SAVING THE OCEANS

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HILLARY HAUSER

IN THE LATE NINETEEN SIXTIES, THE AMERICAN POET ROD McKUEN MADE a record album called "The Sea." Against a backdrop of waves and a single oboe, he speaks about friendship with the ocean: "If we want someone to know/We should get to know the sea."

These words have stayed with me because I swim in the ocean very day, even in stormy weather or the dead of winter. My favorite thing o do is to jump out of bed early in the morning and dive in with my pajamas n. I like the feel of the water, which is sometimes freezing cold. I like vimming across tangly kelp and smelling the plankton that sometimes gets ı my hair. I like the solitude just beyond the breakers, where I can float on ıy back and look up at the nearby mountains. I like to ride a wave and get ınd in my suit. When sea lions or dolphins swim by, I try to swim out and :rike up a conversation.

Throughout time, many people have derived comfort from the sea in imple ways — walking along a seashore, contemplating the surf, watching eagulls dip and soar, getting their toes wet, playing with their dogs in the and.

There is inspiration here, too. Artists have covered miles of canvas with :rashing waves and sparkling inlets, and writers have produced volumes on he mysteries of the deep and the magic of the shore.

Whatever our profession or background, we all scramble to the beach for recreation and regeneration. We swim in the waves, fish in the surf, scuba dive along offshore reefs, and sail in boats around harbors and bays. We ask

Opposite:
Eel grass (Zostera marina) *helps to stabilize muddy shorelines and provides food and shelter for coastal animals.*

JEFF FOOTT

Sea horses (Hippocampus) *are often found in tidepools, clinging to seaweed. Their inshore habitat makes these small fish vulnerable to local pollution, trawling and dredging.*

for oceanfront hotel rooms, and in restaurants we request tables with a view of the water. In many countries, prospective house buyers pay a premium for every square inch of ocean view—even if that view is from a small window in a broom closet. There is no doubt about it—the seashore is precious.

The problem is, we may be loving our shorelines to death.

After I graduated from college I went to work for a magazine that had a publishing office in Los Angeles. I leased a small garage apartment on a local beach, where I swam in the sea every morning. I felt very fortunate to be able to do this. When I landed a month-long assignment in Mexico, I subleased my little place to a co-worker. On my return, I was amazed to learn that my friend had moved out after only a few days, "because it was too damp and the ocean was just too noisy!" I remember thinking at the time that maybe it was a good thing that some people did not like the beach. This left more of it for the rest of us who did.

Wishful thinking! The fact remains that a great many people want to be near the ocean. The result is an immense push on the shoreline. This drive to be near the sea has even been analyzed by some psychologists as an attempt to return to our origins. Conjecture aside, the world's population has swelled by about 1.2 billion people in the last fifteen years. If all of the coastline in the world, including the Arctic and Antarctic, is combined and divided by the Earth's population, approximately five inches (13 cm) of coastline exist for each person.

This depressing statement was made by the eminent American marine scientist Carleton Ray, who went on to say that five inches is "not much—in fact, you couldn't stand side by side, because most people are wider than five inches." He also noted that this swelling population has tended to congregate around important biological areas of the sea:

> Consider the fact that man has always gone to protected coves and harbors for development . . . nice protected places which are—or were—among the richest places for living resources in the world. So, the richest places in the world are also the most populated. . . . This leads to the extremely alarming fact that man, while he's increasing his numbers, is also decreasing the earth's coastal zone capacity to provide biological living materials for him, since estuarine places are nursery grounds for most forms of ocean life.

JEFF FOOTT

This mangrove (Rhizophora) *swamp is protected in Everglades National Park, Florida, USA. In some areas of the world, such as Bangladesh, so much mangrove forest has been destroyed on outer islands that storm surges caused by cyclones now move much further inland, resulting in destruction and loss of life.*

THE MAGIC OF ESTUARIES

Estuaries or wetlands — places where freshwater rivers and runoffs meet the sea — often appear as shallow swamps, rimmed with high marsh grasses and splotched with patches of algae growing on still waters. When the waters recede. they can look like soggy, pock-marked river bottoms. In some places, such as the Florida Everglades, the dominant vegetation is mangroves — tangled greenery that is flooded by a brackish mixture of fresh and salt water.

To the uninformed eye, estuaries may look stagnant, even unattractive. There was a time not long past, in fact, when people looked at such places and wanted to convert them into something more useful and attractive. Because estuaries are places where the sea encroaches inland, many of them have become prime sites for harbors. They have been dredged, which automatically fills them with salt water, and breakwaters have been built, with marinas for boats situated inside. Ship chandleries, fish markets and cafés have been erected to attract visitors. The largest estuaries of many countries are

JEFF FOOTT

Purple shore crabs (Hemigrapsus nudus) *live in estuaries. The 4,500 species of true crabs range worldwide from shorelines to the abyss.*

now important seaports, and those not replaced by a harbor or marina have been altered with some other type of waterfront development—condominiums, waterfront homes with boat docks, or oceanfront business areas, complete with hotels and restaurants offering rooms and tables with ocean views.

Marine science has only recently caught up with such developments. Research has shown that estuaries are important nursery grounds for two-thirds of all the animals that live in the sea. Young larval fish migrate to estuaries, where they find an abundance of food in the brackish water. These fish include colorful reef fish, as well as food and game fish such as snapper and tarpon. In the estuary, the young fish can grow in a safe environment free of ocean predators, until they are large enough to defend themselves in the open sea. Other estuary inhabitants that set up permanent homes in the muddy bottom include clams, oysters, mussels, and some types of shrimp.

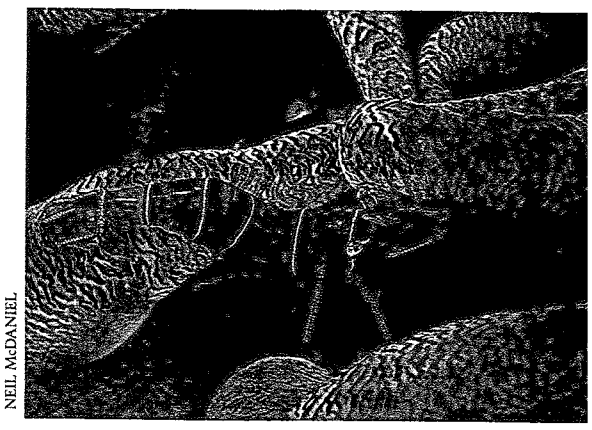
By stripping our coastlines of estuaries, we have inadvertently stripped ourselves of entire unknown populations of marine animals and a potential food supply. However, despite this scientific revelation, estuaries and wetlands are still being destroyed in the name of "progress." As this book goes to press, the Sheraton Hotel in Nadi, Fiji, is bulldozing acres of mangroves to build golf courses. In the United States, the Walt Disney Company proposes to fill in 250 acres (100 ha) of land along California's Long Beach shoreline for the building of a $3-billion amusement park.

Three-quarters of American wetlands are owned by coastal developers, ıdividual farmers and large landholders. Although such areas are major esting and roosting areas for many species of ducks, habitats for small ıimals, and vital nursery and breeding grounds for many types of fish, an ;timated 290,000 acres (117,000 ha) of wetlands are being lost each year. ı August 1991, U.S. president George Bush held out a life preserver, a policy ıper authorizing the purchase of as much as 1 million acres (400,000 ha) of etlands. The policy paper also proposed to expand research and to restore ›me wetlands on federal property.

Unfortunately, the policy paper had some holes in it. It revised the efinition of "wetland," which critics said would expose millions of acres to evelopment. It also included a proposal to speed up the approval process for evelopment. Bush defended his policy as balancing two factors: it would otect the wetlands, while allowing for sustained economic growth and evelopment. To some, this mixing of philosophies is untenable. Economics ways seems to win in the end.

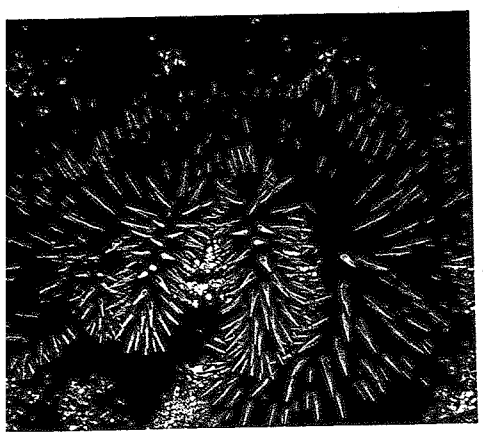
Similarly, when the French ocean explorer and filmmaker Jean-Michel ›usteau told a large tourism convention in Fiji that the destruction of angroves to make golf courses would rob the world of fish, there was a ajor stir among the locals against his statement. "Fish? — the Fijians have ough fish!" said one. "There are miles and miles of mangroves here. The jians need jobs. This development is giving the Fijians jobs!" Not surprisgly, Third World countries have a difficult time understanding how rich tions, which have produced wealth by exploiting their own environments, n ask them to stay poor and preserve theirs. Can the Fijians be convinced at tourists might be persuaded to visit a wildlife preserve rather than play lf? Only time will tell.

The estuaries of the world are not only threatened by direct digging, edging or filling. Their waters are also changing in character, with the result at many forms of estuary life cannot survive in them. Freshwater rivers wing to the sea are being dammed at alarming rates, to harness water for wer, agriculture, irrigation and drinking. It has been estimated that by the ar 2000 about two-thirds of the world's total flow of water to the ocean



NEIL McDANIEL

Estuaries, which are being drained or altered in many parts of the world, are an important nursery for many species of shrimp, including this candy-stripe shrimp (Lebbeus grandimanus)*, which lives in the northern Pacific.*



PAUL S. AUERBACH

The crown of thorns starfish (Acanthaster planci) *preys on living coral. Population explosions, possibly due to human removal of their predators, have destroyed parts of Australia's Great Barrier Reef and other coral reefs in the Pacific.*

will be controlled by dams. When freshwater is withheld from the sea, the saline content of estuary waters soars. The shrimp, oysters, mussels and fish that live in coastal wetlands cannot survive in high-salinity water.

What scientists are now realizing, with their more sophisticated instruments and increased knowledge, is that seawater is a finely tuned combination of elements. They have also come to know that everything in the sea is connected. When one thing is changed in the ocean, a ripple effect occurs—something else happens down the line.

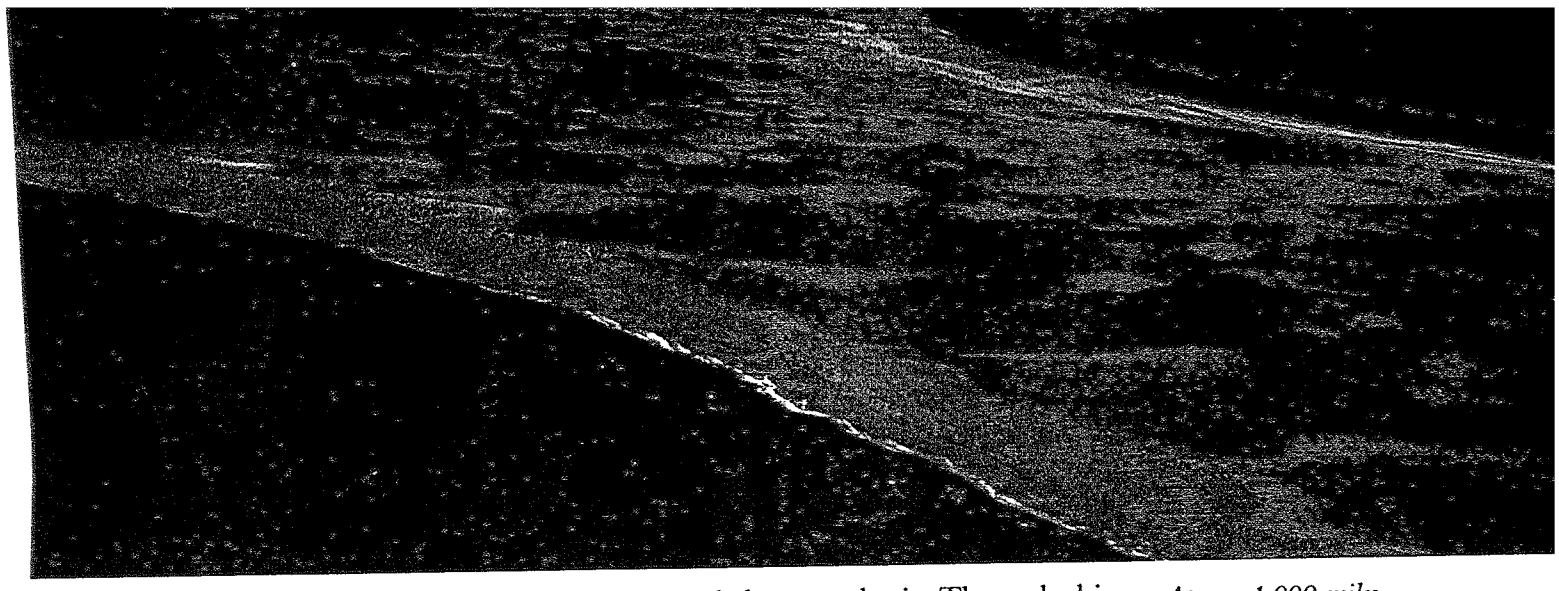
Such an effect can be seen in the spreading eutrophication of the world's shorelines. Rivers are emptying vast quantities of pollutants into the sea, the result of storm runoffs from cities and countrysides. Excessive nutrients, such as phosphates, find their way to the ocean this way, and cause algae blooms where they settle. Algae consume oxygen from the water. When vast quantities are present, the resident fish fail to get their fair share of oxygen and they die.

Massive fish kills along the beaches of countries around the world are now commonplace. The sardine fishery of the eastern Mediterranean perished because of algae bloom. In the Albemarle and Pamlico sounds of North Carolina, low levels of dissolved oxygen in water have suffocated hundreds of thousands of striped bass, crabs and eels. Puget Sound in Washington State is battling similar problems. Dead fish, algae and nursery grounds turned into graves—it is a sad story told along too many of our shorelines.

THE WORLD OF THE REEF

Around every continent and island in the world is a submerged "shelf" that angles up to the shore. Some shelves are wide, some narrow. Some drop off precipitously into a deep abyss and some stretch out so gradually that ten miles (16 km) out from the beach you might find yourself in only one hundred feet (30 m) of water.

Of all the zones of the sea, the continental shelf is the most fertile because it receives more sunlight than the other zones. In the ocean, as on land, the

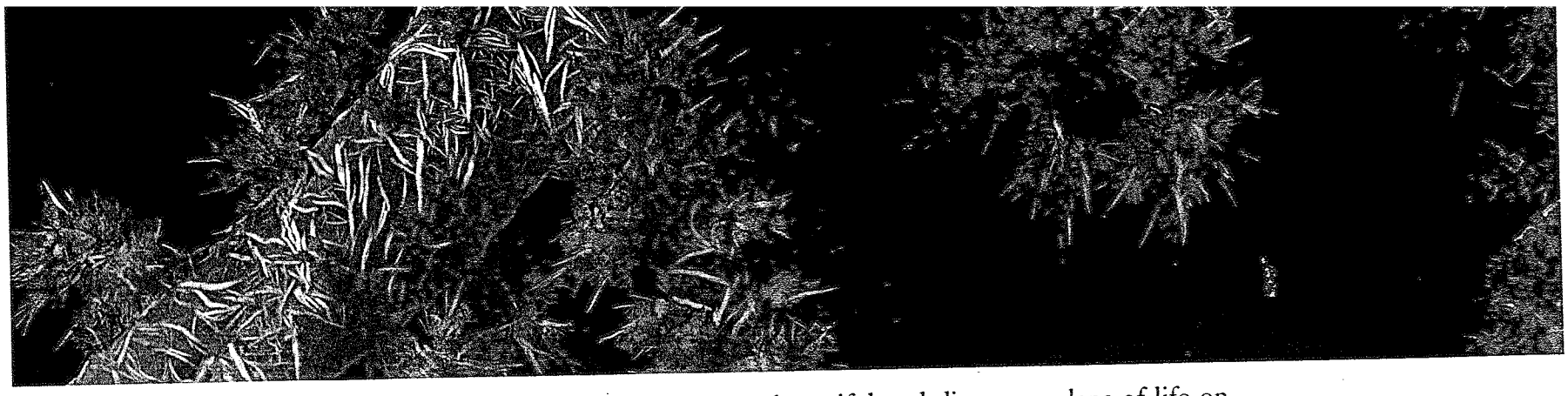


At over 1,000 miles (1,600 km) in length, the Great Barrier Reef off the northeast coast of Australia is the largest coral reef system in the world. The Great Barrier Reef Marine Park Authority oversees its conservation.

sun's energy is used by plants in the process of photosynthesis. Through this chemical process, marine plants grow and become food for many fish and other marine life forms. In the tropics, the sun encourages the growth of coral.

Not long ago, I was decompressing from a deep scuba dive on the Great White Wall at Taveuni, Fiji. On a shallow, fringing coral reef I waited at ten feet (3 m), and with time to spend, I began watching everything around me in detail. I studied the colorful fish darting in and out of knotty coral branches, and teased the little wrasses that alternately picked at my fingers and peeked into my faceplate.

In the distance I could see the waves breaking on the reef. As I watched the white bubble-and-foam action of the surf from this underwater viewpoint, I could not help but reflect on how these semisubmerged coral reefs do such a fine job of protecting nearby islands from the fury of ocean storms. The enormous fields of spun coral diffuse and break up the force of waves that roll across the open sea.



NEIL McDANIEL

A closeup of the polyps of soft coral (Dendronephthya *sp.*). *Unlike stony corals, the fragile soft-bodied corals do not build reefs.*

Coral reefs are among the most beautiful and diverse gardens of life on our planet. Like those "magic rocks" that many of us played with as children, coral seems to have magically fizzed and solidified into miniature castles upon contact with water. These castles do not appear to be animal in origin, but they are. Coral reefs are composed of the delicate, calcified structures of tiny anemone-like creatures, which slowly but surely build upon each other, generation after generation.

There are two important factors in this living and building process: sunlight and clean water. The coral polyps extend their tentacles into the passing currents to strain out plankton, which they feed upon. They rely on the sun and the process of photosynthesis to encourage the growth of the symbiotic dinoflagellates and algae that provide them with oxygen and with the lime they use for their skeletons. Dredging, which often occurs during the construction of tropical hotels and marinas, spreads silt over a coral reef, smothering the tiny animals.

The importance of coral reefs cannot be overstated: they not only provide the lands they surround with protection from open-ocean storms, but underwater they provide protective homes for millions upon millions of fish and invertebrates. Large pelagic fish, such as the tuna and jack, swim into the shallow reef communities to feed on the resident sea life, a fact well known

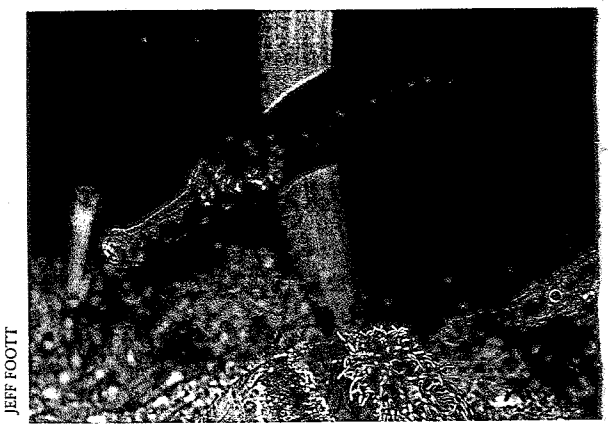
fishermen around the world. Among the most important biological sites the planet, reefs serve both as protection and pantry.

They are also a joy. Scuba divers everywhere have discovered, by the ndreds of thousands, the colorful magic of these coral kingdoms. Yet one 'er stepping on a coral branch can break off in less than a second what ral animals have taken eons to create. With hordes of underwater visitors ɔloring a reef site day after day, year after year, these little breakages can d up to serious degradation. The anchoring of boats on the reef adds to : damage.

Dr. Ray, who proposed with Ilia A. Tolstoy the first land-and-sea park in : world, the Exuma Cays Land and Sea Park in the Bahamas (created ·ough the Bahamas National Trust), explains the problem this way:

> It's what we call carrying capacity. Just as a field can hold just so many cows, so a reef can hold just so many divers without damage. It's not sufficient to protect a reef from spearfishing and the collecting of corals, seafans and shells. The very presence of continuous, high-intensity use disturbs fish and corals, [and] causes some breakage of delicate coral structures.

The solution, he says, is through management plans to give some reefs iver relief" from time to time. Many terrestrial parks have had to do this protect wildlife habitats, and there is no reason why similar management ıns could not be developed for threatened ocean areas. Many of today's ıba divers are aware of their effects on the reef environment. They are .rning to use buoyancy vests more so that they kick less, and they are opting a hands-off policy when swimming around the corals they have me to see.



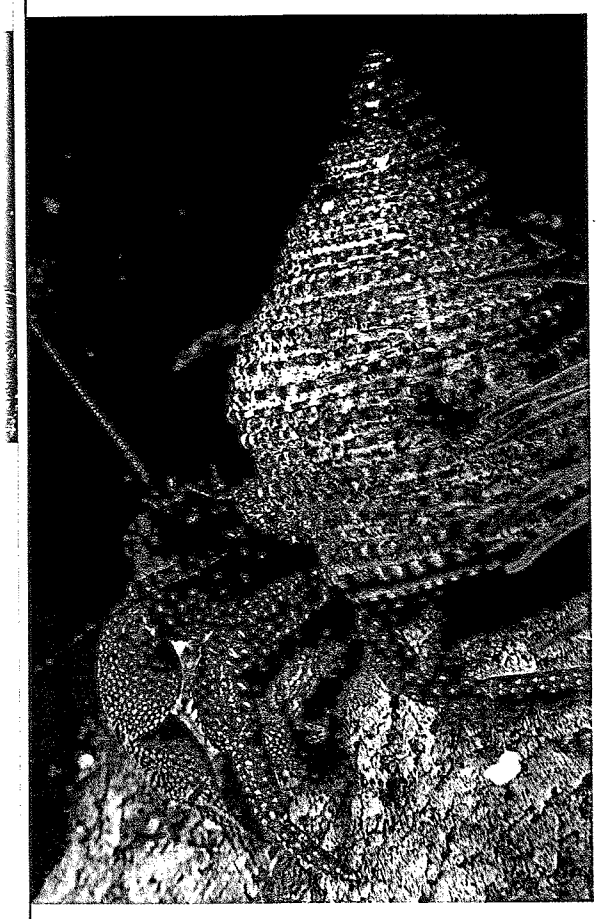
JEFF FOOTT

Bay pipefish (Syngnathus leptorhynchus)*, Puget Sound, USA. These aptly named fish have bony plates encasing their bodies instead of scales. Because these fish generally inhabit inshore areas, they are vulnerable to coastal pollution.*

THE SOLUTION TO POLLUTION

ıere was a saying in the 1950s and 1960s that was supposed to be clever ıt that revealed an astonishing attitude toward the sea: "The solution to ıllution is dilution." In other words, take all the waste you do not know ıat to do with and simply dump it into the sea. It was thought that the ean was capable of diluting and absorbing vast amounts of liquid and solid ıste.

Following pages:
Starfish, which are also called sea stars, are echinoderms, members of a widespread group of animals that exists only in the sea. FREEMAN PATTERSON



JEFF FOOTT

Hermit crabs can be seen in shallow coastal waters throughout the world. This species, Pagurus granosimanus, *occurs on the west coast of North America. To protect their soft bodies, hermit crabs find and wear an empty shell, which they exchange for a larger one several times during their lives as they grow.*

As idiotic as this practice sounds on paper, we are doing it daily. We are dumping into the sea everything from radioactive waste to sewage. The errors of this solution-is-dilution practice became painfully obvious in Minamata, Japan, in the 1950s and 1960s. Beginning in 1953, the people of this small coastal town began to suffer strange neurological diseases, which ended in death for many. It took years to trace the cause to fish and shellfish overloaded with a lethal form of mercury. Fingers were pointed at a manufacturing plant that discharged its wastes—including mercury—into Minamata Bay. However, the mercury sent into the sea by the plant was inorganic and relatively safe when ingested in small doses, while the deadly mercury that poisoned the people was organic. For the time being, the manufacturer was absolved of any responsibility. It was not until 1967 that scientists discovered that the sea is able to transform the properties of chemical substances from safe to toxic. The mercury of Minamata Bay, ingested by the fish and shellfish, had been transformed into deadly poison.

In the shallow waters of the shoreline, where rich fishing industries thrive, it seems inconceivable that we would dump lethal wastes. And, in fact, these wastes are usually deposited in deep water. But sometimes substances dumped into water far offshore end up in shallow water. Thirty miles (48 km) west of San Francisco, California, 47,500 steel barrels containing chemicals such as plutonium, cesium and mercury have been scattered over an undersea area of more than 350 square miles (900 km^2). Scientists are now trying to determine whether these cannisters have broken open, and if their lethal contents have reached the Point Reyes-Farallon Islands National Marine Sanctuary, one of the richest marine habitats in the world.

The most insidious form of ocean dumping in shallow coastal waters is dredging. It has been estimated that 80 percent of all ocean dumping in the world is the result of dredging harbors, which tend to silt in and fill up, becoming too shallow for visiting ships. The toxic waste and bacteria that accumulate at the bottom of a harbor for months are suddenly dug up and spewed out in the ocean currents that travel down the coast. There is evidence that fish are contaminated by this practice, but some scientists argue that the toxic heavy metals accumulate in the guts of fish, while the edible parts remain

ee of contamination. This reasoning might be fine if one assumes all people e like fugu chefs, highly trained Japanese cooks who know how to avoid ıe parts of the fugu blowfish that can kill a person outright. Unfortunately, ɔt many of us are.

Another problem for nearshore areas of the sea occurs on a daily basis in ıe form of sewage and sewage sludge. In the United States alone, an estimated billion gallons (30 billion L) of municipal sewage are discharged each day to coastal waters. Too large a percentage of it is raw and untreated. Sewage udge is a mix of solid human waste, viruses and pathogenic bacteria, along ith carcinogenic chemicals such as PCBs and heavy metals. In addition to ıe effluent from sewage treatment plants, sludge contains waste from city reets that is washed into sewers. This includes oil and grease, along with :avy metals such as mercury, lead, copper and cadmium, which accumulate marine organisms and poison the people who eat the contaminated seafood.

The most commonly accepted way to dispose of sewage has been to pipe :eated sewage into the sea, very often in nearshore areas. Sewage effluent :her gets primary, secondary or tertiary treatment. "Primary" treatment eans the solids have been removed from the effluent; "secondary" means e effluent has been chlorinated to kill bacteria; and "tertiary" means that e effluent has gone through additional processing that renders it suitable for ricultural use.

The subject of sewage disposal in the ocean became of paramount interest me during the six years I covered commercial fishing and other marine bjects for a Santa Barbara, California, newspaper. There are five sewage ınts in the area that dump their effluents into the Santa Barbara Channel, important commercial fishing ground.

One day in 1987 an alarming report came across my desk. The report ted that California's seafood might become inedible within three years cause of sewage. Issued by the U.S. Office of Technology Assessment (an vestigative arm of Congress), the report stated that harmful bacteria occur- ıg in human waste do not die off quickly, as scientists had long believed. ıtead, the bacteria lie dormant until they find a suitable medium in which grow, such as the stomachs of fish and shellfish, where they return to their

STEPHEN SCOTT PATTERSON

The tides of the Bay of Fundy in eastern Canada, which are the largest in the world, sculpt sandstone formations along the coast. This formation was photographed in July at low tide.

FREEMAN PATTERSON

A wreck lies on a beach in Queensland, Australia. Countless wrecks have been abandoned on the shores and in the waters of the world ocean. Among them are seven nuclear submarines.

previous "fully virulent form." The report noted that more than 1 billion gallons (4 billion L) of sewage were being dumped each day off the California coast, and that commercial harvesting of seafood was already prohibited or partially restricted in about one-third of California's productive shellfish areas because of contamination.

I was angry. I decided to conduct a local "sewage roundup," to see what our area was contributing to this mess. I learned that Santa Barbara was dumping about 16 million gallons (61 million L) of sewage effluent into the Santa Barbara Channel each day. I asked the managers of the five sewage treatment plants exactly what it was they were dumping, and where. It was like pulling teeth to get this information from them, and no wonder. I learned that millions of gallons of secondarily treated sewage were being poured daily in less than one hundred feet (30 m) of water within one or two miles (1.5 or 3 km) of popular swimming beaches. Unbelievably, one outfall was in 35 feet (11 m) of water only 1,500 feet (460 m) off a beach in front of an elegant hotel.

I talked to marine biologists studying the kelp beds in the channel. They told me that although the once-prolific forests of giant brown kelp (*Macrocystis pyrifera*) had been severely damaged by the El Niño storms of 1983, they suspected the real reason for their decline was the continued dumping of sewage in nearshore waters.

Amid all this depressing news was a single shining light: there is one pilot treatment plant serving a community in the Los Angeles area that is giving its effluent tertiary treatment. Everything produced from the Fountain Valley plant is used for irrigation and agriculture.

Today, too many coastal communities around the world are closing beaches and advising swimmers to stay out of the water because it is polluted by sewage and storm water runoff. I think of this and of the Fountain Valley treatment plant that gives its effluent tertiary treatment, and I cannot help but think that many of us would not mind paying an additional monthly fee for such treatment—for the privilege of knowing that at least what goes down our household pipes is not adding to the ocean's ills. The solution to the pollution is simply to stop doing it.

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This sign on a deserted beach in Gdansk, Poland, warns of pollution.

THE PROBLEM OF OIL

It used to be that oil companies drilled for oil primarily on land. There was a simple reason for this: the human hand was the best instrument to deal with the valves and flanges of oil platforms. With the development of underwater technology, however, oil operations moved offshore. In fact, the spread of oil fields at sea followed the depths to which man could dive. Now that there are Remote Operated Vehicles (ROVs) and one-man submersibles with high-tech manipulators for hands, oil platforms are being installed in deeper and deeper water—even on the Outer Continental Shelf. Whether shallow or deep, the coastlines of some countries are rimmed with giant steel platforms.

CHUCK PLACE

Seals (family Otariidae) congregate on a buoy in the Santa Barbara Channel, California, USA. An oil platform stands in the background. Some seal species are able to coexist with humans, taking advantage of man-made objects to haul out on or stealing fish from nets, while others, such as the monk seals (Monachus)*, are less able to tolerate human disturbance of their shoreline habitat.*

The most visible environmental problem of offshore oil operations is the oil spill — tar-black or rainbow-greasy slicks coating the surface of the sea. Notable platform spills range from the 1969 blowout of Union Oil platform A off Santa Barbara, California, which poured 2 million gallons (7.5 million L) of oil into the Santa Barbara Channel, to the Ixtoc blowout in Campeche Bay, Mexico, which spilled 140 million gallons (530 million L). Oil tankers have come to grief on the shorelines of the world, too — from the *Amoco Cadiz* off Brittany in 1978 (68.7 million gallons of oil/260 million L) to the *Exxon Valdez* off Alaska in 1990 (11 million gallons/42 million L). It has been estimated that somewhere between 3 and 7 million tons of oil are spilled into the ocean each year. Much of it ends up on the beaches and the rest sinks to the bottom, poisoning the creatures that live there.

Processes for cleaning up an oil spill are woefully inadequate, and in some cases may present problems worse than the oil spill itself. For example, the chemical dispersants used to force the oil beneath the surface (an out-of-sight, out-of-mind approach to cleaning up) have proven to be more toxic to marine life than the oil itself. And after the *Exxon Valdez* catastrophe, it was learned that the high-pressure spraying of the shoreline actually stripped the coast of small plant and animal life.

Although oil spills are ugly and tragic, a more insidious and hidden form of oil pollution is the subsurface dumping of drilling muds from oil platforms. Drilling mud (more correctly called drilling fluid) is a clay-based (barite) fluid used to lubricate the drill bit, circulate the drill cuttings to the surface, help seal the well wall, and control pressure in the well. Lubricants and other substances are added to the "mud," including arsenic, cadmium, chromium and mercury, all highly toxic.

By itself, the oil platform does not harm the environment. The prolific plankton, drifting on the open seas, cruise into the platform area and settle on its steel legs. Very soon after the platform is installed, in fact, it begins to function as an artificial reef. The legs become covered with mussels, crabs, starfish, sea anemones and sponges. Then the fish arrive to feed on the resident creatures.

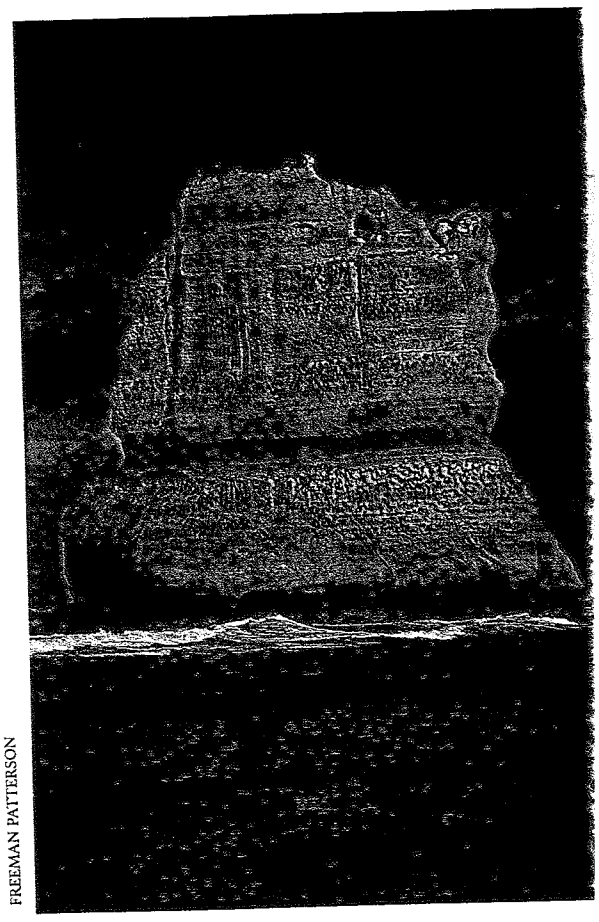
I have made many dives under the oil platforms in the Santa Barbara

annel. For years, I recorded and wrote about the underwater life that ıgregates on the legs of these structures. My photographer friend Bob ıns and I documented a cabezon (*Scorpaenichthys marmoratus*), a California ı, laying its eggs on the cross-pilings of a platform, and we observed starfishes ł crabs battling for space and food. One day, however, underneath a .tform where we had spent hours recording an abundance of marine life, ›b discovered a devastating seascape of decay and death. The bottom was vered with drill mud. He reported his discovery to the oil company that ⁄ned the platform, but his reports were ignored. They were also ignored the governmental agencies overseeing the oil company's operations.

Not long after Bob discovered the accidental dumping of drill mud under e platform we knew so well, oil companies operating in the area applied r blanket permits to dump drill mud in the Santa Barbara Channel. They :eady had permits to dump this waste in federal waters, which are three iles (5 km) out, but in state waters closer to shore, it had to be hauled to a ›xic waste dump on land. The oil companies wanted to bypass the expensive ıd time-consuming process of barging the drill mud to shore.

I again went to work on an investigative piece for my newspaper. I :tended numerous hearings, where I listened to biologists (hired by the oil ›mpanies) state that sea life can withstand the dumping of drill mud at sea. 'hey acknowledged poisoning and immediate smothering of animals near ıe platforms, but said such damage is "temporary, and the marine animals uickly recolonize." I read voluminous environmental studies that said most f the drill mud drifts down-current, dispersing the offensive elements in such way that they are not hazardous. The fact that these poisons can be ingested ›y marine life and transformed into toxics lethal to humans (as in the Min-mata disaster) was not addressed in these studies, and neither was the effect ›f drill mud on plankton.

Since plankton are not easily seen with the human eye, they can be easily ›verlooked by those who choose to overlook them. However, since they are ılso the building blocks for all marine animals, entire populations can be killed off when the life processes of the invisible plankton are interrupted. During the drill mud issue, Daniel E. Morse, a professor of molecular genetics



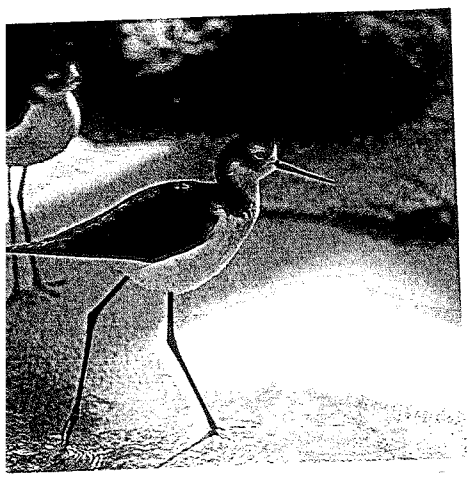
FREEMAN PATTERSON

Coastlines are in a constant state of change brought about by erosion, deposition and sea level changes. This erosion formation is found near Port Campbell, Victoria, Australia.

and biochemistry as well as a marine researcher, came to the plankton's defense. He pointed out that their finely tuned system of chemical transmitters and receptors was completely blocked by the dumping of drill mud. He summed up the issue this way:

> Typically, adult animals and plants exposed [to drill muds] for a short amount of time will probably live. But more important is the very critical life-cycle stage of marine animals that depend on settling of the very young larvae to grow into adults. . . . What they [oil companies] don't tell you is that the sea life that survives where drilling muds have been dumped are worms and things of that nature. Hundreds of different worms could be described as a "rich biological community," but is that what society wants?

ROLL ON, THOU DEEP AND DARK BLUE OCEAN



JEFF FOOTT

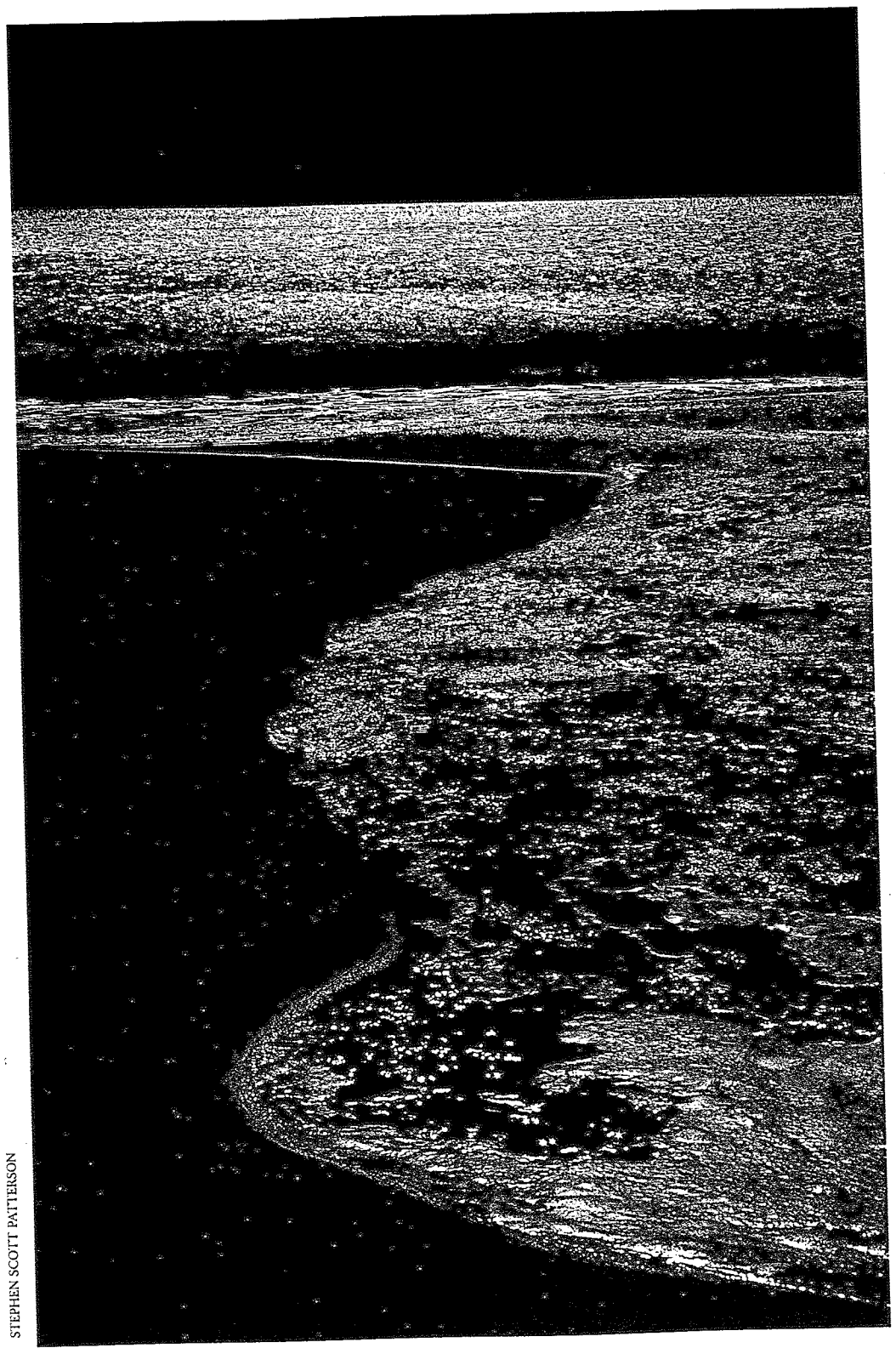
The black-necked stilt (Himantopus himantopus) *inhabits the shorelines of all continents. Shorebirds are particularly susceptible to coastal pollution.*

In 1955, when my family moved to the seashore in Santa Barbara, it was quite a different shore than it is now. As children, my brother, sister and I liked to play in front of the hotel down the beach. We would congregate with our friends at the lifeguard station at the foot of the stairs to the sand. On one side of the stairs was a children's playground with a big slide and swings. On the other side was a raked beach where adults sat in neat rows of backrests.

As I walk this same beach today, I find it hard to believe it is the one I knew as a child. The large stairway was replaced long ago by a small set of steps descending sideways from the boardwalk rather than straight toward the sea. The slide and swings for the children and the lifeguard station have also been relegated to memory.

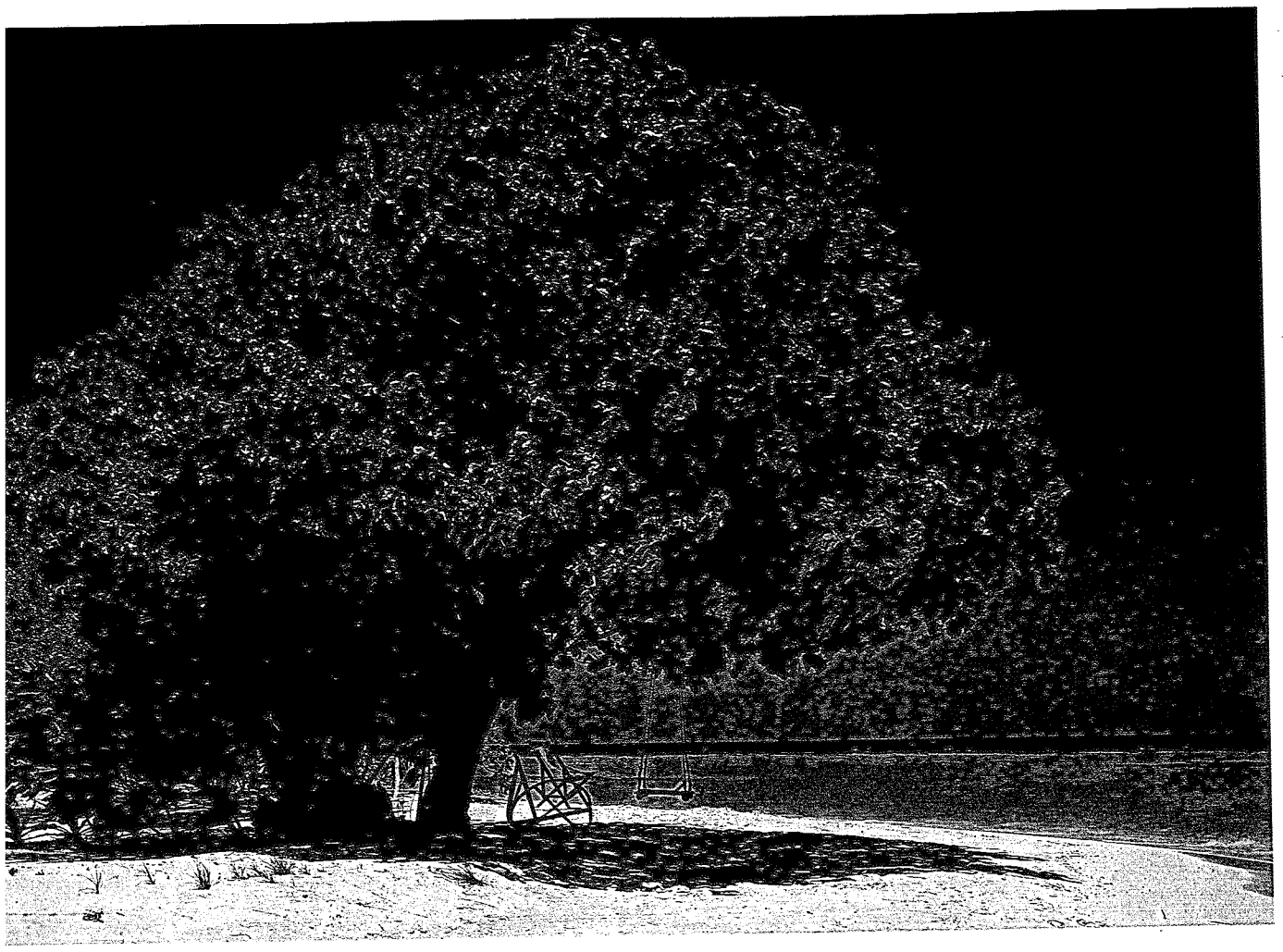
The reason for this change is simple. The sea regularly storms under the boardwalk, sometimes once or twice a day. In 1955, this occurred during an occasional winter storm, but rarely in the summer. Today sea levels are higher, beaches are narrower, and beach houses and other waterfront developments are often "hammered" by the ocean.

One reason given for skinnier beaches is the damming of rivers. Less and less sand is being deposited at river mouths for transportation downcoast.



STEPHEN SCOTT PATTERSON

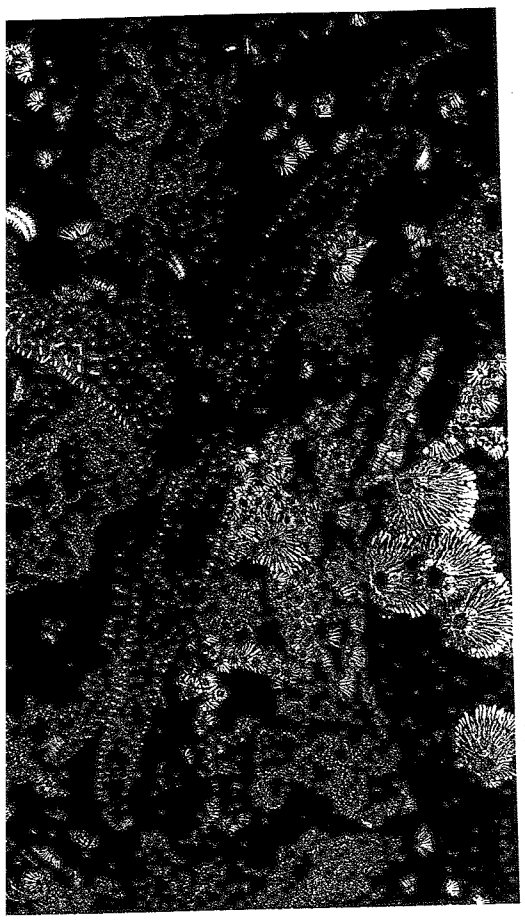
Canada has the longest ocean coastline in the world. This particular beach on the Atlantic side of Cape Breton Island, Nova Scotia, is protected in a national park called Cape Breton Highlands National Park.



nother theory concerns the higher concentration of carbon dioxide in the ırth's atmosphere, or the greenhouse effect. Because carbon dioxide traps :at, this increase is warming up the planet. With this rise in temperature, ıe ocean is also rising. Glaciers will begin to melt and retreat, adding to a ırther elevation of the world's sea levels. Inevitably, the warming water will :cupy more space, which will contribute to the ocean's unstoppable march ıland. The U.S. Environmental Protection Agency (EPA) estimates that with resent warming trends, the world's sea levels will have risen from four to :ven feet (1 to 2 m) by the year 2100.

A sea-level rise of this magnitude could mean that the Maldive Islands in ıe Indian Ocean, now about six feet (1.8 m) above sea level, would disappear.

Opposite and above:
On the Maldive Islands in the Indian Ocean, the removal of coral rock from the surrounding reefs to use as building material and fill has meant a loss of habitat for species dependent on coral. The elimination of part of the protective reef has also caused increased erosion of the small islands.



FREEMAN PATTERSON

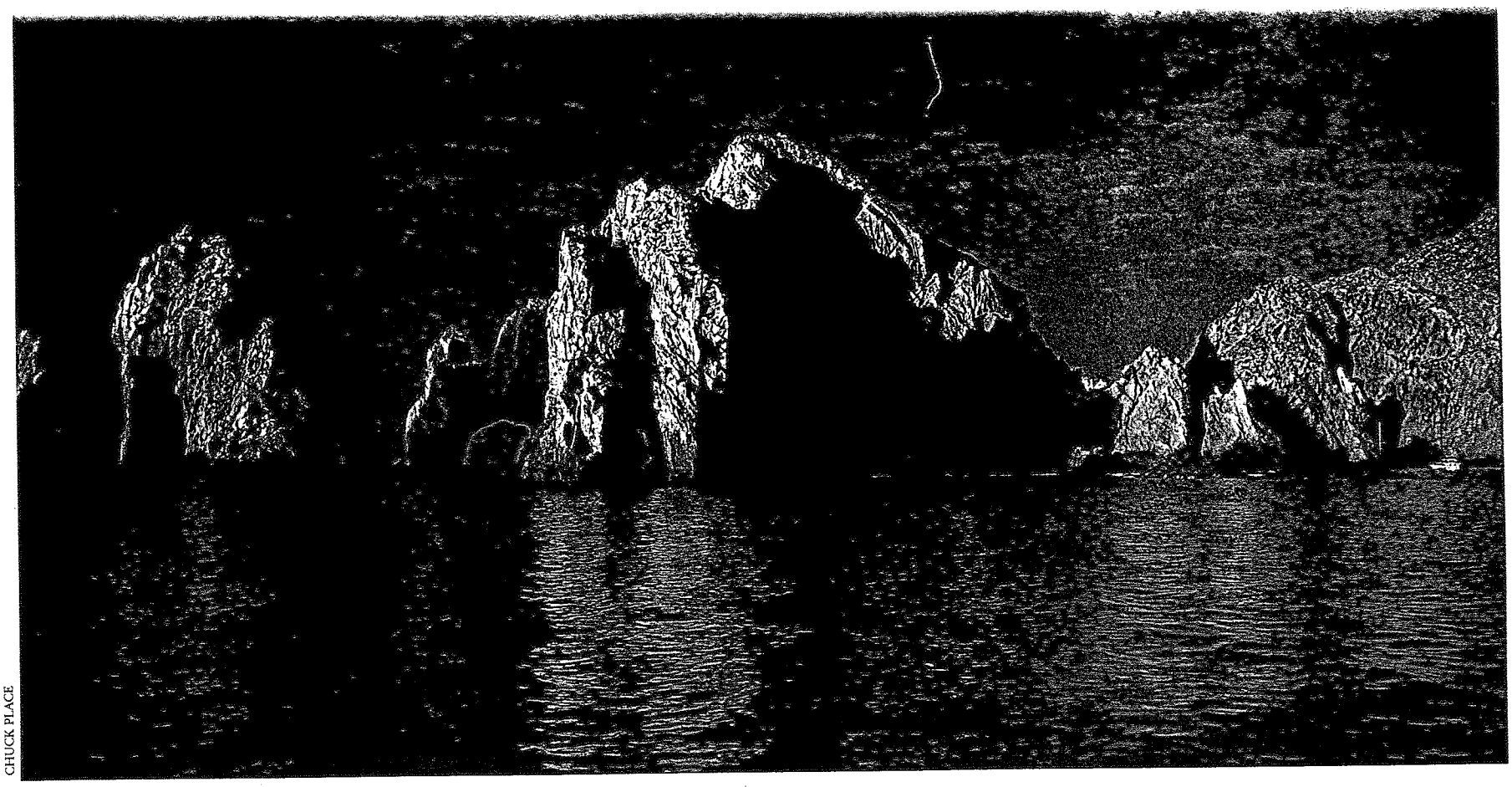
Starfish are frequently encountered in the intertidal zone. Some, like the Evasterias troscheli *shown here, are known for the considerable force they can exert with their suction-cupped tube feet to pull apart the shells of clams and other bivalves.*

Storms would drive an angry ocean inland to regularly flood Bangladesh and the Nile delta in Egypt. A sea-level rise of four feet (1 m) would submerge marshes, sounds and bays, push into river mouths, shove coastlines inland, and penetrate underground coastal aquifers everywhere.

If such a scenario comes to pass — and many scientists are saying it will — there is little we can do about it. Already there are discussions about constructing barrier islands, or dikes and levees such as already exist in Holland. However, Bill McKibben, in his excellent book, *The End of Nature*, points out that such measures may be self-defeating. Existing estuaries would be flushed by the new, advancing sea levels. If we construct walls, dikes and levees to protect oceanfront properties, these would prohibit the formation of new marshes or wetlands. Instead of the ocean "meeting the land with ease and grace," McKibben writes, it will bump into "an endless cement wall."

There are critics who scoff at the idea of irreversible warming and sea-level rise, who say that the ocean has always "run in cycles." Scientists admit that accurate measurements might not be possible until the year 2000, but by then the rise in both temperature and sea levels may be irreversible. Many scientists, though, are taking the carbon dioxide problem seriously, and are meeting in workshops to consider various solutions. They talk about fertilizing the oceans around Antarctica, to increase microscopic plant life there that uses carbon dioxide drawn from the air. They talk about growing millions of square miles of seaweeds that consume carbon dioxide. And they talk about collecting billions of pounds of carbon dioxide from the world's power plants and pumping it into the deepest oceans, where they think the gas might solidify and stay put.

Some people find a strange sense of comfort in the idea that the sea could someday reclaim much of the land we thought was ours. It is disconcerting and enlightening at the same time to think that the ocean might, in the end, defy human technology. Many people meditating at the shorelines where the land meets the sea come to the same realization: there is nothing that can withstand the power of a mighty ocean wave. It is this same power that stirred Lord Byron to write:



CHUCK PLACE

Wave action forms rock arches, such as this one in Cabo San Lucas, Mexico, by deepening caves on either side of a headland until they join.

Roll on, thou deep and dark blue Ocean—roll!
Ten thousand fleets sweep over thee in vain;
Man marks the earth with ruin, his control
Stops with the shore; upon the watery plain
The wrecks are all thy deed, nor doth remain
A shadow of man's ravage, save his own,
When for a moment, like a drop of rain,
He sinks into thy depths with bubbling groan,
Without a grave, unknelled, uncoffined and unknown.

Perspectives are needed at this hour. There are energy sources other than oil—including harnessing the tidal power of the sea—but these technologies require serious development. In the meantime, the industries operating upon or near the sea must be honest about what they are doing to it. There should be a willingness to pay whatever it takes to stop industrial poisoning of nearshore waters. The technology exists for reclaiming our sewage and wastes, but this reclamation costs money. Yet should we not be willing to spend this money, knowing that the ocean is capable of feeding the world? I am reminded of Rod McKuen telling us that the sea is our friend. The sea has given us so much. Can we not treat a friend more kindly?