industry of Virginia, as it is today, would cease to exist.

Additional, but minor, sources of planting stock to private growers are those quantities of seed produced on certain private leases located in the James, Great Wicomico and Piankatank rivers and on the Seaside of the Eastern Shore.

Seed obtained from the James and other areas is usually transported to planting areas by buy-boats. However, in certain instances, trucks transport the small oysters overland and then reload onto boats for planting. When the growing area is reached the seed is shoveled or washed over the side and distributed or "planted" at rates which may average from 500 to 1,000 bushels per acre. In most areas two or three years are required for the seed oysters to reach maturity. On the Seaside of Virginia seed is left on growing grounds 12 to 18 months depending on the location of the area. If left longer, usually the grower experiences unacceptable losses of oysters due to predators and diseases. (Distribution of predators and diseases, and hence survival and production of both seed and market-sized oysters is often related to salinity.)

While higher yields have been assumed by earlier writers, and in some instances actually been experienced, our studies show that the statewide average yield is a single bushel of market oysters realized from each bushel of seed planted.

To the extent funds are available, oyster shells are planted by the Marine Resources Commission in areas where unavoidable pressure exists or where a natural strike is expected. Private growers also plant shells to firm bottoms or provide cultch for spatfall, or both. Such shell plantings may be at densities ranging from 5,000 to 10,000 bushels per acre. Small oysters attaching to these shells are often harvested and sold as seed. Sometimes they are allowed to remain and grow to market size in the area.

Oysters from private leases may be harvested by tongs but generally towed dredges designed to catch oysters are used (Figure 6). Dredge boats may be 40 to 60 feet long although smaller ones are sometimes used. In Virginia all are powered by internal combustion engines. Interestingly, in Maryland sailing vessels are still used as a conservation measure though restrictions of dredges to sail-power alone are weakening.

Oysters are transported to the shucking house or to the place of sale by these boats.

<u>Shucking Houses</u>

Oysters from public rocks as well as private leases are processed or opened in shucking houses which are scattered along most rivers. Formerly many more such houses existed but a number have been closed as the industry has declined. The current number is estimated at 227.

Oysters are transported from the dredge boat to a small storage room adjacent to the shucking house by a wheel-barrow or by a mechanical conveyor. There on waist-high benches rests a small elevated block on which the oysters are placed while being opened. The method of shucking or opening oysters has changed little in the past 100 years (Figure 7). Shuckers may use a small hammer to break off the thin bill of the oyster so a knife may easily be slipped between the shells. Some merely insert the oyster knife between the shells without breaking

Figure 7

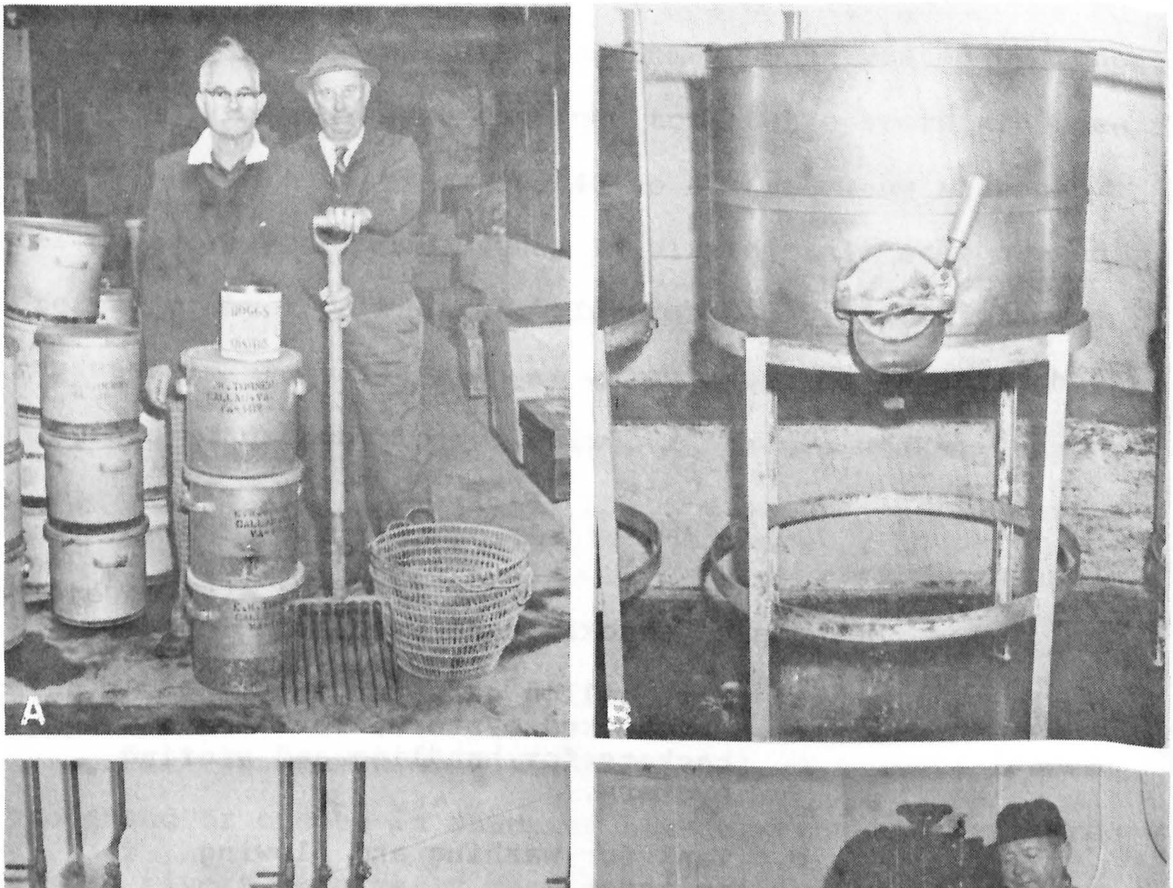
Methods of shucking and processing oysters.

a. Five gallon cans for shipment of shucked oysters, fork and baskets for handling and storing oysters.

b. Tank for washing and blowing oysters.

c. Blowing tanks and tables for washing and draining oyster meats.

d. Equipment used for canning oyster meats for shipment.


A
B
C
D

the shell. The shucker deftly cuts one end of the adductor muscle loose from the shell with the knife and the shells are forced apart with a quick twist of the wrist and blade. The other end of the adductor muscle is separated from its anchorage on the other valve and the meat is dropped into a gallon container half-full of fresh water.

When this container is filled with meats it is emptied onto a stainless steel table perforated with round holes, sized so that water and bits of shell fall through while retaining the meats. Tax payment for shucked oysters is based on the volume of drained meats.

Meats are next placed in a large stainless steel tank holding several hundred gallons of fresh water. These tanks have air jets at the bottom (to "blow" or agitate the meats) and the meats may be held in this apparatus for no longer than 30 minutes (Figure 7). "Blowing" time (the time air jets are on) has two effects. First, the meats are cleared of mucus, sand, mud and small bits of residual shell. Secondly, the meats take up fresh water and volume may be increased from 10 to 20 percent.

After blowing, oysters are cooled to 40-45^{o}F and then packed into containers ranging in capacity from less than a pint to five gallons which are then packed in ice. In this form they may be shipped by truck to markets all over the United States. Some are frozen for later consumption. In some instances the shucked oysters are processed as breaded oysters. Other oysters, "soups," are steamed open without shucking. This latter practice usually precedes further processing into stews or soups.

Shucked and cleaned oysters are sold commercially in graded sizes. Ranges in numbers per gallon are: Standards--300 and up; Selects--210-300; Extra Selects--160-210; Counts--160 or less.

Regionally there are major differences in quality. The reason for this is not known exactly, but it is known to be largely due to the plankton and other sources of food and nutrients in the water. Other aspects of water quality may also be involved.

Of course, not all oysters are shucked or processed. Some are shipped in the shell for opening and processing elsewhere as for the raw-bar trade. The "packing" required to get such oysters to market or to the consumer is relatively simple.

Price

The factors governing price paid by the processor or shell-stock shipper to the grower or harvester for whole oysters are discussed in the main report. In actual practice the price paid is usually on the basis of how many pints of meats the oysters will "shuck" per bushel. This is usually determined by taking a small sample prior to shucking them or by paying for the yield on the entire lot after the oysters are sold.

Types of Business (Wholesale Level)

In the United States dealers shipping oysters interstate must be certified by the U.S. Food and Drug Administration. Consequently, there is a listing of certified companies published monthly. Basically there are four types of businesses:

> RS-Reshipper--Shippers who trans-ship shucked stock in original containers, or shell-stock from certified shellfish shippers to other dealers or to final consumers. (Reshippers are not authorized to shuck or repack shellfish.)
>
> RP-Repacker--Shippers, other than the original shucker, who pack shucked shellfish into containers for delivery to the consumer. A repacker may shuck shellfish or act as a shell-stock shipper if he has the necessary facilities and permits.
>
> SS-Shell-Stock Shipper--Shippers who grow, harvest, buy or sell shell-stock. They are not authorized to shuck shellfish or to repack shucked shellfish.
>
> SP-Shucker-Packer--Shippers who shuck and pack shellfish. A shucker-packer may act as a shell-stock dealer.

As of 1975 the following numbers of businesses in each category in Virginia were:

Reshipper	0
Repacker	46
Shell-Stock Shipper	54
Shucker-Packer	83

The manner in which the businesses listed above may interact to influence price is almost completely unknown. There is, from all available information, much activity in which several shuckers ship oysters to a packer, who in turn may sell to a repacker. Complete understanding of the oyster industry of Virginia would require careful and comprehensive study of this phase of the industry.

Yields

Factors governing oyster quality or yields are only partly understood. Yields of meats may vary seasonally and regionally and a statewide average might be 6.0 to 6.5 pints per bushel. The range, however, is from 4.0 to about 8.0 pints. A yield of 7.5 or over is regarded as exceptional.

Predators

Among the principal predators of small oysters and oyster spat are oyster drills. These marine gastropods kill small, developing oysters as well as adults by drilling a small hole through the shell and ingesting the meats. When salinities average less than about 15‰ drills do not live; about and above this value, they do and are serious and destructive pests. Within Chesapeake Bay the two screw-borers or oyster drills,

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On the Seaside of the Eastern Shore the drills are somewhat different from those within the Bay. Here there are two subspecies, Urosalpinx cinerea follyensis and Eupleura caudata etteri. These subspecies are larger than the animals found within the Bay and they occur in nearly all oyster-growing regions because there are few or no low salinity areas. With appetites matching their size, their destructiveness is very great. Where oysters are planted in areas of heavy drill abundance, few survive to market size.

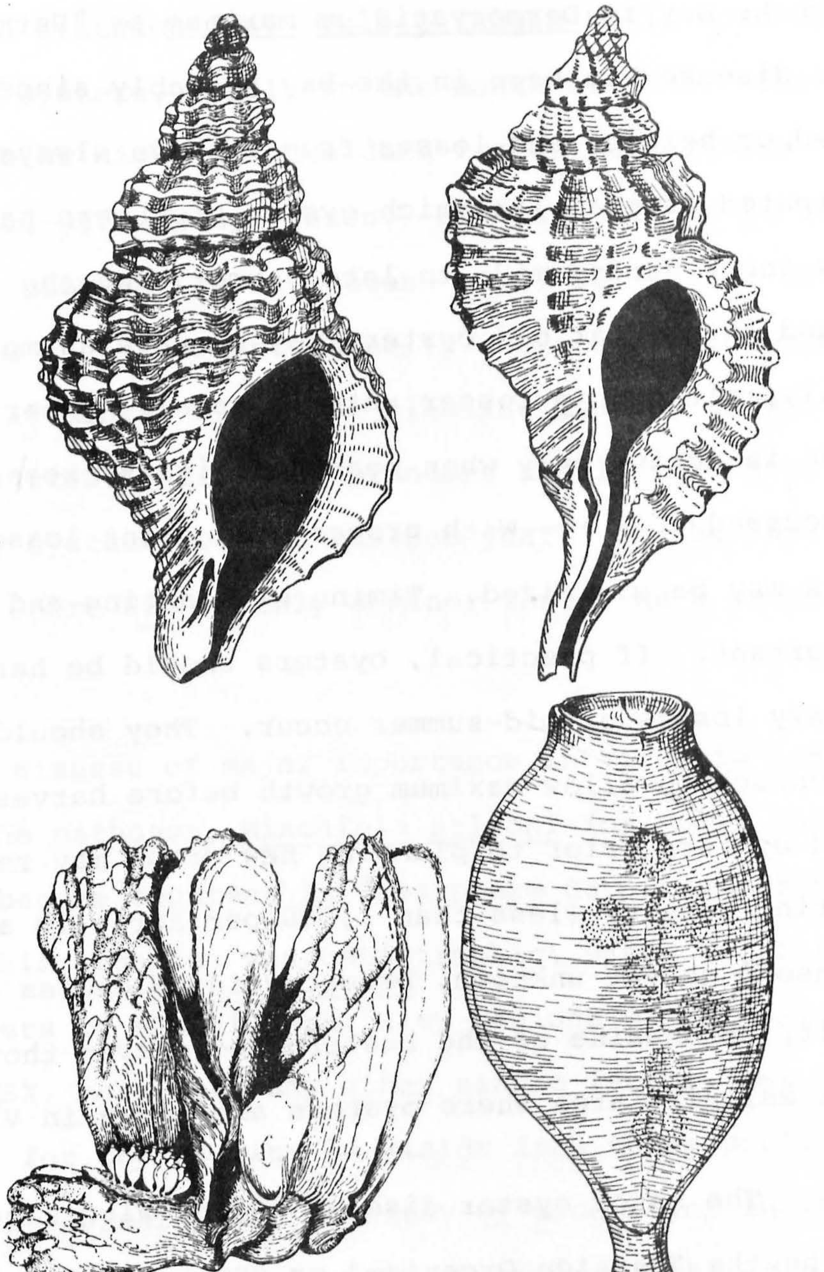
Appetites of drills of all sizes for small oysters whose thinner shells are easily penetrated, are enormous. Other predators of small oysters are the oyster leach, Stylochus ellipticus, mud crabs, Panopeus, and blue crabs, Callinectes sapidus. Oysters are also eaten by fish such as drum and cownosed rays. In recent years (1972-1977), cownosed rays have been especially destructive on leased bottoms in the Rappahannock River.

Pathogens

There are three known oyster pathogens in Virginia which cause varying degrees of mortality in oyster populations.

Figure 8

Species of oyster drills (screw borers) found in Virginia. *Urosalpinx cinerea* (left) and *Eupleura caudata* (right).



Showing the two kinds of oyster drills that occur in Tidewater—*Urosalpinx* (upper left) and *Eupleura* (upper right); the drill egg cases of *Urosalpinx* (lower left) attached to shells and an individual egg case (lower right) with 8 embryos. (By J. G. Mackin)

One which has evidently always been a problem in Chesapeake Bay is Dermocystidium marinum or "Dermo." This fungus disease has been in the Bay probably since oyster culture started, or before, and losses from it have always been an anticipated aspect with which oyster producers had to deal. Deaths occur during mid- to late summer, and the death rate in two- and three-year old oysters may average as much as 25% annually, although a lesser rate is usually experienced. The disease is active only when mean salinities exceed 12-15 parts per thousand ($^{o}/oo$). With proper management losses to oyster growers may be minimized. Timing of planting and of harvesting is important. If practical, oysters should be harvested before the heavy losses of mid-summer occur. They should be planted early enough to allow maximum growth before harvest. Removal of all old oysters prior to planting new crops may reduce losses. A planting density (less than 1,000 per acre) is also recommended. For reasons as yet unknown, Dermocystidium causes only limited mortality on Seaside of the Eastern Shore even though it is the highest salinity area where oysters are grown in Virginia.

The major oyster disease of the Virginia Seaside is caused by the "Seaside Organism" or SSO. The scientific name of the organism believed to be responsible is Minchinia costalis. It occurs in populations from Cape Henry, Virginia to Cape Henlopen, Delaware. However, since the original discovery of this disease in 1966, there has been little effort to study its range and distribution. This pathogen kills both native and imported oysters, mostly in the month of June. The death rate tends to be high, but the duration of mortalities is short and well-defined by season. SSO may kill up to 36 to 44 percent of a crop during the second year, but losses usually range from 12 to 14 percent annually. Oysters held beyond the usual 12 to 18 months from seed planting usually experience heavy mortalities; therefore, planters should make every effort not to carry oysters over to another year. On the Bayside of the Eastern Shore SSO is only a minor factor as a cause of mortality.

A disease of major importance in Virginia has been caused by the pathogen, Minchinia nelsoni (or MSX), which entered or became apparent in Chesapeake Bay about 1959. The effect of this organism was catastrophic, since it killed most of the oysters in the high-salinity regions of the Bay. Since 1958-1959 MSX, more than any other single factor, has been responsible for the decline in yields from those public and private beds, formerly the mainstay of production in the Commonwealth. Because of the great impact of this Minchinia-caused disease on the industry, it will be briefly reviewed here.

As far as we know, MSX was first observed in Virginia in February 1959, in lower Chesapeake Bay and in two years its effect was noted throughout the Bay in nearly all areas where average salinity exceeded about 15‰ (Figure 9).[5] It did not cause appreciable losses on the Seaside of the Eastern Shore.

The areas heavily influenced include nearly all of Chesapeake Bay from the mouth of the Rappahannock south, and the lower oyster-growing regions in the James, York and Rappahannock rivers. Even now, 17 years after the onslaught, annual losses in susceptible seed stocks in high-salinity areas may approach 50% to 70% (Andrews, 1968). The high mortalities associated with this disease made commercial oyster culture almost impossible in these regions in the 1960's. The loss of these growing areas to private planters caused a major drop in production for the State. Public rocks also suffered significant reductions.

The effects of MSX on oysters taper off in regions where mean salinity begins to fall below 15 ppt, and the disease is virtually absent where salinities average below about 12 ppt. In most river systems there is a transition zone of varying extent where the intensity of the disease decreases from high to low intensity. Many public oyster grounds are located within this transition zone where productivity has declined in recent years.

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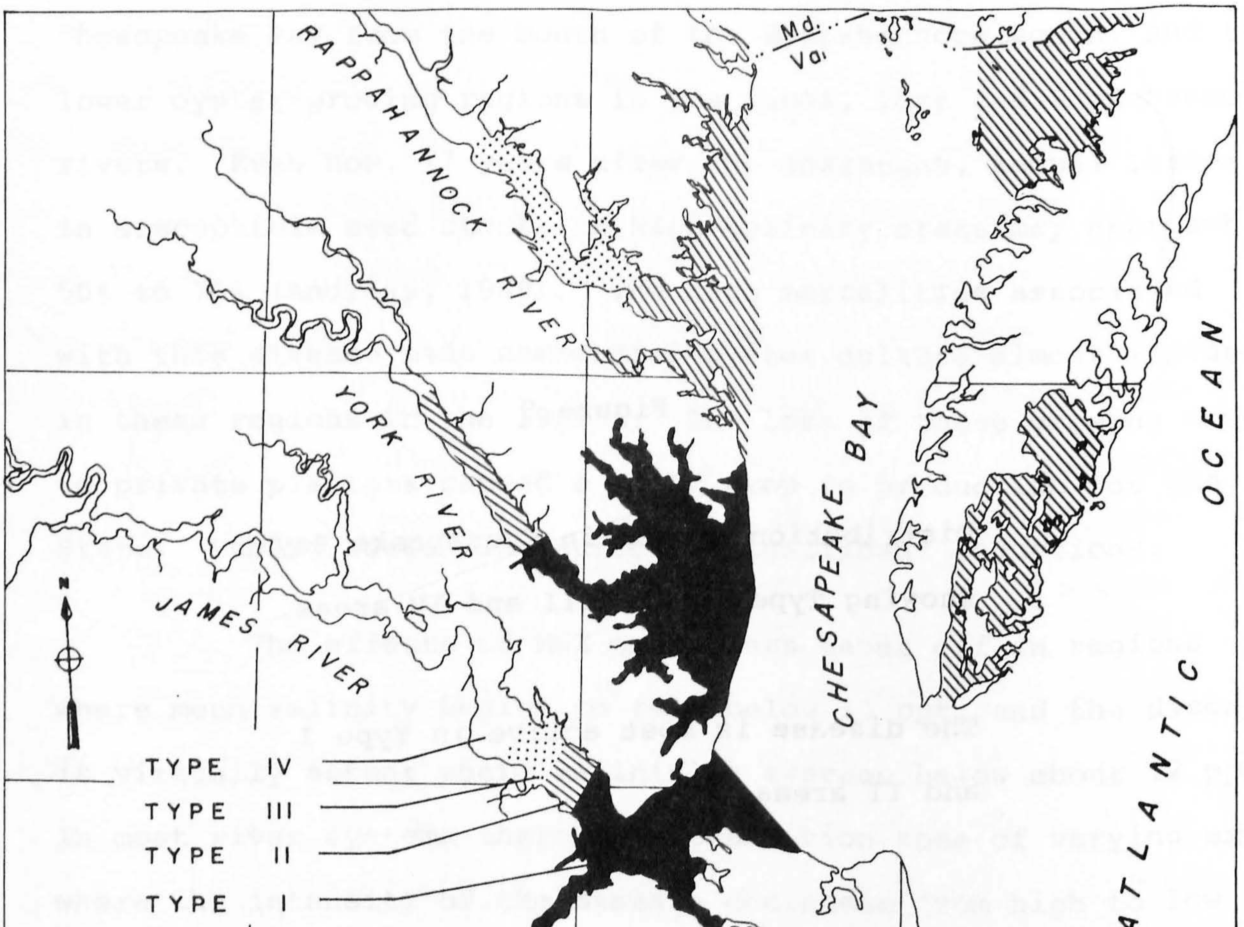
[5] Oyster mortalities have occurred in times past in the Chesapeake. The causes are unknown but much consternation resulted when they occurred. It is, of course, possible that those epizootics were caused by the same organisms as are active today in the Bay.

Figure 9

Distribution of MSX in Chesapeake Bay showing Type I, II, III and IV areas.

The disease is most active in Type I and II areas.


RAPPAHANNOCK RIVER
YORK RIVER
JAMES RIVER
CHESAPEAKE BAY
ATLANTIC OCEAN
Md.
Va.
N
TYPE IV
TYPE III
TYPE II
TYPE I

Private growers still hold many leases in this zone adopting the policy of planting only areas above this transition zone where they feel they will not suffer significant losses.

One major effect associated with MSX is the decline in setting of small oysters on the important James River seed beds. This complex question is discussed in the main report.

According to certain evidence oysters setting in certain high salinity regions, where heavier mortalities occurred earlier, may show only minor losses from MSX in recent years, i.e., since 1972. However, data are required to allow determination of whether this is a permanent change or only temporary.

Availability of Oysters to the Fishery

A fact requiring emphasis at the start of this work, especially in reference to oysters from public bottoms, is this--the number of spat or oysters existing in an area at any given time is the sum total of a multitude of interrelated environmental and man-associated factors. Basically, it is determined by the initial set, as modified by natural and fishing mortality. In the main report various aspects associated with these three points will be discussed. It is pertinent to state here that fair-to-good information exists concerning the basic set of oysters. Also available are quantitative data on natural mortalities associated with predators such as drills and diseases such as MSX, *Dermocystidium* and SSO.

Lacking, however, are data on <u>fishing mortality</u> (the quantities of oysters removed from natural populations by harvesting activities) associated with the annual harvest from the Baylor Grounds.

Fishing mortality may be evaluated in two basic ways:

1. On the basis of catch-per-unit-of-effort data in which the daily or yearly catch is related to information on effort, based on numbers of boats fishing, or man-hours.
2. By relating annual catch in bushels or numbers of oysters to the magnitude of that portion of the resource which remains on the bottom.

It is emphasized that production of oysters from leased bottoms occur, in most instances, only when the area is <u>planted</u> by a grower. It is the growers' expectation of an adequate economic return which determines whether or not leased bottom will be planted. In the past, and to a lesser extent today, most of the oysters produced in Virginia came from leased bottoms. It has been the decline in landings from leased bottoms which has been responsible for the major part of the decline in total landings from the State since 1960. Even if our public beds are restored by a major repletion effort to their former productivity, Virginia's waters will not attain their full level of total productivity, potential or even past production levels unless production from leased areas increases. If market oyster production is to be restored, seed production must also be restored and markets must be found or developed.

SECTION III. SUMMARY AND RECOMMENDATIONS

Introduction

Historically the oyster industry of Virginia has passed through six phases. The first started over 200 years ago and was characterized by underutilization of a huge population of oysters existing throughout most sections of Tidewater. Beginning in the mid-1800's the second phase began.[6] It was characterized by increasing demand and production caused by increasing growth of our population, especially along the Eastern seaboard. Production, generated in response to this demand, grew eventually reaching a plateau during the third period lasting from 1894 to about 1912 with annual harvesting ranging from about 5 to 7.5 million bushels.

A gradual decline in landings was associated with overharvesting of the public beds which fell to a low in the fourth period from 1931-1932 when annual production from the State declined to 2,396,287 bushels. The fifth phase began shortly after this as landings increased to about 4.0 million bushels in the 1958-1959 season due largely to production from leased or private bottoms. The sixth phase, which we are now

[6] According to Brooks (1891) demand for Chesapeake Bay oysters increased markedly around the time that the oyster packing business began in Baltimore in 1834.

experiencing, has been characterized by a catastrophic reduction in production which began when MSX entered the Bay. This last decline has been continued by a complex and interwoven series of events in which MSX and other diseases, pollution and socioeconomic aspects have all interacted. During the 1974-1975 period annual production from private and public bottoms totaled only 895,597 bushels!

In the main report we have described the most important individual facets of the activities of nature and man affecting the production of oysters. The scope of matters analyzed can be reviewed by reference to the Table of Contents in the main report.

The drastic reduction in landings of oysters since 1961 has been associated with several factors. MSX caused the initial decline. Afterward, an additional and continuing reduction occurred not only in waters of higher salinity affected by the disease, but also statewide in disease-free, low-salinity beds, and even on Seaside of the Eastern Shore in those high-salinity waters where MSX is not a problem. The drop has taken place on Baylor Grounds and on leased bottoms.

This seventeen-year decline in oyster production from Virginia waters has occurred and persisted not only because of biological and environmental problems such as mortalities due to diseases or predators, lowered brood-stock levels, lowered setting rates or pollution, but also for economic causes.

Rising production costs, stagnant dockside prices, consumer resistance, failure of the industry to adjust to modern production methods, inadequate management by industry and by the public sector, and competition from growers and harvesters outside of the State, have all contributed.

With so many factors operating it is difficult to separate or rank them completely and, in fact, some can never be evaluated separately because of their intertwined nature, yet clarification is possible. Admittedly, all facets of the problem are not equally understood and further study and analysis is needed but one point is quite evident: to bring production of oysters from Virginia waters back to their pre-1960 levels, or even to pre-1900 levels, whichever goal is selected, several of the pressing problems, biological as well as economic and sociopolitical, will have to be solved. To remedy or obviate the biological and environmental problems without correcting the essential elements of public and private management practices or improving the economic or technological restrictions will do little to rectify the present deplorable state of the oyster industry. Problems of all phases of the industry will have to be addressed concurrently--or at least close upon one another. It will not be easy!

Despite the difficulty associated with this complex task, it is our conviction that marked improvement in production at all levels within a reasonable period is possible and that every effort should be bent toward revitalizing the public and private sectors of the industry. We intend here to review the major causes of the reduction in oyster production from Virginia waters and recommend remedial measures. To do this it is necessary for clarity that definitions of the various words and phrases describing the oyster industry and the factors affecting it be clearly understood. For example, one cannot use the phrase "oyster production from Virginia waters" to mean "oyster production in Virginia" since many oysters processed by the Virginia oyster industry are grown in out-of-state waters and are merely shucked, processed and packaged here. They are products of the Virginia oyster industry but not of Virginia waters. Obviously, both bring money into the Virginia economy and create employment. One must also separate actual production on the bottom from those harvested as seed, soups or markets and also characterized as production.

The Decline in Production

The major factors involved in the decline in production of oysters from Virginia waters are as follows:

The Impact of MSX

MSX was the cause of the initial drop in production on public grounds and leased bottoms in the Chesapeake Bay and the lower ends of its tributaries where fall salinities average about 15 parts per thousand or above. It struck oyster populations in these areas in 1959 and caused severe mortalities in all age groups, except newly-set spat.

The Magnitude of the Decline on Baylor Bottoms and on Leased Acres

A major point established in this report is that it has been largely the drop in harvested production from leased bottoms since 1960 (after MSX) which has been responsible for the catastrophic decline in Virginia's total landings. The 100,000 to 130,000 acres of bottoms under lease from 1951 to 1960 produced nearly 5 times more oysters than the 243,000 acres of Baylor bottoms. Average production from all leased acres from 1951 to 1960 was about 2.6 million bushels. This declined to about 556,000 bushels annually in the 1971 to 1975 period (79%). On Baylor bottoms, for the same periods, annual production went from about 550,000 to 370,000 bushels (32%).

Lowered Setting Levels

While MSX caused a decline in the numbers and densities of seed, soup and market oysters on the beds in high-salinity locations, it also indirectly influenced landings in lower-salinity regions by impairing setting. The cause of this indirect damage has been a reduction of the brood-stocks of adult oysters which produce the larvae that set in regions often far removed from where the parent stocks are living. The consequence of this reduction in brood-stocks has been far reaching. It has resulted in fewer larvae in the water, which has meant lowered setting levels of oysters. This has resulted in fewer seed to transplant and fewer soup and market-sized oysters to sell at maturity.

In the lower James seed area this effect has been especially severe since it has resulted in a 50% decline in the numbers of seed oysters in the vicinity of Wreck Shoals from 1965 to 1972.[7] Similar declines in setting and of numbers and density of seed and other young oysters have been noted in other areas during the same period.

While strong evidence points to MSX as the cause of reduction in brood-stocks in the James River seed area, and hence of larvae which can set and develop into spat as the major factor responsible for lowered setting in that river, other factors may have contributed. For example, chlorine and chlorine derivatives once thought harmless under estuarine conditions have been found to be extremely toxic to oyster larvae at very low levels, i.e., 0.005 parts per million, and concentrations exceeding these levels have been found in parts of the James

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[7] In 1974 there was an unusually high set of oysters in the lower James River beginning at Wreck Shoals and extending to Nansemond Shoals. While this set may have temporarily reversed a trend which started in 1960, there is no evidence that it will be repeated in the near future, and in fact, the 1975 set was much lower.

seed area. The sources of chlorine are sewage treatment plants, refineries and power plants, or other chlorine users.

It is also possible that MSX is synergistic with increased pollution level. However, set has also declined and mortalities have occurred in areas which are not (as far as we know) affected by chlorine or other detectable or known pollutants. While chlorine may be implicated as a cause for lowered setting, other chemical substances as yet unidentified, may be responsible as exemplified by the recent finding of Kepone in the James River.

Whatever the cause or causes (and they may vary from place to place and time to time), the lowered level of setting is one of the major problems needing further attention by both science and management because seed is vital.

The Importance of an Adequate Seed Supply

Without a reliable source of high-quality, low-cost seed the private oyster industry as it exists today, with its dependence upon seed from natural waters, will cease to exist. The public beds (those which derive their populations naturally and replenish themselves) also need an adequate set for their survival. Those with diminished levels of setting will continue to decline in productivity and then stabilize at much lower levels of production (provided fishing pressure stabilizes, which it will when economics dictate).

Different Problems Face Leaseholders and Those Working or Managing Baylor Grounds

The problems facing private growers who operate using leased grounds are not the same as those facing the public managers (VMRC) and users (the tongers) of the public or Baylor Survey grounds. Though individual private growers or private oyster companies are or have been bound to specific regions or areas, the private segment of Virginia's oyster growing industry has greater flexibility than those dependent upon Baylor Grounds with their fixed locations and boundaries, and their patent dependence on a natural set, and on public monies.

Failure of Leaseholders to Relocate After MSX or for Others to Increase Production in Non-MSX Areas

Undoubtedly, MSX was the immediate cause for the severe decline in oyster landings in Virginia which began in 1960 in that it killed millions of bushels of oysters on leased beds in the higher-salinity, downriver beds and in the lower Chesapeake Bay. This eventually caused catastrophic economic problems for at least four major oyster-producing companies and severely dislocated many others. With the advanced warning provided by concerned marine scientists (from VIMS, Rutgers, and NMFS among others) as well as by oystermen from the Delaware Bay region (which experienced mortalities first), some companies were able to harvest and dispose of their oysters before mortalities became severe, thus reducing their losses. Some did nothing and suffered severe economic disruption.

Some even perished. In no case has either one of the four major companies then occupying leases in the lower Bay area been able to resume former levels of productivity. Two have gone completely out of business.

Interestingly, neither of the four largest companies relocated in non-MSX areas to continue production at high levels despite suggestions of scientists to do so. We have pondered their failure to do so ever since. Perhaps good low-salinity beds were not available to them.

After this initial negative impact of MSX other factors began to operate. Most of the remaining oyster growing companies operating in lower-salinity waters, where MSX was not a factor in survival, did not increase production materially to fill the market void left by the withdrawal of the major lower Bay producers, though a few did increase harvests immediately after the disaster. Instead, the needs of the oyster packers (that stage or segment of the industry which packs and/or processes for dispersal in the marketing network) in Virginia have been increasingly satisfied by imported oysters produced on the public rocks in Maryland.

The reason or reasons why the oyster growers of Virginia failed to increase oyster culture activities in regions less prone to MSX damage and thus maintain production in Virginia waters are complex and still only partially understood, but they are largely based upon economic factors related to increased costs of production, transport, processing, marketing and other operational aspects of oyster culture. Discussion of the major economic factors involved follows.

<u>Stable Wholesale Prices and Consumer Resistance to Higher Prices--Less Profits to the Growers</u>

Since about 1964 the demand for oysters at the consumer level seems to have reached a plateau. Apparently, the reason for this has been associated with consumer resistance due to the high price of the marketed product. The effects of these stable demand levels have rebounded down the chain of supply and demand through the various middlemen to the processors and packers who, themselves, have resisted increases in prices paid to the growers or market tongers selling oysters at dockside. The net effect of this stable or declining wholesale price (adjusted for inflation) during this whole inflationary period has been especially severe on the grower operating on leased bottom.

The private grower has been faced with major escalations in costs of labor, plant and marine equipment, vessels, supplies and money in a period of stable dockside prices. This circumstance has reduced the margin of profit. As a consequence, surviving growers find it economically advantageous to plant seed and culture oysters only on their best bottoms where they may expect the highest and most reliable yields. In quantitative terms, these are the beds on which a grower might hope to secure an average of two bushels of market oysters for every bushel planted.

The beds on which the historically profitable average yield of one-to-one could still be easily realized are no longer being utilized to the same extent because costs no longer warrant the effort, time and cost.[8] These and many lower-yield beds are still, however, held by lessees. In relation to this point, our study showed that about 40% of the leased beds are being held in units of a size inadequate for use as the sole source of full-time income for a person or a corporation. This aspect definitely needs the attention of VMRC.

Increasing Statewide Oyster Production

Statewide oyster production may be increased by appropriate action but the approach must be to remedy several aspects simultaneously.

Leasing Unproductive Baylor Bottoms to Increase Statewide Oyster Production

Since economic factors have driven the grower to discontinue use of beds whose productivity is marginal and the existing economic situation seems unlikely to change in the immediate future, the State could provide incentives for growers

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[8] If the cost-of-production to price relationship could be improved, either by lowering the former or increasing the latter, planting on average-yield bottoms might be renewed.

merely by making more high-quality bottoms available so that more oysters could be grown per acre or unit of time or cost and at a profit--even at current stable dockside prices.

Many of Virginia's best growing areas, however, are within the Baylor Survey boundaries. Most are not being effectively used and hence are not very productive. A large percentage is unproductive. Among the possible remedies for the unavailability of good bottoms to leaseholders would be for the State to arrange to make unproductive Baylor grounds which it does not now use, or does not plan to use, available for leasing. Conditions of leasing these newly available bottoms should be such that active efforts at culture must be pursued upon them within a reasonable period of time or they automatically revert to the State. Furthermore, fees should be sufficiently high as to discourage "idle leasing." It is not our purpose to develop details of such lease arrangements here. That can be left to the management agency. We are confident, however, that suitable legal terms can be developed which will assure that the State's (the peoples') goals in making such leases of publicly-owned bottoms available are met and, at the same time, made attractive to potential private oyster culturists. Furthermore, this will not damage the State's own repletion efforts in any way but, on the contrary, will enhance them.

Altering Terms of Leasing Bottoms to Prevent Holding Without Use

To remedy the situation in which firms or individuals hold potentially productive currently leased or leasable grounds, but do not use them to produce oysters, conditions of leasing should be altered so as to prohibit acquisition or holding of leased grounds for purposes other than oyster culture--or such other productive uses as are in the interest of the State.

Using Leases for Purposes Other Than for Oyster Culture

Of course, there are other "legitimate" goals for leasing public bottoms to private entities or non-state public or semi-public bodies, such as other private or public uses or protection of amenities; for example, marl or shellmining, fishing, clam culture, diving, historical preservation, archaeological activities, etc. The potential use for such leases should be identified and leasing conditions appropriate to the use arranged.

There is no question the current system of leasing shellfish-growing bottoms has allowed publicly-owned bottoms to be used for purposes other than shellfish production. Some of the uses have been questionable, such as to deliberately interfere with industrial and public construction projects. In fact, some shellfish beds have been more valuable for use in business or legal contests than in shellfish production. Often such suits have been contrary to public interests. There also have been "legitimate" uses other than oyster culture. Our primary purpose here is to consider the ills of the oyster industry and to suggest public and private remedies for those ills. We must leave detailed consideration of other uses of public bottoms for a later time. There is no question, however, that the entire matter of uses of the bottoms of tidal waters of the Commonwealth must be carefully reconsidered and revised. Current leasing arrangements, which incorporate the fractionated and ill-considered conditions of the past, are no longer sufficient to encourage economic development of and conservation (where necessary) of the valuable bottoms of Virginia. There is also no question that a new system of leasing is required, one geared to identified purposes for such leasing.

<u>Consumer Demand May Be Enhanced by a Reduction in Retail Price</u>

Demand on the part of the ultimate consumer may be enhanced by a reduction in retail price since several competent economists have expressed the belief that demand for oysters is "elastic." That is, if the retail price is lowered then demand at the consumer level for the oysters will likely increase. This increase in demand will help stimulate a higher level of production by the processor, and perhaps by the oyster grower or tonger who catches market oysters, as well as by seed tongers.

A reduction in retail price, however, would be possible only if productivity is increased at no increase in costs of production or if production costs are decreased. These are critical issues. It has not been possible for us to evaluate seriously the possibility of increasing consumer demand by other methods such as increased efforts at advertising, improved processing or packaging and otherwise encouraging use by food vendors, restaurants, institutions, government agencies and housewives.

Management Steps Necessary If Demand for Market Oysters is Stimulated

If the demand for market oysters is stimulated as suggested above, without improvements in the basic seed supply, there is a very real possibility that supplies of seed from currently productive public seed beds of the Commonwealth will not equal the demand, especially in light of the monetary limitations now applying to the seed-oyster repletion program of the Commonwealth. Ways of increasing seed supply include:

1. The encouragement of the development and successful operation of oyster hatcheries by private business and by public institutions or agencies as necessary. Work along these lines is already well underway at VIMS and elsewhere by others, but it should be increased;
2. Making a reasonable number of areas where natural seed production may be expected or

where such production can be undertaken or available for lease to private growers;

3. Increase the State's repletion activity;
4. Introduction and utilization of new technology to improve setting and increase utilization of existing levels of spatfall; and
5. Increasing brood-stocks with desirable traits in strategic locations so as to increase levels of larval production and spatfall.

Increased efforts are needed by scientific groups to understand details of the natural mechanics of natural seed production. It is especially important to identify the principal factors involved in setting and its ups and downs. Methods of improving setting should be developed and then, through this research and engineering development, the conditions that are identified should be remedied.

The State Repletion Program

The Repletion Program, carried out by VMRC, is supported by funds generated by State and Federal sources. Through this program the Commission assays management of the common-property oyster fishery resource. Historically, in Virginia and elsewhere, this has proven to be a very difficult accomplishment.

Virginia's Repletion Program, like those of many other states, is largely financed by State subsidy and it is not self-supporting. The returns to the State in direct taxes or fees from production resulting from the program, itself, never equal the costs of the State's efforts to maintain or increase the production of seed or market oysters on Baylor bottoms.

It must be quickly enjoined, however, that the economy of the State as a whole benefits from the program, probably far in excess of original expenditures. These are largely self-renewing resources which, like agriculture, if handled properly, produce considerable yields in relation to cost of production. Economists have calculated that a dollar developed at the basic level is enhanced about five times as it passes through various levels of the economy.

Unfortunately, the efforts of the State have not succeeded in reversing the serious downward trend of production from public ground (Baylor) which began many years ago.

Increasing Production

There are ways that the State can increase production on Baylor bottoms at little extra cost. Instead of being planted throughout the oyster-growing regions of all of the tidal waters of the State, as has been done for many years in the past, shells intended for cultch should be planted only in those known setting areas which may be classified as moderate to heavy by the standards described in Chapter IV of the main report. Furthermore, they should be planted only at those times which are most propitious biologically.

If additional funds can be secured, other improvements in repletion technology are possible. For example, the State's resources of buried or unused "reef shells" might be utilized to increase cultch planting. Also, hatchery activities which will contribute seed or brood oysters of desirable characteristics could be supported. A full list of the possibilities is presented later in this summary.

Failure to Follow Recommendations for Improving Repletion Activities

It has been remarked above that many recommendations which would have helped increase production have been made numerous times since the Civil War period. Unfortunately, most have been partially or totally ignored. Deliberate avoidance of professional advice is not a new phenomenon but began in the last century when Dr. W. K. Brooks (1891) made many of the same recommendations as VIMS' scientists and others have since. Sad to say, resistance to scientific and engineering advice and to modernization has been true of all fisheries, not just those based upon shellfish. However, it is particularly unfortunate that public and private shellfish culturists have been so refractory to sound and useful advice since shellfish are the most readily susceptible to deliberate management of all marine animals.

Management Problems--Modifying Laws and Regulations

Four major public management problem areas are offered as examples in addition to those suggested above. They are:

1. Need for adoption of clear and consistent policies and goals to guide programs;
2. Need for more adequate and responsive management controls;
3. Need for laws and regulations which will allow management flexibility and meet these goals and fulfill policy; and
4. Need for adequate resource and production data which can be utilized by public management.

The present policy, as interpreted from explicit statements of policy (i.e., the Constitution of Virginia and, more specifically, Title 28 of the Code of Virginia and VMRC regulations), seems directed toward deliberate encouragement of oyster (and other fishery) production from Virginia waters and bottoms, as do other laws and implicit elements of law, various legislative and executive attitudes and actions, and other relevant regulations. Judging from both the explicit documentation and from the implicit evidence, it is intended that this production is to be ultimately handled by private individuals or companies as well as by individual tongers harvesting from the public rocks. In other words, established public policy is to enable and aid both the public and private sectors of the oyster-based industry.[9]

Many believe the public tongers to be the only recipients of State help. In actual practice, State effort is expended in the maintenance of both phases of the industry. Of course, the individual public oysterman is more directly dependent upon State expenditures for a larger percentage of his gross and net income than are the growers operating on leased bottoms who are directly engaged in a more sophisticated approach to oyster production which requires a higher order of management activities. An analogy between oyster growers and oyster tongers in estuarine waters can be drawn considering the differences between farmers and husbandmen as against herb and root gatherers and hunters on land.

Also, the oyster grower, the processor, and the survival of the extensive oyster-producing potential of the private sector are dependent upon State-supported efforts such as the Repletion Program (resource management), policing, environmental control, marketing development, research and engineering developments and other activities of the State.

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[9] We have assumed that this policy, which is based upon 350 years of legislative and executive activity in Virginia, will be continued at least for the foreseeable future. Hence, recommendations are largely based upon this assumption. Different policies would require different combinations of the remedies suggested herein.

As an example, the private oyster growers of the Commonwealth presently obtain 77 percent or more of their seed from James River beds managed by the State. There has been considerable discussion, much of it philosophical or political, over which segment of the oyster industry is most productive at least cost to "the people" and whether it is reasonable or wise to continue to support the "hunters" (the tongers) or to provide help to the entrepreneurial activities of the oyster growers and processors. Our investigation has shown that both elements are benefitted significantly by public management and research activities. There is no question, therefore, that the "private sector" of Virginia's oyster industry as it is carried out today is almost as dependent upon the public seed oyster rocks as are the tongers. Without publicly encouraged seed production the industry as it operates today would almost cease to exist. There is also no question that it could be made less dependent if the State were to alter its management practices and allow and encourage private growers to produce a much larger percentage of their own market oysters from their own seed. This objective would be possible if certain high-setting Baylor bottoms were made available for leasing.

Many of the oyster related laws and regulations of Virginia are outmoded. In fact, some were of little or no value when they were adopted or established. Many of the rest have lost their utility and meaning. Survival of obsolete or counterproductive laws and regulations help maintain production costs at higher levels than are necessary. For example, the requirements of the use of tongs on public bottoms when dredges are more effective. As another illustration, it is highly doubtful that the three-inch cull law where it is applied allows oystermen to harvest oysters at the most favorable sizes, if we wish to maximize yields (in terms of meats) or economic returns (in terms of possible uses). As an example of the latter, the soup markets prefer smaller oysters, many of which must be thrown back under the cull law.

Furthermore, present seasonal limitation on the taking of oysters is not realistic and should be changed to allow harvesting over longer periods to take advantage of favorable market conditions. Other questionable, inappropriate, inadequate or archaic laws or regulations are reviewed elsewhere in the main report.

A Need for Reliable Statistical Data on the Fishery

In our efforts to identify problems of the oyster industry and seek remedies, a major difficulty in evaluating the status of the oyster industry today (as of 1975-1976), as in the past, has been the almost complete lack of: 1) reliable, quantitative data on numbers and densities of oysters on and taken from the public beds (Baylor Grounds); and 2) production figures from and inventories on leased bottoms. Additionally, reliable data related to fishing effort expended, catch-per-unit-of-effort, costs of production (public and private) and recruitment and generally not available. Socioeconomic data are extremely sparse.

Naturally, lack of important data has limited our study to a considerable degree. Continuation of the lax and irresponsible attitudes of the past which disapprove requiring and encouraging availability of all of the necessary data will seriously hamper efforts at improvement of oyster productivity (as it does with other fisheries). No businessman could work effectively without accurate records and an adequate knowledge of all costs and results including effort, inventory, productivity and profit. It is important to recognize that if deliberate efforts are made to rehabilitate the Virginia oyster industry by suggesting changes in public management policies, it will be necessary to have cost, effort and productivity data relating to all phases of the public and private sector of the industry. This information will be needed to allow evaluation of the effectiveness of those programs (or efforts) and to decide on changes, if and when necessary. We are encouraged that the Marine Resources Commission is now taking steps to secure more adequate data. It needs help and encouragement in this effort.

The Need for Research and Engineering Innovations

Research and engineering are essential supplements to effective management. Much scientific and engineering effort has been directed at the oyster fishery, especially since World War II. Despite the considerable research and engineering effort (mostly the former) directed at learning more about oyster-based economic and social activities, considerable ignorance remains about key aspects! Scientists, for example, still cannot transmit MSX from one oyster to another even though they understand the epidemiological aspects fairly well and can identify and induce disease resistance in selected oyster populations. On the Seaside, SSO is a major deterent to oyster culture but its life cycle is only partially known. We do not understand the phenomenon of acquired resistance versus genetic immunity to MSX or other diseases. Effective control of oyster predators remains elusive. We do not have yet a firm grasp of the normal and abnormal cytology and histology of oysters and their associates. Many of the aspects of the nutritional and environmental requirements of oysters are still mysterious. Many aspects of the oyster's ability to deal with toxic or damaging materials such as oil, pesticides and heavy metals must be learned in order that Federal, State and local management of wastes and water quality can be fully conducive to oyster cultivation.

Of major importance is the existence of considerable technological or engineering inadequacy. Reliable growing systems must be planned and arranged and more adequate mechanization must be installed to increase productivity and reduce costs for the industry. Additional discussion of needed research and the engineering developments and socioeconomic investigations which should be carried out is presented elsewhere in this Section.

Detailed Recommendations for Increasing Oyster Production

Following this introductory assay of some of the highlights of the detailed chapters in the main report, it is now our purpose to consider each finding and recommendation in greater detail.

Leasing Unproductive Baylor Bottoms

We have clearly recommended the leasing of some of the presently unproductive grounds within the Baylor Survey in order that private growers can grow more marketable oysters on grounds which are likely to be more highly productive than those available to them now. Oyster production can be increased quickly with little or no direct cost to the Commonwealth by utilizing this promising management strategem.

Private growers, who have historically produced the major part of the landings, would benefit since their ability to produce marketable oysters in larger volume and at lower cost per acre would be enhanced.

If seed oysters continue to decline in numbers, it will be necessary to enhance seed production. This can be done at no cost to the State by making some of the seed-producing acreage within Baylor Grounds or other publicly-controlled bottoms in seed-producing rivers and reaches of rivers available for leasing to induce and enable the private growers to produce seed. It would also be possible to develop a seed-ground leasing plan which would allow persons who are now tonging to grow seed for their own use or for sale to growers. Such a move might make leasing of Baylor Ground more practical for tongers. A similar arrangement, with preferential treatment for tongers--at least in the beginning, might be made to encourage market oyster leasing of Baylor Grounds.

There will be some resistance to leasing of Baylor Grounds by tongers or by traditionalists in the industry or State government, but it should not be allowed to eliminate this useful management alternative. There are no good reasons to abstain from such an highly promising practice. All significant objections can be met. To do so would <u>not lower</u> the productivity of those Baylor Grounds retained under State management and would enhance overall oyster production. Neither will it damage the independent watermen. In fact, if oyster growers are successful, there will be additional opportunities for the independent watermen in that there will be greater demand for seed and more work on the water. Jobs for tongers, boat operators and others who work directly for the growers or processors, including shuckers, would be increased. Improvement in these sectors will encourage supporting businesses. Clearly, it is in the public's interest to encourage private oyster culture by all reasonable means.

Until very recently beds under management by private growers have historically out-produced those cultivated by the State for harvest by independent watermen by a factor ranging from 2-to-5, this despite leases being limited to bottoms having little, if any, natural set and which are generally of much poorer quality and producing potential. There is little question that private enterprise, using its own money to produce seed and market oysters, can do as well as the State. In fact, it can do better in many ways, especially where control of shell and seed planting and harvesting is concerned. (The State is frequently forced by political and financial pressure to plant shell or seed in the wrong places and at the wrong time. Also, the State is usually prevented, by political pressure, from keeping areas closed or from limiting harvest. This, too, must change!) For decades many competent study groups, including government-sponsored commissions, and fishery scientists have recommended this action. Lt. Baylor, himself, urged emphasis on private enterprise in 1894 as have many scientists and even a number of State fishery commissioners. It will be to the State's interest to encourage this improvement.

Accordingly, we recommend that legislative action be taken as quickly as possible to allow the Marine Resources Commission to make selected, currently unproductive Baylor Survey Grounds available for private leasing and use. The Commission, working with the Institute, must determine which acreages should be leased first and which should be retained for State use. It has been established that such action can be taken by the General Assembly. We urge prompt action!

It would be worthwhile at this juncture to reiterate that quantitative information of the detail and accuracy that science and management should have concerning which of the public grounds are most productive or potentially productive is sparse or lacking. This shortcoming must be eliminated quickly! To do so careful surveys are needed, as will be discussed in more detail later. However, it is now possible to identify a sufficient number of currently unproductive bottoms to get this phase of the program going based upon existing knowledge and experience. As soon as the General Assembly makes leasing possible, the following should be done:

1. Areas to be leased should be determined by the Marine Resources Commission with assistance of the Institute of Marine Science. Those so identified should be subdivided into blocks, each with a minimum size of 50 to 100 acres. The larger the better!

2. Rights to lease such areas should be established by public bidding, perhaps with some preference given to individual watermen presently employed as tongers. There should be a minimum rental fee set at a sufficient level to prevent "frivolous" bidding and to help defray costs of public management.

3. Leases could be for a sufficiently long term to encourage private growers and yet short enough to protect the public's interest.

   Ten years seems reasonable for such purpose. They should be renewable, but all should be quickly recoverable by the State on a reasonable and fair basis. Of course, the lessees' interests should be considered, but potentially productive public bottoms should not be leased without protecting the public's rights, interests and future alternative use options.

4. Proof of "use" should be required or the lease would become void at the end of the fifth year.

To assist in establishing proof-of-use, we recommend a law, or better, a regulation (since the Commission should be given more latitude in regulations and to do so laws should be reduced to a minimum), to require leaseholders to submit a sworn statement of use of the bottoms during the preceding year when payments for annual rental fees are submitted. Data required should involve yields, estimates of oysters on the ground and amounts of shell or seed planted. Failure to supply the required information should be established as <u>prima facie</u> evidence of lack of genuine intent to use and cause the lease to automatically become void. The Commission could be given the power to continue the lease should legitimate mitigating circumstances be established by the leaseholder and at his or her expense. Not infrequently, bad growing periods occur, and it is also conceivable that adverse economic periods would act against reasonable use.

Recommendations to Improve Seed Production

While the preceding recommendations for State action are intended to facilitate an increase in market oyster production by private oyster growers, it is also clear that steps must be taken gradually to increase seed production both at public and private expense. To assist in achieving this goal we recommend that a reasonable but limited quantity of Baylor Ground, known to have the potential of producing consistently good sets, be assigned to leasing by private growers.

Leasing requirements for seed-producing grounds would be more stringent than those suggested above for the currently "unproductive" market oyster producing grounds. Annual fees might be as high as $50 to $100 per-acre-per-year or higher (or a percentage of the seed yield for State repletion activities or a percentage of the profit--this arrangement would be more flexible than a fixed-fee rental and would allow for bad years) and proof of use should be required as a condition of lease retention. Shorter terms for leases and for the proof-of-use period should be arranged. It should be easier for the State to recover these beds, if the leaseholder does not use them for the purposes for which they are leased. The reasoning behind this set of recommendations is that seed areas would be established on the basis of their known success at receiving sets and their high survival rates for very young oysters. Furthermore, these grounds are most amenable to public improvements and they are now widely used by seed tongers. The market beds from the Baylor Survey Grounds mentioned above do not have these valuable characteristics. The higher fees and resulting increased revenues should be used to increase seed production on those Baylor Grounds retained for use "by the public," i.e., the individual, non-leaseholding tongers.

Those unleased, but non-Baylor Grounds which are in the James River setting (seed) area should also be made available for private leasing. Seed production is so vital that it should be encouraged in any reasonable manner.

Recommendations for Improving the Public Repletion Program

The Baylor Survey Grounds in the James River, and to a lesser extent the Great Wicomico and Piankatank Rivers, have produced almost all of the seed oysters planted by private planters (over 90%). Without seed from these three sources, the Virginia oyster industry as we know it would cease to exist!

Grave danger now faces the Commonwealth's oyster industry since there has been a decline over the past eighteen years in setting intensity in all three rivers with a resulting decrease in numbers and density of seed oysters. The exceptional 1974 season in the James is regarded as atypical for the period 1961-1975[10]; it is not a reversal of a trend. Even though it

[10] Seasonal sets in 1976 were below average. In 1977 annual set was high in relation to the preceding 17 years, but was still less than the average set for the 1947-1960 period.

was a good set for the period, it did not compare with average 5-year sets of the pre-MSX period. As was pointed out earlier, the lower demand for seed may now be in equilibrium with the lower annual rate of production of seed. However, if demand increases or if the supply of seed itself declines, then natural seed stocks will clearly become inadequate. Therefore, we recommend that the main objectives of the Public Repletion Program be:

1. To increase the production of low-cost seed in existing, productive public areas such as in the James and Piankatank rivers;
2. To develop new seed areas in Virginia waters;
3. To identify new sources of seed outside Virginia;
4. To encourage private planters to develop their own sources of seed to augment seed from public bottoms, and
5. To encourage development and adoption by industry (and by the State, if necessary) of new techniques for producing and cultivating hatchery-reared seed.

Assuming that environmental factors such as pollution, predation, disease and other pests do not change markedly from their present patterns, the objective of more seed at a lower cost cannot be attained by the system of management presently employed by the State. Such a goal, however, may be attained by more efficient management as outlined below.

1. Shell-planting practices should be modified as follows:

   It is recommended that shell not be planted in areas which historically receive low sets until those areas which do receive moderate-to-good sets have been completely replenished. Shell should be planted only in known moderate-to-high setting areas, or in those moderate-to-high setting areas which might be discovered by the surveys which are also urgently recommended.

   Areas which, according to present knowledge, should receive shell-plantings for the purpose of growing seed are listed in order of their importance:

   a. The entire James River from Wreck Shoals downriver, especially the seed beds which are producing at this time--Traditionally, much of this valuable area has not been shelled due to the complaints of tongers who believe that planted shell "dilutes" the catch and makes culling more difficult. It obviously does, but this effect may be eliminated by planting shells on barren bottoms which will be located by surveys. Furthermore, shelling of currently productive bottoms may well be necessary to keep them productive! In such cases the need for full productivity must outweigh convenience to the harvester. Therefore, it is recommended that shell be planted in the James over those wide areas which do not have harvestable quantities of seed or anywhere where shell is obviously needed regardless of complaints. The seed beds must be maintained at all costs! Without them there will be no oyster industry or no tonging activity. Old, partially buried shell reefs could be located and restored since the presence of such reefs indicate potential for use. This would have to be done carefully and deliberately because such reefs may have "died" because oysters could no longer survive there.

b. The Piankatank River and the Great Wicomico River--In the latter case, however, shell should not be planted until the problem of low oxygen levels is thoroughly investigated. It has been reported that the low dissolved oxygen condition in the Great Wicomico results from residual and continuing contamination from wastes generated by the menhaden fishery and associated processing plants. The validity of these reports should be investigated.

c. In the lower York and Rappahannock rivers where shellbags and shellstring studies have disclosed areas of moderate setting--Beds recommended for shell-planting are those below Towles Point in the Rappahannock and those extending from Gloucester Point to Tue Marsh Light in the lower York. Seed raised in these areas might show acquired resistance to MSX. If drills come back in these areas, then the seed shell "dilutes" the catch and makes culling more difficult. It obviously does, but this effect may be eliminated by planting shells on barren bottoms which will be located by surveys. Furthermore, shelling of currently productive bottoms may well be necessary to keep them productive! In such cases the need for full productivity must outweigh convenience to the harvester. Therefore, it is recommended that shell be planted in the James over those wide areas which do not have <u>harvestable</u> quantities of seed or anywhere where shell is obviously needed regardless of complaints. The seed beds must be maintained at all costs! Without them there will be no oyster industry or no tonging activity. Old, partially buried shell reefs could be located and restored since the presence of such reefs indicate potential for use. This would have to be done carefully and deliberately because such reefs may have "died" because oysters could no longer survive there.

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d. On the Seaside of the Eastern Shore where many bottoms receive moderate-to-high sets.

e. Recent studies indicate that shells planted by VMRC in the Poquoson River area and in Lynnhaven Inlet have received moderate-to-heavy sets during the past two or three years and that survival has also been good. These sites seem to offer great potential as seed areas, and they should continue to receive trial plantings of shells especially in the tidal creeks around Plum Tree Island in Poquoson. Seed grounds in each might have to be delineated and set aside.

2. It is even possible to utilize drill-infested beds to increase seed production, especially where the setting potential is high. If a set of oysters is obtained on shells in an area where the oyster drills are active, it should be transplanted in

October or November of the first growing season to a drill-free area. Areas where drills are or may become a problem are the Piankatank, the lower Rappahannock, the Bay between the Rappahannock to the York River, including Mobjack Bay and the lower York, off the Poquoson River, off Plum Tree Island and in Lynnhaven Inlet. Drill abundance varies with time and space. Recently, Tropical Storm Agnes killed many drills in these areas. If surveys disclose that drills here are scarce or doing little damage, then the seed oysters should be allowed to remain where set, provided they are not too dense for proper growth. Settings that are too dense should be thinned in accordance with guidelines provided below. Monitoring of natural conditions, drill activity, oyster condition and survival would be necessary.

3. It is further recommended that decisions to move seed from the areas where the set is obtained for planting elsewhere or to allow it to remain and grow to maturity should be based on the following considerations:

a. High-density seed (over 500 spat-per-bushel) could be used where predation will take a toll, but where sufficient numbers will survive to allow a 2:1 yield. Contrariwise, low density seed should not be exposed to predation.

b. Moderate-density seed (130 to 500 spat-per-bushel) could be transplanted to suitable growing areas so oysters will not be unduly crowded as they reach maturity.

c. Shell with counts of about 130 or fewer spat-per-bushel should be allowed to remain in place where the small oysters will grow to maturity or perhaps even receive an additional set in the next setting season.

d. Seed setting in Type I or Type II MSX areas should be allowed to remain in place to help build brood-stocks, or it should be transplanted to other growing areas where MSX is a problem since such seed may have acquired a resistance to MSX. However, if drills are abundant in the prospective growing site within the Type I or Type II MSX area, the seed should be moved to other sites where drills are not a problem. In any case, the probable disease-resistant qualities of such seed should be recognized and considered.

4. It is recommended that the Marine Resources Commission review its policy regarding the use of seed developed in the Repletion Program. Other things being equal, the least costly use of seed resulting from a "strike" on planted shell is to allow it to remain in place to grow to maturity providing that the area is one which will produce marketable oysters in reasonable time with minimum loss and maximum market-to-seed ratio. Unavoidable mortalities due to mechanical damage and stresses occur each time oysters (especially young ones) are taken-up, exposed during transfer, moved around in transfer and replanted. Further, each relocation requires labor and costs money, increasing production costs. For example, seed production in the Great Wicomico and Piankatank costs 98¢ per bushel. If the seed is left in place to experience only the normal mortalities during growth, no further costs or unexpected losses are involved. If it is

dredged, moved and replanted, seed costs rise by 66¢ or more to at least $1.64 per bushel and deaths due to damage and stress usually reduce productivity.

5. It is recommended that the Commission carefully review the percentage of its annual seed oyster production derived from its repletion activities (outside the James) which will be allocated for its own use, i.e., for replenishment of retained Baylor Grounds. In the future the Commission should utilize a higher percentage of this seed in replenishing brood-stocks or in growing market-sized oysters (for the soup and chowder, shucking or half-shell trade) on the Baylor Grounds. If it sells to private interests the price should be more realistic in respect to the cost of raising the seed.

6. We recommend that the Commission take all possible steps to optimize set on the shells it plants. Certain historical practices will have to be revised to do so. We are encouraged that steps along these lines are already being taken by the Commission. However, further useful changes can be made and shell-planting can be even more fully directed to good setting areas and suitable times.

It must be noted, however, that there will be certain sociopolitical costs in changing some of the traditional practices. The tongmen, industry and some of their supporters may object. However, the benefits to be gained should not be overlooked, denied or avoided merely because of political pressure. Tongboats and oystermen are, by and large, mobile, and eventually all (including the tongers and processors) will realize the wisdom and necessity of such management actions as they share in the benefits, the value of more realistic and productive repletion practices. Where superannuated oystermen or vessels exist which the political system decides must be served, i.e., a "senior citizens program," special arrangements can be made. Likely, necessities for such arrangements will be few.

In the past, costs of planting, proximity of shell piles, availability of cheap labor and the sociopolitical pressures to have shell planted "in our district" have largely dictated where and when shell were to be placed into the water. If the objective is to secure maximum sets-per-bushel of shell planted as it properly should be, the concept of timing shell plantings to keep costs down or positioning them to respond to pressures is not appropriate and should be abandoned. Shell at 40¢ a bushel which obtains a set because it is clean when placed overboard and arrives on the bottom when larvae are ready to "strike" is inexpensive when compared to one or even two plantings of 27¢-per-bushel shell put overboard at the wrong time or place which receives little or no strike! We recommend that the Commission adopt a policy of paying the price necessary, even a reasonable premium, if required to achieve this end, to have the shells planted at the optimum time and place.

7. We recommend that gear and techniques be developed which will efficiently prepare beds to catch maximum spatfall. On many beds, shells become heavily and quickly fouled with a scurf of small plant and animal forms as well as mats of colonies of bryozoans, tunicates, sponges, barnacles, etc. Even new shell plantings which are mistimed (and there will be some even under the best shell-planting program) quickly become

fouled in summer. Oyster larvae cannot strike effectively on shells in this condition and the cultch is of little value for seed production.

In some regions or unusual years, fouling is reduced naturally due to changes in environmental conditions, usually by abnormal flows of fresh water which reduces salinity, and higher oyster sets are made possible. In many localities, however, such conditions do not exist and fouling and silting is so heavy that setting is regularly or frequently interferred with or even prevented. And it is these areas which would require regular attention. Shell cleaning programs, of course, would have to be based upon detailed historical and current knowledge of specific beds. Two approaches to cleansing cultch are suggested below.

Commercial growers, the Institute, and the Commission have long conducted casual experiments or made occasional efforts at cleaning the shell beds by "harrowing" them with a toothed (and bagless) dredge just prior to historical setting time for the area. The limited tests conducted by the Institute and the VMRC of those "experimental" treatments indicate that it works if properly timed and conducted in moderate set areas. Unfortunately, "harrowing" in this manner is time-consuming, inefficient, and at times of limited effectiveness. Possibly, as a result of these limitations, it is not widely practiced.

Considering several relevant engineering developments of the last decade, it seems likely that efficient gear to agitate and turn the shell operated by mechanical or hydraulic power can be produced.

These aspects will be discussed elsewhere when research and development needs are examined.

8. It is recommended that the Commission investigate the advisability of resuming the use of reef shells harvested from Virginia waters as a means of reducing costs of the State's Repletion Program.

The reef-shell program conducted by the Commission in cooperation with Radcliff Materials of Norfolk, Virginia, with occasionally-followed advice from the Institute of Marine Science, from

1962 to 1967 was successful in providing the State with large quantities of shell to be used for cultch at little cost.

In this program Radcliff Materials used (or sold) a portion of the shells as a raw product for cement production. Royalties to compensate the public were provided to the Commission, usually in the form of planted shells. While there were problems associated with this particular arrangement (and we do not recommend a return to the shell-mining industry as it was originally conducted) the operation effectively demonstrated that shells suitable for cultch now lie buried beneath the surface of the bottoms of our rivers in many locations.

In the past few years (since 1973) the Commission has imported several million bushels of reef shells annually from Maryland. Comparable shell available in Virginia might well cost less than that for the Upper Bay.

We recommend that these possibilities be examined carefully by the Commission in concert with VIMS. Part of the examination should involve a thorough survey to determine the magnitude, potential and conditions of availability and use of reef shells in Virginia. At the same time, the cost and potential of securing reef shells or other suitable cultch materials elsewhere should be carefully investigated to enable a fair comparison of costs, availability and promise. Should the Commission decide to proceed with a local reef-shell program, which might well be done prior to or during the studies described above, mining should be done on a regular contractual basis for the Commission by an established dredging company.

Should shell mining by contract be resumed, adequate surveys of shell resources must be arranged. Realistic knowledge of the resource is necessary for proper management!

9. We recommend that the Commission, working with VIMS, undertake a comprehensive program of monitoring the State's Repletion Program. Improvements in monitoring and data acquisition have been made in recent years by the Commission and this progress is commendable but more should be done. The data which must be secured should be: 1) quantities of shell or seed planted; 2) nature of shell or seed planted, i.e., size,

condition, mortalities, and 3) final yields. The areas involved should be accurately and precisely known, as should effort and costs.

10. We recommend that experiments devoted to evaluating, developing and utilizing hatchery-produced seed be more actively pursued by the State. It is already possible to rear seed of known parentage and predictable characteristics, i.e., features, shell shape and thickness, disease-resistance, in large quantities under controlled conditions. Further, we can determine time of spawning and the speed of passage of the larvae through the juvenile stages to maturity. As with agriculture and animal husbandry, controlled and predictable developments seem most promising.

    While laboratory production of seed is now a technical reality, problems remain regarding assurance of the survival of such seed in nature so that it will reach market size. We should discover how to economically rear seed to market size under more tightly controlled and predictable conditions. The promise warrants the costs and efforts required.

Preliminary tests show up to 50 percent survival of laboratory-reared, cultchless (and uniform) spat in low salinity regions. This compares favorably with survival of naturally-produced seed. Unfortunately the price per-oyster of cultured seed is about twice as high as that of James River seed of much larger size, but we believe that the unit price may be reduced through research on improvement of the technology. If price can be reduced, or survival increased or other advantages which change the economic picutre are developed or discovered, hatchery-produced seed will be most useful in improving the State's (or industry's) Repletion Programs.[11] The advantages possible in hatchery-produced seed are:

a. Disease-resistant seed can be produced for planting in areas where disease agents are prevalent. Seed, resistant to MSX, is now available as a result of research done by VIMS scientists.

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[11] Or if costs of natural seed production increase or natural seed is no longer available.

Resistance to different diseases such as SSO (on Seaside), Dermocystidium and others will undoubtedly be developed with further research.

b. Seed with other characteristics, such as rapid growth, high meat quality, good flavor, uniform shell shape and fast-growing, thick shells (for predator resistance), can be produced in quantity.

c. Additionally, there is a need to increase survival rates of hatchery seed on high-salinity growing beds through research. Even with this need, it is our opinion that hatchery-reared seed can be planted and reared successfully on many large areas of bottom where salinities are low and where predation by drills and even crabs is reduced.

11. Natural seed is a valuable product of natural setting beds. An adequate seed supply is the foundation and keystone of the oyster industry. It seems likely to us that revisions in current regulations and laws governing the James River seed beds would result in more efficient utilization of this valuable resource. Hence, we recommend

that current laws and regulations regarding the James River seed area concerning such factors as season of harvest, leasing bottoms, openings and closures of beds, etc. be reviewed by the Commission and the Institute and revised as necessary. (This may require legislative as well as executive action.)

Evaluating the Resource and Improving Utilization

Virginia does not know the extent of the resources available to it for growing oysters or other shellfish from its tidal waters. Furthermore, current practices and arrangements for leasing the public's bottoms, for raising money for replenishment and conservation, for related research and development activities and for gathering data for management are inadequate. Eliminating these weaknesses is of major importance to improving the management and utilization of this self-renewing, economically and socially valuable resource. Steps required are as follows:

1. We recommend that a thorough and careful survey of the extent and quality of the Baylor Grounds, including the numbers and density of oysters present in each area,

spatfall, setting potential, survival potential and other factors, be conducted.[12] While there have been some efforts along these lines by the Institute, we have some knowledge of numbers and density on a few specific sites and, understanding the setting and growing potential of most areas, there has been no evaluation of a large proportion of the acreage incorporated within the limits of the Baylor Survey since a study was made in the James River in 1909. This can be hardly considered as being current or all inclusive and we should move quickly to fill this sixty-five year gap. Possible plans for conducting such a comprehensive survey have been made.

2. We recommend that the Commonwealth take steps to determine the extent to which potentially productive public bottoms, ostensibly leased to private persons and companies for purposes of culturing oysters,

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[12] A beginning attempt at developing and carrying out such survey is now in progress by VIMS. As of 1977 it was about one-third completed. It will be very useful but requires improvement. Additional time and funds are required to refine and complete these important efforts.

are actually being used for that purpose. This suggestion is based upon our findings that many leases are not now employed to produce oysters. Some have never produced quantities of oysters for lack of cultivation. Some have been actively cultivated, but only rarely. Some have been used regularly.[13] Since leases under the current scheme may be held for 20 years with an option for renewal at very little cost-per-acre and little financial risk to the leaseholder, lack of cultivation of such lands is probably quite extensive. Where potentially productive bottoms are involved in unused leaseholds, it amounts to lost oyster production for the State.

The recommended study should determine whether the bottoms are not being used because of being: a) actually unsuitable for oyster culture; b) only marginally productive; c) economically inadequate; d) affected by disease or predators; e) used in rotation (a reasonable practice); f) employed as a margin

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[13] Of course, some were never productive, having been unsuited for oyster culture for many years--or never.

or barrier (also a reasonable practice), and g) held to block other uses for purposes of law suits or whatever. These data should be used to: a) evaluate current leasing arrangements, b) determine the parameters for a new one, and c) recover for the State for reassignment for re-use those lands which are being held under false pretenses.

As has been noted previously, there are other reasonable uses for bottoms than oyster culture, such as clam culture, establishment and maintenance of fishing stands, or mineral production, which are also in the interest of the State to encourage or facilitate. Such uses should be considered in any revision of the leasing arrangement.

3. We strongly reiterate the recommendation that the system of oyster-fishery statistics be further improved. Major improvements over former practices have been recently instituted by the Commission, but they must be enhanced considerably with other data which would allow more detailed knowledge of productivity, effort, potential productivity, etc. Modern data-handling methods should also be used.

4. The need for more adequate knowledge of the fishery, itself, has been noted. Among the significant data gaps is knowledge of the location and area involved in repletion or harvesting activities, effort expended to harvest specific catches, and the total catch. The Marine Resources Commission should acquire "catch-per-unit-of-effort" for specific well-defined areas.[14] Such data along with data on numbers and densities of oysters occurring naturally on a specific bed or area of the bottom would help answer questions such as: Are seed production and availability increasing or decreasing in the James River or elsewhere? Are market oyster numbers waxing or waning? Is fishing pressure too heavy for the level of replenishment and the rate of growth of the resource, etc.? [Basic or verification data (and verification of written reports by independent means must be involved) could be acquired by daily boat counts, including--for example, determination of locations fished, numbers of tongers or

[14]The VMRC is now collecting some of these data.

units of gear in operation, and number of bushels harvested which could be determined with periodic counts from the air or from patrol boat or both.] Aerial observations, even with photography, as necessary for accurate counts and records would also be utilized for counts or for checks.

5. We recommend that the system of fees and taxes currently applied by the State be re-examined with a view toward updating the system and making the income from oyster production match, more nearly, the actual costs of maintaining an adequate public oyster management effort. The entire tax and fee system should be involved in this review.

   A special study commission, including a variety of capable and experienced representatives from the major interests involved (a mechanism that has been employed in earlier fishery studies and improvement efforts), could be convened for this purpose.

   Whatever the outcome of this recommendation, it is clear that VMRC should introduce a system for objectively determining whether or not the various yield or production data and the taxes paid for some are accurate. Some type of check or audit is obviously needed.

Availability of a plentiful supply of seed which can be produced and sold or purchased at a reasonably relative cost to that of market oysters is crucial to the oyster-growing industry. To encourage growers to plant more seed in these times requires efforts to see that such seed is available at a relatively stable and low cost. To maintain such a supply of seed while numbers and densities of seed decline will require: a) increases in productivity (mentioned above) or b) conservation efforts--perhaps both.

Our studies indicate that the supply of seed from Virginia seed areas is generally adequate to meet present levels of demand from the growers. Additionally, the demand for soup oysters (which are smaller than either standard shucking oysters or half-shell oysters) can be met from these same bottoms. However, should demand increase, the production of our seed areas, especially the

James River, would be insufficient. If a significant increase in demand from private planters (or by soup houses, for that matter) develops or is anticipated, several alterations in the management system would have to be considered. A possible course of action would be to:

a. Restrict use of oysters produced on public seed grounds in the James to sale and use as seed.[15] We must remember, however, that the utilization of oysters in making oyster soup or stew, which has grown considerably in the last decade, is a legitimate use. They are being used as food and the use is profitable, aiding the entrepreneur, the workers, the harvesters and the State. The demand it creates does absorb natural productivity of a renewable resource and sale of oysters for the soup

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[15] Since about 1975 soup companies have not utilized James River oysters because of Kepone. Since Kepone is no barrier to employment of small oysters as seed, because they cleanse themselves quickly, the elimination of their use in the soup trade is likely the most serious damage done by the Kepone incident to the James River-based oyster industry.

trade meets a market demand which might not otherwise be available to oysters. Jobs and income are provided to tongers and growers (especially the former). Ways should be sought and found to allow both seed and soup demands be met.

b. Encourage Virginia oyster growers to increase the productivity of Virginia waters. To do so the Commission should be prepared to restrict the sale of seed to the export trade to meet internal demands.

As a suggested conservation measure we recommend stopping the sale of seed for export when the Virginia export exceeds 15 percent of the previous year's production. We must note here, however, the need for caution. As has the "soup" market, export demand for seed has helped maintain a market for the output of individual oyster tongers. In the face of declining demand for Virginia seed (if the trend is not abated), it would be unwise to cut off or reduce this source of demand for our oysters and income for tongers.

It would be worthwhile developing and considering other strategies for accommodating the several purposes presented above, i.e., enhancement of soup production, increase in market-oyster production and conservation and continuation of this valuable renewable resource.

Research Recommendations Which Will Benefit Both Public and Private Participants

Both public and private segments of the oyster industry are dependent upon ready and inexpensive access to sufficient quantities of palatable oysters which are or will be safe to eat whether for shucking or for the half-shell trade, for the "soup" market, or merely for seed. There is a direct relationship between the quality of the oyster beds, the sediments under and around them and the water above them. If there are predators or disease, oyster population levels are affected. If the waters or the sediments are contaminated, the oysters may be killed, their life cycles may be interrupted, or they may become unsafe to eat or genetically damaged or whatever.

We must give consideration to maintenance of water quality suitable to growing oysters which can be eaten! Consideration must also be given to biological and physical factors as well as to economic and technological aspects.

For public and private management to be able to operate effectively it must have adequate scientific and engineering assistance and advice. Much scientific knowledge of environment and biology exists. Expertise and engineering and other useful skills abound and more effective management is possible. Much remains to be learned and done, however, before we will be able to effectively manage the oyster industry with assurance and continuing profit.

It is to these investigatory requirements that the following is addressed. It is our purpose to use the list of needed research and technological study to develop research and advisory projects for the near, mid- and long-term research programs of the Institute. There are also tasks that the Marine Resources Commission and others must participate in or conduct by themselves. Though some of these recommendations for research and engineering studies have been presented before they are repeated here in order that all may be arranged and available in this section.

1. The James River has received only one adequate spatfall (in 1974--about 500 spat per bushel) in over 17 years. Indications are that sets have failed in at least two other river systems, i.e., the Great Wicomico and the Piankatank rivers, in the last three to four years. A continued trend toward low setting will seriously damage the Virginia oyster industry as it is now conducted.

Lack of brood-stock, caused by natural mortalities and overfishing, is implicated. However, other factors such as contamination from chlorine and its derivatives, Kepone and other pesticides acting by themselves or synergistically with other causes of debilitation may also be involved. Also, low levels of dissolved oxygen which develop in many places in late summer have gained added importance as probable causes. Only additional, carefully-done research can answer the numerous questions involved. Among the problems to be approached are:

a. Laboratory studies utilizing bio-assay techniques should evaluate survival of laboratory-reared spat and the plankton used by larvae as food in water from the major river systems to determine the possible existence of lethal or sublethal factors in the water--for example, chemical contaminants in red-water blooms. If the existence of such substances is demonstrated, then an extensive effort by VIMS should be directed toward determining what substance or substances are involved. These initial tests might concentrate on chlorine and chloramines, Kepone, PCB's and others. Additional financial support to do the extensive field and laboratory studies required is necessary.

b. Oyster set has failed for the past four years in the Great Wicomico River (as previously stated) and oxygen has been demonstrated to be deficient in the bottom waters and sediments of this system during the spawning season.

A direct relationship between low oxygen concentrations in summer and early fall and low setting seems likely. Nearby fishmeal and oil processing plants may be the source of organic matter which causes the O_2 depletion, but natural conditions related to circulation of Bay water may also be responsible. This area should be studied carefully to determine what the basic causes are and what steps may be taken, if any, to remedy the situation. Field studies should evaluate BOD, COD, O_2 and H_2S values in that system to see if levels are low or high enough to kill oyster larvae or the plankton on which they feed.

c. There is a possibility that fouling of shells on the bottom has increased over the past ten years due to increasing nutrient enrichment of the water. If this has occurred it might be one of the reasons for the decline in setting of oyster larvae on shell substrate in the James, Great Wicomico and Piankatank rivers.

2. The oyster disease MSX continues to be the second major problem needing further study. All related signs indicate that it still remains the major reason why growers cannot raise oysters effectively on their down-Bay or down-river high-salinity beds. It is the reason why Baylor Grounds in Type I and II areas are producing less. Many unanswered questions, which if answered could lead to possible control measures, remain. We, therefore, recommend:

   a. Determine by laboratory studies the mechanism of transmission of MSX from one oyster to another. We must find out if the disease is waterborne or whether there are vectors or reservoir hosts involved.

   b. To accomplish these objectives, experiments will require controlled production of MSX infections by exposing experimental oysters to MSX cultures of known purity. But MSX has not as yet been cultured. Hence, renewed effort should be devoted to development of pure cultures of the MSX disease-producing microorganism.

c. A study should be done to determine the effect of low salinity on oysters infected with MSX. That is, do freshets caused by storms like Tropical Storm Agnes eliminate MSX from oysters or reduce their incidence or virulence?

d. Studies on breeding MSX-resistant oysters should continue, but a change in emphasis should occur. Effort should be now shifted toward evaluating present stocks on suitable experimental plots in MSX regions. The possibilities of restoring oyster production in Type I and II MSX areas in all rivers in Virginia should be tested by making trial plantings, perhaps one acre in extent or more (as required), of James River, Piankatank and/or laboratory-raised resistant seed.

The purpose of this program would be to determine if it is possible in these locations to realize the "break-even" point of a bushel of marketable oysters to one bushel of seed yield and how long it takes oysters to reach maximum biomass or the size of maximum economic yield. These would be long-term studies.

e. We should make every effort to determine the exact nature of MSX resistance. Is it genetically determined or is it related to acquired resistance? Research along these lines should be started immediately.

f. Similar studies should be made of Dermocystidium marinum (Dermo) and other disease-producing organisms.

3. The third major problem needing further research and development effort in Virginia is development of practical methods of controlling oyster drills. While drills have become less of a problem, relatively speaking, in Chesapeake Bay in the last six years because of Tropical Storm Agnes and MSX, they remain the major problem on the Seaside of Virginia. Furthermore, drills will again become significant when oyster culture is resumed in full throughout the areas where it has been reduced, especially if MSX-resistant oysters are planted in high-salinity areas. We recommend, therefore, the following possible lines in research:

a. Control of drills by sterilization of males and introducing them back into the population as outlined by Hargis et al (1957).

b. Development of chemical barrier coatings on the surfaces of oysters which will repel oyster drills.

c. Utilization of suction-dredging or other mechanical techniques to clear large areas of drills.

d. Study possible means of killing drills over large bottom areas using "gel" coats on the bottom which will allow hydrogen sulfide to generate below it so that it will kill all drills.

e. Oysters often set in an area where drills are abundant, but the small oysters are nearly always killed by drills before the seed grows large enough to move. If drills were controlled, then the downriver areas might become sources for inexpensive seed. It need not be added that this seed (especially if it competes with James River seed in price, survivability and growth) is badly needed by the industry.

It has been shown that oysters raised from the spat in MSX regions would be more resistant to MSX than older seed matured in non-MSX areas. If seed were cultured as outlined in the preceding paragraph, then there would be the added bonus that it might be profitably grown to maturity in MSX areas.

4. The oyster pathogen, SSO, and the large oyster drills, *Urosalpinx cinerea folleyensis* and *Eupleura caudata etteri*, are the major biological problems facing oyster growers on the Seaside of Virginia. Since the discovery of SSO-disease, its mortality pattern in respect to season and part of its life cycle have been described. However, nothing is known about how it is transmitted or possible effects of temperature and salinity on the organism. Knowledge of these factors might enable growers to manipulate their culture practices to minimize the severity of this disease. We recommend:

   a. Continued monitoring of the incidence of this disease on the Seaside.

   b. A series of laboratory studies to determine how SSO is transmitted from one host to another.

c. Laboratory studies to investigate the effects of low salinity on SSO to determine if low salinity *per se* is the reason why SSO is not a problem in Chesapeake Bay.

d. Efforts must be made to induce genetic or acquired resistance, or both, to SSO-disease in oysters.

5. An adequate supply of inexpensive seed oysters is vital if the Virginia oyster-producing industry is to survive and compete with imported oysters from Maryland, and with those from other oyster-producing regions in the nation (or enable independence and survival should outside sources fail). Therefore, every effort should be made to improve the quantity and supply of seed oysters. We recommend:

   a. Assurance of an adequate supply of low cost seed in the future. To do so new sources of seed must be developed. Particularly desirable are sources which do not involve as much labor to harvest as is required by tonging. Some possible sources are spat collectors (such as the wire bags of oyster shells which are used by some private seed growers today) and hatchery-reared, cultchless spat.

b. Efforts to develop an efficient method of cleansing cultch in place should be vigorously pursued. One possibility is development of an efficient underwater harrow to turn up or uncover buried shell so it may be available to receive a good strike of small oysters. A possible gear design would include a strong "A"-frame which would be towed from a boat. Affixed to the base of the "A"-frame would be a steel cylinder to which are affixed flexible steel "tines." These would be rotated by an underwater hydraulic motor.

c. The use of marl and surf clam shells or other materials as possible cultch for spat attachment should be studied.

d. Lime (quicklime) has been said to control fouling on oyster shell so that oyster larvae may attach. Studies should be conducted along this line to establish its utility. Many other possibilities for improving setting can be developed.

e. To locate or develop alternate sources of seed, we recommend systematic, careful evaluation of growth and survival of small oysters from outside the Bay system. For example, Seaside seed is available in quantity but limited tests suggest it does poorly in low-salinity areas of the Bay. Seed from Lynnhaven is abundant but has never been tried elsewhere. Perhaps the Lynnhaven River can be developed as a seed area. In a similar way, South Carolina seed, while abundant, is said to die extensively during colder winters in the Bay. However, these tests were, at best, limited and further studies should be made.

6. It is strongly recommended that the State, through VIMS, continue and expand its controlled oyster breeding program with the following purposes:

   a. To determine if an acquired resistance exists apart from resistance which has a genetic basis.

   b. To develop oysters resistant to SSO and <u>Dermocystidium</u> as well as to MSX.

c. To develop oysters which show a fast rate of growth as well as high-meat yields.

d. To evaluate the results of a., b. and c. above with a well-designed, statistically-sound program.

7. Hatcheries likely have a definite place in the future of both the public and private sectors. It is recommended that the State continue to encourage development of private hatcheries in Virginia. Toward that goal, we recommend that experiments and engineering developments designed to increase production and quantity of hatchery-reared seed, including validation of economics of hatchery and hatchery-based oyster culture, be vigorously pursued by the government, VIMS and industry.

8. It is recommended that research be conducted in Virginia on the use of ponds for experimental shellfish culture especially in connection with raising hatchery seed. Initial studies should concentrate on the use of ponds 12 x 40 feet with plastic liners and dyked "earth" sides. It might be necessary to experiment with ponds in different areas. These ponds might be used to raise large

numbers of small oysters for trial plantings in MSX studies. In respect to this last recommendation, it is recommended that initial trials be made using spat set on oyster-shell cultch. However, other studies might concentrate holding cultchless spat until it grows large enough to resist predators. Newer type predator-resistant collectors, such as the "French collectors" now being used by Dr. DuPuy at VIMS should be carefully tested.

9. An evaluation of material presented in this report and of the work being done at VIMS and elsewhere shows a dearth of research efforts in the fields of engineering development and in food technology. That is, while answers to biological problems are of use to industry, it is apparent that many of their economic problems can best be solved by new marketing methods, new ways of packing and selling their product, and new processing techniques. Also, oyster growers as well as tongers working the public rocks may be helped if machines are constructed to harvest oysters, to turn buried shell to increase spatfall, to open oysters, etc. Among a possible list of projects which may be of value would be:

a. Working with industry to determine its needs for new methods of food processing, marketing, etc.

b. Development of gear to process oysters mechanically, which would include machines to plant, culture, harvest, open and process oysters.

c. Investigate and evaluate the Pringle Heat Shock Method of gaping oysters and other opening machines and methods.

d. Determine ways to keep cownosed rays and other predators away from oyster grounds. Such things as fences and electrical fields should be considered and promising leads or variations examined.

10. There is a major need to study and understand the economics of the seafood industry. Questions which should be answered include:

a. Why have the wholesale market prices (adjusted for inflation) of oysters remained stable in the last ten years? To what extent would a drop in retail prices stimulate an increase in demand for oysters?

b. What is the consumer demand for oysters? How does it develop and change? Can consumer demand be increased significantly and for reasonable lengths of time? Can we capture a larger percentage of the market for Virginia?

c. Has promotion by advertising such as that now practiced by the Virginia Seafood Council resulted in increasing sales? If the study shows sales to have been increased, this activity should be expanded.

d. Would new and better processing help demand and sales and/or reduce production costs sufficient to create useful markets or increase economic profit?

11. It is recommended that studies of the lethal and sublethal effects of heavy metals, pesticides and other pollutants on all stages of the oyster's life history be more vigorously presented. The recent oil spill, chlorine and Kepone problems are excellent examples of why this work is vital. Included in such research would be consideration of the phenomena related to routes and pathways for toxicants in

nature, uptake, distributions in the organisms, and duration of self-cleaning by the young oysters.

12. A pilot-scale depuration plant should be constructed and evaluated for its production in controlled studies on cleansing of bacteria or other polluting substances from oysters.[16]

13. Studies should be made in the James River at stations in mid-channel at 15 feet (4.6m) during September at Brown Shoals and Wreck Shoals to determine if eyed-larvae are present and the relative numbers at each station.

14. It is recommended that the effect of low oxygen and hydrogen sulfide on oyster larvae and their planktonic foods be studies in the laboratory since these two factors may be a major reason of the consistent set failures in the Rappahannock, the Great Wicomico and elsewhere in the Chesapeake Bay. Other aspects such as availability of broodstock, larvae, etc. should be studied in the field.

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[16]Plans for this are underway but funding is doubtful.

15. Every effort should be made by State and Federal officials to encourage expansion of the oyster-canning industry. We recommend that Federal laws be modified to permit canning of oysters from condemned areas. This is not unreasonable since crabs taken from these same waters may be canned.

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