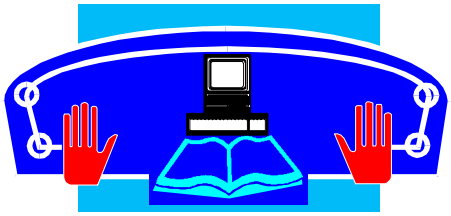

The Chesapeake Bay Oyster Fishery; Traditional Management Practices
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20 THE CHESAPEAKE BAY OYSTER FISHERY: TRADITIONAL MANAGEMENT PRACTICES

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The Chesapeake Bay and its numerous salt-water tributaries contain prolific and valuable oyster beds, probably about equally divided between the two states of Maryland and Virginia. . . . The legislatures of Maryland and Virginia have, at every session for many years, revised and re-revised the laws upon this subject for their respective states; but have always been content to work in the dark, knowing nothing practically, and never seeing the value of obtaining full information upon so important an industry.

—E. Ingersoll 1881. *The History and Present Condition of the Fishery Industries. The Oyster Industry.*

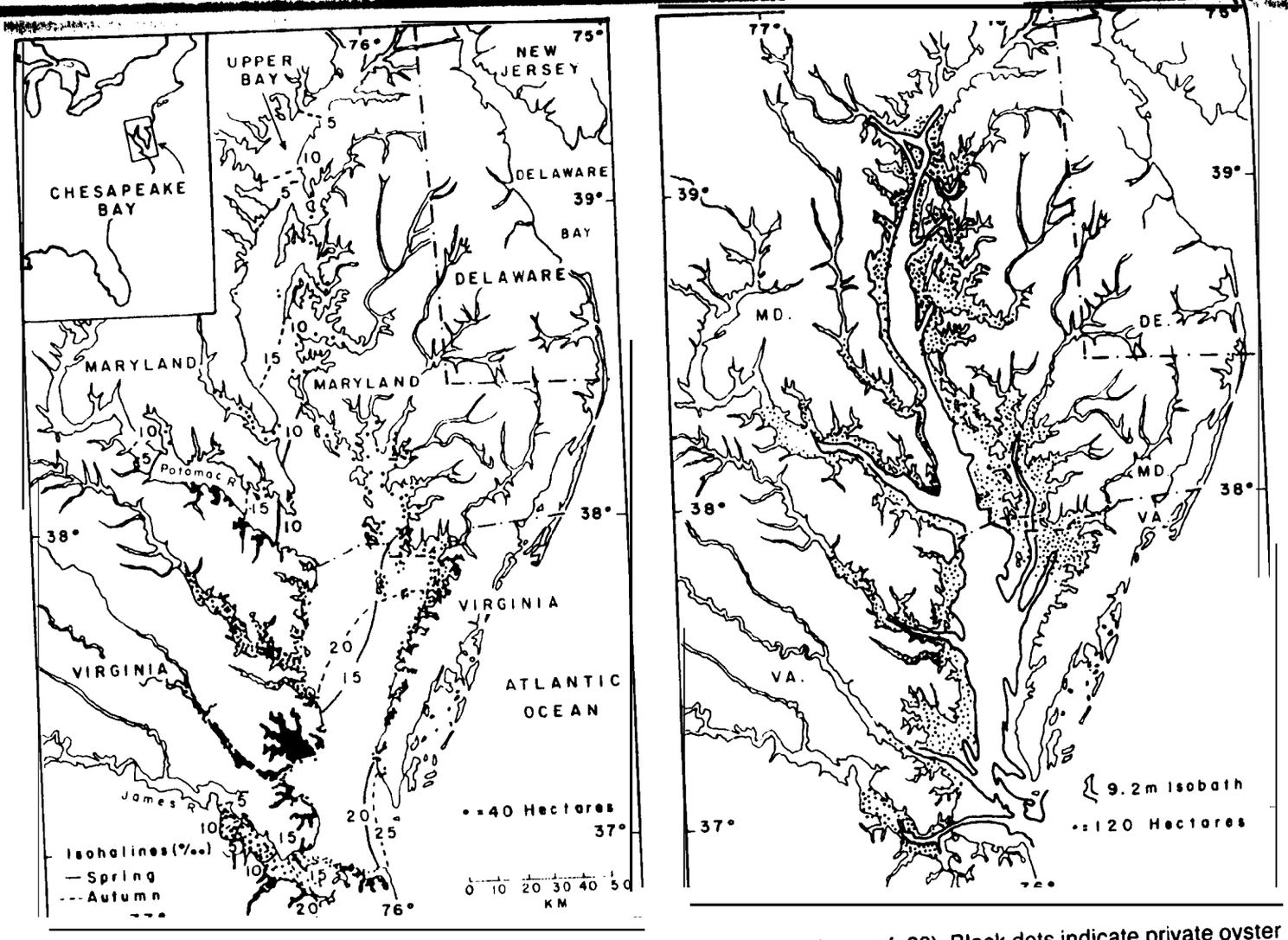

Figure 1. (Left) Chesapeake Bay region with spring and autumn isohalines (from ref. 20). Black dots indicate private oyster grounds. Modified from Alford *Geographical Review*, 1973, with permission from the American Geographical Society (9). (Right) Public oyster grounds (black dots). Modified from J. J. Alford, *Annals of the AAG*, Vol 65, p. 230, Assocation of American Geographers, Washington, D.C., 1975 (10).

in large quantity. In Chesapeake Bay, reproduction occurs mainly from June through September with release and external fertilization of gametes (up to 60 million eggs may be released at one time and up to 250 million in a season by a large female). The planktotrophic larvae develop for 8 or more days depending upon temperature and food. Thereafter, they settle on hard substrate upon which they crawl. If the substrate (usually oyster shell) is attractive, they cement their left valve to it; if not, they swim away to search another area of the bottom. Once attached, the oyster is called a spat. The result of a mass settlement of larvae over time is called a "set." Growth is rapid in the Chesapeake Bay. Seed oyster size (about 2.5-4 cm) may be reached by the end of the first summer by early settling spat. Market size (7.5 cm) is reached in 3 or 4 yr, depending upon location.

3. THE HABITAT

Chesapeake Bay is one of the world's largest estuaries, lying on the temperate east coast of North America and stretching north-south for about 290 km (Fig. 1). It was formed at the end of the Pleistocene by the drowning of the Susquehanna River as sea level rose and water intruded inland to attain a surface area of about 5200 km^2. Within this sedimentary environment, extensive oyster beds (about 250,000 ha) form the major source of hard substrate (cultch) on which oyster larvae can settle. Without human interference, there was undoubtedly a dynamic ebb and flow between the building up of calcium carbonate reefs by living oysters and the smothering effects of storm- and flood-distributed sediment, with a tendency for oysters to form dense agglomerations in optimal environments. When European explorers first visited the bay, they reported that oysters were present in these optimal regions in immense abundance (19), to the extent that their reefs in shallow waters reached the surface and were navigational hazards. The initial dredging of these oyster ''rocks' in the early 1800s was beneficial (2) in that the tightly consolidated virgin reefs were broken up, with oysters and shell spread onto new ground to expand the area of the beds. AS a result, the less crowded oysters were probably subject to less competition for planktonic food and therefore became larger and attained better condition. The expanded area of exposed shell may have enhanced spat settlement. However, as dredging and harvesting continued, oyster stocks diminished in abundance and shell debris built up in proportion on the exploited beds (3). In addition, in the absence of cull laws before 1890, little hard substrate was returned to the beds. The resultant lowering of reef height tended to shift the balance in the reef expansion-smothering cycle toward a smothering of overexploited beds and their loss as cultch. Deforestation of bay watersheds as human populations expanded undoubtedly resulted in increased sediment input to the bay, compounding the problem. Today, many formerly productive areas of Chesapeake Bay contain large areas of buried shell.

Chesapeake Bay is prime oyster habitat if suitable hard substrate is available for settlement. Sixty-five percent of the bay is shallow (<9 m; 10), allowing for

rapid warming in spring. At about IO°C, feeding commences on the bloom of phytoplankton, enabling mature gametes to be produced by May. Throughout the bay there are a few regions where excellent sets occur, resulting in dependable production of seed oysters. Most seed areas are in secluded low-salinity regions where growth is slow. More open areas provide for rapid growth of market oysters.

Salinity distribution varies seasonally, with the vernal freshwater pulse affecting especially the upper bay and the upper reaches of tributaries (Fig. 1; 20). Below about 10‰ oysters do not reproduce successfully (21). Thus their populations wax and wane in these regions. In Maryland, therefore, the upper bay is not suitable for sustained harvest because freshets or floods inhibit reproduction, recruitment, and growth (22). However, the rest of Maryland's portion of the bay is quite suitable for natural and artificial culture. Maryland's mesohaline (5-18‰) salinities deter predators such as polyhaline (18–25‰) oyster drills (the gastropod ***Urosalpinx cinerea*** and ***Eupleura caudata***) and starfish. Also, disease organisms, specifically ***Perkinsus marinus*** and ***Haplosporidium nelsoni***, are inhibited. In contrast, Virginia's saltier waters allow these predators and pathogens to survive with serious effects on oyster survival and the industry (see below).

4. THE FISHERY

4.1. The Present Situation

The oyster industry in Maryland and Virginia is complex in organization. The basic philosophy of management has been different in each state. Virginia supports production from private leased bottom whereas Maryland discourages such production and PRFC bans it. These strategies have resulted in different types of gear predominating in each management region. Furthermore, in Maryland especially, different management practices have been applied in main-stem bay waters as compared to tributary (county) waters.

Figure 2 presents a general outline of harvesting, processing, and distribution of seed and market oysters in Virginia and Maryland. Seed oysters are harvested by hand tongs from public seed beds such as in the James River in Virginia or in some tributaries on Maryland's Eastern Shore of the bay. Seed oysters may be harvested from private beds by dredges and tongs; such harvesting is more common in Virginia than Maryland. Seed oysters and oyster shells are placed on public grounds in both states. Shells are obtained from shuckers or packers in both states and from the dredging of buried shell in the bay, primarily in Maryland. Private lease operators also have access to public seed beds and purchase shell from various sources to stabilize their beds or to act as cultch. Various fishing gears are used to harvest market oysters from public and leased grounds. Divers operate primarily in Maryland. Dredges are permitted on public grounds in Maryland but only on public management areas and private bottom in Virginia. Harvested oysters are processed in a variety of ways for sale to the consumer.

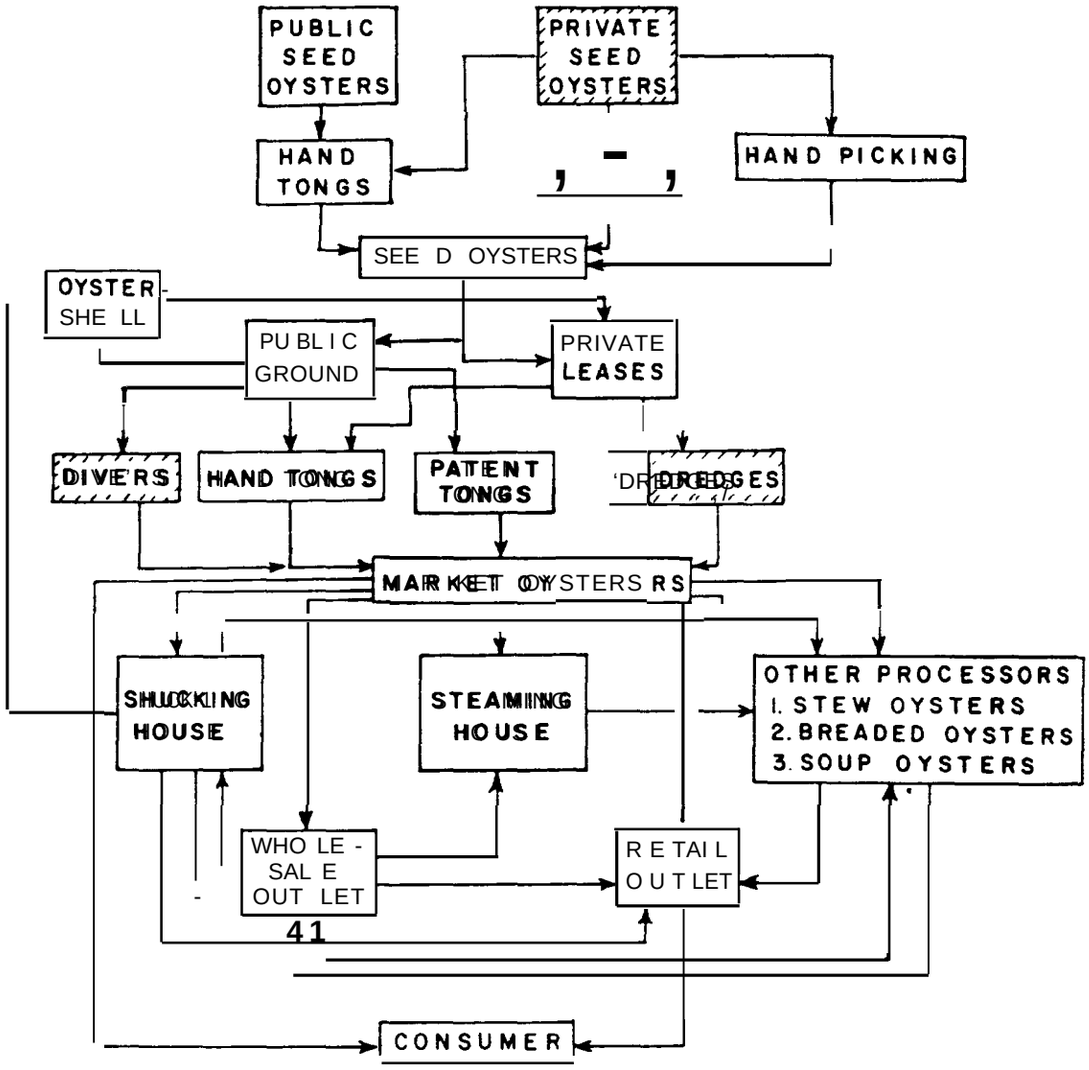

Figure 2. Stages in harvesting, processing, and distribution of seed and market oysters in Virginia and Maryland, Hatched boxes represent the following differences between states (from top of chart and left to right): (1) Private seed oysters are harvested mainly in Virginia, where powered dredges are employed. (2) Divers operate predominantly in Maryland compared with Virginia. (3) Dredges are used on public grounds in Maryland. Figure modified, with permission, from Haven et al. (13).

A variety of boats and fishing gear is involved in the oyster fishery of Maryland and Virginia. Tongers scrape oyster beds with hand tongs (Fig. 3) that consist of two long, flexible wooden shafts (usually 5.5-7 m long) joined in scissor-like fashion toward the ends. to which metal basket rakes are attached. The tonged contents are spilled onto an on-deck ***culling board*** for sorting. Tongers usually operate from shallow-draft, multipurpose boats (Fig. 3) that can be converted in season for crab fishing (trot-lining and potting). Harvesters are assisted usually by one or more individuals, perhaps another tonger or an individual (sometimes the tonger's wife) who culls the catch by separating market-sized oysters from the mass of undersized oysters, shell, and debris. Culled material must be thrown back

Figure 3. Hand tonging in Maryland's Chesapeake Bay. One person works at culling board while another tongs. Courtesy of Skip Brown and University of Maryland Sea Grant College.

on the **oyster bar to serve as cultch and to allow undersized oysters to grow to market size.**

Market oysters are usually sold by the bushel on the day of harvest. In the past, ***buy bouts*** (20-30 m long) would sail near a group of tongers to purchase their catch. The decks of these wide-beamed boats (Fig. 4) earned several thousand bushels of oysters, which were transported to a wharf for off-loading at a shucking or packing house. More recently, buy boats have been used less commonly; tongers take **their boats to a dock and off-load onto a conveyer belt that carries the catch into a truck owned by a packer or planter.**

Patent tongs were developed to fish in waters deeper than hand tongers can reach, although they are sometimes used in shallow waters. They are large and heavy **metal tongs** (Fig. 4) operated by a winch system. They are raised and lowered by a cable that **runs** through a block on the vessel's boom and are usually opened and closed by a hydraulic system. Boats may be single or double rigged (one or cwo sets of tongs, respectively). Harvesting usually involves one (single rig) or two (either rig) people.

Dredges are large, heavy, triangular metal frames with a collection belly and pocket made of metal rings and S-hooks and a toothed lower bar at the mouth that acts as a rake. In the past, dredges weighed hundreds of kilograms and undoubtedly did enormous damage to living oysters and spat as they were dragged over beds. They are now restricted in size and weight in Maryland. Usually two dredges are towed on alternate sides of a boat, with the catch being winched up and dumped on deck for culling. Smaller dredges, called hand scrapes, can be used in certain waters from smaller boats of the size of tonging boats. Engine-powered dredge boats are used in Virginia and on leased bottoms in Maryland. However, sailboats, called skipjacks, are used on public grounds in Maryland (Fig. 5).

The sailing fleet in Maryland is the last all-sail fleet of commercial craft operating in North American waters. The wooden sailboats (about 10-18 m long) are very graceful, sporting clipper bows with carved trail boards and a sharply raked single mast positioned well forward. They have shallow, wide. V-bottomed hulls with a centerboard and a square stem. These sturdy, highly maneuverable vessels have low freeboard to facilitate hoisting dredges on board over a roller. The raked masts make coming about easy and the triangular sail spills wind easily when gusts occur, permitting steady even hauling of the dredge over the bottom. A century ago the bay was fished by more than 1000 sailboats, with many, including schooners, being larger than today's vessels. In the late nineteenth century, smaller, shallow-draft, cheaper skipjacks (the name apparently is an archaic English word meaning ''inexpensive yet useful servant' became common. With the decline of the fishery and the banning of dredging in most tributaries, the fleet dwindled and only about 35 vessels are still afloat in Maryland. Most are more than 50 years old and those that are have been placed in the National Register of Historic Places as of 1985.

Most recently, oysters have been collected by divers using scuba or hookah devices delivering air from the boat to the diver below. This is a more efficient system for collecting larger oysters from deeper areas untouched by tongers and

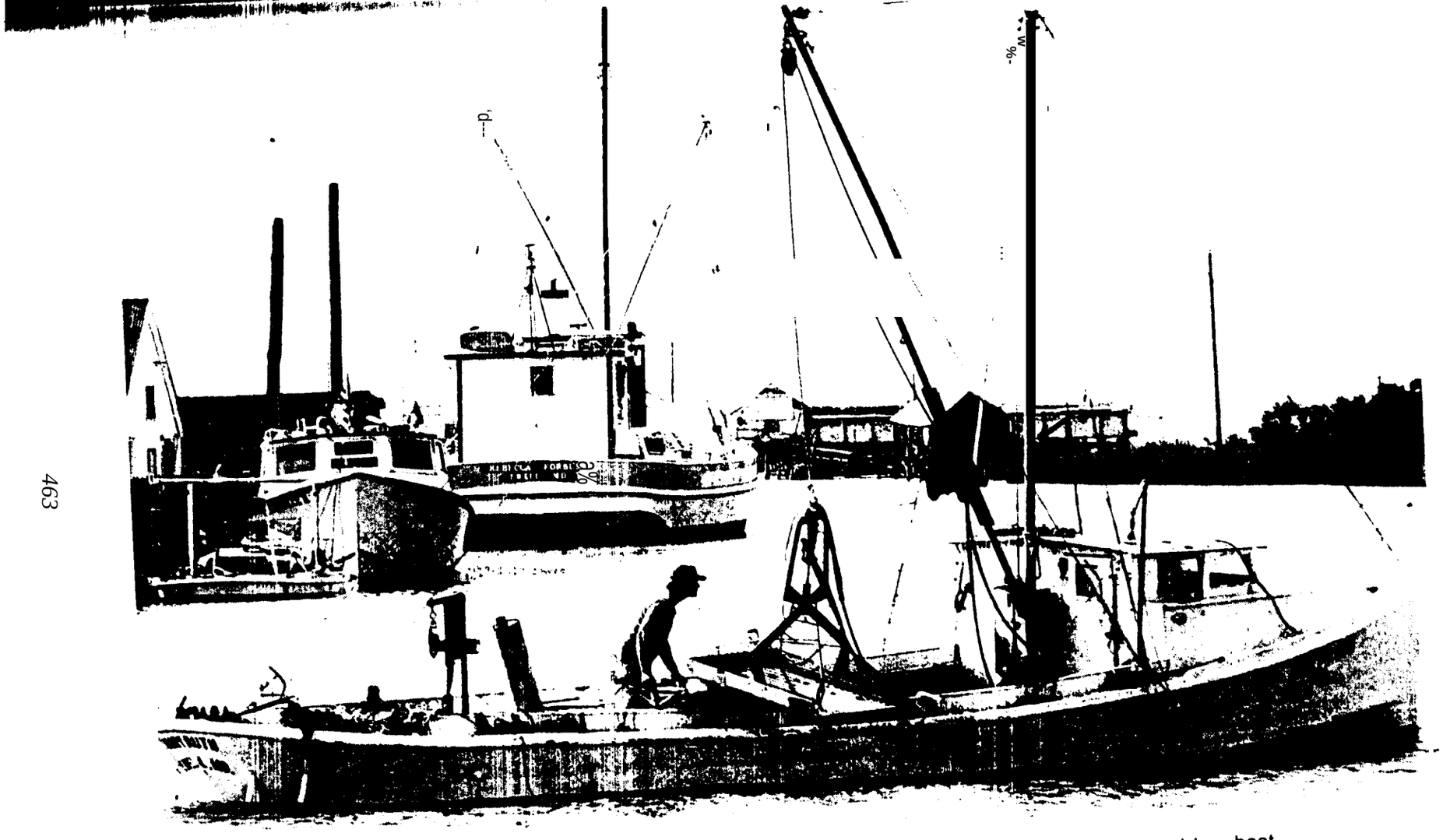

Figure 4. Patent tonger with hydraulic tongs resting on culling board. Note wide-beamed buy boat *Rebecca Forbush* moored in background. Courtesy of Skip Brown and University of Maryland Sea Grant College.

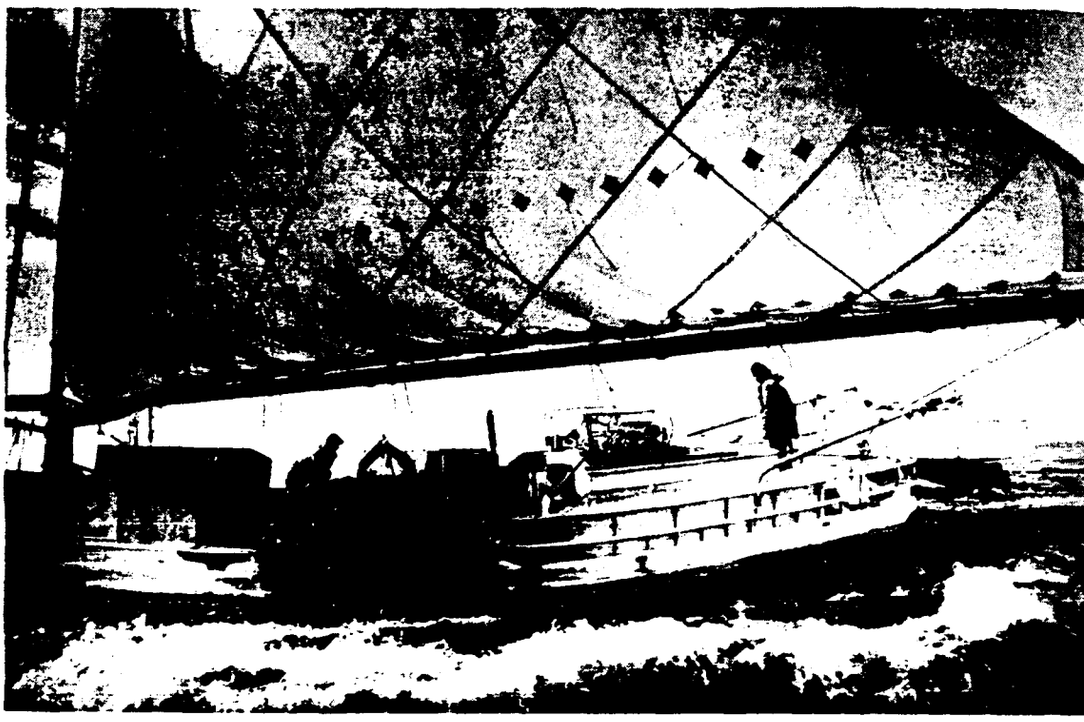

Figure **5. Skipjack under way. Working dredges (on both** sides of boat) are out of the water with catches being culled by three oystermen. Note extra dredges, roller on side, and "push boat" or yawl hoisted at the stern on this sailing day. Courtesy of Michael Fincham and University of Maryland Sea Grant College.

from more scattered clumps of oysters than could be fished efficiently by dredge boats or patent tongers.

Table 1 presents a condensed listing of regulations governing the oyster fishery in Maryland, Virginia, and the Potomac River. Although five types of gear tire listed. only hand tonging and hand scraping arc allowed in the Potomac River. All five methods of fishing are practiced elsewhere in Ma aryland and Virginia. although diving is uncommon in Virginia.

Generally, entry into the fisheries is virtually unrestricted, being regulated only by one's period of residence in a state and by the requirement of a license fee. Seasons and hours of fishing vary according to gear type and location. For dredging in Virginia, there are few or no restrictions on season. hours, catch limits, or dredge size. Maryland has more restrictions because dredging is allowed on public beds.

Regulations have been aimed at protecting the public stocks by mandating use of the most inefficient gear or by hobbling more efficient gear. The per capita catch using a motorized dredge has been estimated to be more than 10 times the catch of a single hand tonger in the same time period (10). Sail dredges are also more efficient than hand tonging, though probably less so than motor dredges. To counter such efficiency, therefore, the dredging season is 1 imited in length and hours of operation in Maryland, and power can be used only on Mondays and Tuesdays

TABLE 1 Comparative Fishing Regulations Governing the Maryland, Virginia, and Potomac River Oyster Industries, 1985.[a]

	Maryland	Virginia	Potomac River
A. *Gear Type*			
Hand tonging			
License fee	$50/person	$10/person	$50/person
Season	Sept. 15-March 31	Oct. 1--June 1[a]	Oct. 1-March 31
Hours	Sunrise-sunset	Sunrise- sunset	Sunrise- 1500 EST
Daily catch limits			
Per licensee	25 bushels	No limit except in a few areas	No limit
Per boat	75 bushels		No limit
Restrictions	No Sunday tonging	No Sunday tonging	No Saturday or Sunday tonging
Patent tonging			Banned
License fee	$50/person	$35/person	
Season	Sept. 15-March 31	Oct. 1-March 1	
Hours	Sunrise-sunset	Sunrise-- 1400	
Daily catch limits			
Per licensee	75 bushels	No limit except in a few areas	
Single-rig boat	100 bushels		
Double-rig boat			
Restrictions	No Sunday tonging; certain counties off limits	No Sunday tonging; certain regions off limits; tongs < 100 lb weight. ≤ 4-in. teeth	

(Continued)

TABLE 1 *(Continued)*

	Maryland	Virginia	Potomac River
Dredging			Banned
License fcc	$50/person	$50/dredge	
Season	Nov. l-March 15	No restriction	
Hours	Sunrise- 1500	Daylight, except sunrise-1400 in some management areas	
Daily catch limits	150 bushels/boat	None, cxccpt in some management areas	
Dredge size	<200 lb weight	None specified except in onc management area	
Rock bottoms	≤ 42-in. tooth bar		
Mud bottoms	≤ 44-in. tooth bar		
Restrictions	No Sunday dredging; Iimitcd to bay waters and a fcw tributaries; sail only, cxccpt Monday and Tuesday when a yawl may push dredge bout	No Sunday dredging; banned on public grounds; legal only in management areas and on leased grounds"	
Hand scraping			
License fcc	$50/person	$50/scrape	$100/boat and person
Season	Two weeks maximum if inclement weather has disrupted tonging season	No restriction	Nov-Dee, M-W-F; March. M-T-W-Th
Hours	Sunrise- 1200	Sunrise-sunset	0800-1200
Daily catch limits		No limit	No limit
Pcr licensee	10 bushels		
Pcr boat	30 bushels		
Restrictions	No Sunday scraping; all	No Sunday scraping	No Saturday or Sunday scraping"

Restrictions	No Sunday scraping; all but two counties off limits	No Sunday scraping; banned on public grounds; legal on leased grounds	No Saturday or Sunday scraping
Diving			
License fee	$50/person	Not regulated per se; considered to be taking oysters by hand, thus coming under hand tonging regulations	Banned
Season	Sept. 15-March 31		
Hours	Sunrise-sunset		
Daily catch limits	30 bushels/boat		
Restrictions	No Sunday fishing; attendant required on board; certain grounds off limits		
B. *Culling Laws*	In all three fisheries shell must be returned to fished bed; maximum market size is 3 in.		
C. ***Taxes*** (per bushel)			
Unshuckcd oysters shipped out-of state	$0.15 inspection tax	$0.20 export tax	—
Oysters fished from public grounds	$0.45 severance tax	$().50 replenishment tax"	$0.50 inspection tax
Tax on purchasers, planters, packers, importers, shippers	—	$0.03 inspection tax	—

"Generally, licenses available only to 12-month residents of the appropriate state. EST = Eastern Standard Time; 1 in. = 2.54 cm; t lb = *0.45* kg; 1 bushel = about 300-350 oysters.

"James River seed area season, Oct. 1-July 1.

"Dredges are powered by engines.

'James River seed area taxes, $0.05-$0.50/bushel depending on market price of the bushel of oysters.

and then only through use of a ***push boat*** (Fig. 5). When divers began operating in Maryland in the late 1970s, an uproar ensued because of the efficiency of the method. Nondiving waterrnen agitated to ban the harvest system entirely, claiming that divers collect the older brood stock which, they believed, maintain recruitment to the oyster fishery. Soon thereafter, divers were limited to collecting oysters of ≥ 10 cm, rather than ≥ 7.5 cm, as was the case with the other harvest methods, That regulation is no longer in effect and diving is now tolerated in Maryland, but with catch and manpower restrictions (Table 1). Also, certain grounds have been made off limits, to be reserved for tongers.

In Maryland it is not uncommon for certain counties to pass laws imposed on state regulations for even more conservative management. For example, although patent tongs are legal, they are banned in certain "county waters" (i.e., in tributaries in the county as opposed to open bay waters where the state has control). As Power (8) notes, such variations have no rational justification but they do prevent uniform management of the resource.

Taxes are applied by all three jurisdictions but they vary in name and amount (Table 1). A bushel of oysters harvested from public grounds and shipped in the shell out of the region would be subject to taxes totaling $0.60.$0.73, and $0.50 for Maryland, Virginia, and the Potomac River, respectively.

4.2. History of the Fishery

It can be said that the regulations summarized above have produced an economically inefficient industry but that depletion of the fishery has not been abated (7), although it may have been slowed. Thus in spite of regulations and legislative attention paid to the oyster industry in the Chesapeake Bay, harvests have declined over the past century (Fig. 6). An understanding of (he reasons for the decline in both states requires a brief retracing of the history of management practices of the states (13, 14) and an evaluation of recent disease and pollution problems.

Maryland's earliest oyster-related law was enacted in 1820, prohibiting dredging and out-of-state transport of oysters in ships not wholly owned for the preceding year by a state resident. This law was necessary because earlier in 1811 Virginia had prohibited dredging by nonresidents, thus forcing Connecticut-based dredge schooners to fish in Maryland to obtain oysters. The Connecticut dredges were in Chesapeake waters because the New England oyster grounds to the north had been polluted and overfished. By 1808 it was necessary to harvest Chesapeake Bay oysters to meet market demand in Connecticut (1). With the bay states restricting transport of oysters to residents only, New England tradesmen opened packing "houses in Maryland and Virginia in the mid- 1830s and took advantage of improved turnpikes (roads) and railway systems to ship canned oysters north, south. and especially, west (23). Harvesting began to involve more Marylanders and Virginians and catches increased greatly (15). As a result of essentially unregulated fishing, the catch peaked in both states in the 1880s.

The ensuing decline in harvests disturbed watermen, processors. and politicians. In Virginia in 1892, Lieutenant Baylor of the U.S. Coast and Geodetic

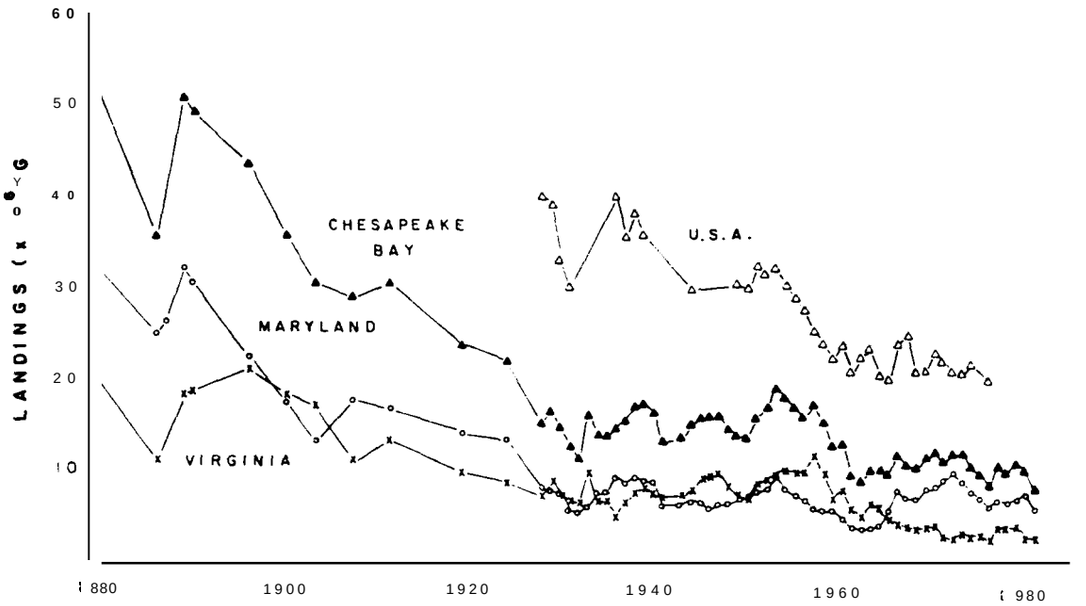

***Figure** 6.* Reported landings of oysters in Chesapeake Bay and the United States. Data from Fishery Statistics of the United States (1950, 1952, 1965 and 1966-1977) and Stagg (24). Data for the United States are more limited because there were orlly 12 yrs between 1880 and 1952 in which complete data on oyster harvests were available for all states.

Survey was commissioned by the state to survey the oyster grounds (13). He issued a repott in 1894 delineating the boundaries of all the natural oyster reefs in Virginia (about 210,000 acres or 84,000 ha) and, with occasional adjustments, the "Baylor Grounds" have remained essentially as he outlined them (even though many beds are now overfished or silted over). In 1906. Maryland's Shellfish Commission sponsored a 6-yr survey of oyster grounds by the Coast and Geodetic Survey's Lieutenant Yates (15). His survey produced 37 m^2 of charts of Maryland's oyster beds; many of these beds no longer exist. Both Baylor's and Yates's surveys have been the basis for defining the locations of public oyster beds in Virginia and Maryland, respectively (Fig. 1). However, within the last decade both states have undertaken new surveys of the public beds because of the loss of overfished beds and the demand of watermen wishing to fish for clams (*Mya arenaria* L. or *Mercenaria mercenaria* (L.)) on abandoned oyster grounds.

In their conclusions concerning the future of the industry, both Baylor and Yates urged the leasing of unproductive or ''barren" bottom for private planting purposes. They were not alone in this, for similar recommendations had been made by Winslow (3), Brooks (5), and numerous others during the late nineteenth century when the bay oyster industry was beginning its major decline. However. the results (especially in Maryland) have been limited. Figure 1 (left) reveals that more oyster grounds are leased in Virginia than in Maryland; this is also true in the Potomac River whose south shore is in Virginia. Compare Figure I (left and right) to see that the relative lack of private beds in Maryland is not due to a lack of suitable oyster habitat. Even marginal oyster ground can be improved by careful manage-

ment by leaseholders. For example, private leases have been common on Virginia's lower Eastern Shore of the bay (Fig. 1 left), whereas natural oyster beds are limited **(Fig. 1 right) because higher salinity in this region allows predators and disease to penetrate the Bay along that shore. In regions such as this, mortality can be limited to a certain extent by collecting predators mechanically and by transplanting** oysters when they have reached **seed or even market size but before they succumb to disease.**

The difference in the mix of public and private grounds in the two states has had an effect on harvest and gear use (Fig. 7). From 1952 until the mid- 1960s (see also Fig. 6), Virginia landed more than 50% of all oysters harvested in both states, with most of that coming from privately leased beds (Fig. 7A), which represent about one-third of the oyster acreage in Virginia (Table 2). In contrast, Maryland landings were predominantly from public beds (Fig. 7A); nevertheless, Maryland's private oyster grounds (-3% of total acreage, Table 2) have yielded an average of 11 % of Maryland's total catch (24). It is typical that private grounds outproduce public beds. For example, in 1943, 13% of all U.S. oyster-producing bottoms were privately leased or owned but produced 55% of the total oyster crop (25).

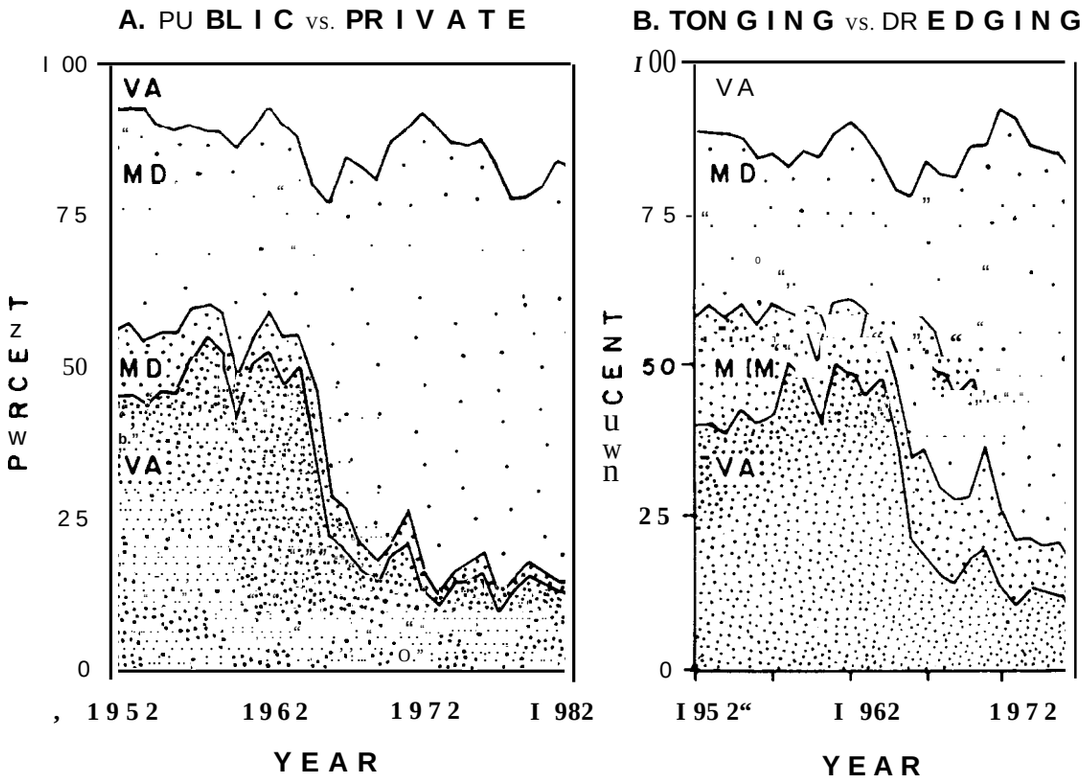

Figure 7. Historical trends in percentage composition of oyster landings from *(A)* public and private grounds harvested by (B) tongs or dredges in Maryland and Virginia. Data on private landings and on dredged oysters from Virginia (VA) and Maryland (MD) are presented in the lower two (darker) segments of A and B, respectively, whereas public harvests and tonged harvests are presented in the upper two (lighter) segments of *A* and f3, respectively. Data from Stagg (24).

TABLE 2 Comparative Data on Public and Private Oyster Grounds and on Leasing Policy in Maryland and Virginia, 1985."

	Maryland	Virginia
Approximate extent of all oyster grounds (acres)		
Public	270,000 (97%)	243.000 (69%)
Private	9,000 (3%)	1 I 1,000 (31%)
Quantity leased to any one person (acres)		
Bay	5-500	≤ 5000
Tangier Sound	1-1oo	—
Elsewhere (tributaries)	1-30	≤ 250/assignment; total ≤ 3000
Annual rental costs		
Tributaries	$3.50/acre	S I .50/acre
Bay	$3 .50/acre	≥ S0. 75/acre
Duration	20 yr initial; 5 yr renewal	10-20 yr, depending on when lease was granted; 10 yr renewal
Restrictions	Natural bars off limits, as is any area within 150 ft (county waters) or 600 ft (bay waters) of a natural oyster or clam bar; illegal in six tidewater counties; no private corporation may lease oyster grounds; Maryland residents only; tonging allowed only on some leased grounds: hand scrapers and power dredges allowed in other limited leased areas: moratorium on new leasing imposed in 1976	Natural bars (Baylor Grounds) off limits; Virginia residents or state-chartered oyster culture corporations only

"1 acre = *0.4* ha. 1 ft = 30 cm.

This is probably due to the better culture and management practices of leaseholders whose capital is at risk. In spite of evidence of the greater yield possible from privately leased grounds (usually marginal "barren bottoms" at best), Maryland has persisted in inhibiting leasing. The history of the consistently strong hostility of Maryland's waterrnen and their political representatives to private culture is outlined in greater detail in Kennedy and Breisch (15).

Because of higher harvests from Virginia's private beds than from public beds, the yield from dredging exceeded that from tonging from 1952 to 1975 with few exceptions (Fig. 7*B*). Contrarily, tonging has predominated in Maryland because more beds are in the public fishety.

Figure 7A reveals a sharp drop in harvests by Virginia's private leaseholders beginning in the early 1960s. This decline was the result of an invasion or manifestation of a lethal disease in Chesapeake Bay in 1959-1960. This disease, initially dubbed MSX, had virtually destroyed the oyster industry earlier in Delaware Bay (Fig. 1) (26). The disease organism was eventually determined to be a haplosporidan protozoan (27) now designated ***Haplosporidium nelsoni.*** In Chesapeake Bay where salinities were >15‰ (predominantly in Virginia, although also in southern Maryland waters) the disease reached epizootic proportions during some years after 1960 (28). Several large processing companies in Virginia that had extensive leaseholdings were crippled or driven out of business (13). Nearly half the leased bottoms were abandoned. resulting in a major decline in total landings (Fig. 6). Lower-salinity waters of Maryland were much less ravaged by this disease, although MSX killed oysters well up into Maryland's portion of the bay during recent drought years. The impact of MSX was exacerbated by the persistent presence of the common polyhaline disease. ***Perkinsus (= Dermocystidium) marinus.*** which increases in intensity during dry periods and extended warm autumn seasons.

Since the epizootic. [here has been a continued decline or depression of landings and recruitment in Virginia since 1961 (13). This decline has occurred on public and private grounds both in high- and low-salinity regions. In addition to disease, it is thought that pollutants, especially chlorine and chlorine derivatives resulting from sewage treatment and fouling control programs, may be implicated in larval mortality. However. economic factors have also played a role. Haven et al. (13) implicated ''rising production costs, stagnant dockside prices. consumer resistance. failure of the industry to adjust to modem production methods, inadequate management by industry and the public sector, and competition from growers and harvesters outside of the State" as contributing causes of the decline in the industry.

Most or all these factors undoubtedly affected Maryland's industty as well. However, Maryland's harvests have risen somewhat since the early 1960s during Virginia's decline (Fig. 6). This has been attributed to Maryland's more extensive public repletion program. This program includes seed transplantation from poor to good growing areas and p[anting of fresh oyster shell (purchased by the state from shucking houses) and "fossil" shell (dredged from extensive buried reefs) in productive areas (1 1). From 1960 to 1978, more than 120 million bushels of dredged shell, fresh shell (thought to be more attractive to setting larvae but less available than dredged shell), and seed oysters were planted by the program. at an annual cost of about $1.3 million (D. G. Swartz, University of Maryland Sea Grant College, personal communication). The program has been moderately to heavily subsidized by Maryland taxpayers even though legislation in 1967 and 1968 was enacted in an effort to make it self-sustaining by taxing the industry. Few studies have been performed to determine the efficacy of the repletion program, either **from a biological or an economic perspective (1 1). Recently, however, some**

evidence has accrued from modeling efforts that indicates that repletion activities did influence production positively in certain regions (29,30; D. G. Swartz, personal communication). Unfortunately, mortality from MSX resurgence in drought years and poor or no settlement in wet years have resulted in declines in Maryland's production since about 1973 (Fig. 6).

Haven et al. (13) examined possible reasons for Virginia's sustained decline in production, as mentioned. As in Maryland, a major biological factor involves lowered setting levels, especially in the seed beds of the James River, once the major source of seed for leaseholders but now producing about one-quarter as many seed oysters as in the 1950s. Reasons for poor settlement are unclear. but it is thought that the MSX-caused reductions in brood stock of adult oysters have led to reductions in the larval populations once produced by these adults (31). If true, this phenomenon may be exacerbated by the extreme sensitivity of oyster larvae to chlorine and its derivatives (13). Another factor affecting Virginia's production may be competition in Virginia markets from oysters imported from southern states. The decline in James River seed beds and losses to MSX led to reluctance by planters to spend money on private culture. More recently. high interest rates and inflation led to a greater perceived risk of private oyster culture in Virginia. Processors have turned to imported oysters to meet consumer demand. In addition. the decade of the 1970s was wet, exacerbating poor reproductive success. This. combined with continued harvesting, has driven oyster population levels even lower in Virginia and Maryland.

5. THE PRESENT AND THE FUTURE

At present, there are few or no dependable statistics collected in either state concerning fishing mortality, natural mortality, recruitment success over the long term. stock size, damage caused by harvesting, and so on. Those statistics that have been collected have been unreliable (11. 13). Cabraal (11) found errors in the transfer of data by DNR from records made by buyers in the field (bar name. date, boat and waterman license numbers, bushels caught, price per bushel. buyer license number) to coding sheets, then to computer cards, and finally to magnetic tape. He discovered that data had been erased accidentally on some records. different codes for fishing gear were used in different years, the number of people on board different kinds of fishing boats was arbitrarily set (e.g., five for dredge boats). and deciphering the actual bar location where the oysters were harvested was difficult because of the multiplicity of local names in use. Yet DNR's records are the only source of detailed oyster production information available in Maryland. Aggravating this lack of reliability (which applies also to Virginia) is the penchant for watermen and processors to understate their catch information and any other data that might allow monitoring of their incomes for taxation purposes. Naturally, management of the industry is hindered by lack of such information.

In addition, political-pressure in Maryland especially has inhibited attempts to encourage private leasing (Table 2). Thus the state has operated a subsidized repletion program, with management decisions dependent on demands of waterrnen

who **put pressure** on DNR through their county committees of **tongers** and dredgers. Similar pressures exist in Virginia. For example, in both states, shell has been planted in places where historical data indicate that limited spat settlement **occurs,** and at the wrong time for successful settlement. Both states have been pressured to open areas to fishing and to lift harvest limits when it has **not** been scientifically appropriate to do so. In the Potomac River, the management agency appears to be **somewhat less susceptible to such political pressure.**

At present, both states are undertaking major examination of the management of their oyster fisheries. Although these examinations are not new—as previously noted, Maryland has sponsored numerous studies over the last 100 yr and has largely neglected the resulting recommendations (l S)—there may be more urgency now, because recent oyster recruitment has been so erratic and harvests continue to decline. Deliberations coordinated by DNR in 1985 brought together oystermen, politicians, packers, and scientists. The result was a consensual "White Paper" for managing the fishery. Among the shortcomings of this document were the neglect of either oyster bottom leasing or encouragement of private oyster culture. Instead, the proposed action for 1986 involved banning oystering on Saturday, limiting catches to 50 bushels per tong boat and 100 bushels per dredge boat, and prohibiting the placement of oysters in containers except during unloading at a dock (to prevent the hiding of illegal-sized oysters in baskets filled at sea). These proposed regulations seem insufficient to revitalize Maryland's industry. In addition, in spite of the involvement of oystermen and politicians in production of the White Paper, other oystermen and a local politician opposed the agreed-upon regulations; many did not become law in 1986. A major disease outbreak has since reduced landings to -0.5 million bushels (1988). Virginia's management plan was completed in 1986. It remains to be seen how substantive it will be.

In their review of Virginia's fishery, Haven et al. (13) made numerous sound recommendations for rehabilitating the industry (most of these recommendations would be useful in Maryland also). They lamented the inattention paid by manage**ment, politicians. watermen, and** leaseholders to the litany of scientific advice over the past century. Such inattention is discouraging because shellfish, of all marine animals. are among the most readily susceptible to deliberate management. McHugh (32) has stated that

> It appears that reasonable solutions to the problems of the oyster industry will come about only by the route that so many fishery solutions appear to take, when resistance to change is so weakened by disaster and virtual destruction of the industry and the resource that resistance crumbles and the industry finally begs for help.

It is not clear that such an end has been reached yet in Chesapeake Bay.

6. CONCLUSIONS

In spite of the demonstrated resilience of eastern oyster populations in Chesapeake Bay, decades of overfishing and mismanagement, coupled with recent failures of

recruitment, have led to historically depressed harvests. The harvest rate exceeds the repletion rate, in spite of gear restrictions. Broodstock and cultch are removed with insufficient attempts to establish adult reserves or to return shucked shell to appropriate regions of the system. The leveling of reefs that originally projected above the surrounding bottom has undoubtedly produced less suitable oyster habitat. This is because reefs are probably (a) less susceptible to effects of suspended sediment, (b) more favorable setting sites, and (c) better growing sites because they project into the food-laden water column.

Recent imposition of measures to minimize sediment runoff from farming and land clearing should help slow smothering of oyster beds and cultch. Further rehabilitation will require brood stock protection, planting seed oysters in good growing regions where the bottom has been stabilized by hard substrate, placing mounds of cultch only in regions with a history of excellent settlement success, and managing by scientific principles rather than in response to political pressure. Such rehabilitation would be facilitated by encouraging private culture, especially in Maryland. Thus the costs of rehabilitation would be shared among numerous leaseholders, not just by state taxpayers. The effort of rehabilitation would also be shared. The public grounds could be restored as larval populations increased with the success of privately operated oyster bottom. Shelling of public grounds could provide suitable substrate for settlement of these pelagic larvae, which are not restricted by property lines. In both states, an understanding of the reasons for continued depressed recruitment is needed, as is encouragement in Virginia of a renewed level of private culture. Finally, dependence on a politicized, heavily subsidized public fishery will have to yield to a moderate mix of public and private production.

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