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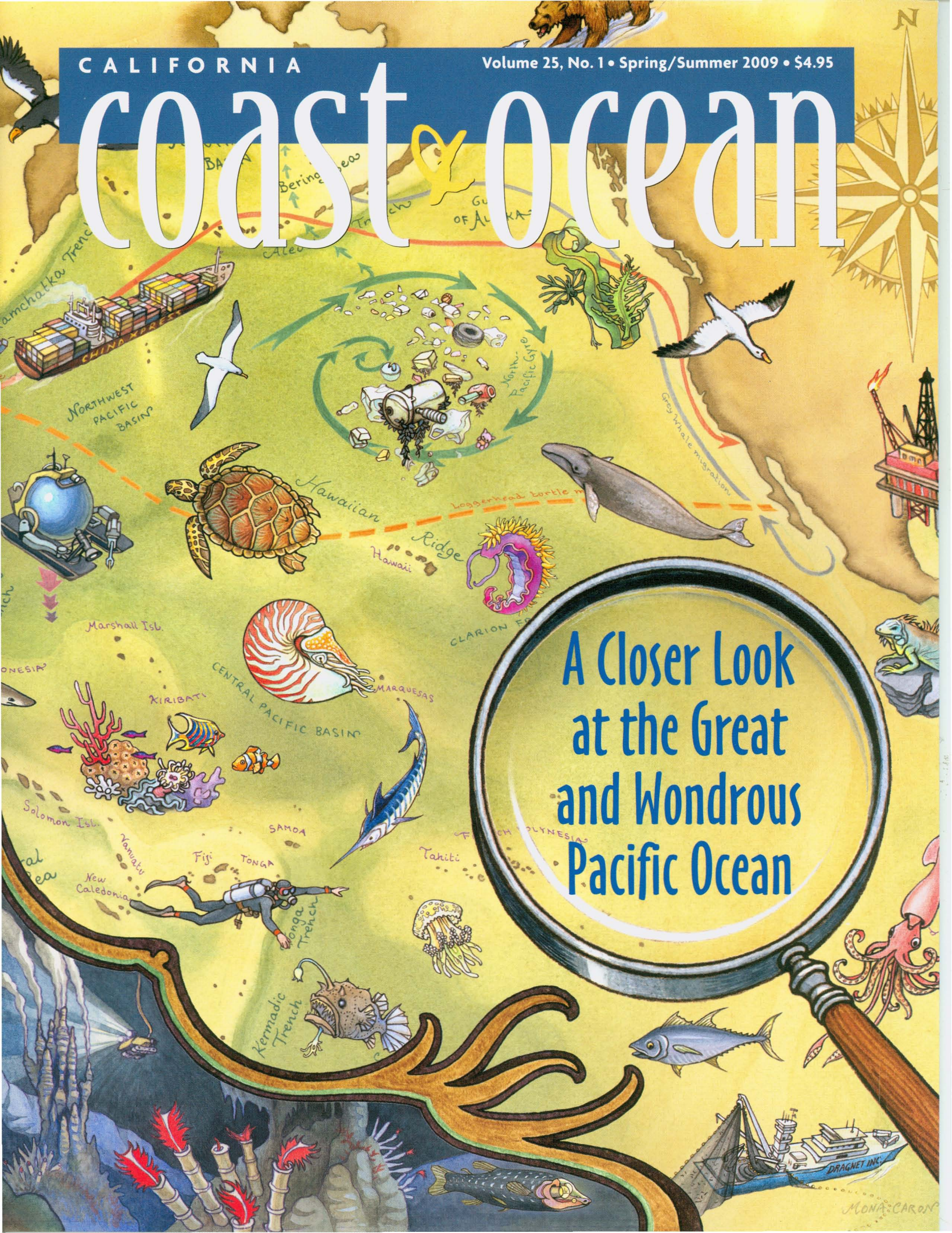
coast ocean



A Closer Look at the Great and Wondrous Pacific Ocean

Coming next, another special issue (apparently our last):
The Big SF Bay Watershed
with a pull-out map painted by Mona Caron
Another collector's item!

CHECK OUT OUR WEBSITE
The *Coast & Ocean* website, **www.coastandocean.org**, includes most articles from the current print edition (some abridged), many color images, back issues, and other information.

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The Coastal Conservancy is a state agency that works with the people of California to preserve, improve, and restore public access and natural resources along the coast and around San Francisco Bay.

Coastal Conservancy

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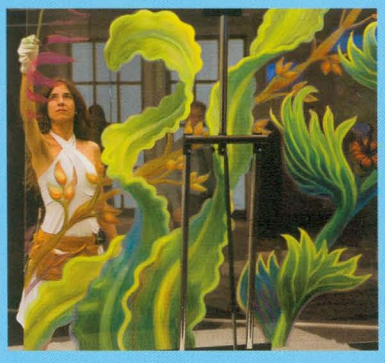

Mona Caron, the illustrator of both this issue's cover and the enclosed map, *The Great and Wondrous Pacific Ocean*, is better known in the San Francisco Bay Area as a public muralist. She is the artist behind the Duboce Bikeway mural, the Market Street Railway mural, and several other pieces adorning public spaces in the Bay Area. Much of her work, in all scales, deals with history, society, and utopian possibility, and is inspired by her passion for botany and the natural world.
www.monacaron.com

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JOANN94024 AT EN.WIKIPEDIA

A red-footed booby *(Sula sula)* on Baker Island, now part of the Pacific Remote Islands Marine National Monument

IMPORTANT NOTICE TO OUR SUBSCRIBERS AND READERS

WE ARE SORRY to have to inform you that this is the next-to-last issue of ***Coast & Ocean.*** Because of the State's budget crisis, the Coastal Conservancy cannot afford to renew the grant on which the existence of this magazine has depended for more than 24 years. Subscriptions cover only part of the cost of production.

If you value ***Coast & Ocean,*** we would greatly appreciate it if you would write and tell us how you have found the magazine worthwhile and useful. Such letters might help build support in the future. Should the magazine be saved? Is it important?

If you have ideas on how to rescue ***Coast & Ocean,*** perhaps through a partnership with another organization with a coastwide mandate, let us know. Likewise if you know of any sources of possible funding. Perhaps this crisis is the right moment to find a new format for ***Coast & Ocean,*** or to do more on the Internet and with other electronic media.

Right now, however, we are sad to say that there will be no Winter 2009–10 ***Coast & Ocean,*** which was to have celebrated the magazine's 25th anniversary with a look at some extraordinary conservation victories along the California coast, and major work in progress.

You can write to us at the postal address on the inside front cover, or send e-mail to calcoast@scc.ca.gov.

If we have your e-mail address, we will let you know if a way is found to revive ***Coast & Ocean.*** Please send it to our subscription manager, Ginger Hertz: ghertz@scc.ca.gov, with "sub info" in the subject line.We will gladly send more copies of this or any other issue we have in stock to those of you who still have issues left in your subscription. Information about refunds will appear in the next issue.

We hope you will enjoy this special issue on the Pacific Ocean as much as we have enjoyed bringing it to you.

—The Editors

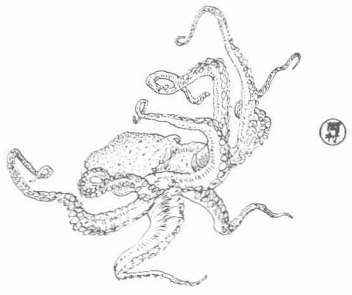
THIS ISSUE OF *COAST & OCEAN* grew out of reflections about our place on the planet over the course of the last 23 years—my time here as editor. In California, we look out onto the world's largest ocean, larger than Earth's total land area; yet until recently, most of us, even those who love the shore and the surf, were largely unaware of the underwater world. That is now changing.

Back in the 1970s, when citizens rallied to save the coast, they were driven by fear that private development would wall them off from the beaches and ocean views. In 1972 they passed the "Save Our Coast" voter initiative, Proposition 20, which led to the 1976 California Coastal Act. That law defined a strip along the shore as the Coastal Zone, and created the Coastal Commission to ensure the people's right of access to the shore and protection for their natural heritage. But it became apparent that protecting the coast required looking upstream and to nearshore waters as well. The Coastal Conservancy, also established in 1976, now works within all the coastal watersheds on projects to restore and protect streams and other habitats, farms, and open spaces. Lately it has also been increasingly active in nearshore waters, which receive land-based pollution and are vital for birds, fish, and myriad other creatures. Public understanding of ecological interconnectedness has grown, but it still doesn't extend far beyond the shoreline.

In fact, our coast is inseparable from the ocean and all that surrounds it. Ocean issues affect every one of us. Our mountains and rivers don't stop at the waterline. The pollution and junk that we dump into the ocean does not vanish. Scientists, recreational divers, underwater photographers, and filmmakers, shocked by what they find, have been calling for action. Undersea explorers using new technologies have been discovering strange creatures at depths long assumed to be devoid of life. And slowly but surely, an ocean protection movement has arisen throughout the Pacific Basin, with aquariums, new nongovernmental organizations, and some older conservation groups playing major roles.

This issue of *Coast & Ocean* contains articles about some of the greatest threats to the Pacific Ocean, as well as hopeful trends. The most alarming article concerns ocean acidification, the least-talked-about but perhaps most serious effect of climate change. Doug George, an oceanographer and science writer, learned that the current rapid change in the ocean's chemistry appears to be irreversible.

OUR WONDROUS OCEAN



Glen Martin reports on the impacts of large ships on sea life. That's an ocean pollution problem that can be mitigated—if enough people demand it. David McGuire and Anne Canright write about sharks, top predators that play a vital role in ocean ecosystems but are rapidly declining. Although they were here before the dinosaurs, their future is uncertain. McGuire is among their passionate defenders.

Despite the rather grim picture these stories paint, there's good news too. Many recreational divers have become activists and are inspiring others. Preservation efforts, including a movement to establish marine protected areas, have been launched by many Pacific nations, ranging from tiny Kiribati to Australia, New Zealand, and the United States, with California in the lead. It's not too late to start working together for our ocean.

This issue is built around the map you will find inside the back cover. Maps commonly focus on the continents, with the world ocean as blue backdrop. In most maps of North America I've come across, you see only the eastern part of of the Pacific Ocean. Mona Caron has now created a joyful map of the entire Pacific for *Coast & Ocean*. It is an artist's evocation, sparked by the desire that everyone learn about the underwater world and the role we play in it, and become engaged in protecting it. Among those who helped in this map's creation we are especially grateful to John Cloud, historical geographer at the National Oceanic and Atmospheric Administration Central Library.

Younger children will not read the articles in this issue, but we expect that they will be intrigued by what they see on the map and ask questions. You might use other maps, such as those of *National Geographic* and Google, and books and the Internet, to satisfy their—and your—curiosity about features you find on the map. Note that we have not put in city or country names, only those of continents and selected islands, and not even all of those—there are more than 20,000 Pacific islands, and the size of the map did not allow that much detail. We hope this map will lead to further geographical exploration.

You might hang our map next to your bathroom mirror or medicine cabinet, to study while you brush your teeth. Or simply use it as a bright reminder of our connection with the place we all came from—the sea.

—Rasa Gustaitis

LEFT: ABE DOHERTY; RIGHT ARTHUR OKAMURA

A filmmaker works in behalf of these amazing predators

FOR THE LOVE OF SHARKS

DAVID MCGUIRE

THE TIGER SHARK'S FINS FLARE wide as the animal rises from the deep, swimming directly toward me. Seawater pushes through the pass in the limestone reef, boiling with the forces of the ebbing lagoon, carrying fish and my friends along with it out into the deep coral drop-off. Known in French Polynesia as the *mascaret*, the current piles up in standing waves, and creates spinning vortices and back-eddies far beyond the atoll out into the blue Pacific. Camera rolling, I can count the stripes and see the fine scars along the shark's muscular flank as it glides by. I sailed from San Francisco to the remote atolls of the Tuamotus with my friends from Trillium Films to make a documentary on sharks called *Sharks: Stewards of the Reef.* On this small coral island inhabited by a few hundred people we have found the sharks—or the sharks have found us.

From the bottom of the narrow pass, a shadow takes shape, then another and another as more sharks arrive. Soon scores of reef sharks join the tiger, all gliding effortlessly in the currents, banking sharp and sweeping back like 747s in holding patterns. A fin's breadth away from the lens the shark rockets ahead to swallow up a preoccupied snapper. Clouds of colorful fish dart and delve into the niches among the coral. It is near nightfall and it is feeding time: the planktivores and the herbivores, the predators and the voyeurs, all combining in this explosion of tropical ocean life. This is the ocean in its most resplendent and complete form, from the apex predators like sharks down to a vibrant coral reef. This is wildness.

Yet even here, human impacts are evident: plastics washed ashore, a tangled fishnet on the reef, and fishing boats speeding past from the sea to the village. In search of a prisitine coral reef to film, we set sail the following day for less impacted islands and more sharks.

Our friend Tuare guides our sailboat, the *Bluefin,* to an uninhabited atoll to the southeast, deep into this island group known by mariners as the Dangerous Archipelago. There are no beaches here on Tepoto-iti, no safe harbor, and the entrance to the lagoon is so shallow and narrow that even our inflatable dinghy can enter only during the mildest of surf. We anchor *Bluefin* in the deep water of the island's lee, set up camp on bare coral rock beneath the palm trees, and prepare for the day's diving. Penetrating the blue waters, we expect to see swarms of large sharks, but our dives reveal that large sharks are entirely absent, and even small ones are far fewer than at other islands.

"They were here last year, but today there are not so many sharks," says Tuare. "The commercial fishermen put out the longlines. They catch the tuna but they also catch the sharks." By evening, we are tired and hungry, and disap-

PETE FAULKNER/MARINE PHOTOBANK

A gray reef shark at Osprey Reef in the Coral Sea near Australia

pointed. The water is crystal clear, the reef is healthy and undamaged, and small fish glitter in the sunlight, but we have seen only a few sharks. As we organize our new base camp, Tuare tends the driftwood fire built in a ring of coral rock. Palm fronds clatter in the tradewinds over the constant voice of the sea. "The longliners are not permitted to fish here," Tuare says with a shrug, "But there is no one to stop them. There is no enforcement." He nods his head. His golden earring glitters in the firelight, but his usual smile is absent. To the north, a 50-foot boat hangs on the horizon, its bright lights outshining the stars' reflections. Tuare pokes a steaming package of reef fish wrapped in palm leaves, and as if drawn by the odor, the lights creep sideways to the reef's edge like crabs, but it is not the odor of fish they chase: it is the smell of money.

"That boat is killing sharks." Tuare points. "They catch them in the currents between the atolls. They take them for the *ailerons*, for the fins. *Pas bon.*" He shakes his head. "No good." The foreigners come in large ships and kill Pacific sharks by the thousands.

Inspired by Beauty

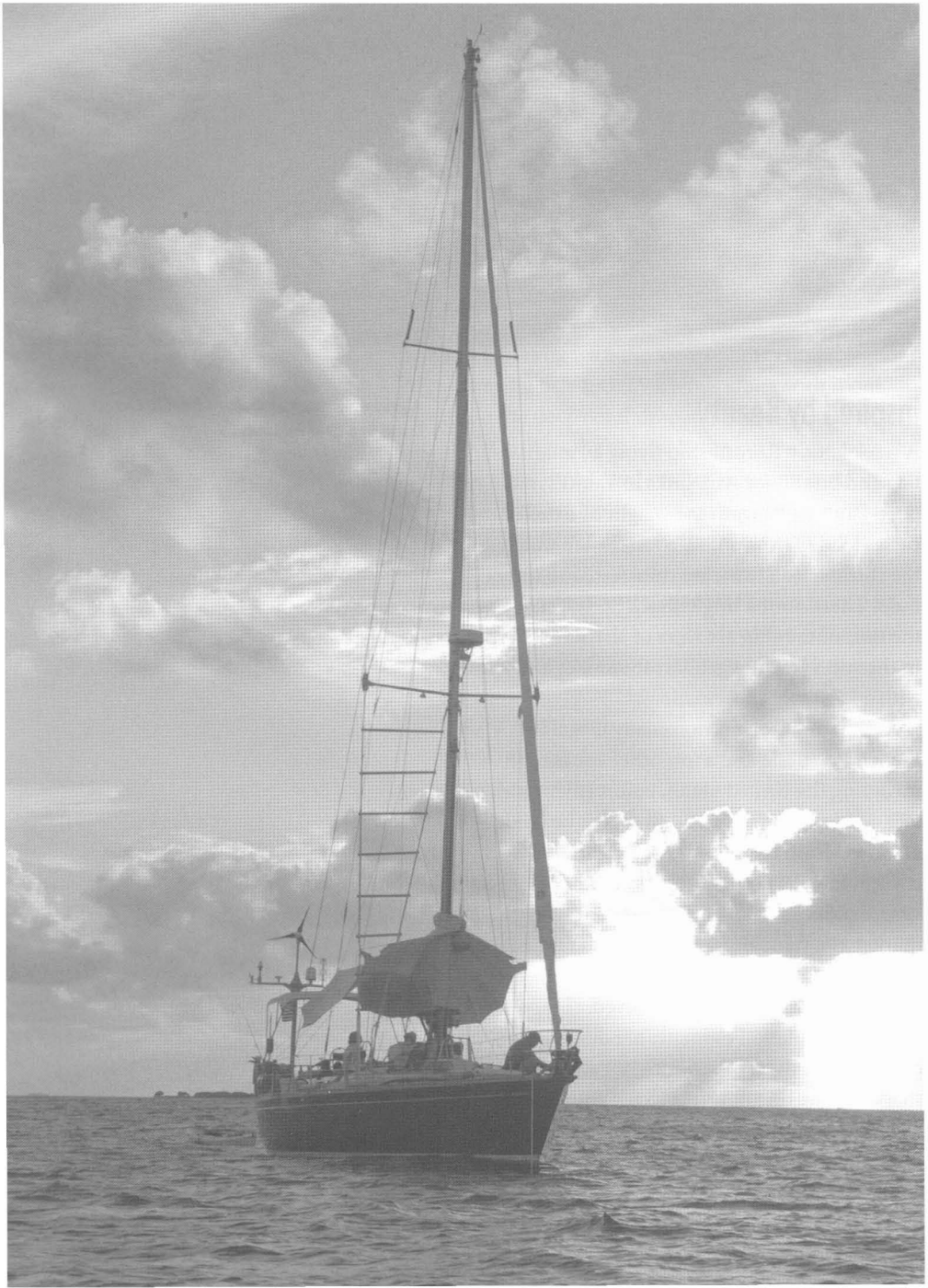
A week later, a Korean ship flying a Panamanian flag and bound for Asia sinks in Tahiti's main port, Papeete, beneath the weight of frozen carcasses loaded from smaller vessels. We watch as the carcasses, all tuna, are transferred to the hold. There's not a single shark body, yet lining the rails of the ship are rows of shark fins drying in the sun. Nearby a gendarme smokes and jokes with a local longshoreman.

Although finning is nominally illegal in French Polynesia and a few other countries, including the United States, enforcement is difficult and legal loopholes allow fins to be landed detached from the shark. Once the fin has been landed, there is no requirement to document its source or legality, and the fins enter the world market as a valuable commodity. The transition from sleek ocean predator to a handful of high-priced body parts is easily achieved.

Shark population estimates are difficult to come by, and most fisheries do not account for sharks, yet we do know that shark populations experience significant threats globally, from

overfishing, to longlining, to shark finning. One study estimates that some large oceanic shark species have been reduced by 90 percent in the last 50 years. Over 50 species, including great white sharks, are endangered or threatened. Although research indicates that apex predators like sharks are important for maintaining healthy ocean ecosystems, sharks are at best disregarded, or at worst killed for a few fins.

Inspired by the beauty of these animals in the wild and the information emerging from film interviews, I formed Sea Stewards, an organization dedicated to a healthy ocean. Our efforts in media development and advocacy are helping to raise awareness toward protecting sharks and all ocean life. In one case, we teamed with a young student from the town of Tiburon, on a peninsula in San Francisco Bay, to urge that town, named with the Spanish word for shark, to proclaim itself fin-free and in favor of protecting sharks, which it did.



Killed for Their Fins

Along Stockton Street in San Francisco's Chinatown are small shops where you can buy shark fins. Squeezing past an apothecary shop with a sign reading "Fresh Ginseng and Medicines," I duck into the fluorescent light of a dried-seafood market. It's filled with bins of shriveled scallops, shrunken abalone, and other seafood products, including shark fins. The matron watches me warily as I wade into the densely packed aisle of the shop, camera in hand.

I study glass jars stuffed with obscure sea animals, sea horses, dried fish, and the indecipherable jellies and cartilages of defunct marine animals displayed like a natural history collection from Darwin's voyage.

Stopping before a shelf crammed with dried triangles, I surreptitiously pan the camera from jar to jar and bag to bag. "$480 pound" is marked on one bag. Chinese characters I cannot understand and "Special $228 per pound" is marked on another bag of small gray fins.

"Can I help you, sir?" A young woman approaches me and I drop the lens of my camera. "Yes. What is that?" I point at a jar of fins. "Oh, that is shark fin." "What kind of shark is it?" She giggles and speaks to the matron in rapid Chinese. "I don't know."

"Where do they come from?"

She shoots another query to the matron and laughs awkwardly. "We don't know."

"Why you want to know?" The older woman eyes my camera suspiciously. "I collect shark parts." I reply. "Teeth, jaws, you know?"

She shrugs. I'm not completely lying. Although I don't collect shark parts, I collect shark images in the flesh, but I leave them living, and I am here to collect images of the end of the line for too many sharks. I finger a bag containing a hundred gray fins, about three inches long. They are faded, stringy and difficult to identify. Each could be the anal fin of a

PHOTOS THIS PAGE: DAVID MCGUIRE

Top: David McGuire

Left: The *Bluefin* at sunset

reef shark like the ones I had dived with on the remote reefs of the Tuamotus, or the dorsal fin of the leopard shark that lives in our home waters. This 400-square-foot shop might contain the remnants of 10,000 sharks, I figure, and it is only one among many on this street, and more across the world.

"Take this one." The young woman points to a jar filled with over a hundred small pale triangles with feathered edges. "These are better." Another sucker in her eyes, I smile. "OK, I'll take one."

"Only one?' I nod as she weighs the fin carefully—0.60 ounce—then places the small triangle into a cellophane bag and heat-seals it. "Twenty dollars." She smiles brightly. "So much?" I recoil.

"Very good quality. Very good deal." She places a hand on my arm and smiles.

It's not a very good deal for the sharks. Like a black-market drug, this tiny fin represents a journey from harvester to processors, through middlemen to this small shop. The merchant does not know the origin or the species because shark fishing is poorly regulated, few species receive protection, and the trade is hugely lucrative.

Shark fin, known in China as *yu chi* or "fish wing," is used as a textural additive to soup—a delicacy consumed by wealthy and powerful Chinese since at least the start of the Sung dynasty in 960 A.D. Once valued by a small group of the elite, growing prosperity has created broader demand for this high-status dish to celebrate weddings or business luncheons. A burgeoning demand for shark fin soup in both Asia and the West motivates fishers to kill the sharks only for their fins.

Finning is an ignoble death for an animal so consummately adapted to the sea. With only a tiny percentage of the animal consumed, this practice is also a terrible waste of food for a growing population reliant on protein from the sea. Despite recent estimates that less than 10 percent remain of some large oceanic shark populations, the hunt for shark fins is escalating, and the practice is unregulated in most parts of the world.

The United Nations Food and Agricultural Organization estimates that over 100 million sharks are killed each year by finning and as bycatch. A 2006 study estimated that as many as 73 million sharks per year may be killed for fins alone, and the World Conservation Society estimates that the shark fin trade is growing by five percent a year.

Captive Ambassadors

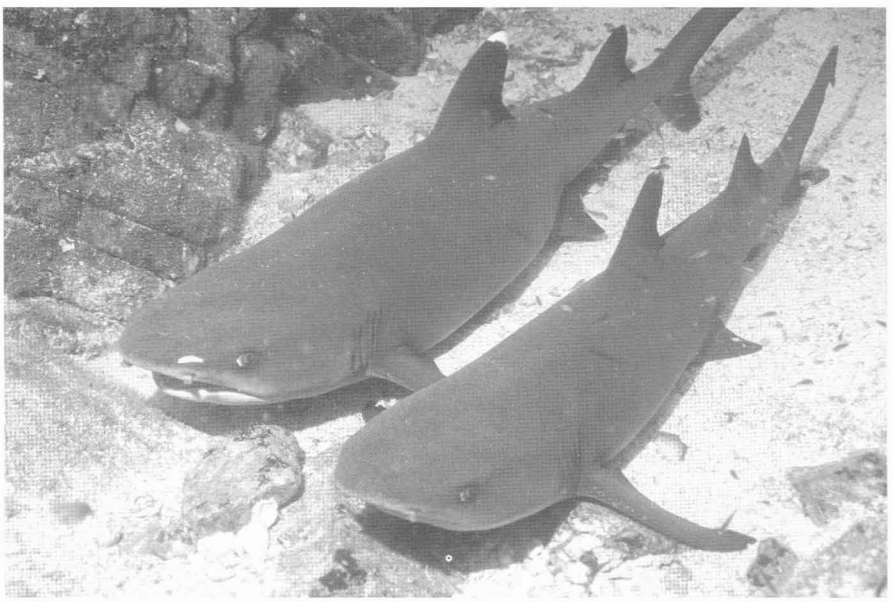
Gripping my packaged fin and feeling depressed, I walk down to the waterfront a few blocks away. At a wharf along the Embarcadero, a fisherman pulls a struggling shark from the water, and a small crowd marvels as he removes the hook and releases it into the green waters below. "Some guys like to eat sharks. I just like to catch them and let them go." The fisherman says, recasting his line into the tidal flow.

The waters of San Francisco Bay are not nearly as clear as the waters of Polynesia, so it's difficult to see, or to film, sharks here. You can, however, watch them in crystal-clear water farther up the waterfront at the Aquarium of the Bay. From inside the large shark tank, I have filmed a group of schoolchildren watching me as I dived with the sharks, while making a film on local sharks, *City of the Shark*. Surrounding me, in the film, are large sevengill sharks and smaller soupfins, leopard sharks, smoothhounds, and spiny dogfish. All live in my home waters. Swimming in a tank is not quite as exciting as diving with sharks in the wild, of course, nor is an aquarium true shark habitat, but I am moved to think that these captive animals are acting as ambassadors, impressing and educating the public about the beauty and importance of living sharks.

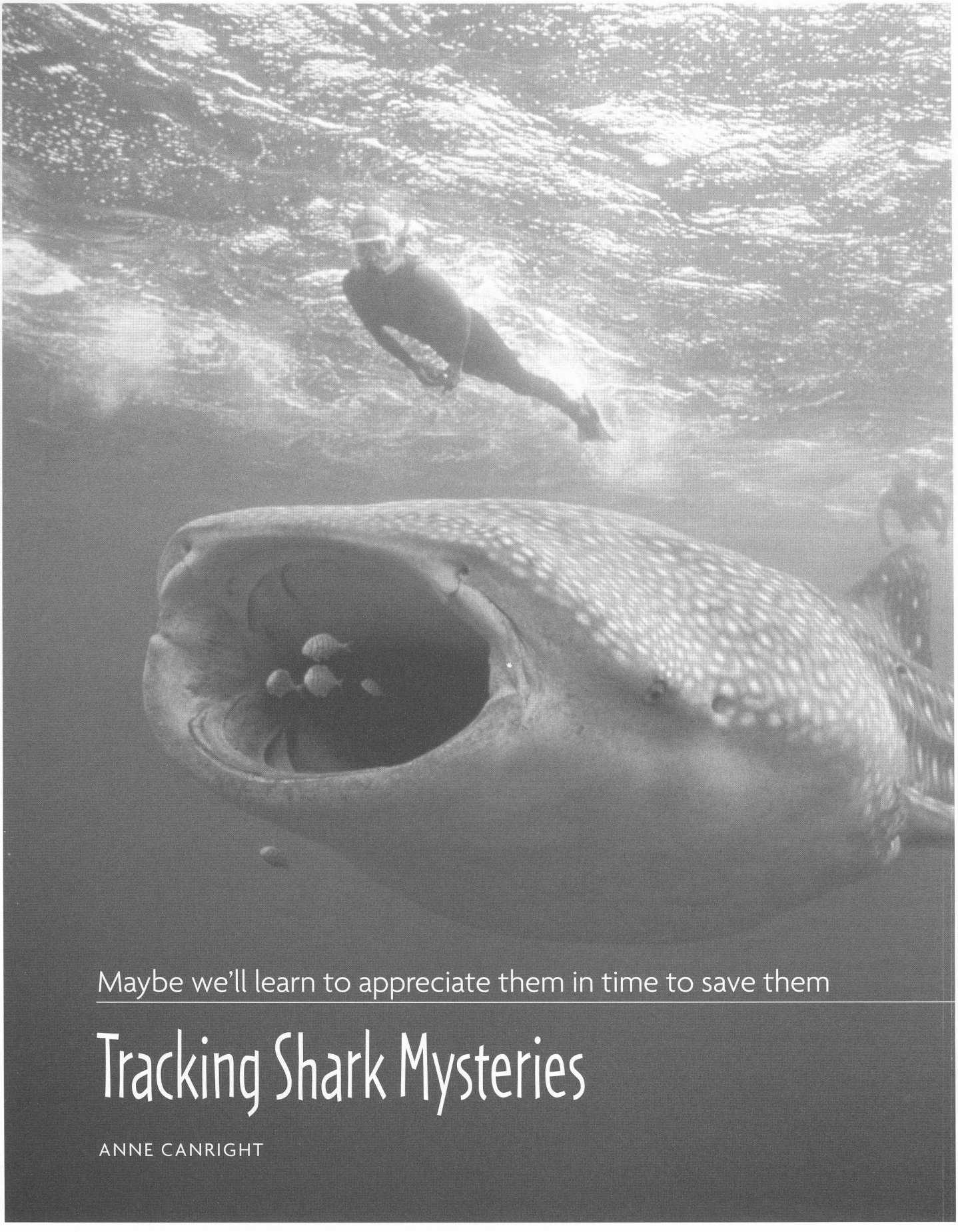
continued on page 38

Below: Dried shark fins sell for high prices in Chinatown shops.

Bottom: Whitetip reef sharks *(Triaenodon obesus)*, Cocos Island, Costa Rica



TOP: DAVID MCGUIRE; BOTTOM: © 2006 RICHARD LANG



Maybe we'll learn to appreciate them in time to save them

Tracking Shark Mysteries

ANNE CANRIGHT

LAST APRIL, GARY ADKISON, manager of the U.S. branch of the Swiss-based Shark Foundation, got an anonymous call telling him of a shark-fishing tournament to be held in early June in Fort Myers, Florida. The caller was distressed; this was an annual event he thought was no longer acceptable, but he said he could not speak out in public.

Adkison sent an appeal to his worldwide e-mail list of shark supporters, and within a day tournament sponsors and city officials were flooded with protest calls and mail. He and his allies then contacted the local chamber of commerce and other sponsors of Shark Fest 2009, a two-day event with a street fair, boat show, and children's fishing derby, as well as the shark tournament. They suggested an alternative: a catch-and-release tournament, captured on streaming video that could be viewed on a large screen by the public.

On May 20 the local *Beach Observer* reported that "due to an overall dissatisfaction and a misinformed general public about the killing of sharks," the rules of the June 6–7 tournament would change: it would be catch-and-release. Five sharks would be tagged in advance, and a $10,000 prize would be awarded to anyone who caught one of these.

Adkison was jubilant as he told the story. Sure, he said, it would have been better to have no shark tournament at all, but this was a big step toward the larger goal of shark protection worldwide. "Word is getting out that the sharks are in trouble," he observed.

Whether that information will help save these awesome ocean predators from extinction remains to be seen. Sharks have plied Earth's waters since before the dinosaurs, but now their survival is threatened by human actions.

Within the past 50 years, populations of some large shark species have declined by 80 to 90 percent, said Andy Nosal, a doctoral student at Scripps Institution of Oceanography. Actual numbers are hard to come by and most are from the Atlantic Ocean, where fisheries have been better monitored than in the larger Pacific. "Asian nations don't monitor catches and kills as Europeans and Americans do," said Adkison. Yet as Nosal pointed out, "a decline in one area affects the whole world," because some sharks travel great distances. A basking shark might swim from the Atlantic around Africa to the Indian Ocean or around South America to the Pacific, for example.

The numbers of large sharks such as scalloped hammerhead, great white, and thresher—apex predators all—in the North Atlantic declined by 79 to 89 percent between 1986 and 2000, according to a report by Ransom Myers of Dalhousie University in Halifax, Nova Scotia, published in *Science* in 2003. The International Union for the Conservation of Nature has listed some lesser-known species as critically endangered and others, including the great white shark and longfin mako, as vulnerable.

The main culprits are longline fishers going after tuna and swordfish and snagging sharks as bycatch, and European fishers capitalizing on the growing popularity of shark meat worldwide. Shark finning is a third—and increasingly destructive—practice that is affecting shark populations worldwide. Nosal considers finning the greatest threat now, with overfishing close behind. As other species are overfished and no longer available, he said, shark meat provides an inexpensive alternative.

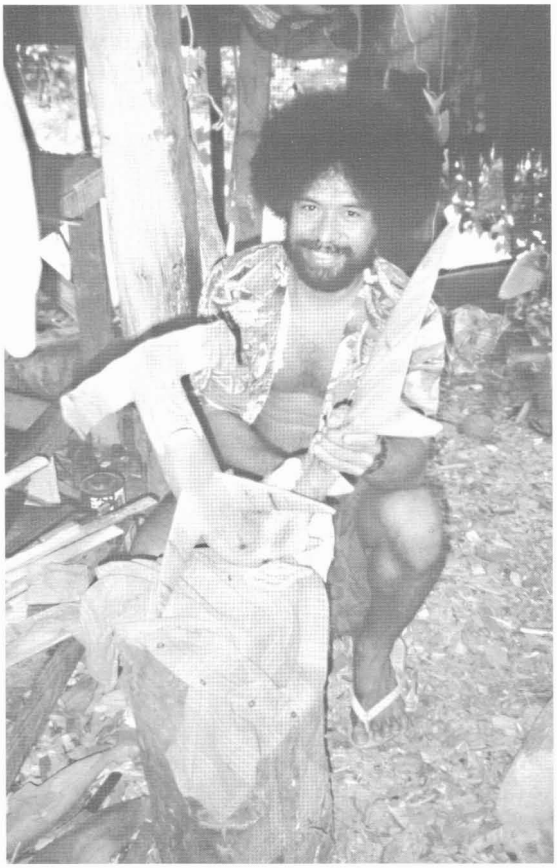
Protectors and Monsters

In many traditional Pacific island cultures, sharks play an important role in human lives and are revered. Fishermen seek their protection and assistance, and reciprocate with gifts of food and song. Fijians have a shark god named Dakuwaqa, who protects the people of Kadavu Island from shark attacks—so they're not afraid to go into the water. Some native Hawai'ians continue to pay respects to their shark *'aumakua,* a particular animal whom they can identify and who recognizes them, and who indeed may be a reincarnated family member. Stories are told of men at sea who were rescued and brought home by their *'aumakua.*

A California surfer who has spent some years on the beaches of Hawai'i said that Hawai'ian surfers "have a pact with the sharks," so that neither will harm the other. In the rare incidents when a shark attacks a surfer, it's understood to be a case of mistaken identity: from below, a surfer paddling on a board looks like

Opposite: Diver Adra Ross tries to keep up with a whale shark *(Rhincodon typus)* at Ningaloo Reef, Australia. The world's largest fish, whale sharks are filter feeders that eat plankton, krill, and other tiny creatures. The small fish are taking refuge from predators in the shark's mouth.

Below: A master woodcarver of Noumea, New Caledonia, holds his rendition of a hammerhead shark.



BEN MIEREMET/NOAA

a sea lion or a sea turtle, favorite foods of great white and tiger sharks, respectively.

Adkison said he's seen tiger sharks and great whites heading toward him from below more than once. "When you see that, the only thing to do is to dive straight toward him," he said. "He sees he's made a mistake and turns away."

In much of the Western world, however, sharks are feared more than they are understood, and the vital role they play in the ocean is not widely known. From the 1778 painting *Watson and the Shark* by John Singleton Copley, to Hemingway's *Old Man and the Sea,* to the movie *Jaws,* popular culture has painted a vivid picture of sharks as bloodthirsty snaggle-toothed horrors. Many of my friends are terrified of sharks—and they don't even swim in the ocean.

"The fewer sharks the better," is a widely shared view. Yet one result of the North Atlantic shark decline has been the decimation of scallop beds along the East Coast of the United States. In a healthy ecosystem, the big sharks keep populations of smaller sharks and rays, which feed on shellfish, in check; throw that ecosystem out of whack and, well, all hell breaks loose. Andy Nosal suggests that a factor contributing to the recent spread of huge Humboldt squid from Mexico south to Chile and north to Humboldt County, where they are decimating hake, may be the absence of sharks that prey on them.

Gray reef shark *(Carcharrhinus amblyrynchos)*, Fiji

"Large sharks are at the top of the food chain and directly control the population of species in the food web, including marine mammals," Nosal explained. "When they're gone, there's a trophic cascade, a chain reaction down the food web, and entangled in that are things *we* like to eat."

Tracking Pacific Sharks

Much of what scientists know about sharks they have learned in the last 50 years, said Nosal. With acoustic telemetry—the use of underwater receivers to monitor radio tags—researchers have gathered information about movements of several types of migratory sharks. For most of these wide-ranging species, however, very little is known about mating, or where the sharks give birth.

Sharks range in size from the world's largest fish, the filter-feeding whale shark, which can reach 50 feet in length, to the six-inch (yes, inch) spined pygmy shark. Most of these animals go about their business quietly, snarfing up crustaceans from reefs and fish out in the open ocean, while a very few—such as the great white—have a taste for marine mammals. (Hence the occasional attack on a human in waters off California and Australia.)

The species we know more about fall into two categories: those typically smaller species, such as leopard, horn, and angel sharks, that do not stray far from their home territory; and larger species with commercial value. The Southwest Fisheries Science Center (SWFSC), a regional research branch of the National Oceanic and Atmospheric Administration (NOAA), publishes fact sheets about 16 species of shark, but the thrust of active research is devoted to three species: shortfin mako and common thresher sharks, which, considered good eating, come to market typically as bycatch in the swordfish fishery; and blue sharks, which are also caught as bycatch in gillnets but are then discarded at sea, having no commercial value.

In 2006, SWFSC reported that in Pacific Ocean waters thresher shark stocks were possibly rebuilding after being overfished during the 1980s, while shortfin makos and blues showed a slightly decreasing trend in abundance, with decreased size as well. No crash, but trends that bear watching.

Large sharks are highly migratory, and spend at least some time far from shore. Scientists are gaining a certain amount of knowledge of their movements from satellite tagging studies and analysis of catch patterns. "Marrying . . . satellite

imagery to the animals' tracks, we've started to identify the ocean equivalent of desert oases or the watering holes of African savannahs, where the animals gather to feed and to breed," states the website of Tagging of Pacific Predators (TOPP), a project that is part of the Census of Marine Life and is comanaged by NOAA's Pacific Fisheries Ecosystems Lab, Stanford's Hopkins Marine Lab, and University of California, Santa Cruz's Long Marine Laboratory. A map showing "near real-time" tracks of individual mako sharks over the course of a year can be viewed at the TOPP website (http://topp.org/species/mako_shark); sometimes they are clustered off San Diego, and at other times they scatter widely. TOPP has also tagged blue and great white sharks.

The tags used on blue and mako sharks, which often swim close to the surface, are called SPOT (smart position or temperature transmitting) satellite tags, and are attached to the animal's dorsal fin. When the antenna breaks the surface, it sends data—including water pressure, water temperature, and travel speed—to a satellite. The animal's location is estimated by calculating the Doppler shift in the transmission signal in successive transmissions. When the animal goes beneath the surface, a saltwater switch turns off the tag.

Another sort of tag, the pop-up archival tag (PAT), is more suitable for animals that don't spend a lot of time in surface waters, such as thresher and great white sharks. Divers insert PAT tags into the animal using a small surgical titanium anchor. At a preset time, such as 30, 60, or 90 days after the tag is attached, the battery triggers the tag's release and it floats to the surface. The tag then sends samples of its data to a polar-orbiting Argos satellite for about two weeks. If the tag is later found, the entire data set can be downloaded and analyzed. The information collected includes pressure (to determine dive depths), ambient light (to estimate location), and internal and external body temperature.

All this information tells us quite a bit about where these fish go. The data also show which fish stray over national borders—an area of concern for fisheries management—or out into longline-infested open-ocean waters.

Blue sharks, for example, have been tracked from the West Coast of North America westward to the Hawai'ian Islands and Midway. Thresher sharks are thought to have a seasonal north-south migration between Baja California and Oregon and Washington, with pupping taking place in southern California in early spring. The SWFSC description of shortfin mako shark movements, meanwhile, is full of words like "appear to," "estimated," and "presumably." Apparently, they start off in southern California waters, then move offshore or to the south. Many tagged fish have been recaptured in southern California, but some have been taken as far north as Point Arena, as far south as Acapulco, and as far west as Hawai'i.

DAVID MCGUIRE

Leopard shark *(Triakis semifasciata)*

Fish Know No National Boundaries

We have fairly solid fisheries management in U.S. waters, but what happens when a subadult thresher shark passes over the border into Mexico, or a blue shark heads out into waters crisscrossed by longlines—or simply into international waters, and into the hands of fishers interested only in their dorsal fins? Dan Cartamil, also a doctoral student at Scripps, is interested in this area where biology, politics, economics, and conservation intersect.

He is looking at how artisanal fisheries affect elasmobranch (sharks and their ray and skate cousins) populations in Baja California. "We're starting to understand [these animals'] movements in U.S. waters, but we don't know anything about their habits in Mexico or [commercial uses] in Mexico," he said. The study involves a detailed survey of traditional, small-scale fisheries from the U.S. border to the Vizcaíno Peninsula, halfway down the Pacific coast of Baja. "We visit every single camp at various times of the year to determine what the fishing effort is there, what the target species are, how many fishermen are at the camp, and what kind

of gear they use," he explained. "Once you know that, though, it doesn't tell you much about what they're doing with the catch." So he's chosen two camps to focus on, going once a month and spending five days. "We're on the beach the entire day when the boats come in, and we collect data on every animal that comes in—what species they are, what sex they are, how they were caught."

Some 30 species of sharks and rays are taken in the study area, and all except two species are being used (because they're too small and don't have any market value). "The catches are being correlated. The basic idea is to get some biological information of the species being caught. If, for example, you're getting a lot of juveniles of one species, that indicates that the area is a nursery for these animals. If you're only getting males at one part of the year and females at another part, that tells you about sexual segregation of these animals."

The study also involves looking at the animals' market value; where they end up—whether in local cooking pots or in markets in Ensenada; and what the impact of the fishing enterprise is on the local economy. "The economic part is more complicated, so we're going to be teaming up with people who specialize in that," Cartamil said. In particular, he points to a working group of Mexican and American fisheries biologists and managers that has come together to address issues of conservation, known as the Southern California Bight Elasmobranch Consortium (www.sharkbight.com, site now under construction).

Threats to Sharks

Research like Cartamil's will add to our knowledge of sharks and shark fisheries, but will it be enough, and come in time to prevent decimation of these populations? Cartamil's doctoral adviser, Jeff Graham, points to three factors that are working against sharks, especially outside U.S. waters, where fishing regulations lack teeth. The first is sharks' natural history—their story from birth to death, including how they find food and where and when they bear their young. The fact that as a group they reproduce late in life and have relatively few offspring is especially critical. "They simply don't have the reproductive potential to recover from overwhelming mortalities," Graham said.

The second is commercial fishing—not for sharks necessarily, but in other fisheries in which sharks are bycatch. Graham pointed to the gillnet as being particularly harmful; he called it "the scourge of fishing" because it kills everything that blunders into it. Off California, beyond the three-mile limit, drift gillnets are used in the swordfish fishery. Bycatch includes mako and thresher sharks, which are taken to market, and blue sharks, which are not. "Every time a drift gillnet is set, which usually means every night" during the season, said Graham, "eight blue sharks are killed."

Longlines, too, kill sharks. A 2007 report published by the Western Pacific Regional Fishery Management Council and Blue Ocean Institute summarized a study of 12 longline fisheries from eight countries; it found that sharks comprise more than 25 percent of the total catch in the Australian longline tuna and billfish fishery and Fiji longline tuna fishery. Prior to a prohibition on the use of squid for bait, sharks comprised 50 percent of the catch of the Hawai'i-based longline swordfish fishery; now they make up 32 percent of the total catch. The largest proportion was blue sharks, ranging from 47 percent to 92 percent of the total shark catch. The study noted that "incentives to avoid sharks vary along a continuum, based on whether sharks represent an economic disadvantage or advantage."

The third factor that is rapidly leading to sharks' decline worldwide is finning, an inhumane and largely unregulated practice that has increased dramatically in the last 20 years. Dried shark fins are a principal ingredient of shark-fin soup, which—ever since its political "rehabilitation" in the late 1980s in China (Mao Zedong had discouraged its consumption, declaring it "elitist")—has become increasingly popular, a "must" at most weddings and corporate functions. Because a fin is so much more valuable than the fish itself (one pound of dried shark fin can sell for up to $500, and the tailfin of a huge basking shark can fetch nearly $10,000), fishers will, if they can get away with it, keep only the fins and discard the fish. The World Conservation Union's Shark Specialist Group estimates that tens of millions of sharks are finned worldwide every year. The true number is impossible to determine, given an active black market.

In U.S. waters, finning is allowed, but the body may not be discarded; only two percent of the total shark catch can be in the form of fins. A bill introduced by Sen. John Kerry would close the loophole in the law, which exempted boats that stopped in a U.S. port while in transit. Other

Scalloped hammerhead shark *(Sphyrna lewini)*, Cocos Island, Costa Rica

countries with similar laws include Australia, Brazil, Canada, Costa Rica, Ecuador, Oman, the Seychelles, and South Africa, as well as the European Union. However, according to the Food and Agriculture Organization (FAO) of the United Nations, the only organization maintaining a database on the shark fin trade, the world leaders in shark fin production are Indonesia, Singapore, and India, collectively accounting for 80 percent of production. China, which together with Hong Kong accounts for 90 percent of shark fin imports worldwide, has never reported any shark fin production to the FAO. These countries have no laws regulating the practice of finning.

To Love Them Like Dolphins

Nosal, also in Graham's lab, sees outreach as the key to shark conservation: communicating the value and beauty of these animals, and educating people about what they can do to protect sharks. "We need to love them," he said, "just as we love dolphins, whales, and seals."

Humans who are at ease in the underwater world tend to appreciate their magnificence. "You have to see a shark, see it move, almost like a plane," Nosal said, his voice rich with emotion. "They soar through the water, graceful, not at all erratic; their movement is beautiful. They have an amazing sense of smell and can detect electric signals. They have inspired submarine design. Their skin, too, is amazing. It has denticles, like microscopic teeth. Olympic swimmers wear suits made with denticles to help [them] swim faster."

Because it is so easy to appreciate marine mammals, said Nosal, "we now have the Marine Mammal Protection Act, but we have nothing like that for sharks." He does not advocate as stringent a law, but does believe comprehensive and international protection against finning, overfishing, and other threats is essential.

Some countries have moved to protect certain species. In 1991, South Africa made it illegal to hook a great white shark within 200 miles of its coast. In 1997, the United States shut down commercial fishing for great whites, and limited recreational fishing to tag-and-release along the Gulf and Atlantic coasts. In California that year, Governor Pete Wilson signed a bill that afforded great white sharks complete protection, and Australia did the same a few months later. Other sharks are beginning to receive similar treatment.

These efforts, however, can only go so far, due to the highly migratory nature of the most threatened sharks. Sean Van Sommeran of the Pelagic Shark Research Foundation noted, "Local independent grass-roots education and advocacy are crucial to the efforts of wildlife conservationists and management officials." One example from our own coastal waters is a regulatory change instituted in March 2009 in the Gulf of the Farallones National Marine Sanctuary, prohibiting people from getting closer than 50 meters (165 feet) to a great white shark within two nautical

miles of the Farallon Islands. The rule also prohibits the use of decoys or chum to lure sharks. Mary Jane Schramm, spokesperson for the sanctuary, commented, "We have had cases where people in vessels come charging up to the sharks, scaring them away from food they have just caught." In making this change, sanctuary managers relied not only on scientific research, but also on public comment—underscoring the importance of education and advocacy.

Nosal tries to get the public "to be more conscious of how their fear of sharks has developed, and how it has been fostered over time." People have access to sharks in three main ways, he said: directly, through a personal encounter; at aquariums (the Monterey Bay Aquarium has even had success in displaying great white sharks, an incredible and awesome sight); and—the predominant way—through the media, which, he said, typically show sharks in a sensationalist and negative light. "The background music they use is always scary. It affects you emotionally." Direct encounters, in contrast—except of course for the exceptionally rare shark attack—are "invariably positive," Nosal said. "Scuba divers will tell you it's an amazing experience to be able to share company with a shark." Independent filmmakers have weighed in to counter the frightening media image (see p. 4).

And then there's our consumption of sharks, as meat, cartilage (as in chondroitin supplements taken for arthritis), and, most commonly, in shark-fin soup. Nosal said, "I don't want to vilify people who buy shark meat—it's tasty, it's good. Finning is the big thing. There is a demand for it. We can do all we can to make shark finning illegal, but the bottom line is, if there's demand, there'll be a black market."

Gradually, efforts to educate people on this barbaric practice are bearing fruit. In 2005, Walt Disney Co. bowed to pressure from animal rights groups and agreed not to offer shark-fin soup at the new Hong Kong Disneyland theme park. Celebrities have gotten into the fight as well: in August 2006, Yao Ming, the seven-foot-six Shanghai-born star of the Houston Rockets, publicly swore off shark-fin soup at a Beijing press conference held by the environmental advocacy group WildAid. When WildAid conducted a survey in Hong Kong and China, said Nosal, "the vast majority didn't know what was in shark-fin soup, because in Chinese it's known as 'fish wing soup.'" But when told how the soup comes to their banquet table, the majority immediately said that they would find an alternative. A discussion thread on www.singaporebrides.com, in fact, offers many scrumptious-sounding substitutes for the traditional soup.

The combined efforts of people who have come to love sharks are building momentum. The Shark Foundation's Gary Adkison draws inspiration from a famous saying by Margaret Mead: "Never doubt for a single minute that a small group of thoughtful committed citizens can change the world. Indeed, it's the only thing that ever has." Perhaps it's not yet too late for these ancient and amazing fellow creatures. ■

Anne Canright can often be found at the Monterey Bay Aquarium gazing in awe at the various species of sharks on display there.

Horn shark *(Heterodontus francisci)*, Channel Islands, California

The Great Dissolvin

DOUG GEORGE

DROP A DIRTY PENNY into a glass of Coke. If you examine the penny after a week, Abraham Lincoln's head will be gleaming. The carbonic acid in the cola has dissolved the organic grime on the copper-plated coin. It's a science-class experiment many of us will remember from childhood. Now consider that the ocean is becoming corrosive, like Coke.

The phenomenon is called ocean acidification, and, like climate change, it is a result of increasing carbon dioxide (CO_2) emissions. The oceans have absorbed about one third of the CO_2 released into the atmosphere by humans over the past 200 years, and that is changing the waters' chemistry. The oceans are not fizzing like that glass of Coke—the chemical change is not that extreme—but they are becoming more acidic, with ominous consequences. A shift in the pH balance of seawater is under way, and it threatens shell-building creatures, corals, fisheries such as salmon, oysters, mussels, and sea urchins, and entire marine ecosystems.

The chemical reactions involved in acidification are well understood. There is also no controversy over the fact that acidification is happening on a global scale. And what can be done to slow it down is simple from a scientific view: eliminate all sources of human CO_2 emissions, immediately. Even if it were possible for this to occur, however, the harm will likely continue. Enough CO_2 may have already entered the ocean to cause hundreds of years of damage to millions of years' worth of evolutionary progression.

Acidity is measured on a pH scale, which ranges from 0 (strong acid) to 14 (strong base), with pure water a neutral 7. Like the seismic scale for earthquakes, the pH scale is logarithmic, so each additional 0.1 is in fact an increase of 30 percent. Depending on the marine habitat and depth, seawater can range in pH from 7.5 to 8.4, so it's slightly basic. When CO_2 dissolves in seawater, it forms carbonic acid. A few chemical reactions later, extra hydrogen ions are released; it is those ions that lower the pH level, making the water more acidic.

Ken Caldeira, an ocean acidification researcher at the Carnegie Institution for Science, recently described a demonstration experiment simple

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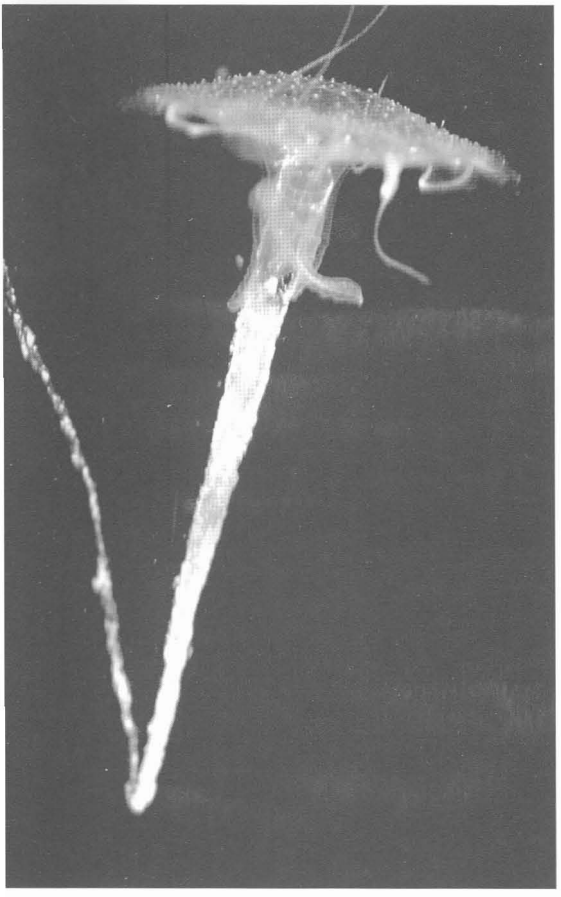
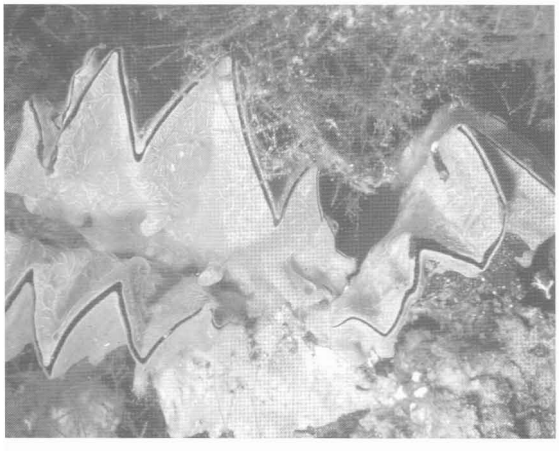
Sea whips and feather stars, Redang Marine Park, Malaysia





enough for a middle-school science fair. First, place a beaker of water inside an airtight bell jar and start pumping CO_2 into the jar. The water begins to absorb the gas as the bell jar fills. A few dips of litmus paper into the water over a short amount of time will give pH readings. "You can test the pH of the water and watch it shift," Caldeira said.

Unlike pure water, seawater contains many dissolved ions that help maintain a stable pH, including carbonate ions. The more CO_2 is forced into the water, the more carbonate ions are needed to keep the system balanced. If seawater were used in Caldeira's experiment, it would take longer to see the pH change because of the carbonate ions—at first. Once those carbonate ions run out, however, the pH would plummet and the water would acidify. In the oceans, whatever carbonate ions are used to equilibrate the seawater chemistry are no longer available for corals and other animals to build their protective shells.

Top: An Indian sea star *(Fromia indica)* spawning

Center: The pteropod *Creseis acicula* has a fragile shell.

Bottom: Cock's comb oyster *(Lopha cristagalli)*, Great Barrier Reef, Australia

A Dissolving Food Web

Researchers estimate that the oceans have absorbed about 33 percent of the CO_2 produced by human activities since 1750. During that same time, the average surface ocean pH has dropped 0.1 units, translating to a 30 percent increase in acidity. That humans could change the chemistry of 329 million cubic miles of water is a mind-boggling thought. "People are astounded," said Victoria Fabry, a biological oceanographer at California State University, San Marcos.

Fabry's research on the effects of ocean acidification brings in a group of zooplankton called pteropods, which can constitute up to 45 percent of the diet of Pacific salmon species. "Pteropod" in Latin means "winged foot," but these planktonic snails are more playfully called sea butterflies because of how they flit through the water column. Pteropods need carbonate ions to build their aragonite (a form of calcium carbonate) shells, and Fabry and her colleagues observed in laboratory experiments that the shells start to dissolve in more acidic seawater: the sea butterflies were alive and swimming even as their protective calcium carbonate shells started to dissolve. "The juveniles secreting calcium carbonate may be particularly vulnerable," said Fabry. If fewer youngsters survive to adulthood, large changes may radiate through food webs. A 10 percent decrease in pteropod numbers could lead to a 20 percent drop in mature salmon body weight, according to preliminary research done by some of Fabry's colleagues.

Other researchers look at another foundational group of organisms, called coccolithophores. Like microscopic baseballs made from hubcap-shaped calcium carbonate disks, these single-cell algae are at the base of the food web. In laboratory experiments that mimic the predicted pH of the ocean in 2100, one species, *Emiliania huxleyi,* showed an 18 percent drop in shell-building. But a cousin, *Gephyrocapsa oceanica*, was even worse off, with a 45 percent decrease. This could have serious consequences for food webs in some of the ocean's most productive regions—especially in upwelling zones, like the California Current ecosystem.

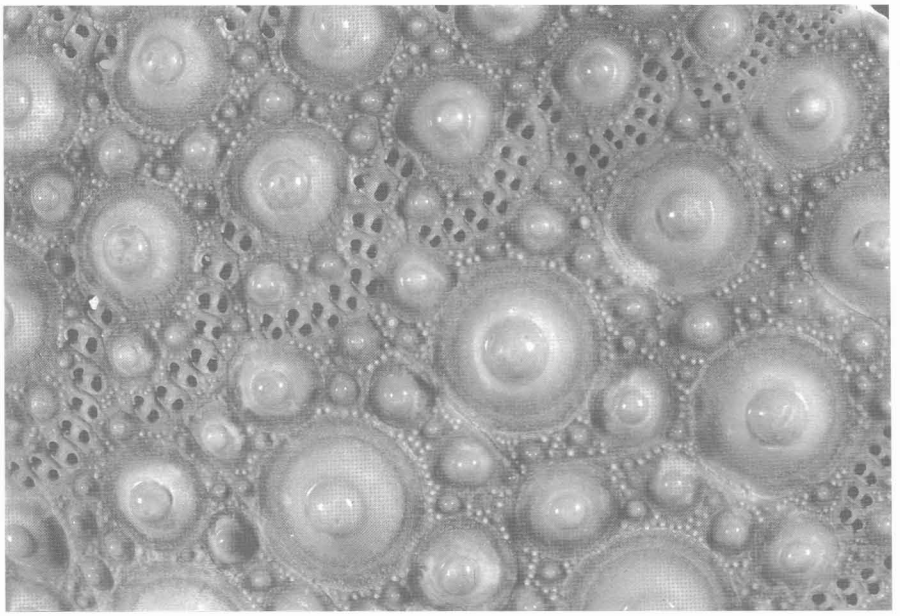
Late in spring on the West Coast of North America, the dominant winds shift from blowing onshore to heading south. The constant blowing peels the surface layers of the ocean to the west and draws deep, cold, and nutrient-rich

waters upward. The sudden supply of nutrients allows fantastic growth of phytoplankton, which builds the complicated food web that reaches up through fish, birds, and marine mammals, such as sea lions and the California gray whale.

Last year, researchers discovered that the upwelled water also carried an unwelcome amount of CO_2; moreover, it was more corrosive than they expected. Richard Feely, a chemical oceanographer at the National Oceanic and Atmospheric Administration's (NOAA) Pacific Marine Environmental Laboratory in Seattle, and his collaborators sampled seawater from Canada to Baja California to analyze water chemistry during May. Upwelled water typically has high amounts of CO_2 and low amounts of oxygen due to the natural respiratory processes of marine life and because the water has not been exposed to fresh air at the sea surface for decades. The water Feely sampled probably last saw daylight 50 years ago, when atmospheric CO_2 concentrations were less than today. Even so, the scientists found higher amounts of CO_2, low levels of carbonate ion concentration, and an undersaturation of aragonite; chemical reactions from the increased CO_2 resulted in the lowered carbonate ion concentration, which in turn caused the aragonite undersaturation. Aragonite shells will dissolve in seawater with such corrosive characteristics.

In the northeastern Pacific, the aragonite undersaturation started only 100–300 meters below the ocean surface, which happens to be exactly where upwelled water originates. "These corrosive waters are on our continental shelf right now," said Feely at a joint U.S. Geological Survey and U.S. Fish and Wildlife conference in San Francisco in January 2009, adding that climate change models did not predict these levels of aragonite until the end of this century. "This is a serious problem for our region and its ecosystems," Feely said.

Researchers from the University of Chicago published a study in 2008 that found ocean acidification was occurring ten times faster than predicted. The large difference could be related to how the climate change models were first designed. Most of the ocean chemistry data that forms the backbone of the models was collected from the open ocean, not the coastal zones. The models are appropriate to use thousands of miles from the California coast, but new ones are needed that incorporate the complex circulation patterns in upwelling areas along the coast.



The calcareous test (skeleton) of a purple sea urchin *(Strongylocentrotus purpuratus)*

Fisheries at Risk

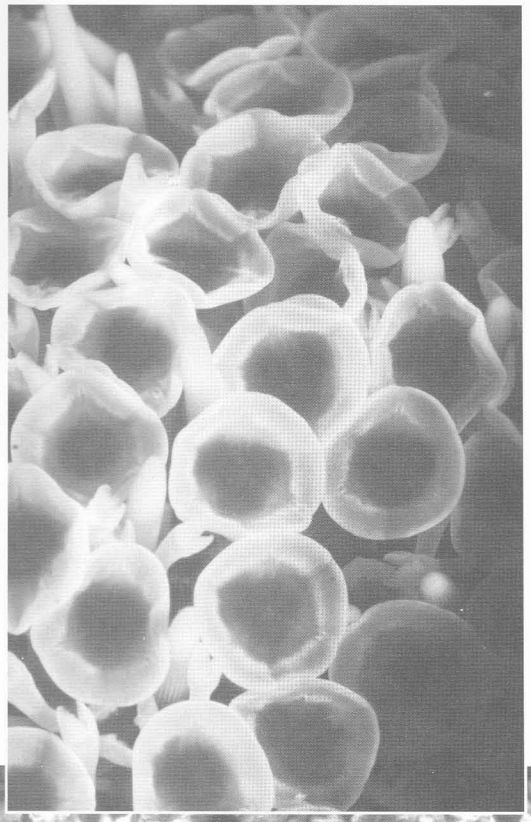
The upwelled corrosive water gives a sneak peek at what some West Coast marine organisms will be facing in the coming decades. For levels of atmospheric CO_2 that the Intergovernmental Panel on Climate Change predicts by the end of the century, mussels show a 25 percent decrease in shell formation, and oysters 10 percent. Less shell could mean higher mortality rates because the animals are weakly defended against the harsh living conditions of the ocean and coastline. Besides being what Feely calls "ecosystem engineers"—critters that form the physical structure and biological basis of a local ecosystem—mussels and oysters are part of a $2 billion at-risk fishing industry that also includes shrimp, crabs, lobsters, and sea urchins.

Sea urchins are spiny globe-like creatures about the size of a human fist. Anyone who's visited an aquarium would instantly recognize an urchin, with its spindly rigid spines that look like a frozen fireworks explosion. In their natural habitat, urchins feed busily on algae as they slowly tip-toe across the seabed and rocks. They construct their spines by calcification, using available carbonate ions in the water to build calcium carbonate crystals. As with pteropods, the sea urchins' ability to build those vital crystals decreases with declines in seawater pH and availability of carbonate ions. Researchers at the University of California, Santa Barbara, found that in more acidic waters the animals grow "short and stumpy skeletons" and are more easily killed by temperature increases. For the Channel Islands

region of southern California, deformed and disappearing sea urchins evoke a nightmare scenario.

The Channel Islands are outcrops continuing the Santa Monica Mountain Range west into the Pacific off the coast of Santa Barbara and Ventura Counties. The Santa Barbara Channel is a prime shipping route for the ports of Los Angeles and Long Beach, but it is also a crucial sea urchin fishing area. From 2003 to 2008, fishermen in the Santa Barbara–Ventura–Oxnard region landed 3.1 billion pounds of red and purple sea urchins, according to records from the California Department of Fish and Game. Urchins are sold for sushi, with the Channel Islands region contributing the bulk of California's supply.

"I like to say we should ban ocean acidification from the Channel Islands," joked Shiva Polefka, a marine conservation analyst at the nonprofit Environmental Defense Center (EDC) in Santa Barbara. In 2008, EDC published "Ocean Acidification and the Channel Islands National Marine Sanctuary: Cause, Effect, and Response," a report that looked at how the Sanctuary can plan for a future when some of its iconic species are dissolving. The Sanctuary encompasses about 1,470 square miles of water surrounding the five islands of Anacapa, Santa Cruz, Santa Rosa, San Miguel, and Santa Barbara. It was carved out of the Santa Barbara Channel in 1980 and given a special protected status. Oil and gas drilling are prohibited and fishing is restricted. Polefka said the EDC report suggests that the Sanctuary should take the lead in acting to slow ocean acidification by reducing its operational CO_2 emissions with increased use of biodiesel. The report also says many questions remain unanswered about whether the marine organisms of the Sanctuary will adapt to an increasingly acidic ocean, and how they might do so. "What's uncertain is the time scale of what will happen," said Polefka, adding that the Channel Islands Sanctuary could become an advocate for managing the 14 national marine sanctuaries in less carbon-intensive ways.



Below: Flower urchin *(Toxopneustes pileolus)*, Belau, Micronesia

Bottom: Pencil urchin *(Cidaroida)* on coral, Réunion Island

Upsetting the Balance

When an environment changes radically, some organisms suffer while others thrive. "Seagrasses represent a group of winners as ocean acidification is making it harder for calcifying organisms," said Richard Zimmerman, chair of the Department of Ocean, Earth and Atmospheric Sciences at Old Dominion University in Norfolk, Virginia. Larger fields of eelgrass would trap more suspended sediment and clear the water column—solving a widespread problem in polluted places such as Chesapeake Bay.

Zimmerman and a postdoctoral researcher conducted a year-long experiment on eelgrass in 2001–02, bubbling emissions from the natural-gas power plant at Moss Landing into tanks of sea grasses to test their reaction to a more acidic environment. They found that photosynthesis increased, as did the amount of flowering and the overall growth rate. "Seagrasses are the legacy from a different environment—they evolved in a high-CO_2 environment," Zimmerman said. The ocean he is describing is from 100 million years ago, when atmospheric CO_2 levels were higher than in recent times—until humans started burning fossil fuels at extraordinary rates, that is. "We're doing an uncontrolled experiment now [on our atmosphere]," he added.

As with most experiments, more questions will undoubtedly arise. A next step in ocean acidification research is to look beyond individual species and examine how ecosystems will respond. As part of his work on deep-sea ecology, James Barry, a senior scientist at the Monterey Bay Aquarium Research Institute (MBARI), studies scavengers that feed on the carcasses of animals that fall to the sea floor. "Deep-sea animals are less physiologically able to tolerate large perturbations to the environment," he said. Despite the constant rain of dead organisms from above, the sea bed is a food-poor place, and that predisposes its dwellers to vulnerability. The predicted large change in pH and the higher levels of CO_2 will hit the deep-sea animals with a "double-whammy," Barry said. For example, large amounts of CO_2 are known to act like a narcotic and lull larger fish to sleep.

Imagine an ocean filled with dozing tuna or halibut. While it may make for easy fishing, growth rates and reproduction could plummet, with only negative effects hypothesized for their populations. "We need to do coordinated ecosystems studies to see how changes in parts of the system will affect the whole thing," he added.

Adapting to a Different Ocean

Adaptation to those new ecosystems will be the future. As with global warming, there is no realistic solution to reverse acidification. The growing amount of CO_2 will stay in the atmosphere for thousands of years. Most of it will eventually be dissolved into the oceans, where it will take even longer for the extra hydrogen ions to fully impact the ecosystems. When asked if there are technological solutions, Caldeira suggested installing limestone blocks around coral reefs to mitigate corrosive waters, but said that would only work in a small bay or marine sanctuary.

"We have to look back 40 million years to see a similar ocean environment [to what is expected]," said Barry. Since then, over the millennia, corals, large predators, and kelp forests have evolved in an ocean that was less acidic. This proliferation of life built the complex food web that has sustained humans and other creatures.

Future ocean ecosystems will be simpler, Barry said. "We may lose [species] that are important to us, but it's not going to be the end of the world—just a different one."

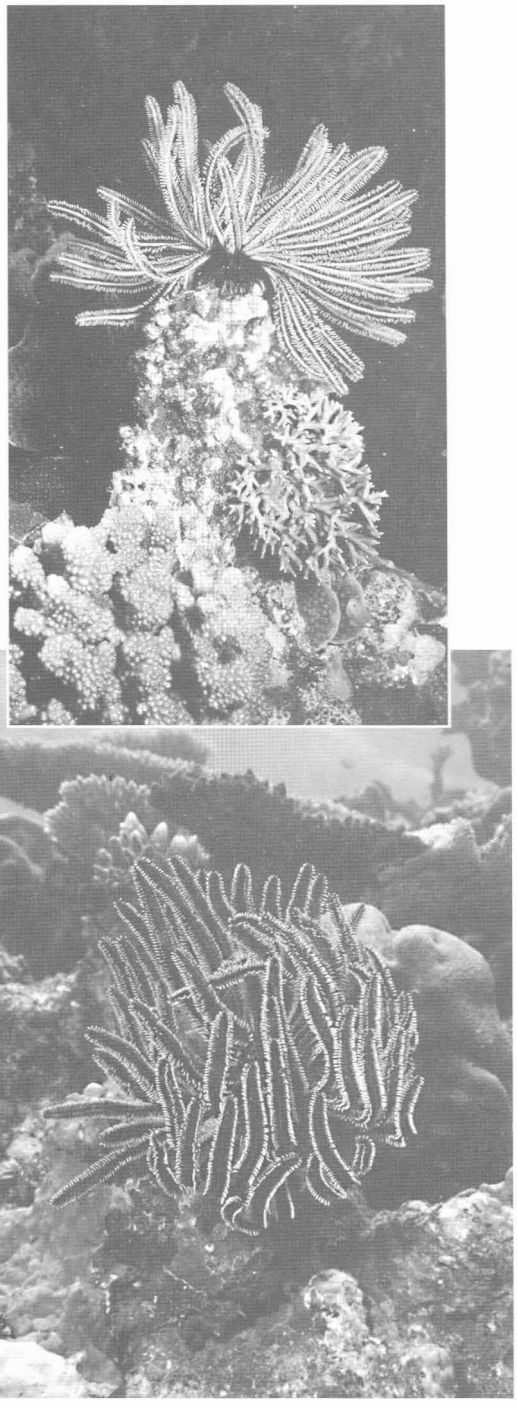
To survive in this new world, many current practices need to change, including those of the fishing industry. Acidification is damaging not only shellfish but other commercial stocks, such as English sole, a bottom-dweller that feeds on invertebrates. Phil Levin, a research fisheries biologist at the NOAA Pacific Marine Environmental Laboratory, works with computer models that predict a 50 percent decrease in the sole population with expected levels of ocean acidification by the end of the century. Without changing current fishing quotas, "we would overfish if we ignore ocean acidification," Levin said. The risk of overfishing in a more acidic ocean increases the need to understand the ecosystems. "Knowledge of indirect effects can promote sustainable fishing," he said.

"Protect and control what you can," said Fabry when asked about adaptation strategies. She referred to a 2006 report titled simply "A Reef Manager's Guide to Coral Bleaching," published by the Great Barrier Reef Marine Park Authority in Australia, NOAA, and the World Conservation Union. The guide describes effective responses to a bleaching event and the steps to take to restore an affected reef. While reef bleaching is a much different problem caused by warming ocean temperatures, a search through the 178-page report did not find any reference to ocean acidification, which can potentially dissolve reefs entirely. Adaptation plans still have a ways to go.

The U.S. Congress intends to give those plans a strong boost. In January 2009, a bill was introduced in the House of Representatives called the Federal Ocean Acidification Research and Monitoring, or FOARAM, Act, with a nod to foraminifera, a group of calcareous protists threatened by falling pH. Over four years, from 2009 to 2013, the Act authorizes $55 million to NOAA and $41 million to the National Science Foundation to develop, among other things, adaptation plans to cope with the loss of marine species and ecosystems. The first adaptation plan is to be produced within the next four years, including a National Academies review of the strategy.

Ultimately, cutting CO_2 emissions is the only way to slow down ocean acidification. But the process has already begun, and the oceans may be unrecognizable by the end of the century. The geologic record shows that the ocean ecosystem took five million years to fully adjust to new levels of acidity. That vast time scale is intimidating and almost paralyzing. Hopefully, the creativity that led us to this brink will give us an opportunity to change our ways. ■

Doug George is an oceanographer and freelance science journalist based in the San Francisco Bay Area. He currently works for the Ocean Protection Council, and now avoids Coke to save his teeth.



Crinoids (probably *Oxycomantus bennetti)* at Davies Reef, Australia. Even these feathery echinoderms, related to sea stars, and gorgonians like sea whips, have calcareous skeletons that are threatened by ocean acidification.

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JOURNEY THROUGH THE FLOATING WORLD

A SCIENTIST STUDIES FLOTSAM

HAL HUGHES

WHEN OCEANOGRAPHER Curtis Ebbesmeyer's mother handed him a newspaper clipping about thousands of sneakers washing up on the shores of the Pacific Northwest, she inadvertently launched him on a lifelong study of ocean currents, based on tracking sneakers, bathtub toys, and other flotsam. Ebbesmeyer was determined to find where those Nike sneakers had come from. The shipping industry was not inclined to talk about its mishaps, but the Nike company not only told him when and where the shoes had hit the sea—the *Hansa Carrier* had lost 21 containers in a storm in the North Pacific on May 27, 1990, five filled with Nikes—but even gave him a serial number for each lost shoe.

The great sneaker spill proved to be a boon to oceanography. Having precise data for the spill and its contents allowed Ebbesmeyer, working with W.J. (Jim) Ingraham, Jr. and the latter's computer program, OSCURS (Ocean Surface Current Simulator), to reconstruct the route of the shoes to the beaches they washed up on in January 1991. The sneakers were good study objects because they were buoyant, durable, and resistant to barnacles and other fouling creatures. Beachcombers who retrieved them were often able to match pairs, give them a good washing, and wear or sell them almost like new.

Ebbesmeyer had long employed "drift sticks," drogues, and other floaters to track currents, mostly to predict paths of oil spills and sewage outflows, at first for oil companies and later for his own firm. The sneaker event, and the accuracy of the OSCURS predictions, led him to study other flotsam to understand ocean currents better. Following cargo spills, he also gathered information from beachcombers around the world. These contacts developed into a network connected by Ebbesmeyer's newsletter and website (http://beachcombersalert.org).

As Ebbemeyer learned more about flotsam, he became ever more fascinated by oceanic gyres—cyclical currents that flow around all parts of the seas—and obsessed with understanding how they function as parts of a global system.

This growing interest in the "floating world" led him to scour history and literature for records that might throw light on the subject. Poring through writings as diverse as Norse sagas, the logs of Christopher Columbus, and the stories of Edgar Allan Poe, he learned that long before scientific oceanography, people had gleaned knowledge of currents from flotsam. Along the way he studied records of messages in bottles, glass fishnet floats, "sea beans" and other floating seeds, derelict ships, volcanic pumice, surfboards, even floating coffins and cadavers, and especially plastic—*lots* of plastic.

He found that ancient mariners used flotsam to find sea routes and safe harbors. Evangelists spread the Gospel by putting tracts in bottles and "casting them upon the waters." Archaeologists learned about human history and migrations, including how and when people from Asia may first have reached the Americas.

Ebbesmeyer's new book, *Flotsametrics and the Floating World*, is a delightful read, filled with humor and charming stories of his life, work, and friends, but there is a dark side, as well. The inescapable fact is that humans have abused the oceans on a massive scale, and we're only beginning to recognize the consequences. Much of the rich soup that is seawater is now permeated with plastics, right down to the molecular level, doing damage far beyond unsightly beach litter. There are at least eight garbage patches in the 11 major oceanic gyres, not just the famous one in the North Pacific. "Collector" beaches, where winds and currents dump tons of debris, give overwhelming evidence of our thoughtless profligacy. "Studies . . . show plastic particles increasing tenfold every ten years in the 1970s and 80s—and tenfold in just three years in the '90s." Ebbesmeyer's research on oil spills and sewage flows was ignored again and again by government and industry, till he despaired of science being able to affect policy.

He expects climate change to have major impacts on the gyres, especially as Arctic ice melts, allowing the three north polar gyres to speed up dramatically. He's found that all the world's gyres are interconnected in harmonic relationships akin to musical intervals—a change in one current affects all the others. Here, as in so much of what Ebbesmeyer has to tell us, the beauties and dangers of ocean systems are bound together. The joy of discovery is mitigated by new understanding of impending crises. ■

Flotsametrics and the Floating World: How One Man's Obsession with Runaway Sneakers and Rubber Ducks Revolutionized Ocean Science,
by Curtis Ebbesmeyer and Eric Scigliano. Collins/Smithsonian Books, New York, 2009. 304 pp., $26.99 (hard cover).

DIVER KURT LIEBER BATTLES DERELICT GEAR

Pulling Out the Junk

JUDITH LEWIS

FOR KURT LIEBER, IT ALL STARTED with the kelp. Now the director of Ocean Defenders Alliance, an organization he founded a decade ago, he became somewhat famous early this year for leading a dangerous dive to retrieve gear off the sunken fishing boat *Infidel* near Santa Catalina Island. Among environmentalists and divers in southern California, that feat made him something of a local hero. But his activism in behalf of the sea began many years ago, when as a young scuba diver he began to see alarming changes in the marine life around him.

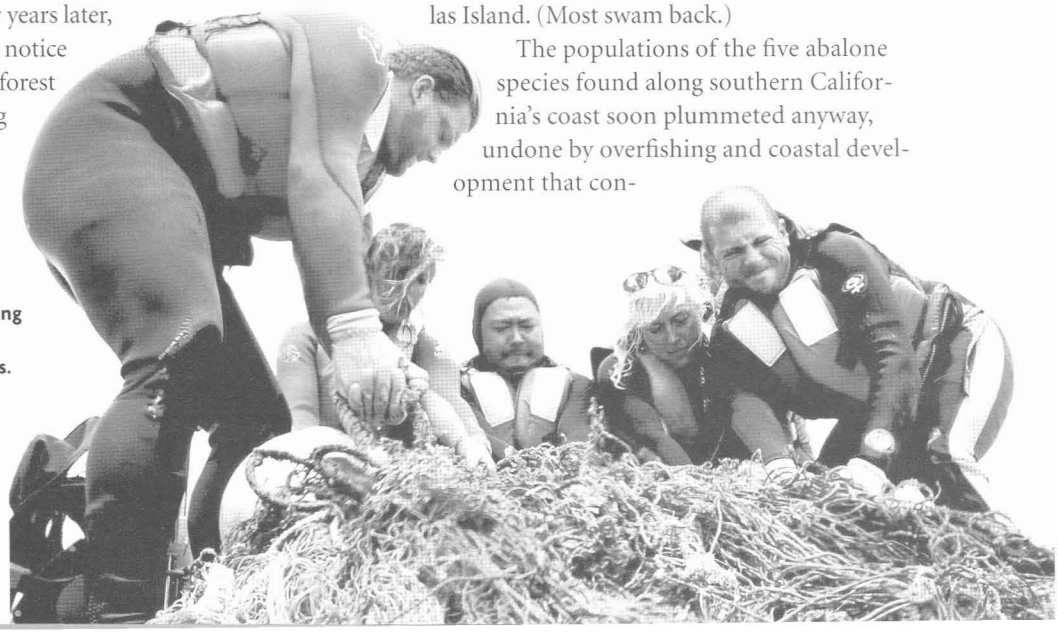
In 1979, at age 25, Lieber had come to Laguna Beach from his native Cleveland, Ohio, to pursue a passion for diving. Too broke to afford many boat dives, he dove mostly off the coast, which meant contending with lots of kelp. "It was so thick," he remembers, "that you couldn't swim on top of the surface. You had to dive down deep."

Just a few years later, he began to notice the marine forest diminishing along the Orange County coast. By the early 1980s the kelp was almost gone, along with the giant abalone that fed on it. In their place were urchin barrens, large areas where sea urchins had proliferated and devastated the algae.

"I started asking, 'What's going on?'" he says, "Then I found out. And the story was one of man's intentions gone terribly awry."

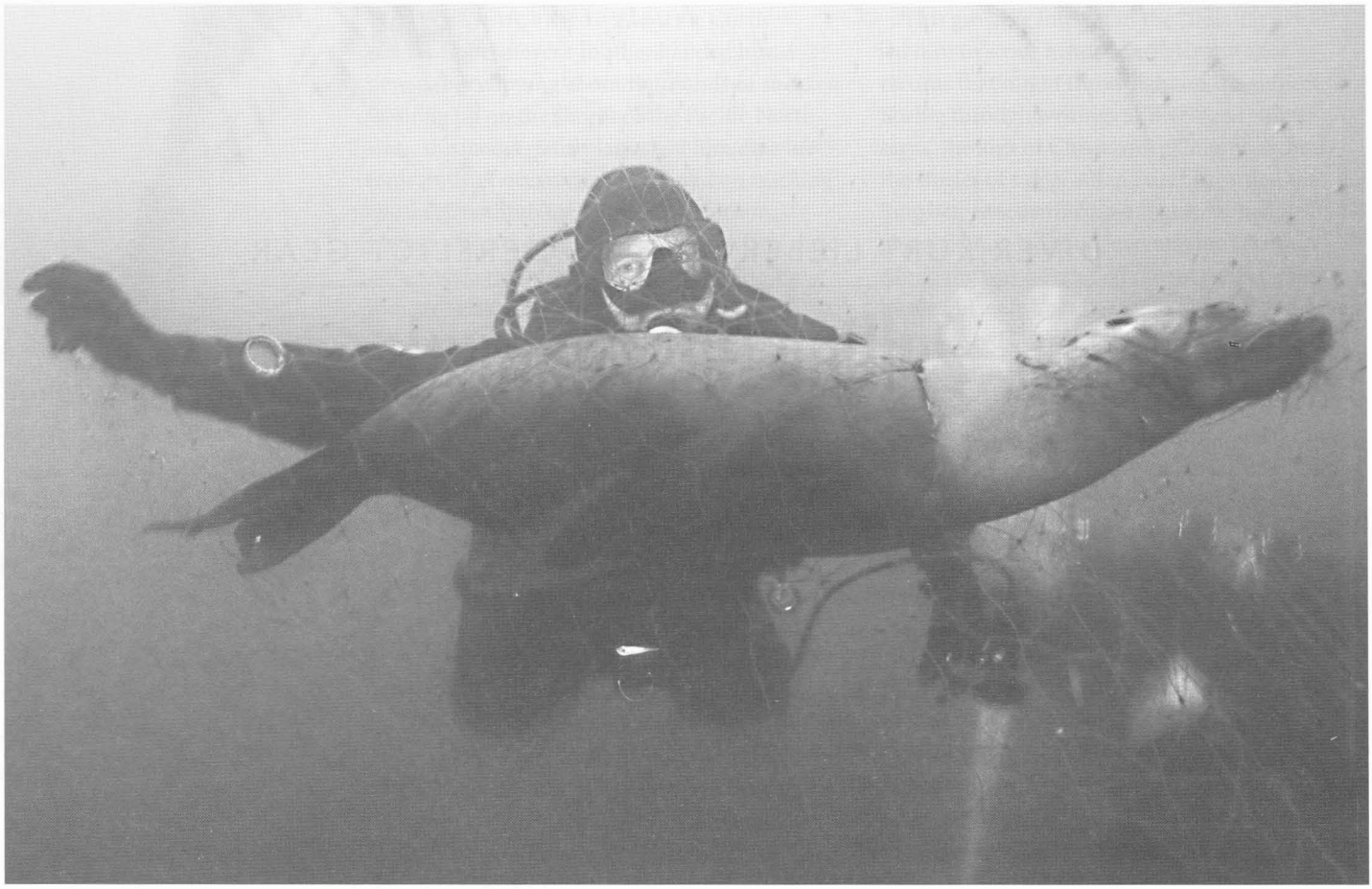
Sea urchins, like abalone, are food to sea otters, and as long as there were otters along the California coast, they had kept urchin populations in check. Then the otter populations were decimated, first by fur hunters and later by commercial fishermen who viewed them as competitors for abalone and routinely killed them. After the Marine Mammal Protection Act was passed in 1972, that was no longer a legal option. In 1986, in support of the fishing industry, Congress declared California waters south of Point Conception an "otter-free zone" and attempted to move the remaining population to San Nicolas Island. (Most swam back.)

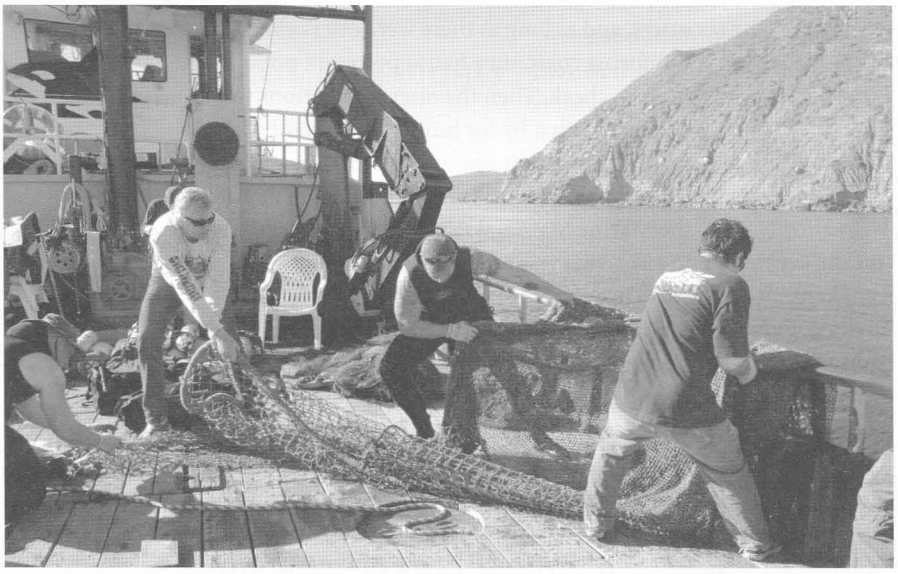
The populations of the five abalone species found along southern California's coast soon plummeted anyway, undone by overfishing and coastal development that con-



NOAA/NMFS

Volunteers haul in derelict fishing gear from coral reefs in the Northwestern Hawai'ian Islands.





Top: Ross Overstreet of Ocean Defenders Alliance found a sea lion caught in a two-mile-long abandoned gill net that killed dozens of birds and marine mammals.

Above: Kurt Lieber (left) and crew haul in a derelict fishing net.

tributed to degradation and loss of nearshore habitat. "Without otters, the urchin population just exploded," Lieber says, "devouring all the kelp." The urchins are voracious eaters, rasping away at the kelp plant till eventually it weakens and can be ripped out by a strong storm surge. So the kelp went the way of the abalone.

Among his diver friends in Laguna Beach, Lieber had heard talk about Rudolphe Streichenberger, who was trying to restore kelp beds off Newport Beach in a controversial manner, defying objections from the Coastal Commission and the Department of Fish and Game. "He was transplanting kelp and trying to get it to reattach to different substrates," Lieber says. "He was putting rubber tires down there, and different bottles, and garbage, basically, to try to get things to attach to it. It was amazing how fast that kelp came and attached itself." In 1981, Lieber began devoting some of his dive time to Streichenberger's experiment. It soon ended, however, as the regulatory agencies had warned it would: When massive Pacific storms rolled in, "the tires and everything else washed back up on the beach, and it was a disaster."

Temporarily disillusioned, Lieber volunteered

PHOTOS THIS PAGE: OCEAN DEFENDERS ALLIANCE

with Friends of the Sea Lion and Pacific Wildlife Project for a while, rehabilitating sick and injured pinnipeds. Then he heard about Captain Paul Watson and his direct-action tactics to confront illegal fishing and whaling, and joined the volunteer crew of Watson's Sea Shepherd Conservation Society, which is devoted to protecting wildlife and preventing habitat destruction in the world's oceans. He took part in two campaigns, one in Alaska, the other in Washington State, where the Makah Tribe was trying to resume traditional whaling and Sea Shepherd tried to stop them. Watson became a mentor and close friend, and Lieber now sits on Sea Shepherd's board of directors.

He Found a Way to Help

Even in the sterile conference room of the Orange County manufacturing firm where he works as a mechanical engineer, Lieber looks like a man of the sea. He is 6'5" tall, wind- and sunburned, and is wearing a short-sleeved shirt printed with swimming dolphins.

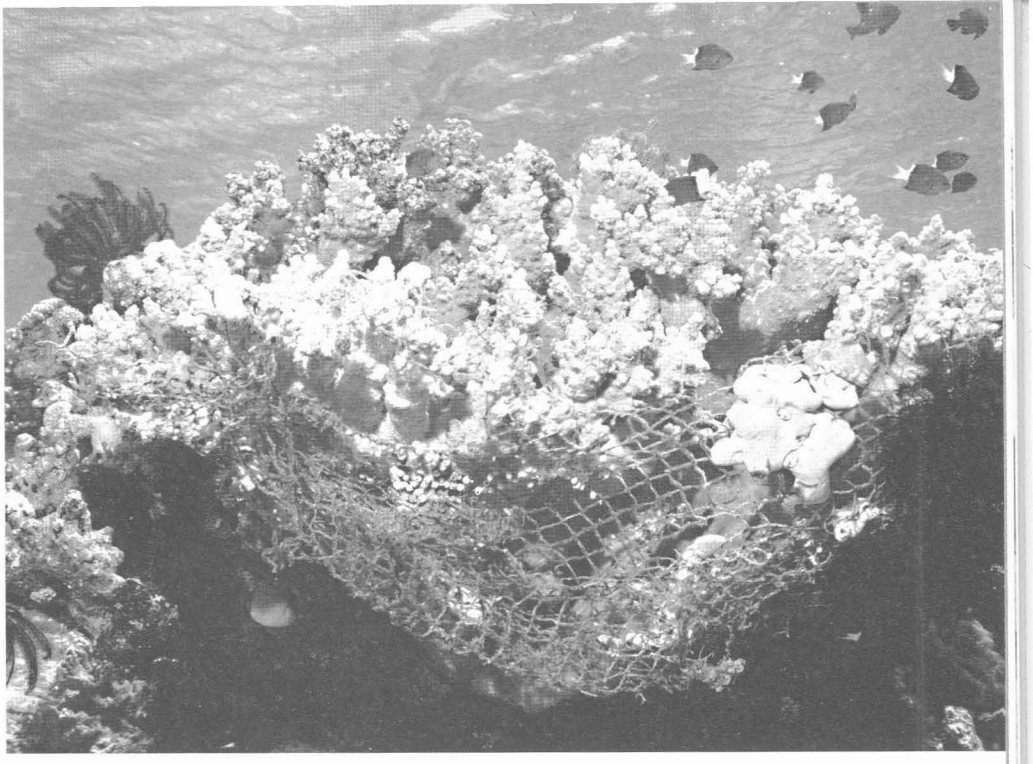
"I never felt I could go out and be like Watson, out there on the high seas confronting illegal vessels. I have to work like everybody else. Most people do," he says. But he followed Watson's advice to "take whatever you do best and do it for the environment."

As a diver, and also as an avid underwater photographer, he had seen the accumulation of commercial fishing debris, now known as "derelict gear," in the ocean and noticed that no one seemed to be addressing the problem. So in 1999 he gathered some like-minded allies and, under the name of Ocean Defenders Alliance, began to pull stuff out of the water.

They started close to shore, with lobster traps, but when people began alerting him to discarded nets and fishing line strewn about the open ocean, he acquired a boat—a 38-foot Coast Guard rescue vessel that could just barely float—and spent two years and $20,000 making it seaworthy. In 2007, dubbed the *Clearwater,* it became the organization's flagship. In 2002, Ocean Defenders gained official nonprofit status.

Now Lieber works with a team of about a dozen regular volunteers, including several skilled divers and some nondivers. He recognizes that the problem of abandoned and lost fishing gear in the ocean is immense, but believes his contribution is significant.

Derelict fishing gear—a category of marine trash that includes lobster traps, indestructible nets made of hemp and monofilament fiber, longlines, and shrimp pots—is a leading cause of marine mammal deaths. More than 267 different animal species have been affected, including sea lions, porpoises, turtles, and sharks. Some birds, such as brown pelicans, die by ingesting bits of debris, while other animals perish after becoming entangled in "ghost-fishing" nets; still more are caught in abandoned traps.



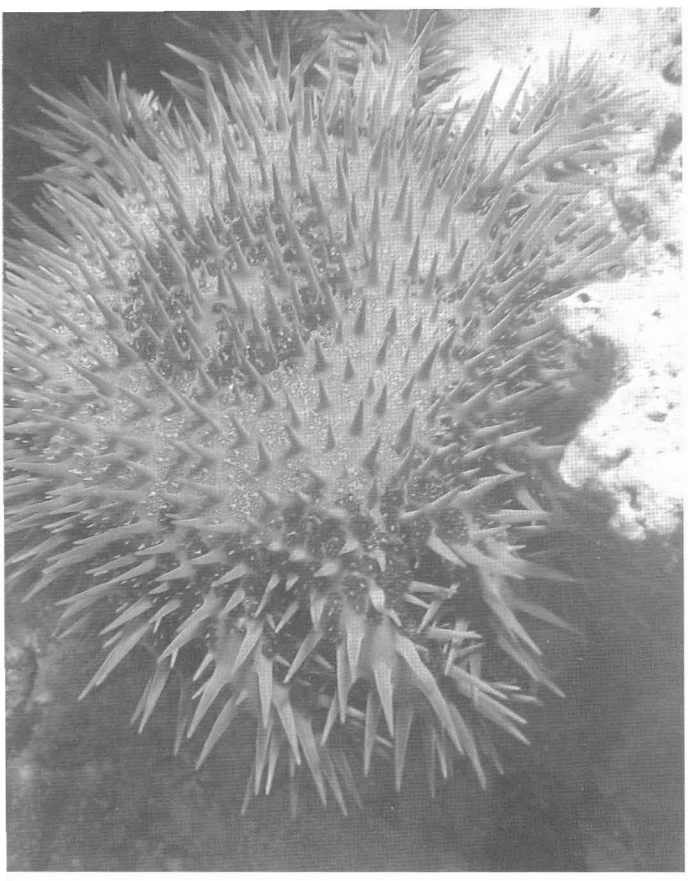
Gill net caught on a coral reef in the western Pacific

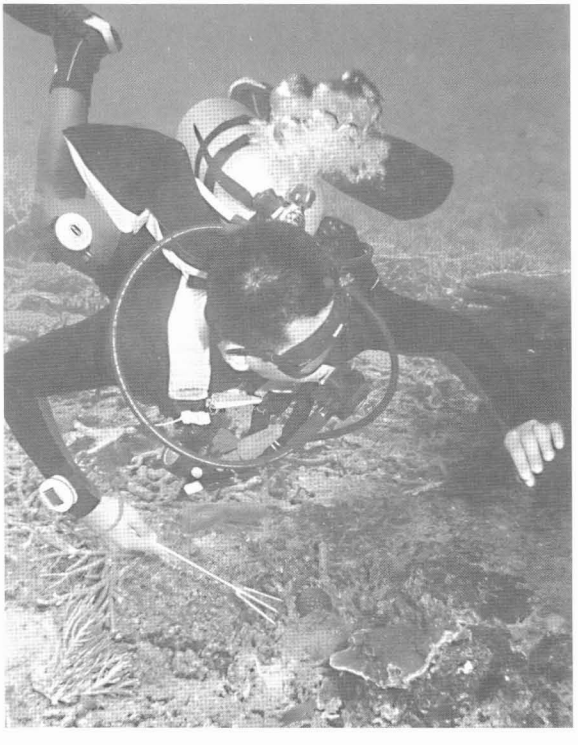
A study conducted at South Farallon Island by researchers at the University of California, Davis, between 1986 and 1998 counted 914 pinnipeds caught in lost nets, including elephant seals and Steller sea lions. Even higher kill rates, among a broader population of marine creatures, were found in 2007 in Puget Sound, where divers counted more than 30,000 animals entangled in 870 nets they pulled out of the water, most of them dead. Marine life decomposes after just ten days in the sea, so it's likely many thousands more died before the nets were found.

"It can get depressing worrying about the ocean," Lieber admits. "It wears on me all the time. But with what Ocean Defenders is doing, there's an immediate return. I pull these nets out, and I know that when I go back in a couple of months or a year, life is coming back. It gives me a reason to have some hope."

Momentum Gathers

In the past several years, new efforts have been launched to remove derelict gear from Pacific waters, first in Puget Sound, then Hawai'i and California (see *Coast & Ocean*, Autumn 2005).





Top: Crown-of-thorns sea stars *(Acanthaster planci)* can cause great harm to corals when their populations explode due to pollution.

Above: A diver searches for crown-of-thorns sea stars on a reef at Pulau Redang, Malaysia.

In Washington State, the Northwest Straits Commission engages the public in reporting nets and fishing line and sends divers out to retrieve them, sometimes hiring idled urchin fishermen for the job. Hawai'i's program is focused on removing gear that threatens coral reefs.

In California, the SeaDoc Society at UC Davis, supported by the Coastal Conservancy and the Northwest Straits Commission, began the California Lost Fishing Gear Recovery Project. Since May 2006, the project has cleared 11 tons of fishing debris out of the waters around the Channel Islands. The work has been set back by California's budget crisis, but Jennifer Renzullo, one of the project's lead divers, expects it to start up again this summer.

Renzullo says the SeaDoc program recruits volunteer divers to retrieve recreational gear from fishing piers. "But when it comes to commercial fishing gear, just because it's so dangerous, we contract with merchant and commercial divers." For that reason, when Lieber offered SeaDoc his services, he was rebuffed. "We're really appreciative of what Ocean Defenders have done," says Renzullo. "But to be honest with you, it really freaks me out. It's just such a dangerous thing."

Still, Lieber continues his all-volunteer efforts, with success and, so far, no casualties. He once led a dive to retrieve 800 pounds of fishing net off the coast of Orange County that took six divers seven dive days spread over three months. To clear out the 9,000 pounds of net draped from mast to sand over the *Infidel,* 16 volunteer divers worked over 15 days, diving to depths of 150 feet—50 feet deeper than any safe recreational dive.

"A lot of time they were risking their lives," Lieber says. "They had to pack pieces of the nets into float bags and send them to the surface." Had the divers been caught up in the nets themselves, the bag would have pulled them to the surface too fast, and they could have died from the bends. But the project's success motivated him to continue.

Even all-volunteer projects require money, however. Lieber estimates he used only $5,000 in individual donations on the *Infidel* retrieval, but the work would have cost much more if Watson had not already donated the *Clearwater.* No diver was paid. Lieber is currently applying for a grant from the National Oceanic and Atmospheric Administration to hire a professional crew.

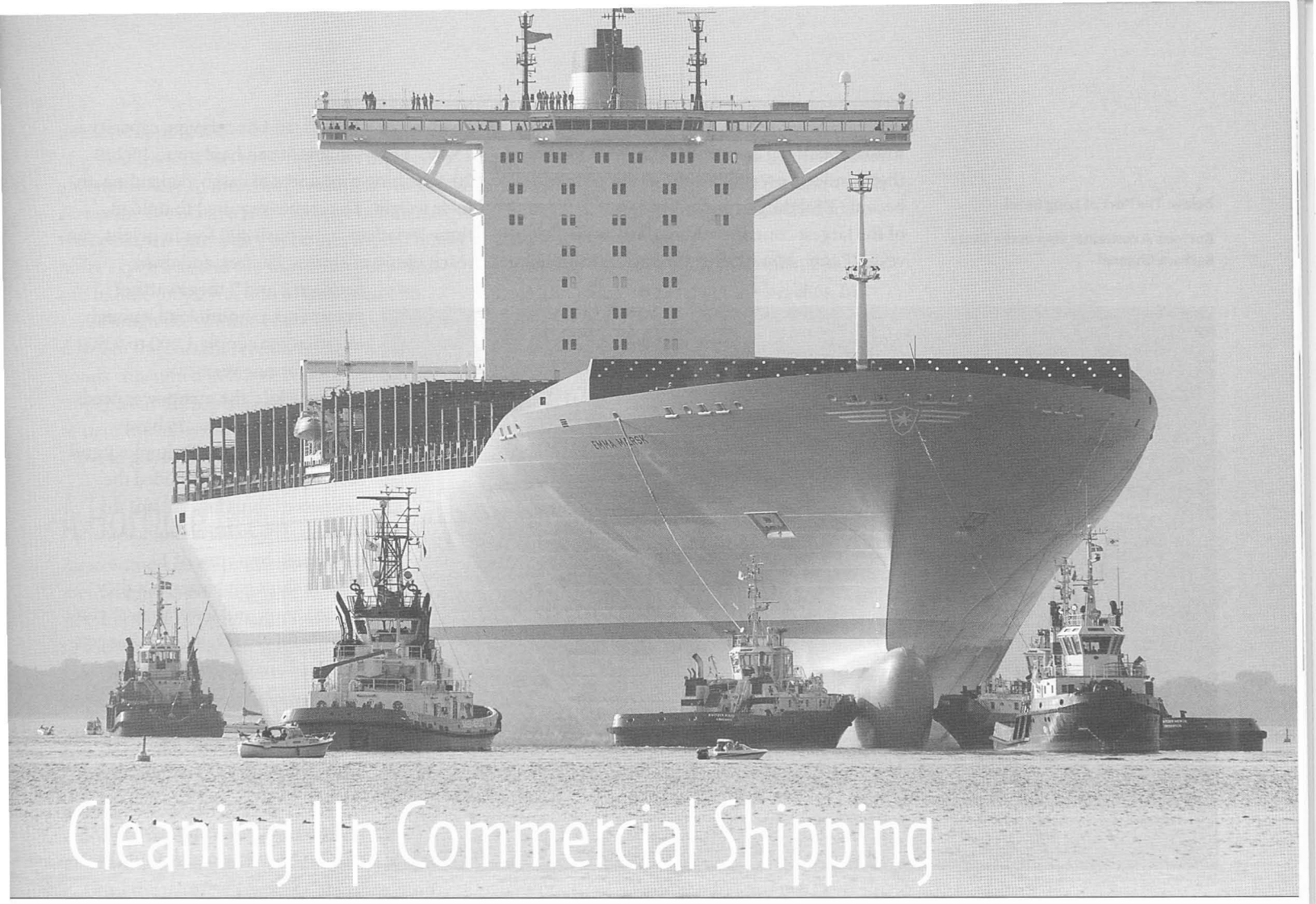
In 2007, State Senator Joe Simitian introduced a bill that would fund efforts to prevent the accidental loss of fishing gear and also facilitate its retrieval. Though the legislation passed by wide margins in both senate and assembly, Governor Arnold Schwarzenegger vetoed it on September 30, 2008, pointing to the state's budget crisis. Simitian brought the measure back to the floor in the next legislative session, with Heal the Bay as cosponsor and Californians Against Waste as supporter.

News reports of the *Infidel* project brought calls and e-mails to Lieber from as far away as England, Denmark, and Spain, asking for help in clearing out gear abandoned in Atlantic coastal waters. "I tell all of them to do what I did," he says. "Round up all the troops you can, and get to work on the problem. And make it a community thing. If we're going to save this planet, it means getting everyone involved."

One day, Lieber says, he'd like to go back to where it all started, and lead an effort to pull out the junk left behind by the well-meaning Streichenberger's crew. "That will take a lot of money, and time," he says. "But it's a dream." ■

Judith Lewis writes about the environment from Venice, California.

TOP: MATT WRIGHT, WIKIMEDIA COMMONS; BOTTOM: JAMES OLIVER, WWW.REEFBASE.ORG



Cleaning Up Commercial Shipping

A GLOBAL PROBLEM NEEDS GLOBAL SOLUTIONS

GLEN MARTIN

STAND ON THE MARIN HEADLANDS and look down on the Golden Gate, preferably in the late afternoon when the sun is arcing toward the Farallones, and San Francisco Bay and its encompassing cities are cast in a honey-colored light. Gulls and pelicans are wheeling, and container ships and tankers are moving in and out of the estuary. At such a moment, only an obsessive landlubber will not feel the pull of the ocean and of the ships that traverse it. The romance of the sea remains—though more for the recreational sailor or dreamer, perhaps, than for the professional seaman. For those who actually work at sea, life is onerous and the difficulties very real: pirates, typhoons, and the ennui of a life defined by blue water, gritty ports, and little else. Most ships entering U.S. ports fly foreign flags. The crews are often overworked and underpaid, and even the minimal pleasures once afforded by port calls are typically denied them. When a ship docks at Los Angeles or Long Beach, the crew seldom if ever gets to visit Malibu or Hollywood; instead they stay on board for the hours or days it takes to unload their vessel.

Roughly 90,000 commercial ships now ply the world's oceans, accounting for 90 percent of the goods imported and exported in international trade. Fully 95 percent of the products imported to the United States come by ship, and about 80 percent of those goods arrive through West Coast ports, including Los Angeles and Long Beach, collectively the busiest port in the United States and the fifth largest in the world. The three major West Coast ports—Los Angeles/Long Beach, Oakland, and Seattle—handle close to $500 billion in trade goods annually.

***Emma Maersk*, one of the world's largest container ships**

MAERSK LINES

Big ships are needed to transport this kind of tonnage, and big equipment is needed to unload them. Indeed, everything about shipping has become Brobdingnagian. As of this writing, one of the largest container ships afloat is the Danish vessel *Emma Maersk*. It is 398 meters long, has a beam of 56.5 meters, and its carrying capacity is 15,200 TEU—that is, it can haul up to 15,200 20-foot-long containers of cargo, depending on their weight. The cranes required to unload these leviathans now push 400 feet in height, can reach outward almost 250 feet, and draw between 2 and 7 megawatts of power at maximum load, enough electricity to supply 1,600 to 5,600 homes for one year.

Below: The Port of Long Beach

Bottom: A container ship in the Santa Barbara Channel

Meanwhile, the manpower needs of the shipping industry have declined drastically. Technology and economy of scale have aided the business of shipping, but not the workers. The massive *Emma Maersk* is operated by a crew of 13.

"The ships got bigger, but they needed fewer and fewer men to run them," said Carl Nolte, who has covered maritime issues for the *San Francisco Chronicle* since 1961. "One guy on a crane can now do what it took 100 longshoremen to do 50 years ago. Ships used to take days to unload; now they do it in hours."

The culture of shipping may be moribund, even dead, but the busi-

TOP: CALIFORNIA COASTAL RECORDS PROJECT; BOTTOM: © 2005 WOLCOTT HENRY/MARINE PHOTOBANK

ness of shipping has boomed with the explosion of global trade. It has to be that way; there is no alternative way to move large quantities of goods across the oceans in a cost-effective manner. Air transport, the only other option, is exponentially more expensive, and the world's airplane fleet can handle only a fraction of trade demand.

Although the volume of goods shipped is down in the current recession, most finished goods consumed in North America still come by ship. Just as during the Age of Discovery, ships remain the most economical means available for moving goods in quantity for long distances.

A Horrible Brew

Big commercial ships leave tremendous environmental impacts in their wakes. They release massive amounts of pollutants and greenhouse gases to the atmosphere, discharge noxious chemicals into the water, disseminate exotic organisms in ballast water, emit sounds that disorient marine mammals, and even collide with whales, injuring or killing many. In ports, the trucks, offloading equipment, and power production facilities needed to service ships also are gross polluters, emitting hundreds of thousands of tons of contaminants into the air yearly.

Until the past few years, the shipping industry's environmental issues remained largely unaddressed, but that is changing. New regulations being implemented at global, national, state, and local levels include rules for cleaner fuels, strictures on ballast water discharges, tougher standards for air quality in the ports, measures to prevent collisions with marine mammals, and greater regulation of ships hauling hazardous waste to less developed countries.

The most dramatic progress on this last issue may well be in Bangladesh, one of the world's poorest countries, notorious for its ship-breaking enterprises. Derelict ships from around the world are driven up on beaches there and dismantled, with no regard for environmental safety or worker protection. Earlier this year, the Goldman Fund awarded one of its prestigious environmental prizes to Rizwana Hasan, director of the Bangladesh Environmental Lawyers Association, for her efforts in securing tighter regulations over the ship-breakers. "It's an incredibly destructive process," said Hasan. "In virtually all countries save Bangladesh and India, ships are broken down in dry docks. Here, they're driven up on beaches where mangrove forests once flourished. A work force of young men using torches and small tools dismantles them, and a horrible brew of toxics—PCBs, petroleum distillates, asbestos, TBT, heavy metals such as zinc and chromium—just pours into the sea."

Between 2005 and 2007, more than 250 ships were broken up on Bangladesh's beaches. In 2009, Hasan obtained rulings from Bangladesh's Supreme Court to shut down all of the country's 36 ship-breaking yards, which were operating without environmental safeguards. Her organization continues to monitor the situation to ensure the court orders are enforced.

"It's essential we have full implementation of these rulings soon, because all of Europe's single-hulled commercial vessels must be phased out by 2012," Hasan said. "That means that about 2,200 ships could end up on the beaches of Bangladesh and India from this single program."

Still largely unaddressed are the cargoes that ships take to the developing world from U.S. ports. Hungry for natural resources, Asian countries consume large quantities of recycled steel and paper. They also import huge quantities of "e-waste"—old computers, antiquated cell phones, and other electronic components. These items can yield a rich harvest of rare metals, but they are often processed in a wholly unregulated fashion; large quantities of pollutants enter the atmosphere and waterways as the valuable elements are reclaimed.

Ship Spills Near and Far

The maritime industry's environmental problems are most apparent when ships run into things and spill fuel or toxic cargoes. The most recent event of this sort in California occurred on November 7, 2007, when the container ship *Cosco Busan* smacked into a tower of the San Francisco–Oakland Bay Bridge, releasing about 60,000 gallons of bunker oil into San Francisco Bay. The incident was later pegged to pilot error.

Bay Area ports are uniquely hazardous, said John Kaltenstein, the clean vessels program manager for Friends of the Earth. "The traffic for the ports of Los Angeles and Long Beach are busier, but the weather and the currents make entry in and out of San Francisco Bay much more problematic."

The *Cosco Busan* forced a needed reevaluation of Bay Area shipping, said Captain Peter McIsaac, president of the San Francisco Bar Pilots. In conjunction with the U.S. Coast

Guard, the pilots association drafted an enhanced set of visibility guidelines for traffic in the bay.

Bay Area shipping could be made even safer, said McIsaac, if pilots simply had more information, and in electronic form. Good piloting depends on accurate soundings from the U.S. Army Corps of Engineers; this is especially critical for large ships that may draw 50 feet of water, because the Bay's shipping channels bottom out at 55 feet.

"Right now, the Corps conducts most soundings annually, and they're delivered as printouts that have to be transferred to sounding charts," McIsaac said. "We're working with them to conduct quarterly soundings and to provide them in electronic form. That will make the information both more accurate and more accessible—and that means more secure shipping."

Ship spills are widely felt wherever commercial ships venture, including some of the world's remotest regions. An area of great concern is the sea around the Aleutian Islands, which thousands of ships ply annually.

"Aleutian waters—including the Bering Sea and the North Pacific Ocean—are part of the Great Circle Route, the quickest way to the ports of Los Angeles and Long Beach from Seoul and Tokyo," said Whit Sheard, Alaska program director for Pacific Environment, a group concerned with marine safety and environmental issues. "These are some of the most biologically productive waters on the planet, but they're also extremely hazardous. The high volume of ship traffic means the risk of environmental catastrophe is always high."

Pacific Environment has documented more than 20 significant oil spills from ships in Aleutian waters over the past two decades, the worst being the loss of the *Selendang Ayu,* which broke in half near Unalaska in 2007, dumping 335,000 gallons of bunker fuel and lubricants into Skan Bay. "We've also had many, many close calls," Sheard said.

A big part of the problem is congestion—close to 5,000 ships a year negotiate Unimak Pass, a narrow passage between the Alaskan Peninsula and the Aleutian Island chain that connects the Bering Sea with the North Pacific.

"The other issue is that shipping regulations are complicated in these waters given the various state, national, and international jurisdictions, and enforcement is difficult to implement," Sheard said.

Pacific Environment is calling for the reform and streamlining of shipping safety statutes and a greater regulatory and rescue presence in the Aleutian region. "Up front, we need a traffic management system for Unimak Pass and precise tracking for ships in the entire Aleutian region. We need to know where all ships are at all times. And we need to pump up our prevention capability—station rescue tugs throughout the area, as they do in Prince William Sound and Puget Sound. That way, when ships get into trouble, we can deal with them before they break up."

An encouraging, if tentative, move has been made in this direction: the Arctic Council, an intergovernmental forum composed of representatives from Arctic nations and indigenous peoples, recently authorized a risk assessment for the region's shipping. The evaluation will be completed in two years, though interim recommendations are expected next year.

"Frankly, I don't think there's the political will to move on this until the assessment is complete," Sheard said. "But it should ultimately provide us the authority we need to get some real things accomplished."

The *Cosco Busan* spilled 58,000 gallons of oil into San Francisco Bay after striking the fendering of the Bay Bridge on November 10, 2007.

PRENTICE DANNER, U.S. COAST GUARD/MARINE PHOTOBANK

Port Cleanup Begun

Collisions and oil spills may gain the most attention, but in port cities the greatest threat posed to public health and safety by the shipping industry is airborne. In the Los Angeles Basin, 20 percent of the air pollution is generated by the maritime industry, from the vessels that call on the ports of Los

Angeles and Long Beach, the harbor craft that service and monitor the ships, the equipment used to load and off-load the ships at dock, and the trucks that transport the goods from port to market. "That's roughly equivalent to the emissions from 6 million cars," said Ryan Wiggins, a campaign associate with Communities for Clean Ports, an environmental advocacy group based in Los Angeles. "So any effort to improve the basin's air quality must treat the ports as a priority—it's critical to achieving state air quality standards." Like a supertanker that has begun a long and ponderous turn, regulatory mechanisms are slowly—but ineluctably—addressing maritime air quality issues.

In 2007, the California Air Resources Board mandated low-sulfur fuel for ships transiting within 24 miles of the coast and alternative energy sources for cargo-handling equipment at port. The air board's rule requires ships to

Detour: Whales Ahead

SHIPS CALLING AT WEST COAST PORTS traverse some of most biologically productive waters in the world. From Alaska to Baja California, vast portions of the marine environment are subject to upwelling, the transport of cold, nutrient-rich water into coastal areas. Upwelling stimulates extravagant blooms of phytoplankton, which in turn generate massive populations of krill, the small, shrimplike crustaceans that are food for a vast assemblage of marine life, including blue, fin, humpback, and gray whales. Yet upwelling can also create danger zones when shipping lanes impinge on areas with dense krill populations.

The Santa Barbara Channel, a major shipping lane for vessels in transit to and from the ports of Los Angeles and Long Beach, is a particularly dangerous place for whales. Upwelling there is often strong, providing abundant forage for cetaceans of all varieties. Because the channel is relatively narrow, both ships and whales can find themselves in congested conditions. In 2007, four blue whales were killed by ships, and "we strongly suspect that there are many more incidents that go unrecorded, simply because the whales sink or fail to wash up on shore," said John Calambokidis, senior research biologist and cofounder of Cascadia Research in Olympia, Washington.

Part of the problem is that upwelling zones can move around, said Calambokidis, one of the foremost cetacean researchers in the country. "In 2007, we noticed that the blue whale foraging areas had shifted closer than usual to the shipping lanes." The Coast Guard issued a marine advisory calling for a voluntary ship slow-down for 2008. No whale strikes were recorded for that year in the Santa Barbara Channel, but the advisory may not have been the key reason, said Calambokidis. "It's not clear if the ships did indeed slow down. And the data indicates that blue whales were not as concentrated in the shipping lanes in 2008 as they were in 2007—that could well have been a more significant factor."

A similar traffic conflict exists around Cordell Bank and the Farallon Islands, where powerful upwelling creates one of the richest marine environments in the world. Several species of whales are seasonally numerous in these waters, including blues, humpbacks, fins, and grays. Some stray into San Francisco Bay.

"Ships use very specific lanes coming into the Bay, but the feeding areas for whales move around, and in recent years we've noticed there has been a strong nearshore shift, particularly for humpbacks," said Mary Jane Schramm, spokesperson for the Gulf of the Farallones National Marine Sanctuary.

From 2006 through 2007, two fatal whale strikes were confirmed in the region—one humpback and one gray. Two humpbacks that strayed into the Bay in 2007 also bore wounds likely sustained from ship strikes.

"And that's probably just the tip of the iceberg," said Schramm. "It's almost certain there were more. It's very difficult to see whales from the bridge of a large commercial vessel, and it's even more difficult for ships moving at speed to evade whales even if they are seen."

Jaime Jahncke, director of marine ecology for PRBO Conservation Science, a research and advocacy group that focuses on avian and marine issues, concurs with Schramm that slowing down would help.

"Large container ships move at 20 to 30 miles an hour through the [Gulf of the Farallones] Sanctuary," said Jahncke. "At those speeds, you're going to see significant cetacean mortality. Ultimately, shifting the shipping lanes away from the primary feeding areas will be the best solution. But that will take a major effort and a good deal of time to accomplish. Short term, we should be able to achieve some good results by requiring ships to reduce their speeds from 30 to 10 miles an hour as they transit sanctuary waters."

For the long term, Calambokidis said, a more coordinated and rigorous approach is needed—preferably one that employs the carrot more than the stick. "There are already some port fee reductions offered [near southern California ports] to ships that reduce speeds in order to cut [atmospheric] emissions. That's a good model that we could expand to the Santa Barbara Channel when whales are near the shipping lanes. But to make that work really well, we'd also need to increase our monitoring."

More research also is needed, he says, to devise a long-term solution—the adjustment of shipping lanes. There already is a precedent for such a move: off the Atlantic Coast, shipping lanes have been moved to protect North Atlantic right whales, which number only a few hundred individuals.

"It doesn't necessarily have to be disruptive to shipping," Calambokidis said. "The lane shift may be quite modest. We need to look into it more, but some of our research indicates the whales forage closer to the surface at night than during the day. That could mean we might be able to adjust ship speed and location accordingly—the ships could go faster during the day and slow down at night. That would cause minimal impact on commerce while achieving significant protection for the whales."

—*GM*

The *Elly Maersk* leaves port.

MAERSK LINES

switch from dirty bunker fuel to distillates with no more than 1,000 ppm/sulfur for their engines by the year 2012. When that happens, pollution will be reduced considerably, according to the air board: 75 percent of engine particulates should be eliminated, 80 percent of sulfur dioxide, and 6 percent of nitrogen oxides. That translates to 23 tons of soot, 15 tons of sulfur dioxide, and a whopping 200,000 tons of sulfur removed from the L.A. basin.

The cargo equipment rule mandates "best available technology" for cargo-handling equipment and drayage vehicles in port areas. Practically, this means switching them from diesel to electricity or liquefied natural gas (LNG), a move that could eliminate 870 tons of particulate matter and 19,000 tons of nitrogen oxides by 2020.

Another noteworthy development in the ports has been the Clean Truck Program for Los Angeles and Long Beach, launched in October 2008. Both ports are phasing in bans of older, polluting diesel trucks and providing financial assistance to drivers to replace them with trucks that meet stricter emissions standards, including some that use electricity or cleaner fuels such as LNG. Hopes for the program were heightened by a recent decision by U.S. District Court Judge Richard J. Leon to deny a request by the Federal Maritime Commission for a preliminary injunction that would stall implementation. But a separate suit dealing with truck owner-operator issues filed by the American Trucking Associations could still stymie the plan. Nonetheless, the Clean Truck Program marks a significant effort to address the West Coast's environmentally challenged ports.

Earlier this year, the Port of Oakland also approved a long-range master plan to reduce air pollution in and around the port. "We're looking for an 85 percent reduction in particulates," said Richard Sinkoff, the port's director of environmental programs and planning. "About 2,000

trucks that frequent the port are subject to the new state air-quality regulations. We'll use $10 million [approved by the port and the Bay Area Air Quality Management District] for either the purchase of new vehicles or the retrofitting of old ones with particulate filters."

The port also is moving to shift ships from their auxiliary engines to the local power grid while in port, Sinkoff said. Currently, most ships maintain power at dock with bunker oil–burning auxiliary engines, adding to the ports' already heavy pollution load. "Ultimately, we want them to hook up to facilities on shore," he said. "Short term, they can alternatively choose mobile generators that run on LNG. Either way, we'll see a dramatic improvement in air quality."

Port commerce can also account for major water pollution. Ports invariably encompass hundreds to thousands of acres, much of it concrete or asphalt surfaces soaked with diesel, gasoline, lubricants, and other distillates. Equipment such as cranes and drayage vehicles are also contaminated with grease and fuel. When it rains, vast amounts of tainted runoff sluices into the nearest waterway. Sinkoff notes that the Port of Oakland is building a system of vegetated berms to filter contaminants from storm water before it hits the bay.

"We already have 58 acres of these filtration strips bordering five miles of roadway around the port," said Sinkoff. "These plantings are simple to construct and maintain, but they're also extremely effective at trapping contaminants, which are then degraded by natural bacterial action."

Progress on the High Seas

Recently there have also been some heartening developments on the high seas. John Kaltenstein, the clean vessels program manager for Friends of the Earth, cites the International Maritime Organization (IMO), a United Nations agency, as the prime mover in the campaign to clean up international shipping. Through the Marpol Treaty, an international environmental convention, the organization provides guidelines for various categories of ship-associated pollution: sewage, oil and its distillates, garbage, and air emissions. These standards are then implemented and enforced at the national level by the treaty's signatories.

A 1997 annex to the treaty that concerned ship fuels ultimately will make a huge difference in air quality at the world's ports, said Kaltenstein. "It signaled a move away from heavy bunker to more highly refined distillates. The annex went into force in 2005 and specifies stepped changes to the fleet's fuel."

At the root of the shipping air emissions problem, Kaltenstein explained, is bunker, the preferred fuel for commercial and military ships since they transited from steam. Bunker is the dregs of the refining process, heavy, almost viscous—and dirty.

"It's loaded with sulfur, nitrogen oxides precursors, heavy metals—it's really filthy," said Kaltenstein. "When it's burned, all that stuff goes out the stack and directly into the air."

Most ships burn bunker with an average sulfur content of 27,000 ppm. Under the IMO's conven-

Gigantic shipping cranes along the Oakland Estuary were made in China. When they arrived in San Francisco Bay, there were only inches of clearance between them and the Bay Bridge.

EILEEN ECKLUND

tions, a reduction to 5,000 ppm must be achieved by 2020, "and that will make a tremendous difference in air quality," Kaltenstein said. If the supply of substitutes for bunker is deemed insufficient, the target goal will be extended to 2025.

But the IMO also allows countries with particular emission control problems to petition for an accelerated conversion schedule to low-sulfur fuels. The United States and Canada submitted such a petition in March, and the IMO is expected to consider the request later in the year. "If it's approved, ship emissions within 200 nautical miles of the U.S. and Canada will be reduced to sulfur contents of 10,000 ppm by 2012 and 1,000 ppm by 2015," said Kaltenstein." According to the U.S. Environmental Protection Agency (EPA), the new standards could reduce deaths associated with air pollution by 3,700 to 8,300 annually, and eliminate up to 3.4 million incidents of respiratory ailments a year.

There's also some progress on noxious discharges from the ships. Most tankers in the global fleet are now double-hulled, said McIsaac, and all new ships built after 2010 will have their fuel tanks isolated from their hulls. Antifouling coatings have undergone a rigorous evaluation, and the industry is now moving to a nontoxic silicon-based hull coating.

In 2008, the EPA adopted a rule requiring ships to exchange their ballast water—which can transport exotic organisms—offshore before coming into ports. The rule went into effect this year, but some ocean advocates are suing the agency, arguing that it's not enough. "The EPA could have pushed this along by requiring ships to treat their ballast water with UV radiation or filtration," said Linda Sheehan, an activist who has worked on ballast issues since 1998 and is now an associate with the California Coastkeepers Alliance. "This technology is available, and already is being used by some lines. We are at the point now where most of the biomass in San Francisco Bay consists of exotic organisms. All of our native estuarine species are threatened."

Many states, including California, adopted regulations tougher than the EPA's years ago, Sheehan said.

A Global Problem

While the shipping industry can hardly be deemed green, it is slowly chugging toward that portion of the spectrum. Perhaps it would be best to call it khaki or olive. The momentum, in any case, is toward a cleaner, more environmentally responsible industry. "I really believe we're on the cusp of a new chapter in the maritime industry," said the Port of Oakland's Sinkoff. "The regulations and plans now taking effect will drive new technologies and alternative fuels—they're pointing to a sustainable era for shipping."

Goldman Prize winner Hasan agrees there is scope for measured optimism. But she also noted that recent changes in the shipping industry are largely the result of unrelenting pressure from citizens, environmental groups, and regulatory agencies. That pressure, she maintains, must remain in force—and it must be international in scope.

In her native Bangladesh, a great concern is that ships flying flags from developed countries where environmental laws are tough and rigorously enforced are now switching flags and sneaking into the Bangladeshi breaking yards before the rules are tightened.

"Developed countries are playing a very large role in the tragedy that is occurring on Bangladesh's beaches," she said. "Our ship-breaking problem is the global shipping industry's problem, and it must be addressed at the global level. We need the world's help on this."

Hasan's plea points to the very heart of the shipping trade's great environmental dilemma. The planet's oceans are indivisible and all-encompassing, and the damage inflicted by the ships that ply them are endured by all. The world as a whole benefits economically from shipping, so it is both appropriate and necessary that the entire world undertakes the Herculean task of cleaning up the industry. ■

Glen Martin, a former environmental reporter for the San Francisco Chronicle, *has contributed to many periodicals, including* Audubon, Discover, Sierra, Wired, Men's Journal, Reader's Digest, Outside, *and* Bay Nature. *He lives in Santa Rosa.*

MARINE RESERVES

TO HELP COMMUNITIES RECOVER

RASA GUSTAITIS

Now nearly everyone can see, on a home screen, some of the wonders scientists are discovering in the oceans as they descend to unprecedented depths in submersibles, map the seafloor, and track the migrations of whales, sharks, and sea turtles via satellite. We watch, and gradually the ocean with its living creatures enters our personal world.

At the same time we are learning that the oceans' intricate web of life is being torn apart. Scientists have long been warning that unless humans stop overfishing and other destructive activities, much of the planet's once-abundant marine life will be lost.

"Fisheries are the major catastrophe that has befallen the animals in the ocean," says Daniel Pauly, director of the Fisheries Center at the University of British Columbia and board member of Oceana, an organization devoted to ocean conservation. His words echo from a video posted on Oceana's website. "It's almost as if we use our military to fight the animals of the ocean—and we are winning the war. We are gradually exterminating them." Hundreds of scientists around the world agree that overfishing is one of the greatest threats to the ocean, along with pollution, habitat destruction, and climate change.

In response, a worldwide ocean conservation movement has surfaced and is gathering strength. It involves governments, international agencies and conservation groups, aquariums and universities, small island communities, and countless individuals. Some of the most promising recent marine conservation successes were sparked by individuals and small groups.

In the Pacific Ocean, hundreds of marine protected areas (MPAs) have been established in the past few decades, mostly on the western side. An MPA is a geographically defined marine area within which fishing and other human activities are banned or limited to varying degrees.

Because the best habitat areas are frequently the most productive fishing grounds, MPAs are often controversial. Research and experience so far, however, support the view that they can help

Wreckage on the coast of Baker Island in the Pacific Remote Islands National Marine Monument

JOANN94024 AT EN.WIKIPEDIA

depleted fisheries to recover, as the fish populations they protect "spill over" to adjacent areas. The reserves also offer a kind of insurance against the impacts of global warming and ocean acidification, especially for coral and other calcifying organisms (see p. 15). "Research suggests that ecosystems that are more biodiverse may be more resilient," points out Cheri Recchia, director of the Marine Protected Areas Monitoring Enterprise of the California Ocean Science Trust.

In the United States, California leads the way as it works to complete the first network of ecosystem-based marine reserves in state waters, some of which will be no-take areas where marine life is completely protected. But overall, this country lags behind many others. Australia has the world's largest network of no-take reserves, covering more than 38,610 square miles. In 2004, the government rezoned the Great Barrier Reef Marine Park, placing more than 20 percent of each of 70 bioregions within the network. In 1977, New Zealand became one of the first nations to establish a no-take reserve, and now has a network of 31.

Small Nations, Big Steps

Much of the recent action has been in the southwestern Pacific, where several small island nations have thrown a mantle of protection over huge ocean areas to reduce overfishing, particularly for tuna and other large species, and to protect coral ecosystems. They were able to do so because they are spread across many islands and, under international law, each nation has sovereignty over resources within an exclusive economic zone (EEZ) that extends 200 nautical miles off its shores.

Tiny Kiribati, which is about halfway between New Zealand and Hawaii, spans three groups of islands spread over 1,350 square miles. It has only about 110,000 inhabitants and only 313 square miles of land, but controls a larger area of the Pacific than any other nation. In 2006, Kiribati established the Phoenix Islands Protected Area, and in 2008, doubled its size to 158,000 square miles, 12 percent of its EEZ, creating the largest MPA in the world and extending protection over some of the world's rare pristine coral reefs.

In another bold action, in December 2008, eight island nations and territories who are members of the Western and Central Pacific Fisheries Commission imposed unprecedented restrictions on industrial tuna fishing vessels, which have moved into this region in larger numbers since tuna populations were devastated in the Atlantic and depleted in the eastern Pacific. These Commission members closed 560,000 square miles to fishing for tuna, swordfish, sharks, and other large migratory species, and restricted fishing practices within the combined extent of their EEZs. As of January 1, 2010, deep-sea fishing vessels there will be required to carry on-board observers and satellite tracking devices to monitor compliance.

These actions by eight of its members encouraged the Fisheries Commission to follow suit. They "served as an important benchmark for developing compatible measures on the high seas," wrote Andrew Wright, executive director of the Commission, in response to an e-mailed question. In December 2008, the Commission, including nine other island members, agreed by consensus to ban the use of large-scale driftnets on the high seas and forbid the use of fish-aggregating devices (platforms that attract mostly juvenile fish) for several months a year, starting this coming August. Purse seiners must retain their entire catch, instead of throwing back small fish to make room in the hold for big ones. In April, the Commission began tracking the positions of hundreds of fishing vessels with a satellite-based vessel monitoring system (VMS).

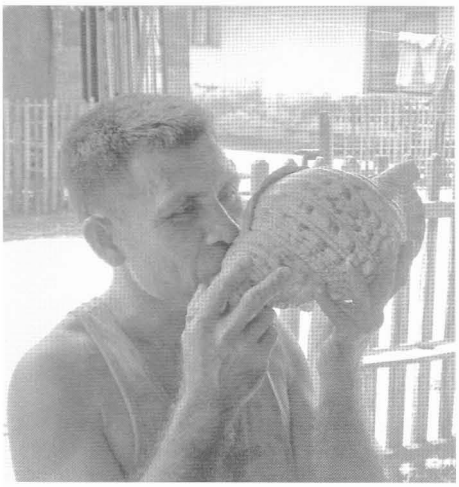
Pacific islanders know first-hand what scientists are trying to convey to the world. Most depend on subsistence fishing and have been watching their food supplies shrink. Many are already experiencing sea-level rise because they live just a few feet above water, and storm waves have been washing through communities that have no higher ground to run to. Islanders have also noticed an unusual coral bleaching, which could be a consequence of changing ocean chemistry, as well as of increased pollution. The population of the islands has been growing, but some islanders are prepared to become climate refugees.

Meanwhile, interest in protecting coral reefs has grown, both in the region and elsewhere in the world.

The story of Kiribati's MPA begins with the "career-changing experience" of Greg Stone, then vice president for ocean systems at the New England Aquarium in Boston. As he tells it, he was invited to Fiji to design a science program around the remote Pacific Islands and came with a team of researchers to dive and take photographs. What they found in the Phoenix Islands was "what the oceans must have looked like a thousand years ago," he said.

Stone urged Kiribati's president, Anote Tong,

A man of Halmahera, Indonesia, blows a giant triton shell to call people to come and catch fish.



IMRAN TAERAN, WWW.REEFBASE.ORG

to create a reserve that would protect this paradise. Tong was receptive, but pointed out that a huge percentage of his country's income consists of revenue from licensing commercial fishing vessels. Stone sought the support of Conservation International (where he is now senior vice president of marine conservation and chief scientist for oceans), which initiated an endowment to reimburse the government for lost revenues.

From the Village Up

Meanwhile, some 500 communities in 15 island countries have established locally managed marine areas, LMMAs, to conserve and restore food supplies and support livelihoods. A comprehensive 140-page report on these community reserves was published in May for the Coral Reef Initiative for the Pacific, sponsored by France. Marine biologist Hugh Gowan, of Suva, Fiji, with 30 collaborators, wrote and compiled *Status and Potential of Locally Managed Marine Areas in the South Pacific.*

Unlike MPAs, these local reserves exist outside of government structures; some are not even recognized by their country's government. They rely on traditional resource-management practices updated with scientific knowhow, usually with some help from outside experts.

Most islands have common fishing and harvesting areas that are owned or controlled by a community or clan. Traditional management methods include closed seasons, limited entry, and restrictions on gear and take—all familiar in marine resource management today. It turns out that traditional knowledge often coincides with science. In Papua New Guinea, for example, tradition holds that some particularly dangerous or hard-to-get-to areas are protected by spirits, *masalai.* Anyone going there had better be respectful and careful. Researchers have found that these are often areas of upwelling and places where fish spawn and aggregate—especially important to protect, from a scientific perspective.

In Fiji, after a chief dies, fishing is *tabu* for 100 days in part of the *qoliqoli*, the common area. When the *tabu* is lifted, everyone comes out to fish for the feast that celebrates the end of mourning. This tradition of periodic fishing bans has helped to lay the groundwork for LMMAs, according to Gowan and others.

A success story in the village of Ucunivanua, on Fiji's largest island, launched the LMMA movement, according to a case study published in *World Resources 2005,* and updated in 2008. In the early 1990s, Ucunivanua's people were spending more and more time searching in mudflats and seagrass beds for a clam, *kaikoso (Anadara antiquate)*, a staple food that was becoming scarce. The son of the high chief of the Verata district, in which the village is located, then a student at the University of the South Pacific in Suva, asked his instructors if they could help.

The university brought workshops in environmental education and community planning to the village, which led to villagers using a traditional ceremony to make an area *tabu* for three years as an experiment. They chose 30 people to manage this no-take area, and experts from the university taught them basic monitoring and sampling techniques. The data gathered in 1997 and 2004 showed a dramatic increase in the number and size of clams, not only in the *tabu* area but also adjacent to it.

Word spread, with similar results. According to Bill Aalbersberg, director of the Institute of Applied Science at the University of the South Pacific, and principal author of the *World Resources* articles, now has about 200 local protected areas, linked in the first national network in the islands. "For developing countries, you have to start with meeting people's needs via marine management and then upscale to bigger issues," he said.

Gowan found that marine reserves that originate with local people (as the Fiji *tabu* areas did) tend to be more effective than those launched by outsiders. He cautions strongly against promising side benefits, such as income from ecotourism, as incentives for reserve creation. These can lead to disappointment and generate projects that conflict with the resource protection goal. The recovery of a community's resources is a reward in itself, he writes.

From the Top Down

In contrast to the bottom-up approach to ocean conservation in the southwestern islands, the three national marine monuments proclaimed by President George W. Bush on January 6 in the

Alga sellers at a market in Suva, Fiji

ALEX TEWFIK, WWW.REEFBASE.ORG

far reaches of the American domain are top-down. They are to be administered by the U.S. Fish and Wildlife Service, in consultation with other federal agencies, with the Department of Defense having the power to override.

The Marianas Trench Marine National Monument contains the deepest known points on the planet, a series of undersea volcanoes and thermal vents, and three coral reef islands in the westernmost U.S. territory. The Rose Atoll monument, at the southernmost point of U.S. territory, has an abundance of rose-colored corals, according to Doug Rader, chief oceans scientist at the Environmental Defense Fund, who said he was personally involved in the science behind the reserve designations. "They could have, and perhaps should have included more territory," he said, but they are "nonetheless a giant leap for fishkind."

The Pacific Remote Islands monument, in the central Pacific, includes Kingman Reef, Wake Island, and other coral islands inhabited by dozens of seabird and coral species. President Bush banned drilling and mining there, which Rader said is especially important. Fishing is restricted or banned in some parts of the monuments, but allowed in others.

"Combined, these designations represent the largest fully protected area in the world," the White House announced. "Under the President's plan, 195,274 square miles would be conserved."

"We're thrilled," said Kaitlin Gaffney, director of Pacific Ecosystem Protection for the Ocean Conservancy. "It's proactive; it's a historic shift from the tradition of waiting for signs of ecosystem collapse to do anything, until it's clear it's too late."

Just what "fully protected" means, however, is subject to question. President Bush stipulated that "nothing in the proclamations impairs or otherwise affects the activities of the U.S. Department of Defense. Among other things, the DOD is ensured full freedom of navigation in accordance with the law of the sea, and the U.S. Navy can continue effective training to maintain its antisubmarine warfare and other capabilities."

Some islands are highly contaminated by past military uses. One of the worst is 50-square-mile Johnston Atoll, now part of the Remote Islands monument. Expanded to ten times its natural size by coral dredging, it was used to launch nuclear missiles (two exploded, scattering radioactive waste) and as a disposal site for military chemical agents, including residue from drums of Agent Orange from the Vietnam War. Plutonium was buried on the atoll under cement domes, and now the seawall protecting the domes is eroding, according to Andrew Gude, marine program coordinator for the National Wildlife Refuge System, which now is charged with managing the monuments.

The Department of Defense, the polluter, is technically responsible for cleanup, but its record elsewhere is far from encouraging; Midway Atoll, which became a wildlife refuge in 1986, is still heavily contaminated by lead and solid waste. "You could literally write a book on the cleanup needs" of these areas, Gude said.

"It's like declaring Chernobyl a pristine reserve," commented Zeke Grader, executive director of the Pacific Coast Federation of Fishermen's Associations. Gaffney said that military uses have been an issue in the process of creating California's Central Coast MPAs, and that the Department of Defense worked with the State successfully to establish a fully protected 20-square-mile MPA offshore of Vandenberg Air Force Base.

Charting a Course

The MPA network in California is moving forward, but its path is thorny. Unlike some Pacific island villages, coastal communities here do not readily unite around a common interest in marine life. Some citizens hold out for "the right to fish," others object to what they see as high-handed action from the state capital, or complain about scientists who they claim ignore local knowledge of abundant abalone and rockfish.

The first set of 29 MPAs was established along the Central Coast in 2007, providing varied degrees of protection to 204 square miles, 18 percent of state waters between San Mateo and Santa Barbara counties. Planning for MPAs in other regions is under way.

No matter how effective any type of reserve turns out to be, MPAs alone will not end the crises building in the ocean. At the Ocean Solutions Center at Stanford and elsewhere there is talk of the need for ocean "spatial planning," a decision-making process based on zoning precepts that could help alleviate growing conflicts over uses and conservation needs. Amid talk about "ocean management," however, one thing is clear: There's no way we can manage the ocean—we can only manage ourselves. ■

Eileen Ecklund and Hal Hughes contributed to this article.

Can't We All Just Get Along?

When Rodney King uttered his now-famous plea for understanding in Los Angeles in 1992, he was speaking of human relationships, trying to calm the rioting that swirled around his beating by the Los Angeles Police Department. It's too bad he didn't copyright the phrase; it is so useful in so many situations. For instance, I'm writing this in Sacramento across the street from the state capitol, a building now swirling with protesters, lobbyists, and all kinds of citizens bemoaning the severe budget cuts looming in the wake of voter rejection of propositions 1A through 1F. Can't we all get along? Can't we decide through rational conversation what we'd like our government to do, how to pay for it, and move on? Apparently not.

Human beings often don't get along very well with each other, and so we have wars and lawyers, riots and revolutions. We also don't get along well with our fellow travelers on the earth, particularly those creatures that are large, taste good, or eat meat. In his book *Guns, Germs, and Steel,* Jared Diamond describes the evidence linking human migration to North America and Australia with the extinction of most large or carnivorous land mammals on those continents. In more modern times, here in California we have pushed wolves and grizzly bears to extinction. The last grizzly bear in California was shot in 1922, leaving only the one on our state flag.

As this issue of *Coast & Ocean* makes clear, our inability to coexist extends to our oceans. Whales, sharks, sea turtles, tuna, manatees, swordfish, have all been hunted, fished, or casually killed "by accident" when they collide with boats, nets, or other human activities. So prevalent is our tendency to extirpate the largest creatures first and then move on that scientists have coined a phrase for it: "fishing down the food chain." Eaten all the big fish? Go after the little ones . . . and don't worry if a few sea turtles get in the way.

Over the long haul of geological time, species come and go. There have been repeated mass extinctions in the life of our planet; the most recent one allowed mammals to emerge from the shadows of dinosaurs, and thus led to us. I accept that some creatures will go extinct in the normal course of events. What I have never understood is the casual indifference we so often show toward the rest of creation. Why exactly did we exterminate the passenger pigeon, and push both bison and the right whale to the brink? We do not tolerate hunters who cut off one leg of a deer, leaving it to die in the forest, but we seem fine with slicing off the fins of sharks and tossing them back into the water to bleed to death.

I am not exactly an animal-rights guy, and I am certainly no vegetarian. In fact, I like venison and shark, and have even eaten turtle soup. Animals eat other animals and plants all the time. It's the way nature works, and we are as much a product of evolution as anything else that has ever grown, swum, slithered, crawled, or walked the earth. Lions, however, don't eat all of the antelopes, and orcas don't eat all of the seals. Humans, on the other hand, have displayed a tendency to eat all of the cod, all of the whales, and exterminate anything that competes with us for food or just seems like it might get in our way. I just don't get it.

Maybe I never grew up. Children are fascinated by nature, animals in particular. It is perfectly natural to be fascinated by creatures that walk the earth like us, going about their business, but are not us. All through history animals have been imbued with human characteristics, played key roles in mythology and religion, and continue to be characters in stories. (See *Charlotte's Web, Finding Nemo,* etc.) Somewhere along the line we lose our fascination and start to think of them only as food or competition, or both. I'm not sure why that happens, but the global consequences have been severe. We go from living with the animals and plants in a state of wonderment and joy, to viewing nature as merely something for our use. Even worse, we assume that nature is limitless and can be exploited endlessly without consequences.

This last assumption has done great damage, nowhere more so than in our oceans. Until very recently in California, the law and policy said, in essence, "Take as much as you possibly can out of the ocean. Leave only enough to come back next year, and assume that the supply of fish is limitless." The groundfish collapse of the past decade proved all of this false, as surely as the cod collapse on the East Coast did in the '80s. We now know better, although knowledge is taking a long time to make its way into policy and practice.

Can't we all just get along? I wish we could. It seems no easier for humans to get along with each other than it is for us to adopt a different ethic toward land and water, one that leads us to take only what we need, to waste nothing, and return enough to make sure that our children inherit no less than we did. I don't have a good answer for Rodney King, but he sure asked a good question.

Sam Schuchat is the executive officer of the Coastal Conservancy.

BOND FREEZE UPDATE

As of June 1, slight progress had been made toward a gradual release of some voter-approved bond money that was frozen by the State on December 18, 2008. However, the paralysis of California's restoration economy continued. In light of the State's worsening budget crisis, no sound predictions were possible at press time as to when interrupted projects might resume or new projects might be considered for approval.

The freeze on bond-fund spending was imposed after the Pooled Money Investment Board, which consists of the director of finance, controller, and treasurer, found that the State might run out of money by February 2009 if the legislative stalemate continued. Without a budget, California would no longer be able to cover obligations. So the Board decided to put an immediate stop to all spending of voter-approved bond funds, a total of over $3.8 billion committed to some 2,000 projects statewide. These were projects to improve schools, transportation, and environmental infrastructure. All work was stopped as of December 18.

Since then, the sale of some bonds in the spring made it possible for the Coastal Conservancy to begin paying invoices for work completed before the freeze was imposed. The release of funds from Proposition 12, 40, and 50 bonds to restart a limited number of existing projects was approved by the State Treasurer's Office on May 22. The Conservancy anticipates that funds from the sales of Proposition 84 bonds will be available soon.

The release of these funds, which include federal economic stimulus funds, have yet to be confirmed, but might allow some large wetland and infrastructure projects to restart before summer's end. It's likely to be a while before State bond funds become available for new projects.

STATE PARKS VISITORS SPEND BILLIONS

The economy gets a boost of about $4.32 billion a year from visitors to California state parks, a survey conducted by Sacramento State University's Recreation, Parks and Tourism Administration suggests. That's the estimated total spent by the 74.9 million people that State Parks estimates visit its 279 parks each year, for items and services ranging from groceries and other supplies to lodging, food, gas, auto repairs, and equipment rentals.

The estimate is based on preliminary results of the survey, conducted by faculty and students under supervision of Professor David Rolloff. From fall 2007 to February 2009, they interviewed 9,700 visitors at 27 parks around the state and found that the average spent per person was $57.63 per visit: $24.63 inside the park and in nearby communities, and $33 in communities more than 25 miles from the park. People from out of state (11.95 percent of those surveyed) spent an average $184.91 per person, or $1.66 billion per year.

"The numbers were kind of shocking to us, they were so huge," said Rolloff. Complete results will be released later this year, he said, but the information about spending "was so significant, we felt it was worth releasing ahead of time." The survey was commissioned and funded by State Parks.

(Sharks from page 7)

When we hear about sharks in the media, it is generally in the context of a shark scare or shark attack, especially when a great white shark is involved. Yet little is said about declining shark populations, or that many people encounter sharks in the wild without incident.

At the Farallon Islands, 28 miles west of the Golden Gate, a boat has brought a few intrepid tourists to enter a cage for a glimpse of a white shark in the flesh. An anxious group gathers near the stern of the boat and searches the rough waters encircled by barren rocks. I'm here to film, but am as interested in the tourists as in the sharks."White shark!" the divemaster exclaims, pointing excitedly as the group squeezes to the rail. Below in the cage, the divers get to see a truly wild animal in its own habitat. Most aboard have never seen a live shark before, and they leave the vessel with a feeling of respect and even admiration.

Cage operations are controversial, but shark tourism may raise awareness and help protect sharks. Some irresponsible practices such as chumming and feeding sharks have been eliminated in the Sanctuary. Perhaps seeing sharks first-hand—whether in a cage, an aquarium, or in the open ocean—will motivate more people to protect them. My own experience diving and filming sharks in the wild has convinced me that sharks are beautiful animals, and that all ocean life is important and worth protecting. ■

David McGuire is a diver, ocean voyager, field associate with the California Academy of Sciences, and independent filmmaker specializing in underwater cinematography. Based in San Rafael, he is the founder of Sea Stewards (http://seastewards.org), an organization dedicated to protecting sharks and advocating a healthy ocean. He is the writer, producer, and underwater cinematographer of Sharks: Stewards of the Reef *(see http://trilliumfilms.net).*

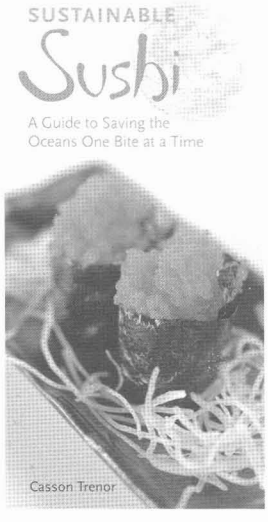
ASK BEFORE YOU EAT

Sustainable Sushi: A Guide to Saving the Oceans One Bite at a Time, *by Casson Trenor. North Atlantic Books, Berkeley, 2008. 128 pp., $15.95 (paper).*

Ah, sushi—the essence of the ocean in a single bite. Those little bites are adding up and could one day consume all the fish in the sea. Almost all of the fishes offered at sushi bars are dwindling in numbers in some parts of the world, and a few are nearing extinction. So what's a sushi lover who cares about our oceans to do?

Casson Trenor has some answers. He describes 39 types of fish commonly found in sushi bars and ranks them as "sustainable" (eat up), "use caution" (limit your consumption), or "unsustainable" (avoid). Sound simple? It's not. Only five of the described fish are unambiguously ranked as sustainable—*muurugai* (mussels) and *mirugai* (geoduck)—or unsustainable—*toro* (bluefin tuna), *unagi* (freshwater eel), and *anko* (monkfish)—while the rest may be sustainable, unsustainable, or in between depending on which species is being served, where they come from, and how they're caught or farmed.

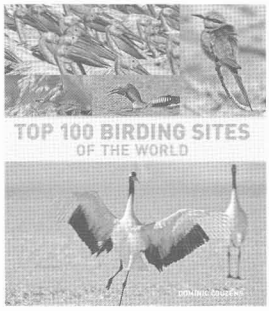
Trenor's advice? Ask questions and stick to your principles. A sushi chef should know the provenance of the fish on the menu, and restaurants should learn that customers care. *Sustainable Sushi* was designed to fit into a purse or pocket, so you can easily bring it to a restaurant. You can also download a one-page printable guide to sustainable sushi from the Monterey Bay Aquarium, www.montereybayaquarium.org. Simplest of all? Go to Tataki Sushi & Sake Bar in San Francisco, North America's only sustainable sushi bar, for now, but maybe the start of a trend.



—Dick Wayman

BIRDING NEAR AND FAR

Top 100 Birding Sites of the World, *by Dominic Couzens. University of California Press, Berkeley, 2009. 320 pp., $45 (hard cover).*



Korgalzyhn lies about halfway between Omsk and Astana in Kazahkstan. If you are ever in the neighborhood, grab a pair of binoculars and head out, because this national park is one of the 100 best places to birdwatch in the world. Here you may find the sociable lapwing (endangered despite its apparent friendliness), the demoiselle crane, and the black-winged pratincole, whatever that is.

Dominic Couzens's *Top 100 Birding Sites of the World* is filled to the brim with fascinating and entertaining tidbits such as the ones above. It is also a beautiful, lavishly illustrated, and well-indexed guide to every birdwatcher's life list of places to visit. The author is clear to state at the outset that it is not a guidebook. It doesn't tell you how to get to any of the places it discusses, or where to stay or eat, or what to wear. But if you are a birdwatcher planning a trip to Europe, Asia, Africa, Australasia, Antarctica, South America, Central America, the Caribbean, or anywhere in North America, you will surely want to consult *Top 100 Birding Sites* before you go.

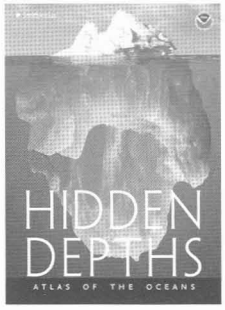
I say consult because you won't be taking it with you; it's a coffee table book, not a field guide. I am sure that Joe or Jane Birdwatcher on every continent will find something to quibble with. I, for instance, can't understand why southeastern Arizona or California's Central Valley were omitted in favor of . . . Niagara Falls? Still, thumbing through this book had me counting the days until I can retire and devote my life to traveling and birdwatching. Until then I will have to make do with the occasional vacation and day trip, while enjoying the gorgeous photography in *Top 100.* For those of us who are familiar with our local avifauna, looking at pictures of red-fronted serins, Sri Lankan frogmouths, purple-bearded bee-eaters, satyr tragopans, and houbara bustards can induce hours of daydreaming.

If you like to watch birds and are thinking about the next few decades of vacations, I highly recommend this book!

—Sam Schucha

A GREAT OCEAN RESOURCE

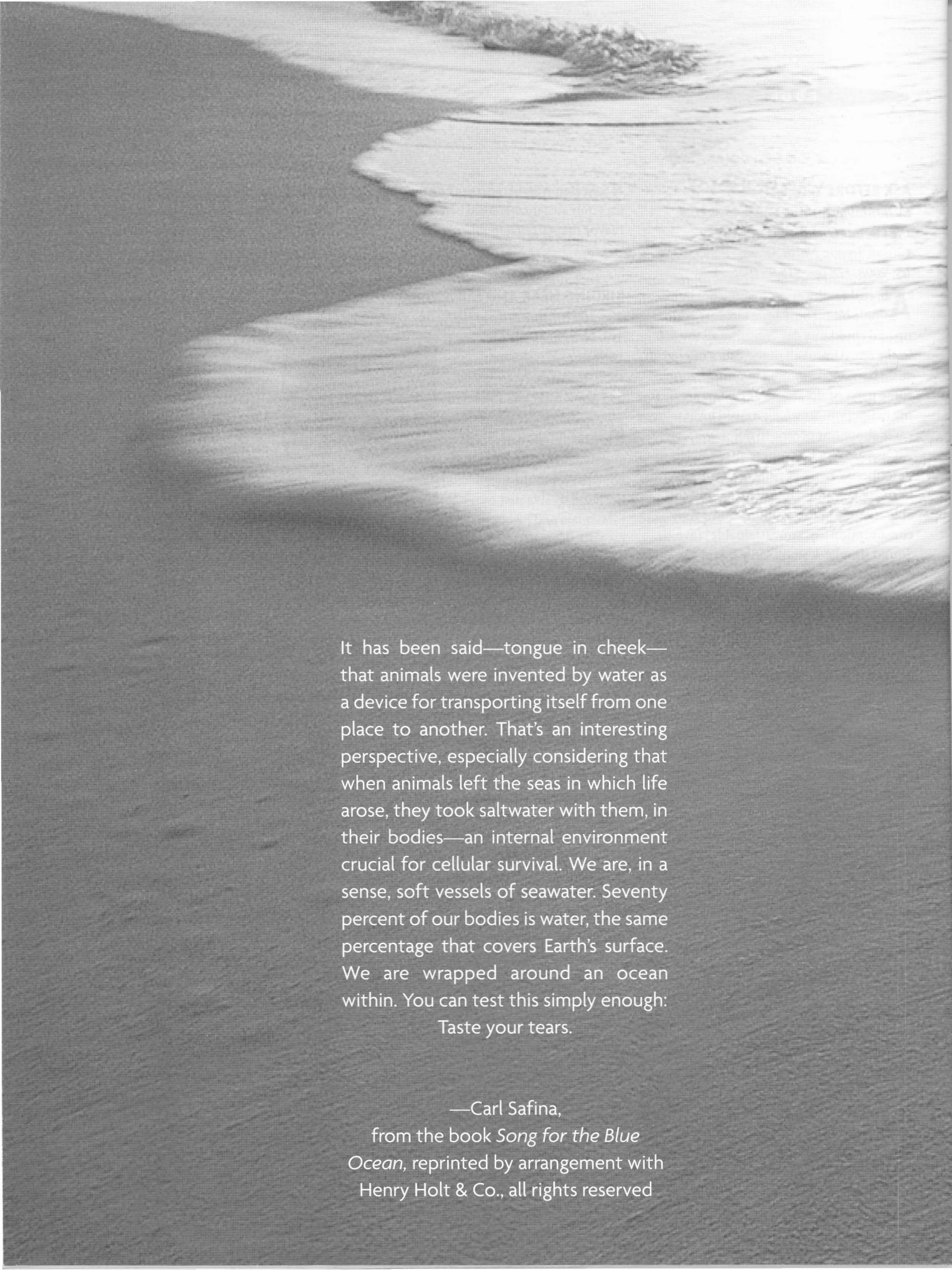
Hidden Depths: Atlas of the Oceans, *by NOAA, Albert Theberge, consulting editor. NOAA, Smithsonian Institution, HarperCollins Publishers, New York, 2007. 256 pp., $39.95 (hard cover).*



Written by ocean scientists at the National Oceanic and Atmospheric Administration (NOAA), with color illustrations on almost every page, this volume compiles up-to-date information on the world's oceans in an engaging and accessible manner. Though it was published a couple of years ago, it is readily available, and proved to be a valuable resource for putting together this special issue on the Pacific Basin.

From the biogeochemistry of seawater to threats of rising sea levels, *Hidden Depths* covers the oceans and related issues past, present, and future, including weather and climate, habitats and ecosystems, shipping and fishing, coastlines and submarine volcanoes, natural hazards and human impacts. It is a superb single resource for learning about our oceans from the global scale to the microscopic.

—HMH



It has been said—tongue in cheek—that animals were invented by water as a device for transporting itself from one place to another. That's an interesting perspective, especially considering that when animals left the seas in which life arose, they took saltwater with them, in their bodies—an internal environment crucial for cellular survival. We are, in a sense, soft vessels of seawater. Seventy percent of our bodies is water, the same percentage that covers Earth's surface. We are wrapped around an ocean within. You can test this simply enough: Taste your tears.

—Carl Safina,
from the book *Song for the Blue Ocean,* reprinted by arrangement with Henry Holt & Co., all rights reserved

The Great and Wondrous Pacific Ocean

Dear Subscriber, Reader, Parent, Grandparent, Student, Teacher, Citizen, Anyone, and All,

This map was created for *Coast & Ocean* to help us all see and understand the Pacific Ocean and our relationship to it better. We hope it will pique your curiosity, inspire you to follow the clues it contains, and lead you to books and websites to explore in greater detail the images and links you see here. Most especially we hope that this map will encourage everyone, especially children and young people, to see the Pacific Ocean as one intricately interconnected whole, rich with life.

If you love this map by Mona Caron as much as we do, we hope you will post it in your office, schoolroom, kitchen, a child's room, or some other place; that you will take it to meetings where coastal and ocean issues are discussed and use it in ways we never thought of, so that all will get to know and love the great and wondrous Pacific Ocean better and help to protect it.

(IN BANNER) MANDARINFISH
The reef-dwelling mandarinfish *(Synchiropus splendidus)* lives in the western Pacific, from the Ryukyu Islands to Australia. Its vivid blue, orange, and green colors make it popular in the aquarium trade, where it is also known as the "psychedelic fish."

1. SEA HORSE
Sea horses *(Hippocampus)* are fish. During courtship, pairs often entwine their tails and swim side by side, or grasp a strand of sea grass and twirl in unison. A female deposits eggs in a pouch on the belly of a male, which carries them till they hatch.

2. NUDIBRANCH
Nudibranchs (sea slugs) are among the most diverse creatures on the planet. This Spanish shawl nudibranch *(Flabellina iodinea)* is among the species that can swim. It feeds only on orange hydroids, and changes the orange pigment into its own three bright colors.

3. CHAMBERED NAUTILUS
The chambered nautilus *(Nautilus pompilius)*, a relative of squids and octopuses, has about 90 tentacles without suckers, and a shell that provides buoyancy. Like all cephalopods, it swims using jet propulsion, forcing water through a siphon.

4. DUMBO OCTOPUS
Dumbo octopuses *(Grimpoteuthis)* live in the deep oceans and swim using fins, webbed arms, and jet propulsion. Their fins look like cartoon elephant ears.

5. JELLYFISH
The deep-sea jellyfish *Benthocodon* is found near undersea mountains.

6. TUBE WORMS
Giant tube worms *(Riftia pachyptila)* live around deep hot water vents on the ocean floor. They have no eyes, mouths, or organs for eating or excreting, living in symbiosis with bacteria that nourish them. Temperatures around the vents can reach 572 degrees F.

7. SEA STAR
Many sea stars *(Asteroidea)* can push their stomachs outside their bodies through their mouths to surround and digest their prey. Most of the 2,000 species of sea stars have five arms, but some have as many as 40, and if arms break off, they can grow new ones.

8. RADIOLARIAN
Radiolarians are microscopic one-celled zooplankton with intricate geometric mineral skeletons.

9. KELP
Kelp, a seaweed, often grows in forests that support a rich array of ocean life.

10. SAKHALIN ISLAND
On Sakhalin Island, off the coast of Russia north of Japan, rich petroleum and natural gas reserves are being exploited. Many whales feed offshore and are threatened by the heavy industrial activity.

11. SEA EAGLE
Steller's sea eagles *(Haliaeetus pelagicus)* breed around the Sea of Okhotsk, in far-eastern Russia, and overwinter in Japan. They eat mostly salmon and trout, but also dead seals and other carrion.

12. SALMON
Where salmon *(Oncorhynchus)* go after spawning in their native streams is still a mystery, but recently some have been seen in the North Pacific Gyre. These fish were plentiful along northern Pacific coasts, from Korea and Japan to Alaska and along the coast of North America to Baja California, but many salmon populations are now severely diminished. Fishery closures and efforts to restore stream habitats may help them recover.

13. CONTAINER SHIPS
Ships loaded with up to 15,000 containers now carry most of the world's manufactured goods. Storms wash many containers overboard.

14. NORTH PACIFIC GYRE AND GARBAGE PATCH
Vast amounts of plastic trash spin in the North Pacific Subtropic Gyre, one of 11 major gyres in the world's oceans. There are four Pacific garbage patches and four in other oceans.

15. RUBBER DUCKS
Bathtub toys spilled from a container ship in the North Pacific in 1992 have been riding currents and washing ashore ever since. By 2007 some had made their way across the Arctic to the Atlantic Seaboard.

16. SEAWEED
Edible seaweeds harvested for human consumption include (on map, left to right) *arame, kombu,* and *wakame.*

17. NUCLEAR WASTE
For over 20 years, radioactive waste and chemical weapons were dumped off the California coast, especially near the Farallon Islands near San Francisco. It is now thought to be more dangerous to try to remove them than to leave them there.

18. SNOW GOOSE
Snow geese *(Chen caerulescens)*, breed in the Arctic, and many travel the Pacific Flyway to overwinter in California's Central Valley.

19. MARLIN
The Indo-Pacific blue marlin *(Makaira mazara)* is related to swordfish. Marlins can grow over 15 feet long, and can swim almost 70 miles per hour.

20. DEEP-SEA EXPLORER
The Mariana Trench is the deepest place on earth—36,201 feet below sea level—almost 1.5 miles deeper than Mt. Everest is high. When the manned bathyscaphe *Trieste* reached the bottom in 1960, the explorers were surprised to find life there. Creatures at these depths must survive extremes of cold, heat, and high pressure.

21. LOGGERHEAD TURTLE
Loggerhead turtles *(Caretta caretta)* have been tracked from Baja California to Japan, swimming about 7,500 miles.

22. ALBATROSS
Albatrosses *(Diomedeidae)* have the largest wingspan of any living bird, some over 11 feet, and can glide for hundreds of miles. Chicks hatched on Midway Island, at the western tip of Hawai'i, may die from eating plastic, tons of which wash ashore there.

23. GRAY WHALE
Each year, gray whales *(Eschrichtius robustus)* travel 12,000 miles between the Bering and Chukchi Seas of the Arctic, where they feed in summer, and the warm lagoons of Baja California, Mexico, where they give birth in winter.

24. CORAL REEFS
Healthy coral reefs, built by colonies of tiny animals called polyps, provide homes for thousands of species, from fish to crabs to nudibranchs. Reefs are threatened by siltation, dynamite fishing, ocean acidification, derelict fishing gear, and bleaching caused by climate change and pollution.

25. ALBACORE TUNA
Albacore *(Thunnus albolunga)*, like other tuna, are speedy swimmers; some have been clocked at 45 miles an hour. Some species of these large carnivorous fish are warm-blooded, so they can range from the tropical ocean to the far north.

26. JELLIES
Jellyfish, or sea jellies *(Cnidaria)* live in all parts of the ocean, and may proliferate as fish populations are depleted. Sea turtles and some large fishes love to eat them.

27. GALAPAGOS ISLANDS
This giant iguana is one of many species that live only in the Galápagos Islands, which are protected within a 43,500-square-mile ocean reserve, one of the largest in the world.

28. DIVER
Many divers are now working to explore and help protect the ocean.

29. ANGLERFISH
Anglerfish *(Lophiiformes)* use the first spine of their dorsal fins as lures to attract prey. Males are tiny, and attach themselves to females like parasites to feed and breed.

30. TRAWLER
Industrial trawlers drag huge nets across the sea floor, inflicting damage to deep-sea habitats. This is one of the most harmful types of fishing, so it is increasingly banned or regulated.

31. SHARK
Sharks *(Selachimorpha)* have been around millions of years longer than land animals, and live mostly in coastal waters. Some of the 440 shark species have complex migration patterns. Millions are killed each year, often only for their fins.

32. GIANT SQUID
Giant squid *(Architeuthis)* can be over 40 feet long. In the Pacific, they live in the deep sea mostly off Japan and New Zealand, and are prey only to sperm whales. The first photos of a live giant squid were taken in 2004.

33. BLUE WHALE
The blue whale *(Balaenoptera musculus)* is the largest animal that ever lived, but eats mostly krill. It filters its tiny prey from the water through baleen plates in its mouth.

34. SPOOKFISH
The deep-sea spookfish *(Winteria telescopa)* has barrel-shaped eyes that look out through its transparent head.

35. & 36. MAGNIFIER
A close look at seawater reveals tiny life forms—plankton (36) such as copepods, radiolaria, diatoms, and algae—mixed with fragments of plastic (35) that keep breaking down into ever-smaller bits.

Coastal Conservancy

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