MDU-Q-82-001

Sea Grant
IN MARYLAND

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Table of Contents

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Since early natives first pulled oysters and fish from its shallow waters, the Chesapeake Bay has proven a faithful provider. We have looked to the Bay, the nation's largest estuary, for food, for transportation, for recreation, for solace. Now we must look to ourselves to take on the growing responsibility of managing this major resource.

In Maryland, the Bay's worth is well known, most notably for finfish and shellfish—and especially for the oyster, valued at over $20 million a year in dockside sales alone. Thousands of harvesters, processors and retailers depend on the Bay-related economy which has evolved around this watershed.

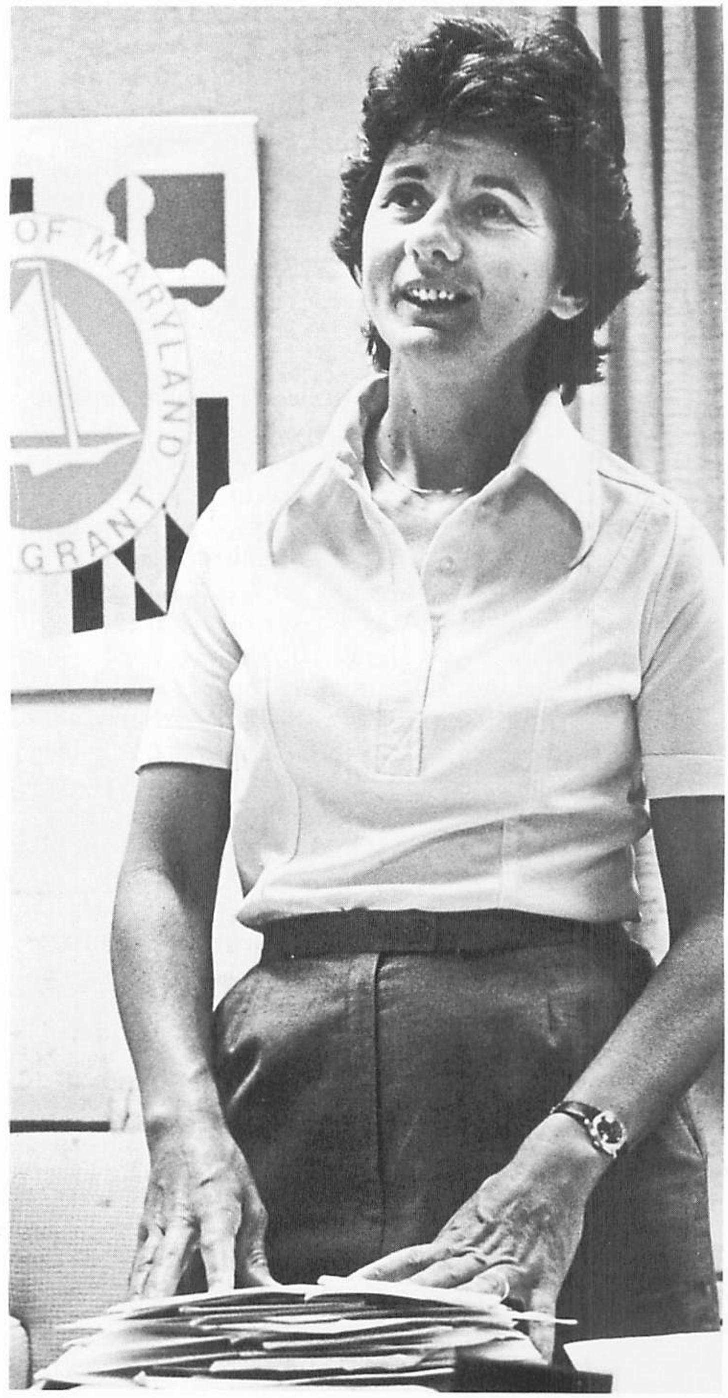
And the Bay's presence reaches far beyond Maryland. As many as ninety percent of the striped bass, for example, which traditionally flourish off the New England coast, spawn in the Chesapeake. Other species, like the American shad, also count on the Bay as nursery and spawning ground; and when the biological cycles which nurture these species shift or falter, the effects reverberate up and down the Atlantic coast, from New York's Fulton Market to fishing boats that sail out of the region's major fishing ports.

Yet the 2,200 square miles of the Chesapeake Bay must play other roles as well. Each year the Bay receives 400 million gallons of sewage and some 2,000 tons of metals and synthetic compounds. Agricultural, urban and suburban runoff dumps sediments, fertilizers and herbicides into the Bay's estuarine waters. More than 160 million tons of cargo pass through its channels, and enough Bay water passes through a single nuclear power plant to constitute the equivalent of the estuary's fourth largest river.

Of course stresses on the Bay are not new. Ever since the first colonists began clearing the land, the estuary has seen increases in turbidity and felt the pressures of man's agriculture and habitation. What *is* new is the escalation of many pressures by orders of magnitude and on such a scale that choruses of worry are rising from those who monitor the Bay's condition and work for its protection.

The growing Bay population, which now numbers around 8 million, is expected to double in less than 40 years. Thus, for the immediate future, the Bay will be subjected to increased waste disposal and chlorination; greater influxes of industrial chemicals and heavy metals like copper, lead, zinc and cadmium; burgeoning recreational use; and more agricultural run-off in the form of fertilizers which—along with other nutrients—can over-nourish the Bay and can choke some of the estuary's important species.

To make clear what threats beset the Bay and to foster new opportunities presented by wise management, improved technology and new developments, the Maryland Sea Grant Program supports research



Dr. Rita R. Colwell, Director
Maryland Sea Grant College Program

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and education in the biological, physical and social sciençes: in aquaculture and oyster biology, in hydrology and ecology, in seafood technology and the economics of marine businesses.

Maryland Sea Grant, a comprehensive program at the University of Maryland since 1977, forms part of a national network established by Congress in 1966. Through that network, colleges, institutes and universities join with state and federal agencies to help develop the nation's marine resources and to encourage wise and efficient use of our lakes, rivers, estuaries and oceans.

The National Sea Grant College Program, operating under the auspices of the Department of Commerce and the National Oceanic and Atmospheric Administration, works across the country in such areas as aquaculture, fish diseases and genetics in order to increase both yields and quality of seafood. It focuses on marine engineering and technology to improve man's ability to harvest seafood and mine minerals from the ocean floor. Through courses, scholarships and in-service training, Sea Grant helps to educate the next generation of technicians and researchers in marine-related industries and disciplines. Sea Grant — especially through its marine advisory services — also helps improve the technical skills of those already working in industry and helps increase public awareness about the value of marine and estuarine resources.

For Maryland, the Sea Grant effort has meant an improved understanding of oysters, crabs and finfish. It has meant a clearer picture of how herbicides and heavy metals interact with estuarine waters. It has meant a better definition of long-range cycles and their effects on the Chesapeake Bay's major commercial species. In the following pages you will gain a glimpse of that effort.

Such work lays the foundations for taking advantage of the Bay's shifting profile. Employing new developments in bioengineering and aquaculture and new understanding of animal behavior and estuarine processes, Maryland Sea Grant is helping to turn the Bay's natural resilience and fertility to new opportunities for the 1980s and beyond.

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Because of Maryland Sea Grant's excellence in marine research and education, Secretary of Commerce Malcolm Baldrige in 1982 named the University of Maryland a Sea Grant College. With this distinction, Maryland became the nation's seventeenth Sea Grant College, a position indicative of the University's commitment to Sea Grant's mission: wise development of the nation's lakes, rivers, oceans and estuaries.

Dr. Rita R. Colwell, *Director*
Maryland Sea Grant College Program

CULLING MARYLAND'S OYSTERS

A joint state-university study takes a long look at Maryland's oyster fishery.

In the winter season of 1882, Maryland watermen hauled out of the Chesapeake Bay an oyster harvest of more than 12 million bushels.

Most of them sailed on two-masted schooners and bugeyes and pungys, and for a decade they sent to the packing houses a bounty that outweighed all the beef raised on all the cattle farms of Maryland, Virginia and Delaware.

Those great seasons are smaller now. In the winter of 1982, oystermen worked those same brown-green waters for a state-wide harvest of 2.2 million bushels.

What happened to those huge harvests of a hundred years ago?

Overfishing.

Poor conservation.

Political interference with efforts to manage the fishery.

According to a recent Sea Grant study, those are the forces that broke the back of the oyster boom of the late 19th century.

What can be done to raise future harvests above current levels? Quite a bit, according to biologists Vic Kennedy and Linda Breisch, co-authors of *Maryland's Oysters: Research and Management,* a two-year, 286-page study of the history, science and management of the fishery. Kennedy and Breisch reviewed hundreds of journal articles, technical reports, fishery records, annual summaries and accounts of administrative and legal proceedings. Their report, cosponsored by the state's Tidewater Fisheries Administration, will help guide future research and management work on developing the potential of the state's most valuable and controversial fishery. The current harvest—still the largest oyster catch in the country—brought in $20 million in dockside sales, helping to support more than 4,000 licensed watermen and creating another $60 million for the state's economy through processing, packing, shipping and sales.

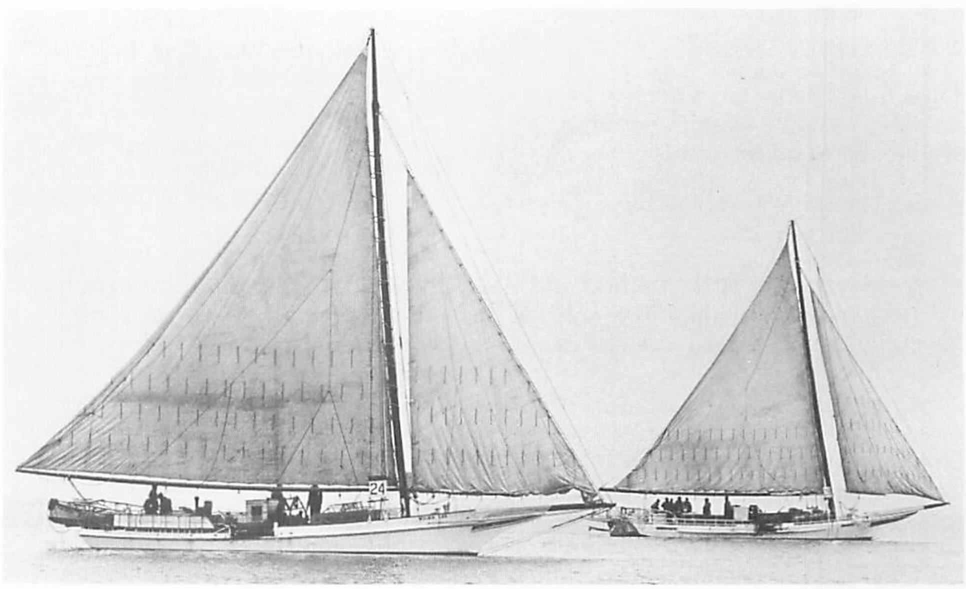
To raise these harvests, Kennedy recommends continuing or increasing management practices such as:

- enforcing a cull law that returns young oyster spat to the bottom;
- replanting the bottom with shucked shell, much of which now leaves the state for processing in Virginia;
- protecting the best growing and setting grounds as seed areas;
- identifying the location and abundance of the best brood oysters;
- encouraging private oyster farming.

According to his review, most of these management practices—all controversial when first proposed—helped keep the fishery profitable for over half a century of diminished harvests and could now help increase production. The American oyster in the Chesapeake Bay, despite early decades of overfishing, remains a resilient species, he says. And the estuary, despite recent decades of increasing pollution, retains many large, still-fertile oyster grounds.

The overfishing that caused the shrunken harvests of this century began during the post-war prosperity of the 1870's. As railroads and refrigerated cars opened new markets, the demand for oysters soon outraced the supply, pumping up prices and profits, turning Bayshore villages into boomtowns and sparking battles between tongers and dredgers, Marylanders and Virginians, oystermen and the Oyster Police. In the midst of the boom—harvests hit 14 million bushels in 1875, 15 million in 1885—researchers warned that the oyster grounds were deteriorating, but progress in regulating and husbanding the resource came slowly and only after years of slumping harvests.

According to Kennedy's research, the Maryland General Assembly in past decades would sporadically establish oyster commissions, boards and departments, staff them with resource managers and scientists and then largely ignore any recommendations that displeased the fishing industry. The result: slow progress in enforcing a cull law (1890), in planting shucked shell to rebuild oyster bars (1922), in planting old shell dredged from fossil beds (1961) and in protecting the best setting and growing grounds as seed areas.



Above: Like images from the past, skipjacks dredge for oysters—and for survival as the nation's last commercial sailing fleet. Left: On the culling board, watermen search for market-sized oysters from the Bay's stressed but resilient waters.

One of Kennedy's recommendations remains controversial. Private oyster farming, he says, should be encouraged. It could increase annual harvests, provide a year-round supply, lead to new oyster products and help revitalize the industry here as it has in Long Island and Louisiana. Most Maryland watermen have long opposed the leasing of Bay bottom for private farming. They fear eventual control of oyster supplies, prices and markets by a few large corporations, an outcome Kennedy claims legislation could prevent.

Watermen would rather work the Bay as their fathers and grandfathers did. Most now spend their days at the hard labor of handtonging, using long, low-sided workboats with a small cabin forward and a long cockpit aft for culling the day's catch. A growing number have equipped their boats with patent-tonging rigs that use power winches rather than arm labor to haul up the tongs. A small number have even taken to the water in scuba diving gear, a change in harvesting technique that angers many more traditional watermen. Only 30 skipjacks still work the Bay, the graceful survivors of a sailing fleet that once numbered in the hundreds.

To rebuild this public fishery, says Kennedy, or to encourage private farming, research has to answer key questions about:

- the biology and behavior of new oyster larvae;
- the food needs for oysters of all ages and the food sources currently available around the estuary;
- the genetics of breeding bigger, faster-growing oysters;
- the diseases that strike natural and hatchery-spawned populations and the pollutants that could affect the animal and its ecosystem.

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Though research on the Bay's oysters has been underway—often in a sporadic fashion—for more than a hundred years, the pace of research has quickened in recent decades. There are more researchers skilled in benthic biology and plankton ecology, there is a better sense of

Biologist Vic Kennedy searches Bay waters for clues to the health of an erratic oyster fishery.

what the important questions are, there is a stronger interest among management agencies in applying research findings in the field.

In six years of fisheries research, the Maryland Sea Grant College Program has made good progress on some hard questions. To understand the causes of erratic reproduction in recent years, Kennedy analyzed oyster samples collected from around the Bay over several years and found clear evidence that Maryland's oysters are sexually healthy, that they are spawning well and that sex ratios are not wildly unbalanced as was widely feared—results that suggest events in the water column between spawning and spat set are implicated in causing years of poor spat set.

To understand what is happening in the water column, Kennedy and William Boicourt have been documenting the ways in which tidal currents in specific regions affect the distribution of oyster larvae over oyster bars.

Dale Bonar has described more precisely the oyster larvae's ability to delay metamorphosis from free-floating larva to a bottom-dwelling spat until suitable cultch is found.

Ron Weiner has described microbes that coat oyster cultch and identified a specific species that attracts spat set by producing melanin—a substance much like the L-dopamine used to treat Parkinson's disease among humans. This finding may lead to a chemical attractant that could be used to increase set in seed hatcheries or on planted cultch.

George Krantz—supported in part by Sea Grant—explored the problems and potential of developing effective oyster seed hatcheries. His work identified the production bottlenecks, established cost-effective planting times, evaluated the economics and feasibility of commercial seed production hatcheries, and assisted the resource managers in their efforts to start a series of small-scale seed hatcheries that could help supplement natural reproduction. To help tap the natural productivity of the Bay's oyster grounds, Krantz developed an off-bottom man-made seed collector that has already generated many orders and stimulated interest in the potential of aquaculture for creating profitable private oyster farming.

To help state resource managers organize a more productive seed and shell planting program, Dave Swartz and Ivar Strand, two Sea Grant resource economists, built an oyster seed model that can help identify the best places in the Bay to plant seed and shell.

OYSTER PROJECTS

Biosynthesis of Sterols in the Oyster and Correlation of Sterol Composition to Oyster Productivity. G.W. Patterson, R/F-28, 1981. This project has established, in laboratory studies with oyster tissue culture, that there is no *de novo* synthesis of sterols; in complementary field studies, a direct correlation has been observed between growth rate and sterol composition. These results are important for oyster aquaculture systems that must develop optimum nutrition regimens.

Chemical Induction of Setting in *Crassostrea virginica* with Emphasis on Melanin-Producing Autochthonous and Pathogenic Bacteria. Ron Weiner and Dale Bonar, R/F-33, 1982. This study is investigating the symbiotic role of the LST bacterium and oyster larvae. This research could lead to a chemical attractant for boosting spat set in seed hatcheries, as well as a new understanding of shellfish-borne disease.

Developing a Marine Molluscan Cell Line. Frank Hetrick and Nancy Lomax, R/I-2, 1977, 1978, 1979, 1980. This project, while unable to sustain an oyster cell line indefinitely, developed and refined a number of procedures for so doing, including nutrient formulations and culturing methods and techniques of oyster tissue preparation.

Experimental Investigations on the Behavioral Basis of Oyster Recruitment. Victor S. Kennedy and William Van Heukelem, R/F-34, 1982. These laboratory studies of oyster larval responses to light, pressure, gravity, temperature and salinity are providing details on larval behavior and survival. Results so far show that larvae respond to changes in salinity by rising or descending in the water column.

Frontal and Interfrontal Tidal Regions in the Chesapeake Bay: Their Effects on the Spatial Distribution of Phytoplankton and Oyster Beds. Howard Seliger, R/F-13, 1979, 1980, 1981. This study describes dynamic relationships among estuarine waterflow patterns and the location of oyster larvae and their phytoplankton food source. The end result should lead to a better understanding of where plankton are and, thus, where to focus oyster seed and shell planting for optimal recruitment.

The Influence of Periphytic Bacteria on the Attraction and Antagonism of Oyster *Crassostrea virginica* Spat to Surfaces. Rita R. Colwell and Ron Weiner, R/I-8, 1980, 1981. This project has identified a melanin pigment of a newly observed marine bacterium, named LST, that acts as a cue for oyster larvae to settle and metamorphose into spat.

The Influence of Suspended Particulates and Salinity on the Estuary Budget of the Oyster *Crassostrea virginica*. Roger Newell, R/F-14, 1981, 1982. This study has found, contrary to the commonly held hypothesis, that oysters can select food that is mixed with high levels of inorganic particulates and that even in low salinity regions, where oysters experience the greatest stress, high food levels could compensate for that stress. The results suggest that those who plant oyster seed can identify optimum sites for growth, based on salinity regimes and on locations of high natural food concentrations.

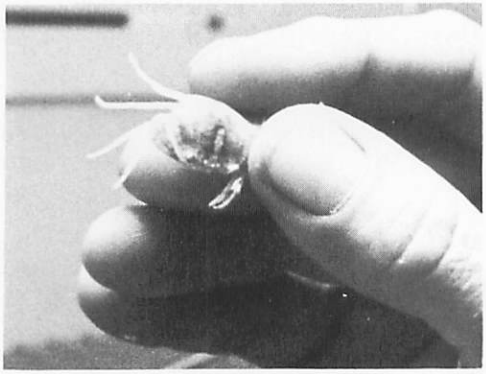
Variability in Growth and Survival of Two Oyster Populations. Brian Bradley, George Krantz and Joseph Wutoh, R/F-17, 1980, 1981. A major result of this study establishes that estimates of genetic variation of growth rates and different stages of spat growth were well below previously published data, all of which were based on much smaller experiments. One implication: Under hatchery conditions, selection for faster growth rate at the spat stage would not be successful.

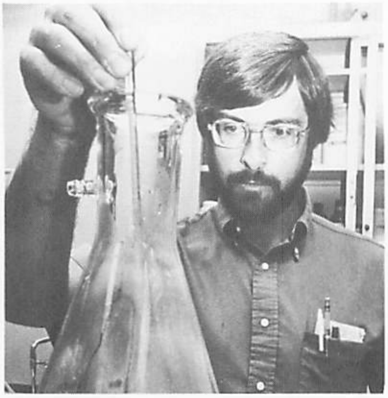
For those able to weather its unpredictable seasons, the Bay still provides the nation's biggest oyster haul.

CRAB PROJECTS

Growth, Development and Dispersal of Larval and Postlarval Stages of the Deep Sea Red Crab. Stephen D. Sulkin and William Van Heukelem, R/F-15, 1979, 1980. Extensive laboratory experiments of red crab larval behavior have led to the development of a testable recruitment model that could account for the presence of red crabs in deep slope waters. The model predicts an abundance of red crab larvae in Gulf Stream waters and a continuum of genetic communication among adult populations throughout the mid-Atlantic bight region.

Identifying Nutritional Requirements During Larval Development of Blue Crabs Using Microencapsulation Techniques. Stephen D. Sulkin, R/F-20, 1980, 1981. This project developed a microcapsule system which is versatile and highly applicable for studying dietary requirements in brachyuran crab larvae. This work is significant for its experimental implications and because it demonstrates that crab larvae are not obligate carnivores. Laboratory studies have further demonstrated that the lipid fraction of brine shrimp nauplii is the significant component of that very successful diet.





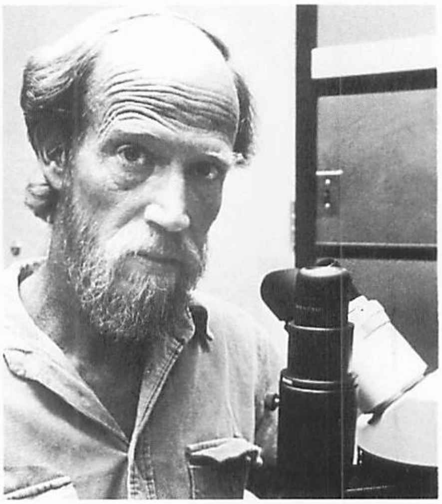
Investigation of the Genetic Relationship Among Populations of Chesapeake Bay Blue Crabs. Timothy Cole, R/F-21, 1981. In a study of gene exchange among estuaries, statistical analysis indicates that blue crab populations south of Cape Hatteras are more similar than those north of this area. These observations suggest that there are at least two subpopulations of blue crab with little gene exchange or interchange of larvae.

Regulation of Post-Recruitment Dispersal of Young-of-the-Year Blue Crabs to the Upper Chesapeake Bay. Stephen D. Sulkin and William Van Heukelem, R/F-32, 1982. The new larval recruitment model suggests that management of the blue crab resource is better directed at those crabs already recruited to the estuary; this project is providing an understanding of behavioral factors which influence post-recruitment dispersal and the first winter stresses on juvenile crab survival.

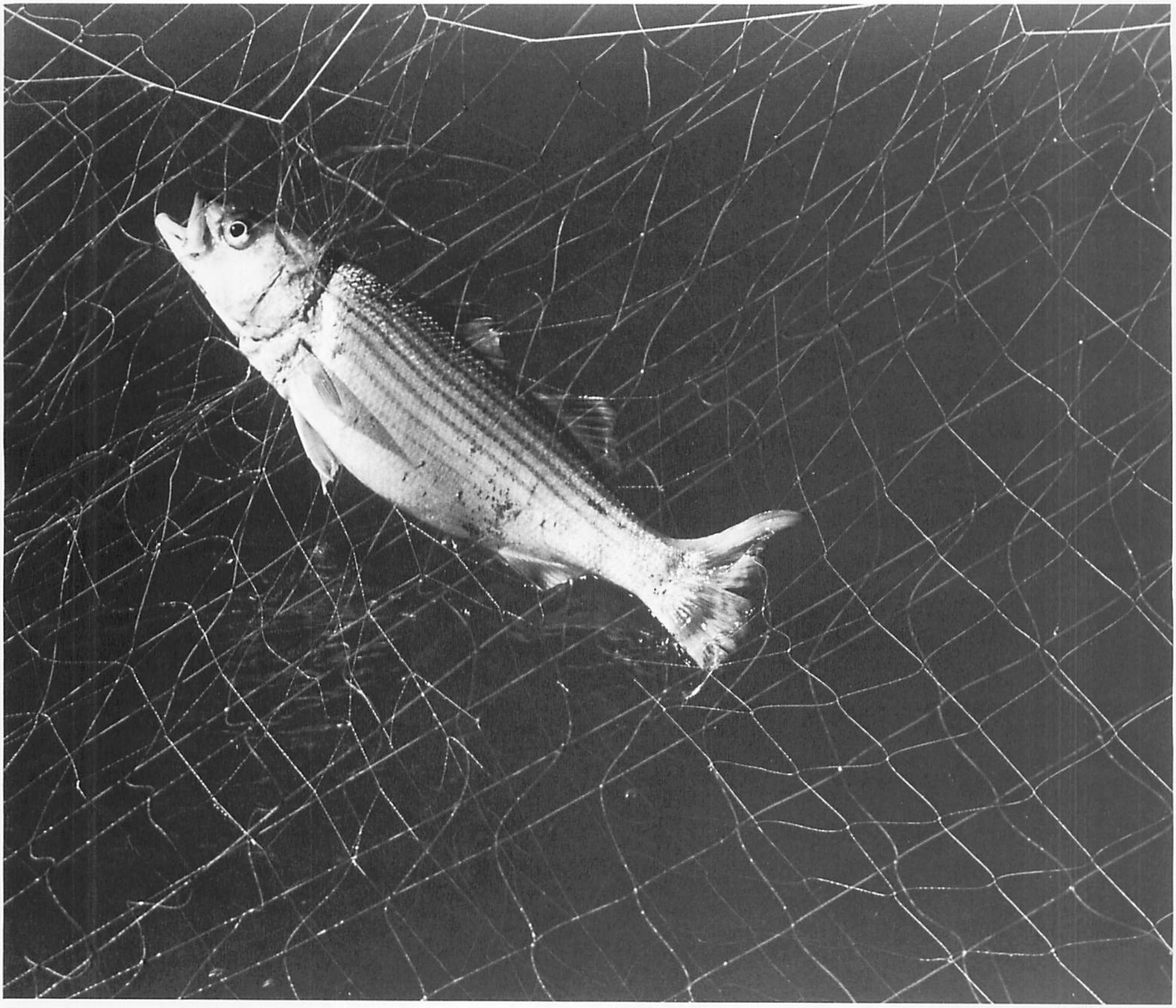
Below: Caught inside those hard shells and claws is a delectable meat – and the state's second most valuable fishery. Top Left: Long eluding researchers' grasp, the tiny juvenile blue crab now fits into an understandable pattern of seasonal movement. Bottom Left: Probing an invisible sea, researcher Tim Cole unlocks genetic and cellular secrets of the blue crab, Callinectes sapidus. *Right: Questioning blue crab behavior, William Van Heukelem has helped map the crab's peculiar migration pattern.*

The Source of Blue Crab Recruitment in Mid-Atlantic Estuaries. Stephen D. Sulkin and William Van Heukelem, R/F-19, 1978, 1979, 1981. Laboratory studies on blue crab behavior at the University of Maryland, together with field studies by researchers at the University of Delaware and Old Dominion University, have led to a new model of blue crab recruitment. According to the model, newly spawned larvae are flushed out to sea in surface waters at the mouth of the estuary and, in later stages, depending on hydrographic conditions, return to the estuary from offshore. This model provides a major step toward understanding and predicting blue crab population and harvest dynamics.

Synthesis of Sea Grant-Supported Projects on the Source of Recruitment of Blue Crabs to Mid-Atlantic Bight Estuaries. Stephen D. Sulkin, R/F-31, 1982. The principal investigators and researchers have produced a report summarizing the blue crab recruitment and hydrographic models, providing reference documents, and detailing further research needs and implications of the model for resource management.



FINFISH PROJECTS



Gasping for life, the once plentiful striped bass faces a dismal decline. New research and new management strategies are trying to bring the rockfish back.

A Comparison of Food Habits Between Larval Striped Bass and White Perch. Eileen Setzler-Hamilton, R/F-23, 1980, 1981. Study of diet overlap in the Potomac estuary suggests that striped bass and white perch larvae may have to compete for available zooplankton resources during years or portions of the spawning season when these food resources are scarce. The spatial, temporal and dietary overlap of these two species may be significant in determining year-class success of both populations.

An Economic Evaluation of the Chesapeake Bay Sport and Commercial Striped Bass Fishery. Virgil Norton and Ivar Strand, S/L-6, 1979, 1980. The project results indicate that the effects of striped bass declines have varied substantially among states and suggest reasons for this imbalance. Because of interstate competition, state-by-state management of striped bass will not maximize overall benefits from this resource.

Forecasting Commercial Finfish Landings and Crab Catch from Estuarine Waters. Robert E. Ulanowicz and William C. Caplins, R/F-22, 1981, 1982. This project is developing mathematical models for harvest predictions of blue crabs and such commercially important fish species as rock, menhaden and alewives.

Restricted Common Property in the Chesapeake Bay Fisheries. Oran R. Young, R/F-27, 1981. Using both theoretical analysis and case studies of fisheries with restricted entry rights, this study examines the potential applicability of restricted common property strategies to Chesapeake Bay.

AFTER CRAB PICKING

A mountain of crab waste is piling up around the Chesapeake.

About 10 percent of a succulent blue crab turns up in crab cakes; in Maryland at least, the remainder ends up mostly in landfills.

If Fred Wheaton's plan works out, however, a lot of that crab waste will end up on farms as fertilizer for traditional land crops like corn and soybeans. And a lot of crab processors will be able to stay in business.

The technique Wheaton is using —composting—is hardly new, but the potential applications of this ancient art to crab wastes are so promising that the state's Tidewater Fisheries Administration agreed to help fund a Sea Grant feasibility study by agricultural engineers Fred Wheaton, Russ Brinsfield and Tom Cathcart and by resource economist Doug Lipton.

For seafood processors, crab waste is a big problem. In one day, Clayton Brooks' seafood plant in Cambridge turns out 1500 pounds of picked crab meat and nearly 12,000 pounds of crab waste—a six-ton mountain of broken shell and scrap that no one wants. Multiply his mountain by 44 processors and you begin to see the size of the problem. In an average year Maryland watermen pull in about 23 million pounds of crabs from the Chesapeake Bay. Out of this haul comes some 2 million pounds of premium meat and nearly 21 million pounds of waste.

For years Brooks could ship his scrap to rendering plants which turned crab waste into chicken feed. When rising costs, changing markets and new environmental regulations made business unprofitable, rendering plants closed down, leaving processors with nowhere to go but the nearest landfills. Now landfill operators are threatening to close their gates also. They don't like the odor of crab waste, the special handling, the late deliveries, or the risk of groundwater pollution. An industry problem could become an industry crisis.

A side order of shells builds outside a Cambridge processing plant. Researchers like Russ Brinsfield want to turn that fecund waste into fertilizer.

Turning crab waste into a fertilizer, though not a new idea, could be a long-term solution of that crisis. Processors and farmers have sporadically used crab waste as fertilizer because of its high levels of nitrogen, phosphorus and potash. The great drawback is that farms need fertilizer only twice a year—just before planting and just after harvesting—but crab waste won't wait: it quickly raises a stink, loses its strength and becomes a public health problem. The trick is to turn that waste into a stable, storable fertilizer that farmers can use when they need it.

This is where composting comes in. Composting is controlled biological degradation. It differs from the natural rotting that takes place in a landfill or an open field in that significant variables are controlled—variables like pH, particle size, temperature, moisture and carbon-to-nitrogen ratios. To reach the right rates of rotting and cooling, the right ratios of carbon and nitrogen, the researchers are experimenting with straw and sawdust, propolyene barrels and air injections. Out of these experiments could come a composted crab waste with low odor, high nutrient value and long shelf life. In short, a safe, inexpensive disposal method and a saleable product that processors could make and market themselves.

Wasting away in landfills along the Eastern Shore: a source of fertilizer and cash.

The economics of the project could also be crucial. To assess the value of the compost as fertilizer, the researchers will test its nitrogen, phosphate, potash and calcium contents. At that point economist Doug Lipton of the Agricultural and Resource Economics Department will join the research team to look at the engineering data and to determine optimum plant sizes and locations, costs to the processor, and markets and market values.

"We're not sure," Brinsfield says, "where the final product will best be used. We hope to develop a variety of markets by working with the Agronomy and Horticulture departments. Maybe one market is gardeners."

Crab compost may never be a high-profit product, but it doesn't have to be. If the compost proves rich enough and stable enough for farmers to use in large quantities, it will prove its worth to Clayton Brooks and dozens of other seafood processors around the Bay. It will help keep them in business.

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Other Sea Grant efforts in seafood technology include the publication of booklets on such topics as crab pasteurization techniques and waste disposal, as well as personal consultation by seafood technology specialists with those who own and operate crab-shedding facilities, oyster shucking houses or blue crab processing plants. Future work will focus on improving seafood quality, establishing indices for commercial product standards and developing new seafood products.

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THE CHOLERA CONNECTION

New research sheds light on a dreaded disease.

Across the calm waters of Eastern Bay moves an uneven line of boats, thin white shapes against a dim dawn. Most of these boats are low-slung Chesapeake workboats pulling pots from the estuary's rich crab grounds. But one large boat is hunting for something other than crabs, something the crabbers can't see, something they would not expect to find in North American waters.

That bulky boat is the twin-hulled research vessel *Ridgely Warfield* and what the scientists on board seek is a tiny bacterium called *Vibrio cholerae*—the causative agent of cholera.

On the deck of the research vessel a young English scientist works with the samples, small portions of the Chesapeake that will get labeled, filtered and run through sophisticated scanning equipment. The scientist's name is Paul West and he forms part of a research team organized by Rita Colwell, a University of Maryland microbiologist who has tracked cholera in India and Bangladesh, as well as in the Chesapeake Bay.

The history of this cholera research effort recalls the history of modern science itself, an attack on difficult riddles whose answers have shifted some of our basic beliefs about the invisible microbes that share our water planet. This coordinated attack has also become a model of the relationship between basic research and applied research, of how scientific investigation can help answer practical problems while piecing together the world's puzzles.

For centuries cholera epidemics have caused suffering throughout much of the world and they still kill thousands every year in the Far East—in India, Bangladesh and Indonesia. The disease has, in its long history, posed some hard-to-answer questions.

Left: Among the most fertile environments on earth, Chesapeake marshes and estuarine waters hold the key to productivity—and to the processes that threaten or encourage the region's important commercial species.

Wiggling beneath the gaze of an electron microscope is the bacterium Vibrio cholerae, *the cause of a sickness we call cholera. Recent research reveals that such vibrios also occur nationally in estuarine waters—and need not threaten either public health or seafood industries there.*

One recent riddle began in 1973 when a man in Texas came down with cholera. Though the disease raged elsewhere in the world, causing history's seventh cholera pandemic, the last cholera epidemic in America had died out more than a half-century ago, and there seemed no explanation for this isolated case. In 1977, another isolated cholera case turned up in Alabama: another riddle. Was cholera coming to this country?

But the cholera vibrio also appeared in other places where there seemed to be no disease, no host for the bacterium. Scientists isolated the cholera germ in the waters of Germany in 1973, Eastern Europe and Greece in 1975, England in 1977. Where was the cholera germ coming from? No one knew.

Then, in 1978, the tiny vibrio made the front page. Eleven people in Louisiana came down with cholera, infected by the same strain of vibrio which had turned up in Texas five years earlier. Authorities were confused—and understandably so. Traditional scientific opinion held that cholera vibrios could come only from cholera patients, perhaps surviving betwen epidemics in the form of mild cases, perhaps lingering in waste supplies or in feces used as fertilizer. Where had this cholera come from? Was there a threat to public health?

All the evidence pointed to a single batch of locally caught crabs, cooked but improperly stored before being eaten by the cholera victims. And though no one died of the disease, seafood production in several parts of Louisiana was shut down. Business plummeted. Samples taken along the Louisiana coast turned up further isolates of *Vibrio cholerae*, and those whose livelihoods depended on the seafood industry began to worry.

In an effort to answer these puzzling and pressing questions, the National Sea Grant Program organized a research effort which could shed light on the nature of the microorganism and the dread disease it causes. The scientist picked to head this research effort was Rita Colwell.

Along with two other researchers, James Kaper and Sam W. Joseph, Colwell published a paper in 1977 (a year before the Louisiana outbreak) which revealed the occurrence of *Vibrio cholerae* in the Chesapeake Bay. In that paper the authors held that these vibrios lived at large in the estuarine environment and were probably "important in the ecology of brackish and marine aquatic ecosystems." In other words, the vibrios, natural inhabitants of these waters, had been there all along.

Here was an answer to some of the riddles, an answer to the mystery of cholera cases separated by many miles and bv many years.

The Sea Grant-funded effort now in progress will determine more clearly the occurrence of *Vibrio cholerae* and its relationship to public health and the seafood industry. True to the Sea Grant concept, funds go to universities in several coastal regions—to Ronald Siebeling at Louisiana State University and to other researchers in Maryland, Oregon and Florida. And consistent with the design of federal, state and university cooperation, funds also go to Nell Roberts and Henry Bradford of the Louisiana

Department of Health and Human Resources. Each participating laboratory plays a part in the overall project. Florida and Louisiana, for example, provide isolation of organisms; Maryland, along with isolations, provides expertise in the areas of taxonomy and identification; Oregon performs pathogenicity tests.

At the crux of the investigation lie questions about cell structure, reproduction and genetics. The researchers want to know more about what constitutes an infective dose; about how the microorganism survives in the open environment; about why some vibrios are pathogenic to man, while others are not.

Clearly, the presence of *Vibrio cholerae* in our waters does not mean imminent threat of epidemic. The stomach acid of a healthy human will destroy many microbes, and good nutrition, efficient sewage treatment, pure water and proper cooking methods protect us from cholera, as from other bacterial and viral diseases. Still, *Vibrio cholerae, Vibrio parahaemolyticus* and other vibrios which can cause sickness and suffering will not simply disappear. We know now that they exist in our waters as part of the natural flora, in the bayous of Louisiana and Florida, the inlets of Oregon, the bays and rivers of Maryland and Virginia.

With proper handling, *Vibrio cholerae* presents no threat to the seafood industry or to those who enjoy seafood. And for those who depend on seafood for a livelihood, this new understanding of a long-feared disease could be one of the biggest hauls to come out of the Chesapeake in a long time.

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Cholera research represents only one area of current concern. Maryland Sea Grant researchers have studied a range of issues, often focusing on imbalances caused by man-made disturbances. Marilyn Speedie of the University of Maryland's Baltimore Campus and Roy Sjoblad of the University's Microbiology Department in College Park have examined the effects of the herbicide atrazine on marine fungi.

David Wright at the University's Chesapeake Biological Laboratory has investigated the effects of heavy metals like copper on sessile organisms, specifically the American oyster *Crassostrea virginica*, the state's most valuable shellfish. Michael Kemp, working with Walter Boynton and Court Stevenson, has focused on large-scale estuarine processes, examining Choptank River sediments for keys to the recycling of nitrogen and phosphorus in the Bay.

The necessity for informed Bay management is evident in the controversy over the use of chlorine for sewage treatment and control of biofouling in electric power plants. Proponents of chlorination argue that the protection of public health against microbial pathogens requires its use; opponents argue that the fisheries resources are becoming the victim of chlorine by-products like chlorinated hydrocarbons. To identify these issues, the Maryland Department of Natural Resources and the Maryland Sea Grant Program have sponsored a comprehensive review of chlorine research to detail the state of our understanding and to specify gaps in our knowledge. This study will set the stage for investigating crucial research issues and developing rational policy for chlorine use in the Chesapeake.

Leading a research effort underway at the University of Maryland—and in Florida, Louisiana and Oregon—Rita R. Colwell has unlocked some of cholera's stubborn secrets.

ENVIRONMENTAL QUALITY PROJECTS

Adsorption, Bioconcentration and Degradation of ^{14}C-Labeled Atrazine in an Estuarine System. Roy Sjoblad, R/P-1, 1979, 1980. These studies showed that sediment samples and mixed microflora were capable of mineralizing the ring carbons of the herbicide atrazine as carbon dioxide. The data provide a firm base for future studies focusing on the fate of microbially produced atrazine metabolites in sediments.

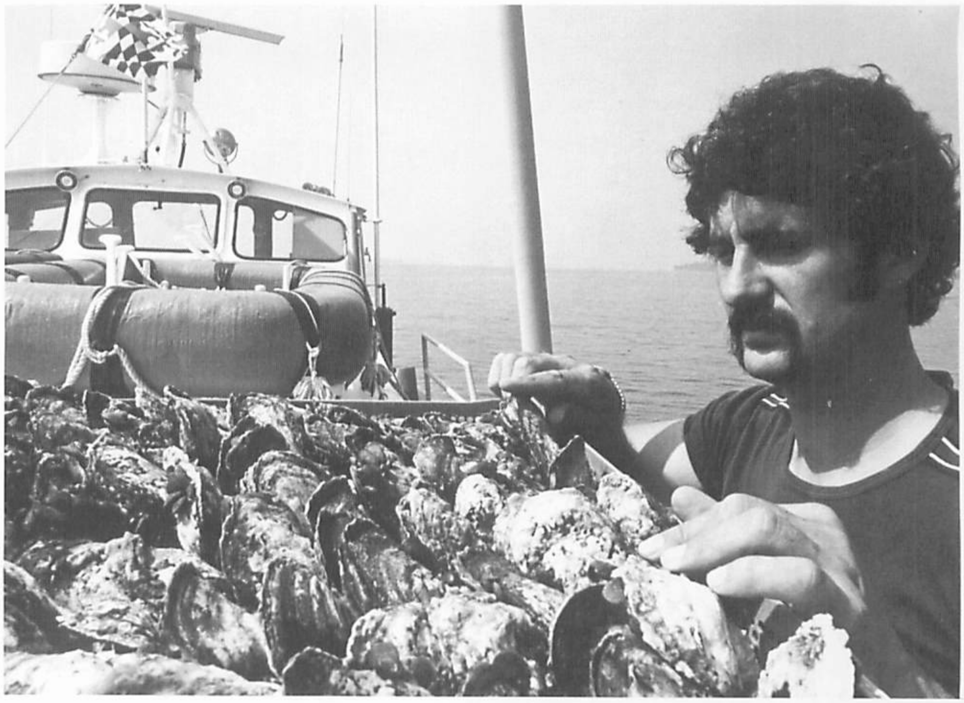
Distribution of *Vibrio cholerae, Vibrio parahaemolyticus* and Related Species, Pathogenic and Nonpathogenic, in Shellfish. Rita R. Colwell, R/NP-1, 1980, 1981, 1982. This is an integral part of a national Sea Grant study with Louisiana, Florida and Oregon to determine the pathogenic potential of vibrios in shellfish and shellfish harvesting waters. Basic information on the geographic distribution of related vibrios in Maryland waters and their presence in shellfish has been developed. This information has gone to the Maryland Department of Health and Mental Hygiene; in addition, the Marine Advisory Service has published information on proper procedures for preparing seafood to avoid health risks.

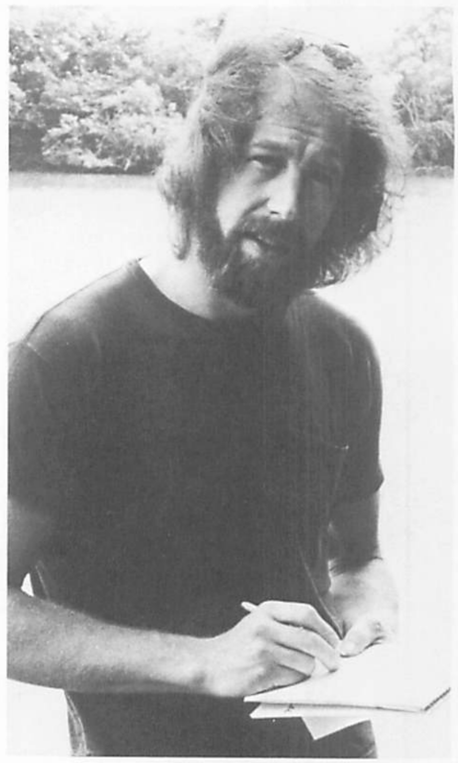
Interactions of Pesticides and Estuarine Fungi. Marilyn K. Speedie, R/P-3, 1980, 1981. The effect of pesticides on fungal growth differs for different species of fungi: from toxicity to neutrality to stimulation. While fungi act as a "safety net," preventing high levels of pesticides such as atrazine from reaching Bay waters, they can also serve as a vehicle for transporting pesticides to areas of the estuary that might not otherwise be exposed.

Predicting Chemical and Biological Events in Chesapeake Estuarine Waters as a Function of Lunar Cycle Mixing. C. D'Elia and Jay Means, R/F-26, 1980. The degree of stratification of the Patuxent River, unlike rivers to the south, depends weakly, if at all, on the spring/neap tide cycle. Stratification appears to be more a function of freshwater flow as well as such factors as meterological events. Conceptually accurate models that predict water quality (e.g., oxygen concentrations in the deep water) will depend on the ability to account for those factors which influence time-varying factors in stratification.

Recycling of Nitrogen and Phosphorus in the Sediments of the Choptank River Estuary. Michael Kemp, W.R. Boynton, J.C. Stevenson and R.R. Twilley, R/P-9, 1982. These studies are providing a more precise understanding of the chemistry of nutrients in the water column, at the sediment interface and within the sediments. Results should provide basic information for resource managers who wish to regulate more precisely the flow of nutrients into the estuarine system.

Variations in Trace Metal Profiles in Chesapeake Bay and Their Effect on Metal Uptake and Retention by the Oyster *Crassostrea virginica*. David A. Wright, R/P-5, 1981, 1982. Toxicity of metals to estuarine organisms depends both on dissolved metal concentrations and, most importantly, on the form the metals take. This project is developing a model that will both describe the biological response to trace metals in estuarine systems and assess the response of organisms to increases in metal pollution.





Top: Sent to the bottom near Hart and Miller Islands, these oysters will gather their own environmental data. David Wright is using oysters to determine the presence of heavy metals like copper, possibly emitted from nearby dredge spoil. Bottom: Tallying the balance sheet, researcher Mike Kemp is determining nutrient budgets for estuarine waters. Though Bay life needs nutrients like nitrogen, too much of a good thing can imperil the ecosystem's precarious balance.

BRINGING THE BAY TO BALTIMORE

A science educator turns attention to the bay that brings ships to Baltimore.

Baltimore is a big port. Its docks line a busy harbor; its products travel to far corners of the globe. Ask anyone in Baltimore and they'll tell you that in the port throbs the heart of the city—and the economic heart of the region. Ask them about the Bay that makes Baltimore a port, and they'll tell you about crabs, oysters and rockfish.

But ask them about how that Bay works, how it functions as an ecosystem, and you may get some blank stares.

Their confusion is justifiable: the Bay is a complex estuary, with a multitude of interrelated elements—molluscs that depend on phytoplankton, submerged aquatic grasses that depend on light, molting crabs that depend on those grasses to hide them.

Bill Talbott believes that a public understanding of the Chesapeake is the best protection against damaging that ecological balance. A science education specialist with the Baltimore City school system, Talbott came to Sea Grant with an idea for teaching the city's students about the Bay. His argument: that public schools provide the best place to foster a basic understanding about the nation's largest estuary.

To begin a program of marine-related education, Talbott focused both on students and on the teachers who would instruct them. He knew that before teachers could spread their knowledge and enthusiasm about the Bay to students they needed some special training—not only textbook learning but close-up experiences with the Bay itself and with the methods scientists use to understand it.

Left: Locating Baltimore on a Bay map, Richard Lay takes city students into the harbor aboard the Osprey. *From that vantage point students see for themselves how Baltimore depends on the Bay and how the Bay feels the effects of the port. Above: Convinced that Baltimore schools needed to teach students more about the Chesapeake Bay, William Talbott began a program that took students and teachers down to the harbor for a closer look.*

Working with the administration of the Baltimore City schools, Talbott mapped out both student field trips and a teacher-training program, but he needed a way to get those teachers out on the Bay, where they could get that firsthand experience. For this Talbott turned to the Chesapeake Bay Foundation, an organization well known for its expertise in field education. Richard Lay, manager of the Foundation's Baltimore City Estuarine Study Center, agreed to take the teachers out aboard the Foundation's 42-foot workboat, *Osprey.*

The only thing lacking was enough money to get the program away from the dock. Sea Grant was able to help: with a modest $12,000 from the Sea Grant Program and with other matching funds, Talbott launched the program. He screened educational materials from across the country for their appropriateness to Baltimore harbor and the Chesapeake Bay. Then he recruited teachers and began a lively program of curriculum development and teacher-training that took participants from the classroom to the Baltimore harbor and into the open reaches of the Chesapeake Bay.

The result?

Not only did Talbott's program increase the number of teachers and students interested in and informed about the Chesapeake Bay, but it convinced the Baltimore City school system to place more emphasis on Bay-related education. After the conclusion of Sea Grant support, the City committed resources to continue the program—which is now an ongoing effort of Baltimore's educational system. Over the last three years, almost 300 days have seen students and teachers down on the Bay to learn about estuarine ecology.

In short, Talbott's project convinced the school system of a major port city to take a closer look at the importance of nearby waters—a giant step in the direction of greater understanding and appreciation of the region's marine and estuarine resources. And, in Talbott's words, "Sea Grant made the difference."

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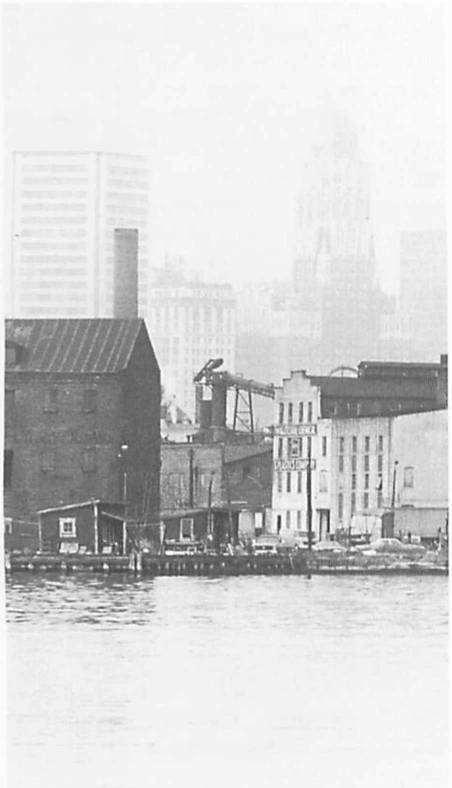
At the same time that Talbott was boosting marine education in Baltimore, Ken Stibolt mobilized Sea Grant funds and the resources of Anne Arundel Community College to train teachers in Anne Arundel County. In addition to a group of well-trained teachers, Stibolt's efforts produced an 80-page manual describing marine education workshop techniques and basic scientific methodologies.

Marine education efforts have continued to spread down the Bay, with Sea Grant support. In St. Mary's County in southern Maryland, Marianne Chapman has developed the Elms Environmental Center on property set aside as the future site of an electrical power plant. She used Sea Grant funds specifically to increase marine education and public participation efforts there. And Robert Paul, working at St. Mary's College, developed a summer program for high school and undergraduate college students in estuarine biology.

On the other side of the Bay, John Groutt of the University of Maryland Eastern Shore is combining classroom training with canoe trips to put teachers in touch with the complex environments of their own marshy backyards. Though the Eastern Shore abounds with marsh life and its attendant estuarine ecosystem, Groutt found that many science classes used exotic contexts for teaching biology and other sciences, while local examples of basic scientific precepts went unnoticed right outside the window. "The science materials they were using," Groutt said, "could just as easily have been applied to Arizona." Now science teachers can use materials from—and do experiments in—the Chesapeake Bay, their own living laboratory.



Above: Built right to the banks of the Patapsco River, Baltimore depends on the Bay for its life's blood. Increased environmental awareness is shifting attention to the Bay and to a revitallization of rundown waterfront areas. Right: Students face down a shark's jaw at the National Aquarium. Their class is taught by a Sea Grant intern, one participant in a series of marine education efforts begun by Maryland Sea Grant in Baltimore and around the Bay.

MARINE EDUCATION PROJECTS

Cooperative Research Program—University of Marseilles and the University of Maryland. Rita R. Colwell and David W. Carley, E-2. Supporting an exchange program between the University of Maryland and the University of Marseilles, France, this project allows experts in the fields of marine biology, microbiology, aquaculture and other related areas to investigate research methods and technologies employed at the respective universities.

K-12 Marine Science Education Professional Improvement Workshop. Kenneth Stibolt, E-4, 1980. Developing curricula and teacher-training resources at the Anne Arundel Community College, this project resulted in the production of an 80-page workshop guide for teachers interested in estuarine education.

Sea Grant Fellowships. Rita R. Colwell and David W. Carley, E-3. This continuing project supports undergraduate students enrolled in the Environmental Sciences Program at the University of Maryland Eastern Shore or graduate students enrolled in the University's Marine-Estuarine-Environmental Sciences Program, active on all campuses of the University.

Sea Grant Trainees. Rita R. Colwell and David W. Carley, E-1. This is a continuing program, where degree-seeking graduate students gain practical knowledge in their area of specialization, while assisting investigators working on Sea Grant-approved projects.

MARINE EDUCATION PROJECTS

Field Training Project in Estuarine Education. John Groutt, E-10, 1982. This project is designing an estuarine study curriculum and field study program for Maryland's lower Eastern Shore. Teachers receive classroom instruction and on-site training in marsh ecology.

Development of Estuarine Biology Training Program for High School and Undergraduate Students. Robert Paul, E-8, 1980. Using the marshlands and waters available there, this project expanded and developed an estuarine biology program at St. Mary's College, Maryland.

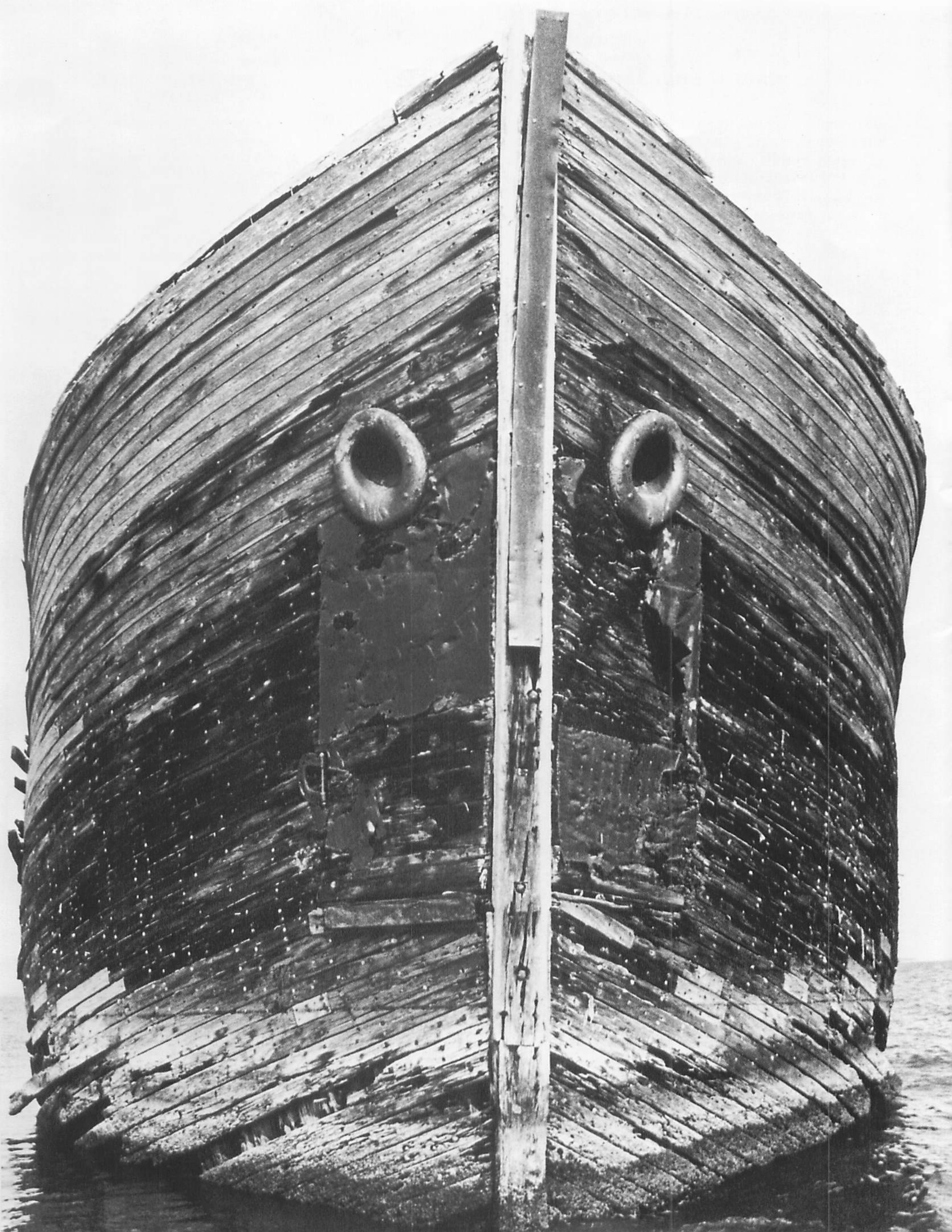
In-Service Marine Education Project, 5-12, Baltimore City Schools. William Talbott, E-6, 1980. Teachers received training in marine and estuarine education relevant to Baltimore harbor and the Chesapeake Bay.

Internships in Marine Education, National Aquarium. David M. Pittenger, E-7, 1981, 1982. This project began an intern program at the National Aquarium in Baltimore. The interns, invited from area colleges, learn marine education methodology while helping the Aquarium develop marine education materials and programs.

Development of Public Participation at the Elms Environmental Education Center. Marianne S. Chapman, E-5, 1981. Adapting a future site for an electrical power plant, this project takes advantage of a prime location on the shores of the Chesapeake Bay for the development of marine education and public participation programs.

SOCIAL SCIENCE PROJECT

The Level of Awareness of Local Government Officials to Citizen Preferences Concerning the Chesapeake Bay. P. Florestano and P. Rathbun, S/L-4, 1980. This project examined the attitudes of government officials and compared them with citizen attitudes. Results showed that such a comparison is complex: citizen attitudes often varied depending on subgroup (as determined by income, education and other factors) and could not be constituted as a single entity. The study also suggests that local officials—often presumed to be closer to their constituents—may not in fact share or have a knowledge of the opinions of those people they serve.



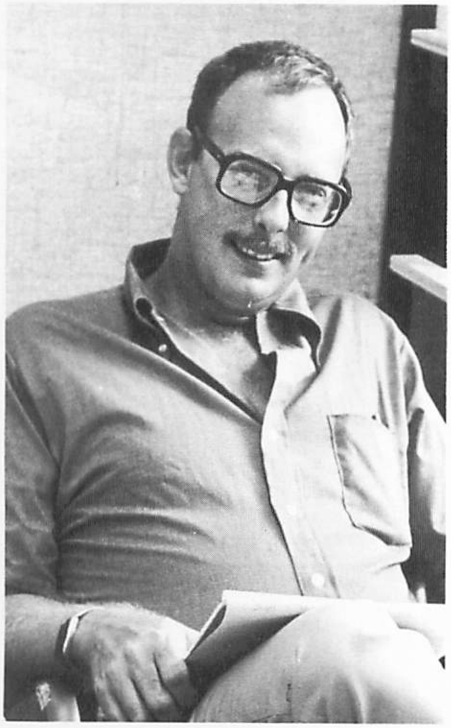
WAR ON WOOD ROT

Wherever wood meets water, there's a battle going on.

When lobstermen pull their pots from the sea, they bring up more than lobsters. In fact, they may haul up everything from algae to tube worms to barnacles — a mat of marine growth thick enough to keep even interested lobsters out of their wooden traps. The pots, worm-eaten, may fall apart after a single season.

All that fouling means lost fishing efficiency and lost revenues for lobstermen — or for anyone who uses wood to work the water.

Bob Kocher, a marine technology specialist with the Maryland Marine Advisory Program, has firsthand knowledge about critters that attack wood. He owns a wooden workboat himself and has seen the ravages of wood rot, tube worms and a host of fouling organisms. To mount an aggressive campaign against these interlopers, Kocher has tested various preservatives and antifouling techniques, taking a long look at what is available on the market for the commercial fisherman.



Handy with a caulking hammer or sophisticated Loran C navigational equipment, Bob Kocher has discovered some helpful strategies for fighting wood's water enemies. Left: Hanging on near Hooper Island, this riddled hull succumbs to the ravage of rot. Above, right: Like casualties of war, abandoned workboats remind a Bayside community of a constant and costly battle.

For three years Kocher impregnated sample boards with various compounds and mixtures and dangled them off a pier in Wachapreague, on the Eastern Shore's Atlantic side. He found some big differences in rot-prevention treatment and shared his observations with thousands of readers through a series of articles in *National Fisherman* magazine, articles which contain a wealth of information about fighting biofouling and wood rot.

The response was staggering. After one article, some 5,000 requests came in for more information, all of them mentioning the *National Fisherman* piece.

What sparked that kind of interest was Kocher's comprehensive approach to the problem. He covered the basics of wood rot and reviewed some of the tried-and-true methods for combating it. Some readers were surprised to learn that "dry rot" only happens when wood gets wet and then dry — creating an ideal environment for the fungi that cause rot. But water, Kocher explained, can also help to prevent rot in two ways. First, it can keep essential oxygen from the rot-causing fungus, as when a board remains continually submerged. This explains why the sides of a boat may rot while the keel, always under water, may not. Second, water can help preservatives penetrate wood — and preservatives are only effective when they reach places where rot might go. Logically, the places where water flows are also the places where rot, which depends on water, thrives.

It's important to keep this in mind, Kocher found, since penetra-

Still part of a shifting ecology, an old workboat sprouts marsh grass. Wherever wood and water meet, a host of plants and animals seek a foothold—and spell the beginning of the end for a waterman's boat.

tion may become the key question when choosing and applying a wood preservative. Many petroleum-based preservatives, for example, may do an excellent job of preserving wood as far as they go, but they may not saturate wood well unless applied under pressure. Pressurized applications make sense before or even during a boat's construction, but for already-constructed boats such techniques prove impossible. This is where water-compatible preservatives—such as copper salts—excel; they wash around difficult-to-reach places in the bilge and soak deep into the wood, carried there by water, a ubiquitous solvent.

From his descriptions of basic wood preservation techniques, which included everything from creosote to copper salts, Kocher moved to a discussion of a new product on the market. This anti-fouling agent relies on tributyltin for its efficiency, but one manufacturer manipulated the compound's structure to make it less volatile. This meant that the chemical would adhere to wood longer and not leach into the water—or into the air when pots are stored.

Kocher's tests found this new treatment amazingly effective. Lobstermen who began using the chemical discovered that they could fish the treated pots right away—without harming the lobsters or driving them off. In fact, the newly treated pots attracted lobsters quite well, and pots pulled from the sea came up almost as clean as when they went down. Not only did this increase the efficiency of the pot while it was in the water, but it saved cleaning time and promised to preserve the pot for another season.

All this adds up to reduced cost and greater profit. An antifouling agent this effective is good news for anyone who works the water, whether they own wooden workboats or a raft of wooden crab-shedding floats, whether they fish the Chesapeake Bay or the waters of the continental shelf.

Work done with wood preservatives represents only one example of Kocher's practical investigations. His articles have covered lightning protection and shipboard electronics, hull construction and fiberglassing techniques, hydraulics, corrosion, engine mechanics. Seeking his advice, letters and calls have come from all over the state, the country, the world. Many repeat the same remark: Bob Kocher has the special gift of making complicated technical information easy to understand.

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Such work in marine technology represents only one facet of the Maryland Marine Advisory Program, a joint effort of the Maryland Sea Grant Program and the University of Maryland Cooperative Extension Service. The Advisory Program is charged with the task of transferring research results and marine-related education to those who use marine resources, especially those who depend on them for their livelihood—whether they be fishermen or aquaculturists, crabbers or lobstermen.

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MARINE ADVISORY PROJECTS

Using a system of agents and specialists, the Advisory Program focuses on information and technology transfer in the following areas:

Aquaculture. The Advisory Program produces publications and helps sponsor workshops for those engaged in or interested in the culturing of shellfish or finfish. An aquaculture specialist offers direct advice on such topics as oyster shell planting and oyster seed survivability.

Seafood Technology. Seafood specialists investigate and share their insights into such areas as pasteurization techniques, soft-shell crab shedding systems, effluent and waste disposal methods, and seafood quality and health standards.

Marine Business and Economics. The marine advisory economist produces fact sheets and workshops aimed at helping those with marine-related businesses manage financial matters. He also investigates economic trends and the effects of occurrences such as unfavorable publicity on the regional seafood market.

Consumer Education. Working with Extension economists, the Advisory Program helps train those who can teach others about buying, preparing and serving seafood, with an emphasis on nutritional characteristics and health considerations.

Marine Safety and Survival. Through publications, broadcasts and personal contacts, the Advisory Program alerts both commercial and recreational boaters about dangers such as lightning, collision and fire. One recent poster describes flags used to steer boaters away from diving operations.

Marine Engineering and Technology. This area focuses on hull construction and maintenance, shipboard electronics, hydraulics, corrosion and other technical matters of concern to both recreational and commercial boat owners and seafood harvesters.

Right: Balanced precariously over the Bay's cold waters, this waterman wears no safety equipment. Hypothermia and long-standing habits have made the Chesapeake prone to more fishing fatalities than anywhere else in the United States, except Alaska.

PUBLICATIONS

□□□ FISHERIES □□□

Oysters

Attempts to develop a marine molluscan cell line. F.M. Hetrick, E. Stephens, N. Lomax and K. Luttrell. 81 pp. UM-SG-TS-81-06.

Biological efficiency of off-bottom collection devices placed on oyster seed areas in Maryland. G.E. Krantz and H.A. Davis. 6 pp. UM-SG-TS-80-07.

Comparative reproductive patterns of the oyster *Crassostrea virginica* in central Chesapeake Bay. Victor S. Kennedy and Lucretia B. Krantz. (Journal of Shellfish Research, in press.)

Comparison of recent and past patterns of oyster settlement and seasonal fouling in Broad Creek and Tred Avon River, Maryland. V.S. Kennedy. (National Shellfisheries Assoc. 70(1980):36-46.) 11 pp. UM-SG-RS-82-02.

The forecasting of oyster harvests in central Chesapeake Bay. R.E. Ulanowicz, W.C. Caplins and E.A. Dunnington. (Estuarine and Coastal Marine Science 11:101-106.) 6 pp. UM-SG-RS-80-01.

Identification of 4α-methylsterols in the oyster, *Crassostrea virginica*. S.-I. Teshima and G.W. Patterson. (Comp. Biochem. Physiol. 69B:175-181.) 7 pp. UM-SG-RS-81-06.

Identifying climatic factors influencing commercial fish and shellfish landings in Maryland. Robert Ulanowicz, M.L. Ali, A. Vivian, D.R. Heinle, W.A. Rickhus and J.K. Summers. (Fisheries Bulletin 80:3.) UM-SG-RS-82-07.

Induction of settlement and metamorphosis in *Crassostrea virginica* by a melanin-synthesizing bacterium. R.M. Weiner and R.R. Colwell. UM-SG-TS-82-05.

Maryland oyster spat survey, fall, 1979. G.E. Krantz and D.W. Webster. 34 pp. UM-SG-TS-80-01.

Maryland oyster spat survey, fall, 1980. H.A. Davis, G.E. Krantz and D.W. Webster. 22 pp. UM-SG-TS-81-03.

Maryland oyster spat survey, fall, 1981. G.E. Krantz, H.A. Davis and D.W. Webster. 16 pp. UM-SG-TS-82-02.

Maryland's oysters: an annotated bibliography. V.S. Kennedy and L.L. Breisch. 53 pp. UM-SG-TS-81-05. Cost: $3.00

Maryland's oysters: research and management. V.S. Kennedy and L.L. Breisch. 286 pp. UM-SG-TS-81-04. (Includes Annotated Bibliography, UM-SG-TS-81-05, above.) Cost: $8.00

Molluscan cell culture; a workshop report. J. Gillespie and F. Hetrick. 16 pp. UM-SG-TS-79-01.

Monitoring Chesapeake Bay shellfish for human enteroviruses. N. Lomax and F. Hetrick. 24 pp. UM-SG-TS-79-03.

Morphological, physiological and biochemical aspects of variable developmental and growth rates in oyster larvae. D.B. Bonar. 4 pp. UM-SG-TS-81-02.

Oyster culture in Maryland '79: proceedings of the annual oyster culture conference, Annapolis, Maryland, January, 1979. D. Webster and H. Ahearn, eds. 157 pp. UM-SG-AS-80-01.

Oyster culture in Maryland 1980: a proceedings. D. Webster and J. Greer, eds. 138 pp. UM-SG-MAP-81-01. Cost: $3.00

Oyster hatchery technology series. G.E. Krantz. 128 pp. UM-SG-MAP-82-01.

The relationship between dietary phytosterols and the sterols of wild and cultivated oysters. C.J. Berenberg and G.W. Patterson. (Lipids 16(4):276-278.) 3 pp. UM-SG-RS-81-04.

Residency laws for oystering: the legal and economic consequences of *Douglas vs. Seacoast Products, Inc.*. T.B. Lewis and I.E. Strand, Jr. (The Maryland Law Review 38:1-36.) 36 pp. UM-SG-RS-79-01.

Role of chitin in the accumulation of heavy metals in the American oyster. J.J. Cooney and R.A. Smucker. 3 pp. UM-SG-TS-81-08.

Seasonal concentration of coliform bacteria by *Crassostrea virginica*, the Eastern oyster in Chesapeake Bay. D. Hussong, R.R. Colwell and R.M. Weiner. (Journal of Food Protection 44(3):201-203.) 4 pp. UM-SG-RS-80-09.

A selected bibliography of worldwide oyster literature. L.L. Breisch and V.S. Kennedy. 309 pp. UM-SG-TS-80-11. Cost: $8.00

Sex ratios in oysters, emphasizing *Crassostrea virginica* from Chesapeake Bay, Maryland. Victor S. Kennedy. (The Veliger, in press.)

Sixteen decades of political management of the oyster fishery in Maryland's Chesapeake Bay. Victor S. Kennedy and Linda Breisch. (Journal of Environmental Management, in press.)

Sterol biosynthesis in the oyster, *Crassostrea virginica*. S.-I. Teshima and G.W. Patterson. (Lipids 16(4):234:239.) 6 pp. UM-SG-RS-81-03.

Sterols of the oyster, *Crassostrea virginica*. S.-I. Teshima and G.W. Patterson. (Lipids 15(12):1004-1011.) 8 pp. UM-SG-RS-81-05.

Δ5,7 sterols of the oyster, *Crassostrea virginica*. S.-I. Teshima and G.W. Patterson. (Comp. Biochem. Physiol 68B:171-181.) 2 pp. UM-SG-RS-80-10.

Subtidal distribution of barnacles in Chesapeake Bay, Maryland. Victor S. Kennedy, and Jane DiCosimo. (Estuaries, in press.)

Taxonomic implication of sterol composition in the genus *Chlorella*. M.J. Holden and G.W. Patterson. (Lipids 17(3):215-219.) 5 pp. UM-SG-RS-82-04.

The transport of oyster larvae in an estuary. H.H. Seliger, J.A. Boggs, R.B. Rivkin, W.H. Biggley and K.R.H. Aspden. (Marine Biology, in press.)

Crabs

The behavioral basis for blue crab recruitment in mid-Atlantic estuaries. S.D. Sulkin. 72 pp. UM-SG-TS-81-07.

The behavioral basis of larval recruitment in the crab *Callinectes sapidus* Rathbun: a laboratory investigation of ontogenetic changes in geotaxis and barokinesis. S.D. Sulkin, W. van Heukelem, P. Kelly and L. van Heukelem. (Biological Bulletin 159:402-417.) 16 pp. UM-SG-RS-80-05.

The blue crab in mid-Atlantic Bight estuaries: A proposed recruitment model. S.D. Sulkin, C.E. Epifanio and A.J. Provenzano. 36 pp. UM-SG-TS-82-04.

Crab byproducts and scrap, 1980: a proceedings. M.B. Hatem, ed. 120 pp. UM-SG-MAP-81-03. Cost: $3.00

Ecological and evolutionary significance of nutritional flexibility and planktotrophic larvae of the deep-sea red crab *Geryon quinquedens* and the stone crab *Menippe mercenaria*. S.D. Sulkin and W. van Heukelem. (Marine Ecology-Progress Series 2:91-95.) 5 pp. UM-SG-RS-80-04.

Larval recruitment in the crab *Callinectes sapidus* Rathbun: An amendment to the concept of larval retention in estuaries. Stephen Sulkin and William van Heukelem. (Estuarine Comparisons, in press.)

On the locomotory rhythm of brachyuran crab larvae and its significance on vertical migration. S.D. Sulkin, I. Phillips and W. van Heukelem. (Marine Ecology-Progress Series 1:331-335.) 5 pp. UM-SG-RS-80-03.

A pelletized diet for captive benthic crustaceans. S. Rebach. 8 pp. UM-SG-TS-81-01.

Processing recommendations for pasteurizing meat from the blue crab. Maryland Sea Grant Advisory Report. J. Winter Duersch, Michael W. Paparella and Ralph R. Cockey. 21 pp. UM-SG-MAP-81-02. Cost: $1.00

Finfish

Comparative feeding habits of white perch and striped bass larvae in the Potomac estuary. Eileen Setzler-Hamilton, Philip W. Jones, F. Douglas Martin, Karen Ripple and Joseph A. Mihursky, George E. Drewry, Melvin Beaven. (Proceedings of the Fifth Annual Meeting of the Potomac Chapter of the American Fisheries Society, May 1981, 139-157.) UM-SG-RS-82-08.

Economic aspects of commercial striped bass harvest. I.E. Strand, V.J. Norton and J.G. Adriance. (Proceedings of the Marine Recreational Fisheries Symposium, Boston, Massachusetts, March 27-28, 1980 51-62.) 13 pp. UM-SG-RS-81-08.

Histological and morphometric criteria for assessing nutritional state of larval striped bass, *Morone saxatilis*. F.D. Martin and R. Malloy. (Proceedings of the Fourth Annual Larval Fish Conference 157-162.) 10 pp. UM-SG-RS-81-01.

Reproductive success of Choptank River, Maryland, striped bass in a hatchery situation. G.E. Krantz. 2 pp. UM-SG-TS-80-09.

□□□ ENVIRONMENTAL QUALITY □□□

Aquatic microbial ecology: proceedings of the ASM conference, Clearwater Beach, Florida, 7-10 February, 1979. R.R. Colwell and J. Foster, eds. 460 pp. UM-SG-TS-80-03. Cost: $8.00

Avoidance costs associated with imperfect information: the case of kepone. D.G. Swartz and I.E. Strand, Jr. (Land Economics 57(2):139-150.) 12 pp. UM-SG-RS-81-07.

Bacteria associated with false-positive most-probable-number coliform test results for shellfish and estuaries. D. Hussong, J.M. Damare, R.M. Weiner and R.R. Colwell. (Applied and Environmental Microbiology 41(1):35-45.) 10 pp. UM-SG-RS-80-07.

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Co-oxidation of petroleum hydrocarbons by estuarine organisms. J.J. Cooney and M.P. Shiaris. 8 pp. UM-SG-TS-81-09.

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Social Science

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□□□ MARINE EDUCATION □□□

The American oyster in the Chesapeake Bay: a marine education workbook. Science Teaching Center, University of Maryland, College Park. 57 pp. UM-SG-ES-80-03. Cost: $2.00.

Food webs in an estuary: a marine education workbook. Science Teaching Center, University of Maryland, College Park. 28 pp. UM-SG-ES-80-02. Cost: $2.00

Study guide for marine science education workshop. K. Stibolt. 3rd Edition. 98 pp. UM-SG-ME-80-01.

Tides and marshes: a marine education workbook. Science Teaching Center, University of Maryland, College Park, Maryland. 37 pp. UM-SG-ES-80-01. Cost: $2.00.

□□□ PUBLIC COMMUNICATIONS □□□

Making and breaking Sea Grant news: proceedings of the annual conference of Sea Grant communicators, Washington, D.C., April, 1979. H. Ahearn and J. Greer, eds. 161 pp. UM-SG-TS-80-02. Cost: $3.00.

Maryland Sea Grant. Annual report, 1977. 28 pp.

Maryland Sea Grant on the Chesapeake. A biennial report, 1978, 1979. 48 pp.

Maryland Sea Grant. A quarterly newsletter reporting on the activities of the Maryland Sea Grant Program and on issues and events affecting the Chesapeake Bay and the state's coastal waters. 1978-present. Back issues available.

Sea Grant Fellowships. Two pamphlet/posters which describe fellowships available to students in the marine, estuarine and environmental studies program at College Park and the environmental sciences program of the University of Maryland Eastern Shore.

□□□ MARINE ADVISORY PUBLICATIONS □□□

LEAFLETS

Keep clear: big ships in the Bay. ML137.

Lightning: grounding your boat. ML138.

The Maryland marine advisory program. ML139.

FACT SHEETS

Applying for a fishing loan. N. Bender. FS225.

Budgeting in a marine business. N. Bender and B.V. Lessley. FS231.

Choosing among marine business investments. D. Swartz. FS322.

Developing a watermen's credit union. N. Bender. FS224.

Evaluating investment decisions in marine business. D. Swartz. FS321.

Financial assistance for watermen. N. Bender (revised by D. Swartz). FS222.

Fishery cooperatives. N. Bender and R. Beiter. FS228.

How watermen can minimize business risks. D. Swartz. FS301.

Leasing boats and marine equipment. D. Swartz FS309.

Retirement plans: preparing for the future. N. Bender. FS227.

Seafood processors and the clean water act. R. Brinsfield. FS308.

Tax law changes affect fishing industry. N. Bender. FS226.

Why seafood prices rise and fall. D. Swartz. FS300.

BULLETINS

Hydraulics in commerical fishing. 16 pp. #257.

Waste treatment in seafood processing. 20 pp. #264.

The waterman's recordkeeping manual. 26 pp. #304.

The waterman's record book. 62 pp. #305.

Workboat DC electrical systems: design, installation and repair. 32 pp. #259.

REPRINTS

Loran C systems. R.L. Kocher. UM-SG-MAR-80-01. 28 pp.

Marine diesel engines. R.L. Kocher. UM-SG-MAR-82-01. 31 pp.

Marine alternators. R.L. Kocher. UM-SG-MAR-82-02. 34 pp.

PUBLIC COMMUNICATIONS

Bay/shore reports, Vol. 1 (June—October, 1980). J. Greer. 26 pp. UM-SG-MAR-80-02. Reprints from weekly column carried by newspapers in Maryland communities around the Bay.

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1980 BUDGET

Expenditures By Activity

	NOAA Grant Funds	Matching Funds
Marine Resources Development		
Aquaculture	$ 26,900	27,700
Biological Oceanography	54,000	20,500
Commercial Fisheries	133,800	25,500
Socio-Political Studies	26,000	12,000
Pathology of Marine Organisms	68,000	10,900
Marine Economics	189,900	90,200
Marine Environmental Research		
Environmental Models	29,000	9,300
Pollution Studies	35,000	18,400
Marine Education and Training		
Other Education	134,000	61,000
Advisory Services		
Extension Programs	210,000	125,500
Program Management and Development		
Program Administration	20,500	83,600
Program Logistic Support	108,500	45,200
Program Development	45,100	89,600
TOTAL	**$1,080,700**	**$619,400**

1981 BUDGET

Expenditures By Activity

	NOAA Grant Funds	Matching Funds
Marine Resources Development		
Aquaculture	$ 2,000	$ 33,800
Living Resources	208,100	95,200
Marine Economics	131,800	61,100
Socio-Economic and Legal Studies		
Socio-Political Studies	9,500	32,300
Marine Technology Research and Development		
Resources Recovery and Utilization	10,500	0
Marine Environmental Research		
Ecosystems Research	60,600	9,200
Pollution Studies	50,800	23,800
Marine Education and Training		
Other Education	154,000	54,900
Advisory Services		
Extension Programs	235,000	117,400
Program Management and Development		
Program Administration	196,900	206,100
Program Development	72,600	38,500
TOTAL	**$1,131,800**	**$672,300**

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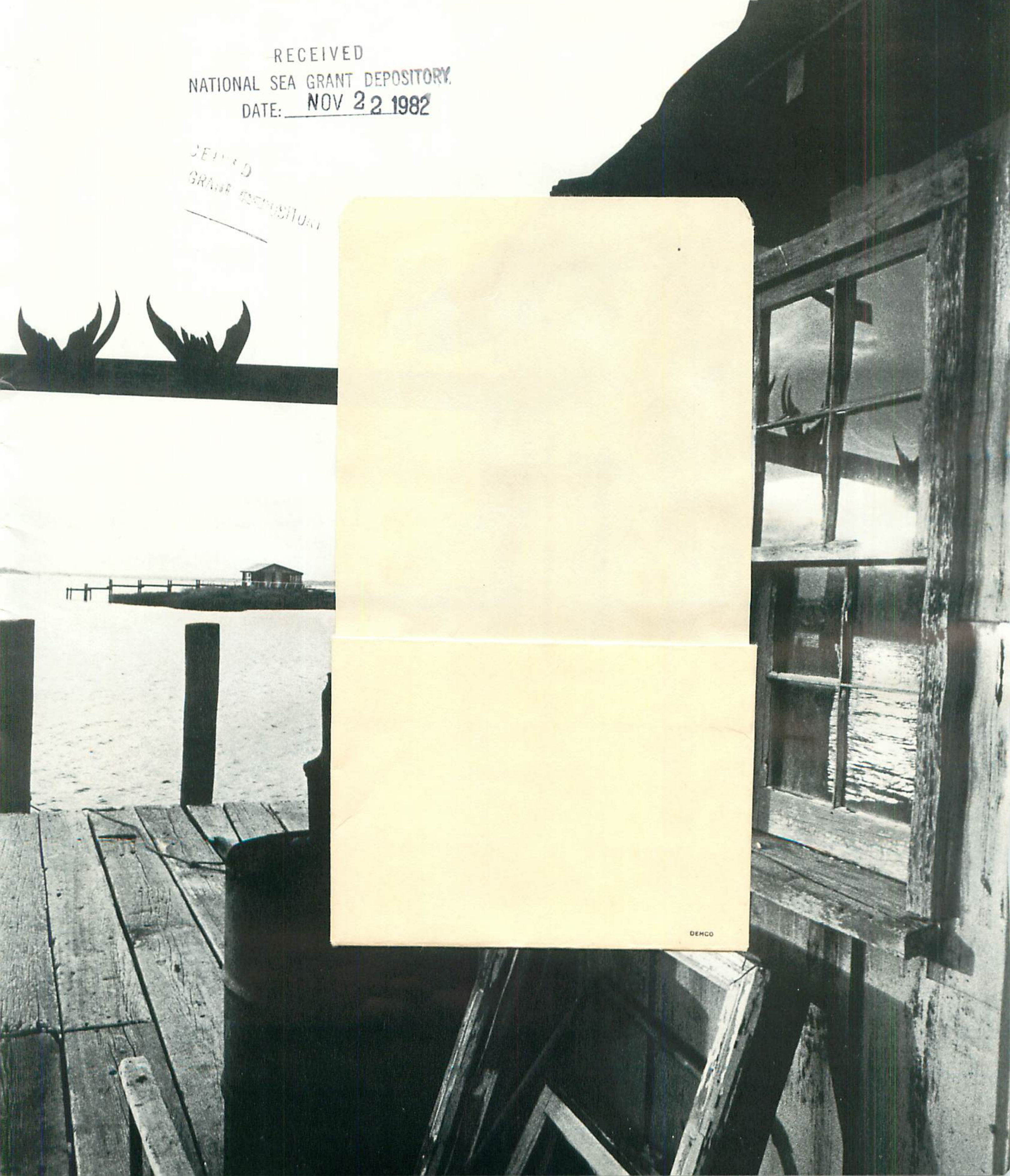

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