WILLIAM McCLOSKEY

THE CHESAPEAKE BAY:

Was 1983-84 the turning point for restoring the Bay's declining water quality?

The Chesapeake Bay is one of the most productive bodies of water in the world and also one of the most complex in its interactions between salt and fresh waters. In recent years, a number of disturbing changes have occurred: dramatic increases of toxicant and nutrient levels, decline of bay grasses, spread of anoxic waters, and near-disappearance of some finfish species. A massive seven-year study released in late 1983 by the Environmental Protection Agency focused on several Bay problems more comprehensively than ever before. It was effective enough to result in a landmark conference of governors, a formal agreement to cooperate among the federal and state governments involved, and some substantive legislation. Scientists caution that the job has only begun and that we need far more research to determine accurate causes and effects of the problems identified. However, there is a positive start.

The Chesapeake Bay, one of the world's great seafood grounds and marine recreation centers, can be a mellow place, a hard one, or both. Some of it depends on the season, some on one's purpose and state of mind.

One June morning we went sailing aboard the 40-foot cutter-rigged sloop Osprey. *We left the creek under power, but with sail covers off and halyards attached ready for hauling. The still water reflected darkly the low shoreline of trees and houses. Smells of pine and seaweed filled the air. Some of the channel markers we passed had bulky twig nests crammed into their towers. It meant that the ospreys—namesake of our boat—were back in health. Bay people consider these big, graceful birds a good omen; scientists call them an "indicator species" of the Bay's health. Two decades ago, ospreys were in danger of becoming zoo items when eggshells weakened from DDT spray made hatching of the next generation chancy. Conservationists flagged the danger in time and succeeded in pushing corrective legislation. Now we can see a black and white osprey head watching us calmly from the nest.*

Ideally it happens that way: responsible people identify problems; they are corrected; equilibrium is restored. Actions in the next handful of years will tell whether more sinister signals in Chesapeake waters will be turned around: the disappearnce or acute shortage of oysters and certain species of fish, an increase of blue-green algal blooms that choke other water life, the thinning of ecologically vital sea grasses, the spread of deep water areas devoid of life-sustaining oxygen. The causes appear to center around the effluents of civilization: a growing concentration of industrial metals and toxic organic compounds that settle to the Bay floor rather than flush to the ocean, and a surge of nutrient runoffs from farms and lawns.

A bright day for sailing on a tributary leading to the open Bay. The boat speeds past a marker in which an osprey has built its nest.

Such problems were addressed in greater depth than ever before, in reports from a massive seven-year study released by the Environmental Protection Agency (EPA) in the fall of 1983. The study flagged enough dangers and aroused enough concern that the cause

All photographs in this article are by William McCloskey.

of the Chesapeake Bay has become a popular one, even politically popular. In December 1983, during a major three-day meeting that drew an over-capacity attendance of scientists, legislators, and environmentalists, the governors of Maryland and Virginia (the two Bay states) joined with the Administrator of EPA, the mayor of Washington, D.C., and the lieutenant governor of Pennsylvania to translate the problems identified by EPA into courses of action. In the spring of 1984, the legislatures of Maryland and Virginia voted $38 million and $10.4 million, respectively, in new money for Bay environmental programs, while the other jurisdictions and EPA also budgeted new funds. Concern reached the top national level when President Reagan, in his 1984 State-of-the-Union Message, asked for an added EPA commitment of $10 million for Chesapeake Bay. (The President underscored his interest by a personal visit that July to a Bay watermen's community, Tilghman Island, Md., to speak of a national "commitment" on behalf of the Bay.) With funds of the same magnitude (and more) being budgeted for the next fiscal year by all the jurisdictions involved, and an EPA office now open in Annapolis to coordinate Chesapeake Bay programs, the effort to stem the destructive forces on the Bay appears to have settled in.

Aboard the Osprey, *a southerly breeze ripples the water where the creek enters the Bay, catching sunsparkles everywhere. Other sails fill the horizon clear to the opposite shore four miles across. We crank up both main and jib. A firm flap of canvas, and wind fills our sails. It bears us firmly, quietly, from amidships rather than pushing us from astern as would a noisy engine. This is one of the exhilarations of traveling under sail, the feel of being taken over by natural power. We spend the day coming about, reaching, tacking, making quick reefs and other adjustments for wind changes, sometimes taking a burst of spray and shivering in our waterproof jackets, sometimes stretching out to take our fill of the warm sun. (Bay weather and Bay winds suffer from no foolish consistency.) Sailing the Chesapeake Bay is one of life's delights.*

On another day, in winter, aboard the 42-foot working skipjack Sigsbee, *an easterly rain slashed our faces as we left Tilghman Island with a crew whose business was dredging oysters. Four-thirty AM, hours before daylight. We wore thermals, coveralls, oilskins, heavy boots, and thick waterproof gloves, but we still hunched against the cold, and stomped the deck to keep warm. The little cabin below had barely space for all of us together, knee to knee, as Sonny started the bacon frying.*

We reached a section of shore that Sigsbee *captain Wadie Murphy had waited all year to work, an area so close-in and shallow that it required both a favorable wind for maneuvering and the season's highest tide. By Maryland law we could only dredge under sail from Wednesday to Saturday. (Power from a motor-driven "yawl boat" is allowed on Mondays and Tuesdays. The law, by retaining 19th century inefficiency except for a "donkey" engine on board to lift the dredges, protects the fishery from the mechanization that would quickly deplete the finite oyster stocks.) For hours, our work pattern repeated itself every five minutes: dredges over, dredges up, rocks and oysters dumped on deck and culled, sails close-hauled to come about on reverse course, debris shoveled overboard, dredges over. Dredges by themselves weigh over a hundred pounds, double and triple that with a load. A windlass did the heaviest lifting, but not all. The work of culling bruises the knees or strains the back, depending on the position you take. Then there was the shoveling of rocks and shells, and the pull to adjust heavy canvas each time we came about. All under pressure, steadily, from dawn to late afternoon. It was a different sail on the Bay from that of a summer yachtsman.*

The harvest for a day's labor by five men? Eighty-five bushels of a possible 150 bushel quota, an unusually good haul in the slim 1983-84 season. Ironically, since 1884 was the year that Maryland landed its biggest oyster harvest of 15 million bushels,[1] 1984 turned out to have the record lowest harvest since statistics began to be kept: a mere 868,000 bushels.

The 1985 harvest may be lower. Marine biologists have recently begun blaming the spread of oxygen-depleted water for at least part of this alarming situation. A recent article in *Science*[2] by three Johns Hopkins University biologists supports this contention. They attribute the record low 1984-85 oyster harvests to "a major anoxic catastrophe" that occurred in Chesapeake Bay during the summer of 1984. The spring-summer flow of fresh river water became so concentrated and sustained that it formed a barrier over deeper oxygen-poor layers; an offshore weather system drove heavy intrusions of low-oxygen seawater under the barrier; a relative absence of summer storms provided no modifying force to mix the two layers. This unprecedented combination of weather conditions caused oxygen-depleted waters to spread far beyond their previous limits, from a normal 33 feet below the surface to water only half that depth. In the areas sampled, oysters living more than 20 feet below the surface had all died.

A HISTORY OF BLOODSHED AND ABUNDANCE

The Bay, as millions call it, recognizing no other, has for nearly four centuries of recorded history been a cornucopia of marine abundance, a major route of commerce, and a source of waterside pleasures. In 1607 in Jamestown, along the James River of the lower Bay, Captain John Smith helped establish the first permanent English settlement of the New World. He was hardly among the first inhabitants, since at that time he recorded some 200 Algonquian settlements located along Chesapeake shores, living from the riches of the waters and adjacent lands. Captain John (as he would be called by present-day watermen of the region) wrote: "... a faire Bay...with fruitful and delightsome land" where "Heaven and earth never agreed better to frame a place for man's habitation."

During an exploratory voyage in 1608, Smith noted abundant fish "lying so thicke with their heads above the water, as for want of nets (our barge driving amongst them) we attempted to catch them with a frying pan..."[3]

Chesapeake Bay abundance has remained legendary. A century ago, with catches at their peak, the succulent Bay oysters were such a profitable commodity that piracy and bloodshed were routine within the huge fleet of sail-powered dredge boats. Also enslavement—drifters and immigrants were often shanghaied to handcrank the heavy dredges.[4]

The brutality is hard to imagine in retrospect because Chesapeake Bay is a place of such mellow ambience and human-sized proportions. Its low, intimate vistas promise a relaxed lifestyle, and few places are regarded with such devotion. To watermen like Wadie Murphy and his crewmen, the Bay is more than a mere workplace. In their community of tight frame houses, every road leads to the water, which inescapably dominates not only their livelihood but also their hunting, recreation, and most other activities. The talk in the general store seldom strays from some aspect of the Bay. Elsewhere, Maryland and Virginia issue about 300,000 licenses every year for power-driven pleasure and work boats. Add to this all craft under only sail, oar, or paddle, and the number probably approaches half a million. On a calm summer day, boats dart everywhere like flitting insects, while on a bright breezy weekend from spring to fall (or a dark squally one for that matter) the number of sails on the horizon resembles a flock of low-flying birds.

If Captain John were to return he might still recognize some of the quiet marshes and inlets but, with his Algonquian neighbors, he would be startled by much of the rest. Over 12.7 million people now live in the Bay region, 4.2 million more than in 1950. The region includes the inhabitants of Baltimore, Washington, Richmond, and the Hampton Roads-Norfolk complex, and of numerous towns, villages, developments, and farms. By the year 2000, the projected population will rise to 14.6 million. At present, the major commercial activities are forestry (among the Appalachian-fed rivers of the Piedmont), agriculture, food processing (vegetables, poultry, seafood), ship-building, and leather tanning. Major industrial facilities manufacture steel, plastics, paper, resins, and chemicals. All manner of boats harvest the Bay's oysters, crabs, clams, eels, and various finfish. Bay water (including tributaries) provides the coolant for more than 30 power plants. The swelling population exploits more of the Bay every year.

THE GREATEST ESTUARY IN THE UNITED STATES

> 20,000 years ago: There was no Chesapeake Bay. There had been one 100,000 years before, and there would be one again, but it would be another 15,000 years before a waterman could find in it his familiar landmarks.[5]

Statistically, Chesapeake Bay is a very impressive place. It stretches nearly 200 miles from the mouth of the Susquehanna to the Atlantic Ocean, ranging between 3 and 22 miles wide. This makes it the largest estuary in the United States—second in North America only to Hudson Bay. (An estuary is a semienclosed body of river-fed water that meets the ocean and is affected by its tides. A more graceful definition: "To qualify as an estuary, a body of water must be well enclosed, provide easy entry and exit from open sea water and enjoy a vigorous infusion of fresh water from one or more rivers."[6])

Including its rivers, the Bay has a water area of 4300 square miles, providing 8100 miles of shoreline, about 4000 on the Bay itself. The Bay proper runs through the eastern parts of Maryland and Virginia. Some dozen major rivers and 40 lesser ones, as well as numerous streams, feed the main body. They flow from the two states named above as well as from Pennsylvania, Delaware, West Virginia, and even New York, to form a drainage basin of 64,000 square miles. Counting its rivers, the Bay touches, and is affected by, approximately 90% of Maryland's land area and 60% of Virginia's.

Some of the rivers, many with haunting Indian names that evoke the past, are systems in themselves. The Susquehanna, northern source and mother stream, provides 50% of the Bay's fresh water. (In the late Pleistocene era referred to by Schubel,[5] the Bay was merely the Susquehanna riverbed.) The long Potomac, which flows through Washington, D.C.; the James, which flows through Richmond and past Norfolk; the Patapsco (a smaller river), which empties into Baltimore harbor; and the Rappahannock, which flows through Fredericksburg, all support industries and extensive suburban development. Other major western shore rivers are the Patuxent and the York. On the flat eastern shore are the shorter, seafood-rich Eastern Bay and the Choptank, Nanticoke, Wicomico, and Chester Rivers.

A dredge-reinforced channel allows Baltimore to be one of North America's major seaports although located 150 miles from the ocean. Aside from this, the Bay is relatively shallow. Depths no greater than 15 to 30 feet allow sunlight to penetrate and oxygen to mix throughout the entire water column (except where man's sediments and pollutants have produced clouding and anoxia). Shallow depths also make the water quickly responsive to changes in surface temperature.

The Bay, as a large estuary affected by circulation, salinity, and temperature, is one of the most complex ecological systems in the world. Fresh water pours from its rivers and streams, while salt water enters on tides from the ocean, creating a continuous flow of fresh and salt water from opposing directions. With the Bay as long as it is, water at the northern river sources remains fresh, usually unaffected by the sea. The salt ocean water, being denser than fresh, enters the Bay in the deeper layers. The layers retain their characteristics, while mixing where they overlap. In some places, the mix varies with the season; e.g.,

spring thaws and rains pour a great concentration of fresh water into the areas near river mouths. Another profile, having to do with tidal circulations and the earth's rotation, makes Bay water saltier along the eastern shore. Thus every segment has its own geographical and seasonal pattern. These patterns in turn dictate the availability and type of nutrients, the growth of feed organisms, and the concentrations of plant and animal life.

A Web of Biological Dependencies

In the words of Baltimore's writer-sage Henry L. Mencken: "Baltimore lay near the immense protein factory of Chesapeake Bay, and out of the bay, it ate divinely."[7] Among the Bay's 2700 species that contribute to the pleasures of Maryland and Virginia tables are such mollusks as oysters; such crustaceans as blue crabs; catadromous fish (those that spawn in the sea but feed in fresh water for part of their lives) including menhaden, eels, sea trout, flounders, bluefish, and croakers or "hardheads"; and anadromous fish (those that lay eggs in fresh water but return to the sea), including shad, striped bass or "rockfish," and herring. Tied to the Bay for their habitat are also the geese, ducks, and swans that stop over during their seasonal migrations south from Canada, as well as eagles, ospreys, and other resident and migratory birds.

This teeming life makes the Bay a web of biological dependencies. There are five identifiable communities: the marsh-dwellers, the bay grass inhabiters, the benthics or bottom residents, the floaters and drifters or plankton, and the swimmers or nekton.

The marsh-dwellers—certain birds and animals plus a host of invertebrates that end as feed for higher creatures—live close to shore in the moist vegetated areas called wetlands. Here they receive a rich nutrient supply centered around decomposed plants. The bay grass inhabiters—the young of many species including crabs, perch, and striped bass—receive cover and food in shallow water from submerged grasses of which the Bay has ten major species. The marshes and the bay grasses also act as nutrient buffers, taking up nitrogen and phosphorus, then releasing them when the plants decay.

The benthic community on the bottom of the Bay includes clams, oysters, mature blue crabs in some stages, and many other invertebrate creatures. Plant and bacterial groups are also crucial parts of this ecosystem. With limited or no mobility, the benthics are especially affected by variations of salinity and by lack of oxygen. The deadly oyster parasite MSX, for example, thrives in dry years when the rivers pour less fresh rainwater into the Bay. Hard-shell clams require higher salinity than soft-shell clams, and this determines their locations. The floaters and drifters, primarily zooplankton and phytoplankton (microscopic animals and plants), are the larger Bay creatures' basic feed. The community also includes the bacteria, essential for decomposing dead matter, and the jellyfish, which are the bane of summer bathers. The fifth community, nekton, comprises the swimmers: certain crustaceans, squid, and some 200 species of fish that either live permanently in the Bay (generally the smaller species) or enter it for part of their spawning and feeding cycles.

Three of the great delicacies of the Chesapeake Bay are oysters, rockfish (striped bass), and blue crabs. The seasons for catching them are fall and winter for oysters, spring to fall for rock, and summer for crabs. Recent trends have seen diminished oyster harvests, a virtual disappearance of rockfish, but an increased abundance of crabs.

THE EPA STUDY[8]

The current Bay consciousness—what area newspaper has not headlined some variant of THE BAY IS

DYING, with the implication that the reporter hears the final gurgle as he writes?—received its impetus from a provision in the 1976 appropriation bill for the EPA. The provision, shepherded by Maryland Senator Charles McC. Mathias, appropriated $25 million for an intensive five-year study of the Bay's resources and water quality. (This eventually was extended with additional funds.) While many studies existed on the negative effects of pollution in specific areas of the Bay, much of this had never been tied together. Also, some painfully apparent problems had been documented but not analyzed for causes, particularly the steady decline of Bay grasses and of certain fish, such as the popular shad and striped bass. Researchers were charged with reviewing the available literature, establishing patterns from it, then assessing the significance of the patterns and suggesting management strategies to deal with the problems identified. The panel published preliminary conclusions in September 1982, and delivered its full documentation and recommendations in late 1983.

The EPA study enlisted the efforts of some one hundred scientists and other professionals and resulted in approximately 40 final research and survey reports. Frances Flanigan, public participation director of the study under a contract with the multiorganization Citizens Program for the Chesapeake Bay, characterizes it as "a snapshot of the entire Bay system that we lacked before."

While the study and its findings have received general approbation, many in the scientific community express disappointment over the small percentage of precious funds allotted to primary research. (*"Research? They've done the research," declares one of my waterman friends, echoing a popular prejudice. "Now they'd better start doing something to bring back the oysters and rockfish!"*)

Dr. Maurice P. Lynch of the Virginia Institute of Marine Science, director of the Chesapeake Research Consortium, feels that the EPA study was responsible for "some good research and reasonable recommendations." He noted in particular the toxics study, whose solid accomplishments include providing a toxics baseline that had not existed before. "Now we have the capability to develop a monitoring system that would give us an early warning if some toxic material starts to build up." However, said Lynch, "the main fault I have with the whole report is an impression that no more research is really necessary. Actually we've barely scratched the surface, and it'll be that way as long as we put such small amounts of money into Bay research." Lynch points out that the study, which had "extremely modest funding, not enough to build and equip one military aircraft," was forced to choose only three of ten problem areas identified with the Bay.

The EPA study concentrated on the decline of submerged aquatic vegetation, accumulation of toxic substances, and nutrient enrichment. Lynch finds four other of the problem areas particularly important because they tie in with local commerce and industry as well as with historical conflicts between recreational and commercial uses of the Bay. These areas are fisheries "modification" or management, dredging and dredge material disposal, shellfish bed closures, and the effects of boating and shipping on water quality. The remaining three areas are wetlands alteration, shoreline erosion, and hydrologic modification.

Changes in Water and Sediment Quality

Following is a summary of the changes and trends that the study identifies in Chesapeake Bay water and sediment quality:

Toxic Organic Compounds. High concentrations of hydrocarbons, pesticides, and herbicides were found in bottom sediments of the northern Bay (i.e., farthest from the sea), especially near sources, river mouths, and areas of maximum turbidity. Sediment samples of the Patapsco and Elizabeth Rivers, draining Baltimore and Norfolk, contained the highest toxic concentrations. According to the EPA report, "These general trends suggest that many of the problem organic compounds in the Bay tend to adsorb to suspended sediments, and then accumulate in areas dominated by fine-grained sediments. Benthic organisms located in such areas tend to accumulate the organic compounds in their tissues. Studies of Kepone, a toxic organic substance which was discharged into the James River during the 1970s, have further substantiated these conclusions. A major mechanism for accumulation of this persistent pesticide appears to be bioconcentration by plankton; this fact has implications for transfer of this and similar toxicants through the food web."

A "degraded urban stream" gets a second chance amid general TV and neighborhood attention. After a cleanup campaign, biologists from the Maryland Department of Natural Resources' Save Our Streams Program emptied bucketsful of rainbow trout into Stony Run. This small urban stream rambles into the Patapsco River from a north Baltimore suburb and thence to Chesapeake Bay. One of the biologists estimated that the stream has probably not seen trout for 200 years; lead and zinc levels are as much as 10,000 times greater than back then, from such substances as gasoline, oil, and old paint poured into storm drains, while the runoff also includes great quantities of pesticides, fertilizers, and pet droppings from lawns. The loads of nutrients and toxics from urban/suburban streams are two to four times greater than from farm streams, whose runoff is also considered a major problem to the Bay.

(a) The classic concept of Chesapeake Bay oystering must include the famous skipjack, a vessel of rakish design that has plowed Bay waters for generations. (b) Smaller vessels are also used by oystermen like Captain Lester Lee and his son Don, seen here shaft tonging, or (c) like John Orme using a technique called patent tonging. (d) Dredging and culling aboard a skipjack results in mounds of marketable oysters fore and aft as the day wears on. (e) Equally important to the industry, in mid-April each year, the State of Maryland Department of Natural Resources hires watermen to dredge up tons of oyster shells that have been seeded with oyster young, called "spat," and to plant them in other selected locations in order to maintain a potential for the next year's harvest. (f) Dredging oysters by skipjack often requires constant and arduous shifting of sail to maintain position in a small, carefully controlled area. (g) At the end of a day's work, oysters are measured out in regulation-size buckets for delivery to their buyers.

CHESAPEAKE BAY OYSTERING

The traditional cycle for Chesapeake watermen who live in small Bay communities and "follow the water" is to work the oysters from mid-fall to mid-spring, take a short breather to mend gear and boats (perhaps in spring to set out eel pots and various fish nets), then work trotlines and pots for blue crabs throughout the summer. With the oysters, "If you haven't made it by Christmas, you won't make it," is the accepted wisdom, because winter weather closes in and, curiously, consumption of oysters drops off. (How many people hold mid-winter or spring oyster roasts?)

The Chesapeake Bay oyster fishery had an amazing history of piracy and brutality a century ago. A ready urban market for the succulent bivalves inspired entrepreneurs to finance boats in the fishery. Those boats, under sail and without hauling machinery, required bull labor to hand-crank the dredges—in the bitter, wet cold of winter. It was a classic scenario of greed and cruel human exploitation. Shanghaied workers were often held near-captive aboard the boats,[3] sometimes murdered at the end of the season rather than being paid off. The vestiges of this hard oystering life remain in the famous sail-powered workboats called skipjacks, except that a "donkey engine" on deck now hauls the heavy dredges, and the hardy men who work aboard do it by choice.

Chesapeake oysters grow on rough surfaces like oyster shell, in relatively shallow-water "bars." Watermen harvest them with four different kinds of gear: dredge, hand (shaft) tong, patent tong, and wetsuit diving. The latter is a new and controversial method, resented by many older watermen, that allows hand selection without disturbing an entire bed. Dredges dragged by the skipjacks bring up everything, including big rocks. The most self- sufficient, and hardest, method is with the 30-foot shaft tongs, operated by hand, that most watermen have used at some time in their lives. There may be ways to ease tonging with body rhythm and balance, but it remains a backbuster. Hydraulically powered patent tongs allow one man to operate without the heavy manual work of shaft tongs.

Metal Concentrations. While these chemical elements occur naturally in the environment, an excess of them can be toxic to organisms. Among specific sources, cadmium, in particular, comes from industry, chromium and iron from shore erosion, copper from municipal and industrial plants, lead from urban runoff, and zinc from atmospheric deposition. "The most contaminated sediments are located in the Patapsco and Elizabeth Rivers, both heavily industrialized tributaries. Metal concentrations up to 100 times greater than natural background levels were found in these areas." High levels were also identified in the upper Potomac, upper James, small sections of the Rappahannock and York Rivers, and the upper mid-Bay; moderate contamination was recorded in the Susquehanna flats and off the mouth of the Potomac. According to the EPA report: "These trends suggest that higher concentrations are found near industrial sources and in areas where fine sediments accumulate, such as in the deep shipping channel of the upper Bay. In general, there is little movement of metals out of the most contaminated areas, except when physically transported, as might occur through movement or disposal of contaminated dredge material."

Nutrients. Nitrogen and phosphorous compounds (the nutrients) are entering the upper- and mid-Bay in increasing levels, although pollution control measures have lowered the levels in the Patapsco, Potomac, and James Rivers. The Susquehanna River flowing through the rich Pennsylvania farm country furnishes nearly half this excess, from fertilizer and manure runoff, while other "nonpoint" sources pour in significant levels from lawns and city streets. Nutrients are essential for plant growth, thus for primary productivity in the Bay. However, an oversupply of nutrients stimulates blooms of undesirable algae, in the process reducing dissolved oxygen and decreasing water clarity. Where these conditions result in a scarcity of feed organisms and shelter, all water life diminishes.

Dissolved Oxygen. Dissolved oxygen is necessary in water to sustain the growth of feed organisms. It appears to be disappearing in spring and summer from the deeper water of the central Bay as well as from some major rivers feeding the Bay. One of the effects is to drive out the crabs, sometimes to the beaches. Another is to kill such benthics as oysters, which cannot shift location. The anoxic water was first observed in the 1930s, but the condition appears to have increased manyfold since then. The EPA study blames excess nutrients for the condition, at least in part. The nutrients stimulate an overgrowth of algae, which then die, settle to the bottom, and in decaying, consume the available oxygen. (An ancillary theory suggests that some of the anoxia may result from physical stratification of the water column that results from seasonal spring inundations of fresh water.) According to the EPA study, "It is estimated that the volume of water with DO [dissolved oxygen] concentrations equal to or less than 0.7 milligram per liter was 15 times greater in 1980 than in 1950. The duration of oxygen depletion has also increased. It was sporadic during the mid-1950s; it occurred from mid-June to mid-August during the 1960s; and, in 1980, it began the first week in May and continued into September. This increase in the spatial and temporal extent of low DO levels reduces the area of the Bay that can support normal finfish and shellfish populations." Studies in progress indicate that 1984 may be the year of record low levels of dissolved oxygen.

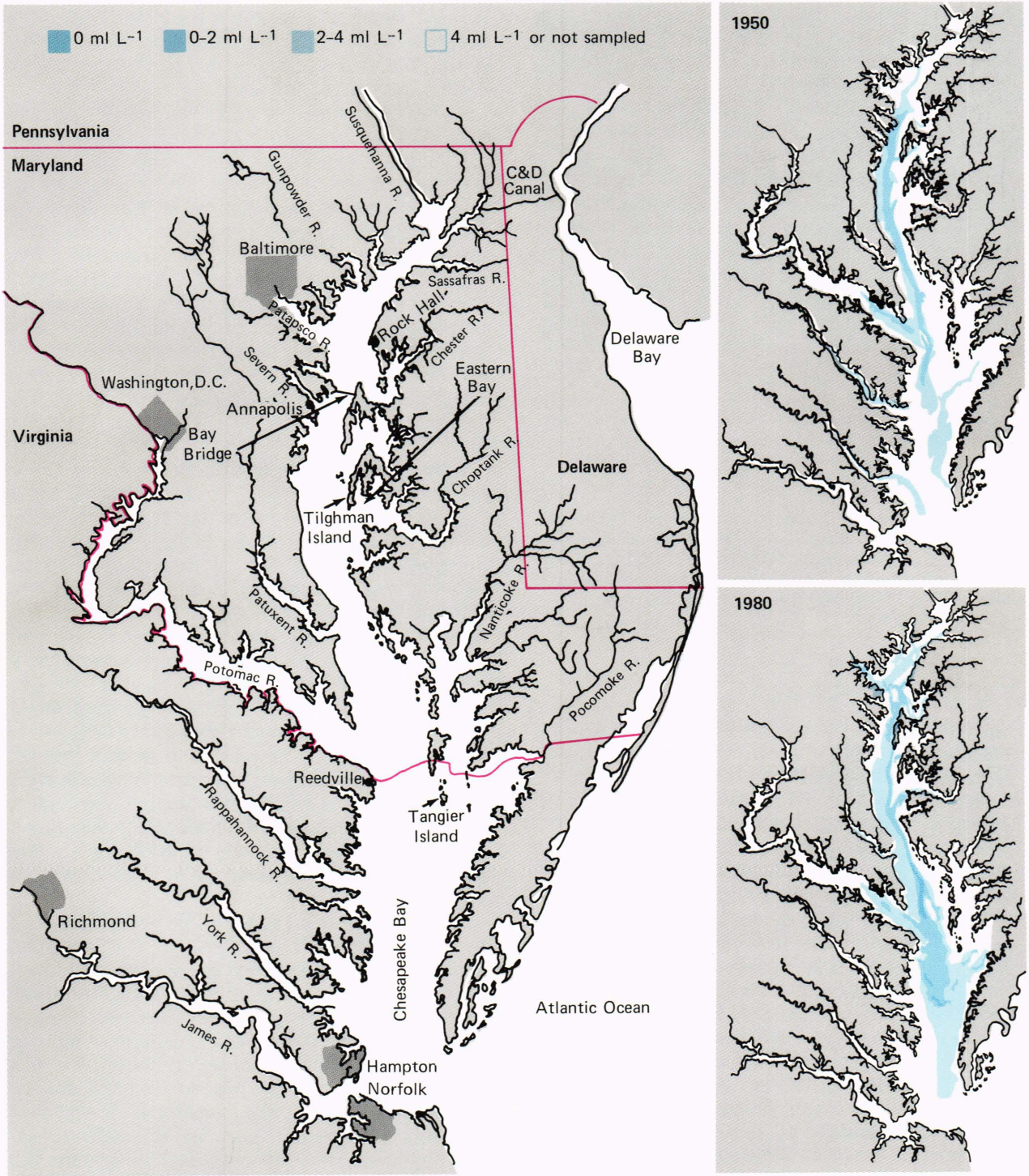
What Goes In, Stays In. The study emphasized a condition recognized recently enough to remain startling: due to complex tidal and circulation patterns, the Bay is a series of "sinks" that trap and keep toxic materials rather than permitting a tidal flush that would eventually send them into the ocean. Sediments in the upper- and mid-Bay show high permanent levels of nutrients and synthetic organic chemicals. Thus the Bay collects and recycles pollutants.

Changes in Living Resources

The EPA study also reprinted data from other sources on several major changes in the living resources of the Bay. The most significant were the decline of aquatic vegetation, the decrease in anadromous fish, and a parallel increase in some stocks of catadromous fish.

Submerged Aquatic Vegetation. Since the 1960s, submerged aquatic vegetation has declined dramatically in abundance and diversity. Studies by the Fish and Wildlife Service and by the states show that the decline, which seriously affects many of the Bay's ecological cycles, is most severe in the upper Bay and western rivers. However, the loss is moving progressively downstream. As noted above, this vegetation provides habitats for a great variety of creatures along the food chain. For example, it shelters and feeds baby crabs at a stage where they can easily become feed for large fish. All manner of wildfowl eat the grasses. Some, like the redhead duck, now stop elsewhere in their annual fall migration south from Canada since the grasses have thinned. Redheads, once the chief target of recreational hunters on the bay (duck blinds were part of the autumn scene), now are a rare sight. Other wildfowl, like geese and whistling swans, have adapted to grazing in nearby farm fields while continuing to roost on the water, and their numbers have actually increased.

The Harvest. It took no study for those who fish the upper and middle Bay to see the thinning of striped bass and shad since the early 1970s. Shad has disappeared from the Bay as a commercial species. (In spring, Chesapeake area residents still relish the bonelaced, rich shad and its luscious roe, but the fish is caught in other waters, principally Delaware Bay.) And catches of striped bass, the signature "rockfish" of the Chesapeake, have declined by 90 percent in a decade. Less known, except to those involved, is the growth of recent harvests of menhaden, a sardine-like fish seined by the millions for fish meal. The menhaden seine fleet centers in Reedville, Va., on the lower Bay. It follows the fish as they travel in vast schools into



Dissolved oxygen levels in Chesapeake Bay in 1950 (top right) and 1980 (bottom right). Locations of communities and rivers are identified in the larger map at left. (Derived from maps and data provided by the Environmental Protection Agency.)

the Bay and along the east coast from New York to North Carolina. Since 1969, catches have increased steadily to almost three times their former level, the most coming from Chesapeake Bay. Bay sportsmen sometimes blame the menhaden seiners for decimating the feed of other species. However, one of the prime menhaden feeders, bluefish, has also shown a steady increase in Bay waters.

As for oysters, the annual harvest has dropped to one third of the averages 30 years ago. Catches of blue crabs, on the other hand, have increased. The EPA study speculates that this may be due only to increased fishing effort by watermen who must make up in the summer for fewer oysters in fall and winter, and for empty fish nets in spring. (If this is the case, it could mean trouble ahead for the blue crab stocks.)

Full menhaden seine in one of the world's highest volume fisheries. Two "purse" boats surround a school of menhaden with their purse seine, while the 160-foot mothership waits nearby to take the haul aboard by means of a suction hose that pulls the catch into the hold at a rate of 10,000 fish per minute. The abundance of the haul can be seen from the rim of fish swelling the net beneath the water. The work is fast-paced and organized, with spotter planes seeking out schools of fish and guiding the boats to them. The menhaden fleet of Reedville, Va., has been part of the lower Chesapeake Bay scene for over a century, providing fish meal and oil. Around the turn of the century, menhaden gave Reedville "a reputation of having the highest per capita wealth of any community in the country."[13]

The Web of Relationships

A summarizing excerpt from the EPA study illustrates the interdependencies of the problems identified. "The observed relationships between the water quality and resource trends, and laboratory research, has enabled us to begin to identify cause and effect. For example, Bay-wide, the areas experiencing significant loss of SAV [submerged aquatic vegetation] have high nutrient water column concentrations. The high levels of nutrients enhance phytoplankton growth and epiphytic fouling of plants, thus reducing the light reaching SAV to below critical levels. However, it is also probable that high levels of turbidity and herbicides contribute to the SAV problem in localized areas. In another analysis, the reduced diversity and abundance of benthic organisms in urbanized areas was related to toxic contamination of sediments. Low dissolved oxygen in the summertime is also a major factor limiting the benthic population, particularly in the upper- and mid-Bay. The low oxygen content is attributed to increased algal production and decay triggered by nutrient enrichment. Lastly, nutrient enrichment and increased levels of toxicants occur in the major spawning and nursery areas for anadromous fish, as well as in areas experiencing reduced oyster spat."

Aboard the Osprey *the wind begins to pick up as it shifts to the southeast. In late afternoon the sky has turned gray and the water roughens. We decide to find shelter for the night at Solomons, a small southern Maryland town with an enclosed harbor. Since we're heading into the wind and bucking floodtide, we must tack every few minutes and our headway is painfully slow. It seems that we stay for hours abreast of the Baltimore Gas & Electric Company's Calvert Cliffs power plant with its 560-foot turbine building and two cistern-like reactor structures.*

Calvert Cliffs used to be known best for its easily accessible sea fossils from the Myocene era 15 to 20 million years ago: shark's teeth, whale and porpoise vertebrae, oyster and clam parts. Now the location also represents the requirements of human population along Chesapeake Bay. The nuclear-powered plant, operating since 1975, delivers 1650 megawatts of electricity to a surrounding area of 2300 square miles. It uses Bay water to cool its reactors, a staggering 2.4 million gallons a minute. Studies indicate that this in itself does not damage the surrounding water life, but the volume gives a sobering picture of the scale on which some parts of the Bay are used.

BACKGROUND OF PAST ACTIONS

Efforts to deal with specific Bay problems did not begin with the EPA study. The disastrous mid-1970s Kepone contamination of the James River in the lower Bay was the worst recent example of toxic waste dumping. It sparked better enforcement of existing Virginia laws (even though much of the monitoring still relies on information supplied by the potential pollutor). Greenpeace, an activist environmental organization, began in 1983 to hold consciousness-raising demonstrations beside the effluent pipes of some Maryland factories pumping into Bay waters. On another front, Maryland and Virginia have been regulating the discharge of chlorine from sewage treatment plants, especially in spawning rivers. As one example, the Blue Plains plant near Washington now removes nutrients as well as bacteria, toxicants, and sediment. As a result of such controls, the EPA study reports some improvement of water quality in the heavily polluted Potomac River.

Concern continues, also, for the water life affected by power plants. For over a decade, The Johns Hopkins University Applied Physics Laboratory conducted site evaluations for the State of Maryland. It assessed, for preventive action, potential Bay problems that might arise from locating power plants at certain sites. Studies included the effect on Bay water of biocides such as chlorine that are used to kill organisms that foul plant condensers, and of coal waste leachates like the heavy metals arsenic, selenium, and cadmium. One APL study was aimed at preventing fish eggs and shellfish larvae from being caught in intake screens or being drawn into plant cooling systems.[9] A number of studies during the past several years have dealt with the population dynamics of striped bass, including studies of their migratory behavior, as well as the effects of specific pollutants on striped bass eggs and larvae.[10-12]

Another APL program that is just beginning will coordinate the work of several Johns Hopkins divisions to produce an understanding of the interrelated biophysical processes present in the Bay. In the long

In a Chester River tributary, Ronald Klauda (right) of the APL Aquatic Ecology Section and technician Steve Fischer, capture spawning blueback herring to remove and fertilize their eggs. The resulting larvae will contribute to a study for the Maryland power plant siting program at APL's Shady Side facility, to determine effects of acid rain and dissolved aluminum on eggs and juveniles of Bay-spawning fish.

term, the program will develop data that may result in a comprehensive Bay computer model. Potentially, such a model could be used to evaluate the effect of human activities on the ecology of the Bay. The initial study is exploring the processes that control the Bay's oxygen levels, focusing on the summer disappearance of oxygen that sweeps life from certain deep Bay waters.

Congress, in 1965, authorized the Army Corps of Engineers to build a massive three-dimensional hydraulic model of the Chesapeake Bay. The resulting scaled replica, operational from 1978 until 1983, covers 14 acres under a single roof. It duplicates the flow of the Bay, with tidal seawater entering from the ocean and fresh water flowing from the rivers at exactly the rates (to scale) that occur in nature. An actual 14-hour tidal cycle takes eight minutes. The model can, with seasonal variations, reproduce tides, currents, salt- and freshwater mixes, some temperature changes, and sediment dispersions for numerous tests of Bay functions. At this writing, the model has been closed down and its fate is uncertain because of budget cuts. Among Bay scientists, attitudes toward the model range from disdain (especially among computer model advocates) to concerned support. Since much significant Bay research is just beginning, some suggest that a combination of physical and numerical modeling would produce a whole greater than the parts. One option would incorporate the model into a new Chesapeake Bay Educational Center. Many consider it too valuable a tool to waste.

The Chesapeake Bay hydraulic model, constructed by the Army Corps of Engineers, covers 14 acres. It simulates to scale the flow and mixture of Bay water from the rivers and the ocean. The model is shown from the perspective of Baltimore Harbor.

SORTING THE BAY ORGANIZATIONS

The number of organizations involved in Bay activities can be confusing, since their titles are similar. Among the principal ones, the **Chesapeake Research Consortium** coordinates the Bay-related work of four major research organizations: William and Mary College's Virginia Institute of Marine Science; the University of Maryland's Center for Environmental and Estuarine Studies; the Smithsonian Institution's Smithsonian Environmental Research Center; and The Johns Hopkins University's Chesapeake Bay Institute and Applied Physics Laboratory.

The **Chesapeake Bay Commission** is a legislative advisory group, funded jointly by Maryland and Virginia, that deals primarily with Bay matters of mutual concern to the two states. (Pennsylvania is now in the process of joining.) The **Chesapeake Executive Council** was established at the Governors' Conference in December 1983. Chaired by EPA, it will coordinate the Bay-related programs of the EPA and of Maryland, Virginia, Pennsylvania, and the District of Columbia.

Among private organizations, the **Chesapeake Bay Foundation** is the most visible. With some 23,000 dues-paying members, the Foundation lobbies actively on Bay matters, distributes Bay information through a monthly newsletter, plans a variety of educational field trips, and manages several hundred acres of land adjoining the Bay for education and conservation. The **Citizens Program for the Chesapeake Bay** is a confederation of some 45 organizations concerned with the Bay. With a mission to provide "a neutral forum" on Bay issues, it works as a consultant to government agencies concerned with the Bay. In recent years, under contract, it has coordinated public participation in the EPA study, laid the groundwork for the National Science Foundation for a Bay Information Center, and managed the Governors' Conference. It is now under contract to EPA to follow the study with practical action. Currently under consideration in Maryland is the formation of a **Chesapeake Bay Trust**, a

corporate entity outside the state government through which the private sector could channel funds for Bay projects.

WHAT ARE WE GOING TO DO ABOUT IT?

In Chesapeake Bay annals, the EPA study and the Governors' Conference that followed may make 1983 as important an historical date as 1607, for the founding of Jamestown, and 1884, for a 15-million-bushel oyster harvest. The fact that four legislative heads signed a mutual cooperation agreement with the federal government is considered significant because historically the jurisdictions have not always shared the same interest in using the Bay. For example, over the years, Maryland has regulated its portion of the Bay more tightly than Virginia. Often bad feeling erupted into open fighting among watermen of the two states—it still does—when Virginia fishermen worked migrating stocks forbidden to Maryland fishermen. (Maryland has more at stake. The Bay floor is 20 percent of Maryland's total area, but only 5 percent of Virginia's, whose western counties also have no contact with the Bay nor reason to be concerned for it.) As for Pennsylvania, it derives no direct benefit except recreation from Chesapeake Bay. But the great Susquehanna River, draining hundreds of miles of Pennsylvania farmland, creates at least 50 percent of the excess nutrient problem and carries other pollutants besides.

There were thoughtful and encouraging words spoken at the conference. "At the same time we have been nourished by its spirit," said Virginia Governor Charles S. Robb about the Bay, "we have been neglectful of its vitality." Pennsylvania Lieutenant Governor William W. Scranton III declared his state's intention to be a "good neighbor." Maryland Governor Harry Hughes stated: "You have told us to save the Bay, and we will." Said EPA Administrator William D. Ruckelshaus, "The Chesapeake, more than most bodies of water, is a people's bay. Its survival is up to all of us." District of Columbia Mayor Marion Barry called the Potomac "the nation's river" and pledged an effort to clean the District of Columbia portion. Captain Jacques Cousteau, guest speaker, said: "We have to convince people that actions for the Bay are in their own long-range interest. We have to tell them we are not doing this for the fish, we are doing it for them." (The famous engineer and oceans publicist has recently opened a Bay studies laboratory in the lower Bay.) In his keynote address, Dr. Eugene Cronin, then-director of the Chesapeake Research Consortium, defined the job ahead: "Collectively, we must reverse the threats and trends of the past, reduce pollution to a tolerable level and assure, as far as humanly possible, that they will not again exceed the capacities of the Bay system."

The Governors' Conference had the double purpose of enlisting support from the leading administrative bodies involved and of pooling expert thought on the best ways to manage the work of solving Bay problems. The 700 participants spent one day in workshops

In the shadow of the Chesapeake Bay Bridge, on May 29, 1984, Maryland Governor Harry Hughes signs 10 new bills aimed at improving Chesapeake Bay water quality. At his right are Melvin A. Steinberg, President of the Maryland Senate, and William D. Ruckelshaus, then-Administrator of the Environmental Protection Agency. The EPA head attended in order to underscore the federal government's commitment to cooperation with the states in cleaning up the Bay. Said Hughes: "We are the first generation to reject our thoughtless negligence towards the Bay." Added Ruckelshaus: "We can do it as long as we have the political will."

on specific issues, considering proposals that pilot groups had drafted earlier. Hopefully, some of the thinking thus generated will enrich future planning. On the final day, the heads of the three states and the District of Columbia each outlined specific programs. (Later they succeeded in following them through within their jurisdictions; see below.)

Governor Harry Hughes presented the largest budget, for Maryland, involving $40 million in new capital and operating funds in fiscal year 1985. He noted realistically that the complete restoration of the Bay would take two decades. Hughes' opening actions were subsequently embodied in 10 legislative bills. In spring 1984, the Maryland General Assembly debated some of the bills hotly, and Hughes was forced to alter certain other state programs to find the money, but his 10 bills passed with only a $2 million cut. (The programs were renewed in Maryland's fiscal 1986 budget at the same funding level, with an approximate 5 percent increase for inflation.) The most controversial of Hughes' programs established a Critical Areas Commission to set standards for development within 1000 feet of the Bay and its tributaries. It passed only in the final late-night session after heavy scrutiny from developers and local governments who feared it might infringe on traditional local control of zoning and development. Besides the commission, the new Maryland bills provided funds to work on the following:

- Triple the state's share of federally supported sewage treatment improvements
- Fund dechlorination throughout the state
- Implement conservation plans on all farms in critical areas within five years

- Protect nontidal wetlands
- Arrest the loss of forest lands
- Implement pretreatment programs
- Computerize inspection and monitoring data
- Centralize and enforce the sediment control program
- Develop management plans for major fish species
- Triple the shore erosion control program
- Restore oyster and finfish populations
- Build a hatchery for black ducks
- Expand education programs for students

Governor Charles Robb proposed a $6 million program for Virginia. However, the Virginia General Assembly, meeting in spring 1984, considered Bay cleanup important enough to increase the funding to $13.4 million over a two-year period. Significantly, $1.7 million was added for *research* in three areas: toxic studies, fish populations, and the relation of toxic circulation to oysters. The Virginia package of initiatives included the following:

- Assist the agricultural community with cost share grants to protect land against erosion
- Reduce urban runoff through grants to local governments for staff and for demonstration projects
- Correct infiltration and inflow problems in old sewer lines
- Install new systems to replace failing septic systems
- Reduce chlorine and substitute other disinfectants
- Replant bay grasses
- Monitor toxic chemicals
- Expand public education programs
- Improve fisheries data
- Develop fisheries management plans
- Establish and administer a tracking system to coordinate in-state programs and monitor their effectiveness

Lieutenant Governor William Scranton announced a plan to reduce Pennsylvania's nonpoint (mostly farm-related) pollution. The $2 million he proposed was approved in June by the Pennsylvania General Assembly, which also passed a resolution to investigate the state's role in affecting the Bay. Included in the Pennsylvania effort are the following:

- Increase the financial assistance available to farmers to implement best management practices
- Provide additional technical staff to accelerate programs
- Conduct an education program that includes the Farmer's Association, the Grange, and the Farmers Union
- Develop a pilot program on manure marketing
- Create a community methane digestion system from animal wastes
- Fund research on nutrient and pesticide loss from no-till farms
- Implement the Mason-Dixon Erosion Control Project

The key to the program announced by District of Columbia Mayor Marion Barry was enactment of a comprehensive water pollution control act. Three water quality projects also required implementation: to reduce combined sewer overflows, dechlorinate sewage effluent at the Blue Plains sewage treatment plant, and dispose of sludge from Blue Plains.

William Ruckelshaus, then-Administrator of the Environmental Protection Agency, outlined EPA's ongoing programs in support of the Bay. These included spending $163 million in 1984 in the Bay states for sewage construction grants, and $15 million to support state water quality programs. New initiatives included establishing a liaison office in Annapolis and a toxics program in Baltimore Harbor (one of only three such efforts in the United States), giving technical assistance, and coordinating other federal activities that affect the Bay.

One important EPA program is a computerized database of Bay characteristics that was prepared as part of the Bay study. It is said that the Bay computer (in the Annapolis office) contains the largest set of information in the world about an estuary. EPA and the states are now designing a Bay monitoring program—50 stations were established last summer—that will continue to measure such scientific variables as salinity, temperature, dissolved oxygen, nutrient concentrations, water clarity, and plankton.

LOOKING BACK AND FORWARD

Three decades ago, the Thames River, which flows through London, and several of the Great Lakes were so contaminated by pollutants that they were considered dead or dying waters. In both cases, the alarmed governments (the United States and Canada jointly for the Great Lakes) took drastic measures to manage waste disposal. Water quality was improved dramatically. Edible fish now inhabit the Thames for the first time in centuries. Lake Erie is no longer an endless garden of algal blooms that choke all other life and even obstruct navigation. Neither a great single river nor huge freshwater lakes pose the range of problems inherent in the mighty Chesapeake Bay estuary. But the fact that man has successfully reversed the pollutant destruction of two other important water systems offers hope for the Bay.

Lewis Cain of Rock Hall, Md., has fished a living on the Chesapeake Bay for 29 years, from the time he was young and went out with his dad. His son Herb now fishes beside him. When they anchor-net for striped bass and perch, they work away from their 42-foot boat *Judy*, each in a separate motor dory. With a small hydraulic roller in the dory, one man alone can handle a 1200-foot string of nets. He pulls it up to pick the fish caught by the gills in its mesh, and simultaneously keeps it in order, straightening weights, floats, and tide-anchors at the end of each 100-foot panel, and replacing torn panels. Someone without a feel for the job, standing upright in the pitching bow, would quickly become tangled in mesh, spars, and lines.

I went fishing with Cain in March of 1984. The experience has already proven to be a piece of history. Cain worked anywhere from 100 to 350 panels. He set them in relatively shallow water, 8 to 12 feet. He explained: "In the past few years, the fish have been tending toward the shallow water, probably due to the chemical pollutants that are just lying in the deep out there. We've got vast areas of dead water now." Cain pushed hard, fishing even through squalls and blows, as long as the water did not rise to swamping heights. (I stayed thoroughly wet all day.) Most of the striped bass he caught—"rockfish" or "stripers," the money fish, one of the delicacies of the Bay—were smaller than the 14-inch limit and had to go back, still wriggling. It indicated at least that a good year-size was working its way to maturity. Would they survive? Cain was optimistic and said he'd seen it worse. His haul at the end of the day was a modest bushel basket, mostly full.

Two days later, at the behest of the Maryland Department of Natural Resources, the Maryland legislature closed striped bass to both commercial and sport fishing for the spring months of the spawning season. In mid-September, the state resources department bit the bullet further and announced a four-year complete moratorium on all catching of striped bass in Maryland, beginning January 1, 1985. The fall catches before the moratorium took effect were plentiful enough in parts of the upper and middle Bay that fishermen hotly contested the closure. Ironically, Maryland Bay headwaters provide the striped bass nursery area for the east coast all the way from North Carolina to Nova Scotia. With Maryland having taken responsibility for preserving the young stock, watermen and sportsmen of the state will lose much of the potential catch to fishermen of other states unless similar moratoriums are enacted elsewhere.

I couldn't help remembering the basketsful of stripers I used to sportfish on the Bay 45 years ago with my dad and grandfather, and then up to a dozen years ago with my dad, son, and daughter. We'd clean them ashore as it grew dark, slapping mosquitos with fishy hands, and have a great fry, with enough for the neighbors. There hasn't been that abundance recently. I'm hopeful there will be again.

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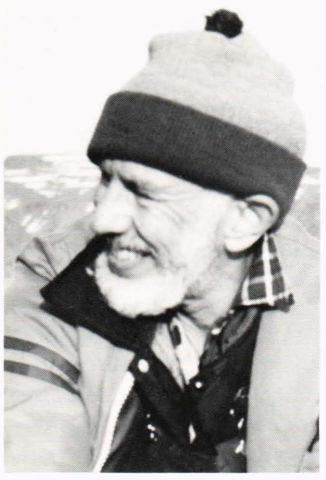
THE AUTHOR



WILLIAM MCCLOSKEY was born in Baltimore in 1928 and received his B.S. degree from Columbia University in 1951. He served for 2½ years in the U.S. Coast Guard as a line officer in Alaska. After working for the *Baltimore Sun*, the U.S. Information Agency in Madras, and in industrial public relations, he joined the APL External Relations Group in 1962. His responsibilities include federal liaison in Washington.

As a freelance writer and photographer, he has become increasingly identified with issues concerning the sea—commercial fishing, marine mammal hunting and protection, ocean politics, and marine environment. His articles on these subjects have appeared in such publications as *Smithsonian, Atlantic, New York Times Magazine, International Wildlife,* and *National Fisherman.* He has recently written articles on the Bay for *National Wildlife* and *Oceans Magazine*, and he serves as a board member of Citizens Program for the Chesapeake Bay.

Mr. McCloskey's most recent novel, *Highliners*, grew from his experiences working during vacations as a commercial fisherman in Alaska. Recently, he has spent periods working as a fisherman in Norway and Labrador-Newfoundland and he has also—in preparation for another book—traveled with inshore fishermen in many parts of the world.

In another field, his interest in opera has led to several appearances as a panelist on the Texaco Opera Quiz during the national Saturday afternoon broadcasts from the Metropolitan Opera.