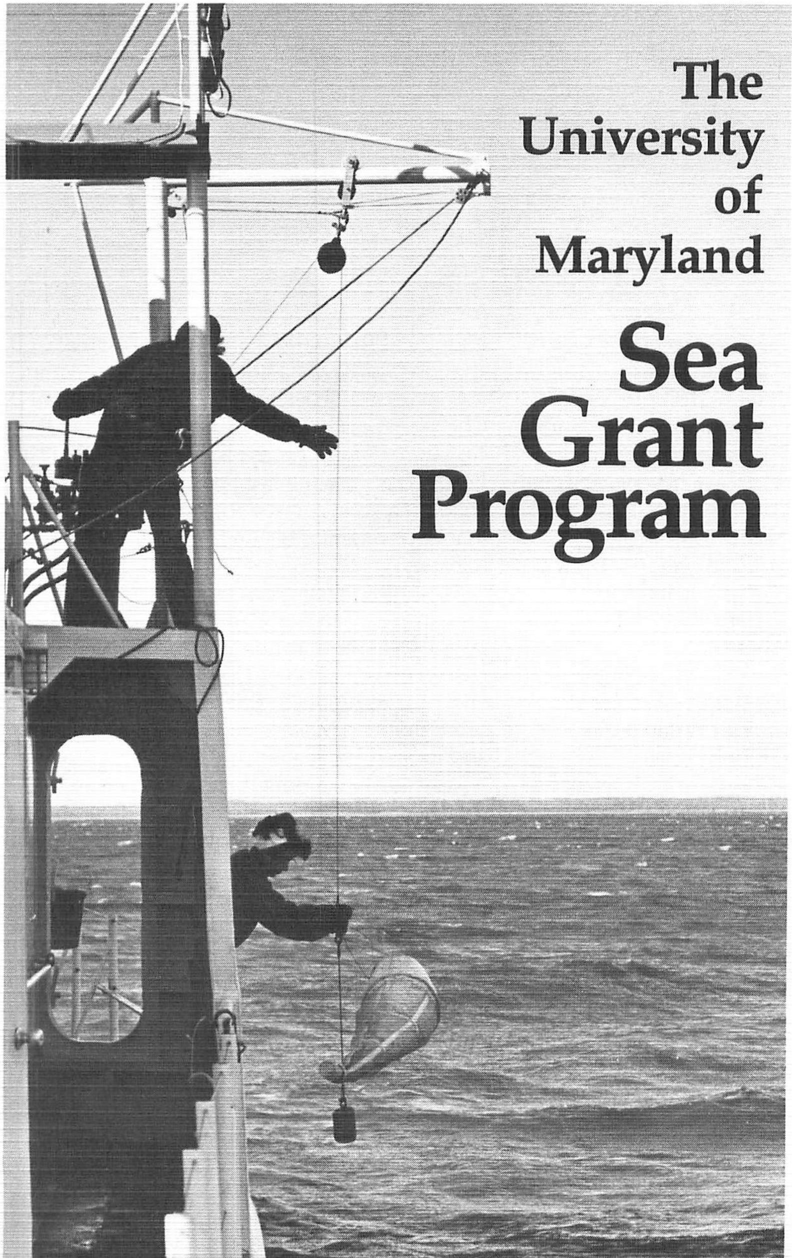
Maryland Sea Grant



The University of Maryland Sea Grant Program

ANNUAL REPORT

January 1, 1977 to December 31, 1977

DR. RITA R. COLWELL, Director

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A Message from the Director



Biological systems—fisheries, forests, grasslands and croplands—form the basis of economic stability. Of these, fisheries have long been crucial for Maryland, where nearly one fifth of the state lies beneath the tributaries and tidal waters of the Chesapeake Bay. Husbanded wisely, a biological system can provide a renewable source of food and energy; harvested beyond its regenerative capabilities, it will become a lost resource. The Maryland oyster fishery, the most valuable by far of all the Bay fisheries, has begun declining again and could soon become depleted. Rehabilitating the oyster fishery of the Chesapeake Bay is a primary goal of the Maryland Sea Grant Program.

Maryland Sea Grant, born in 1977, is part of the National Sea Grant Program, an 11-year-old federal effort that supports university-based research, education and advisory services aimed at applying science and technology to the wise management and development of this country's oceans, estuaries, rivers and lakes. A division of the Department of Commerce's National Oceanic and Atmospheric Administration, Sea Grant follows a "bottoms-up" management approach, calling upon local institutions and residents to identify regional problems and needs and asking local universities to respond with research programs designed to clarify or solve those problems. Sea Grant research is targeted research.

The Maryland oyster fishery, the first target for the Maryland Sea Grant Program, has for nearly a century supplied more oysters than any other state in the country or any other country in the world, largely because the shallowness, size, salinity, circulation pattern, food web and hard bottom bars of the upper Chesapeake Bay create a natural habitat for *Crassotrea virginica,* the American oyster. The fishery has over the last decade, however, suffered a series of oyster reproductive failures that have recently begun to reduce the annual harvests.

Most biological crises eventually become human crises. In Maryland, several generations of Bayshore residents have learned and passed on a tradition of "following the water," choosing to work the Bay as independent, self-employed businessmen, much as ranchers and farmers work a piece of range or cropland. Nearly 4,000 watermen and 5,000 other residents still earn part or most of their yearly income from catching, shucking or selling oysters. For these watermen, the families they raise and the communities they populate, a fall-off in the oyster harvest represents a calamitous crop failure.

With principal funding from NOAA and matching funds from the State of Maryland, the University of Maryland Sea Grant Program is now developing a combination of basic and applied research projects as an organized response to the clearly stated problem facing the oyster industry. As the program grows, it will broaden its aim, choosing other targets such as the rockfish and blue crab fisheries, changes in water quality and similar problems identified by local residents, researchers and citizens.

Maryland Sea Grant will also enlarge its

Marine Advisory Program that as early as 1974 brought practical assistance to watermen who were wrestling with paperwork, tax regulations, business management and boat engineering.

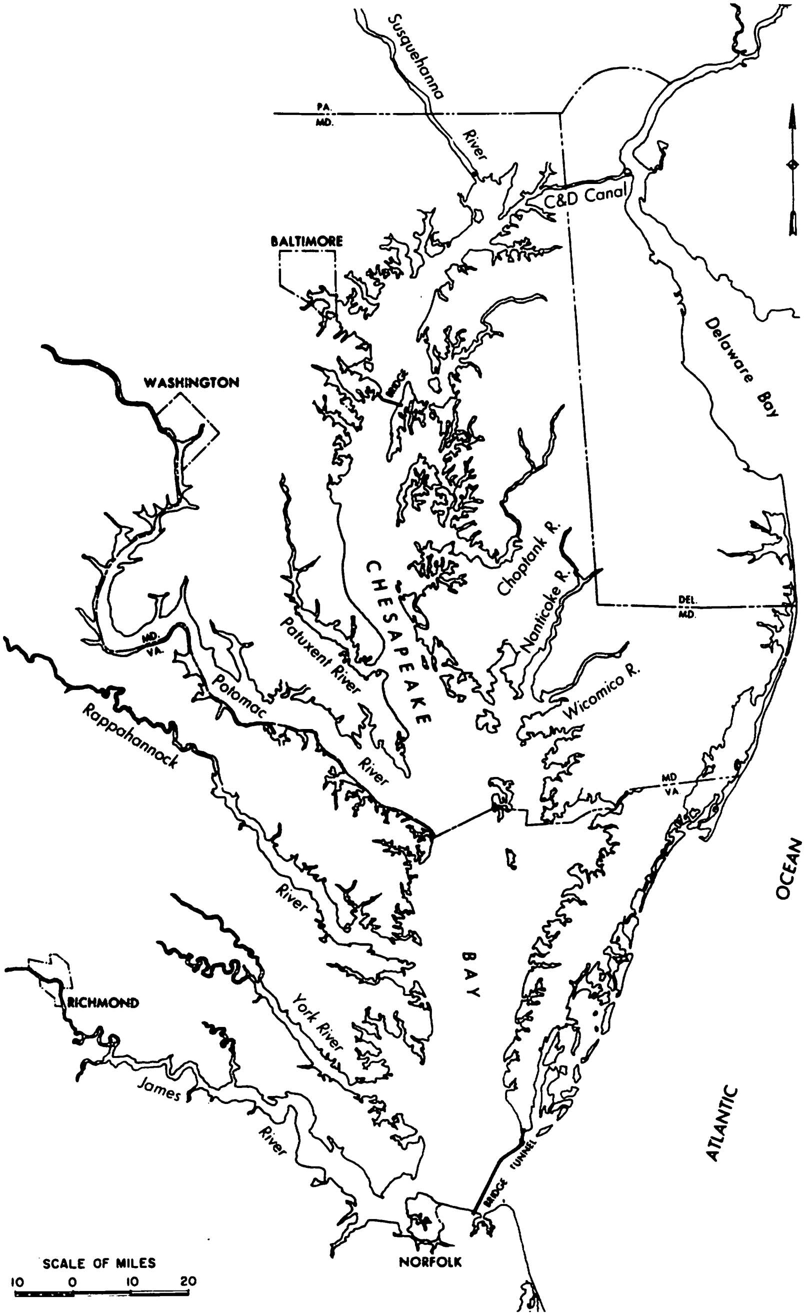
The Marine Advisory Program will also initiate a Marine Education Program broad enough to develop educational materials for primary and secondary schools and specialized enough to supply graduate education in fields like marine and estuarine biology, environmental microbiology, chemistry, toxicology and engineering.

The problems of the oyster industry may only be harbingers of other problems yet unrecognized. The 2,000 square miles of the Maryland Chesapeake, its 4,000 miles of twisting shoreline and its 23 rivers provide a home for thousands of interlinked life forms. With 25 port towns, one major seaport and a regional population passing 3.6 million, the Maryland estuary faces a future replete with potential for interlinked environmental and economic problems.

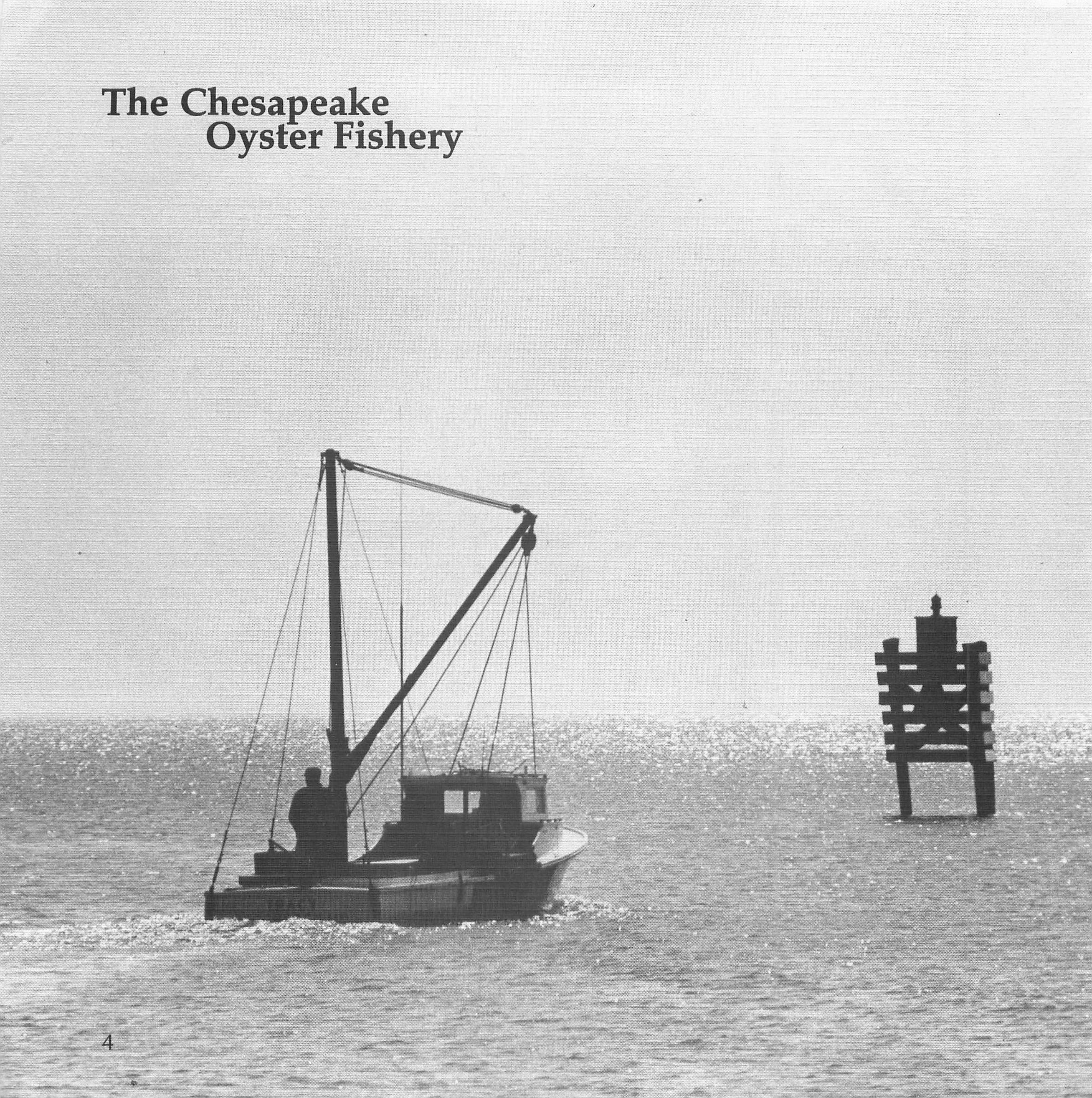
The Sea Grant research work applied to the oyster, its environment, its interrelations with other species and its potential rehabilitation should provide a model for handling or, better yet, avoiding such problems in the decades ahead.

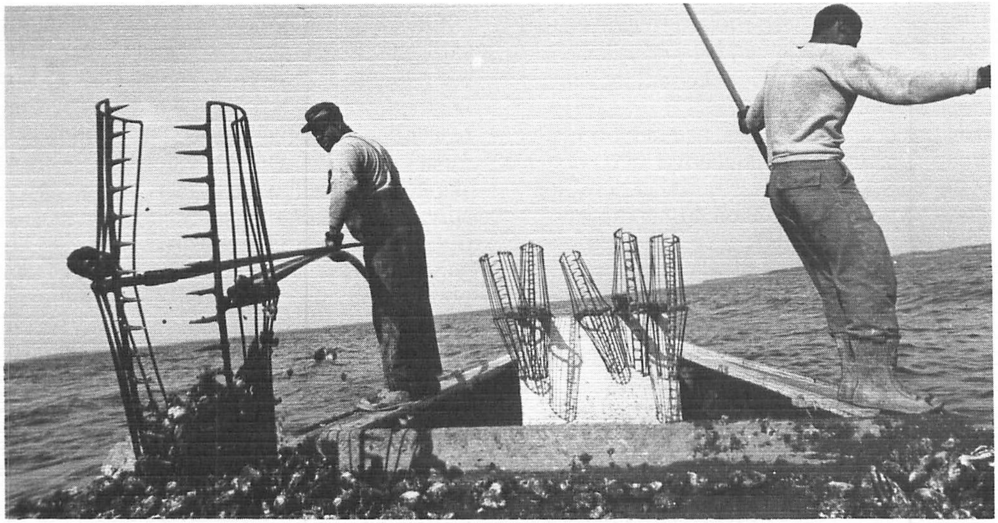
The reports that follow summarize the first year's work for the University of Maryland Sea Grant Program.

DR. RITA R. COLWELL
Director
University of Maryland
Sea Grant Program



The Chesapeake Oyster Fishery





The Harvest

The Chesapeake Bay oyster harvest, say the historians, began thousands of years ago with the Indians who roamed the bayshore on foot and in canoes. Though these first Americans quickly converted the early colonists to the pleasures of corn and tobacco—especially tobacco—it took several centuries for the immigrants and their offspring to learn that oysters were healthy and tasty and catchable in profitable quantities.

When Connecticut watermen at the start of the 19th century began plundering the northern Chesapeake for oysters to replenish their own overfished waters, Marylanders started taking their most plentiful shellfish seriously. From an annual catch of half a million bushels, the state harvest grew gradually to a mid-century total of 1.3 million bushels annually.

From 1870 to 1900 Maryland watermen sailing slant-masted pungys, bugeyes and skipjacks dredged and tonged oysters out of the Chesapeake at better than 10 million bushels a year. In 1875, they hauled home 14 million bushels; in 1885, 15 million. The Chesapeake Bay was producing more meat than the cattlefarms of Maryland, Delaware and Virginia.

Those boom times, unfortunately, faded with the century. The catch records of the 20th century show a sharp drop during the first two decades, followed by a long decline during which the annual harvest averaged only 2.5 million bushels over half a century.

Interrupting this decline have been occasional, short-lived jumps in the harvest, the result of little-understood natural cycles or—more recently—of active oyster management and repletion programs organized by the Maryland Department of Natural Resources.

Chesapeake Bay oysters—despite decades of decline—remain one of the state's and the country's most valuable sea catches. During the last half of the 1960's when catches averaged between 2.5 and 3 million bushels, the Maryland portion of the Chesapeake produced 27 per cent of the United States harvest and outproduced the harvest of any other country. With dockside value running between $10 and $15 million annually, the oyster fishery still outranks all other Maryland catches combined, including crabs, clams, menhaden, striped bass, bluefish and any of 30 other species regularly fished from the Bay.

The Industry

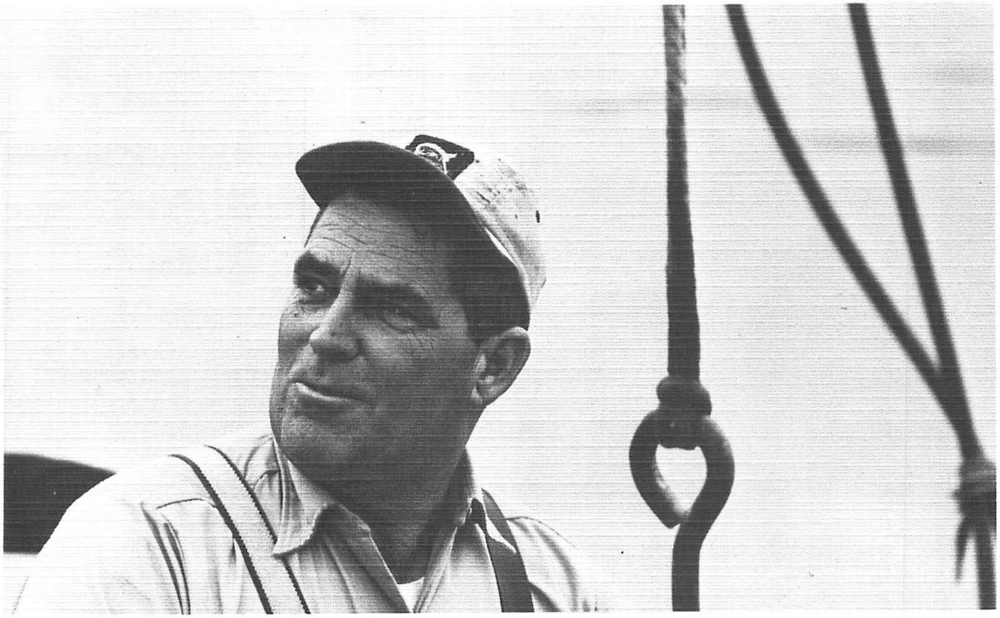
The oyster catch helps support more than 4,000 watermen and nearly 5,000 other Marylanders who work in seafood shucking, processing and shipping.

At present, handtongers, patent tongers and dredgers take oysters off nearly 1,000 public oyster bars spread over 215,000 underwater acres. Most watermen work as handtongers, using small outboards, converted cabin cruisers and long, low-sided tongboats equipped with a small cabin forward and a long cockpit aft for dumping and culling each day's catch. To earn that catch they spend their days anchored over a public bar wrestling with long-shafted tongs made of wooden poles with metal baskets at the end for scooping oysters off the bottom.

A growing number of watermen have equipped their boats with patent-tonging rigs that feature power-driven winches for dropping and hauling up tong baskets, a system that cuts down hand labor but requires greater capital investment.

Only a handful of watermen still sail their skipjacks. Reading the wind and the tides and the currents, they glide these graceful, wide-beamed workboats back and forth across the oyster bars, dragging dredges, large iron claws for scraping up oysters. The three dozen aging skipjacks that still work the Bay are the last survivors of a commercial sailing fleet that once numbered in the hundreds.

Not all Maryland oysters come off the public bars. A few private planters lease plots of Bay bottom from the state, line their sections with old shell or other cultch material and then seed periodically with young oysters. As a result of this kind of close management, the 10,000 private acres produce more bushels per acre than do the public bars. Despite the commercial potential, most watermen oppose private leasing, fearing eventual control of the fishery by large corporations rather than by individual, self-employed watermen.



The Crisis

What currently threatens the oyster harvest and the industry and way of life it supports is a series of oyster reproductive failures dating back to 1968. Analysis of spat-set records reveals that Maryland oysters are not reproducing at their normal rates on natural Bay bottom. If the supply of oysters is not replenished soon, either by nature or man, and if watermen continue to fish off the remaining mature oysters, the Bay harvest may soon decline again and more dramatically than it did during the early decades of this century.

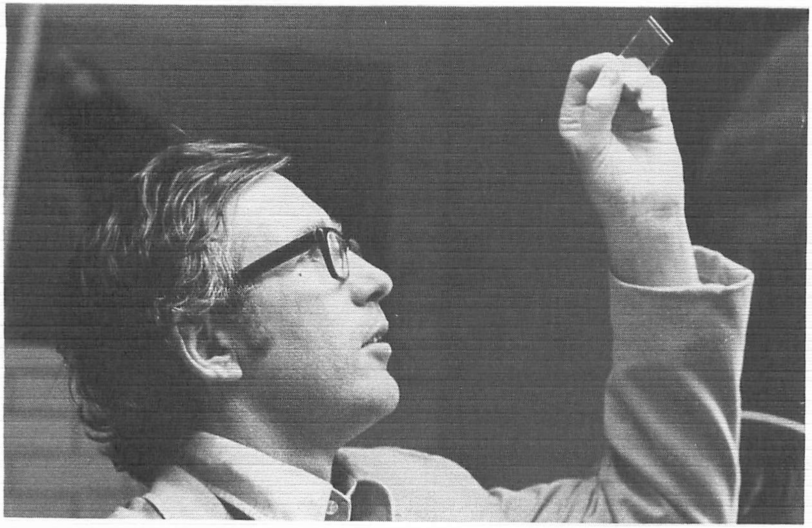
A variety of conditions could be causing the decline:

- decreasing salinities resulting from heavy rainfalls and greater freshwater run-off;
- increasing turbidity that fouls the oyster beds with sediment;
- a decline in underwater grasses, a source of food;
- changes in food cycles;
- changes in water quality;
- overfishing;
- oyster diseases;
- unbalanced sex ratios.

Identifying the causes of the oyster shortage is not the work of one year or one research program. It requires patient, basic research into the little-understood biology of the American oyster and into the less-understood microbiology and chemistry of water quality. How does water change when the hydrocarbons of petroleums, the trace metals of industry and the sewage of cities enter an estuary? How do these changes alter so many inter-linked life cycles?

Testing potential solutions to the oyster shortage calls for applied research into the problems of hatchery technologies, seeding techniques, management policies and marketing strategies.

For 1977, its first year, the Maryland Sea Grant Program helped some researchers get started on studies of these problems and helped others continue projects begun years before. The reports that follow summarize their progress.



The Search for Causes

The search for causes of the oyster crisis starts with basic biology. Research biologist Vic Kennedy spent the first year of this Sea Grant project monitoring public oyster bars, checking on such private matters as sexual health of oysters, male-female ratios, spawning patterns and spat set, the process by which oyster larvae settle, glue themselves in place and begin to grow shells. Disruption of the oyster's life cycle at any of these stages could threaten the Chesapeake fishery.

Consider, for example, sex ratios. Scientists know most American oysters begin life as males, switch sex later on and then remain females the rest of their lives. They worry that several poor reproductive years in a row could interrupt the supply of young, male oysters, leaving the oyster grounds overstocked with aging females who have already switched gender. A poor sex ratio could mean not enough males or not enough male hormones or sperm in the water to encourage female spawning.

To study these questions, Kennedy set up a monitoring program that included:

- surveying 15 widely scattered oyster bars every month;
- collecting 50 oysters per bar per month;
- analyzing over 4,000 oysters for sexual health;
- establishing male/female ratios;
- comparing sex ratios in good and poor spat set areas;
- comparing spat set success in good and poor areas.

His analysis of the data collected produced the following findings:

- Sex ratios varied around the Bay, but not wildly so.
- Sex ratios bear no clear relation to successful spat settlements. Good spat-set areas like Broad Creek and Chicken Cock showed male ratios of 41 and 38 per cent. Poor spat-set bars like Tred Avon and Herring Bay, however, showed better male ratios of 43 and 45 per cent.

These results have important implications both for future research and for present resource management policies. "These findings lead us to believe that gametogenesis (the spawning of sperm and eggs) is not the weak link in the chain of events leading to successful spat settlement," explains Kennedy. "It appears that something occurs between spawning and spat settlement to interfere with success in places like the Tred Avon River."

Next year Kennedy will shift the focus of his research to the problems in larval growth and spat settlement. It is possible that changes in water quality or declining food supplies could be cutting short larval growth. Siltation may be fouling oyster bars, leaving little clean bottom for spat set.

The search for causes, of course, is part of the search for solutions. If siltation is the problem, then expanded shell planting or stricter controls on land-clearing practices could be at least part of the solution. If unbalanced sex ratios had proved a serious problem, then a program of "sprinkle planting" could have restocked the oyster bars with young males. As a result of Kennedy's monitoring program, however, resource managers can now discard "sprinkle planting," a frequently recommended solution, as a probable waste of time and money.

The Hatchery Option

Hatchery-raised seed oysters may provide some relief for the problem of declining oyster reproduction in the Chesapeake Bay. Seed oysters can be spawned, fed, set and grown on land and then planted in the Bay—either on public bars or privately leased plots.

"The idea is to supplement natural oyster reproduction on the Bay," explains George Krantz, a marine biologist specializing in shellfish problems. "By using existing hatchery technology, we could guarantee a certain level of recruitment each year. We would know the oysters are there, because we put them there."

The idea is simple, but the oyster is not. That's one reason shellfish managers for the Maryland Department of Natural Resources have, for several years, developed and then delayed plans for building a production-size hatchery to supply seed oysters for the Maryland fishery. They are waiting for technical, economic and biological data on the myriad of problems that arise in duplicating on land the early stages of a complicated and easily disturbed life cycle.

The data needed should be coming soon out of the research now commencing at the pilot-scale oyster hatchery recently opened at the University of Maryland's Horn Point Environmental Laboratory, a hatchery jointly funded by the University, the Maryland Sea Grant Program and the state's Department of Natural Resources.

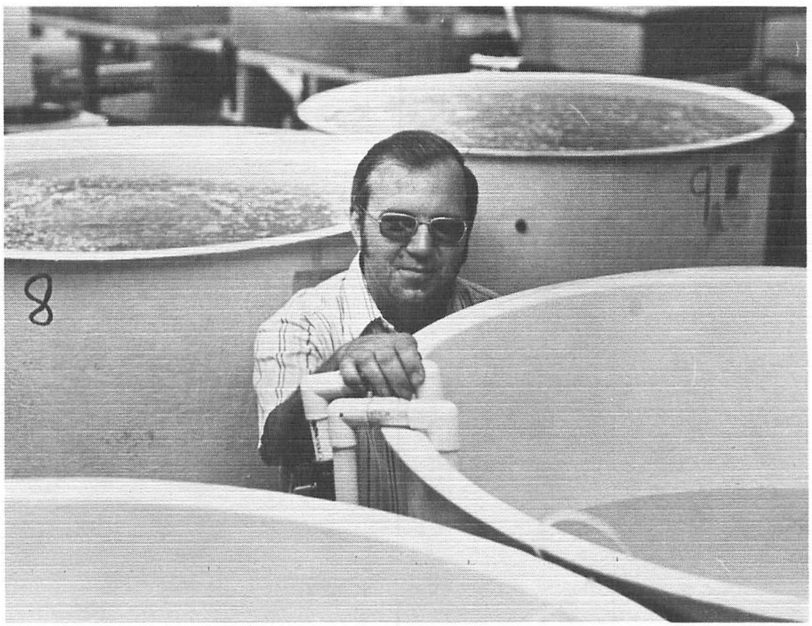
The role of a pilot-scale hatchery, explains Krantz, is to confront and solve problems of food concentration, water salinities, temperatures, cultch materials and planting sizes, while keeping track of all costs. Such data can then be scaled up for construction and operation of production-sized hatcheries—either commercially operated or state-operated hatcheries.

The major problems confronted during the first year of operation, says Krantz, stem from the relatively low salinity of the Chesapeake Bay. Hatcheries in low-salinity areas, he found, can expect longer production schedules, higher flow rates and higher operating costs than previously estimated.

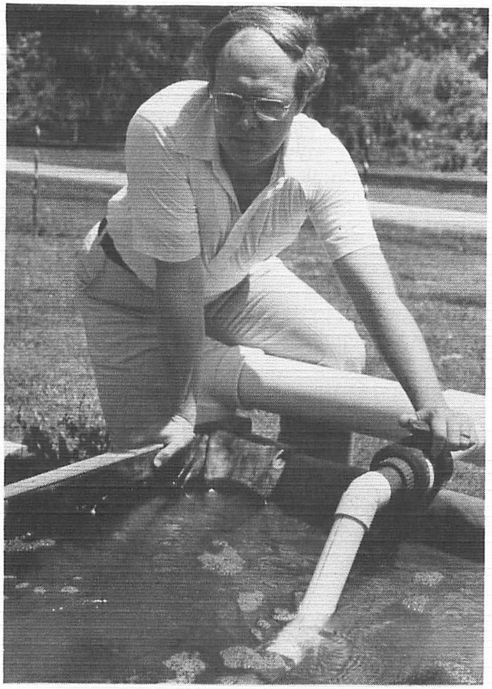
Krantz's work at the Horn Point hatchery over the past year has included:

- the collection of one billion oyster eggs from low-salinity oyster bars;
- the production of 50 to 60 million oyster spat;
- the raising of 7 million spat of plantable size;
- the planting of hatchery-raised spat in test plots in the Choptank, Chester and Little Wicomico Rivers;
- careful observations on the problems of larval growth, larval survival and spat set.

Though he and his associates have encountered formidable problems, Krantz claims the hatchery option could offer a reasonable, workable strategy if developed into large-scale production. "This tactic doesn't replace Mother Nature," he explains, "it just boosts her up during periods of poor spat set. Hatcheries could save the industry during poor years."



The Raceway Option



The major flaw in the oyster hatchery idea is cost. Scientists are confident they can eventually solve the biological and technical problems of raising plantable oysters on land, but hatcheries require large capital investments for buildings, fiberglass tanks and energy-demanding environmental control systems. Economic studies indicate that those investments may prove too expensive for a feasible commercial oyster aquaculture in the Middle Atlantic states.

To reduce those costs, George Krantz and Ken Lomax are developing low-cost, outdoor holding troughs, oyster "raceways" where larvae can set, harden into spat and grow to suitable size for planting in Bay waters. Since outdoor troughs cost out at about $3 per square foot for construction, compared to $54 per square foot for conventional hatcheries with their buildings and tanks, the raceway alternative eliminates much of the large capital investment required for a commercial start-up.

Raceways, of course, carry their own set of biological and technical problems. During the first year of the raceway project, those problems kept Krantz and Lomax busy with tasks such as:

- designing and constructing eight above-ground troughs and eight below-ground troughs;
- installing and testing four types of plastic and rubber lining for efficiency and ease and cost of maintenance;
- experimenting with water flow, aeration, spat densities, spat cleaning and handling;
- identifying technical problems such as heavy siltation, and biological problems such as diatom growth and flatworm infestation in the troughs;
- establishing that hatchery spat raised to 5 mm size can survive siltation and grow in the raceways at the same rates as similar spat can in the hatchery;
- establishing that maximum growth rates require extremely high water flow rates of nearly 10 gallons per minute per 5,000 oysters.

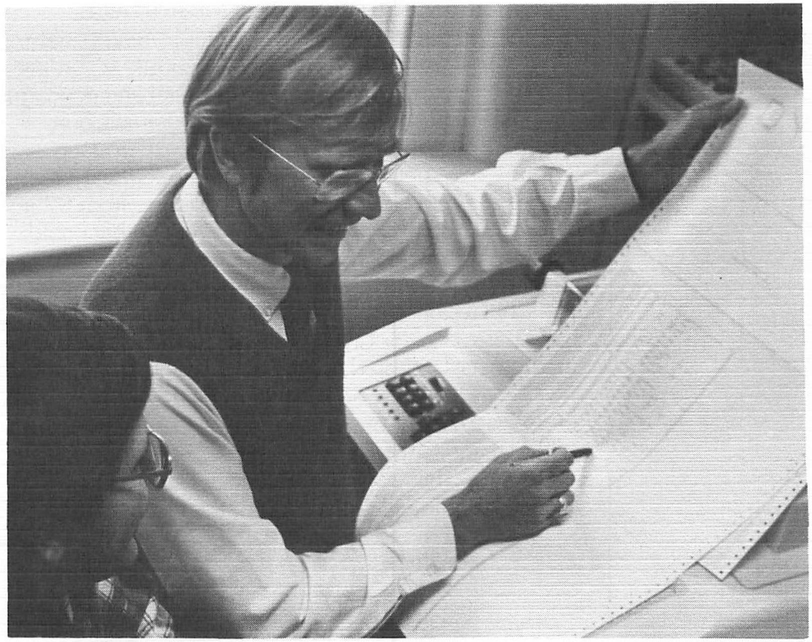
Forecasting the oyster harvest for the coming year has long been a favorite guessing game among Bay-area watermen, seafood distributors and scientists. Working with Sea Grant funds and dozens of mathematical formulas, Bob Ulanowicz and his associates have been trying to take the guesswork out of the game.

He has been developing a mathematical model that should, when completed, generate accurate predictions for the Maryland oyster harvest—not only for the coming season, but also for the next three to four years. Resource managers now make one-year predictions based on preseason surveys of selected oyster bars. The Sea Grant model permits longer forecasts because it includes many more environmental and fishery-related factors, all of them dating back 40 years. The longer predictions should benefit resource managers who must plan seeding, shell planting and catch limit policies. It should also help watermen, processors and distributors who could use the forecasts to make more realistic estimates about potential income and probable expenses for labor and capital.

During the first year of the project, Ulanowicz and his associates, Elgin Dunnington and William Caplins, collected 40 years worth of information on the following variables:

- oyster harvests;
- fishing effort, measured by the number of oyster licenses sold annually;
- spat-set densities, based on annual surveys dating back to 1938;
- salinities;
- water temperatures;
- air temperatures;
- rainfall;
- annual averages, extremes and stress episodes for all environmental variables.

The researchers spent the first eight months of their project collecting information, transferring it to coding forms and typing it into computer storage files, files that will prove valuable to later researchers working on other fishery projects. In all, they located and inserted over 65,000 separate measurements into their computer files.



A Harvest Prediction Model

When he started applying the mathematics, Ulanowicz initially found that a first-order model based on fishery data about harvests, licenses and spat sets proved to be an accurate predictor for the years 1953 to 1970, but not for the years following. Harvests for the 1970's, he found, ran consistently higher than the predictions by the Sea Grant model, a probable result of a state oyster repletion effort that has over the last decade changed the Maryland oyster grounds from a wild fishery to a managed fishery. Those findings sent Ulanowicz and his associates back to work on a second-order model that would incorporate data on management practices such as shell planting, raking and oyster seeding.

Mathematical models, like machines, need considerable fine-tuning before they finally work smoothly.

His current prediction about his own project: work on the second-order model should be finished in time to predict the 1978-1981 harvests well before the first tongboat leaves dock in September.

Oysters, the Court and Economic Change

All state residency laws for all fisheries, including Maryland's oyster fishery, could soon be overturned by the courts, according to a Sea Grant study of the legal and economic implications of last year's Supreme Court decision in *Douglas v. Seacoast Products*.

When the Supreme Court ruled that Virginia could not bar an out-of-state firm from fishing in state waters, it set a precedent that could eventually abolish the Maryland law that currently reserves state oyster grounds for state residents, says Thomas Lewis, an attorney who works for Chesapeake Bay Foundation. Lewis co-authored the study with Ivor Strand, a University of Maryland agricultural economist. Director of the project was Garrett Power of the University of Maryland School of Law.

The Maryland residency law, says Lewis, could fall within a year, the victim of a court suit or the next court trial for out-of-state poaching.

That precedent, say the researchers, puts the whole Maryland oyster industry "in a precarious position." Eliminating the residency law would expose the Maryland oyster beds to out-of-state fishing fleets, encourage short-term overfishing and endanger political support for the current state-subsidized oyster repletion program. To protect the industry, the researchers recommend restructuring the Maryland oyster management program in order to encourage the cultivation of more privately leased oyster beds.

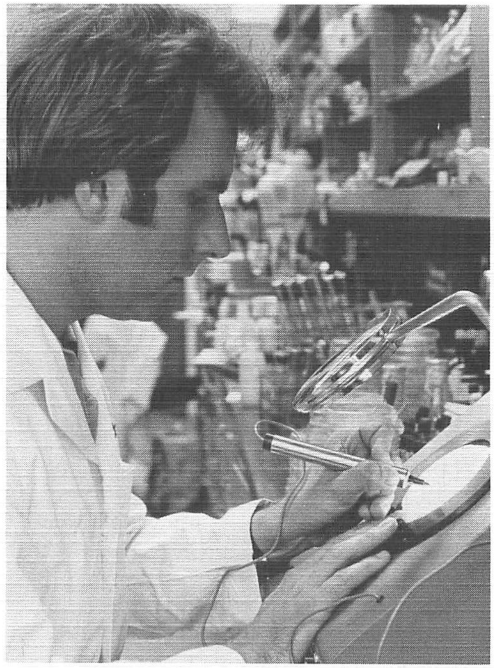
In his legal analysis, Lewis found that the Supreme Court based its decision on the federal boat licensing law, which authorizes vessels licensed by the Coast Guard to fish anywhere for any species, and on the Commerce clause of the U. S. Constitution, which prohibits unreasonable state-created impediments to interstate commerce.

Dropping state residency laws would clearly start an interstate fishing effort, predicts Strand, who analyzed the economic impact of a 1971 court decision banning county residency laws. Strand studied fishing effort, transit costs, prices, profits and oyster landings for three Maryland counties, both before and after the 1971 *Bruce* decision. Watermen, he found, began moving freely from county to county, shifting to areas of greater oyster density and ranging from their home ports, often for weeks at a time.

From those findings, he predicts that interstate fishing would produce a fleet of large fishing boats with living quarters for longer Bay cruises. And that fleet would produce a long-term leveling out of oyster densities around the Chesapeake Bay.

Most of those commercial cruises would head for Maryland waters, Strand says. Public oyster bars in Maryland, he argues, are more productive than those in Virginia, and private oyster leases in Virginia total 100,000 acres, nearly 10 times the number of leased acres in Maryland. Interstate fishing would move north, not south. "It would be," he says, "a one-way street."

The Problem with Water Quality Tests



To guard against typhoid, paratyphoid and dysentery, the classic water-borne diseases, health officials have long used the coliform index, the classic sampling procedure for testing water and seafood products scheduled for human consumption. The index is an indirect test: it samples not for disease agents, but for coliforms, harmless "indicator" organisms. The key assumptions behind the test are two: positive readings imply coliforms; coliforms, in turn, imply disease-causing bacteria.

Those time-worn assumptions may be incorrect, according to findings by Rita Colwell and Brian Austin, two microbiologists working on a Sea Grant study of testing methods currently applied to the water, sediment and oyster beds of the Chesapeake Bay.

They discovered that many other bacteria typical to the Bay can also cause positive coliform counts. That finding supports a widely held hunch that traditional water quality tests need to be re-evaluated. A positive reading on a coliform test may not indicate a health hazard, say the microbiologists, and a negative reading may not imply healthy conditions.

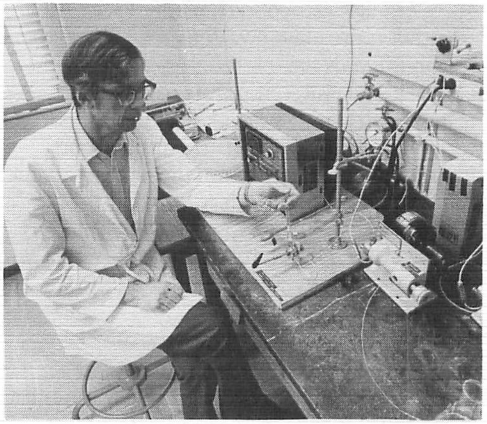
The Coliform Index—also called the Most Probable Number technique—uses a series of tubes filled with a lactose sugar broth previously sterilized. The microbiologists inoculate that lactose broth with water samples, incubate the broth at body temperatures—about 35°C—for two days and then look for detectable gas and acid. Production of gas and acid from lactose is usually interpreted as a positive result.

That result, however, may not indicate the presence of coliforms. After extensive subculturing of "positive" samples and painstaking taxonomic analyses, Colwell and Austin found that bacteria such as *Pseudomonas* and *Aeromonas* were contributing to those positive readings. As many as 25 per cent of the samples examined, in fact, contained bacteria native to Bay waters.

What causes a positive result, says Austin, are bacteria with the ability to ferment lactose in the test broth. Some harmless bacteria, it is now clear, possess that ability and others may be able to acquire it via plasmids—pieces of extracellular DNA that can be passed among and picked up by a variety of bacterial species.

The Colwell-Austin project also had other goals and other findings. After collecting and and analyzing water, sediment and oysters at monthly intervals from four locations in the upper Chesapeake the researchers have:

- evaluated the coliform index and identified sources of error;
- established that extra-chromosomal elements were responsible for lactose-fermenting abilities in *Pseudomonas aeruginosa;*
- named a wide range of *Enterobacteriaceae* that occur in oysters, sediment and water;
- discovered that oyster bacteria resemble sediment bacteria more closely than they resemble water bacteria;
- found no seasonal variations in coliform counts in oysters.



Monitoring Petroleum Pollution

Petroleum is a liquid solution of numerous hydrocarbons. When distilled, it yields such essentials as natural gas, gasoline, kerosene, diesel fuel, heating oils and even the primary makings of asphalt.

When spilled in water, petroleum compounds begin to break apart, with some hydrocarbons evaporating rather quickly and others being metabolized more slowly by microorganisms. A special class of hydrocarbons—a class called polycylic aromatic hydrocarbons—does not readily yield either to evaporation or microbial degradation. As a result polycyclic aromatic hydrocarbons—PAH's—often end up at the bottom of harbors, rivers and estuaries.

PAH's could cause special problems for the oyster industry, since they build up over time, in the sediment, where they could eventually be taken up by bottom-dwellers like oysters. Laboratory tests on animal species show that some PAH's can cause cancer.

PAH's cause special problems for researchers also. Not much is known about PAH's in the natural environment because scientists lacked techniques for extracting and separating the hydrocarbons found in water, sediment or animal tissue. Working with water, oyster tissue and stiff, black, bad-smelling sediment from the Colgate Creek section of Baltimore Harbor, Howard DeVoe, a chemist, has been adapting high-pressure liquid chromatography to the problem of extracting and measuring PAH levels, and Mary Voll, a microbiologist, has been adapting the Ames test—a standard bacterial assay for detecting carcinogens—to the study of PAH extracts.

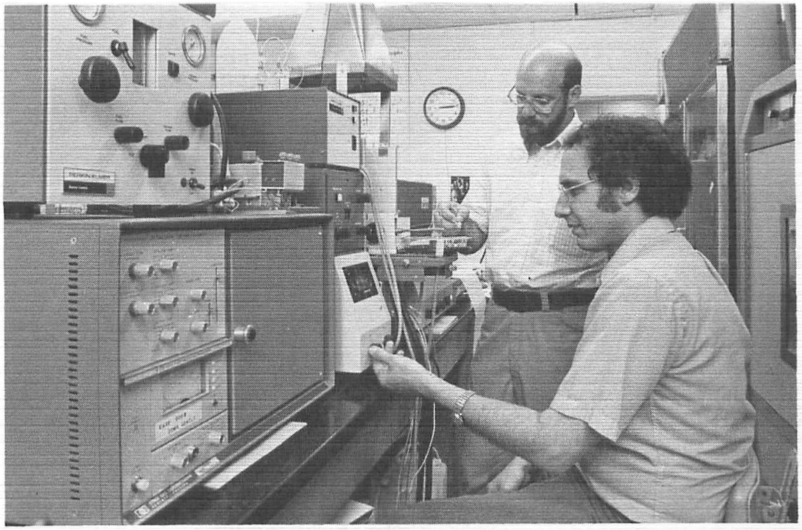
Since most carcinogens cause mutations, the Ames procedure is used to test for carcinogens by measuring the ability of compounds to induce mutations in bacteria. If PAH's extracted from Baltimore Harbor do cause bacterial mutations, the chances are high they could be cancer-inducting agents.

In their research to date, the chemist and the microbiologist have:

- extracted and tentatively identified several four-ring hydrocarbon compounds, including benzo (a) pyrene, a known carcinogen;
- measured extracted PAH levels at over 200 parts per billion;
- found material in Baltimore Harbor which induces mutations as indicated by the Ames test.

Those findings show "nothing alarming," Voll stresses. The harbor floor, heavily enriched by hydrocarbons, is not a typical Bay environment. What would be cause for concern, she explains, *would* be a massive dredging of harbor sediment and the dumping of spoil containing PAH's in other, more biologically productive areas.

The Tracking of Trace Metals



Heavy industry means jobs and paychecks and food on the table for hundreds of thousands of people in the Chesapeake Bay area.

Heavy industry also means heavy metals in the waters of the world's largest tidal estuary, metals like mercury, tin and arsenic. Add to that mixture metals entering from other sources—lead from automobile exhausts, cadmium from brake linings, tin from antifouling paints—and the result is an interlinked economic and environmental problem.

In an estuary, heavy metals may undergo chemical and microbial transformations that help them penetrate the seafood chain at several levels. Trace metals often enter the food chain at the microbial level and then work their way up through the links, moving through bacteria, phytoplankton, zooplankton and fish larvae, sometimes invading the blood and tissue of oysters and crabs and finfish. In large concentrations, trace metals are probably toxic.

Since the links in that food chain are many and tangled, understanding *how* metals move along the chain still calls for a lot of complicated guesswork. Chemist J. M. Bellama spent the first year of his Sea Grant project studying the interactions of metals and microbes, trying to clarify the means by which microorganisms transform tin and mercury into organometal compounds and trying to identify the role of those compounds in the estuarine ecology.

The transformation of metals often starts with microorganisms. Some microbial species incorporate metals into their cell structures, while others act as agents, outgassing organometal compounds that can be taken up chemically by phytoplankton or biologically by shellfish and finfish. In some cases, a synergistic effect can speed the transformation. After microorganisms convert tin into a methyltin species, that organometal species can in turn chemically convert nearby mercury into methylmercury compounds.

"These organometals are dangerous," says Bellama. "They are soluble, both in blood and in lipids. They can pass the blood-brain barrier and the placental barrier." It was an organometal compound that afflicted so many Japanese in the fishing village of Minimata, causing a variety of nervous disorders and many fatalities.

In his first year of work, Bellama has:

- collected and analyzed samples from Baltimore Harbor, Eastern Bay and the mouth of the Chester River;
- identified some of the microbial strains capable of transforming mercury and tin into organometal compounds;
- measured transformation rates.

Bellama's short-range goal is to work out the microbiology and chemistry of metal transformation. His long-range aim is to control the process enough to develop a commercially feasible system for removing trace metals from waste materials such as sewage sludge.

Some microbial and chemical processes, says Bellama, can volatilize metals, making possible a gasification recovery of valuable metals. "It looks like an engineering problem to me," says Bellama. "You have to design the proper means to get the stuff out in large enough quantities and yields. But the basic chemical phenomenon is there."

A Clean Bill of Health

Microbiologist Frank Hetrick and faculty research assistant Nancy Lomax spent the first year of their Sea Grant project looking for evidence of oysters contaminated by enteroviruses—viruses that can cause intestinal infections in humans.

After careful study of oysters taken from 14 oyster bars, they are ready to give Maryland oysters at least a temporary clean bill of health.

Hetrick and Lomax began their project by searching for an accurate method for testing Chesapeake Bay oysters. Working with sample oysters seeded with known viruses, they tested several available laboratory techniques in order to choose one with a documented ability to detect viruses in shellfish tissue.

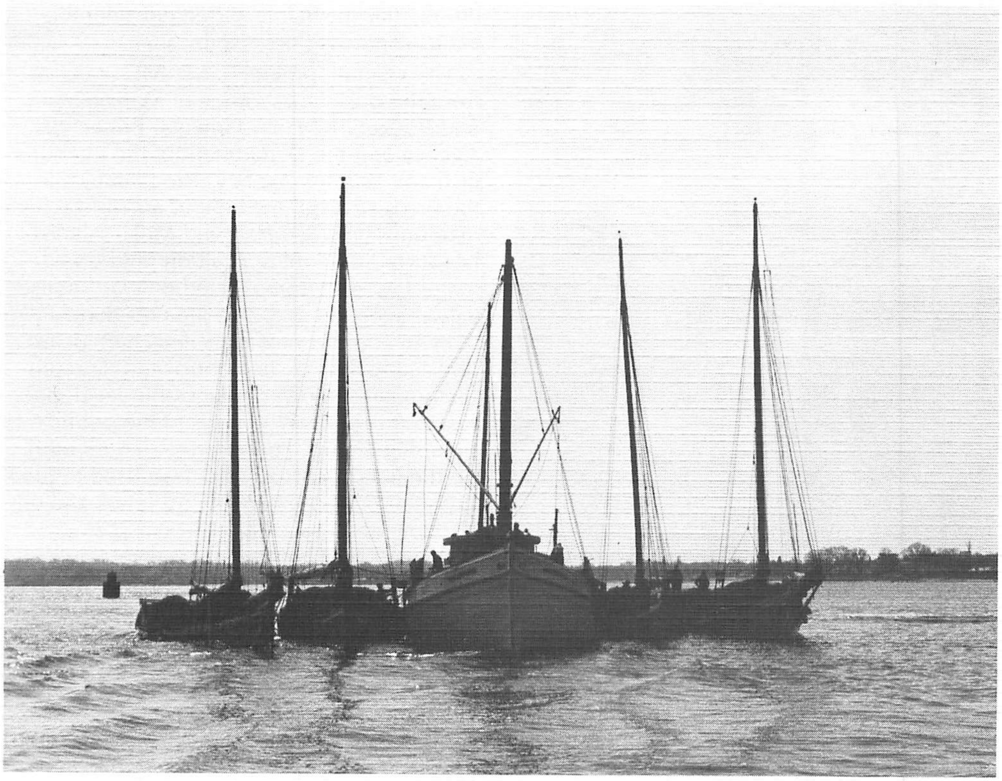
They next collected oysters from 11 commercially harvested bars and from three bars closed by the Health Department because of nearby outfalls from sewage treatment plants. Then they applied their laboratory test to the Chesapeake oyster.

Their findings:

- The technique developed by M. Sobsey of the University of Houston proved an effective test, identifying 60 to 65 per cent of the known enteroviruses seeded into the sample oysters.
- The Sobsey technique revealed no enteroviruses in the Bay test oysters collected from either clean or polluted bars.

"There does not seem to be a problem of enterovirus contamination in commercially harvested oysters from the Maryland portion of the Chesapeake Bay at the present time," concludes Hetrick, summing up findings important to consumers, shellfish distributors and public health officials.

The researchers have also begun work developing a molluscan tissue cell line that could assist significantly in studying how viruses interact with oysters. Scientists already know that shellfish can carry viruses, including those related to blood-borne diseases like hepatitis. The new cell line would help scientists find out whether other viruses could also infect oysters and those who harvest, process and eat them.



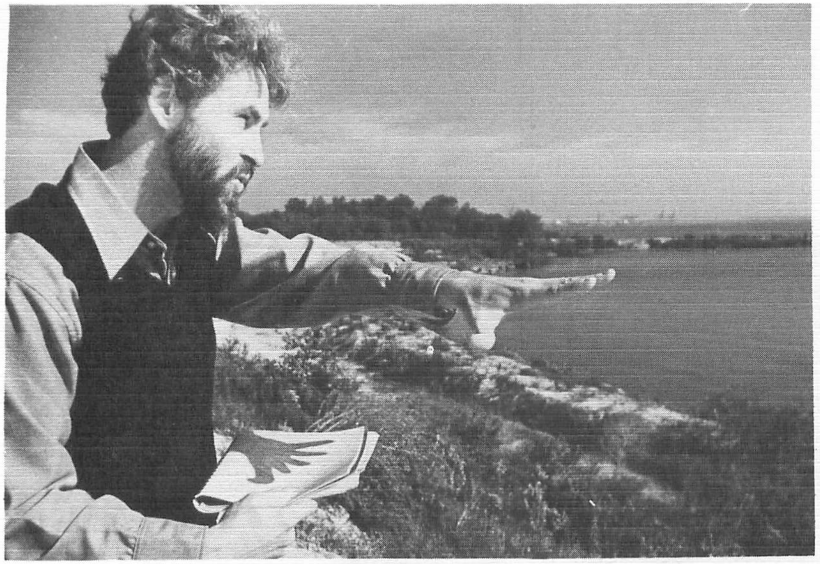
Looking Ahead

There are good reasons to think the current oyster crisis is solvable.

Scientists and resource managers now know more about oysters than ever before. They know ways in which humans can gently but effectively prod the Bay's natural cycles. Out of the Sea Grant projects now underway—out of studies of seed bars and sex ratios and hatcheries—should come techniques for restarting the natural oyster reproduction cycle in the Bay or perhaps for replacing it with a land-born system.

The best reasons for optimism, however, come from the rich productivity and the strong recuperative powers of a large tidal estuary like the Chesapeake. The Bay, despite depradations by humans and hurricanes, remains an ideal oyster growing ground. It has temperatures, tidal circulations and salinity levels that help spawning and growth. It has shallow waters that help sunlight work on bacteria, plankton and bottom plants to build rich food chains.

The Bay is richly right for oysters, in fact, that biologists have been predicting for decades that the potential oyster harvest of Maryland is not 2.5 million bushels or five million or even double that. They say improvements like stabilized water quality, careful cultivation and widespread leasing could eventually reverse the harvest's historical decline. Maryland watermen could one day be hauling home harvests well above the best years of the last century, well above those 15-million bushel years that first made the Chesapeake the world's greatest oyster farm.



Reviewing the Ship Channel Plan

Since 1966, several federal and state agencies have been developing a proposal to deepen the ship channel leading from Baltimore Harbor to the mouth of the Chesapeake Bay. Redredging 53 miles of that channel from 42 feet to a new depth of 50 feet could make the Port of Baltimore reachable by deep-draft vessels carrying in bulk cargos of iron ore and oil and hauling out coal.

These bulk cargos could bring new jobs for Maryland residents, more taxes for state and local communities and greater profits for several local industries, primarily Bethlehem Steel, Exxon Corporation, the Baltimore and Ohio Railroad and the Canton Railroad Company.

Balanced against these benefits are certain costs: a mountain of sediment spoil dredged off the bottom of Baltimore Harbor and the Chesapeake Bay; a variety of possible environmental effects on fish, wildlife and recreational boating; a price tag of $126 million federal dollars for dredging the channel; and a charge of $46 million in state dollars for hauling away that mountain of dredge and depositing it somewhere else.

Planning for such a massive, Bay-altering project has inevitably stirred considerable controversy over the last decade.

The channel project has drawn criticism from the president's Office of Management and Budget, the Environmental Protection Agency and the Department of the Interior's Fish and Wildlife Agency. The plan to pile the dredged sediment behind an 18-foot high dike built between Hart and Miller islands has stirred outright opposition (and one major law suit) from elected officials, conservation agencies and dike-area residents.

In an effort to provide a detached, disinterested review of the controversy, law professor Garrett Power organized a legal, political and economic analysis of the public planning record. Power's research focused on the two major analytic tools used to justify such projects: benefit/cost ratios and environmental impact statements.

Power's analysis dug out several flaws in the benefit/cost ratios favored by the Corps of Engineers. Their ratios, though effective for choosing among competing projects or designs, relied heavily on past trends which could prove unreliable predictors of future economic benefits.

Similar flaws appear in the environmental impact statements filed for the dredge dike proposed for Hart and Miller islands. Though the Corps considered over 70 alternatives, says Power, it provided no up-to-date cost estimates, eliminating any rational basis for choosing the Hart-Miller plan.

To rationalize federal investments in the absence of the profit-and-loss accounting found in private business, Power offers two major recommendations: "Engage in better analytical exercises, better benefit/cost ratios and environmental impact statements. And create a system whereby the users share the cost of the project." Such user charges, he claims, should ensure better analyses. When beneficiaries such as Bethlehem Steel and Exxon have to make their own hard-nosed benefit/cost projections, their decisions could help ensure that such massive water projects do, in fact, promote national economic efficiency.

During its first year, the University of Maryland Sea Grant Program began carrying out its educational mission in two ways: by developing a university-wide graduate program in Marine, Estuarine and Environmental Sciences; and by providing several Sea Grant Trainees with practical research experience.

Called the MEES program, the degree concentration in Marine, Estuarine and Environmental Sciences will provide specialized study for graduate students in a variety of marine-related disciplines. Most of the students entering the program will come prepared with course work in one or more of the following "core" areas:

- ecology and/or physiology courses in botany, microbiology and zoology;
- physics, biochemistry, chemistry, engineering or geological sciences;
- economics, resource development, systems analyses, biology and management of natural resources.

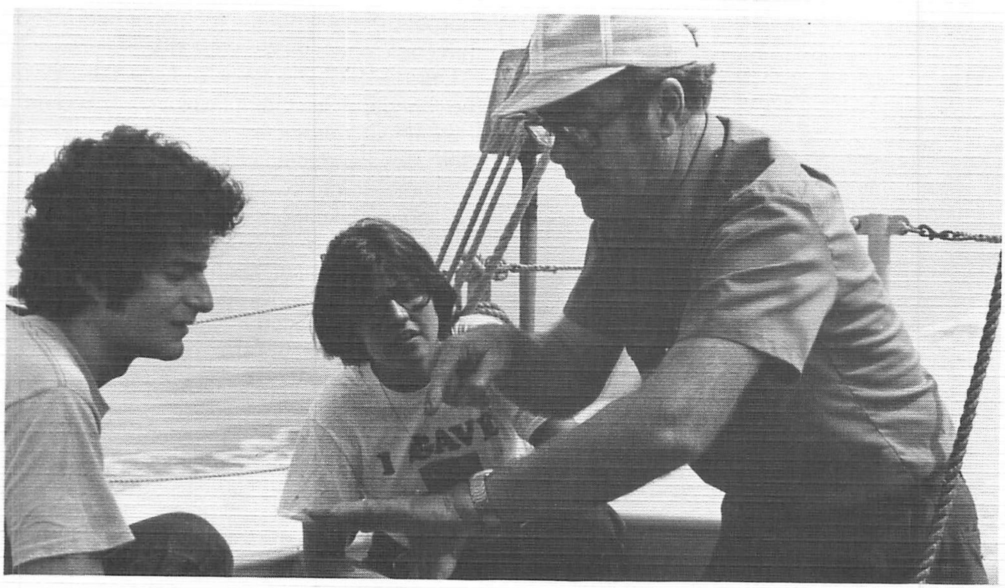
While the MEES program was being developed, a select number of graduate students were already functioning as the university's first Sea Grant Trainees.

David Hussong, for example, worked with Dr. Rita R. Colwell and Dr. Brian Austin, the principal investigators who identified sources of errors in coliform counts, the traditional test for water quality used by public health officials.

Ed Stephens helped Dr. Frank Hetrick and Dr. Nancy Lomax with the painstaking laboratory work that should produce a tissue cell-line useful for studying viral infections among oysters. Under the direction of Dr. Mary Voll, Don Burstyn and John Newland helped develop bacterial assays for identifying possible carcinogens among polycyclic aromatic hydrocarbons (PAH's) extracted from Chesapeake Bay sediment.

A graduate student in agricultural resource economics, David Swartz, developed unusual data documenting the ways in which new coverage of Kepone pollution problems in the lower Chesapeake Bay affected demand for oysters in the Baltimore Market.

In each case, by choosing and completing a portion of a Sea Grant project, a graduate student was able to perform a research thesis towards a masters or doctorate, while simultaneously acquiring practical experience.



Education

Marine Advisory Services

The job of the Marine Advisory Agent and the Marine Advisory Specialist is to get research information out of the University laboratories and scientific journals and into the hands of those who can use it in their daily work, be they deckhands, boat-owners, seafood processors or aquaculture entrepreneurs. Sea Grant founders saw the Marine Advisory Agent as a counterpart to the Agricultural Extension Agent, a kind of "county agent in hipboots."

When the first agent and specialist came to work for the Maryland Sea Grant Program, they didn't need hipboots; they needed calculators. Local watermen and seafood processors had already gone on record asking for help in becoming more efficient businessmen. Most Maryland watermen—boat owners and deckhands—are self-employed contractors, and they wanted practical information on tax filing and business management first, followed by technical information on boat engineering, basic Bay-related biology and interpretation of fishery regulations.

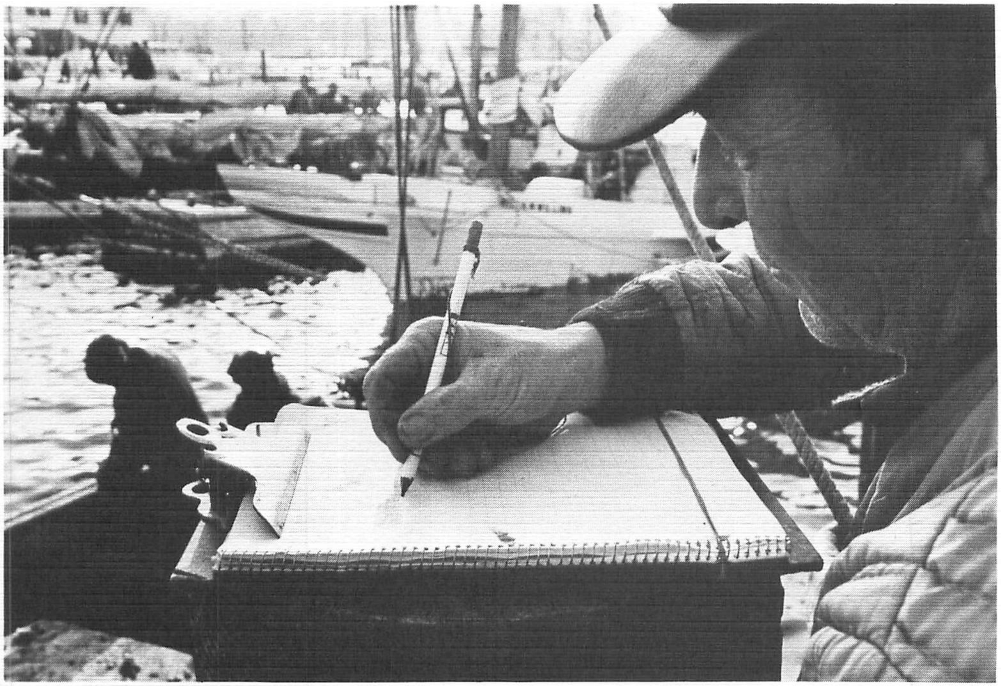
When Don Webster was hired as the first Marine Advisory Agent, he started helping watermen wade through paperwork. He developed a traveling tax-advising workshop and held "how-to-do-it sessions" in Bayshore fishing towns to explain the intricacies of reporting forms, withholding taxes, social security payments, federal and state unemployment taxes.

When Norm Bender came to work as the first Maryland Marine Advisory Specialist, he and Webster helped the Internal Revenue Service to develop a *Tax Guide for Commercial Fishermen*. They also researched and wrote *The Watermen's Record-Keeping Manual* and published *The Watermen's Record Book*. Based on current principles of practical business management, both the *Manual* and the *Book* have a simple goal: to show watermen how better management means more money at the end of the year.

In the Sea Grant scheme, agents and specialists do more than bring research to the marine work force; they also bring news back to the researcher about the current problems facing Bay-related businesses. The advisory agent works the boats and docks and processing plants, trying to find out what kind of luck and problems watermen are running into. The advisory specialist works the laboratories and journals, digging out the technical information that could solve those problems.

During 1977, the agent and specialist for the Maryland Sea Grant Program worked on the following projects:

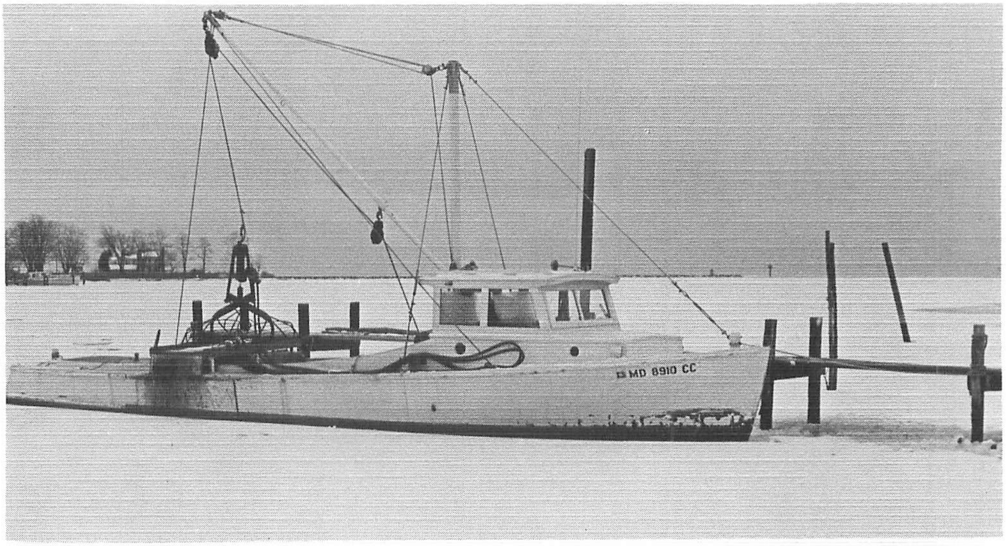
- They conducted workshops and presentations at local watermen's and charter boat associations for over 550 watermen and their wives. Major topics included record-keeping, tax management, and application procedures for special government-assisted loan programs designed for commercial fishermen interested in building new boats, or adding new equipment to their current vessels.
- They updated the *Watermen's Record-Keeping Manual* to reflect new rulings on tax reporting procedures for boat captains and contracted deckhands.
- They helped the Internal Revenue Service revise *The Tax Guide for Commercial*



Watermen, and distributed over 2,000 copies to Maryland watermen through workshops, post offices, general stores, and dockside contacts.

- When winter of 1977 iced up most of the state's oystering grounds and threw thousands of watermen out of work, the Marine Advisory Program provided leadership for a federal emergency relief program by helping over 100 families apply for long-term low-interest loans totaling over $267,000.
- The Marine Advisory Specialist developed and wrote a series of Marine Fact Sheets covering financial aid programs, credit unions, loan procedures, tax law changes and retirement plans.
- The agent and specialist undertook development of materials for publications and workshops on marine electrical and hydraulic systems in response to requests for information on boat engineering.

Special Projects



The B.I.T.E. Survey

When the winter of 1977 — the third worst Baywinter of the century — iced up most of the northern Chesapeake, scientists from the University of Maryland's Horn Point Environmental Laboratory organized a winter damage survey. Faced with an immediate environmental crisis, the Maryland Sea Grant Program responded within days with funds to pay for research boat time and to publish the final report.

Under the leadership of George Krantz, researchers from Project BITE — for Bay Ice Team Effort — traveled more than 900 nautical miles and sampled oysters, crabs, clams and finfish at more than 280 sites around the Bay. By surveying all commercially harvested life forms in and around the Chesapeake, the BITE researchers were able to generate rare data on how a harsh winter affects a large estuary.

Here's what they found:

- The ice-up hit the blue-crab harder than any other commercial fishery. Nearly half the crabs sampled had died.
- Oysters — though weak and watery — suffered no major damage, except in shallow waters where they froze in the ice or starved for oxygen.
- Finfish turned up in smaller numbers than usual for winter, with a high percentage already dead.
- Both soft-shelled and hard-shelled clams survived well, but the rangia clam — a recent arrival from southern waters — virtually disappeared.
- Racoons, otters and muskrat survived at their normal rates, but nutria — rodents recently imported from the south for their pelts — turned up dead in much higher numbers than normal.

A Water-Quality Auto-Analyzer

The Maryland Sea Grant Program purchased a water quality auto-analyzer that is currently being used for studies on nutrient loading in the Chesapeake and its major tributaries. Phosphorous and nitrogen, two widely used agricultural fertilizers, may be washing into the Bay in large quantities and affecting biological activity in the estuary.

By installing the auto-analyzer at the Chesapeake Biological Laboratory, home of the university's research fleet, the Sea Grant Program has made a valuable piece of equipment conveniently available for a variety of water chemistry studies.

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Budget Summary
Expenditures by Activity

This summary is only approximate. In accordance with Federal grant requirements, the official financial report will be submitted by the office of sponsored programs, University of Maryland.

			NOAA Grant Funds	*University Matching Funds*
Marine Resources Development	**Aquaculture:**			
		Aquaculture-Mollusks	$33,000	$32,300
	Living Resources other than Aquaculture:			
		Commercial Fisheries-Biology	63,000	19,900
		Pathology of Marine Organisms	69,300	12,000
Marine Technology Research and Development	**Marine Law and Socio-Economics:**			
		Ocean Law-Coastal	44,200	7,100
	Ocean Engineering:			
		Engineering-Aquaculture	22,000	4,100
Marine Environmental Research	**Resources Recovery and Utilization:**			
		Man-in-the-sea—mapping strategy	12,650	3,700
	Pollution Studies:			
		Pollution—Oil Spills	26,300	4,000
		Pollution—Metals	18,000	–0–
		Viruses	25,100	2,400
Advisory Services	**Extension Programs:**			
		Extension Agent Services	55,000	15,800
	Other Advisory Services:			
		Advisory Services—Other	55,000	15,800
Program Management and Development	**Program Administration**			
		Program Planning	–0–	60,000
		Program Administration	–0–	60,000
		Program Logistic Support	–0–	65,500
	Program Development:			
		New Applications Development	30,200	–0–
		TOTAL	$453,850	$303,200

Publications

Marine Advisory Reports

The Waterman's Recordkeeping Manual, MEP 304

The Waterman's Record Book, MEP 305

Financial Assistance for Watermen, Norm Bender, FS 222

Developing a Watermen's Credit Union, Norm Bender, FS 224

Applying for a Fishing Loan, Norm Bender, FS 225

Tax Law Changes Affect Fishing Industry, Norm Bender, FS 226

Retirement Plans: Preparing for the Future, Norm Bender, FS 227

Fishery Cooperatives, Norm Bender, FS 228

Budgeting in a Marine Business, FS 231

Hydraulics in Commercial Fishing, Harry James, Bulletin 257

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BELLEMA, J. M. Biotic and Mobilization of Trace Metals to Facilitate Waste Recovery and Utilization. (R/W-2)

COLWELL, R. R. Microbiological Studies of Chesapeake Bay Shellfish. (R/I-1)

DEVOE, H. J. and M. J. VOLL. Polycyclic Aromatic Hydrocarbons in Chesapeake Bay. Development and Use of a System for Monitoring Levels in Water, Sediments and Shellfish and for Estimating Potential Hazards. (R/I-4)

HETRICK, F. M. Monitoring Shellfish from the Chesapeake Bay for Enteroviruses of Human Origin. (R/I-2)

KENNEDY, V. S. Comparative Studies of Reproductively Successful and Unsuccessful Oyster Bars and of Exploratory Techniques to Improve Spat Set on Natural Oyster Bars. (R/F-2)

KRANTZ, G. E. and K. M. LOMAX. Development of Low-Cost Oyster Spat Growout System. (R/F-4)

KRANTZ, G. E. Comparative Studies of Production Costs and Planting Success of Cultched and Cultchless Oyster Spat. (R/F-5)

POWER, G. Alternative Strategies for Shellfish Management. (R/F-6)

POWER, G. Legal Aspects of the Recovery and Reutilization of Trace Metals. (R/W-3)

ULANOWICZ, R. Improved Prediction of Harvest, Including Historical Analysis and Development of Predictor Models. (R/F-1)

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Maryland Sea Grant, bimonthly newsletter, Vol. 1, nos. 1-6

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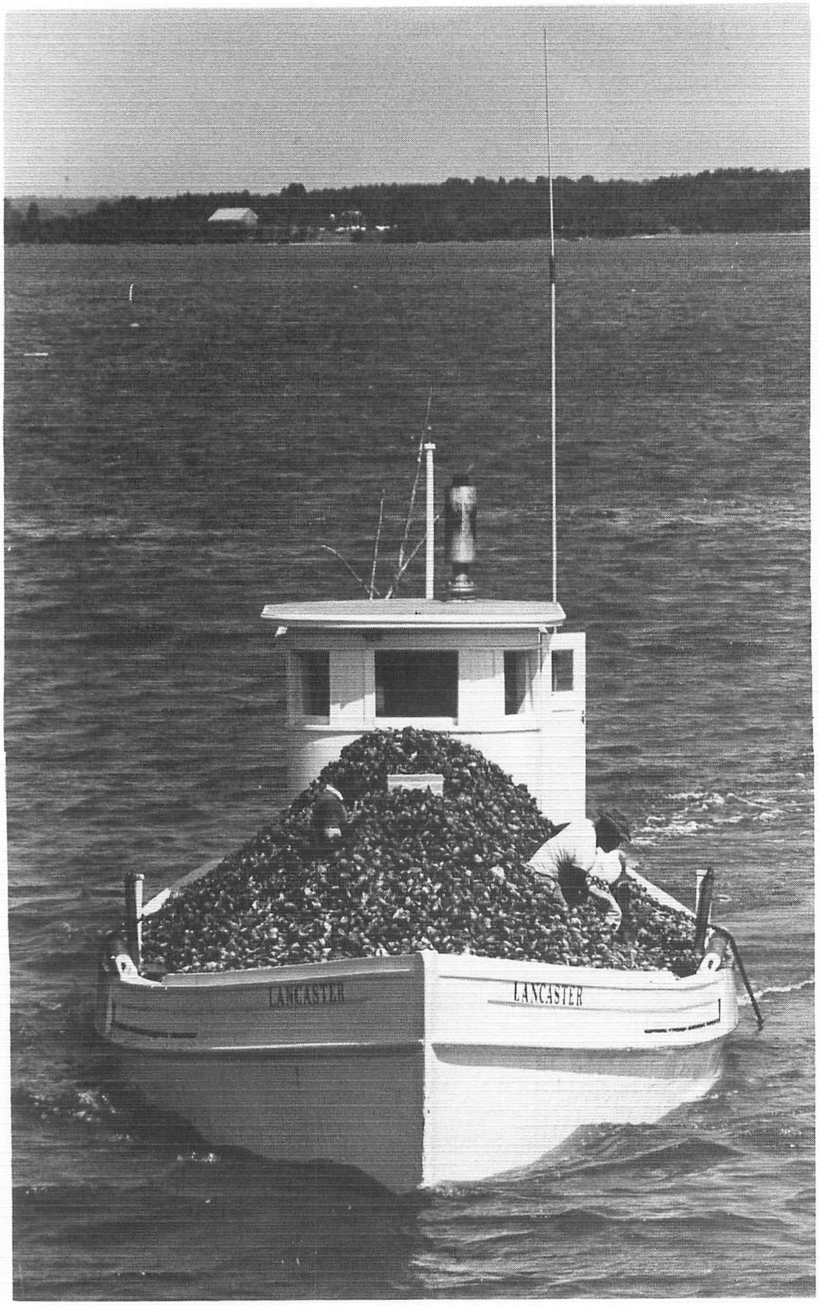

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