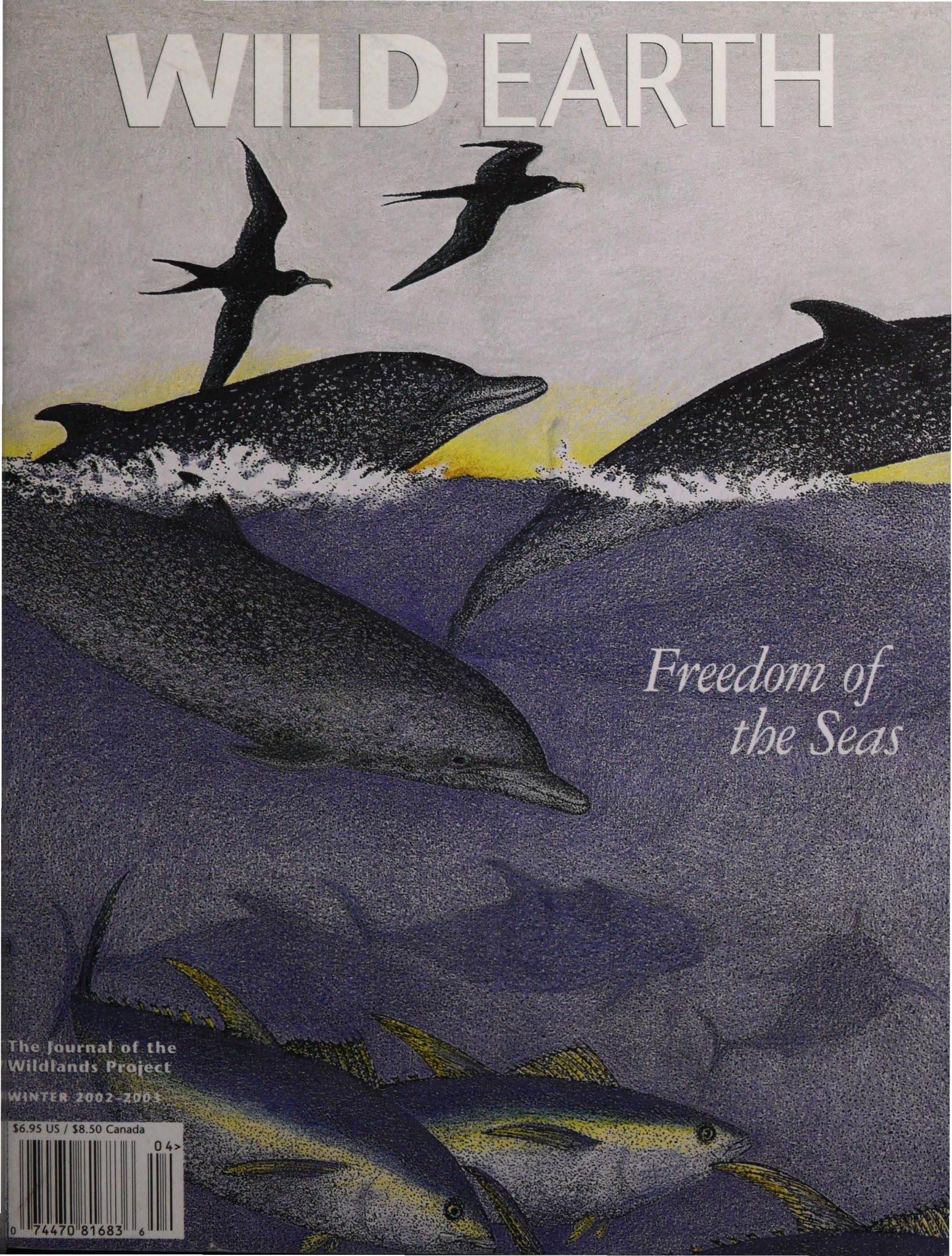
WILD EARTH



Freedom of the Seas

The Journal of the Wildlands Project

WINTER 2002-2003

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WILDLANDS PROJECT

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WE ARE AMBITIOUS. We live for the day when grizzlies in Chihuahua have an unbroken connection to grizzlies in Alaska; when wolf populations are restored from Mexico to the Yukon to Maine; when vast forests and flowing prairies again thrive and support their full range of native plants and animals; when humans dwell on the land with respect, humility, and affection.

Toward this end, the Wildlands Project is working to restore and protect the natural heritage of North America. Through advocacy, education, scientific consultation, and cooperation with many partners, we are designing and helping create systems of interconnected wilderness areas that can sustain the diversity of life.

Wild Earth—the quarterly publication of the Wildlands Project—inspires effective action for wild Nature by communicating the latest thinking in conservation science, philosophy, policy, and activism, and serves as a forum for diverse views within the conservation movement.

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Wildlands Project
P.O. Box 455
Richmond, VT 05477
802-434-4077
802-434-5980 (fax)
info@wildlandsproject.org
www.wildlandsproject.org

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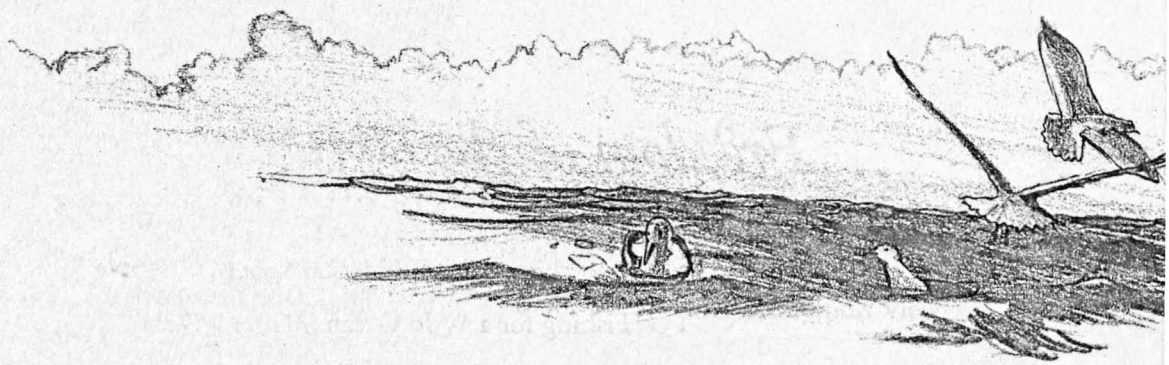
ON THE COVER
Spotted dolphins, yellowfin tuna, and magnificent frigatebirds, ink and colored pencil by D. D. Tyler, ©1978

VOLUME 12, NUMBER 4 ☾ WINTER 2002–2003

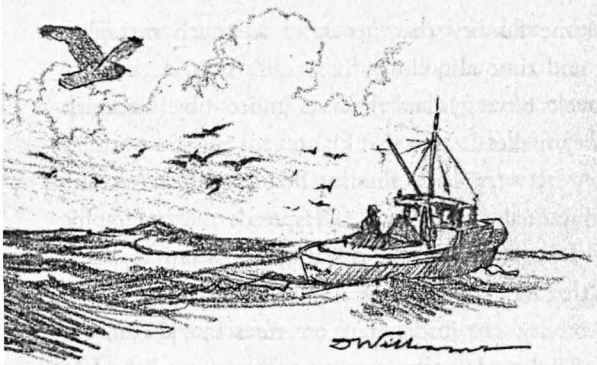
Freedom of the Seas



Launching a Sea Ethic

by Carl Safina

graphites by David Williams



THE OCEAN DISPLAYS TO US a dismissive, inscrutable exterior, all motion and mood, all mask and disguise, seemingly rolling on as always, its face silent about substance, its countenance mute on content, the extent of its wrinkles never varying over time. But don't underestimate her. Ninety-nine percent of Life's habitable volume is in the seas, and planet Earth would likely bear abundant and complex life if no emergent land existed. But without an ocean, this planet would merely spin unnamed three orbits from a star, its browned-out face its own sterile moonscape. How do we begin to acknowledge a debt of such magnitude?

Aldo Leopold's brilliantly articulated Land Ethic seems entitled to stop at the high-tide line. True, his essay "The Green Lagoons" shows clearly that water worked its magic on Leopold as lastingly as on many of us. But from Leopold's Wisconsin farm, oceans lay distant, out of sight and generally out of mind. Were he living now, though, he would probably have extended the vision of his great idea into the grand swirl and suck of the many-fingered tides and beyond. Leopold understood connections, and connectivity is perhaps the main single characteristic of Earth's singularly life-giving ocean.

Whether or not we can see, hear, or feel the ocean from our own home territory, the ocean certainly feels all of us. Between a third and half of the world's people now live within 50 miles of a coast—and few traveled people would find reason to dispute that estimate. In China, population density is three times higher in coastal areas than elsewhere. The collective weight of humanity may rest on land, but we levy heavy pressure on the sea. Marine fisheries contribute more animal protein to human diets than beef, poultry, or any other domesticated or wild animals. In Asia, more than one billion people rely on fish as their main source of animal protein. Most of us exert our most direct interaction with the sea through the fish we buy. And much of the human enterprise affects water quality. Even air quality affects water quality because what goes up alights elsewhere. We act as though the ocean is merely a source of raw materials and a waste sink largely because we lack moral standards encouraging us to see otherwise. We don't consider what we do to "the oceans" the same as what we do to ourselves, our families, our communities. Of course, we also inflict disregard upon the land, but we consider the sea even further outside of us rather than seeing ourselves within the ocean's life-sustaining envelope. Even many of us who maintain a nature ethic don't give the sea much thought in that context.

An ethical context is not a strategy or a prescription or remedy. An ethical context is a concept of relationship—one we wish to acknowledge or one we seek to forge. One exemplary resonant ethic, embodied in the U.S. Constitution, is that all people are created equal and endowed by the Creator with inalienable rights. None of this is strictly true—people differ, and rights are won, not endowed—but this ethical conceptualization of what it should mean to be human provides a moral compass pointing to the framework for a truly great nation, striving for dignity and the fulfillment of human potential, with indefinite room for improvement toward that stated equal-rights ideal. It is perhaps no coincidence that a wilderness continent gave thinkers enough breathing room to articulate such lofty aspiration for a new society. Nor is it likely coincidental that a people who saw their relation to each other in terms of equality and rights spawned the generosity of spirit embodied by luminous souls such as Theodore Roosevelt, John Muir, Aldo Leopold, and Rachel Carson.

Leopold's essay "The Land Ethic" unveiled an idea much bigger than just the dry land that covers less than a

third of Earth's surface. It was really a recognition that his "search for a durable scale of values" led inexorably toward extending our sense of community beyond humanity to encompass people plus the whole living landscape. This land ethic's most fundamental corollary is its implication for right and wrong. An action is right, Leopold advised, when it tends to preserve the integrity, stability, and beauty of a living community, and wrong when it tends otherwise. Rightness is reckoned in terms of safeguarding the present and preserving future options not just for people, but for the whole living world that forms humanity's crucible, context, and endowment. Applying this in the real world is not always so simple, but conservation might be thought of as the effort toward what is right.

Aldo Leopold's land ethic is really a nature ethic that includes all forms of life in a concept of community. But Leopold seemed to land-lock his great idea. Perhaps he was too modest to see the reach of its implications, perhaps he was wise and patient enough to leave it for the rest of us to fully uncover its breadth. Maybe, like most people, he didn't give the ocean much thought because he was too busy fighting figurative (and in his case literal) fires closer to home. Whatever the reason, it's now apparent that we must extend our sense of living community below high tide—we need now a Sea Ethic.

Were it not for the fact that we are such visual creatures, our sense of community with the ocean should be easier and more intuitive to grasp than even our sense of the land, because our connection with the sea is more intimate. It has been playfully proposed that animals were invented by water as a device for transporting itself from one place to another. That's especially trenchant for those of us now living on land, because 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 are 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.

But for most of us the ocean is different and unfamiliar, an alien place hostile to human colonization. The ocean differs from land in its *fluidity.* It differs from the atmosphere by its viscosity, hence buoyancy. The buoyancy and motion of water result in transportation capacity unmatched by land or air. This leads to a major life dispersal strategy—planktonic drift—that is essentially unparalleled ashore or even aloft.

The same fluidity that generates so much metaphor about life and time also closes the ocean's skin instantly to hide the tracks of vessels and the scars inflicted by humanity. This fluidity makes it *seem* that the oceans remain untrammeled, yet this very same fluidity that carries the ocean's plants and animals also smears and spreads the geographic footprint of people. Those effects originate from so many directions that they have become ubiquitous. The fluidity creates connectivity, not just among creatures but also in the transport of chemicals, contaminants, and trash, and the easy accidental introduction of alien species. And because the fluid surface is not friendly to fences, and animals roam massively within, it fosters creation of the largest human commons anywhere: the waters of the continental shelves and high seas wherein is executed the largest-scale commercial hunting of wildlife on Earth.

Fluidity is the major difference between sea and terra firma. But similarities between land and ocean are more direct than might be seen on the ever-undulating surface. Ocean fishers speak less of waters than of fishing "grounds." When a professional fisher scans the sea, they do not so much see the water as envision the bottom contours and structures influencing the distribution of fishes. In the open ocean, structure is often comprised of a mosaic of water temperatures and their consequent frontal zones. But for most of the world's fisheries, on the shelves bordering all continents, the structures of interest are the submerged landscapes and topographies of the sea floor, the canyons and ranges and ridges.

These submerged fishing grounds are "wild lands" too—though nowadays, one would need a pretty diluted definition of "wild" to describe any place in the sea. This is not meant as a pun. Daniel Pauly of the University of British Columbia estimates that humans extract fully one-third of the coastal oceans' productivity. Overfishing is a major global wildlife crisis as well as a threat to human food supply. Incidental kill or "bycatch" endangers certain seabirds, marine mammals, and turtles with extinction. While some large patches of forest remain intact, virtually all of the world's continental shelves bear the scars of the large trawl nets that are repeatedly raked across the bottom to take half the world's catch (like gathering wild mushrooms in the forest with bulldozers; it works, but it's heavy on the terrain and on other creatures). Warming is killing corals and melting ice caps, changing the heat balance of the entire world ocean and destabilizing major living communities, especially at higher latitudes. Toxins continue dispersing while trash piles up. Nutrients in unnatural concen-

trations are causing oxygen-depleted seafloor "dead zones." Toxic algae are increasingly blooming out of control and new diseases are appearing, some spreading to sea creatures from humans and our livestock. It may be uncolonized by people, but the ocean is hardly "untrammeled" wilderness.

Extending a sea ethic would mean recognizing the ocean's importance to the continued existence of life on our planet and to human futures. From this recognition would flow an appropriate sense of moral imperative, commitment, and urgency—urgency toward ending overfishing and wasteful bycatch and aggressively rebuilding depleted ocean wildlife populations, stabilizing human effects on world climate, slowing habitat destruction, stemming global transport and accidental introduction of "alien" species, curbing the flow of contaminants and trash, developing sustainable seafood farming, cultivating an informed approach to the seafood marketplace, and implementing networks of protected areas in the sea.

And as the world grows increasingly crowded and the seas increasingly pressured by conflicting users, it seems inevitable that the concept of zoning must move into the water, designating various places for certain kinds of fishing gear, certain regeneration areas for no extractive use at all, some places for seasonal closure to protect spawning aggregations or nursery areas where juveniles congregate, and certain areas for scientific study so that we may better understand the extent of our effects nearby.

All these kinds of concerns have their parallels and precursors ashore. People who think of themselves as conservationists carry a concern for wildlife, wild lands, habitat quality, and sustainable extraction as part of the collective ethic, their sense of right and wrong. It is high time to take these kinds of ideas below high tide, and a sea ethic is the perfect vessel in which to begin the voyage. ☾

Carl Safina *grew up near the sea and started his scientific career studying seabirds. Since 1990 he has worked to highlight, explain, and solve problems facing the oceans' wildlife, including campaigns to ban high-seas driftnets, strengthen fisheries laws, conserve tunas, sharks, albatrosses, and other creatures, and highlight sustainable seafood choices. After a long tenure at Audubon, in 2003 he has founded Blue Ocean Institute to develop sources of information and inspiration about the seas. Safina is author of more than a hundred publications on ecology and conservation, including the acclaimed* Song for the Blue Ocean. *His most recent book is* Eye of the Albatross; Visions of Hope and Survival.

Seals From a Sea Cliff

You swim today where yesterday I walked,
But there is more between us than the tides—
Where waves run over rocks you share
Clouds of air in water with watery air.
My world ends where the sea's unrest
Erodes but never climbs the slanted shore—
And fossil shells appear like flowers, pressed
From a field of stone that stands by more stone stressed—
What comes is built on what has come before.
What rises most between us is stone time
And time never was stone to wash away;
Though somewhere in the rocks remains a day—
An instant—when a being we both knew
Walked a cliff of layered lives, like memory,
And sniffed salt air, and contemplated blue,
And went on loving something of the sea.

Matthew Orr

DAVE FOREMAN'S essay "Don't Worry, Be Happy" [Around the Campfire, fall 2002] is a most intelligent piece of writing. He could have used almost any island in the world as an example. The book *Easter Island, Earth Island* by John Flenley and Paul G. Bahn could be the text on overpopulation, environmental destruction, war, and decimation of a human population.

Haiti is the best current example of the evils Foreman described. I worked in a rural Haitian hospital where the population has tripled since 1950 as a result of simple sanitation, vaccination, and antibiotics without coincident birth control. Haiti is also an example of how, in our modern world, emigration helps keep a lid on social explosions by getting rid of the educated rich—who could possibly change things—and the poor at the bottom of the heap who are burdens to the economy.

Isn't it terribly frustrating that the politicians refuse to embrace family planning as a worldwide priority? On the other hand, the global economy requires an ever-expanding pool of consumers and cheap labor.

John Raffensperger, M.D.
Chicago, Illinois

I HAVE ALWAYS admired the writing of Dave Foreman, publisher of *Wild Earth*, so I was surprised, in the fall 2002 issue ["Don't Worry, Be Happy"], to find that he praised a book by David Ehrenfeld titled *The Arrogance of Humanism*.

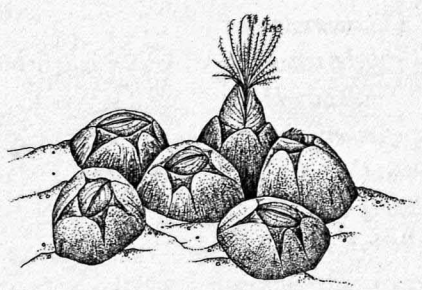
According to Foreman, Ehrenfeld warns that humanism is based on a series of assumptions. I have called myself a humanist for 50 years, and my experience is that the views of humanists are as varied as those of religious people. To allow that to be judged, let me express my own, alongside what Ehrenfeld apparently believes to be the common assumptions of humanists. The quotations given by Foreman are followed by my responses.

"All problems are soluble by people."
People need to strive to solve problems because a benign deity is not going to do it for them.

"Many problems are soluble by technology."
Almost every technical solution has associated problems, and some of those problems threaten to be catastrophic.

"Those problems that are not soluble by technology, or by technology alone, have solutions in the social world (of politics, economics, etc.)."
One thing is certain, namely that all that is necessary for the triumph of evil is that good men should do nothing. So it is necessary to strive unremittingly to remedy the ills of the world.

"When the chips are down, we will apply ourselves and work together for a solution before it is too late."
The human population passed the long-term carrying capacity of the world around 1940, when population was about two billion; thus it is too late to do anything but reduce the extent of the disaster.



"Some resources are infinite; all finite or limited resources have substitutes."
Human beings are already appropriating too much of Earth's renewable capacity. The greatest overload of capacity is associated with overwhelming the planet's carbon sinks. The result has been to increase the concentration of carbon in the atmosphere to a level that is higher than it has been in the last 20 million years (long before humans arrived). This is the most immediate reason why Earth passed its human carrying capacity in 1940.

"Human civilizations will survive."
Another humanist, the cosmologist Fred Hoyle, summed up the situation accurately in these words:

> It has often been said that, if the human species fails to make a go of it here on Earth, some other species will take over the running. In the sense of developing intelligence this is not correct. We have, or soon will have, exhausted the necessary physical prerequisites so far as this planet is concerned. With coal gone, oil gone, high-grade metallic ore gone, no species however competent can make the long climb from primitive conditions to high-level technology. This is a one-shot affair. If we fail, this planetary system fails so far as intelligence is concerned.

While my views, and those of Fred Hoyle, may not be typical of other humanists, they are not particularly untypical, and surely demolish Ehrenfeld's claim that humanists fail to appraise the success of "our interactions with our environment."

Andrew R. B. Ferguson
Henley-on-Thames, United Kingdom

Andrew Ferguson is research coordinator for the organization Optimum Population Trust, based in England.

bay barnacle, pen-and-ink by Todd Telander

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THANK YOU for Stephen Stringham's excellent article ["Smokey and Mirrors"] in the fall 2002 issue on the weaknesses in the U.S. Fish and Wildlife Service's methods for measuring the recovery of grizzly bear populations. He makes a compelling case for the risks that will be taken if federal protection of these animals under the Endangered Species Act is removed.

In addition to the issues Stringham identified, there is another flaw in the proposition that grizzly populations in the Greater Yellowstone Ecosystem have recovered. Yellowstone is an ecological island. Over the last 40 years, every adult grizzly that entered the Yellowstone region was brought there by humans. The landscape connections that would allow grizzly populations in Yellowstone to be naturally connected to source populations in Canada have been severed. Should anything drastic happen to Yellowstone's grizzlies—like a disease or fire that eliminated a large number of animals in a short period of time—they will be unable to recolonize the area on their own.

Until the natural connectivity between Yellowstone and protected landscapes to the north is restored, grizzlies in the Yellowstone ecosystem remain vulnerable to extirpation and should continue to be classified as endangered.

Wendy Francis
Toronto, Canada

Wendy Francis is interim executive director of the Yellowstone to Yukon Conservation Initiative.

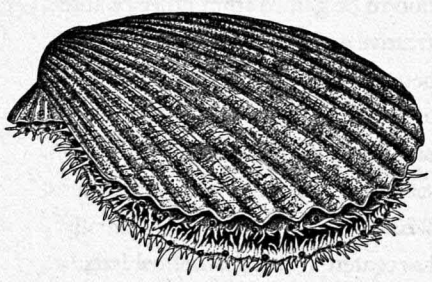
THERE ARE MOMENTS when something wonderfully important happens for a reader, when the words grow to flower then open before your eyes. It is the magic of a story told well. It is the fine work of Lyanda Lynn Haupt's "One-Eyed Dunlin" [fall 2002]. Thank you.

Joel B. McEachern
Mt. Dora, Florida

I READ THE INTERVIEW with Mike Fay in the fall 2002 issue of *Wild Earth*. It set off strong emotions. Ever since I was a child reading Edgar Rice Burroughs' Tarzan novels, I have looked upon the African "jungle" as the last true bastion of wildness. The recent news concerning logging, the bush meat trade, and, of course, ongoing population growth, had made me resigned that this area would soon be lost.

Mike Fay renewed my hope, saying local leaders *do* want to preserve some of this wonderful habitat. I am age 64, living on an inheritance. I belong to many environmental groups, but I've decided I want any financial legacy left when I die to support Planned Parenthood and the preservation of central African rainforests.

Helen J. McGinnis
Harman, West Virginia

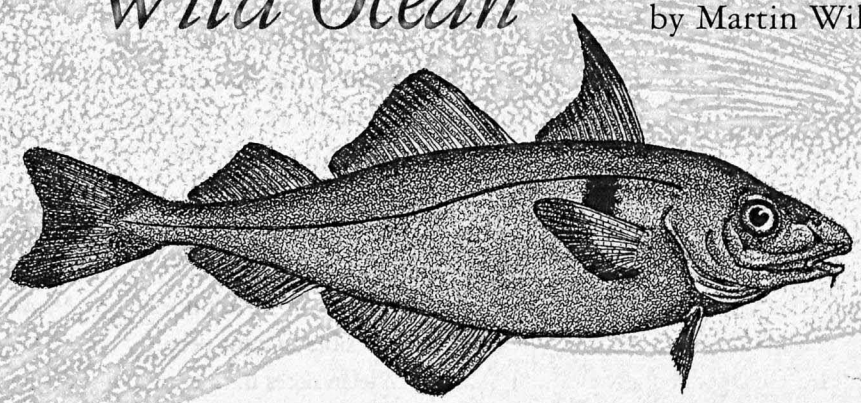


We welcome your comments. Please send them to us at P.O. Box 455, Richmond, VT 05477 or e-mail to letters@wild-earth.org. Published letters may be edited for length and clarity.

Atlantic bay scallop, pen-and-ink by Todd Telander

Fishing for a Wild Ocean

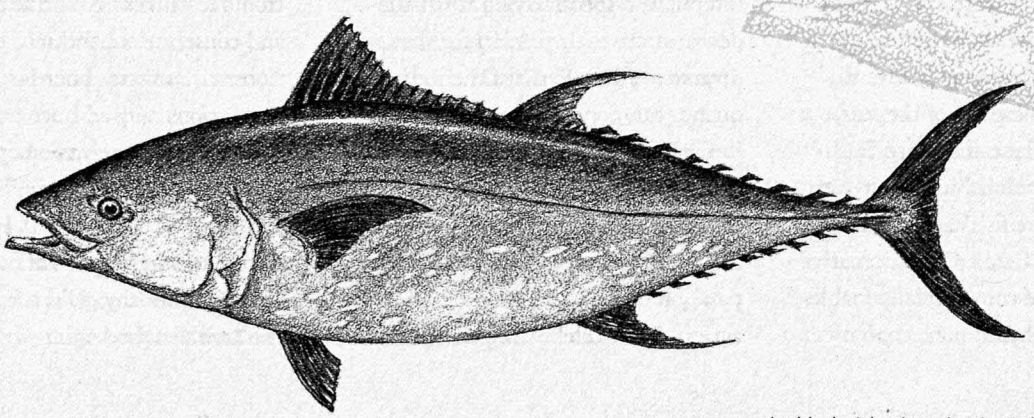
by Martin Willison



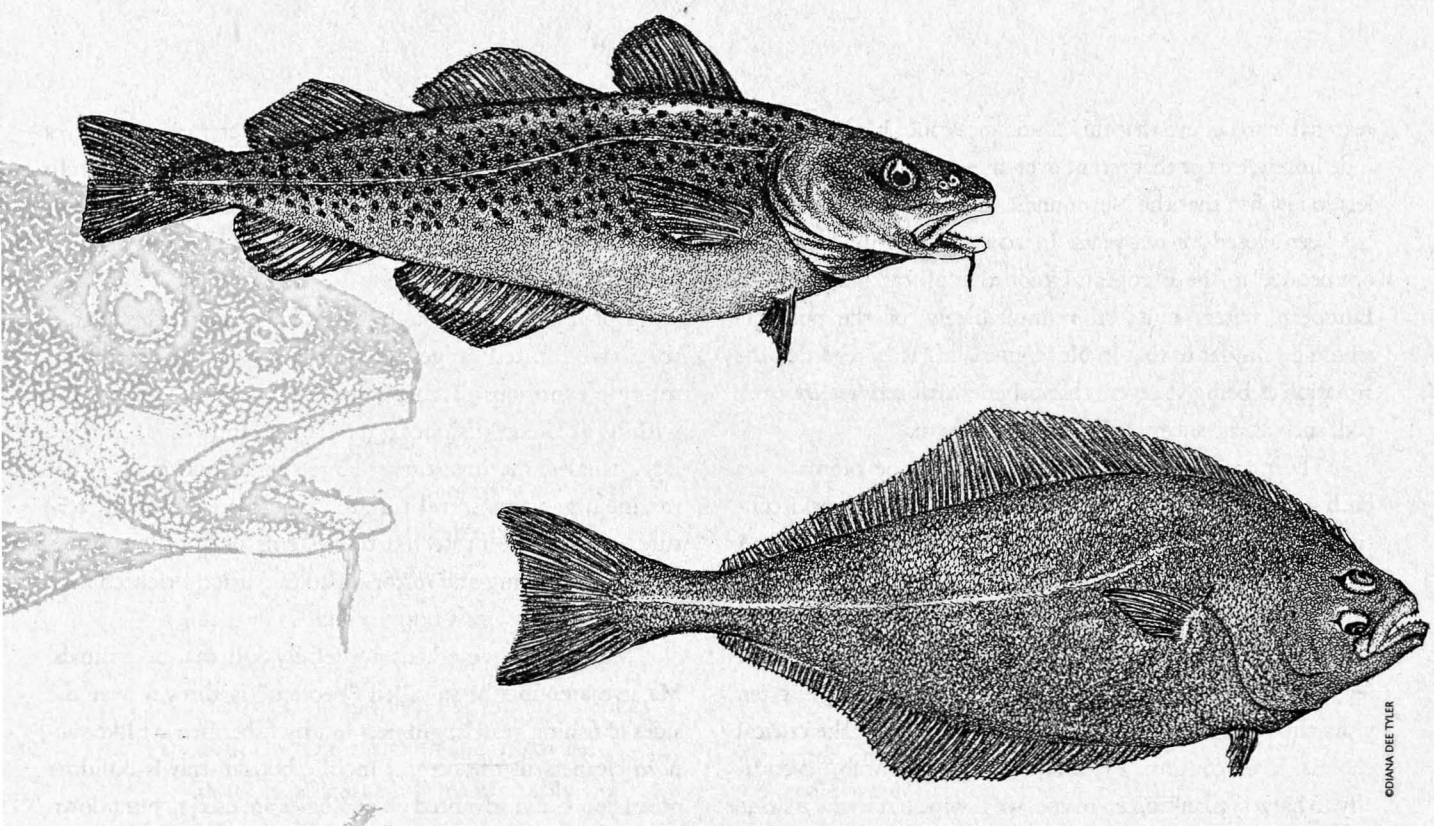
DO YOU REMEMBER the classic Norman Rockwell scene of a boy with a fishing pole? The image was created to imply harmless innocence, but it belies a sad truth. We have largely emptied the world's oceans of fish. Not just fish, but turtles and whales too, and now we're working on invertebrate animals like lobsters, shrimps, and crabs. How could we have collectively so misjudged the truth about fishing, and what can we do to reverse the enormous trend of declining ocean biomass?

Seventy-one percent of Earth's surface is covered by oceans, yet despite their vastness they are profoundly disturbed. This great watery wilderness is suffering from neglect born of ignorance and avarice. The findings of several recent scientific works point the way to a better future, but it won't be easy to get there. Enormous changes are needed in popular awareness, laws, eating habits, marine management, conservation methods, and fishing technologies.

In 2001, Jeremy Jackson of Scripps Institution in San Diego and a host of colleagues published a paper in the journal *Science* entitled "Historical overfishing and the recent collapse of coastal ecosystems." By examining historical and archaeological records, the authors found that abundances of



haddock, Atlantic cod, Atlantic halibut, and bluefin tuna



marine animals at the time humans first arrived in various parts of the world were usually "fantastically large." Huge populations of large marine animals determine the structure and function of marine ecosystems, and by removing them, these ecosystems have become profoundly different. The authors describe this phenomenon as "ecological extinction"—that is, the elimination of a functional component of an ecosystem. It takes awhile for an ecosystem to adjust to the removal of biomass, and this adjustment plays out gradually in the form of an ecosystem "cascade." At present, the world's oceans appear to be experiencing interacting cascades, driven largely by fishing excesses. In some places where fish once dominated, jellyfish are blooming.

My colleague Ransom Myers at Dalhousie University maintains a huge marine fishing database that he analyses using sophisticated statistical methods. He recently reported that there is a consistent pattern of rapid decline of fish biomass as open-ocean species are targeted. These fish are described as "pelagic," meaning that they live and feed near the surface of the ocean. Populations of marlin and tuna species, for example, fall rapidly to about one-twelfth of their original biomass in less than ten years of fishing—and they have been fished to this level throughout the world's oceans. The world's bounty of marine fish has simply been mined away.

Daniel Pauly of the University of British Columbia has similarly found that overfishing has reduced the biomass of what he calls "table fish" (i.e., those large fish that people prefer for eating) to 10% or less of their previous abundance throughout entire ocean basins. This is not just a decline in a few species—it's a decline in all species added together. The hardest hit region of the world is the North Atlantic, where cod, haddock, halibut, and several other once-abundant demersal (bottom-dwelling) species have been enormously reduced.

Nowadays, fishermen are catching demersal fish at depths of over a thousand meters. This is not because they prefer to do so; it's simply that stocks elsewhere have been fished out. Even in my home province, Nova Scotia, where fisheries have been more resilient than in some other parts of the North Atlantic, some fishermen have now turned to harvesting grazers such as sea urchins and sea cucumbers, which are sold to Asian markets. Sea cucumbers are not a preferred food—they are eaten because supplies of more preferable foods have dried up. As the preferred predatory fish, such as halibut and cod, are fished out, people start to eat fish that are lower in the trophic web.

Jeff Hutchings of Dalhousie University found that about 200,000 tons of codfish were harvested annually in the Newfoundland cod fishery between about 1850 and 1950. It's

(clockwise from upper left), pen-and-inks by D. D. Tyler

reasonable to believe that this abundance could have continued indefinitely, except that recent over-aggressive fishing practices left so few fish that the Newfoundland commercial cod fishery has been closed for ten years. In 2002, a scientific panel recommended to the European Union that all catches of cod in European waters must stop immediately, or the outcome would be similar to that in Newfoundland. They regarded the situation as being so severe that fisheries that *accidentally* catch cod, such as the shrimp fishery, must stop too.

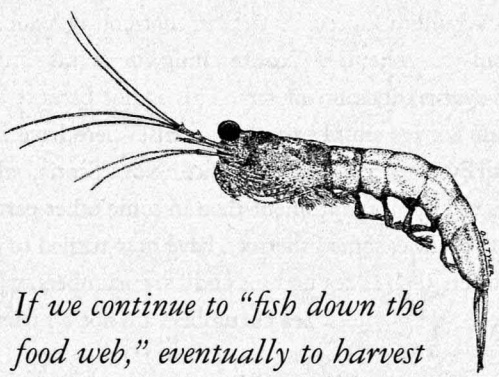
The catastrophic decline of world marine biomass has both economic and ecological implications. The world continues to fill with people, and their diets require protein. A significant proportion of that protein is supplied by marine fish. While those who live in wealthy countries can find alternative food sources, people who live in island nations have fewer options. According to Daniel Pauly, in the next ten years the nations of the world will be forced to make critical choices. If we continue to "fish down the food web," eventually to harvest plankton en masse, we'll wipe out many marine species and commit the oceans to further irreversible changes.

There is no alternative but to institute an immediate emergency global program for ocean conservation, involving all nations. In the last few years it has become evident that marine reserves (also called "marine protected areas") can conserve marine biodiversity and enhance fisheries. Marine reserves achieve both of these objectives by providing havens for fish from which larvae and juveniles "spill over" into adjacent fished regions. As many authors have consistently said, we need intelligently designed systems of marine reserves throughout the world's coastal shelves and open oceans. To obtain these, we need international marine laws that reflect both the fragility of our common ocean heritage and the urgency of the situation.

But it won't be enough just to have sanctuaries for fish that have limited ranges. Some species of marine animals migrate enormous distances and cannot be fully protected within isolated, disjunct sanctuaries. Individual turtles, large whales, marlins, tunas, large sharks, and many other marine organisms travel through whole oceans. Such creatures need to be protected by systems of marine reserves and by developing and restoring conservation-oriented fishing technologies.

Many fishing methods wastefully kill marine animals. Massive amounts of so-called "bycatch" is thrown over the sides of fishing vessels; gill nets lost by fishermen act like vacuum-cleaners in the oceans; mobile bottom-trawls bulldoze ocean floors; and advanced technologies are used to hunt down the last of the prized fish. Government subsidies often encourage these wasteful practices. Only by both curtailing these wasteful methods and by providing marine havens can we hope to restore the world's oceans to some semblance of their previous health. ☾

Martin Willison *is a professor of biology and environmental studies at Dalhousie University and president of the Nova Scotia chapter of the Canadian Parks and Wilderness Society.*



If we continue to "fish down the food web," eventually to harvest plankton en masse, we'll wipe out many marine species and commit the oceans to further irreversible changes.

krill, pen-and-ink by D. D. Tyler

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What the Sea Means to a Rock Barnacle in a Tidal Pool

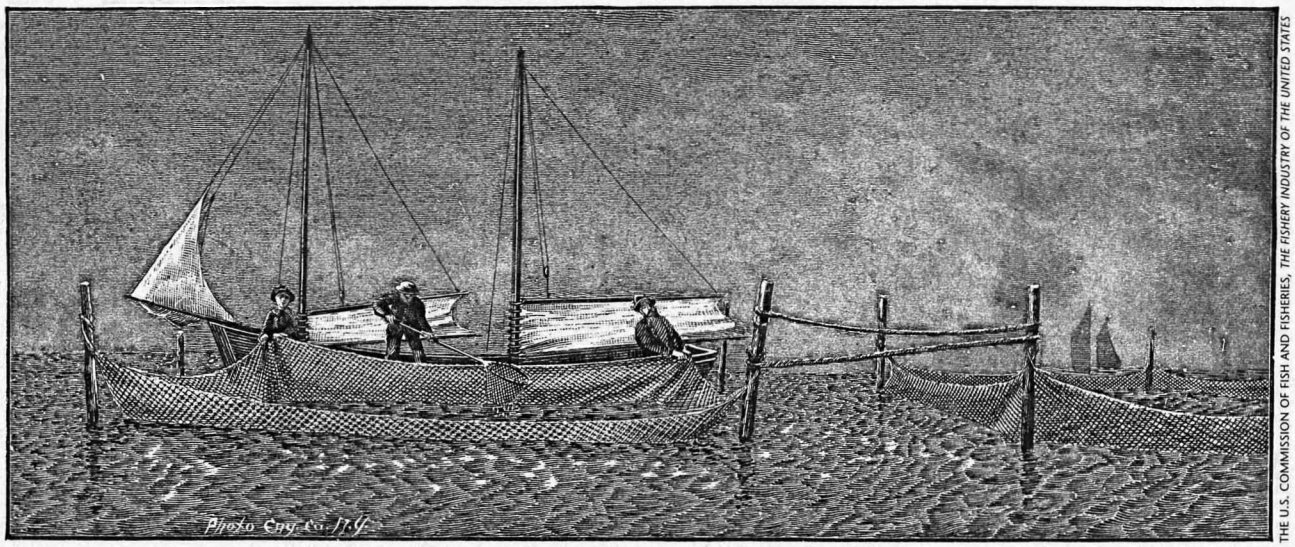
He can never understand its complete
essential being, clinging as he must
permanently to the shore rock
of these shallows. He can't know
how it harbors the fluttering
flags of cuckoo ray and banjo ray,
the banners and streamers of zebra fish
and the common squid or how it tolerates
both the fingerfish and the moray eel
in its coral lair or how comfortably
it holds the breaching sperm whale, as well
as flocks of blue tang and extensive
yellow pastures of plankton.

He can never experience its true
depths, being unable to dive
deep enough to encounter the permanent
twilight, the luminous lanternfish
and gulper eels, the glimmering baubles
of the *Stomias boa.* He will never recognize
the red clay bottom or the pelagic
deposits where his own abandoned
cement crust may one day descend
and descend and descend to lie
at last in the general ooze.

Even though he can tickle the feathers
of his mouth through that swaying
salt-flow with a certain skill,
what could the gyral movement
of northern currents or the great
cold-water basins or the mid-oceanic
rift possibly mean to him?

But in the evenings, when he senses
the vast gold glowing of motion
extending itself before him, announcing
presence so emphatically by its alteration
of light, by his own anticipation,
and when that element rises, as it always does,
rushing, submerging, overwhelming him again
exactly like a great grief or a coming
exaltation, then I know he knows,
in the shudder of his own stalk,
something of the power, something
of the abundance, something of the forming
and failing explanation possessed
by that which he will never remember,
that which he cannot name.

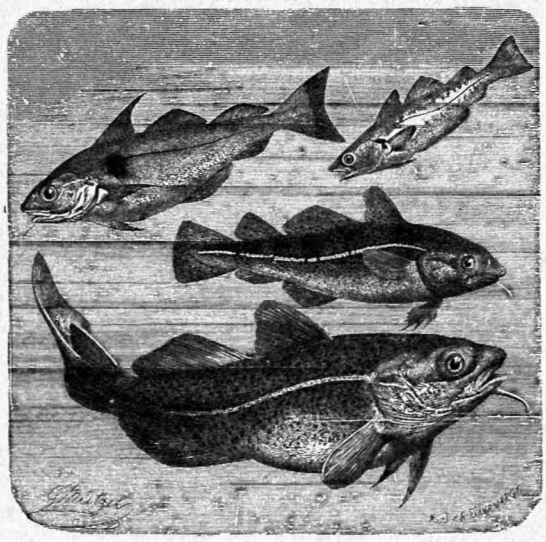
Pattiann Rogers



THE U.S. COMMISSION OF FISH AND FISHERIES, *THE FISHERY INDUSTRY OF THE UNITED STATES*

Distortion of World Fisheries by Capital

by Gerald Smith



"There was a time when the fisherman, the man directly interested in the catching of fish and in the money to be made from the business, was the man most deeply interested in the pursuit. With the decay of the fisheries came changed conditions. Times began to be hard for the fisherman. He had no money to invest in new twine. Then came the man of capital who had money to loan, who was making money in the wholesale-way out of the fishing industry. This man never fished for himself. He stayed ashore. He never endured the hardships of the calling. His interest in the fisheries began and ended with the profits that might be made by buying and marketing fish. His hands were not roughened by exposure. He did not participate in the personal hazards of the calling of the fisherman. As a rule, he had no personal knowledge of the details of the handling of nets, as such information as he possessed was wholly theoretical, yet, before committees, whose business led them to investigate these abuses, his voice has ever been loudest...."

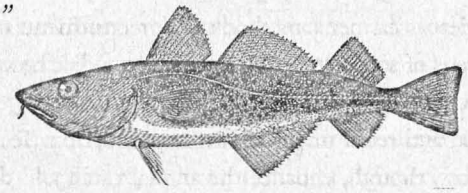
MICHIGAN STATE BOARD OF FISH COMMISSIONERS, 1897

"'Bailing out the pot' of pound-net at Detroit River," 1887 engraving

"EU considers reducing harvests of cod and other species as fishermen protest."

"Chefs boycott declining swordfish and pirated Chilean sea bass."

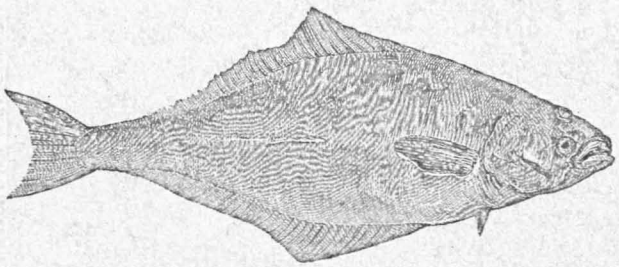
"One billion people in developing countries will face shortages of fish, their most important source of protein, within 20 years."



EACH DAY BRINGS MORE NEWS about the world's declining fisheries catches, yet each year global fishing effort increases, thwarting attempts to maintain sustainable populations.

Over-harvesting in national waters and the open-access fisheries in "the commons" of the sea are causing the decline. The lack of political will to accept and enforce scientific assessments and recommended quotas exacerbates the problem. Non-sustainable increases in fishing pressure can also be traced to overcapitalization of world fisheries by governments, development banks, and investors.

Human impact on fisheries is nothing new. For thousands of years, people have fished for subsistence and (except in the far north) have depleted fish populations they targeted, leaving fewer and smaller fish, as larger, breeding fish were selectively captured. But the current intensity of exploitation is unprecedented. Declining populations signal the potential end of most commercially desirable fisheries, according to current scientific information (Ocean Studies Board 1999; Jackson et al. 2001), as natural fish communities are "fished down the food chain." That is, the large, highly desirable, carnivorous species at the top of the food chain usually decline first, followed by capture of successively lower trophic levels (and less desirable food fishes). These desirable top predators are ranked three or four steps or levels above the bottom of the food chain. Average landings have declined more than one level in the food chain in the past 50 years (Pauly et al. 2002). Expressed a different way, the biomass of top predatory fishes has diminished by more than two-thirds in the past five decades. Fish catches declined 0.7 million metric tons per year over the last 20 years.



The damage is more devastating than even these stark statistics reveal. Bottom trawlers are destroying thousands of square kilometers of marine shelf habitats in a process directly comparable to clear-cutting forests, although the area affected annually by trawling is perhaps 150 times greater (Watling and Norse 1998). More than 100 papers now document extensive habitat damage by bottom trawlers in all of the world's seas (Johnson 2002; National Reserach Council 2002). This means that those benthic organisms not captured and killed in the bycatch of commercial trawling are physically scrambled and their habitat disturbed, with negative consequences for the food webs they anchor and marine biodiversity in general.

Ironically, declines in fish stocks are almost invariably attributed to "environmental causes," owing to occasional correlations with the natural fluctuations in weather and climate, such as the El Niño Southern Oscillations or the North Atlantic Oscillations. Climatic oscillations are natural and even somewhat predictable, and fisheries biologists construct models and recommend harvests intended to protect stocks against extinction in a dynamic world. But opposition to these recommendations by commercial fishers and government officials are the rule. Under the present political-economic circumstances, sustainable fisheries are impossible and extinctions of important fish stocks are inevitable. Conservationists tend to blame the fishers for the threatened state of fisheries, but a broader look reveals some less visible forces at work.

cod family fishes (left), halibut, and cod, engravings ca. 1800

Fish mortality is a function of fishing effort multiplied by gear efficiency

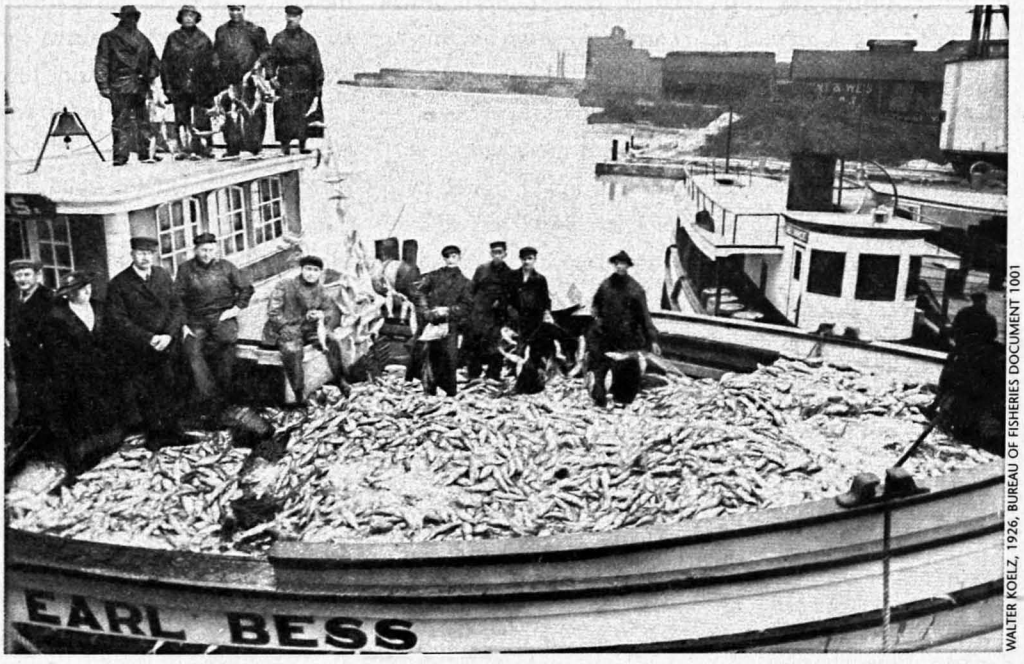
Fisheries assessment methods and recruitment models use hundreds of sources of information to predict how this year's catch and weather variables will influence next year's reproduction and recruitment to future production. Technological advances, though, enhance the annual catch and defeat feedback processes that would otherwise adjust the fishery to the resources. The ability to catch fish has been enhanced by diesel power, nylon netting, power winches, global positioning systems, radar and sonar locators, and many other improvements. Factory ships that fish with many miles of gill nets in the water are among the most destructive forces. (Gill nets are left hanging in the water for several days; often they are lost and go on killing fish, day in and day out, for years; Breen 1990.)

A sustainable fishery depends on the ability of fish populations to reproduce and replace the numbers of fish killed. The mortality rate of a fish population is a function of natural deaths plus fishery harvest and is usually dominated by fishing effort. An added variable—gear efficiency—multiplies fishing effort, causing an ever-increasing escalation of fish mortality (Pauly et al. 2002). Therefore, as technology increases, fishing effort must decrease if fish populations are to reproduce and maintain sustainable catches (Clark 1990). But the suppliers of the technology, the fishers, and the investors routinely avoid looking squarely at the obvious relationship in which gear improvements multiply the impact of fishing effort on mortality and thus on recruitment. The result is industry resistance to scientific assessments of population size and to managers' efforts to reduce fishing.

Politics

Technology industries and investment capital imposed themselves on fisheries over a century ago. For example, in the 1880s, Michigan fishermen recognized that fish stocks and sizes were declining and lobbied the state legislature to impose limits on net mesh sizes and legal fishing seasons on the Great Lakes, "so that our sons will have a livelihood." Appropriate rules were drafted to limit the catch, but at a late hour, investors stepped in and blocked the legislation (Michigan Fish Commissioners 1887; Smith 1994). Why? Probably because harder-to-catch fish meant more purchases of nets and gear, while more indebtedness permitted more profits for investors, as fishermen struggled to repay their loans. When fishers are forced into competition with each other for decreasing numbers and sizes of fish, the response generally is increased investment in boats, nets, gear, and crew, usually on credit. Fishermen became commodities for investors and they

The ability to catch fish has been enhanced by diesel power, nylon netting, power winches, global positioning systems, radar and sonar locators, and many other improvements.



WALTER KOELZ, 1926, BUREAU OF FISHERIES DOCUMENT 1001

30-ton catch of "lake herring," *Coregonus artedi,* from Lake Erie in November, 1918.

were forced to ask for *fewer* restrictions on their fishing effort as they competed with each other to catch more fish to make their payments. Thus the modern "over-capitalized" fishing economy was set in motion, and fisheries were subjected to ever-increasing exploitation of ever-decreasing stocks.

The politics of this higher level of economic control distorted what should be a relationship between fish, fishers, and consumers. According to Pauly and others (2002), the overcapitalization of world fisheries is caused by several factors, including:

1) The open-access to many fisheries in "the commons" (Gordon 1984). The high seas are rarely subject to enforcement and the competition to extract the maximum from the resource is unrestrained.
2) The competitive harvest of stocks in waters shared by nation states (which also results from competition for a decreasing resource).
3) Replacement of small vessels with large ones. This has been the general trend over centuries, culminating in the huge, modern factory ships.
4) Subsidies from development banks and governments; such subsidies are intended to benefit third world economies or intensify the competitive edge of developed nations (respectively) but result in over-capitalization, overcapacity for fishing, destruction of artisanal fisheries, and declining fish populations.

Remedies

The most sustainable fisheries are those that are managed in such a way that debt is held to a reasonable level. Individual Transferable Quota (ITQ) systems limit the number of fishers that have access to the fisheries, enabling long-term, sustainable harvests (see, for example, www.atsea.org/issues/itqpaper.html and www.rff.org/fisheries). ITQs are employed successfully in the management of more than 40 species of Australian and New Zealand fishes. The limited number of licenses allows a good living, relieving the fishers from the competitive race for fish, in which they must take extreme risks at sea to bring back catches large enough to enable payments on their equipment loans.

ITQs and other solutions are not simple, socially. They require decommissioning programs that work to the advantage of the lucky few and the disadvantage of many. License buyouts often have negative effects: they may serve to redirect fishing boats to other species—and to provide collateral for more loans. Nevertheless, restriction of fishing effort will support more fishers over the long run, by limiting the number in the short run. They are painful, however, and usually vigorously opposed by fishermen and investors.

Other programs will also be necessary, including marine protected areas with no-take reserves at their core, large enough to allow for adequate reproduction of all of the species in the ecosystem. Smaller fleets and a ban on bottom trawling will also be necessary. Technology to eliminate bycatch, with a ban on gill nets, would also have positive effects on fish populations.

Like the collapse of cod, most of the world's premier food fisheries are on a downward slide toward unsustainable or insignificant production. Artisanal fisheries that feed people in undeveloped nations are also being destroyed. A significant reduction in fishing effort is required to preserve these resources for the future. But without treaties, limits, enforcement, and appropriate (non-entrapment) use of capital, these fisheries are doomed. We must find methods of fairly paying fishers to leave the system and we must create political alliances strong enough to overcome the resistance of capital and politics. To reduce fish mortality now is to invest in fishery resources of the future. ❨

Gerald Smith *is a fish biologist in the Museum of Zoology at the University of Michigan. His research focuses on fish evolution, ecology, and sustainability.*

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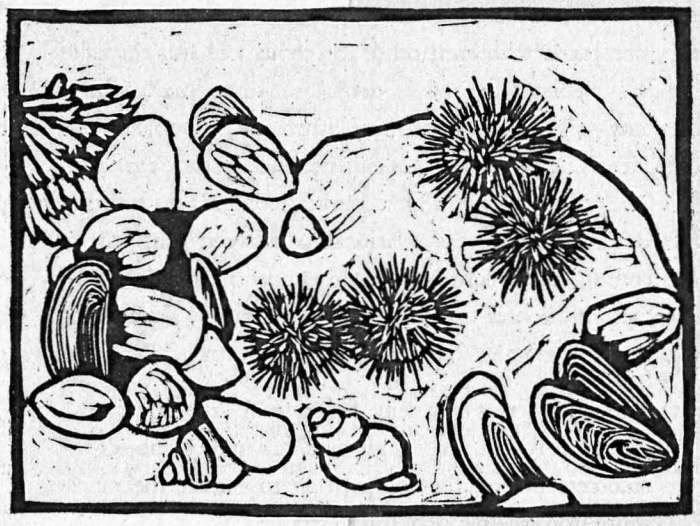
Marine biologist **Sylvia Earle** *is one of America's most prominent advocates for healthy oceans. Now an explorer-in-residence for the National Geographic Society and chair of Deep Ocean Exploration and Research, she has been active in marine science and conservation since receiving her Ph.D. from Duke University in 1966. Sometimes called "Her Deepness," Dr. Earle was a pioneer in the use of scuba gear for underwater research, has held several diving records, and has spent more than 6,000 hours (roughly equivalent to eight months) under water during her long career. That career has included positions in academia, government (she was the first woman to serve as chief scientist for the National Oceanic and Atmospheric Administration), and business (she cofounded Deep Ocean Engineering in 1982 to design and manufacture equipment for deep sea exploration). She has served on various nonprofit boards including the World Resources Institute, Woods Hole Oceanographic Institution, World Wildlife Fund, and The Conservation Fund. Earle is the recipient of many awards and honorary degrees, and has authored over 125 technical and popular publications on ocean science or conservation. She is a charismatic and tireless spokesperson for protecting marine biological diversity, or, as she says, "taking care of the vast blue system that takes care of us."*

Naturalist, birder, and indefatigable Arctic National Wildlife Refuge explorer **Brad Meiklejohn** *(who is also Alaska representative for The Conservation Fund) interviewed Sylvia Earle on November 10, 2002.*



DOER/NUYTCO RESEARCH

linocuts by Suzanne DeJohn

Sylvia Earle

Our Oceans, Ourselves

BRAD MEIKLEJOHN: You've been fortunate to spend time in the deep oceans, in places where few humans will ever visit. Tell us, what is it like down there?

SYLVIA EARLE: There are plenty of ways to experience the ocean up close, firsthand—in a submersible, using scuba gear, snorkeling, or simply exploring tide pools. And it is getting easier all the time for people to explore the deep oceans, which is positively thrilling.

The first astronauts into outer space were rendered nearly speechless by the experience, and much the same thing happens in the deep oceans. We are simply unprepared by our lives on land to fully understand and describe these new environments the first time we encounter them. Fortunately for me, I continue to experience the awe that overwhelmed me on my first dive.

The single most striking thing about the seas is that they are full of life. Everywhere you look, everywhere you go, there are curious and beautiful creatures, and certainly not just fish, or whales, or turtles, but millions of tiny creatures unlike any we've seen before.

It's funny—my deepest dive has taken me to a depth of 3300 feet, but that is nothing. The ocean is over seven miles deep, and we have no idea what is down there. We have barely scratched the surface, but we are exploiting it faster than we are exploring it.

How has your time in the deep oceans affected your view of life?

My time in the oceans has allowed me to see myself in context, to see my fellow humans immersed in this incredible diversity of life. There are many variations on the theme of what it takes to live, with human beings as part of this fabulous matrix. Going into deep waters has helped me see myself not as apart from, but as a part of, the natural systems that support us.

Are you always seeing new things?

It is easy to find new things, and not just in the oceans. It's easy to be an explorer. Many people think that it is rare to find a new species. That is simply not true. Even in our own backyard, if we look carefully in the soil or in the bark of trees, places that are beyond or beneath our notice, we are likely to turn up new bacteria, insects, invertebrates, mosses, or

plants that escape the notice of most people, and may even be new to science.

Because less than 5% of the oceans has been seen at all, let alone really explored, you know you are always going to find new creatures. I have a friend who uses special diving methodologies that enable him to explore beyond where most scuba divers go. Most divers go down to 100–150 feet below the surface. He tends to focus on the area from 200–500 feet down. It seems like such a short distance from the surface, and yet who has been there? He is finding new species of fish on almost every dive. Imagine finding a new kind of bird every time you went for a walk in the woods. This part of the planet has received so little attention. Everywhere we look in the sea—in cold water, warm water, even in places near where many people visit—we are always discovering new things.

What don't we know that we should to better protect the oceans?

I think we already know enough to know what we need to do. Yes, some people want to be further convinced that we have exceeded the limits of what can reasonably be extracted from the oceans. We just keep pushing and pushing and pushing. While we should continue to explore, to do research, to verify what common sense tells us, the facts are overwhelmingly already in: human activity is damaging the seas. What we are putting in, and what we are taking out of the oceans—excessive amounts in both categories—is harmful to marine fish and birds and whales and the ecosystems that support them, and is not in our best interest either. The toxic materials, the excess phosphates and nitrates that we allow to flow into the sea, or put there deliberately, haunt us in both direct and indirect ways.

The most direct way is that we consume fish and other creatures that accumulate disproportionately some of the very poisons that we don't want in our bodies. For example, the PCBs that we dump in the ocean are absorbed by plankton and then become concentrated as much as 50,000 times before reaching our dinner table in a five- or six-year-old fish. In food webs, as fish eat fish, that ate other fish, that ate other fish, that ate plankton, these toxins are concentrated. People have a way of consuming top predators out of the oceans. Almost everything that we eat from the sea is carnivorous. That is not true on the land, even among the wildlife that we hunt. We don't eat lions and tigers and wolves. We tend to cultivate plant-eating animals such as pigs and cows and chickens. But even for those things that we hunt for food, like deer and ducks and turkeys, the bulk of their diet is plant materials. We should eat low on the food chain.

As we undermine the health of the natural world we are chopping away at the underpinnings of our life support system. I was challenged by a reporter once who said, "What can the ocean do for me? I get seasick, I don't go out in boats, I don't eat fish. People don't drink saltwater. If the ocean dried up tomorrow why should I care?" I suggested that she consider Mars as a place where she might feel at home. There are so many benefits from the oceans that we take for granted—the oxygen in the atmosphere, the absorption of carbon dioxide, the home for most of life on Earth. They control our climate and weather, and yet we are so complacent about the oceans.

Have you seen changes in the oceans since you began diving?

Oh yes—that is probably what drives me the hardest. In my lifetime, human beings have shown the capacity to alter the way the world works. I cannot take my children and my grandchildren to certain places that I once knew and loved. Some of them are just plain gone. For instance, in the Gulf of Mexico, some places I used to swim and dive are truly transformed—they are housing developments and parking lots. There is no longer an ocean there. There is land where there wasn't land before. Many of the coral reefs that I visited in Hawaii, early in my career as an oceanographer, simply do not exist anymore. They've died. They are gone. Not even the skeletons of the corals remain.

Much of the conversation about marine reserves is based on utilitarian motives—that is, that marine protected areas will increase the volume and size of fish available for commercial harvest. For you, what is the most compelling reason for protecting specific areas of the ocean? What do you think the top management goals should be for marine protected areas?

Protecting the way the world works. Enhanced commercial fishing is one rationale for marine protected areas and improved sportfishing is another. But ecological function—protecting the natural systems that give us our life support, the oxygen that we breathe, the stability of the planet—is the main reason we should protect the oceans.

Of course I want to see depleted fish populations

restored—marine protected areas, reserves, sanctuaries, not only have a role here, but we know they work. People have been skeptical, but there is evidence aplenty and growing. We should invest in the sea using some of the same techniques that have worked so well and been effective on the land.

I am going to Australia in a few days to help celebrate the establishment of 6% of the coastline in Victoria along south Australia as "no-take" areas: everything—fish, abalone, scallops, kelp, whatever it is—fully protected. Just as we have undertaken to do that in our land-based national parks, so now are some countries, including the United States, understanding that we need to do the same thing in the sea, if we are to save the things that we value.

Right now more than 50 so-called "dead zones" have developed in the coastal waters of the world owing to the actions of humankind. Many of these coastal dead zones are in estuaries, some of the most biologically rich parts of the seas. This is really and truly bad news. We are not taking care of the vast blue system that takes care of us.

Most of the proposals I've seen for new marine protected areas are at the scale of a few square miles, or perhaps tens of square miles. On land we have protected vast swaths of entire ecosystems. Are we thinking at the right scale about marine protected areas?

Not yet. But it is encouraging that people are beginning to think on a larger scale now. The best example is the Great Barrier Reef Marine Park Authority in Australia, which oversees a region of 1,200 miles of coastline and tens of miles offshore, and aims to protect the Great Barrier Reef system. The truth, however, is that there, and along the California coast, where some 5,000 miles of coastline are embraced by the Monterey Bay National Marine Sanctuary, the natural values are not really protected, in the sense that nearly everything you can do outside the boundaries of the so-called sanctuaries or parks is allowed inside the boundaries. Similarly, only a tiny fraction of the 2,800-square-mile Florida Keys National Marine Sanctuary is set aside for full protection of its residents—the corals, fungus, starfish, sea urchins...the whole works.

But that is changing. Just recently, at another of the fairly good-sized marine sanctuaries in California—the Channel Islands—some measures were taken to implement strict "no-take" areas where everything is left alone. And so while we do need to think bigger about conserving marine protected areas, there is compelling scientific evidence that we can also target some relatively small areas and have a magnified impact on the health of a much larger area. At least that is true in coastal waters, in key areas such as spawning sites. If you take the areas where fish spawn or turtles nest or that whales use as a nursery, and really protect those areas, it will have a magnified beneficial impact on thousands of square miles of ocean.

While we need to conduct the research to identify where these critical nursery and feeding areas are, in the absence of certainty, the precautionary principle should apply. That is, we need to designate some larger marine protected areas to be fairly sure that we will capture these spe-

linocut by Suzanne DeJohn

There are many variations on the theme of what it takes to live, with human beings as part of this fabulous matrix. Going into deep waters has helped me see myself not as apart from, but as a part of, the natural systems that support us.

cial sites, without which we cannot hope to save not just individual species but entire ecosystems—and ultimately sustain the health of the oceans and ourselves.

The 1964 Wilderness Act has resulted in the designation of millions of acres of land across the United States that are generally off-limits to extractive uses and motorized vehicles. Do you see a value in setting aside vast tracts of "watery wilderness" in the oceans?

Ocean wilderness is a concept that is taking hold. There are places that people are looking at setting aside for their wilderness values. One reason that we should protect large expanses of the ocean is because they represent a distillation of all preceding history. And we don't know how to put them back together. We should think about ocean wilderness as legacy areas. What right do we have to modify them irreversibly? What right do we have to close the door on future generations? That is so arrogant.

There is no reason to cut another acre of old-growth forest or trawl another pristine stretch of ocean floor. We don't know enough—we will never know enough—to be able to put these systems back together. What need exists that we should destroy the few remaining natural areas?

We should farm where we have already farmed, and build where we have already built, and leave the remaining wild areas for their own sake and for the good health of the planet. It would be selfish for us to do otherwise. We need to consider the health of the planet, and our own health. These systems have evolved over millions of years without us as the dominating forces.

I think the greatest discovery ever made is that we have the capacity to alter the world.

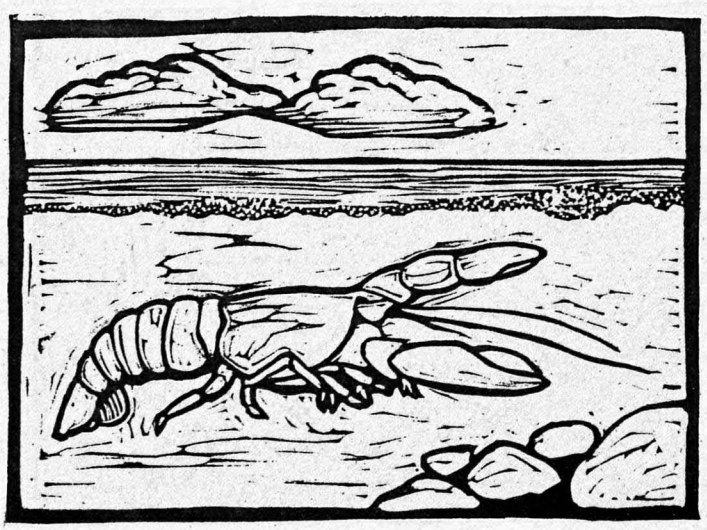
The most compelling reason to protect the oceans may be enlightened self-interest. The oceans contain organisms that can benefit us medicinally. Just like the rainforests, the oceans are an important source of products and services. It makes no sense to destroy this storehouse of health, wealth, knowledge, and beauty.

There are some major ocean restoration efforts underway. We are working to restore certain depleted fish stocks, certain coral reefs, to restore Chesapeake Bay. But these efforts are extremely expensive and success is many decades away, if it is possible at all. We've tried and failed to restore wetlands. The oceans are far more complex. Rather than try to remove pollutants from the ocean, why don't we just stop dumping them? Rather than putting our hopes on restoration, we should protect the remaining wild places and stop the damage we are inflicting.

Those of us who don't travel below the ocean surface have a two-dimensional view of the oceans. As a result it seems that much of the discussion about marine protected areas focuses on drawing lines on the surface of the ocean. Given that the ocean is three-dimensional, do we need to think differently about marine conservation? Do we need to employ different conservation strategies in the deep oceans than in shallower areas?

In many ways what we know about the land and land animals translates nicely into the sea. Many species are fairly

Protecting the oceans is not locking up the oceans. Just the opposite. We are keeping our options open.



linocut by Suzanne DeJohn

sedentary and occupy limited areas of the ocean. Some would use the argument that fish can swim in and out of protected areas as a reason not to designate specific marine reserves. There is a high degree of endemism in the oceans, and we know that marine protected areas work for most, perhaps all, species.

However, we probably do need to apply some new thinking to marine protected areas, particularly about connectivity, just as we have on land. For instance, with migratory birds we now are working to protect networks of places, stepping stones of natural habitat along the path of migration. With fish we need to think about protecting havens that are essential at different life stages. We are also coming to understand that some fish move in response to changes in temperature and salinity, and we may need to establish aquatic corridors that allow for safe movement of fish from one haven to another.

This is the current frontier of marine conservation, just as it is with terrestrial conservation. We are just beginning to grasp the need to create a linked network of protected areas that allows populations to mix. Just as many of the lessons that we have learned on land translate nicely to the oceans, I think we will learn things in the oceans that will translate back to the land.

We certainly need a toolbox of techniques for marine conservation. One size will not fit all. We need a mix of large and small protected areas linked together in a global system. And wherever there is any doubt, the precautionary principle should apply—we should err on the side of protecting too much, rather than too little. The burden of proof should be on those who would dismantle our natural legacy. They should be required to prove that their actions will not take away future choices and will not alter the life-sustaining systems of the planet.

What message about the oceans have you found to resonate most effectively with your different audiences?

What seems to hit home for people I talk to is that the creatures of the sea are not just a meal, they are wildlife. The fish of the sea are not just something to eat, they are the lions and tigers of the oceans. Just as we cannot possibly feed the world a steady diet of songbirds, we cannot continue to consume fish at our current rate. We should think about that slab of tuna in the deli case as "bush meat." We would not consider trying to feed the world on lions and tigers and elk, but that is the way we treat the fish of the sea.

The rate at which we are harvesting fish is not even close to sustainable. There is a fish called hoki, which is being targeted as the next orange roughy. These fish live up to 150 years, yet they are being mined out of the oceans and will be gone before we know it. And for the life of me I cannot understand why some conservationists are urging us to eat wild salmon from Alaska. Alaska has some of the only intact stocks of wild salmon, and we should be leaving these fish alone.

People also quickly grasp the message that whatever we put into the oceans comes back to us. If fish is what is for dinner, what have those fish been eating? If we poison the oceans, we poison ourselves.

What is the biggest impediment to marine conservation? Why have efforts to protect the oceans and marine life lagged behind our work to protect terrestrial natural areas and land animals?

Ignorance and complacency. When people know better, they do better. And when they understand that they are killing themselves and their children and grandchildren, they do change their behavior.

With respect to marine conservation, what is your vision of where we should be 100 years from now?

One hundred years ago we had conservation leaders like Teddy Roosevelt who had the foresight to leave us a legacy of national parks, wildlife refuges, and other public lands that we appreciate today. My vision is that, a century from now, our grandchildren will thank us for our wisdom and foresight in protecting the oceans. Not only do we need to maintain Roosevelt's legacy, we need to add to it.

Presently just a fraction of 1% of the world's oceans are nominally protected, and only a tiny fraction of that 1% is fully protected. We clearly have a long way to go. My vision is that someday our national parks will encompass entire ecosystems, from the mountains to the oceans. My dream is that we will protect all those areas that are vital to the health of the planet.

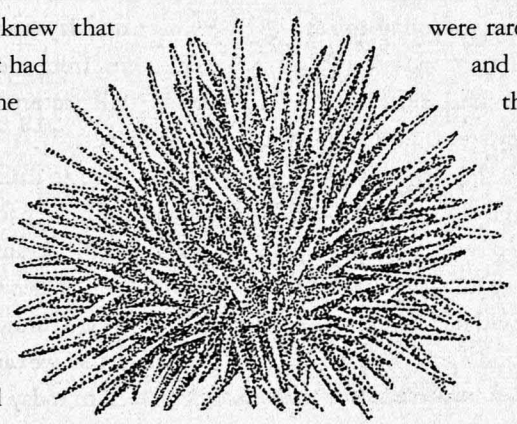
We need to make the best possible investments of time, energy, and money for posterity. Protecting the oceans is not locking up the oceans. Just the opposite. We are keeping our options open. When we destroy the oceans we are taking away choices, we are throwing away the key to the future. It seems so obvious that we can't just squander all of our tomorrows for a small return today. ☾

FROM KILLER WHALES TO KELP

DURING THREE DECADES of research in the Bering Sea and North Pacific Ocean, I watched other scientists struggle to understand the precipitous population declines of northern fur seals, harbor seals, and Steller sea lions, never imagining that my area of research—sea otters and kelp forests—might be affected by these changes. Then, in about 1990, following nearly a century of recovery from the ravages of the Pacific maritime fur trade, sea otter populations in southwest Alaska unexpectedly plummeted.

Why did the otters decline? The emerging evidence forced my colleagues and me to look both to the past and to the open sea for explanations. While much remains to be learned, the insights gained from this work have changed our thinking about food web dynamics and opened fascinating new areas of research. The wave of ecological changes unleashed by the decline of sea otters suggests that predation and top-down effects are key ecological processes, critical to ecosystem function and health. This insight has profound and very practical consequences for conservationists and managers who seek to conserve Nature's diversity—both on land and at sea.

SEVERAL COLLEAGUES AND I began studying sea otters and their coastal ecosystems at Amchitka Island in the Aleutian archipelago in 1970. We knew that marine ecosystems in the North Pacific had undergone significant changes over the past 50 years, but we had little understanding about why. We knew that sea otters had been hunted to the brink of extinction during the Pacific maritime fur trade, and that the extent of their recovery following protection by international treaty in 1911 varied widely both in time and geography. We knew that sea otters ate sea urchins and that sea urchins ate kelp and other macroalgae.



We also held beliefs that later turned out to be either oversimplifications or incorrect. One of these ideas was that populations in the kelp–sea urchin–sea otter food chain were regulated largely from the bottom of the food chain. Thus, kelps would be limited by available nutrients, light, and water; urchins by the abundance and quality of their food—kelp and other macroalgae; and otters by the abundance and nutritional composition of their food—sea urchins and other kelp forest prey species.

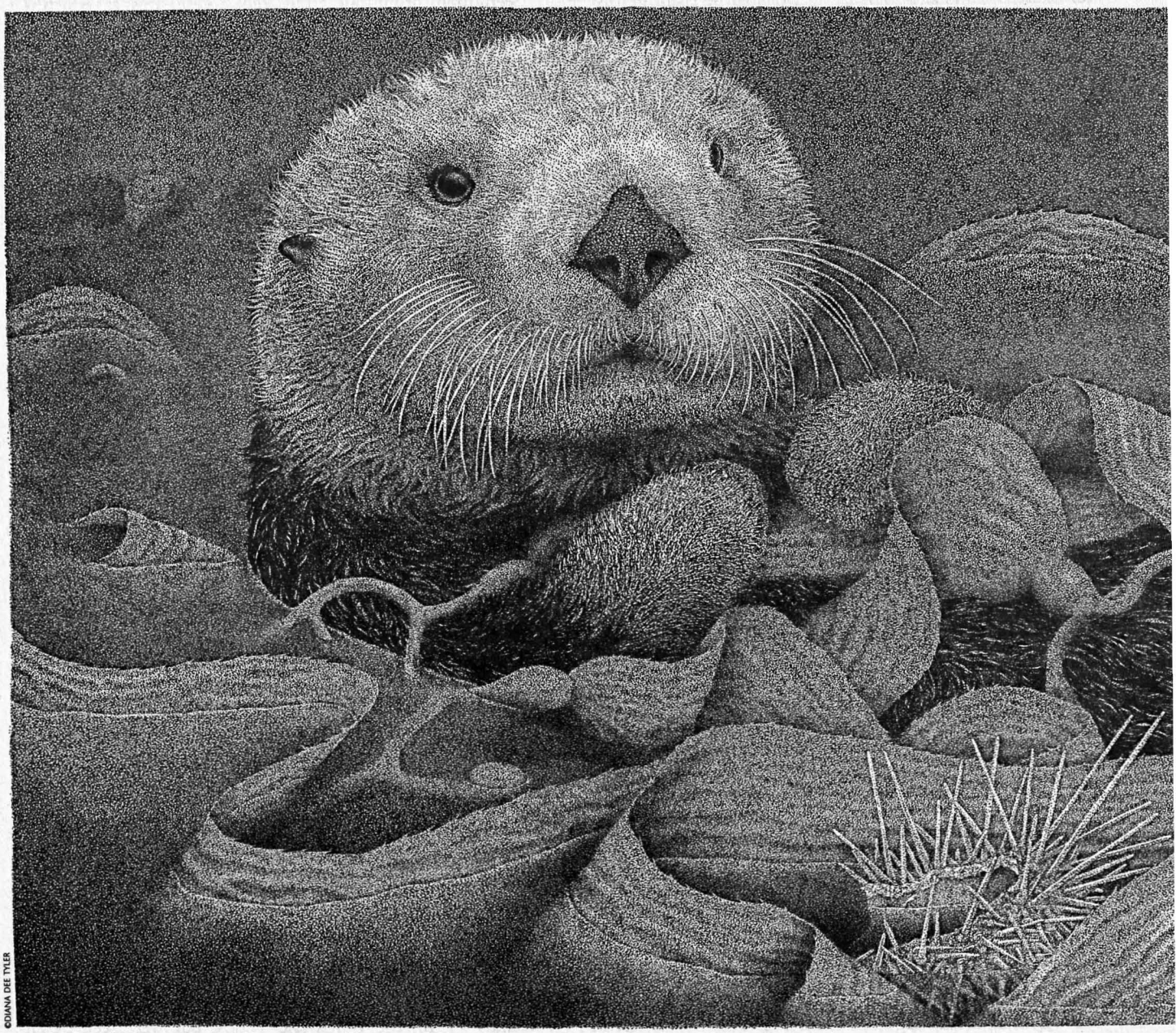
In 1970, there was little precedent for thinking about top-down forcing processes—the idea that organisms tightly linked in food webs could be significantly limited by the things that eat them. A 1969 paper by Robert Paine and Robert Vadas had demonstrated the limiting effects of sea urchin grazing on kelp assemblages. Knowing that sea otters ate sea urchins, we explored this theme further by contrasting islands in the Aleutian archipelago with and without sea otters. These contrasts and subsequent information from other sites as they were repopulated by otters during the late 1970s revealed a consistent pattern: where otters were common, sea urchins were rare and kelps abundant; where otters were rare or absent, sea urchins were common and kelps rare or absent. Thus we found that top-down effects are important in kelp forest ecosystems.

Evolutionary effects

One line of inquiry has centered on the potential evolutionary consequences of sea otter predation. Our general approach was to contrast the North Pacific region (where sea otters

FOOD WEB COMPLEXITY IN KELP FOREST ECOSYSTEMS

by James Estes



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red sea urchin (left) and sea otter in kelp, pen-and-inks by D. D. Tyler

have been present for thousands of years) with other temperate regions that contained similar groups of plants and herbivores but that seemingly lacked bottom-feeding predators of comparable influence to sea otters. Particularly, we compared the three-tiered eastern North Pacific food chain and two-tiered Austral/Asia food chain, looking for differences in chemical defenses (specifically phlorotannins) that the kelps and other brown algae have evolved to deter those who would eat them.

While such studies are fraught with potential confounding influences, our findings are consistent with the expectation that sea otter predation has helped shape the life histories of marine plants and the character of marine plant/herbivore interactions in the North Pacific Ocean. Phlorotannin concentrations are an order of magnitude greater in Australasian macroalgae compared with North Pacific species. In addition, comparable concentrations of phlorotannins deter herbivory by common marine animals such as sea urchins and snails much more strongly in North Pacific than in Australasian species, regardless of whether these compounds come from Australasian or North Pacific algae. We interpreted these patterns to mean that Australasian and North Pacific plant/herbivore systems have evolved in fundamentally different ways, due in large measure to the importance of top-down forcing processes and differences in food chain length between the two regions. That is, herbivores are the apex predators in Australasian kelp forests, and the resulting high levels of damage imparted on marine plants caused an evolutionary arms race between chemical defense in the plants and resistance in the herbivores. This would explain why phlorotannin concentrations are so high in Australasian algae, and why Australasian herbivores are relatively undeterred by these compounds. Predators (sea otters and their recent ancestors) add a third trophic level to North Pacific food chains, thus causing herbivore populations to be strongly limited by predation, in turn decoupling the co-evolution of defense and resistance in North Pacific plants and their herbivores. This would explain why North Pacific algae have such low concentrations of defensive chemicals, why North Pacific herbivores are so strongly deterred by these chemicals, and why North Pacific kelp forests have been so extensively damaged by overgrazing following the loss of sea otters and other key predators.

Sea otter population declines

By the late 1980s, sea otter populations throughout much of the Aleutian archipelago had recovered to levels projected to be near the ecosystem's carrying capacity. Because we assumed populations to be stable or increasing, we initially discounted surveys in 1992 and 1994 that recorded fewer sea otters than expected. Over the next several years, however, the trend at Adak Island where we were working became clear: sea otter numbers were shrinking. This realization prompted several questions: What was causing sea otters to decline at Adak? Had similar declines occurred elsewhere, and if so, how widespread were they? What were the consequences to the kelp forest ecosystem?

This latter question was easy to answer because we had been monitoring numerous kelp forest sites at Amchitka Island since the early 1970s and at Adak Island since 1987. Dense kelp and sparse sea urchin populations characterized both islands through the 1980s. We resurveyed Adak in 1997 and Amchitka in 1999, and found that the kelps and other fleshy macroalgae had been extensively deforested by sea urchin grazing at both locations. These changes almost certainly were a consequence of the reduced number of sea otters. Since sea urchins are one of the sea otter's most highly sought-after prey, these findings also indicate that food limitation did not cause the sea otter decline.

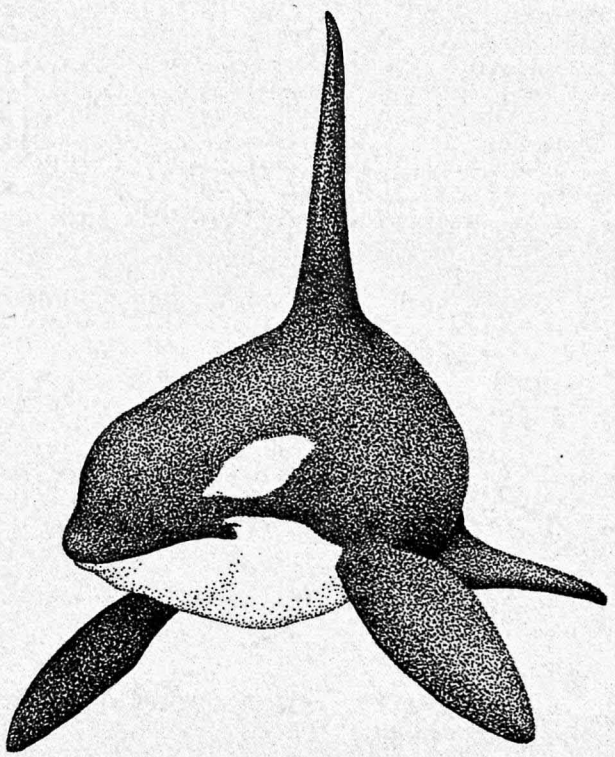
The geographical extent of the sea otter decline was also easy to determine because a variety of earlier survey data existed for coastal Alaska and the Commander Islands. A resurvey of sea otter numbers along the southeast coast of Amchitka Island in 1998 indicated a comparable decline, as did counts later that summer of Little Kiska and Kagalaska Islands. In 2000, the U.S. Fish and Wildlife Service conducted another aerial survey of the Aleutian Islands, and in 2001 the agency surveyed coastal waters of the Alaska Peninsula eastward through the Kodiak archipelago. These surveys show that sea otter densities have declined to a common low value throughout the Aleutian archipelago and that significant population declines have occurred eastward to at least the Kodiak archipelago.

Why did sea otter numbers plummet so suddenly and consistently? Population surveys and tagging and telemetry studies at Adak and Amchitka Islands established the general cause to be elevated mortality as opposed to reproductive failure or redistribution. Starvation, disease, toxins, and direct human take (either purposeful or incidental) were also excluded as likely causes. We found ourselves reexamining our basic assumptions about coastal ecosystems—and looking out to sea for answers.

Killer whales, which were not known to prey on sea otters, were rarely seen in coastal waters of the Aleutian Islands during the 1970s and 1980s, but were seen much

more often in the early 1990s. Many appeared to be hunting, and attacks on sea otters were observed on several occasions. These observations, and the pattern of sea otter population declines around Adak Island (sea otter numbers went down everywhere except in shallow lagoons that were inaccessible to killer whales), led us to suspect that killer whales were responsible. Nonetheless, it seemed that more attacks should have been observed if killer whales truly were responsible for so many losses. A bookkeeping analysis helped resolve this apparent paradox. Estimates of the total number of deaths necessary to drive the decline closely coincided with the observed number of kills when we accounted for the area of the decline, visual detection limits of observers, and time spent watching.

WHY WOULD KILLER WHALES BEGIN EATING SEA OTTERS? Killer whales tend to forage either on fish or marine mammals. The two common species of pinnipeds in the Aleutian Islands—harbor seals and Steller sea lions—declined drastically during the 1970s and 1980s, and thus the sea otter collapse may have resulted from mammal-eating killer whales switching to a new prey source. Such a dietary shift by as few as six killer whales (if these fed exclusively on sea otters), or a less than 1% change in caloric input composition to all of the area's killer whales, could account for the reduced sea otter populations.



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killer whale, pen-and-ink by D. D. Tyler

WHY DID SEALS AND SEA LIONS DECLINE? Since killer whales apparently caused the sea otter declines, might they also have eaten the pinnipeds? Although records of killer whale foraging behavior from the 1970s and 1980s (those periods when pinniped losses would have been highest) are lacking, the weight of indirect evidence seems to line up more consistently with killer whale predation than it does with any of the other hypothesized causes, including reduced food availability for seals and sea lions from overfishing or ocean temperature change, purposeful or incidental killing, disease, or toxic pollution. Modeling suggests that the sea lion declines in the Aleutian archipelago also can be accounted for by small changes in killer whale foraging behavior (as few as 26 killer whales, or a 1% change in diet by the entire population). Predation might also account for the near-absence of carcasses washed up on beaches during the period of decline as well as the sequential nature of the harbor seal, sea lion, and sea otter collapses if killer whales "fished down" coastal marine mammals in this ecosystem.

WHY MIGHT KILLER WHALE PREDATION ON PINNIPEDS HAVE INCREASED? There are several possibilities, but a dietary shift in response to changing prey availability seems most likely, particularly because various prey species important to killer whales in the North Pacific region have undergone radical changes in abundance over the past half-century. One might expect population declines in some other of the killer whale's marine mammal prey just prior to the onset of the earliest pinniped declines. The great whales are obvious candidates. Although depletions by whaling in the North Pacific region began much earlier, it wasn't until after World War II that the area's most abundant species—sperm and fin whales—were harvested in large numbers. This exploitation grew rapidly, spreading eastward from Asia, harvesting some half a million individuals, and reducing the estimated whale biomass by roughly an order of magnitude—from about 30 to 3 million metric tons. Judging from International Whaling Commission harvest records, most of these reductions had occurred by the late 1960s or early 1970s. Killer whales are known to prey on all of the great whale species. If a substantial number of killer whales derived significant nutritional resources from the great whales when they were abundant, then these killer whales must have turned elsewhere for sustenance after the great whales had become rare. Such a dietary shift could easily have driven the subsequent population collapses of seals, sea lions, and sea otters.

Concluding thoughts

Temperate reef ecosystems throughout much of the world undergo distinct phase shifts between kelp-dominated and sea urchin–dominated states. Population changes in apex predators commonly precipitate these ripples down the food chain. Shallow reef habitats in southwest Alaska have undergone two such phase shifts during the twentieth century. The first of these (from the urchin- to kelp-dominated state) occurred gradually in time and space as sea otter populations recovered from the fur trade. What successes we have realized in understanding this phase shift were set up by two assumptions, which in retrospect seem to have been largely correct. One assumption was that top-down forcing processes can be important drivers of change. The other assumption was that the experimental design in understanding these changes could be defined by history.

The second phase shift (from the kelp- to urchin-dominated state) occurred rapidly and consistently across the Aleutian archipelago in the mid-1990s. This event has been more difficult to understand for two apparent reasons. First, the chain of causal events is more complicated. Second, the search for a cause was founded on three incorrect assumptions:

- We assumed that the coastal ecosystem was closed to significant interconnections with events in the open sea. Even as sea otter populations were declining in the early 1990s, we were slow to recognize the trend because all else in the coastal ecosystem appeared normal.
- Researchers trying to understand the cause for seal and sea lion declines assumed that significant forcing processes in open ocean ecosystems were largely bottom-up in nature. Even after the importance of onshore-offshore linkages became apparent, nutritional limitation imposed by competition with fisheries or oceanic regime shifts was thought to be the ultimate driver of the pinniped declines. While a loss of prey species may have played some role, it now appears that the most important forcing processes were top-down in nature.
- Scientists and managers have failed to look far enough back in time for answers. Most of the search has focused on the period from the late 1970s onward, by which time the ultimate cause may have come and gone.

Some of these thoughts are necessarily speculative. While identifying the patterns of change in natural systems is relatively straightforward, understanding the processes responsible for these changes is ecology's most fundamental—and formidable—challenge. Despite the uncertainties, it is clear that kelp forest phase shifts have complex and often unexpected explanations and consequences. This complexity involves linkages across multiple species, large areas, and long periods of time. The uncertainties may never be entirely resolved, in which case policy and management decisions will depend on a fair assessment of the weight of available evidence. However this is eventually done, the implications for conservation and management of living marine resources are profound. ☾

Marine ecologist **Jim Estes** *is a research scientist with the U.S. Geological Survey and adjunct professor at the University of California, Santa Cruz. His lab (http://brd1.ucsc.edu) has ongoing research projects in the Aleutian Islands, central California, the Channel Islands, and New Zealand. The central theme of all these studies is to identify the important high-trophic-level consumers and their influences on the organization of the communities in which they live.* *This article is adapted from a presentation given by Jim Estes at the Mote Fisheries Symposium in November 2002.*

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RESTORING SOUTHERN CALIFORNIA'S KELP FORESTS

by Chantal E. Collier

JUST BEYOND THE WAVES of southern California, kelp forests provide an extraordinarily productive and complex marine habitat for over 800 species (McPeak et al. 1988). However, decades of pollution, sedimentation, overfishing, and climate change have magnified natural disturbance patterns, contributing to a net decline in the abundance of kelp forests and the diversity they support. In response, the California Coastkeeper Alliance, through a partnership with the National Oceanic and Atmospheric Administration (NOAA) Fisheries' Community-Based Restoration Program, has launched a regional project to restore kelp forests to depleted reefs in southern California.

NANCY CARUSO

Kelp forest compendium

Giant kelp (*Macrocystis pyrifera*), the largest species of the brown seaweeds (Phaeophyceae), is the dominant alga of kelp forests in many parts of the world including Australia, New Zealand, the southern coasts of South America and South Africa, and several of the Southern Ocean islands. In the Northern Hemisphere, however, underwater forests of *Macrocystis pyrifera* occur exclusively along the coast of California and the northern reaches of Baja California (Dayton 1985; North 1994).

Macrocystis pyrifera holdfasts, which anchor the plants to the sea floor, require hard substrate for attachment. As a result, most kelp beds are found in nearshore waters, on low-relief, rocky reefs at 8 to 20 meter depths, where adequate light, nutrients, and temperature facilitate growth and reproduction (Patton et al. 1994; Dayton 1985). Under optimal conditions, kelp fronds can attain growth rates of up to 50 centimeters per day (McPeak et al. 1988). Buoyed to the surface by gas-filled bladders called pneumatocysts, mature kelp plants may reach 60 meters—a length to rival the tallest trees on land.

Upon reaching the surface, kelp continues to grow horizontally, creating a canopy, which filters sunlight over the habitat below. The vertical complexity of a kelp forest adds microhabitats to a rocky reef while the kelp itself provides a source of food to many of its inhabitants. Native residents of California kelp forests include important fishery species such as white sea bass, California sheephead, and spiny lobster, as well as rare and endangered species such as black sea bass and abalone. Kelp itself is harvested as raw material for the extraction of algin, a compound widely used in consumer and commercial products, from toothpaste to paint (McPeak et al. 1988).

Threats to kelp and causes of decline

Kelp forest communities are highly dynamic systems that vary in size and species composition between seasons, years, and decades (Dayton 1985; North 1994). Spatial and temporal variability are normal patterns in kelp ecosystems when they result from natural disturbances such as El Niño–Southern Oscillation (ENSO) and storm events. The nutrient-depleted, warm waters associated with El Niño events directly contribute to widespread kelp mortality (Dayton et al. 1992; Dean and Jacobsen 1986), while entanglement and the subsequent extirpation of kelp stipes and holdfasts cause mortality brought on by storm waves (Seymour et al. 1989). Surviving kelp plants and new recruits, which attempt to establish themselves when conditions improve, are often further subjected to the destructive effects of grazing by sea urchins and amphipods (Tegner and Dayton 1991).

Rates of recovery from natural disturbances are variable and depend on many factors including interannual temperature fluctuations, competitive interactions, and the presence of mature kelp to provide a source of spores. When conditions conducive to kelp recruitment and persistence return, kelp communities usually recover. Unfortunately, the resilience of kelp forests may be compromised when anthropogenic disturbances compound the effects of natural disturbances.

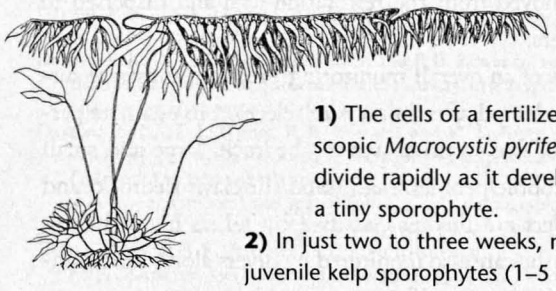
Despite episodic recovery from natural disturbances, aerial kelp canopy surveys have documented a net decline in the abundance of southern California kelp over the last century (Crandall 1915; Neushul 1981; Ecoscan 1989; CDFG 2000). Human activity has had devastating consequences for kelp. Pollution and sediments can introduce toxins, reduce light levels, and increase the amount of particles in the water column that may bury or scour kelp. Years of untreated or poorly treated sewage discharged into nearshore waters (Dayton et al. 1998), thermal effluent from coastal power plants (Ambrose 1994), and the introduction of sediments from coastal development and urban runoff (Devinny and Volse 1978) are just a few examples of pollutants that have damaged kelp. Arguably, the effects of human hunting and fishing of the animal residents in kelp forest communities may be of even greater concern. Important predators including sea otters, California sheephead, and spiny lobsters have been functionally removed from many kelp ecosystems (Dayton et al. 1998). The loss of these creatures has resulted in large-scale ecosystem imbalances in kelp forests. Perhaps the most dramatic consequence of losing these top predators has been the release of sea urchin populations, resulting in destructive grazing by urchins on kelp and increased competition between urchins and endangered abalone (Tegner and Levin 1983; Tegner and Dayton 2000). Overgrazing by urchins can dramatically alter a kelp forest, in many cases leading to total destruction and the creation of an "urchin barren." Global climate change may further compound the problems faced by kelp communities. The sensitivity of *Macrocystis* to increased temperatures has been documented by studies of El Niño events and interdecadal-scale oceanographic climate regime shifts (Tegner et al. 1996; Dayton et al. 1999), supporting the hypothesis that global warming will adversely affect kelp populations. Global warming has also been implicated in the increased severity of recent El Niño events and winter storms (MBC 2002).

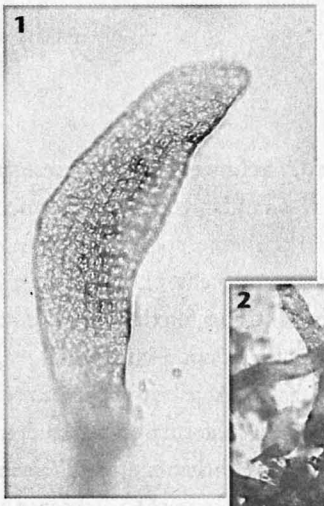
The Southern California Regional Kelp Restoration Project

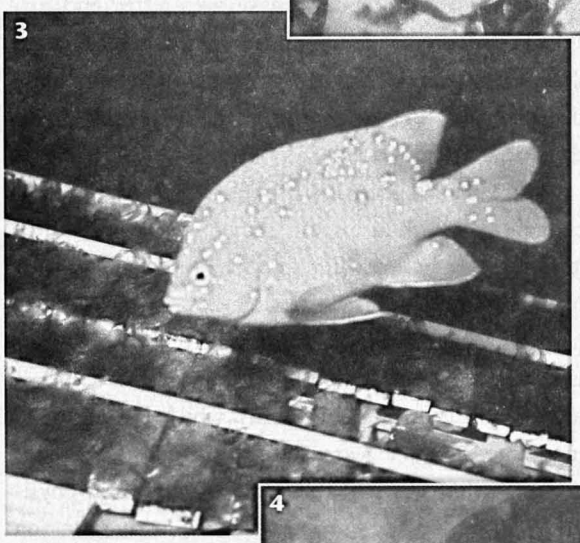
Following the 1997–1998 El Niño, California's kelp resources fell to their lowest levels on record (CDFG 2000). In response to this extreme decline, the California Coastkeeper Alliance—a coalition of nonprofit, environmental "keeper" organizations from the five coastal counties that stretch from San Diego to Santa Barbara—joined forces with the National Oceanic and Atmospheric Administration to implement the Southern California Regional Kelp Restoration Project. The mission of the alliance is to protect and restore coastal habitats, making the loss of kelp a top concern to all its members.

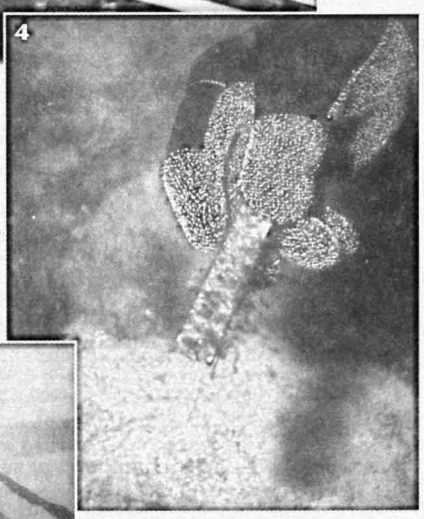
Differing from previous efforts to restore kelp forests, the hallmark of the Southern California Regional Kelp Restoration Project is its high level of community participation. Volunteers, students, scientific advisors, and governmental and foundation supporters all play a crucial role. The use of nonexpert volunteers has been shown to be an effective and reliable means to supplement and enhance research and monitoring programs (Pattengill-Semmens and Semmens 1998). Assistance and support from trained volunteers on the kelp project not only makes such a large-scale effort feasible, but also enables volunteers to learn about the importance of kelp ecosystems and fosters stewardship of the marine environment.

Volunteer scuba divers are trained by and work alongside Coastkeeper biologists to restore, maintain, and monitor kelp forests in their local coastal communities. Volunteers also assist with laboratory cultivation of juvenile kelp. The devel-









1) The cells of a fertilized, microscopic *Macrocystis pyrifera* spore divide rapidly as it develops into a tiny sporophyte.

2) In just two to three weeks, numerous juvenile kelp sporophytes (1–5 mm) begin to appear on the artificial substrate.

3) A curious juvenile garibaldi inspects a tray of laboratory-cultivated kelp sporophytes about to be outplanted at a restoration site.

4) Individual outplant units, each bearing many juvenile sporophytes (2–4 cm), are carefully secured to the restoration reef. Eventually one sporophyte will outcompete the others.

5) After four months, this laboratory-cultivated sporophyte has grown to exceed one meter in height.

DR. CHUCK KOPCZAK (1, 2); NANCY CARUSO (3–5)

opment of a peer-reviewed, "volunteer-friendly" restoration and monitoring protocol was fundamental to implementing community participation in the project.

An equally important component of the project is to increase understanding of and caring for the marine environment among community youth groups. To achieve this goal, portable aquaria, called eco-Karts, have been placed in science classrooms throughout southern California giving students an opportunity to study and grow kelp that is used in restoration efforts. Field trips and classroom visits from Coastkeeper biologists enable students to track the success of the kelp they grow.

Techniques for restoring kelp have been tested and successfully implemented through experimental research and numerous projects conducted by academic institutions, government agencies, and private companies since the 1970s (Wilson et al. 1979; Wilson and North 1983; Schiel and Foster 1992). Coastkeeper Alliance biologists and technical advisors reviewed previously tested methods to determine which techniques were most likely to succeed today.

The goal of the project is to restore kelp to natural reefs that historically supported kelp, but currently lack viable populations. Therefore, the first step in selecting restoration sites is the analysis of historical kelp records, which include aerial kelp canopy surveys and an extensive literature base. Potential sites are then explored by scuba divers to evaluate their physical and biological conditions. An ideal reef for kelp restoration is large and formed of continuous, low-relief bedrock, with minimal sedimentation, adequate light, clean water, and low densities of grazers and competitive species. To maximize efficiency and diver safety, sites are selected at depths close to 10 meters. When an area suitable for restoration is identified, it is divided into four sites of 500 square meters each—three for restoration and one as a control. Up to four techniques are then applied to restore giant kelp to the three restoration sites.

Unique to a project of this scale is our reliance on laboratory-cultivated kelp as the primary restoration tool. This method was selected due to its high level of success in both laboratory and small-scale field studies (Schiel and Foster 1992), and because it is an ecologically and ethically sound means of reforesting barren reefs. To supply juvenile kelp to restoration sites throughout southern California, a Regional Kelp Mariculture Laboratory has been established at the Southern California Marine Institute on Terminal Island, in the Port of Los Angeles. Coastkeeper biologists and volunteers collect sporophylls—the specialized, reproductive blades of giant kelp—from mature plants in healthy forests which neighbor restoration sites as closely as possible. No more than two sporophylls (of hundreds on a mature individual) are collected from any single kelp plant to ensure heterogeneous cultures. In the laboratory, microscopic kelp zoospores are induced to release from the sporophylls and settle onto ceramic tile strips, which serve as temporary artificial substrate until the kelp plants are introduced to the restoration sites. After two months, the juvenile kelp plants reach 2–4 centimeters in height and are ready to meet the Pacific. The tiles, each bearing 10 or more juvenile plants, are secured to protrusions and overhangs on the reef using latex rubber bands. To prevent genetic mixing between regional populations, each culture is isolated at the laboratory in individual recirculating seawater tables, and the resulting juveniles are outplanted to the same region from which their "parent" sporophylls were originally collected. Our plan is to outplant one tile per square meter to reach a goal of one adult kelp plant per 10 square meters.

Reed (1987) showed that of as many as 300 billion spores released from a single mature kelp plant, most settle within just a few meters of the source plant. Thus, the absence of fertile, mature kelp in an area decreases the likelihood of natural propagation on a reef. The introduction of sporophylls into a restoration area is the second technique we use to "seed" the reef. In this method, additional sporophylls are collected, placed in mesh bags, and anchored at the restoration sites.

Two additional restoration methods are employed. First, when fertile drift kelp with viable holdfasts are encountered by chance, they may be transplanted to restoration sites to serve as a natural spore source, a decoy for grazers, and, in the event of successful holdfast reattachment, an addition to the reef. Second, where grazing sea urchins are abundant, they may be removed from the restoration area and dispersed to deeper waters.

As part of an overall monitoring protocol, substrate surveys are conducted after initial site selection to estimate percent cover of five substrate types—bedrock, large and small boulders, cobble/pebbles, and sand/silt/clay. Bedrock and large boulders are further classified by relief. Invertebrates, algae, and fishes are also monitored by divers along fixed transects at each site. Specific taxa were chosen to represent a cross-section of ecological roles found in local kelp forests.

Individual kelp outplants and transplants that reach adequate size and develop a sufficient holdfast are tagged and monitored for survivorship, growth, and canopy development. When successfully outplanted kelp grow off the tiles and attach to the reef, the tiles are no longer required and may be removed. Where outplanted kelp do not survive, tiles and

rubber bands are collected and recorded to ascertain kelp mortality. To complete the data collection for monitoring, subtidal temperature loggers deployed at project sites track and record temperature fluctuations at hourly intervals.

The future of southern California's kelp?

Preliminary results from our first outplanting of laboratory-cultivated kelp in summer 2002 are promising. Nearly three months after outplanting kelp to restoration sites in Los Angeles and Orange Counties, Coastkeeper divers have documented up to 14% survival rates, higher than the 10% expected. Juvenile kelp have grown from 2–4 centimeters at the time of outplanting to 30–45 centimeters as of this writing, with excellent blade differentiation, holdfast, and pneumatocyst development.

Of course, the long-term success of the Southern California Kelp Restoration Project requires not only a sustained and concerted effort towards restoration, but also the mitigation of anthropogenic disturbances to the coastal environment. Continued cooperation and support of the public, government, academic, and private sectors allows progress in both restoration and prevention of further damage (Schiel and Foster 1992). For example, the implementation of marine protected areas through California's recently passed Marine Life Protection Act will support the kelp restoration work through improved conservation mandates intended to restore balance to coastal ecosystems. The California Coastkeeper Alliance's sister programs in citizen-based water quality monitoring and environmental advocacy also complement the Regional Kelp Restoration Project. These programs markedly reduce sewage discharge, oil spills, urban runoff, heat pollution—and the host of other point and non-point source pollutants that threaten coastal waters.

Mild winters and cold, nutrient-rich waters have enabled many southern California kelp beds to recover naturally and rapidly during the past two years. The Southern California Regional Kelp Restoration Project strives to see the full return of the swaying forests just off shore. ☾

Marine biologist **Chantal Collier** *is the regional kelp project manager for the California Coastkeeper Alliance, based in Los Angeles, California. For more information, please visit www.cacoastkeeper.org.*

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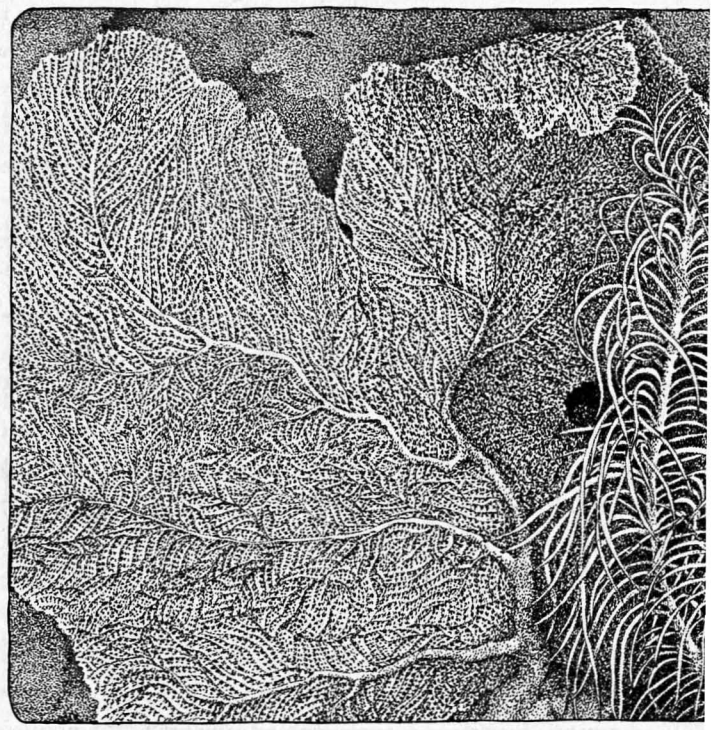
HOMELESS FISH

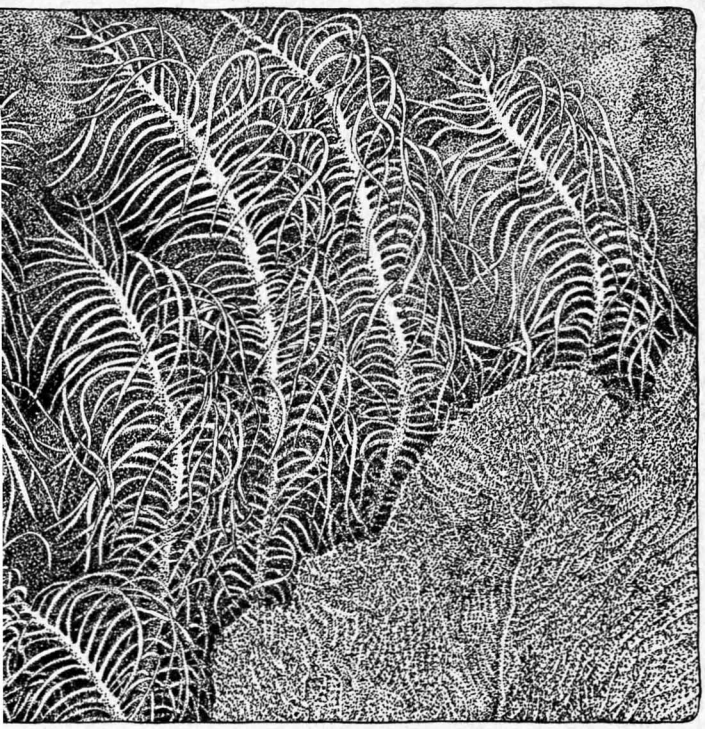
BOTTOM TRAWLS BULLDOZE SEAFLOOR HABITAT

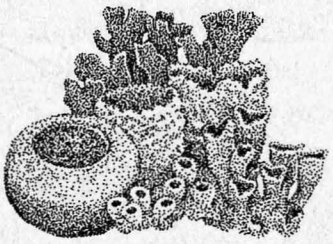


WE ARE UNABLE to readily see the seafloor, and therefore might imagine it as smooth as the surface of the oceans. In reality, however, it is as variable as land, with hills and valleys, ravines and mountains, areas that are smooth and soft and those that are rough and rocky. The smooth areas are roughly equivalent to the land around rivers, frequently washed over and slowly pummeled into homogeneity. Virtually all habitats contain complexity at some level; sand beds can be punctuated by ripples and indentations, and mud allows for digging burrows. "Structurally complex habitats," however, are those whose structures are heterogeneous and infrequently altered. The term is used generally to refer to an array of marine habitats including rock pinnacles (narrow spindles reaching up hundreds of feet from the seabed); fields of mixed cobble, boulders, and crevices; rock ravines and ledges that can drop hundreds of feet; and groves of deep-sea corals and sponges. These habitats are much less able to rebound from disturbance; their heterogeneity is a function of infrequent disturbance which would erode large structures and break them down into smaller ones (such as changing cobble to sand).

Just as downed woody debris creates microhabitats on the forest floor where many organisms thrive, diverse seafloor habitats help sustain the underwater web of life. Fish and shellfish use structurally complex habitats in much the way as birds or mammals—as resting places, shelter from predators, rich feeding areas, and prime spawning and nursery grounds. A great range of behavioral adaptation to different conditions is found in the oceans. Tilefish are known for digging their own burrows, whereas some rockfish will take advantage of holes left by others. Sole and flounder prefer sandy and muddy habitats that are accustomed to currents, storm surges, and other frequent disturbances. Cod, grouper, rockfish, and several shellfishes depend on structurally complex habitats for at least one stage of their lives.

We may think of marine fish as aimlessly wandering the oceans, but the fact is that most species have preferred locales where they congregate. Rockfish, for the most part, stay in one area. Groupers have spawning aggregation sites to which they return regularly. Black sea bass have migration routes that extend hundreds of miles. These site affinities are what allow fishermen to find the fish and to return annually to the same places. The fishermen come back, that is, as long as the fish keep coming back. Diminishing fish populations are not just a sign that too many fish are being caught—they are often also a sign of habitat destruction.





by Hannah Gillelan

The biggest threat to habitat

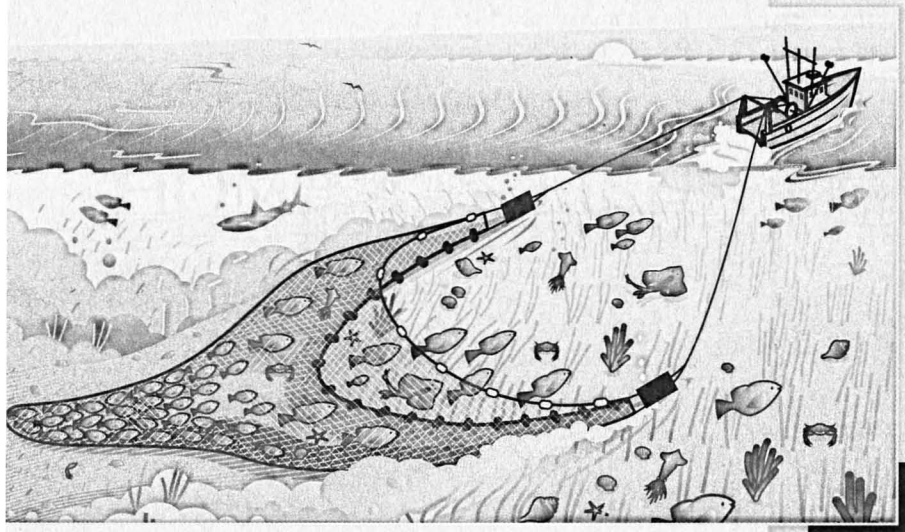
Fish face numerous threats: pollution, overfishing, wasteful mortality when caught as bycatch, or catch of untargeted species that are usually discarded dead. A major problem that receives insufficient recognition is destruction of non-estuarine marine fish habitats. While estuaries and other coastal habitats receive some legal and administrative protections, structurally complex seafloor habitats receive very little protection despite threats deemed significant by many scientists, including the National Research Council and most state and federal fishery management agencies. There is now overwhelming evidence that these critical, ecologically rich habitats are being frequently and intensely disturbed by modern fishing technology, primarily by a gear called "bottom trawls."

Everywhere bottom trawls are used, they alter the terrain. While certain habitats of sand and mud appear somewhat resilient to intense trawling, structurally complex habitats may be severely damaged, perhaps needing decades or even centuries to recover from only a few passes of a trawl. In some cases, the damage is likely permanent. The variables that contribute to determining the extent of damage from bottom trawls include the way they are rigged, the frequency with which they pass over the same area (some areas in the Gulf of Maine are trawled more than four times each month), and the type of habitat. Despite the intense disturbance to ecologically vital habitats, most regulations on bottom trawling aim to prevent overfishing and very few focus on protecting the health of the seafloor ecosystem. It is time to step up and ban or severely restrict bottom trawls, and thereby protect marine ecosystems whose rich blend of corals, sponges, invertebrates, crustaceans, fish, and other marine life is threatened by current fishing practices.

Bottom trawls—a description

A bottom trawl is a type of fishing gear that resembles a very large cone, stretched a bit so that the opening is in the shape of an oval or rectangle. Trawls are used worldwide in some of the deepest ocean waters—deeper than 6,000 feet on the continental slope. The nets may be wider and longer than a football field, and are greater in height at the opening of the net than the uprights of goalposts are tall. Bottom trawls are similar in concept to a butterfly net, but magnified to a degree such that one net could catch an entire flock of geese in one pass, with room to spare. Bottom trawls are so named because they are dragged on the seafloor as opposed to in the water col-

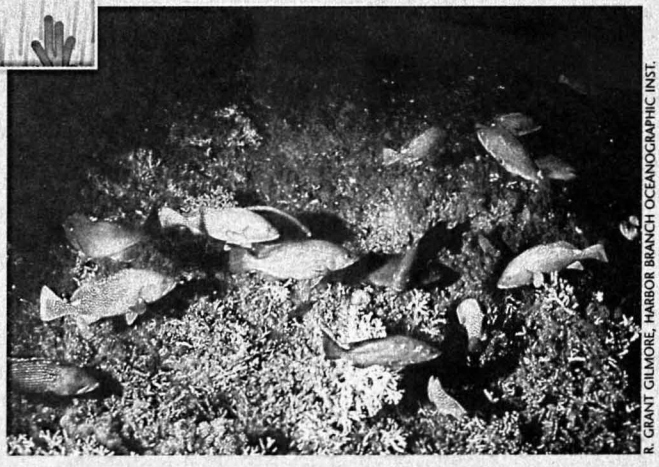
corals and sponges, pen-and-inks by D. D. Tyler



Everywhere bottom trawls are used, they alter the terrain. While certain habitats of sand and mud appear somewhat resilient to intense trawling, structurally complex habitats may be severely damaged, perhaps needing decades or even centuries to recover from only a few passes of a trawl.

umn. Due to buoyancy and the hydrodynamics of the net as it is pulled through the water, the primary contact with the seafloor is by the front, bottom edge of the mouth of the net (the footrope) and the bottom edges of the doors (massive, usually steel structures that may weigh thousands of pounds each and help keep the mouth of the net open and give it an oval/rectangular shape).

The footrope is usually a heavy-gauge chain rigged with weights, rollers, and rockhoppers. Rollers are steel or rubber (actual tires, solid rubber discs, or steel balls) that are free to rotate on the footrope and can weigh hundreds of pounds each. Rollers can be anywhere from 4 to over 18 inches in diameter and are used to reduce the amount of mud that the net collects or to help navigate the footrope over a complexly structured seafloor such as a field of cobble and an occasional boulder. Rockhoppers were developed in the 1980s and are very similar to rollers; they are rubber, are fixed (unable to rotate) on the footrope, and are typically between 8 and 32 inches in diameter. The largest rockhoppers are often airplane tires. Footropes are strung with a very rough average of one hundred rollers or rockhoppers per net. Without large rockhoppers, fishermen will not trawl in structurally complex areas because they would risk expensive damage to their nets from abrasion and snagging on the rough seafloor. Areas of seafloor that were once avoided by trawlers are now pursued with vigor, using large rockhoppers and rollers, including some of the best fishing grounds for groundfish such as rockfish and cod. The recent closures in Pacific fisheries and severe catch restrictions in New England are testament to the poor growth and survival of groundfish whose once complex habitat has been increasingly pulverized over the past 20 years.

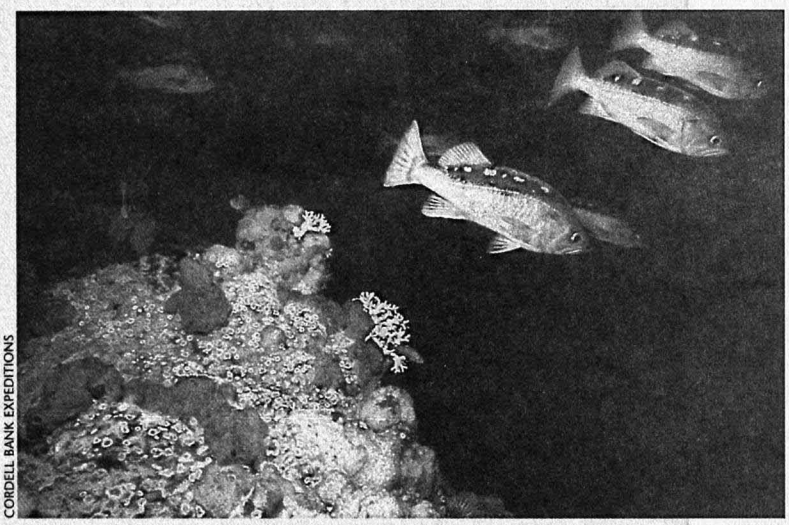


R. GRANT GILMORE, HARBOR BRANCH OCEANOGRAPHIC INST.

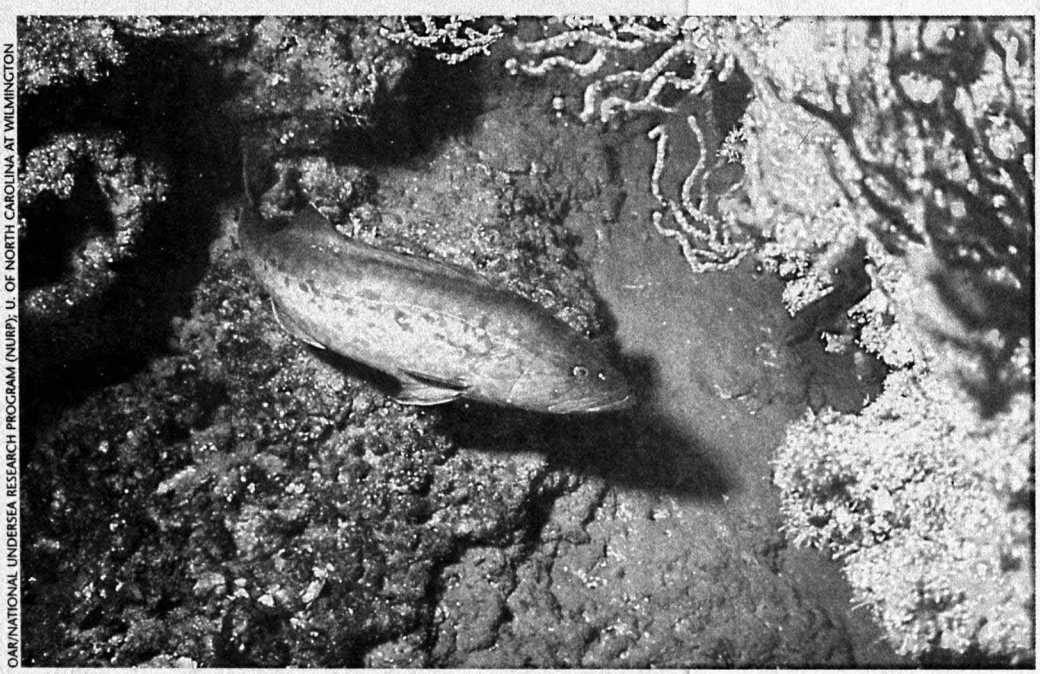
CHRISTOPHER KOENIG, FLORIDA STATE UNIVERSITY

Above: In this untrawled area of the Oculina Bank off southeast Florida, grouper swim among the deep-sea coral *Oculina varicosa. Below:* In another area of the Oculina Bank, where a bottom trawl has completely demolished these fragile deep-sea corals, grouper are absent. Declines in grouper can be partially attributed to the destruction of the structured habitat they use for spawning.

computer-generated illustration by Joe Shoulak



CORDELL BANK EXPEDITIONS



OAR/NATIONAL UNDERSEA RESEARCH PROGRAM (NURP); U. OF NORTH CAROLINA AT WILMINGTON

Above: Yellowtail rockfish off the Pacific coast. *Below:* Gag grouper off the Southeast U.S. coast. Fish and other species use structurally complex habitat for resting, hiding from predators, places to congregate, hatcheries, and feeding grounds.

Impacts from bottom trawls

One of the significant negative effects of bottom trawls is their tremendous catch of non-target species and underage target species that are too young or small to keep. The indiscriminate nature of the bottom trawl means that this bycatch can be more than 17 times the target catch. The web of life beneath the sea suffers as entire swaths of ocean are cleared of creatures unable to escape the massive net.

Perhaps even more deleterious than the high rate of bycatch is the direct damage caused by bottom trawls. Sediments and toxins that had settled on the seafloor are stirred up in massive clouds that can extend for miles. When these sediments drift back to the bottom they can suffocate shellfish, corals, and other fairly sedentary seafloor life. Gouges left in sand and mud as a trawl passes can take days to return to their pre-trawled state, and this recovery time can be lengthened if an area is repeatedly trawled. Most severe, however, is the damage done to complex structures.

Bottom trawls with large rollers and rockhoppers have been documented moving boulders over a ton in weight. As the footrope and doors plow through an area, they can homogenize areas that were complex combinations of cobble, sand, and boulders by flattening and breaking down rock structures deposited by the glaciers. One fisherman has recounted how a row of large underwater hills was flattened after just two years of intense bottom trawling. Such changes are permanent—the rocks will not reposition themselves or migrate in from other areas.

If a bottom trawl can move massive boulders, it is easy to imagine what happens to fragile seafloor life like sea anemones, sponges, and deep-sea corals. Unlike their reef-building, shallower-water cousins in the tropics, deep-sea corals resemble bushes and trees. When interspersed with sea anemones and sponges of varying shapes and sizes, the groves

are colorful and diverse underwater seascapes. Marine fishes and shellfish use the corals and sponges for protection from predators until they have grown to a defensible size, and for spawning and foraging. While deep-sea corals live off all U.S. coasts, from Maine to Florida and from Hawaii to Alaska, very little is known about them or their precise interaction with other species.

Deep-sea corals are able to bend and sway with moving waters, but the crushing force of a large, heavy rockhopper is too much. As living creatures, they are legally considered bycatch, meaning that they are protected by laws and regulations that limit the amount of bycatch allowed and that monitor how much is caught, yet data on how much coral is caught by bottom trawls exist only for Alaska and the Bering Sea. One research vessel in Alaska brought up 2,000 pounds of corals from just one haul of a bottom trawl. While this is not the normal extent of bycatch, 6.5 million pounds of corals and sponges were observed as caught in Alaskan fisheries alone over the past 16 years; that's an average of 400,000 pounds of corals and sponges each year that are observed caught. The damage to these species is far greater, because significant amounts are left crushed, crumbled, and pulverized on the seafloor. And the devastation is not restricted to Alaskan waters; elsewhere, chunks of these slow-growing and long-lived species are inadvertently captured in the net—a waste of decades, centuries, and even millennia of growth.

Other known areas of once-significant groves of corals and sponges are small fractions of what they were. The Oculina Banks off of eastern Florida, for example, has been 90% destroyed. The region was designated as a Habitat Area of Particular Concern in 1984 and all bottom disturbing activities, including bottom trawling, have been banned. Despite the designation, trawls continue to pursue fish in this sensitive habitat by going out late at night and evading the underfunded enforcement agencies that are unable to adequately patrol an area miles from shore. On Georges Bank in New England, researchers who think the area was once filled with sponges and corals are now thrilled to encounter small patches of corals that are still intact.

Some deep-sea coral and sponge species grow less than two centimeters each year. These havens of beauty, life, and untold biological knowledge are therefore unable to recover if trawls pass through them even once a year or every other year. And the young of many fish species that hatch and grow in the protection of the thickets are more vulnerable in more open habitat. Numerous studies have shown how fish, urchins, and crustaceans prefer the protection of structured habitat. Juvenile Atlantic cod have been shown to have far greater mortality in open habitats than in structurally complex ones. Even in the Antarctic, fish take advantage of pockets in the ice, some of the only structure available to them. Such evidence makes plain that bottom trawls are destroying irreplaceable habitats and threatening the sustainability of many marine groundfishes and ecosystems.

What can be done?

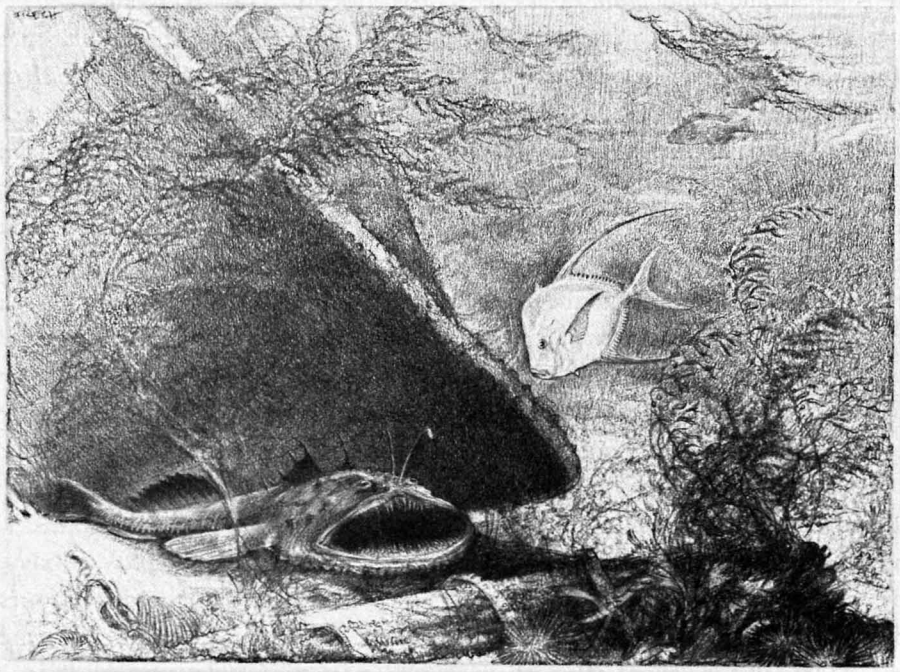
Clearly, the most effective method of stopping habitat devastation caused by bottom trawls would be to ban all bottom trawling in U.S. waters, as the Western Pacific Fishery Management Council has done for Hawaii, American Samoa, Guam, and the Northern Mariana Islands. Closing areas known to contain fragile structurally complex habitat has also been proposed, but to be useful, comprehensive mapping of such habitats would need to be completed and enforcement funding increased. Similarly, restricting the gear that allows entry into these biologically diverse areas by limiting the diameter of rollers and rockhoppers may be helpful. Restricting rollers and rockhoppers to an eight-inch diameter has proved effective in waters off the Pacific coast because trawlers are unwilling to risk snagging and abrading their nets on rough bottoms without the gear that would prevent this expensive damage.

Whichever method or combination of methods is adopted, it is clear that the only reason that such extensive damage has been allowed to continue for the past two decades is because we landlubbers are unable to see the destruction. Were trawls clearing swaths on land, as they do on the seafloor, the practice would have been severely curtailed or halted before now. The level of damage caused by bottom trawls is as unsustainable to a diverse marine environment as it would be to a terrestrial one. For the fishes, for the corals and sponges, for the greater marine web of life, we must protect our precious underwater seascapes by severely restricting bottom trawling to areas that are better equipped to recover from pummeling by the gear—or, better yet, by banning their use altogether. ☾

Hannah Gillelan *is an ocean policy analyst for the Marine Conservation Biology Institute in Washington, D.C. MCBI (www.mcbi.org) is a nonprofit organization dedicated to advancing the science of marine conservation biology and promoting cooperation essential to protecting and restoring Earth's biological integrity.*

Undersea

by RACHEL CARSON



INTRODUCTION
by Linda Lear

"UNDERSEA" WAS ORIGINALLY TITLED "The World of Waters" and written as an introduction to a U.S. Bureau of Fisheries brochure in 1935. Carson's supervisor correctly assessed it as too lyric for a government report and encouraged her to submit it to the *Atlantic Monthly,* where it was published by editor Edward Weeks. "Undersea" subsequently became the basis of Carson's first book, *Under the Sea-Wind* (1941), which remained her favorite piece of writing.

The title "Undersea" was suggested by the *Atlantic*'s editor who was impressed with Carson's illumination of science "in such a way as to fire the imagination of the layman." Its publication marked Carson's literary debut as a writer of critical merit.

Here Carson surveys both the ordinary and fantastic creatures of the sea from the immediate perspective of an underwater eye, making the mystery and beauty of that world accessible to the nonscientific reader. "Undersea" introduces two of Carson's signature themes: the ancient and enduring ecology that dominates ocean life, and the material immortality that encompasses even the smallest organism. From these four remarkable pages in the *Atlantic*, Carson later admitted, "everything else followed."

This essay is drawn from Lost Woods: The Discovered Writing of Rachel Carson *edited and with an introduction by Linda Lear (©1998 by Roger Allen Christie; compilation, introduction, and text other than Carson's writing, ©1998 by Linda Lear) and is reprinted by permission of Beacon Press, Boston. The illustrations by Howard Frech (1893–1977) appeared in the original* Under the Sea-Wind *published by Simon & Schuster in 1941. They are from the collection of the Ward Museum of Wildfowl Art, Salisbury University, Salisbury, Maryland, and were a gift of Shirley A. Briggs, a friend of both Carson and Frech.*

"The angler was lying under the prow of the 'Mary B.'"

WHO HAS KNOWN THE OCEAN?

Neither you nor I, with our earth-bound senses, know the foam and surge of the tide that beats over the crab hiding under the seaweed of his tide-pool home; or the lilt of the long, slow swells of mid-ocean, where shoals of wandering fish prey and are preyed upon, and the dolphin breaks the waves to breathe the upper atmosphere. Nor can we know the vicissitudes of life on the ocean floor, where the sunlight, filtering through a hundred feet of water, makes but a fleeting, bluish twilight, in which dwell sponge and mollusk and starfish and coral, where swarms of diminutive fish twinkle through the dusk like a silver rain of meteors, and eels lie in wait among the rocks. Even less is it given to man to descend those six incomprehensible miles into the recesses of the abyss, where reign utter silence and unvarying cold and eternal night.

To sense this world of waters known to the creatures of the sea we must shed our human perceptions of length and breadth and time and place, and enter vicariously into a universe of all-pervading water. For to the sea's children nothing is so important as the fluidity of their world. It is water that they breathe; water that brings them food; water through which they see, by filtered sunshine from which first the red rays, then the greens, and finally the purples have been strained; water through which they sense vibrations equivalent to sound. And indeed it is nothing more or less than sea water, in all its varying conditions of temperature, saltiness, and pressure, that forms the invisible barriers that confine each marine type within a special zone of life—one to the shore line, another to some submarine chasm on the far slopes of the continental shelf, and yet another, perhaps, to an imperceptibly defined stratum at mid-depths of ocean.

There are comparatively few living things whose shifting pattern of life embraces both land and sea. Such are the creatures of the tide pools among the rocks and of the mud flats sloping away from dune and beach grass to the water's edge. Between low water and the flotsam and jetsam of the high-tide mark, land and sea wage a never-ending conflict for possession.

As on land the coming of night brings a change over the face of field and forest, sending some wild things into the safe retreat of their burrows and bringing others forth to prowl and forage, so at ebb tide the creatures of the waters largely disappear from sight, and in their place come marauders from the land to search the tide pools and to probe the sands for the silent, waiting fauna of the shore.

Twice between succeeding dawns, as the waters abandon pursuit of the beckoning moon and fall back, foot by foot, periwinkle and starfish and crab are cast upon the mercy of the sands. Every heap of brine-drenched seaweed, every pool forgotten by the retreating sea in recess of sand or rock, offers sanctuary from sun and biting sand.

In the tide pools, seas in miniature, sponges of the simpler kinds encrust the rocks, each hungrily drawing in through its myriad mouths the nutriment-laden water. Starfishes and sea anemones are common dwellers in such rock-girt pools. Shell-less cousins of the snail, the naked sea slugs are spots of brilliant rose and bronze, spreading arborescent gills to the waters, while the tube worms, architects of the tide pools, fashion their conical dwellings of sand grains, cemented one against another in glistening mosaic.

On the sands the clams burrow down in search of coolness and moisture, and oysters close their all-excluding shells and wait for the return of the water. Crabs crowd into damp rock caverns, where periwinkles cling to the walls. Colonies of gnome-like shrimps find refuge under dripping strands of brown, leathery weed heaped on the beach.

Hard upon the retreating sea press invaders from the land. Shore birds patter along the beach by day, and legions of the ghost crab shuffle across the damp sands by night. Chief, perhaps, among the plunderers is man, probing the soft mud flats and dipping his nets into the shallow waters.

At last comes a tentative ripple, then another, and finally the full, surging sweep of the incoming tide. The folk of the pools awake—clams stir in the mud. Barnacles open their shells and begin a rhythmic sifting of the waters. One by one, brilliant-hued flowers blossom in the shallow water as tube worms extend cautious tentacles.

The ocean is a place of paradoxes. It is the home of the great white shark, two-thousand-pound killer of the seas, and of the hundred-foot blue whale, the largest animal that ever lived. It is also the home of living things so small that your two hands might scoop up as many of them as there are stars in the Milky Way. And it is because of the flowering of astronomical numbers of these diminutive plants, known as diatoms, that the surface waters of the ocean are in reality boundless pastures. Every marine animal, from the smallest to the sharks and whales, is ultimately dependent for its food upon these microscopic entities of the vegetable life of the ocean. Within their fragile walls, the sea performs a vital alchemy that utilizes the sterile chemical elements dissolved in the water and welds them with the torch of sunlight into

the stuff of life. Only through this little-understood synthesis of proteins, fats, and carbohydrates by myriad plant "producers" is the mineral wealth of the sea made available to the animal "consumers" that browse as they float with the currents. Drifting endlessly, midway between the sea of air above and the depths of the abyss below, these strange creatures and the marine inflorescence that sustains them are called "plankton"—the wanderers.

Many of the fishes, as well as the bottom-dwelling mollusks and worms and starfish, begin life as temporary members of this roving company, for the ocean cradles their young in its surface waters. The sea is not a solicitous foster mother. The delicate eggs and fragile larvae are buffeted by storms raging across the open ocean and preyed upon by diminutive monsters, the hungry glassworms and comb jellies of the plankton.

These ocean pastures are also the domain of vast shoals of adult fishes: herring, anchovy, menhaden, and mackerel, feeding upon the animals of the plankton and in their turn preyed upon; for here the dogfish hunt in packs, and the ravenous bluefish, like roving buccaneers, take their booty where they find it.

"The nereids swam upward to the ceiling of the sea."

Dropping downward a scant hundred feet to the white sand beneath, an undersea traveler would discover a land where the noonday sun is swathed in twilight blues and purples, and where the blackness of midnight is eerily aglow with the cold phosphorescence of living things. Dwelling among the crepuscular shadows of the ocean floor are creatures whose terrestrial counterparts are drab and commonplace, but which are themselves invested with delicate beauty by the sea. Crystal cones form the shells of pteropods or winged snails that drift downward from the surface to these dim regions by day; and the translucent spires of lovely *Ianthina* are tinged with Tyrian purple.

Other creatures of the sea's bottom may be fantastic rather than beautiful. Spine-studded urchins, like rotund hedgehogs of the sea, tumble over the sands, where mollusks lie with slightly opened shells, busily straining the water for debris. Life flows on monotonously for these passive sifters of the currents, who move little or not at all from year to year. Among the rock ledges, eels and cunners forage greedily, while the lobster feels his way with nimble wariness through the perpetual twilight.

Farther out on the continental shelf, the ocean floor is scarred with deep ravines, perhaps the valleys of drowned rivers, and dotted with undersea plateaus. Hosts of fish graze on these submerged islands, which are richly carpeted with sluggish or sessile forms of life. Chief among the ground fish are haddock, cods, flounders and their mightier relative, the halibut. From these and shallower waters man, the predator, exacts a yearly tribute of nearly thirty billion pounds of fish.

If the underwater traveler might continue to explore the ocean floor, he would traverse miles of level prairie lands; he would ascend the sloping sides of hills; and he would skirt deep and ragged crevasses yawning suddenly at his feet. Through the gathering darkness, he would come at last to the edge of the continental shelf. The ceiling of the ocean would lie a hundred fathoms above him, and his feet would rest upon the brink of a slope that drops precipitously another mile, and then descends more gently into an inky void that is the abyss.

What human mind can visualize conditions in the uttermost depths of the ocean? Increasing with every foot of depth, enormous pressures reach, three thousand fathoms down, the inconceivable magnitude of three tons to every square inch of surface. In these silent deeps a glacial cold prevails, a bleak iciness which never varies, summer or winter, years melting into centuries, and centuries into ages of geologic time. There,

too, darkness reigns—the blackness of primeval night in which the ocean came into being, unbroken, through eons of succeeding time, by the gray light of dawn.

It is easy to understand why early students of the ocean believed these regions were devoid of life, but strange creatures have now been dredged from the depths to bear mute and fragmentary testimony concerning life in the abyss.

The "monsters" of the deep sea are small, voracious fishes with gaping, tooth-studded jaws, some with sensitive feelers serving the function of eyes, others bearing luminous torches or lures to search out or entice their living prey. Through the night of the abyss, the flickering lights of these foragers move to and fro. Many of the sessile bottom dwellers glow with a strange radiance suffusing the entire body, while other swimming creatures may have tiny, glittering lights picked out in rows and patterns. The deep-sea prawn and the abyssal cuttlefish eject a luminous cloud, and under cover of this pillar of fire escape from their enemies.

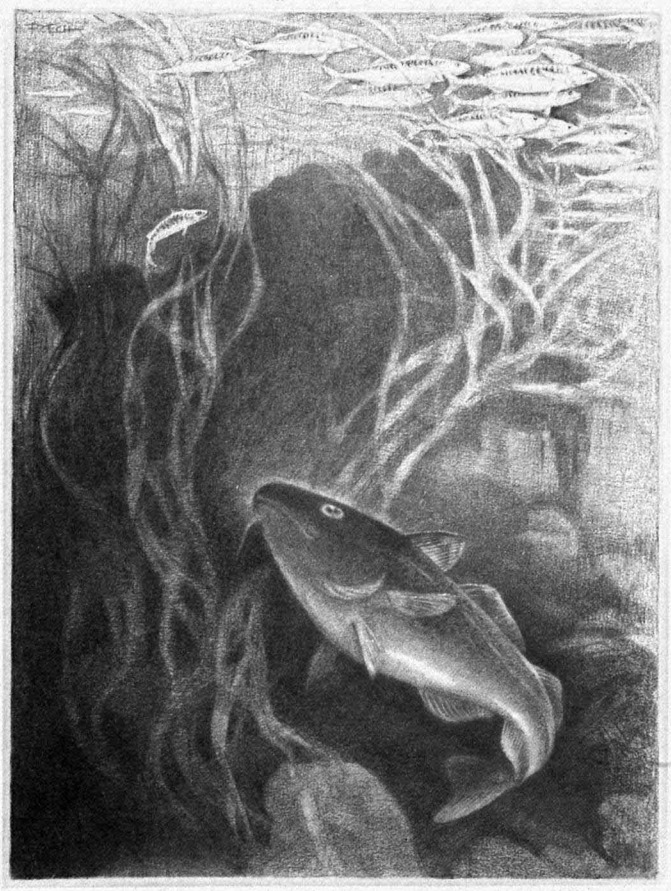
Monotones of red and brown and lustreless black are the prevailing colors in the deep sea, allowing the wearers to reflect the minimum of the phosphorescent gleams, and to blend into the safe obscurity of the surrounding gloom.

On the muddy bottom of the abyss, treacherous oozes threaten to engulf small scavengers as they busily sift the debris for food. Crabs and prawns pick their way over the yielding mud on stilt-like legs; sea spiders creep over sponges raised on delicate stalks above the slime.

Because the last vestige of plant life was left behind in the shallow zone penetrated by the rays of the sun, the inhabitants of these depths contrast strangely with the self-supporting assemblage of the surface waters. Preying one upon another, the abyssal creatures are ultimately dependent upon the slow rain of dead plants and animals from above. Every living thing of the ocean, plant and animal alike, returns to the water at the end of its own life span the materials that had been temporarily assembled to form its body. So there descends into the depths a gentle, never-ending rain of the disintegrating particles of what once were living creatures of the sunlit surface waters, or of those twilight regions beneath.

Here in the sea mingle elements which, in their long and amazing history, have lent life and strength and beauty to a bewildering variety of living creatures. Ions of calcium, now free in the water, were borrowed years ago from the sea to form part of the protective armor of a mollusk, returned to the main reservoir when their temporary owner had ceased to have need of them, and later incorporated into the delicate statuary of a coral reef. Here are atoms of silica, once imprisoned in a layer of flint in subterranean darkness; later, within the fragile shell of a diatom, tossed by waves and warmed by the sun; and again entering into the exquisite structure of a radiolarian shell, that miracle of ephemeral beauty that might be the work of a fairy glass-blower with a snowflake as his pattern.

Except for precipitous slopes and regions swept bare by submarine currents, the ocean floor is covered with primeval oozes in which there have been accumulating for aeons deposits of varied origin; earth-born materials freighted seaward by rivers or worn from the shores of continents by the ceaseless grinding of waves; volcanic dust transported long distances by wind, floating lightly on the surface and eventually sinking into the depths to mingle with the products of no less mighty eruptions of submarine volcanoes; spherules of iron and nickel from interstellar space; and substances of organic origin—the silicious skeletons of Radiolaria and the frustules of diatoms, the limey remains of



"He swung his heavy body out from the ledge."

algae and corals, and the shells of minute Foraminifera and delicate pelagic snails.

While the bottoms near the shore are covered with detritus from the land, the remains of the floating and swimming creatures of the sea prevail in the deep waters of the open ocean. Beneath tropical seas, in depths of 1000 to 1500 fathoms, calcareous oozes cover nearly a third of the ocean floor; while the colder waters of the temperate and polar regions release to the underlying bottom the silicious remains of diatoms and Radiolaria. In the red clay that carpets the great deeps at 3000 fathoms or more, such delicate skeletons are extremely rare. Among the few organic remains not dissolved before they reach these cold and silent depths are the ear bones of whales and the teeth of sharks.

Thus we see the parts of the plan fall into place: the water receiving from earth and air the simple materials, storing them up until the gathering energy of the spring sun wakens the sleeping plants to a burst of dynamic activity, hungry swarms of planktonic animals growing and multiplying upon the abundant plants, and themselves falling prey to the shoals of fish; all, in the end, to be redissolved into their component substances when the inexorable laws of the sea demand it. Individual elements are lost to view, only to reappear again and again in different incarnations in a kind of material immortality. Kindred forces to those which, in some period inconceivably remote, gave birth to that primeval bit of protoplasm tossing on the ancient seas continue their mighty and incomprehensible work. Against this cosmic background the life span of a particular plant or animal appears, not as a drama complete in itself, but only as a brief interlude in a panorama of endless change. ☾

Rachel Carson *(1907–1964) wrote only four books, was robbed of old age by cancer, and was, in some measure, a modest government servant—but she changed the very way people around the world look to the sea and understand their place on the planet. Though* Under the Sea-Wind *(1941),* The Sea Around Us *(1951), and* The Edge of the Sea *(1955) were bestsellers, her 1962 book,* Silent Spring, *alerted a generation to the dangers of pesticides and can fairly be said to have started the modern environmental movement. Along with Thoreau, Muir, and Leopold, Carson is one of the few surnames in American conservation history that stands by itself.* **Linda Lear** *is editor of* Lost Woods: The Discovered Writing of Rachel Carson *(1998), author of* Rachel Carson: Witness for Nature *(1997), and research professor of environmental history at George Washington University in Washington, D.C.*

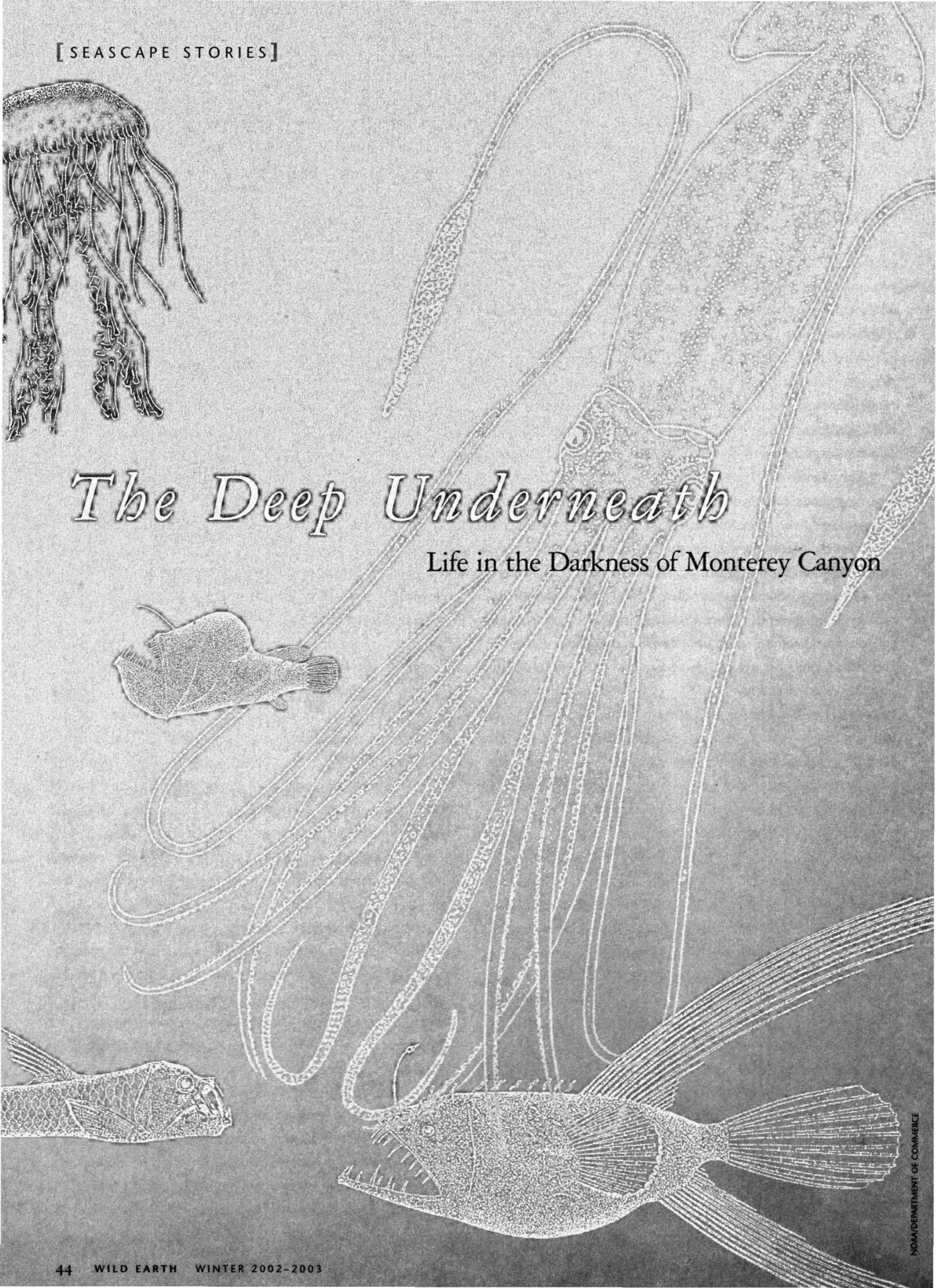
Home From Alaska

Back to the dark
I mourn the loss
of the impossible
light—

the pearly inside
of the oyster
at 2 A.M.
the fishermen
trolling
at 3
the ease of midnight
twilight
calming ancient hidden
fears—

no child trembles here
no monsters haunt
the shadows
gone
and peace sleeps on
the heart and eyes
within
the nightlong summer dusk
our
wild limbs were still
and rocked by
whalesong.

Katherine G. McGuire



The Deep Underneath

Life in the Darkness of Monterey Canyon

NOAA/DEPARTMENT OF COMMERCE

by CAROL HUNTER

THE GIANT GELATINOUS PREDATOR moves silently through cold, dark waters, propelled by a pair of expanding and contracting swimming bells. Its rope-like body is actually a colony of almost a thousand individual subsections, each performing a specific task. Some provide propulsion; others, reproductive functions—but most specialize in capturing and devouring prey. When hunting, these sections deploy thousands of slender, stinging tentacles to capture drifting krill, copepods, small fish, and other jellies. Almost anything blundering into this deadly net of tentacles soon finds itself stuffed into the nearest waiting mouth. Longer even than the blue whale, individual specimens of this animal—the siphonophore *Praya dubia*—have been found measuring over 130 feet in length.

Praya dubia makes its home in the frigid, black waters of the Monterey Submarine Canyon in California's Monterey Bay. Here, starting just a few hundred yards from shore, the coastal seafloor plunges into the underwater equivalent of the Grand Canyon, stretching 60 miles out to sea. Steep, rocky walls and soft sediment beds make up the deepest submarine canyon on the West Coast of the contiguous United States—and one of the largest in the world. While its exact origin is still unknown, the canyon is believed to be 20–30 million years old, produced through tectonic processes between the shifting North American and Pacific plates, continually gouged and deepened by underwater landslides. The canyon system stretches over six miles across and digs almost two and a half miles deep into the ocean floor.

In the ocean's surface waters, life occurs in abundance; algae, phytoplankton, and other plants convert sunlight into food and provide the base of the ocean's food web. This area, known as the photic zone, extends downward to the maximum depth of sunlight penetration. But at only 500 feet down, 99% of the sunlight has been absorbed by seawater, leaving the waters below icy cold and pitch black. In a world far too dark for photosynthesis, canyon creatures like *Praya* must live without the rich algal blooms and flourishing plant life found in the surface waters, depending solely on their ability to make a meal of their neighbors or on nourishment drifting down from the photic zone above. Crushing pressures average three tons per square inch and oxygen levels are about one-sixth of surface levels. While life here is not as abundant as in the nutrient-rich waters above, the deep-sea canyon is home to many diverse organisms, forming a complex web of life that scientists are only beginning to understand.

The privately funded Monterey Bay Aquarium Research Institute (MBARI) has been studying the geological wonder at its doorstep since 1987. "Monterey Canyon is the most heavily studied deep-sea area in the world, without a doubt," says Dr. George Matsumoto, education and research specialist at the Aquarium Research Institute. In its 13 years of research, MBARI has made over 3,000 dives in the canyon using remotely operated, camera-equipped vehicles, or ROVs. The ROV *Ventana*, which has been diving almost daily in Monterey since 1988, can reach a depth of over 6,000 feet, while the updated *Tiburon,* launched in 1997, can reach over 13,000 feet. Altogether, the institute's ROVs, which are operated from aboard deep-sea research vessels, have logged almost 9,000 hours of video of the previously inaccessible environment.

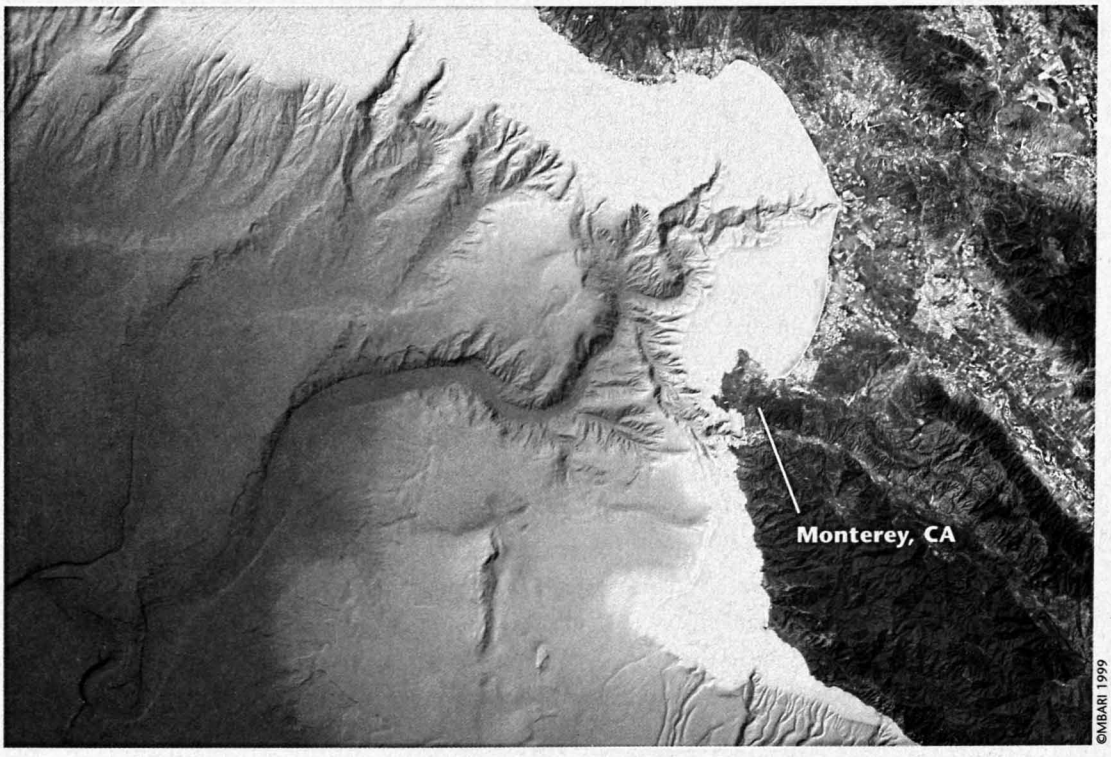
Dr. Kevin Raskoff, a research fellow at MBARI, estimates that hundreds of jelly species live in Monterey Canyon, many unidentified. They include pulsing medusas with the traditional umbrella jelly shape, beautiful comb jellies that move through the waters using vibrating cilia, and the ropelike siphonophores such as *Praya*. One of his favorites, a large medusa called *Solmissus,* is especially easy to study, thanks to its transparent gut. "We've been able to do a lot of interesting research on what they eat without having to collect them," says Raskoff. "We can just drive the ROV around, look right into their stomach, and see what they've had for dinner." *Solmissus* also has a stealthy manner of hunting other jellies. It swims with its tentacles pushed out in front or to the side instead of dangling underneath, allowing it to hide behind its own tentacles and nab unsuspecting prey. Research with submersible ROVs has opened the world of the jellyfish to scientists, allowing them to observe these creatures in their natural environment. "Previous research has pretty much ignored gelatinous animals," says Raskoff, explaining that their soft bodies were often destroyed in nets during classic oceanographic research.

THE CANYON'S DEPTHS also support fish. One resident, the deep-sea anglerfish, has evolved strange behaviors—and an equally strange appearance—to survive its nutrient-poor environment. [See "Species Spotlight," inside back cover.] "They are fascinating fish," says Steven Webster, senior marine biologist at the Monterey Bay Aquarium. "They have a bioluminescent lure on their forehead that attracts their prey." Adult anglers hover in darkness over 1,000 feet below the surface. Since their sit-and-wait hunting technique requires little

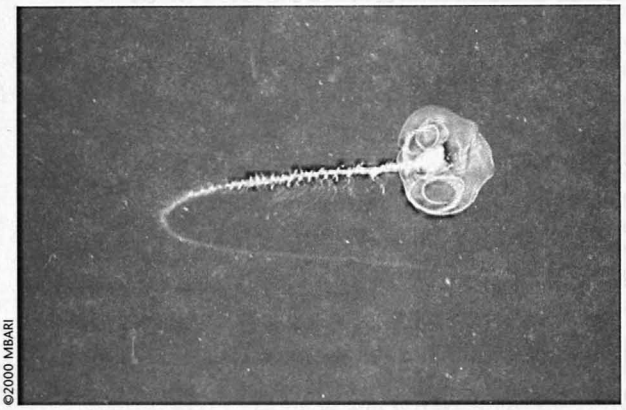
swimming, the angler's body does not need strong, energy-consuming muscles or a streamlined shape. Instead, their bodies consist almost entirely of a giant mouth filled with long, pointed teeth and an expandable stomach that allows them to consume prey nearly as large as themselves. Anglers have also developed an interesting mating strategy. "The big fish that you see is the female," says Webster, "and the male is tiny and parasitic, basically a little sack of sperm embedded in the body wall of the female—which makes it a lot easier finding a mate down there in the dark!" Female anglers have been seen with as many as eleven males attached.

Anglers are only one of many deep-sea creatures to use bioluminescence, a process that works in a similar fashion to a glow-stick. In general, these creatures mix a light-producing chemical known as a luciferin with a catalyst called a luciferase, creating a chemical reaction that produces light. While only a few land organisms emit their own light, an estimated 90% of deep-sea creatures are bioluminescent. The giant red mysid, a deep-sea crustacean, temporarily blinds its predators by producing a bright blue luminescence to help it escape. Similarly, the small jelly *Colobonema* is believed to use bioluminescence in its 32 tentacles, which can drop off to distract predators. Many species of mid-water fish and cephalopods use bioluminescence on their bellies to blend in with the faint light filtering down from the surface, camouflaging them from predators lurking below. Other species like the lanternfish use special light-producing organs called photophores to produce species-specific light patterns, helping them to find a mate in the dark waters.

An important part of MBARI's work is developing the tools and technology needed to explore the deep oceans and the creatures within them. In many ways, it is easier to communicate with a satellite in outer space, which can be solar powered and can transmit data through electromagnetic waves, than with a similar research tool in the deep sea, where it has limited battery life and cannot send data through the virtually opaque waters. Even the ROVs, as advanced as they are, have their drawbacks, including their size, roughly that of a small car. "They're big, they've got lights on them, they're noisy, and they're slow," Matsumoto explains, "which means that everything we see down there are the things that can't see us, can't hear us, can't feel us, and are too slow to get away from us. We're missing a huge part of the picture." He pulls out a picture of a lancet, a three-foot-long fish with a muscular, streamlined body. "The last two months they've been washing up on the beaches all up and down California, [but] we don't know anything about them. We assume they're important predators down there because their mouths are huge and filled up with



The Monterey Submarine Canyon and California coastline. The canyon, which is as much as two and a half miles deep in places, stretches from the central California coast 60 miles out to sea.



©2000 MBARI

Top to botttom:
Praya dubia;
sponges seen on
Davidson Seamount;
hydromedusa jelly
Crossota rufobrennea;
sea cucumber

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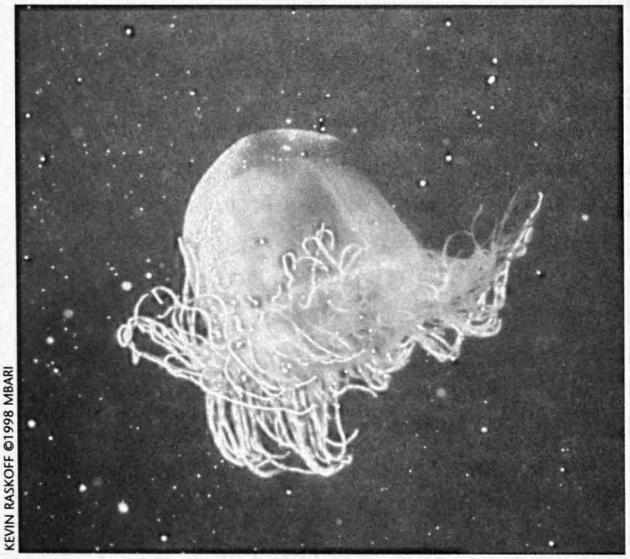


KEVIN RASKOFF ©1998 MBARI

DAVE WROBEL ©1995 MBARI

teeth. But nobody's ever seen one live in the field. That's also true with things like the giant squid. This is a big animal. It's a dominant predator. We've never seen it [in the field]."

OUTSIDE MONTEREY CANYON, the deep sea remains even more mysterious, but researchers worldwide are slowly learning more about it. In May of 2002, a team of researchers from four marine science institutions traveled 75 miles off the coast of Monterey on the first extensive expedition to explore the Davidson Seamount. Underwater volcanoes known as seamounts are scattered throughout the world's oceans and are believed to be biological hotspots, providing a variety of deep-sea habitat on their rocky surfaces and making surface waters above more productive. Davidson, the largest in a chain of seamounts along the California coast, is 25 miles long and rises over 7,800 feet above the seafloor, yet is still 4,000 feet below the ocean's surface. Dr. Andrew DeVogelaere, marine scientist at the Monterey Bay National Marine Sanctuary, acted as chief scientist and co-principal investigator for the expedition, which included geologists, marine biologists, educators, and resource managers. "It's a unique bump offshore, a very dramatic geologic feature that had people curious ever since it was originally mapped. Though nobody had looked at it very carefully, people had an intuitive feel that it was an important spot," he said.

The expedition team spent eight days exploring Davidson with the ROV *Tiburon*—charting maps, logging video, and collecting samples. They saw an unidentified "mystery mollusk" with beautiful wing-like fins that seemed to fly through the water, and big spider-like crustaceans walking across the bottom. "Whenever we came up the seamount, it was like a surprise package," says DeVogelaere. "It was very exciting for us just to see these strange creatures." Atop the ridges were clusters of feathery bamboo coral, giant white sponges as big as garage doors, and deep-sea corals towering over 12 feet high. "Typically when you go diving you think of these corals as groundcover," says Dr. Randall Kochevar, science communications manager at the Monterey Bay Aquarium. "What we were seeing on Davidson were trees. We were driving [the ROV] through a forest."

One of the main objectives of the Davidson expedition was to determine whether the seamount deserves to be included in the Monterey Bay National Marine Sanctuary. The sanctuary, which celebrated its tenth anniversary this past September, encompasses 276 miles of shoreline, stretching from Rocky Point just seven miles north of the Golden Gate Bridge to

Cambria Rock in San Luis Obispo County, and extends an average distance of 30 miles from shore, covering 5,322 square miles of open ocean. "We know a fair amount about kelp forest, the continental shelf, rocky shores, and we have a lot of these areas protected within sanctuaries," says DeVogelaere. "But in no sanctuary is a seamount protected anywhere in the ocean." The sanctuary's management plan is currently being reviewed by the National Marine Sanctuary Program to make sure it still fulfills its mission of conservation and protection. Policy-makers can use data collected from the expedition to determine whether to redraw the borders to include Davidson and other seamounts, protecting them from activities such as oil drilling and mineral exploration, dredging and dumping.

As remote as it is, the Davidson Seamount is not untouched by human activity. The expedition found litter scattered on the seamount's slopes, all well preserved in the cold, dark waters. "What I found interesting but also disconcerting in our ROV surveys," says DeVogelaere, "was that, as we were going up the sides of the Davidson Seamount, essentially looking at places on the Earth that nobody has ever looked at before, we did come across things like beer cans, a 40-year-old milk bottle, a broom, a curtain, a newspaper. And it sort of makes you stop and think. A place that if it were drained would surely be a national monument of some kind, people don't even know it's there and they're just dumping their stuff off right above it."

TRASH ALSO MAKES ITS WAY down into Monterey Canyon, along with pesticides and other chemicals. Although some contaminants are dumped directly into the oceans either on purpose or by accident, the majority come from non-point source pollution—urban and agricultural runoff washing down storm drains, into rivers, and out to sea. "Exxon *Valdez* was a terrible tragedy, but that amount of oil gets into the oceans often," says Matsumoto. "Every time there's a rain after six months without rain, you can get easily that much oil coming into the ocean, just off the streets. Everything you put in the street, every time you wash your car, every time you mow your lawn, everything that goes into the gutters that gets rinsed out by the next rains, all of that dumps into the oceans and is untreated and unfiltered."

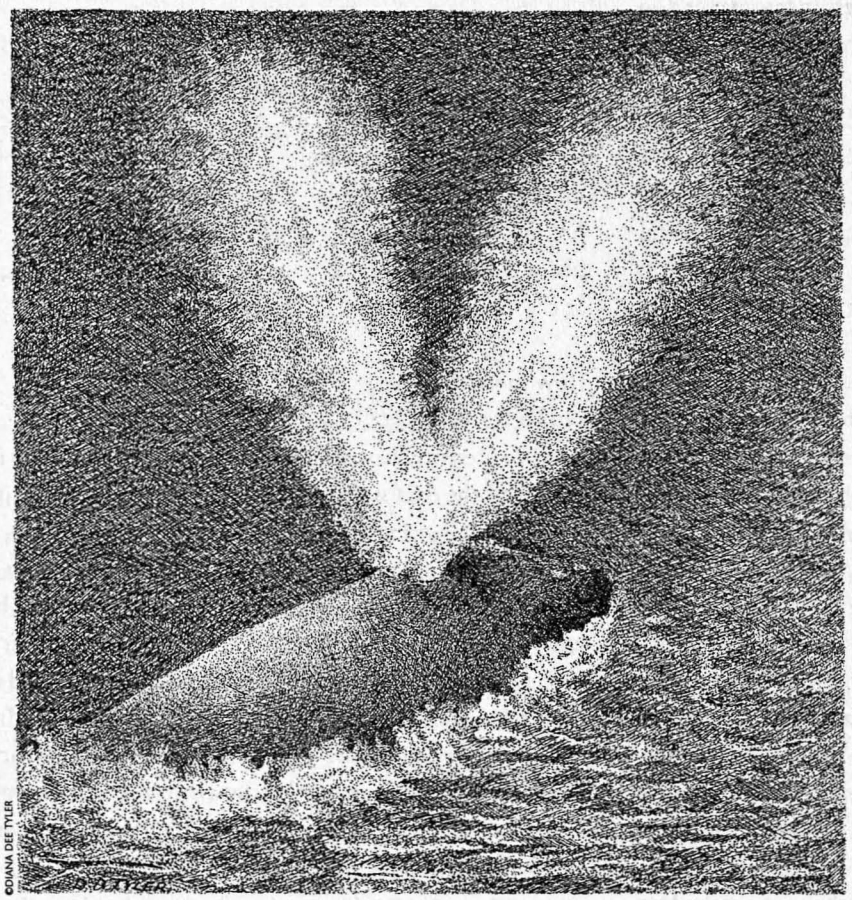
Deep-sea habitats are coming under increasing pressure by the same forces affecting land. For example, the deep sea is currently being considered by the U.S. Department of Energy as a dumping ground for the greenhouse gas carbon dioxide (CO_2) created by the burning of fossil fuels. In theory, liquid carbon dioxide could be pumped into the deep sea where, under the extreme pressure and low temperatures, it would turn into a solid lake of carbon dioxide hydrate on the ocean floor. Because the ocean can actually absorb a great deal more CO_2 than it currently contains, a solid carbon dioxide lake would slowly dissipate into the seawater. It's all very neat in computer models and controlled laboratory tests, but in preliminary field experiments, the liquid CO_2 has behaved unpredictably. It sometimes reacts violently with seawater and sediments in the ocean floor, may or may not form a solid, and absorbs vast amounts of seawater, causing the carbon dioxide lake to become much larger than expected. Says Matsumoto, "The biologists are interested in this because, of course, if you put a solid lake of CO_2 on the ocean floor, whatever is on the ocean floor is going to be buried under carbon dioxide and isn't going to do very well."

In many ways, life as we know it depends on the oceans. Each year, humans harvest 100 million metric tons of food from the sea. Scientists are researching antibiotics, antiviral agents, and other pharmaceuticals that can be extracted from deep-sea sponges and soft corals. The oceans also help regulate Earth's climate. They distribute heat from the equator to the poles, play a vital role in the water cycle that brings rain to the continents, and produce half of the oxygen in our atmosphere. The deep sea also contains a huge diversity of life. Based on the immense size of the habitat and the variety of organisms found there so far, it may even contain a majority of Earth's species. But most of the ocean, the largest biome on the planet, has never been seen.

"Ninety-five percent of the living space on Earth is in the deep sea," says the Monterey Bay Aquarium's Webster. "It's mysterious. We know practically nothing about it. We've explored only 1% of it so far, worldwide. And when you realize the way water circulates through the oceans and the oceans interact with the atmosphere and it's all intertwined, you realize it's all connected. It's something that's said so often it becomes trite, but it's true. Basically, life would not exist on Earth without the oceans." ☾

Carol Hunter *is a freelance writer based in San Francisco. For more information, contact the Monterey Bay Aquarium Research Institute at 831-775-1700 or www.mbari.org and the Monterey Bay National Marine Sanctuary at 831-647-4201 or www.mbnms.nos.noaa.gov/.* ⇐ *This article originally appeared in* Terrain *magazine, published by the Ecology Center in Berkeley, California (510-548-2220 or www.ecologycenter.org).*

Endangered Right Whales



Under the Shadow of Ships

A Conversation with Amy Knowlton and Moira Brown

NORTHERN RIGHT WHALES have been on the wrong side of human technology for close to 1,000 years. Hunted to the verge of extinction before the Puritans made a beachhead on the Atlantic shore of North America, these 40- to 50-foot black baleen mammals still gently ply coastal waters in search of copepods and other zooplankton.

Though the species hasn't been hunted since a 1935 League of Nations agreement (and was protected by the International Whaling Commission in 1946), it hasn't recovered. It seems that the deliberate harpooning of these surface-loving, oil-rich giants (hence the "right" whale to catch) has been replaced by a more insidious accidental "take" in the form of ship collisions and fishing gear entanglement.

In the fall 1997 *Wild Earth* (vol. 7, no. 3), Robert Stevenson presented an overview of right whale biology and conservation status. Today, biologists continue the effort to clarify the causes and dynamics of right whale endangerment—and to secure protections for them into the future. Two of these research scientists are reaching across international boundaries on behalf of the right whale: an American, Amy Knowlton, with the New England Aquarium in Boston, and a Canadian, Moira ("Moe") Brown, who works jointly for the Center for Coastal Studies in Provincetown, Massachusetts and the Canadian Whale Institute in Bolton, Ontario. *Wild Earth*'s assistant editor, **Joshua Brown,** spoke with them on December 17, 2002.

right whale spout, pen-and-ink by D. D. Tyler

large ship goes by that you might assume would wake it up, but it doesn't. So there is something mysterious going on there. If a whale doesn't wake up it's a problem—or if it wakes up and swims in front of a ship it's even worse.

MB: To give you a sense of what these big vessels are like, if one is cruising along at 15 knots, it would take three miles to stop. We have to treat the whales as a navigational hazard, with boats planning way ahead of time. A 1,000-foot-long ship coming out of Saint John, New Brunswick cannot slalom around right whales.

What actually happens to the whales when they get hit?

AK: Sometimes the blunt trauma is enough to knock them unconscious and they drown. There was one female whose death was witnessed in the Bay of Fundy; she must have been bled out internally because she went into huge death throes, thrashing around and then just rolled over on her side, dead. We have seen carcasses with a series of propeller cuts that killed the animal instantly. There was another animal in Cape Cod who had been struck probably 10 days prior to the time she died; it appeared she died of septicemia, an infection.

There is a lot of effort to document every right whale death. If we find a carcass, the National Marine Fisheries Service has mandated that it gets towed ashore. The aquarium has a contract through the fisheries service to respond to all right whale mortalities. We'll do the necropsy, and sometimes we'll see no external evidence of the strike. But as we flense down to the bone through the muscle, we'll see evidence of bruising and broken bones.

MB: The best you can hope for is that a whale struck by a ship has its spine broken and dies instantly. I think a lot of these animals suffer.

Where are the most important habitats for right whales?

AK: Three areas in U.S. waters are designated critical habitats under the Endangered Species Act. First is a stretch from Georgia Bight down to midcoast Florida; this is the only known calving grounds for northern right whales. The whales also migrate north along the coast to get into Cape Cod Bay and the Great South Channel—the other two ESA designated habitats. Also, in the mid-Atlantic migratory corridor, we see a high number of ship strikes; this is an area that needs protection, too.

MB: In Canadian waters the two most important habitats are the Bay of Fundy and Roseway Basin, an area south of Nova Scotia.

AK: We do have right whales in Cape Cod Bay in the winter. But even if you tally all the whales there and in the southeast U.S. in the winter, we are still missing better than 60% of the whales in the wintertime. We do not know where they go.

Earlier, you used the metaphor of a street to describe shipping lanes. On land, roads cause habitat fragmentation. How comparable are shipping lanes to roads?

MB: Unlike paved roads, shipping lanes present no physical boundary. But, like roads, shipping lanes do have different levels of traffic density. Compare Interstate 89 up through Vermont versus I-95 through Connecticut. The shipping lanes in the Bay of Fundy are more like I-89: 1,000 ships a year, 2,000 transits, four to five ships a day. That's nowhere near the concentration of the very busy shipping areas like you find down in Florida.

Although there are no physical boundaries created by shipping lanes, we have been trying to learn if there are acoustic boundaries. There has been some interesting work done with other species. For example, bowhead whales have to migrate past oil rigs and icebreakers and deal with all kinds of in-the-water noise. These studies seem to show that—if the bowheads are heading for their feeding grounds—the animals swim right through the disturbed areas. This could be resulting in hearing loss for the animals. Right whales also do not appear to be displaced—at least based on 20 years of study, a relatively short period of time in terms of whale years—from a habitat because of human-generated noise.

AK: I agree there hasn't been displacement—the whales aren't responding to the noise at all. This makes it *more* difficult to find a solution. The reality is that these animals are probably exposed to noise from ships constantly.

MB: If your computer is on right now, you probably don't hear it. But when you turn it off, you realize how much noise it makes. There's a similar ecological concern when dealing with habitat disturbance. A colleague at Cornell has made the analogy that for whales swimming off the coast of California, it's like being at a rock concert 24 hours a day. We don't know how that affects reproduction, day-to-day activities, communication. It does seem clear that one of the biggest steps the shipping industry could take over the next few decades for all marine life is to make quieter ships.

AK: All ship traffic in the Bay of Fundy was closed for several days after the September 11th disasters. The teams that went out to make recordings said it was eerily quiet, and the right whale sounds were amazing.

MB: I was out on the boats those days. We had a hydrophone in the water and we were hearing echoes from right whale calls in the 100-hertz range, which are normally all blanked out. If these are usually blanked out from ship noise, the whales must have a more difficult time discerning calls at a lower frequency—this must be a form of habitat disturbance.

Amy, what needs to happen to improve protections for right whales in U.S. waters?

AK: In the southeast U.S. there is a different set of problems than we face in the Bay of Fundy, where we have been able to move the shipping lanes around the whale aggregations. In the Southeast there is nowhere else for these ships to go; they have to come into port and pass right through the high-use areas—and there is a lot more traffic into these ports.

Bruce Russell and I co-authored a series of recommendations that are now being reviewed by an internal National Marine Fisheries Service working group ["Recommended Measures to Reduce Ship Strikes of North Atlantic Right Whales" available at www.nero.nmfs.gov/whaletrp/]. The thorniest recommendation—that a lot of people in industry and the government have issue with—is about speed.

Anywhere from 10–13 knots is considered a suitable speed reduction to provide better protection for right whales. But that is not based on a lot of hard science. There is an anecdotal paper I co-authored with a colleague on ship strikes from around the world of all large whale species. We had 54 incidents where the vessel speed and size was known. We learned that under 13 knots most of the incidents were not fatal or even very serious. But once ships, especially the bigger vessels, got over 13 knots we started seeing more lethal impacts.

A big question is: how do right whales respond to an incoming ship? If they do respond—and I believe that the whales do respond, at some point—then going 10 knots will give the whales a better chance to get out of the way than if the ship is going 22 knots. There is a perception among mariners that reduced speed would help the whales—but they don't want to admit that, because that would have huge implications for their industry.

What are these implications? Why is it so hard for the mariners to slow down a little bit?

AK: It's mostly about time. Time is so critical for these large ships; if they lose three hours, they might not get from one port to the next before the tide becomes too low to get into that port. Then they lose a whole tidal cycle and a lot of money.

Amy, your report suggests that the verdict is still out on new technologies, sonar, etc., to give ships more warning of whales. Is there promise there?

AK: The industry keeps hoping for a technological fix, so that they don't have to change the way they do business. They ask, "Why can't you radio tag each whale so we always know where every animal is? We'd gladly go around them if we knew where they were." But it is just not a feasible option. Not only is it too expensive, but also the right whales treat the tags like a splinter and the tag is out of there in a couple of months. Routing and speed have been identified as the only two presently viable solutions.

What are the keys to your success as conservationists?

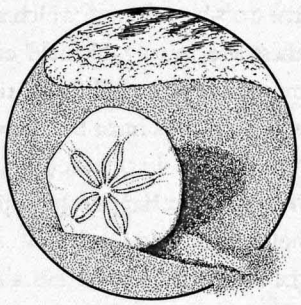
MB: We've been out there collecting the data, we've gotten seasick, we've spent hours pouring over photographs, matching animals, entering the data. (Amy even fell out of the sky one year in a survey airplane and had to sit in the water waiting for someone to pick her up.) We started out as volunteer interns, and we became lifers. We are into this right whale project for the rest of our working lives—and probably beyond because we won't be able to afford to retire! That brings a deeper understanding about these animals and passion about the issues.

When you imagine a best-case scenario—in terms of management protocols and the status of the whales, in the real world—say 20 years out, what do you see?

AK: If in the U.S. we could implement all the recommendations in that report, I feel like right whales might have a chance. If we could also strengthen regulations about fishing gear entanglements the animals would have a fighting chance. But it is going to require a real change in how mariners use the ocean. In the past they haven't had to consider an issue like this. It's a change in how they practice their living. We can succeed if we can get them to understand that nobody wants to put them out of business; we just want to change things enough that ships and whales can coexist.

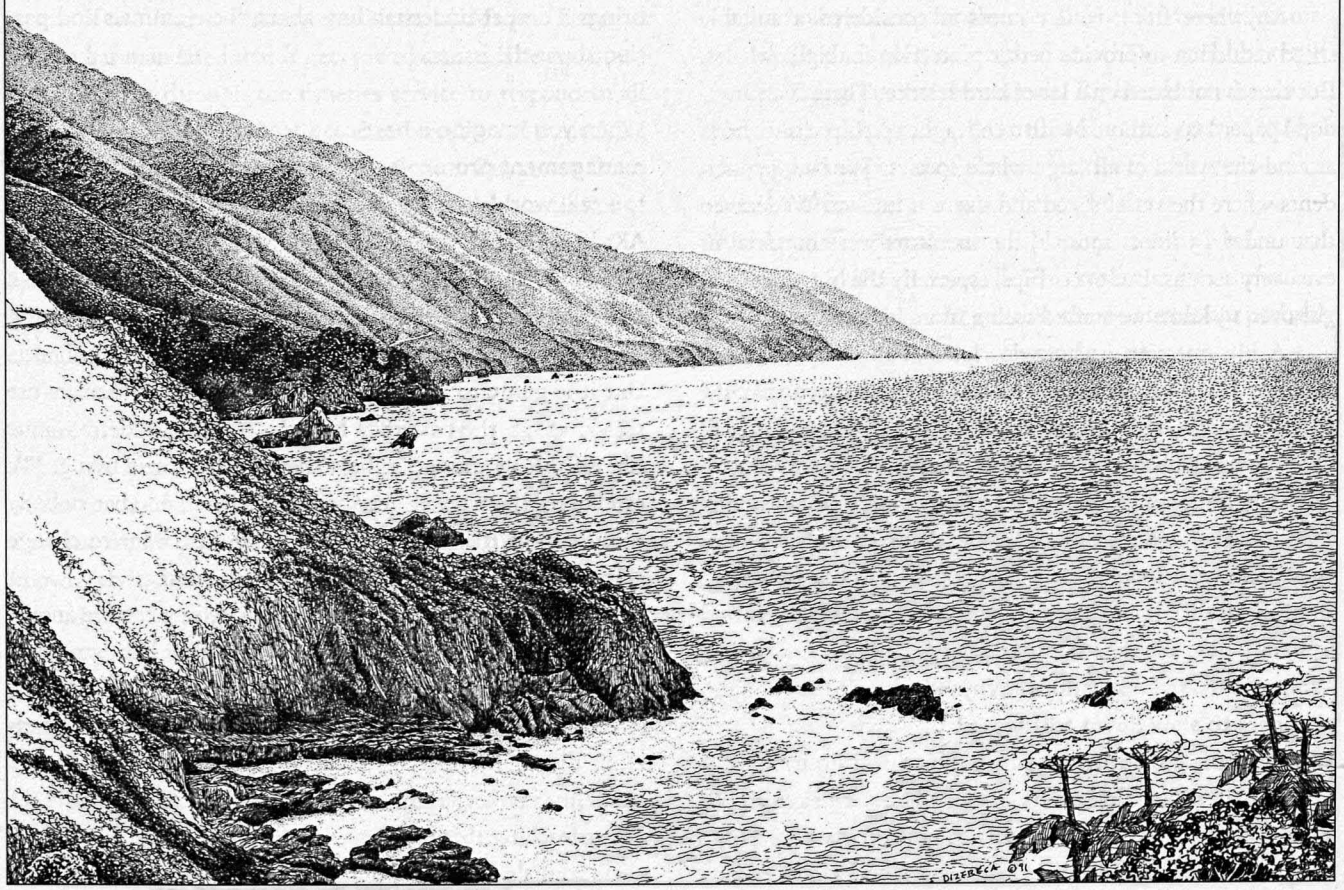
MB: We've got a lot of work to do; it is going to take another 10 or 20 years to protect the other critical habitats. It's a long-term investment in a long-lived species.

AK: But time is of the essence as well. There is population modeling that shows that, if we don't reduce the human-caused mortality, northern right whales might go extinct in 200 years. We're reaching that fine line where there might be no hope for these animals. We need public support for these whales. ❨



Conserving the Sea Using Lessons from the Land

by Bradley Barr and James Lindholm



pen-and-inks by Gus diZerega

THERE IS A WIDE DISPARITY between the total area of land and ocean under federal protective management. Of the total U.S. landmass (more than 9 million square kilometers including Alaska and all territories), approximately 18% is included in some form of protected area. In contrast, the total area of U.S. waters within the 200-mile Exclusive Economic Zone, or EEZ (including all state and territorial waters), is approximately 10.6 million square kilometers. Of this, a scant 0.4% is currently under federal protection, with an even smaller percentage, 0.0004%, actually contained in non-extractive reserves.

This disparity may be a function of time and accessibility. The oceans have until recently been widely considered to be vast and limitless, and efforts to preserve them are a recent phenomenon, while terrestrial areas are more readily accessible to the public and have a long history of public protection. For instance, it is understandable that the beauty and grandeur of the Grand Canyon would be valued and protected years before someplace such as the Monterey Canyon. As a geologic formation, this submarine feature of the California continental shelf and slope may be even more spectacular than its land-based counterparts, but its visual beauty and prolific resources are hidden in darkness, only to be seen in the lights of a submersible or remotely operated vehicle. The disparity may also rise from the vast differences in program budgets, with comparatively little funding being directed to marine protected area designation and management in the federal budget. And it may also be a result of considerable uncertainty over just what we want to accomplish with federal marine protected area programs. Here we discuss the many shared characteristics of the agencies charged with protecting land and water in the United States, and offer suggestions as to how experience in designating and managing public lands can inform the process of protecting the marine environment.

Protecting the land

The development of terrestrial federal public land management has resulted in a "toolbox" with a variety of tools for different tasks (such as the National Park, National Forest, National Wildlife Refuge, and National Wilderness Preservation Systems). The spectrum of federal public lands management programs starts with the Bureau of Land Management (BLM), which has some conservation goals but is more focused on producing natural resource commodities such as forage and minerals from the public lands under its purview. Operating principally under the authority of the Federal Land Policy and Management Act of 1976, BLM is charged with "the management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs for the American people...."

Next in line is the U.S. Forest Service. Deriving its authority from the National Forest Management Act of 1976, the Forest Service establishes conservation goals for the National Forest System, though it pursues these goals through multiple-use management, as opposed to any overarching emphasis on ecological preservation. This is the most protective sort of designation that might routinely permit and perhaps even encourage commercial extractive use of these areas.

Toward the other end of the conservation spectrum are the national wildlife refuges and the national parks, monuments, and preserves, which are designated to preserve areas for their natural values, while allowing compatible recreational use. While commercial extractive uses generally are not permitted, a broad range of recreational activities are allowed (although strictly managed) consistent with the National Park Service and U.S. Fish and Wildlife Service mandates to preserve these areas.

Finally, there is the National Wilderness Preservation System, which is used to preserve the most valued wild areas on BLM lands and in national parks, forests, and wildlife refuges. The goal here is entirely focused on preservation of the attributes that make that area "wilderness" as established under the Wilderness Act of 1964. As of this writing, there are 662 units in the National Wilderness Preservation System, totaling some 428,044 square kilometers of public land administered by each of the four terrestrial protected areas agencies mentioned above. Wilderness areas are designated by Congress under the Wilderness Act of 1964. While there is some variety in how each of these agencies manages wilderness areas under their authority, the diversity of programs provides a greater opportunity to find a "best fit" with the goals and objectives underlying the designation. At its center, however, is the clear mandate to preserve a legacy of wild public lands for this generation and into the future.

Protecting the sea

The management of publicly owned waters and seabed areas is, in practice if not in theory, quite different from that of public lands. Unlike the terrestrial realm, where public lands are but a small portion of the largely privately owned land-

mass of the United States, all the waters of the Exclusive Economic Zone (with a very few riparian exceptions) are owned in common by the people. As established through common law, and long supported in American case law, the state and federal governments hold these waters in trust for the public. In addition, the courts have held that these government stewards also have a duty to protect and preserve the public's interest in natural wildlife resources. Notwithstanding this well-established principle of common ownership of U.S. waters, some users have a strong perception of a special standing, and a few even believe that they actually own the resources and have a greater right to them because of some long-standing tradition of use, or a familial legacy. In most areas of the country, the public has not expressed much concern about the use and allocation of natural resources in these publicly owned waters, and as a consequence the stewardship and management of these ocean areas is strongly influenced by those who have the greatest economic stake in management decision-making. Clearly, the varied perceptions of resource ownership among managers, users, and members of the public have very significant implications for the preservation and management of marine protected areas.

Until recently, the management approach to marine resources was minimalist, owing in large part to the perception of the oceans as "vast and limitless"—a perception that has perhaps been contributed to by the apparent hesitancy of ocean and coastal managers to embrace a "public waters" management perspective like that of their counterparts on land. The resulting governance of these public waters has been largely regional in scope, targeted to individual activities or resources, and involving extensive participation in management from users, but little from the general public, in whose interest the resources are supposed to be managed.

In the past few years, there has been more interagency coordination, but there is much resistance to it by some resource managers who see the need to coordinate as confounding the process rather than making it more effective and efficient. It is therefore not at all surprising that so few marine protected areas have been designated compared with land-based conservation and preservation efforts.

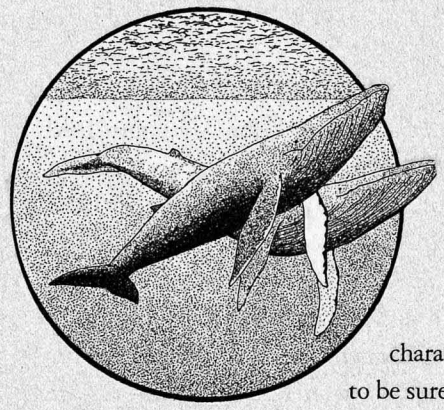
Toward a new paradigm

A system for effective management of marine resources and preservation of marine wilderness areas calls for a public waters perspective equivalent to public lands stewardship of terrestrial protected areas. If we envision such a system, the first level of management would be regional authorities focused on individual activities or resources, with a similar level of authority to that of the BLM. One example of such regional management programs is the National Marine Fisheries Service's implementation of the Sustainable Fisheries Act (officially titled the Magnuson-Stevens Fisheries Conservation and Management Act). This law focuses on managing the commercial and recreational exploitation of particular species of fish and shellfish. As part of implementing this law, seasonal and area closures may be established that target a single species or species assemblage. Such closures have been shown to influence non-target species and taxa. Only recently, however, has habitat protection become a part of a nationwide management effort under the act through the identification and management of essential fish habitat. The Sustainable Fisheries Act has a limited context, largely focusing on the relationship of essential fish habitat to sustainable exploitation of the target species or species complex. Even in area-based management, the law's ability to address other uses not associated with fishing may be quite limited. For example, while the use of mobile fishing gear may be prohibited in such fragile habitats as coral reefs, the authority to prohibit other damaging activities (e.g., anchoring of vessels not engaged in regulated fishing activity) is missing from the Sustainable Fisheries Act. While there have been attempts to broaden the scope of management under this law to embrace ecosystem concepts, such a change in its single-species approach is not likely to happen quickly.

Another law that has resulted in limited area-based management of marine waters is the Endangered Species Act. Under this law, certain areas can be set aside as critical habitats for listed species. Only a small number of critical habitats have been designated for marine species, and only a very few of these are in offshore marine areas. One example is the critical habitat designations in the Great South Channel (located between Georges Bank and Cape Cod, off the coast of New England) and Cape Cod Bay for northern right whales. Like the Sustainable Fisheries Act, whatever management that does occur in these areas is limited to this single (in this case, listed) species and its habitat. The authority to manage human activities in these right whale critical habitats is potentially broad, but the designations in this example brought no new restrictions or protections.

The Sustainable Fisheries Act and Endangered Species Act, as well as other federal laws such as the Clean Water

What is Marine Wilderness?



by Bradley Barr

ANYONE WHO HAS BEEN on the ocean alone, out of sight of land, has experienced some sense of solitude and insignificance. "Vast" is a word seemingly invented for oceans, but is "vast" enough to make any part of the ocean a wilderness?

Reaching consensus on calling something "wilderness" is almost never without controversy. It is only slightly more straightforward on land, with almost 40 years of legislative history under the Wilderness Act. Given the considerable connectedness of marine ecosystems, the often inadequate information available for these areas, and the importance of the ocean's most productive and biologically diverse areas to commercial interests, calling something "marine wilderness" is likely to be hotly debated. Nevertheless, some of the same attributes that people ascribe to "wilderness" on land are those that could be put forward as describing marine wilderness: vast, inhospitable, beautiful, deserted, mysterious, threatening, free and—as grizzly bear cinematographer Doug Peacock has said—containing big, mean animals that can kill you. Certainly, the Wilderness Act's phrase, "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain," must be a cornerstone of a working definition for marine wilderness.

Given the global nature of human influence over ecosystems, finding any place that is "untrammeled" requires the use of a relative scale of measurement.* The history of the wilderness movement includes some very acrimonious debates over the question of whether wilderness needs to be "pristine" (a position viewed by some as a way to avoid designating wilderness because there are few, if any, pristine environments to be found anymore). Accepting such a relative scale *a priori* may avoid the controversy. The challenge is to determine the lower end of the scale for the "untrammeled" character of any marine area to be sure we are not being overly lenient in its application. Perhaps one of the ways to approach this is to seek out areas that are as free of human influences as possible, and where impacts can be limited or controlled through aggressive protection. Work in Glacier Bay National Park and Preserve to phase out commercial fishing, severely limit the air- and water-quality impacts from cruise ships, and establish areas where motorized vessels are prohibited, as well as the clean-up and source-reduction efforts to address marine debris in the Northwest Hawaiian Islands, are examples of efforts to restore these areas to an untrammeled state—and make these useful benchmarks against which other areas can be measured.

Another obvious characteristic of wilderness is remoteness. Yet geography seems to provide only partial refuge from "civilizing" influences. Debris has been transported to the Northwest Hawaiian Islands over great distances by ocean currents, not dumped there directly. Perhaps this "long-distance trammeling" must be evaluated differently than the building of a road; it is more appropriately compared with atmospheric deposition of contaminants in terrestrial wilderness areas.

Benchmark sites for marine wilderness should also contain fine examples of particular habitats, such as the coral reefs at Tortugas Ecological Reserve in the Florida Keys National Marine Sanctuary and the inshore marine areas of the Gulf of Alaska at Glacier Bay. Having these ecosystem exemplars provides opportunities for research needed to understand and better manage marine protected areas elsewhere.

For marine areas, the language of the Wilderness Act that holds that wilderness is a place "where man himself is a visitor who does not remain" perhaps might be measured in terms of how frequently the area is visited or how consequential those visits are with respect to the quality of the wilderness experience. For some areas like Glacier Bay, which is visited by a considerable number of cruise ships each season, the critical question might be whether the wilderness experience is degraded by this visitation.

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* Editor's note: A trammel is a drag-net for fish, a net for catching wild birds, or a hobble for a horse; figuratively, it is an impediment to free action, a constraint, or a hindrance. Thus untrammeled is unimpeded, unconfined, free. For a discussion of Wilderness Act author Howard Zahniser's deliberate use of the word untrammeled and of its frequent misinterpretation as untrampled, see Douglas W. Scott's "'Untrammeled,' 'Wilderness Character,' and the Challenges of Wilderness Preservation" in the fall/winter 2001–2002 *Wild Earth.*

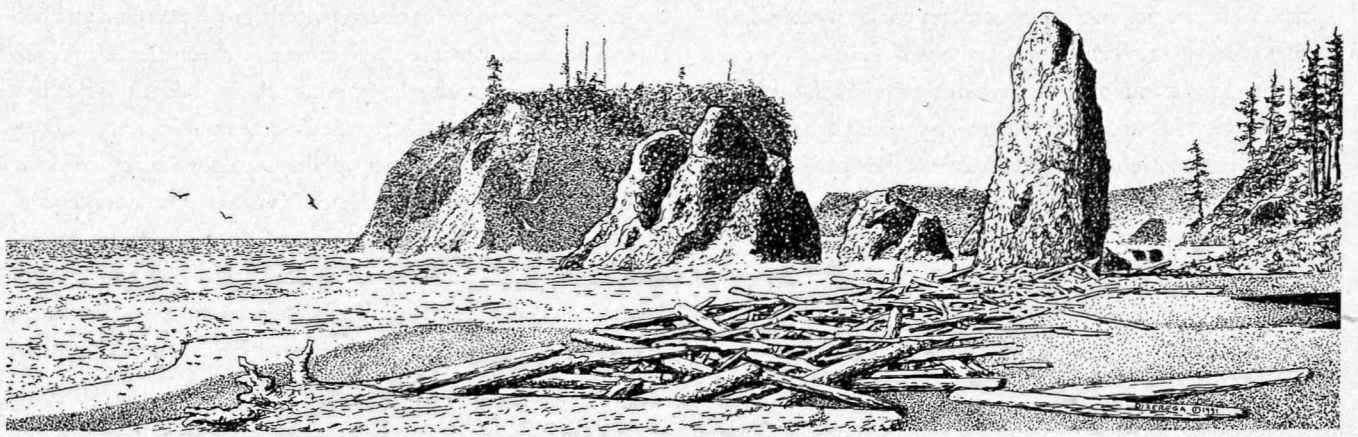
pen-and-ink by Gus diZerega

Act, the Oil Pollution Act of 1990, the Migratory Bird Treaty Act, and a host of others, provide the basis for ocean management akin to the role the Bureau of Land Management plays in the public lands matrix. These laws were established to manage, conserve, and preserve marine areas and resources from specific human activities that occur in public waters. The mission of these laws is to ensure that public waters are used appropriately; extractive uses are managed so that the public interest is served. While more communication and coordination would be helpful—and considerable attention is being paid to the implementation of integrated coastal management both in the U.S. and around the globe—these programs provide the basic resource management for the Exclusive Economic Zone.

The next level of public waters stewardship, roughly comparable with the National Forest System, is the National Marine Sanctuary Program, which is under the authority of the National Oceanic and Atmospheric Administration (NOAA). The National Marine Sanctuary Act provides the authority to identify "areas of special national significance" and establishes "comprehensive and coordinated conservation and management" for these discrete areas of the marine environment in all U.S. waters out to the 200-mile limit (including state waters). The mandate of the program is to "facilitate to the extent compatible with the primary objective of resource protection, all public and private uses of the resources of these areas" not otherwise prohibited by other authorities. These areas are clearly focused on multiple-use management, permitting for-profit extractive uses such as commercial fishing (in many of the sites), and providing "comprehensive and coordinated conservation and management" in large part through the authorities of other agencies by helping them make decisions that will preserve the resources and those qualities that make them "nationally significant."

In the past few years, the National Marine Sanctuary Program has begun to seek greater preservation of marine biodiversity in critical habitat areas within and adjacent to the sanctuaries. It has been particularly successful with initiatives in the Florida Keys National Marine Sanctuary, where the Western Sambo Ecological Reserve and 18 sanctuary preservation areas have been designated. In 2001, the Florida Keys National Marine Sanctuary established the Tortugas Ecological Reserve, sometimes referred to as the "Tortugas Ocean Wilderness," an area west of Dry Tortugas National Park totaling more than 388 square kilometers. The National Marine Sanctuary Program has also been involved in another multi-agency effort to establish marine reserves at the Channel Islands National Marine Sanctuary. In 2002, the Channel Islands NMS, working in collaboration with the State of California, has taken the first step toward establishing a marine reserves network with the protection of approximately 453 square kilometers adjacent to the Channel Islands under state jurisdiction. A process is currently underway to designate marine reserve areas in federal waters managed by the Channel Islands National Marine Sanctuary adjacent to these state-protected areas.

As national marine sanctuaries are principally focused on multiple-use management, efforts to establish a higher level of protection and preservation are generally hard-won. They have required considerable time and effort, through consensus-based multi-stakeholder planning processes, to gain the



pen-and-ink by Gus diZerega

The ultimate question regarding marine wilderness is whether the future of these areas will be dominated by natural processes, and what level of management is needed to sustain the areas' wilderness character. For a marine area to qualify as wilderness, how the area is likely to be affected by the presence of people, the capacity of the area to recover from the impacts of past human disturbance, and whether the agency managers have the technical ability and political will to protect its wilderness character need to be taken into account.

Marine wilderness, as a relatively recent expansion of the concept, can benefit from the long experience of terrestrial wilderness managers. While there has been some concern expressed about the progress of wilderness management within the wilderness community, the responsible agencies, especially the National Park Service, have given considerable thought to how we effectively protect wilderness. In the process of developing first principles for marine wilderness, what has been learned on the land is extremely useful. Surveying the body of information on wilderness management, a number of elements rise to the surface that may help to answer the "how to" question for marine wilderness. While the fit may not be perfect, the concepts are instructive.

MINIMUM REQUIREMENT ANALYSIS. Under provisions of the Wilderness Act, agencies are required to conduct an analysis of whether a given activity is appropriate and if so, how it can be done with minimum impact on the wilderness qualities of the area. Guidance has been provided on how this determination is conducted, and a "Minimum Requirement Decision Guide" developed by Arthur Carhart National Wilderness Training Center is available on its web page: http://carhart.wilderness.net/. Clearly, some activities—including management actions—can significantly affect the wilderness experience; a similar analysis would be appropriate for marine wilderness.

BACKCOUNTRY ACCESS PERMITTING. One way that impacts on wilderness qualities are minimized is to limit human use of the area. National parks require special permits in very sensitive areas to limit access. While limiting access in open ocean areas presents some challenges, the concept is already being tried in the Tortugas Ecological Reserve.

ROADLESS POLICY. With some limited exceptions, no roads are permitted in terrestrial wilderness, and motorized vehicles are excluded. Clearly, there are no roads in the ocean, but there are designated shipping lanes and customary routes between ports that vessels are more likely to use on a regular basis, as well as certain offshore areas where vessels often travel to engage in some activity (such as fishing). The message here might be that marine wilderness should not include designated shipping lanes, customary inter-port routes, or areas where vessels are likely to congregate. The use of motorized vessels for access to many offshore areas may be unavoidable, but the way to provide safe access might be determined through minimum requirement analysis. For some inshore areas, vessel access might reasonably be limited to canoes and kayaks, as in wilderness areas in Glacier Bay National Park and Preserve.

LIMITED ACCOMMODATION OF PRIOR USES. The Wilderness Act and various implementing policies afford a special status to prior uses such as mining, grazing, and, in places, motorized vessel and aircraft use, but within strict limits. While private ownership of ocean waters and the seabed is very limited, leasing for hard minerals and oil and gas extraction are reasonably common in coastal waters, and aquaculture facilities involve exclusive-use issues. Aquaculture activity may be somewhat analogous to grazing, and has been equally controversial. Oil and gas, hard minerals, sand and gravel and (perhaps soon) gas hydrate mining all could be construed as "mining activities" under the Wilderness Act. Policies mandating acquisition of mining rights for marine wilderness could provide an interesting strategy for marine minerals and hydrocarbon leases. At least in the National Marine Sanctuary Act, a mechanism exists that requires certification of existing leases when a site is designated, and can be conditioned if necessary and appropriate (but usually boundaries are crafted to avoid including such existing uses). The trick here will be to provide reasonable accommodation, when it is appropriate, without "giving away the farm" in terms of preserving wilderness values. Under this heading, there is a special case of "rights-based prior uses" that will likely emerge in discussions of marine wilderness. This has to do with the issue of commercial fishing. Under the Wilderness Act, all commercial activities are prohibited, except for those that are needed to enhance appropriate recreational use. Presuming that the model of banning commercial activities is carried forward into marine wilderness, commercial fishing would be prohibited. The ocean, seabed, subsoil, and the living and non-living resources there are owned in common by the people of the United States, and the agencies act as stewards for the owners. Many fishermen, however, believe they have ownership rights over their fishing grounds, and maintain that if

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support of commercial and recreational users of the areas to be preserved. Only a small fraction of the area that has been designated as national marine sanctuaries can be characterized as fully protected marine reserves. Tundi Agardy has suggested that the total area protected by national marine sanctuary designation is "too small to promote conservation of marine ecosystems" because "sanctuaries cater to commercial and recreational needs and have no teeth whatsoever for providing the necessary controls on damage."

There has also been some general concern raised that such multi-stakeholder processes may, through too much compromise and by vesting considerable power in local user groups, result in inadequate protection for critical resources and habitats. While multiple-use management of marine areas that allow commercial and recreational extractive use may be an effective tool to conserve resources in areas that are ecologically robust and resilient, areas that are more fragile and subject to damage from individual or collective human uses may require authorities that more directly embrace preservation.

THERE ARE 51 units of the National Park System that manage marine resources within their boundaries. Under our proposed system, the park service would fill a similar role in the ocean as it does on land. Some examples of national parks, monuments, and preserves that include large areas of the marine environment are: Glacier Bay National Park and Preserve (2,434 square kilometers), Biscayne National Park (665 square kilometers), Everglades National Park (2,072 square kilometers), and Channel Islands National Park (roughly 500 square kilometers). The National Park Service has also focused special attention on preserving ocean areas that include coral reefs. In the National Park System there are nine coral reef areas, totaling 994 square kilometers, located in the Atlantic-Caribbean and Pacific regions. While the park service manages no areas that are entirely ocean, its authority to manage and designate ocean areas already seems to be in place—perhaps only some explicit references to protecting marine wildlife need to be appended to the Organic Act. The Canadians have a similar program, designating what are called "marine conservation areas" under the authority of Parks Canada.

Finally, there is the issue of designating and protecting marine wilderness—perhaps the most difficult, but most critical, task at hand. The Clinton Administration advocated for marine wilderness designations in its Ocean Initiative. The issue, in our minds, is not whether this is a good idea, but how to get the job done. A possible answer is to formally extend the National Wilderness Preservation System into the ocean, as suggested by Tatiana Brailovskaya. This would require some changes to the Wilderness Act to reference NOAA (as stewards of the National Marine Sanctuary Program and managers of fisheries under the Sustainable Fisheries Act and the Endangered Species Act) and to add explicit references to preserving marine wilderness. A first step has already been taken in Alaska, with the designation in Glacier Bay National Park and Preserve of 215 square kilometers of marine wilderness added to the National Wilderness Preservation System and managed by the National Park Service. While these pioneering initiatives in Glacier Bay have been extremely controversial, the agency has been able to use its exceptionally strong public constituency to fend off opposition.

While recent Congresses seem to be disinclined to designate much new wilderness and some critics have expressed concern about the existing implementation on land, the effort for new wilderness designations might benefit broadly from adding the current public constituency for marine preservation to the chorus already advocating for wilderness on land. While the public has been slow to rally to the support of marine protected areas, education and outreach programs related to marine environmental issues (such as those of the Marine Conservation Biology Institute, Oceana, and SeaWeb, for example) are working hard to improve this.

For the National Marine Sanctuary Program, adding the National Wilderness Preservation System mandate might provide a more appropriate authority to protect and preserve wilderness areas within sanctuary boundaries. For the National Park Service, it would provide park managers with the opportunity to wade into the water deeper than their knees.

Through a more effective and creative use of some existing tools, and minor modification of others, the toolbox available to conserve—and especially to preserve—the United States' marine environment would be expanded significantly under the scenario proposed. No longer would everything look like a nail simply because the only tool available was a hammer. There is no doubt that land and water are different. Some of the challenges faced by public lands managers would be wholly unfamiliar to those who manage marine protected areas. However, there are clearly more similarities than differences, and the opportunity to share expe-

rience and expertise could be the tide that lifts all boats. It can help expand what has been called "America's best idea" from the public lands into our public waters. ☾

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Bradley Barr *(Brad.Barr@noaa.gov) is senior policy advisor and East Coast, Gulf of Mexico, and Great Lakes regional coordinator in the Office of the Director of the NOAA National Marine Sanctuary System, Woods Hole, Massachusetts.* **James Lindholm** *(James.Lindholm@noaa.gov) is an adjunct research scientist at the National Undersea Research Center at the University of Connecticut and is science coordinator for Stellwagen Bank National Marine Sanctuary in Scituate, Massachusetts.* *This article is adapted from a fully referenced version that was originally published in* The George Wright Forum, *volume 17, number 3, pages 77–85 (©2000, The George Wright Society, Inc., all rights reserved).*

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you take this "right" away, they must be compensated. While challenging precedents may have been made in "compensating" fishermen for displacement from wilderness areas of Glacier Bay, this approach is not economically viable in larger areas with more extensive fisheries, and may greatly impede progress generally with regard to preserving marine wilderness.

OTHER ISSUES. There are several other issues related to terrestrial wilderness management that could also apply to the marine realm, including the need for wilderness plans, greater accountability among wilderness managers, wilderness training, and a strong commitment to effective enforcement. These tools and strategies provide a good start to developing effective protection of marine wilderness. Undoubtedly others will be needed, but utilizing what is already available helps us avoid having to reinvent the good existing tools.

CONCLUDING OBSERVATIONS. Marine protected area managers have much to learn from terrestrial wilderness managers—and the latter might also learn a thing or two in this cross-talk. Most wilderness values are common to both land and sea. The Wilderness Act (appropriately amended to include agencies such as NOAA with marine preservation authority) would provide a solid foundation for identifying and designating marine wilderness. In addition, expanding our collective perception of wilderness to include marine wilderness would broaden the base of public support for wilderness generally, and provide us with additional opportunities to do the job effectively.

Americans have a heritage of exploration and a collective drive toward wild areas. Wilderness is part of who we are as a people. Oceans are our last true wilderness: "inhospitable, alien, mysterious, and threatening" but also "beautiful, friendly, and capable of elevating and delighting us" as wilderness is so eloquently, albeit unexpectedly, described in dictionaries. Wilderness, novelist Wallace Stegner has said, "is part of the geography of hope." Marine wilderness seems to be unquestionably part of that geography. ☾

This sidebar is adapted from "Getting the Job Done: Protecting Marine Wilderness" by Bradley Barr, pages 233–238 in Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands, *edited by David Harmon (Hancock, Michigan; ©2001 The George Wright Society, all rights reserved). The views expressed herein are those of the author and do not necessarily reflect the views of the Department of Commerce, NOAA, or any of its sub-agencies.*

FROM GRIZZLY BEARS to furbish louseworts, well over a thousand terrestrial species are protected under the federal Endangered Species Act (ESA)—but only a few dozen marine species receive such protection. With just two exceptions, these species fall into four categories: marine mammals, sea turtles, seabirds, and anadromous or estuarine fish. Somewhat paradoxically then, listed marine species are largely air-breathers or dependent on freshwater habitat during part of their life cycle. The two exceptions are a marine invertebrate, the white abalone (*Haliotis sorenseni*), and a marine plant, the Johnson's seagrass (*Halophila johnsonii*). The relative paucity of and narrow slice of the taxonomic spectrum represented by listed species certainly does not mean, however, that marine wildlife is everywhere robust and thriving. Rather, the limited number and diversity of listed marine species is a classic example of "out of sight (in this case under water), out of mind." Until recently, very few organizations or individuals have been actively advocating for the imperiled creatures of the sea. In the past few years, however, several conservation groups and marine scientists have worked to add deserving marine species to the official lists of species protected by the ESA. While these efforts have so far yielded only limited success, they have started processes that in a few years' time should provide substantial additional protections for marine species and their habitats.

ON MAY 29, 2001, the National Marine Fisheries Service (NMFS) formally listed the white abalone as "endangered" under the Endangered Species Act.* The listing came in response to petitions from the Marine Conservation Biology Institute and the Center for Biological Diversity. (Under the ESA, the National Marine Fisheries Service and the U.S. Fish and Wildlife Service can list a species of their own volition or in response to a citizen petition, but in practice, endangered species are virtually never listed by either agency absent a petition.) While invertebrates in general are under-represented on the Endangered Species list (only 14% of the over 1200 species listed in the U.S. are invertebrates), prior to the white abalone's listing, marine invertebrates had been singularly absent.

Abalone are marine gastropods with a flattened spiral shell. White abalone, one of eight abalone species on the West Coast of North America, historically ranged from Point Conception, California, to Punta Abreojos, Baja California. The white abalone is the deepest-living of the West Coast abalone, found at subtidal depths of 20–60 meters. It is also among the largest, averaging 5–8 inches in length, but occasionally reaching upwards of 10 inches. The species, considered by many to be the tastiest of the West Coast abalone, was the subject of an intensive commercial fishery in the late 1960s and early 1970s. The fishery lasted less than a decade before the species was reduced to below commercially viable numbers. Overharvesting so depleted abalone populations that most surviving white abalone were left too far apart to reproduce successfully. From a pre-exploitation abundance of between two and four million individuals, perhaps only 2,500 white abalone remain. Until recently, the consensus among fisheries managers was that species with such high fecundity as the white abalone could not possibly be driven to extinction by commercial harvest. The white abalone example, however, is proof that rapacious exploitation can be as catastrophic to an easily reproducing marine invertebrate as it is to species with much more limited reproductive capacities such as whales and other marine mammals.

The black abalone (*Haliotis cracherodi*) may soon join its cousin on the Endangered Species list; it also suffers from overharvesting, compounded by a mysterious disease known as "withering syndrome." Likewise, the Hawaiian inarticulate brachiopod (*Lingula reevii*) and the Hawaiian sand anemone (*Heteractis malu*) are both threatened by overcollection and habitat degradation, and will likely be petitioned for ESA listing. As many as a dozen other Hawaiian marine invertebrates are sufficiently threatened to warrant listing, while in the Caribbean, three formerly widespread Acroporid corals are also on an extinction trajectory. These species may be just the tip of the marine extinction iceberg; they all occur in U.S. waters and are sufficiently studied so that their declines have been noticed. Throughout the world's oceans, numerous marine invertebrates—many unstudied and unnamed—may be quietly disappearing.

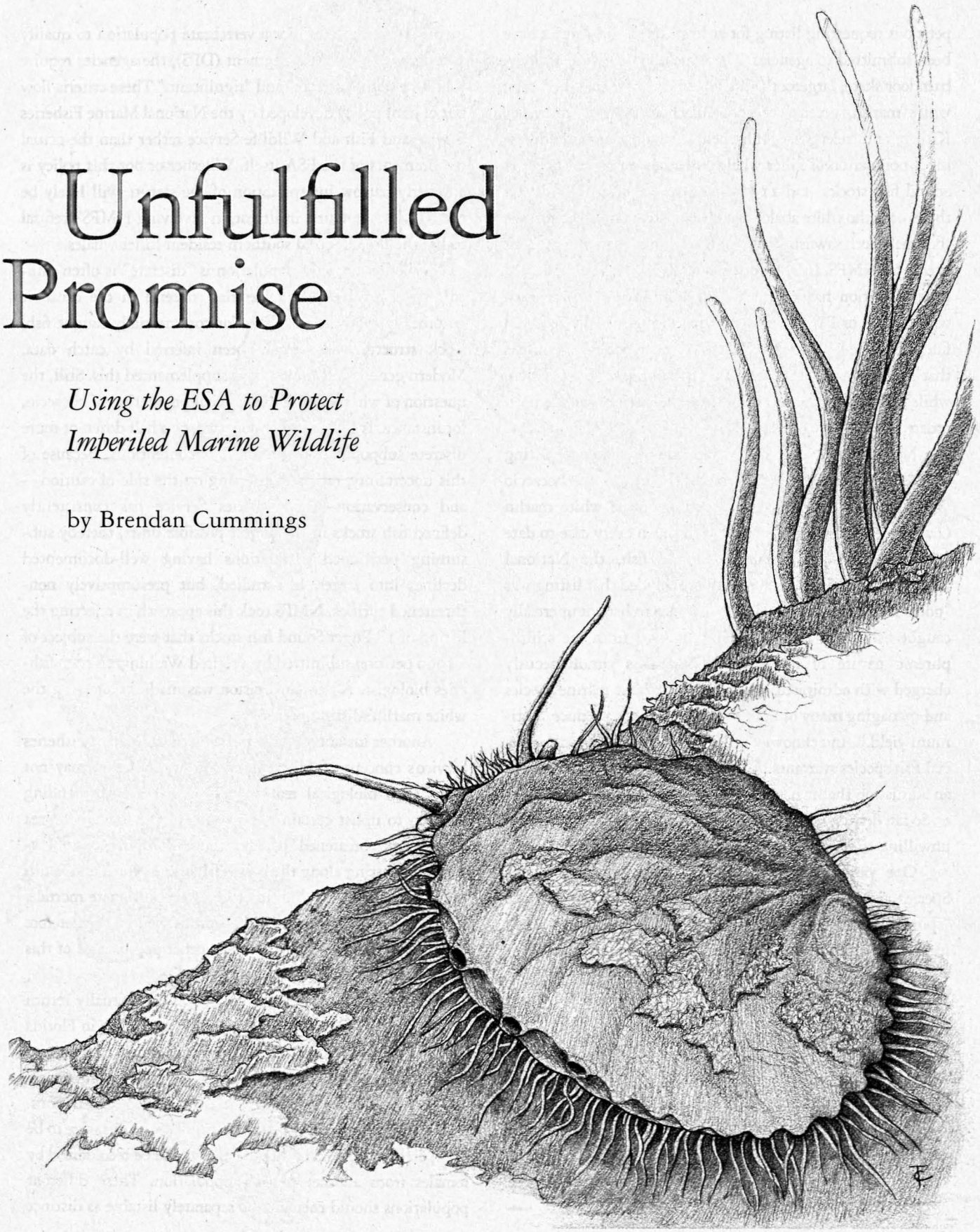
WHILE THE WHITE abalone sailed through the administrative process from petition to actual listing relatively quickly and smoothly, other attempts to list deserving marine species have met with substantial resistance from the National Marine Fisheries Service and Fish and Wildlife Service. Since 1998,

* The U.S. Fish and Wildlife Service (FWS) has responsibility under the ESA for seabirds, sea otters, manatees, and dugongs; the National Marine Fisheries Service has jurisdiction over all other marine species.

Unfulfilled Promise

Using the ESA to Protect Imperiled Marine Wildlife

by Brendan Cummings



white abalone, graphite by Todd Cummings

petitions requesting listing for at least 40 marine species have been submitted to agencies. These include the white abalone, barndoor skate, largetooth and smalltooth sawfishes, bocaccio, white marlin, green sturgeon, eulachon, Xantus' murrelet, Kitlittz's murrelet, Cook Inlet beluga whale, the southern resident population of killer whale, Aleutian sea otter, 18 Puget Sound fish stocks, and 11 bryozoan species from Florida. Of these, only the white abalone has been listed; one other species, the smalltooth sawfish (*Pristis pectinata*), has been proposed for listing by NMFS. In every other case, listing was either denied or the petition has languished in administrative purgatory, with NMFS or FWS simply not making the legally required findings. (The key difference between the agencies' response is that NMFS generally processes and then rejects the petition, while FWS simply fails to process the petition at all until ordered to do so by a court.)

Many of the marine species recently petitioned for listing have been commercially harvested fish such as the bocaccio (*Sebastes paucispinis*), a Pacific rockfish, or the white marlin (*Tetrapturus albidus*), an Atlantic billfish. In every case to date concerning a commercially exploited fish, the National Marine Fisheries Service eventually concluded that listing was "not warranted." The agency's reluctance to list commercially caught fish under the ESA results in part from the schizophrenic nature of its mission: NMFS is simultaneously charged with administering the ESA for most marine species and managing many of the nation's fisheries to produce "optimum yield." An acknowledgment by NMFS that a commercial fish species warrants listing under the ESA is, in essence, an admission that it has failed in its role as a fisheries manager. So far, despite overwhelming evidence, the agency has been unwilling to recognize, much less admit, such failings.

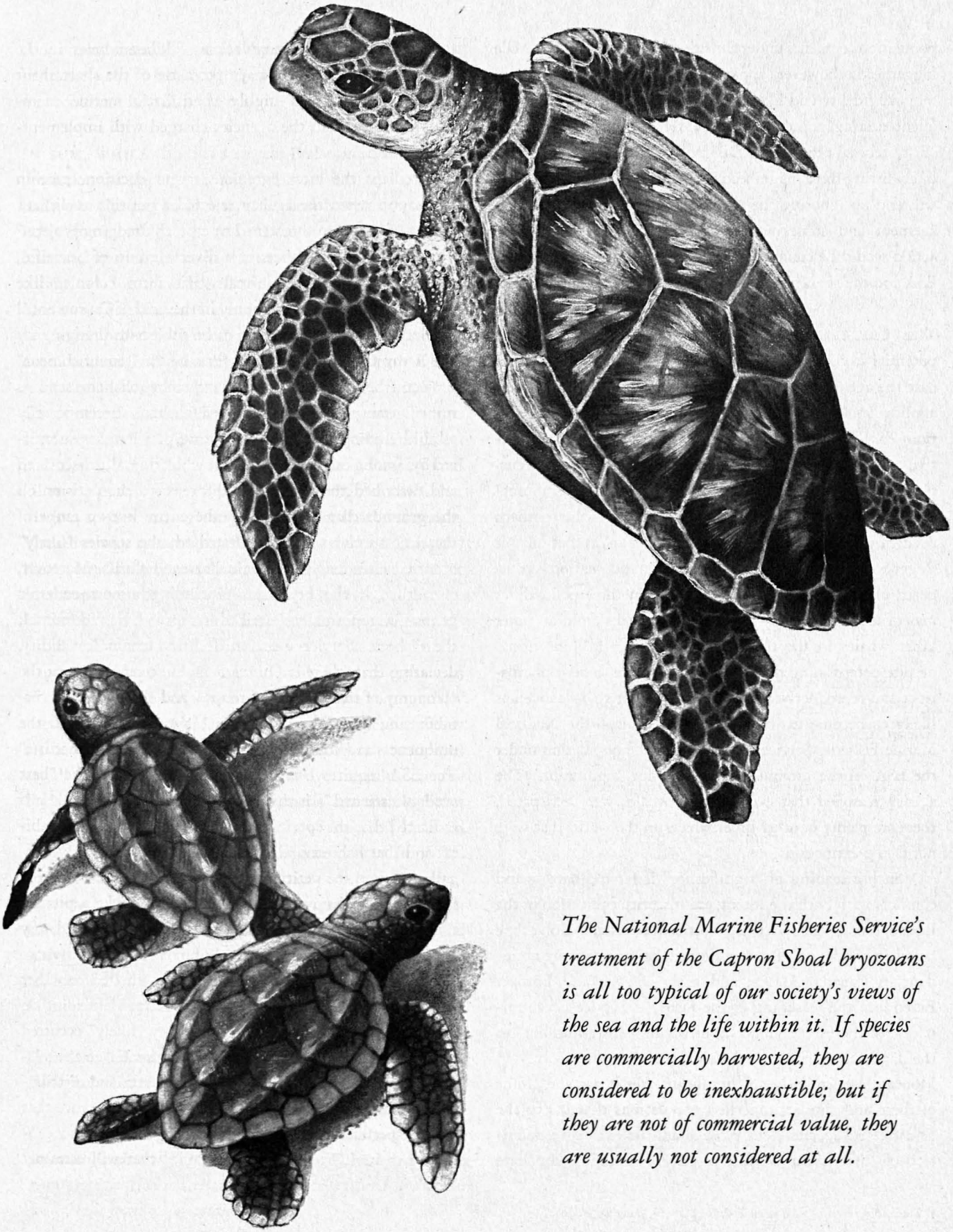
One problematic recurring issue is the Endangered Species Act's definition of "species." Under the ESA, a "species," and therefore a listable entity, is broadly defined to include full species, subspecies, and "distinct population segments" of vertebrates. For a vertebrate population to qualify as a distinct population segment (DPS), the agencies require that it be both "discrete" and "significant." These criteria flow out of joint policy developed by the National Marine Fisheries Service and Fish and Wildlife Service rather than the actual requirements of the ESA itself. Whether or not this policy is an overly narrow interpretation of the statute will likely be resolved by the courts in litigation involving NMFS's refusal to list the Puget Sound southern resident killer whales.

Whether or not a population is "discrete" is often difficult to determine in a terrestrial context; in the ocean it becomes virtually impossible. For commercially caught fish, stock structure has largely been inferred by catch data. Modern genetic techniques have supplemented this. Still, the question of whether or not the global population of bocaccio, for instance, is comprised of one, two, or a half dozen or more discrete subpopulations or stocks is contentious. Because of this uncertainty, rather than erring on the side of caution—and conservation—the Fisheries Service has consistently defined fish stocks in the largest possible units, thereby subsuming petitioned populations having well-documented declines into larger, less-studied, but presumptively non-threatened entities. NMFS took this approach in rejecting the listing of 18 Puget Sound fish stocks that were the subject of a 1999 petition submitted by a retired Washington state fisheries biologist. A similar decision was made in rejecting the white marlin's listing petition.

Another instance in which the National Marine Fisheries Service's concept of "discreteness" in a population may not mesh with biological reality involves a currently pending petition to uplist certain populations of the loggerhead sea turtle from "threatened" to "endangered." Populations of loggerheads nesting along the coast of Florida, North and South Carolina, and Georgia are suffering disproportionate mortality from longline fisheries for swordfish and are therefore declining at a more rapid rate than other populations of this globally threatened species.

After years at sea, female loggerheads eventually return to their natal beaches to nest. A nesting population in Florida would certainly seem "discrete" when compared to loggerheads nesting in the Mediterranean or even Mexico since there is no mixing of the females between these populations. Because of such site fidelity, if a nesting population were to be extirpated, it is unlikely that the area would be recolonized by females from another nesting population. These different populations should therefore be separately listable as distinct

Xantu's murrelet, watercolor by Todd Telander



The National Marine Fisheries Service's treatment of the Capron Shoal bryozoans is all too typical of our society's views of the sea and the life within it. If species are commercially harvested, they are considered to be inexhaustible; but if they are not of commercial value, they are usually not considered at all.

green sea turtle, watercolor and loggerhead turtle young, acrylic by Todd Telander

population segments under the Endangered Species Act. Male loggerheads, however, apparently show much less local or regional fidelity and likely will breed with females from different nesting populations. If NMFS rigidly interprets the "discreteness" prong of its DPS policy so as to preclude separately listing these loggerhead populations as "endangered," it will end up ignoring the logical and relevant unit for management and conservation—the nesting population.* Such action would be counter to both the letter and intent of the ESA and the agency would likely find itself in court.

THE CRITERION OF "discreteness" at least holds some potential to be an objective and uniform measure, even if to date the agency has acted arbitrarily and inconsistently in its application. The "significance" prong of the distinct population segment policy, however, seems inherently more subjective and therefore subject to abuse. The most contentious current debate over whether or not a population is "significant" (and therefore listable under the ESA) involves the southern resident population of killer whales (*Orcinus orca*) that inhabit Puget Sound. These whales, whose current population is composed of approximately 80 individuals in three pods, differ genetically, behaviorally, and morphologically from all other killer whales in the region and elsewhere. In June 2002, despite determining that the population was genetically distinct and reproductively isolated (i.e., "discrete")—as well as likely to become extinct in the near future—the National Marine Fisheries Service refused to list the population under the ESA on the grounds that it was not "significant." The agency reasoned that even if these whales were extirpated, there are plenty of other killer whales in the world that were not facing extinction.

Such a reading of "significance" is far too narrow and conflicts with both the intent and historic application of the Endangered Species Act. Both grizzly bears and wolves are listed in the lower 48 states despite being relatively abundant in Canada, Alaska, and parts of Asia and Europe. Extending the reasoning of the Fisheries Service's determination of the Puget Sound killer whales' "insignificance" to the land, the grizzlies of Yellowstone or the wolves in Montana are similarly not significant. Yet it was the plight of these and similar imperiled populations that led to the Endangered Species Act's passage and its expansive definition of "species" in the first place. For NMFS to conclude that the best-studied population of killer whales in the world is not significant is symptomatic of the short shrift marine species—even highly charismatic marine mammals—receive from the agencies charged with implementing the ESA.

Perhaps the most egregious recent decision came in May 1999 when the agency rejected a petition to list 11 species of bryozoan threatened by a beach dredging project.† The bryozoans—members of a diverse group of beautiful, colorful, filter-feeding animals that form colonies like coral—were known to exist only in the sand of Capron Shoal in Florida. Their habitat was to be subject to dredging by the Army Corps of Engineers for a beach "renourishment" project (the ill-named process whereby offshore sand is mined, transported, and dumped onshore to temporarily rebuild eroding beaches). The listing petition was submitted by, among others, the scientist who originally discovered and described the species. NMFS rejected the petition on the grounds that even though the entire known range of these 11 species was to be destroyed, the species "likely" occurred elsewhere on other unsurveyed shoals. Moreover, even though the bryozoans—including a new endemic genus—were formally described in a peer-reviewed journal, the Fisheries Service questioned their taxonomic validity, declaring that "there is a fundamental uncertainty about the taxonomy of many marine groups," and that "without corroborating genetics information" the conclusion of the uniqueness and vulnerability of the species was "premature." The ESA requires listing decisions be made on the "best available science." In this instance the *only available science* indicated that the species occurred in one very narrow habitat and that habitat *was scheduled to be destroyed.* NMFS illegally required the petitioners to prove a negative—that the species occurred nowhere else—rather than take a precautionary approach and protect the bryozoans in their only known home.

Fortunately, the dredging project was halted on other grounds, and the fate of these creatures was not left riding on the agency's optimistic assertion that they "likely" occurred elsewhere. Other species may not be so lucky. Given the relative infancy of our knowledge about the status and distribution of marine biodiversity, requiring scientists to prove that a given species occurs nowhere else before affording any protection to its known habitat is a policy that will certainly

† The finding is published at 64 Fed. Reg. 28965 (May 28, 1999).

doom many marine species to extinction. The Capron Shoal bryozoans *may*, in fact, occur elsewhere, but such is a gamble we should not be willing to take.

IN SUM, WHILE EFFORTS to gain Endangered Species Act protection for imperiled marine life have increased substantially over the past four years, this effort has yet to translate into many actual listings. As has been so often the case with terrestrial species, the ESA's strict statutory timelines for processing petitions have been largely ignored by the National Marine Fisheries Service and Fish and Wildlife Service. When finally compelled by lawsuit or threat of lawsuit to make a decision, the agencies usually follow the political path of least resistance and make a "not warranted" determination. Thus, the ultimate decision to list or deny protection to many marine species under the ESA will be made by the courts. The denial of listing for the white marlin, bocaccio, and Puget Sound killer whales will all be litigated in the coming months. Other marine species listing litigation is similarly inevitable. Virtually every terrestrial species listed in the past four years has required litigation or the threat of litigation at some point in the process between petition filing and actual listing. Unfortunately, the marine realm appears to be no different.

The National Marine Fisheries Service's treatment of the Capron Shoal bryozoans is all too typical of our society's views of the sea and the life within it. If species are commercially harvested, they are considered to be inexhaustible; but if they are not of commercial value, they are usually not considered at all. Despite the current legislative assaults on the Endangered Species Act and the agencies' less-than-vigorous application of the law, it remains one of America's best and strongest tools for bringing actual protection to imperiled species. Perhaps just as importantly, it serves to focus attention on both the splendor and often precarious status of Earth's biodiversity. With continued effort by scientists and activists, the ESA could play as significant a role in the protection of marine biodiversity as it has in the terrestrial realm for the past 30 years. ☾

Brendan Cummings *is an attorney with the Center for Biological Diversity. His article "White Abalone on the Verge" appeared in the May issue of the online journal* Faultline *(www.faultline.org/place/2002/05/abalone.html). For more information about the Center for Biological Diversity's efforts to gain protection for imperiled wildlife, both on land and under water, visit www.biologicaldiversity.org.*

Spawning in the Rain

No wind today. Three inches have fallen
since dawn, and the felt sky persists
—making a steady, sleep-shaping thrum.

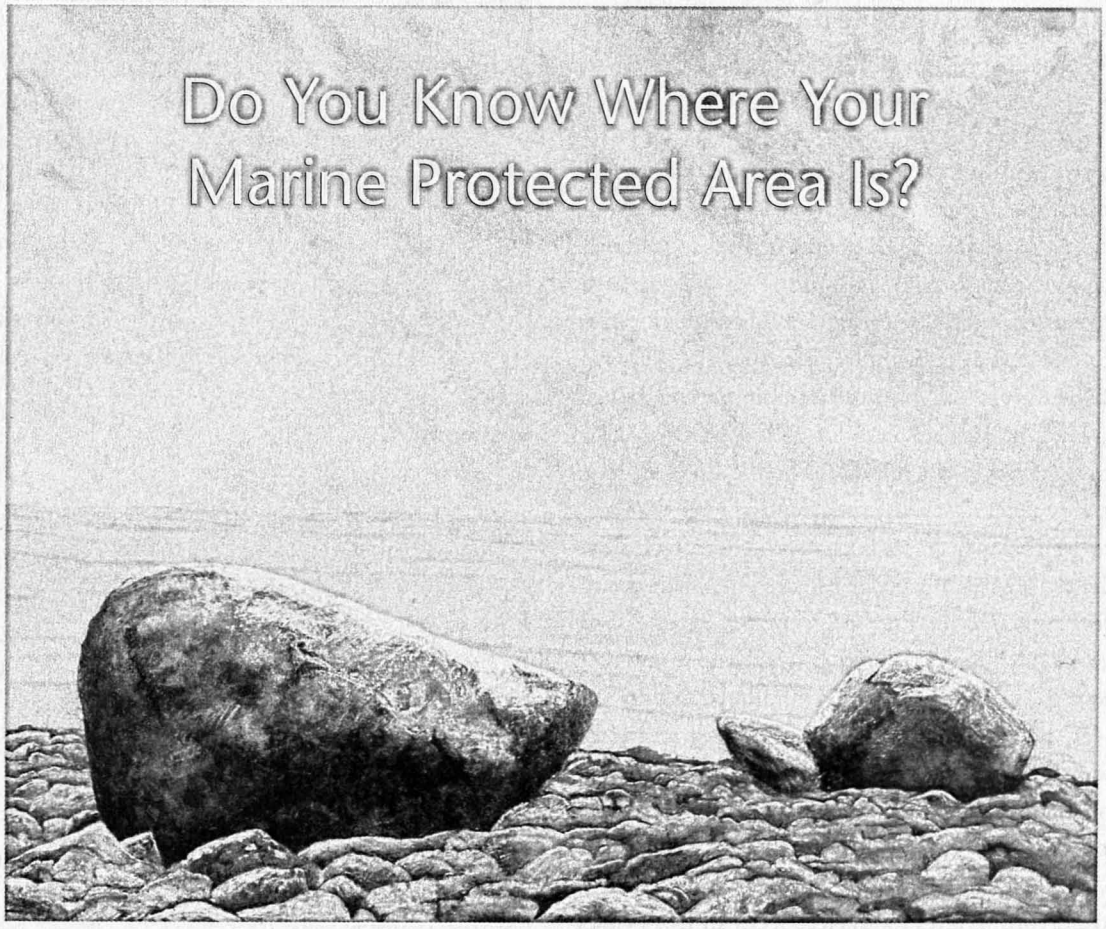
Fishermen call it *freshet*—simultaneous
rain and flood, effect and cause. Gills rake
thin air from foam, while water commits,

continues and forgives. Forgetting all
precursory twists and coils, it complies
with mud and lies down beneath old trees.

Its steady undergoing undoes complexity,
quickening crowds of kindred, swollen salmon.
They move up to greet the downpour, weave

and quiver in shallows—paired ghosts
spilling clouds of milt and spawn,
both enduring and melting away.

Bill Yake



A Primer on Care, Feeding, and Identification of MPAs

by Ron Steffens

If you live near the Pacific, the Atlantic, the Gulf of Mexico, or even the Great Lakes, you are most likely within driving (or boating) distance of a marine protected area. A marine protected area (MPA) can include "national marine sanctuaries, fisheries management zones, national seashores, national parks, national monuments, critical habitats, national wildlife refuges, national estuarine research reserves, state conservation areas, state reserves, and many others," or so we learn from the National Oceanic and Atmospheric Administration's official MPA web site at www.mpa.gov.

The MPA definition encompasses so many marine environments that I can walk the forest trails of my favorite MPA, the South Slough National Estuarine Research Reserve in Oregon, yet I can also kayak beneath spruce and past restored tidal marshes to the mouth of this estuary, floating out on the tide and returning as it rises. Within a 25-mile radius of my southwestern Oregon neighborhood there are two federal MPAs (wildlife refuges) and a federal/state partnership (a national estuarine research reserve). Add to that a few state parks as well as state-managed rocky shorelands and nearshore reefs, plus the entire Oregon beach zone, from wet sand to high tide, border to border, that is owned and protected by Oregon State Parks. And though its level of

oil by Barrie Mottishaw

protection varies, the Oregon Territorial Sea, the state-managed ocean reaching from shoreline to the horizon three miles to the west, is technically classed an MPA. Altogether, these formal or informal marine protected areas provide habitat for shorebirds, seabirds, marine mammals, phytoplankton, jellyfish, baitfish, salmon, rockfish, urchins, mussels, and humans.

Amid these many seascapes and landscapes you can imagine the challenge of identifying, organizing, and supporting the current ad-hoc system. If a protected area is defined geographically, touched by salt water, and within the the 200-mile offshore zone of American territory that entails our "Exclusive Economic Zone" (including the three miles of offshore waters managed by most states), then it is most likely an MPA.

To face this management challenge, MPAs now have a new, lean bureaucracy, a $3 million budget, and a headquarters at the MPA Center in Washington D.C., hosted by the National Oceanic and Atmospheric Administration (NOAA). The bureaucracy has a mission: to identify, catalog, and study MPAs; to enhance and expand the protected areas and recommend new areas; and ultimately to create a national system of MPAs via partnerships with federal, regional, state, tribal, local, and non-governmental partners. So far, the identified MPAs are primarily federal, managed by NOAA and the Department of Interior. These range from the landscape-scale and charismatic—Monterey Bay National Marine Sanctuary provides MPA status for 5300 square miles, including an enormous underwater canyon and cavorting sea otters, and Biscayne National Park offers 173,000 acres in the tropical waters of Florida—to postage-stamp sites of critical marine habitat and cultural interest. The Edmonds Underwater Park north of Seattle, a dive park of a moderate 27 acres, has been closed to harvest for nearly 25 years and has been credited with dramatically increasing the size (and egg production) of resident rockfish. Additionally, the park attracts 40,000 visitors each year.

The Marine Protected Areas Executive Order 13158, signed by President Clinton on May 26, 2000, defines an MPA as "any area of the marine environment that has been reserved by Federal, State, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." This was one of the rare Clinton actions to be reviewed and enthusiastically endorsed by the Bush administration. The MPA Executive Order may do for the ocean what the Wilderness Act did for the land (though with less fanfare and far less inspiring prose). While the MPA movement may provide a relatively non-partisan umbrella, to build and maintain such a broad-based consensus will require some soul-searching compromises. In the Bush administration's affirmation of MPAs, Commerce Secretary Donald Evans proclaimed that "America must strive to harmonize commercial and recreational activity with conservation. We can do both."

As the MPA system evolves, it will face all the management conflicts we're familiar with on land, from the National Park Service's conflict between preservation and recreation to the Forest Service's frequent misuse of multiple use. Yet the diverse missions and all-inclusiveness of the MPA rubric may engage broad interests. Sustaining and rebuilding fisheries appeals to coastal industries; protecting representative habitat and islands of biodiversity has engaged the conservation community. This blend of science, economics, and ecological protection may also yield pork-barrel opportunities for all parties and for coastal congressional districts (a methodology that propelled one wave of growth for the national park system).

Marine protected areas attract boaters, fishers, scuba divers, birdwatchers. Their protections vary widely, from the complete ban of shipping, boat traffic, and harvest to nothing more than a line drawn on a map. These sites require monitoring, protection, and funding. With the artful use of technology, some analysts figure that a well-defined network of MPAs can be closed to fishing and destructive access. The tools in this effort include public education as well as GPS tracking, onboard video monitoring, and bycatch observers on commercial fishing boats.

Such a network of reserves and monitoring might reduce the need for tracking, managing, and enforcing of complex fishing quotas while allowing for increased productivity and biodiversity. The "source-sink" theory of ocean ecosystem dynamics maintains that if we protect those areas that are rich "sources" of biodiversity, then the resulting out-migration to the "sinks" that are less productive will boost overall ocean productivity and therefore allow for a return to sustainable harvests.

Research in marine reserves in tropical and temperate waters has demonstrated the validity of this theory. Reserves protecting urchins in California, rockfish in Puget Sound, and coral spires 30 miles offshore of Florida all demonstrate increased productivity, often in orders of magnitude. Where one pound of fish or one egg is counted in a comparable area outside the reserve, 50 or 100 are found inside the reserve. The reason: for many marine species, older brood fish are significantly larger and produce a far greater number of eggs; the more eggs, the greater potential for breeding success, both

within the reserve and eventually outside of it, as currents spread the progeny. By reducing fishing pressure and habitat damage, MPAs protect the habitat as well as the older (and larger) age classes within that habitat.

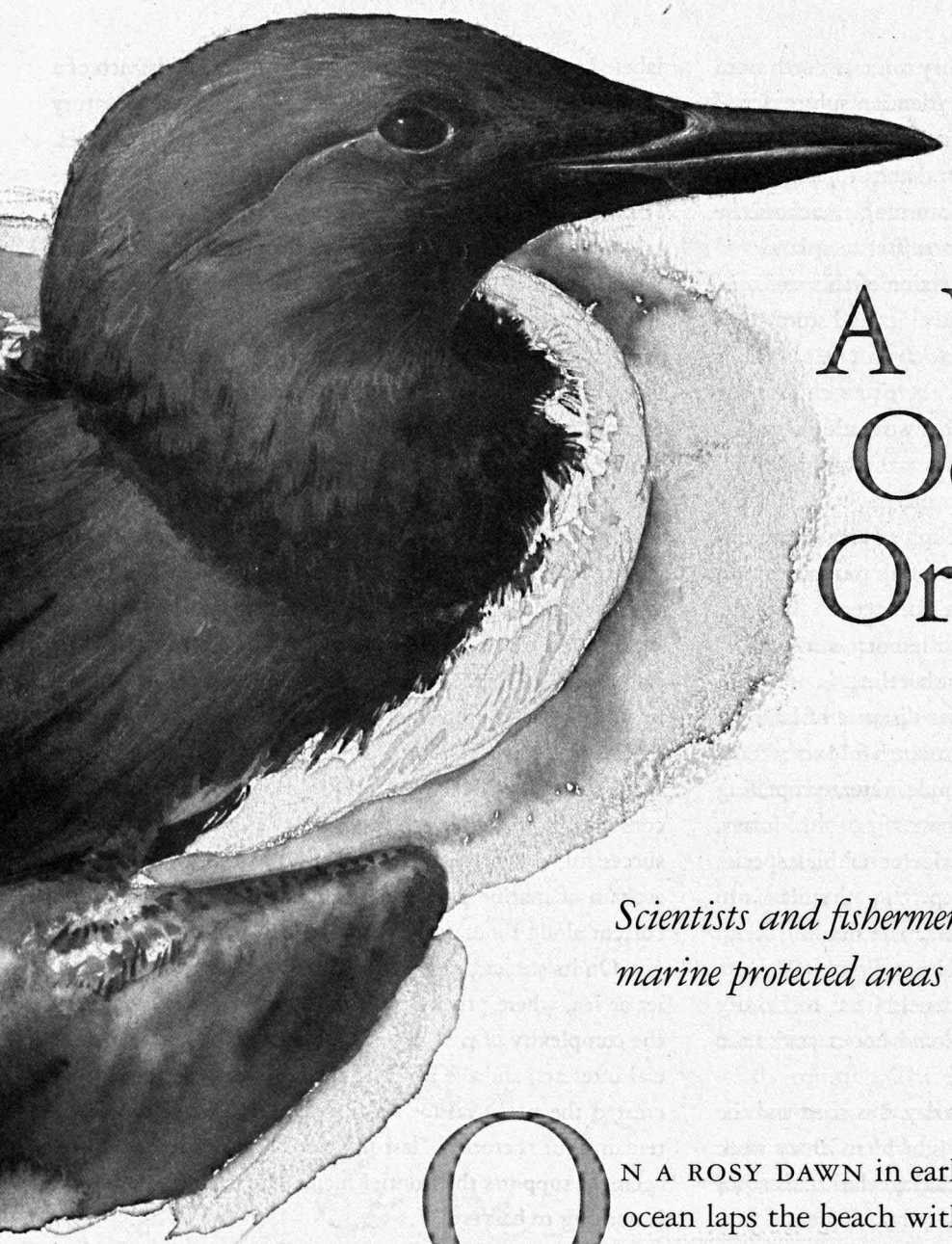
The MPA Executive Order requires that all marine protected areas be identified, including those managed by state and local governments. Once identified, the listing will also require a federal analysis if federal action should threaten an MPA. Other guidelines may follow that will embed protections based on scientific research and local and regional expertise.

While MPAs may counteract the cumulative impact of overharvesting, their long-term value may be even greater to researchers attempting to illuminate the black box of marine ecosystems. The most common disagreement among marine scientists, fisheries managers, and fishermen occurs over whose data is most valid. MPAs are gaining support by fishermen (if sometimes grudgingly) in part because all parties share a common interest in understanding marine biology. The scientific catch-22 is this: we need more data to determine the best locations, types, and long-term effects of MPA systems, but we need more MPAs to collect data that is relatively unaffected by recreational and commercial fishing pressure.

An equally challenging concern lies in the mundane complexity of human bureaucracy, with dozens claiming some management role of oceans and marine ecosystems. For example, in one cross-section of seascape at Cape Meares National Wildlife Refuge in northern Oregon, a collection of 18 federal, state, and local bureaucracies play some role in ocean management. Just as tourists in the Rockies often confuse the level of protection offered for a national park vs. a national forest vs. a city park, we can expect some confusion and battling amid the public stakeholders and managers of our marine resources, sanctuaries, preserves, and parks.

Despite the bureaucratic challenges facing the creation of an MPA system, the momentum is growing. In March 2002, a report by the National Academy of Sciences on trawling impacts provided a scientific review supporting a reduction of destructive fishing techniques in at-risk habitat and fisheries, and the fishing industry has offered their initial support of solutions ranging from fleet reduction, gear restrictions, catch limits, and closed, no-take MPAs. And the newly formed U.S. Commission on Ocean Policy spent the last year traveling the country on a fact-finding tour to study ocean management issues. The commission is a year away from issuing policy recommendations, but it appears that public support for a more unified and effective management process will include the integration of MPAs into ocean conservation strategies.

We once thought that Yellowstone and the Everglades were protected by a frontier that felt infinite. But human technology is pervasive. With the turn of the twentieth century, the American conservation movement congealed in opposition to the market-hunting decimation of egrets and bison; with the turning of the twenty-first century, we must stand together to create new boundaries in the ocean—a wilderness system of marine protected areas—as we face declining fisheries and threatened ecosystems on a far frontier, forbidding and expansive yet most definitely finite. ☾



A Wilder Ocean for Oregon?

Scientists and fishermen envision marine protected areas in state waters

by Ron Steffens

ON A ROSY DAWN in early March, without wind, the ocean laps the beach with unusual calm. But a quarter mile offshore, on a few acres of jumbled cliffs, thousands of birds raise a muted cacophony, a moaning *aaaarrrr* that crashes and wanes in a crescendo of avian surf.

This is the sound of as many as 30,000 common murres. Black-backed and white-bellied, they've flown on stubby wings from the open ocean to nest on Oregon's offshore rocks, just west of the bluffs and beaches of my home in Bandon, Oregon. This morning, rising with the sun, a flock a thousand strong is gyring around Face Rock (named for the nose and smile that appear to rise from the waves). And as they circle in a fluid changeable mass, they remind me of any number of coastal phenomena. Phytoplankton, a source of so much of this massed life. Fish larvae schooling from estuary to ocean. The

common murre, watercolor by Todd Telander

sparrowgrace flight of shorebirds as they migrate north from one coastal estuary to the next. The Aleutian subspecies of Canada geese that stage on a rock a mile south before they launch, 10,000 birds, over the ocean and non-stop to Alaska.

Walking this beach in the early morning you can sense the ocean's complex and lush existence. Between land and sea, along the most accessible cross-section of this seascape, the surf rises and ebbs with waves and tides and storms.

This edge is what most of us know about oceans. When I first moved here I brought my daughter to a cliff on the Pacific boundary of Oregon and told her we could go no further. This is the edge of America. To the west, I said, it is all wild ocean, from here to Asia.

This expanse was more than enough to awe a six-year-old, but most ages are susceptible. Oregon's tourism economy depends, in no small part, on the ocean. And the seabirds—murres and pigeon guillemots and tufted puffins—bring the wild ocean to our shoreline.

The murres nest within binocular distance of land yet spend most of their lives at sea. Their wings fold to become stubby fins with which they fly underwater, propelling themselves 600 feet down as they chase after fish. Murres, though, are not the only charismatic (or edible) species whose lives are attached to ours. We perch on headlands to watch for gray whales that migrate offshore, heading south to Baja at Christmas and north again at Easter. We lure Dungeness crabs into traps, pull mussels from rocks, dig clams from rich tidal mud, lay nets and hooks across the paths of migrating salmon.

Walking the beach on a windless day, this coast and the ocean beyond can be seen through a pastoral lens. But a week before this quiet dawn my neighbor clocked the winds at 74 miles per hour. A week later the waves were rising to 26 feet. Oregon's ocean is a rich, huge, dangerous, wild place that employs many and enthralls more. We herd to its edge to participate in an ebb and flow we're only beginning to sense. But if you work the ocean, if you study the ocean, if you care about this ocean, it is anything but pastoral. Here a salty rhetoric of survival meets legal and bureaucratic prose. With our human talent for buoyancy, we bring fish to dock by the ton, weighing our human harvest (and our changing climates) against a resilient ecosystem, stressed toward collapse.

Why we argue

For much of the last two decades, Oregon has provided a focus for debate over biodiversity. What was simplistically labeled the "spotted owl issue" was in truth the launch of a restoration ecology movement, struggling to heal a century of harvest-happy mismanagement of natural resources. Today, a majority of Oregonians have transitioned from the "timber wars" toward a more general commitment to sustainable management, though resource management issues certainly remain mired in rhetoric, tradition, and frequent trips to the courthouse.

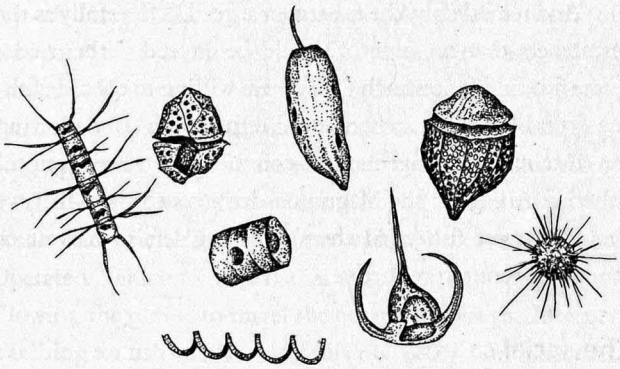
In the past few years, biodiversity issues have gone to sea, where cyclic swings have been exacerbated by decades of market-driven and regulation-sponsored overfishing. The salmon fisheries crashed and partially rebounded, and now the populations of many groundfish species are in such steady decline that harvest levels have been drastically cut. In response to a directive from Governor John Kitzhaber, Oregon's Ocean Policy Advisory Council has developed an action plan that may protect key groundfish habitat while also guiding Oregon's participation in a federal movement to unify marine protected areas (MPAs) into a nationwide system of reserves. Despite, or perhaps because of, its history of spotted owl recipes, Oregon seems poised to craft a consensus solution to marine conservation off its coast. If successful, Oregon may become a lead partner in developing a chain of marine protected areas linked by the California current along thousands of miles of Pacific coast.

On its surface, biodiversity management should be easier at sea, where private property boundaries are moot. Yet the complexity of past practices, bureaucratic and commercial interests, and the myth of the inexhaustible ocean have created the potential for a planning gridlock. If the ocean remains our rhetorical "last frontier," then status quo management supports the frontier mentality: harvest until there is nothing to harvest.

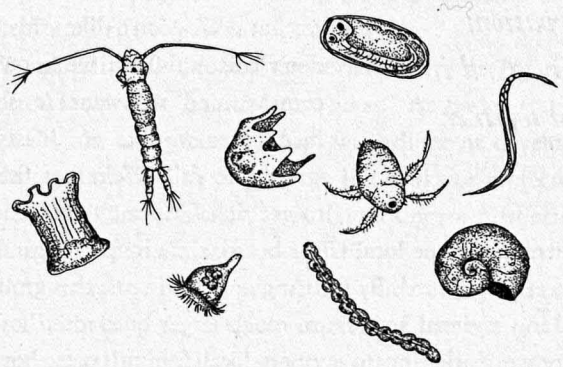
This was the mentality driving the Magnuson Act that helped guide us into our current problems. As Senator Warren Magnuson explained in 1969:

> You have no time to form study committees. You have no time for biologically researching the animal....Your time must be devoted to determining how we can get out and catch fish. Every activity...whether by the federal or state governments, should be primarily programmed to that goal. Let us not study our resources to death, let us harvest them....

Some three decades later, with a number of Pacific coast groundfisheries near collapse, scientists and fishermen both know better. As cited in a report on changing fishery prac-



Because of its tidal intrigue and its productive muck, it is quite possible to love a rocky tidepool or an estuary. It's much harder to feel a love-of-landscape or a "charismatic megafauna" response to stomach-churning swells on the open ocean or a transient column of phyto- and zooplankton.



phytoplankton and zooplankton, pen-and-inks by Todd Telander

tices authored for Environmental Defense by Laura Anderson, Dr. Jeremy Jackson notes, "We started out to study everything that people had ever done to oceans historically and were astounded to discover that in each case [of extinction] we examined, overfishing was the primary driver of ecosystem collapse." Rather than study our resources to death, we have harvested them to death.

Scientists and locals: The OPAC challenge

Over the past decades, timber and power policies decimated salmon habitat while climate change and hatchery fish gutted salmon reproduction; factory trawlers mined the offshore waters; and coastal fishermen set their drag nets and hooks on the ground fishery (with fishing pressure hitting sedentary rockfish the hardest). As Oregon faces the worst of our country's recession, parts of the state's fishery are near collapse. Even the good news may be transient: for the year 2002 at least, both salmon fishing and crabbing appeared strong, yet this cyclic upswing has only increased pressure to maintain past harvest levels while providing fuel to those who support a single-species approach to harvest and management.

Fishermen, researchers, resource managers, conservationists, economists, and politicians seem to concur on one point: the fisheries off Oregon have been diminished and are at risk of greater damage if management policies don't evolve to face the problems. Opinions diverge about the root causes of the problems and the science and economics of the solution. These were the topics of two days of conversation in January, 2002, between Ocean Policy Advisory Council (OPAC) members, scientists, and local experts (primarily fishermen and port managers); the result is a proposal, approved in November 2002 by outgoing Governor Kitzhaber, that should result in a focused, research-oriented reserve system in Oregon waters, with site-specific planning set to begin in 2003 for implementation in 2005.

The greatest challenge in motivating public support for marine protected areas involves the comparative anonymity of ocean environments. Because of its tidal intrigue and its productive muck, it is quite possible to love a rocky tidepool or an estuary. It's much harder to feel a love-of-landscape or a "charismatic megafauna" response to stomach-churning swells on the open ocean or a transient column of phyto- and zooplankton. Though largely invisible and a very tough place for a Sunday stroll, the Oregon near-shore ocean is a

geophysical seascape that can be as engaging as any Rocky Mountain wilderness. Instead of elk and grizzlies, we track the migration of gray whales.

The whales eat ghost shrimp and the shrimp filter out smaller organisms; all are tied to the microcosmic soup of phytoplankton. With the help of the NOAA research ship McArthur and some state-of-the-art ecosystem modeling by Steve Rumrill, research coordinator at Oregon's South Slough National Estuarine Research Reserve, we're beginning to realize that larvae originating at Cape Arago may flow 30 miles south on the California current to Cape Blanco, or even further south to northern California. Rumrill looks at phytoplankton transport and mortality as the key to understanding the success of these multifaceted ecosystems, and therefore the success of more engaging creatures (such as salmon, rockfish, shrimp, crab, seals, killer whales, and gray whales). The phytoplankton connect estuaries and the near- and off-shore environments and are transported up and down the coast by shifting currents, upwellings, downwellings, and ecological "sinks" where floating larvae come to rest and grow into adults.

Rumrill believes that marine protected areas should connect estuaries to ocean, creating a watershed-to-estuary-to-ocean research zone that would provide long-term and system-wide data. Oregon State University ecologist Jane Lubchenco and others support reserve status for those sites that already possess enough historical data to allow researchers to place current and future data in context with global warming and other human impacts. But many if not most scientists and economists concur that any solution will not rest solely on MPAs. The groundfish fleet must be reduced, by as much as 50%. The fishermen agree. And like the researchers, who argued so strongly for reserve status for their favorite study sites, the fishermen argued for fishing access to their most productive sites. Yet the fishermen offered that seasonal closures would protect the spawning fish that gather at certain places.

On one side of the flock a scientist turns us toward preservation; on the other side, a fisherman turns toward sustainability. And if we're alert, if we're watching the edges, we may all turn together.

And remarkably, the fishermen argued as forcefully as the researchers that no reserves should be created without adequate funding for research. They were willing to concede fishing access if the researchers could return with data allowing for sustainable management of commercial and recreational fisheries. All agree: the Magnuson-driven outcome—that we should harvest fish until there's nothing left to harvest or study—is counterproductive.

The social solutions: One town, one state, one ocean

A recurring slogan among MPA proponents is support for local fishermen and local economies. One technique that is often mentioned along with the creation of marine reserves is a shift toward Community Based Management (CBM), a process that integrates the siting and management of marine reserves with guidance from local users, thereby creating protected zones that would honor local expertise as well as be honored and enforced by the community. Scientists would monitor the changes and fisheries managers would respond with more flexible permitting.

Oregon's MPA Working Group is watching a CBM model being piloted in the small fishing community of Port Orford. Bob Bailey, Oregon's Ocean Program Coordinator, observed after a meeting with the Port Orford group that the fishermen appear cautiously supportive of MPAs. Bailey paraphrases the response of many fishermen: "We don't like this, we don't trust this, but we know it's coming, and we want to shape it...because we like our lifestyles, we like to fish. We're not fishing to get rich." With 21 community fishermen on the local CBM board, the group is beginning to feel empowered. By focusing on local issues, this group is seeking regional answers to much larger questions: how to improve marketing to support local fishing boats, how to manage the impact of local trawling in nearshore waters; and how to limit rockfish harvested for the restaurant marketplace, since this fishery may be targeting older broodstock with significant impact on long-term recruitment.

Other MPA studies have suggested that research reserves include active surveys of marine habitat tied to an interactive education program. One proposal, supported by scientists and fishermen, would launch a comprehensive sur-

vey of Heceta Bank, a 50-mile-wide shallow shelf off Newport that holds some of Oregon's richest fishing grounds. The survey would include habitat typing and detailed mapping not unlike the terrestrial ecosystem mapping undertaken over the past decade to support the Yukon to Yellowstone wildlife corridor. But the Heceta Bank proposal also includes real-time video links to Remote Operated Vehicles (ROVs) that would search the seafloor, allowing the public to travel the ocean floor via the Internet, watching for fish and savoring this rich ecosystem from their computer monitor.

As the MPA working group tuned their proposal, a consortium of regional environmental groups and a regional fishery conservation group have both provided their support for a marine protected areas system in the state's three-mile-wide coastal management zone. One key element: in its draft guidelines, fisheries management objectives have been separated from the criteria for defining and determining site selection of MPAs. While MPAs may be conceived because of their implicit and explicit benefits to fish reproduction, they will not be obligated to meet this objective. This may prevent them from being hamstrung by the many political maelstroms that surround recreational and commercial fisheries.

According to Bailey, the MPA working group's approved plan supports "a limited system of reserves to test the effects of reserves for conservation and ecosystem management." The proposal would include a timeline that might feature site selection within four years.

Technically, all Oregon territorial waters are marine protected areas with "multiple use areas." As Bailey states, "It's a bit like a city zoning map, with different development uses allowed. The reserves are like parks or protected riparian corridors. Basically, it is the closing of a frontier. We're zoning the wild ocean."

An unresolved question, and one which Bailey and others feel will shape the ultimate success of ecosystem-wide management, lies in the interconnected management of state and federal waters. The current MPA proposal "only applies to Oregon's territorial sea, but a question OPAC [Ocean Policy Advisory Council] may pursue is to what extent this process can be extended to federal waters. In Oregon territorial waters, the siting and determination of reserves can come through a single entity, OPAC, but on the federal side there is no analog, no single federal agency with clear authority to make these kind of research closures...to whom do you make this request?"

For now, the Oregon MPA process appears to support reserves that will allow for scientific research and limited protections of key habitats and nursery grounds. The basic approach, according to Bailey, will most likely be to "Go slowly and test. To crawl before we walk."

Flying in flocks

At the Ocean Policy Advisory Council meeting, fishermen spoke of protecting spires where rockfish come to spawn. Economists, fishermen, and biologists all spoke of the need for buying out an overcapitalized fleet of fishing boats. All asked for more research, to better understand the "black box of larval transport" and many other processes critical to a balanced marine ecosystem. And when asked if marine reserves and protected areas would help, most all said yes. Oregon State's Jane Lubchenco admitted, "There is no single silver bullet. Marine reserves are a powerful tool in a toolbox with many tools, but if there was only one thing we could do, then marine reserves would be one of my top choices. But we need many systematic changes."

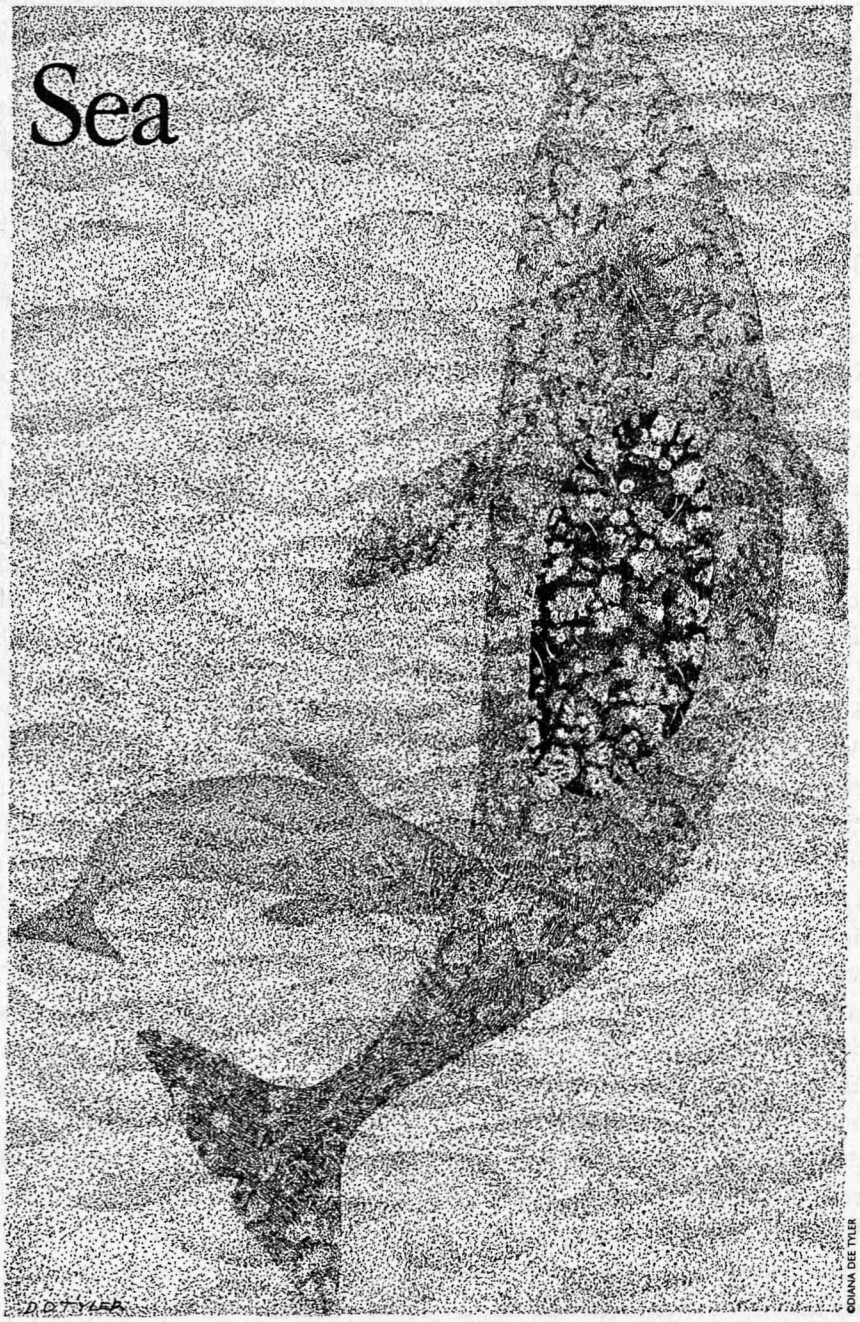
Above all, we need to more carefully watch our oceans. A marine reserve means very little if we don't apply lessons learned within the reserve. Those who have studied the magic of sparrowgrace, the collective flow of a thousand shorebirds or a thousand murres, have noted two key elements that allow a flock to turn in circles while remaining united. Apparently, all flock movement is triggered by the birds turning on the outer edge. Yet this trigger results in collisions unless the birds in the flock's interior are prepared to turn in advance. The interior birds somehow learn from the birds on the edge.

So it may be with the complexity of human change. On one side of the flock a scientist turns us toward preservation; on the other side, a fisherman turns toward sustainability. And if we're alert, if we're watching the edges, we may all turn together.

That is what may be happening in Oregon today. Sparrowgrace amid the many bureaucracies and individuals. Or so we may hope, for the sake of the murres and the fisheries, and ourselves. ☾

Ron Steffens *teaches journalism and writing at Southwestern Oregon Community College. In the summers he works for the National Park Service in Wyoming.*

Baja California to the Bering Sea



A North American Marine Conservation Initiative

by Sabine Jessen and Natalie Ban

gray whale and calf, pen-and-ink by D. D. Tyler

TWICE EACH YEAR, the Pacific gray whale travels over 10,000 kilometers—the longest migration of any mammal in the world—from the warm, sheltered lagoons of Baja California where their calves are born, to the cold, rich waters of the Bering Sea where they feed in summer. Along the Pacific coast of North America, their migration is celebrated by communities, and witnessed by thousands of people who delight in this spectacle of Nature.

In the same expansive spirit, the Baja California to Bering Sea Marine Conservation Initiative envisions a wild Pacific in the region encompassed by this vast migratory route. The aim is to protect ecological links—links that transcend political boundaries—and conserve marine biodiversity and productivity throughout the northeast Pacific Ocean. Combining science and stewardship, the initiative seeks to ensure that the Baja California to Bering Sea region continues to function as an interconnected web of life, capable of supporting all of its communities, for now and for future generations.

Gray whales help remind us why this kind of initiative is crucial: our relationship with these mighty creatures has not always been benign. During the mid-1800s and again in the 1920s, gray whales were slaughtered in the calving lagoons on the Baja California peninsula and elsewhere along the coast. An international agreement to stop gray whale hunting was not enacted until 1937, and was finally adhered to by all nations in 1946. By this time it was not clear whether any whales had survived. Fortunately a few had—and today scientists estimate that the gray whales of the eastern Pacific have recovered to their historical population level of 20,000 (Darling 1999).

The story of the Pacific gray whale, and its return from the brink of extinction twice in the past 150 years, is one that evokes both despair over human abuse of ocean life and hope for the future as we witness the resilience that has enabled this remarkable recovery. And so, the gray whale has come to inspire the conservation imperative for the Pacific coast of North America, and symbolize the work of the Baja California to Bering Sea Marine Conservation Initiative.

Marine protected areas

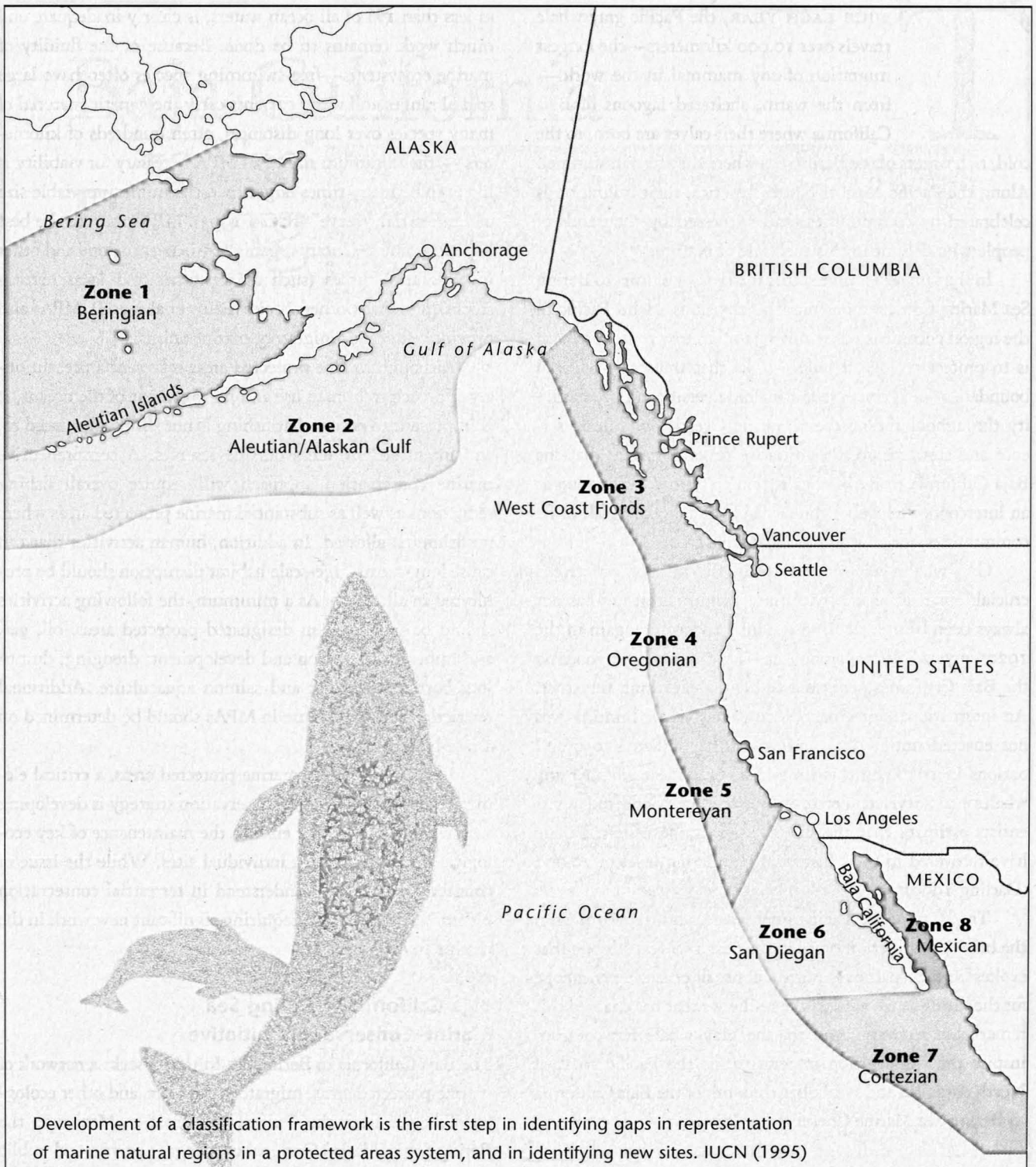
Many marine species have a remarkable capacity to rebound when fishing or hunting is stopped. The gray whale has certainly demonstrated this resilience. While some steps have been taken to establish marine protected areas (MPAs) in different parts of the world, the current system, which comprises less than 1% of all ocean waters, is clearly inadequate and much work remains to be done. Because of the fluidity of marine ecosystems—free-swimming species often have large spatial ranges and water currents carry the genetic material of many species over long distances, often hundreds of kilometers—"the minimum size of an MPA necessary for viability is likely to be many times larger than the minimum viable size of a terrestrial reserve" (IUCN 1992). MPAs may be the best hope for some sedentary organisms (such as abalone and other invertebrates), fishes (such as rockfishes and local herring stocks), and many other species (Pauly et al. 1998). MPAs also provide refuges for migratory marine animals.

Although marine protected areas represent a precautionary approach to human use and management of the oceans, it is important to ensure that fishing is not simply displaced to, and intensified in, areas outside reserves. A comprehensive marine conservation approach will require overall fishing reductions as well as substantial marine protected areas where no fishing is allowed. In addition, human activities that can cause long-term, large-scale habitat disruption should be prohibited in all MPAs. As a minimum, the following activities should be precluded in designated protected areas: oil, gas, and mineral exploration and development; dredging; dumping; bottom trawling; and salmon aquaculture. Additional restrictions on human use in MPAs should be determined on a case-by-case basis.

Beyond individual marine protected areas, a critical element in an overall marine conservation strategy is developing a network of MPAs that ensures the maintenance of key ecological linkages between individual sites. While the issue of connectivity is clearly understood in terrestrial conservation planning, this is an area requiring significant new work in the marine environment.

Baja California to Bering Sea Marine Conservation Initiative

The Baja California to Bering Sea Initiative seeks a network of marine protected areas, migratory corridors, and other ecological linkages from the Gulf of California in Mexico to the Bering Sea in Alaska. Our goal is to engage private and public conservation organizations, scientists, and stakeholders interested in marine conservation. The broad scope of this initiative is attractive to local organizations because it provides a coast-wide vision that can help leverage the protection of individual sites in the ocean. The ultimate aim is not only to create a network of marine protected areas along the coast, but in working



Development of a classification framework is the first step in identifying gaps in representation of marine natural regions in a protected areas system, and in identifying new sites. IUCN (1995) suggests eight biogeographic provinces for the Baja California to Bering Sea region, as identified here (Zones 1–8). Further ecological classification work is required below the broad level of marine province. The British Columbia government has completed this for the Pacific region of Canada (Howes et. al. 1997). World Wildlife Fund Canada has developed a hierarchical marine classification framework for Canada that should be expanded to cover the whole North Pacific coast (Day and Roff 1999).

towards this goal, the initiative is also coordinating a network of people that can unite their efforts to have a stronger voice for marine conservation (Agardy and Wolfe 2002).

Our programs are based on a five-tiered strategy:

- Develop a common conservation vision for the region, including a linked network of marine protected areas and connecting corridors;
- Develop a common understanding of the past and present ecological processes and cultural attributes of the Baja California to Bering Sea region and advocate for new scientific research in these areas;
- Foster an ocean ethic among the public and support for our conservation vision through the development and implementation of communication strategies and materials;
- Develop and support local and regional grassroots efforts to implement the conservation vision for the region; and,
- Promote dialogue, partnerships, and information exchange.

The Baja California to Bering Sea Marine Conservation Initiative (sometimes called "B2B") is an inclusive undertaking, built with partners and regional stakeholders. Another strength of this initiative is the support and involvement of the key government agencies with MPA responsibilities in Mexico, the United States, and Canada. This involvement ensures that cooperative work can be more easily implemented through ongoing government programs. In order to promote marine conservation that leverages resources without duplicating efforts we link with other initiatives wherever possible.

Through a series of meetings from 2000 to 2001, the B2B initiative has built a network of non-profit organizations, academic institutions, government agencies, marine resource users, and interested individuals. There has been strong interest in advancing such a large-scale marine conservation project. For example, in addition to their work with the overall B2B initiative, the North American Commission for Environmental Cooperation is partnering with the Marine Conservation Biology Institute in a project to identify priority areas for protection from Baja California to the Bering Sea, and with the Oceans Blue Foundation on a project on ecologically responsible whale watching in the region.

As a first step towards improving the effectiveness of existing MPAs in the region, a workshop is being planned to bring together MPA managers and practitioners to explore issues facing marine protected areas in the Baja California to Bering Sea region, and to learn how managers are approaching opportunities and problems. Using case studies, the focus of the workshop will be on highlighting innovative solutions to common issues facing MPAs.

The Baja California to Bering Sea vision has created excitement, and proponents of local MPA sites see the benefits of being included in a network of marine protected areas. In order to profile promising local initiatives in the region, we recently published a brochure highlighting four flagship MPA proposals in the B2B region: Magdalena Bay in Baja California, Channel Islands in California, Gwaii Haanas in British Columbia, and Glacier Bay in Alaska. Future plans include bringing local activists working on these sites together to share experiences and develop new collaborative initiatives.

Humans have significantly altered the highly interconnected North Pacific marine environment in past centuries. Marine biological diversity is threatened at the genetic, species, and ecosystem levels as a result of human exploitation. However, precisely because of the interconnectedness provided by water, the marine environment will likely have the capacity to regenerate if given the chance. The Baja California to Bering Sea Marine Conservation Initiative offers such a chance. ☾

ACKNOWLEDGMENT Many thanks to John Roff for his comments and suggestions on an earlier draft.

Sabine Jessen *is the conservation director and* **Natalie Ban** *is the marine campaign coordinator for the Canadian Parks and Wilderness Society–British Columbia Chapter. For more information about the Baja California to Bering Sea Marine Conservation Initiative, contact b2b@cpawsbc.org.*

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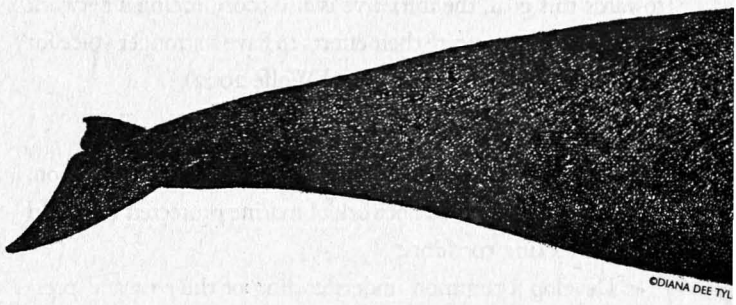


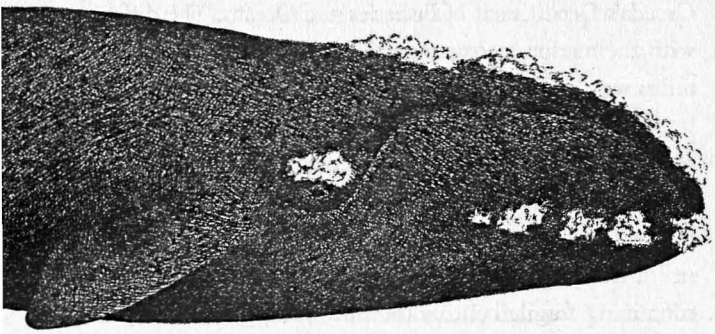
Marine Protected Areas

by Karen Beazley, Martin Willison, and Marty King

As a result of the vastness and inhospitable nature of the oceans, they are seen to be among the last of the truly wild places on Earth. The wildness of the oceans is, however, diminishing as technologies allow us to access their farthest and deepest reaches. These same technologies have also resulted in an accelerating global decline in marine fish populations and other startling changes in the world's marine ecosystems. Consequently, radically new approaches to fisheries and oceans management are being sought. One of the most popular of these is the creation of marine protected areas (MPAs)—areas of ocean that are closed to various kinds of use. Some marine protected areas, described as "marine reserves," "no-take areas," or "wilderness," exclude all resource extractive activities. Other types of marine protected areas may exclude only those activities that cause the most damage, such as seafloor mining and the use of mobile bottom-fishing trawls. The concept that marine areas need to be zoned for uses that are compatible with their local characteristics is gaining popularity.

Although the idea of creating systems of marine protected areas to conserve marine biodiversity has been around for several decades, little actual progress had been made until recently. The belief that ocean environments were so vast and distant that they were immune from harm was so pervasive that is has taken the collapse of fisheries at a global scale to finally show that this idea is false. We must hope that this recognition has dawned early enough that sufficient systems of protected areas can be put in place throughout the world's oceans to insure against further mass extinction. It is now clear that humanity has the technical capacity to cause such an extinction event, and that this event has begun.

In Canada, two main pieces of federal legislation permit the creation of marine protected areas: the Oceans Act of 1997, and the National Marine Conservation Areas Act, which was brought into law in 2002. The Department of Fisheries and Oceans (DFO) and Parks Canada are engaged in identifying marine protected areas under these pieces of legislation. In 2003, some DFO sites will be designated that will focus on providing specific benefits, such as protecting fish-spawning areas and endangered species. Parks Canada's marine conservation areas will be larger and selected to represent each marine region. These will be similar in intent to the marine sanctuaries administered by National Oceanic and Atmospheric Administration (NOAA) in the United States

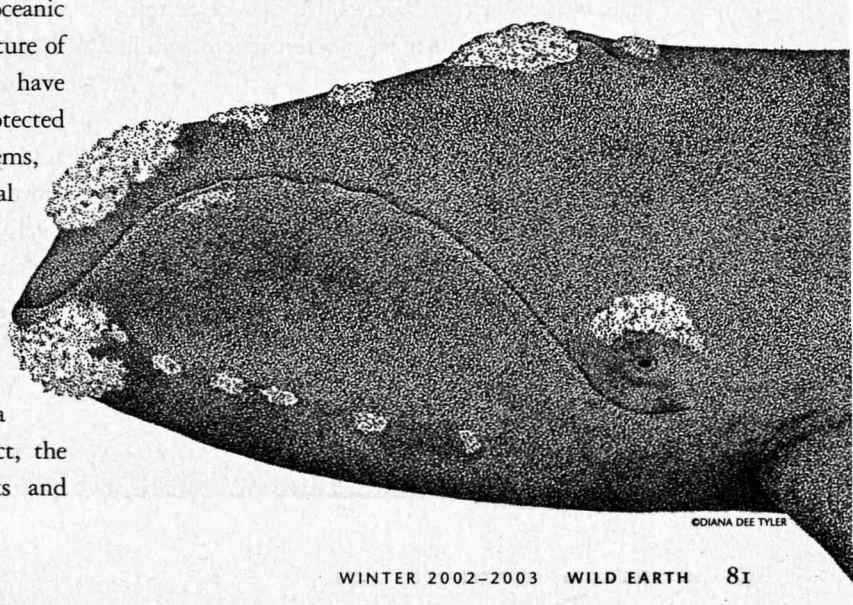


Strategies for Nova Scotia

and will focus primarily on raising public awareness. Sanctuaries for certain marine animals could also be created under the long-standing Canada Wildlife Act, but it has never been used for this purpose.

While there are some clear differences between marine and terrestrial environments, some of the underlying principles of protected areas planning can be applied to marine systems. For more than 30 years, since the advent of island biogeography, terrestrial conservation scientists and advocates have been applying lessons learned from the study of oceanic islands to the increasingly isolated and fragmented nature of wild lands. Consequently, conservation biologists have reached consensus about the critical components in protected area system design: representation of natural ecosystems, special elements, and the habitat requirements of focal species. It is only relatively recently, however, that these concepts have been applied to the marine realm.

Recognizing the importance of both marine and terrestrial ecosystems, the Nova Scotia Wild Lands and Wild Seas Mapping Workshop was held in May of 1999. This intensive two-day planning workshop was a grassroots effort supported by the Wildlands Project, the Ecology Action Centre, and the Canadian Parks and Wilderness Society. It was structured so that the participants (approximately 50 local naturalists, conservationists, and resource managers) could quickly, yet systematically, synthesize the best available ecological information into consensus-based maps of conservation lands and seas capable of sustaining the region's ecosystems over the long term. Specifically, the objectives were to identify terrestrial and marine areas that merit protection to maintain and restore native species and ecosystems, and to generate wild lands and wild seas conser-



right whales, pen-and-inks by D. D. Tyler

vation vision maps to serve as preliminary guides for long-term conservation planning.

A significant part of the wild seas mapping workshop involved adapting and applying land-based conservation planning concepts to the ocean environment. Concepts such as representation of natural regions, special elements of high conservation value, and critical habitat areas for focal species were integrated into the vision. For example, as with terrestrial conservation planning, biogeographic zoning can provide the basis for selecting representative marine protected areas.

Terrestrial habitats can be analyzed and mapped by using satellite images and aerial photographs. It is much more difficult to achieve this in the oceans because the features of interest lie on the ocean bottom, below a thick layer of water. However, modern methods have begun to make it possible to create adequate maps. The "enduring features" approach to predicting habitats can be augmented by multi-beam sonar imaging to create three-dimensional models of the ocean bottom. These can be overlaid with maps of sediment types, based on particle-size spectra. Communities of marine benthic organisms are largely defined by marine sediment types, just as soil types tend to define forest communities. Thus, by sampling relatively small areas of the ocean bottom, it's possible to create wide-scale maps showing the probable distribution of marine benthic communities. This methodology has been pioneered in Nova Scotia by Vladimir Kostylev of the Bedford Institute of Oceanography.

In the future, new advances in research should undergird a sophisticated, science-based ocean management regime that includes a network of rigorously designed marine protected areas. In the meantime, the precautionary principle needs to be applied, and best guesses used to implement an extensive interim system of fishery closures, zones that exclude petroleum and seafloor mining industries, and restrictions within major shipping lanes.

THE WILD SEAS conservation vision (Figure 1) made use of biogeographic zoning by delineating seven marine management units, each having distinctive characteristics based on depth and other enduring oceanographic features as defined by the Nova Scotia Museum of Natural History. The primary goal of each marine management unit is to maintain and enhance biodiversity and other elements of ecological health; a secondary goal is to sustain fisheries in ways that do not compromise these objectives. This concept is consistent with the emerging idea of large ocean management areas that has been adopted by Canada's Department of Fisheries and Oceans. The difference with the marine management units as defined here is that all ocean waters fall into one management area or another. Thus, by including the entire marine realm within these management units, no part of the ocean region is open to human uses that do not sustain the health of the ecosystem.

A series of marine protected areas were identified to represent the diversity of marine regions, to protect unique sites containing fragile benthic (bottom) habitats, and to protect critical habitat components for focal species such as North Atlantic right whales. Within some of the MPAs, core "no-take" zones, where all fishing and other exploitative activity should be excluded, were identified in areas that have unique or sensitive features, species, or assemblages of species. Two special management zones were also identified to protect important areas for larval retention and deep-sea corals. Since the participants at the workshop did not have adequate data to be comprehensive, they did not regard the number of MPAs that they identified to be sufficient. Instead, the MPAs and no-take zones were identified to represent a model of the general zoning approach.

For marine protected areas planning, deep-sea corals are among the most relevant features of ocean environments. Corals are animals found exclusively in the world's oceans, but they create niches that are remarkably similar to those created by plants on land; corals are fixed in place, sometimes literally rooted in place, and some of them branch like plants. Gorgonian corals, for example, are so plant-like that fishermen call them "trees" and "bushes." The most abundant corals around Nova Scotia have this tree-like form, and range from roughly two to six feet tall. These corals grow slowly, taking several years to add an inch in height, and live for centuries. Thus, they literally create old-growth habitat.

A hundred miles or so from the shoreline of Nova Scotia, the continental shelf drops relatively sharply to the Atlantic abyssal plain. Along this shelf edge, groves of deep-sea corals are fairly common, particularly where the shelf edge is cut by canyons. Fish, shrimps, and other marine animals use the coral groves as places to hide, brood their young, and feed. Unfortunately, one of the most common methods of fishing is to drag heavy fishing nets along the ocean bottom. Associated with these nets are metal cables, steel "doors," large rubber "bobbins," "rock hoppers," and "tickler chains." Repeated dragging of this type of fishing gear over the bottom eliminates the corals, as well as other fragile sessile animals, such as sponges, bryozoans, and various tube-dwelling worms. In

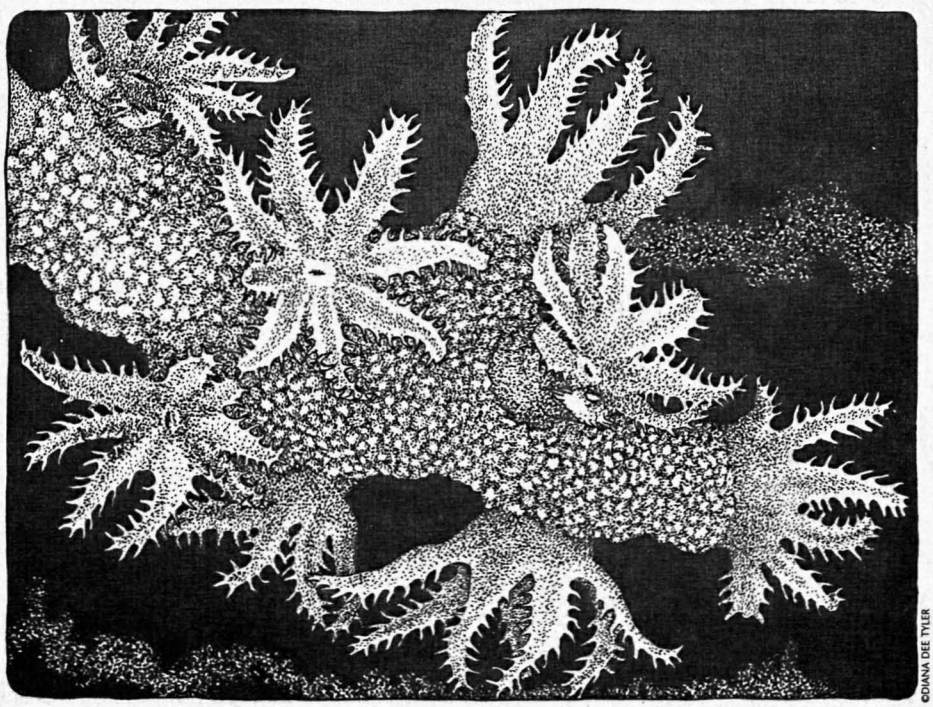
addition, the "doors" of the trawl nets behave like plows, cutting through the thin gravel layer that coats much of the Scotian Shelf, thereby exposing erodable muds. These muds can then deposit elsewhere, smothering the filter feeders that are characteristic of marine benthic habitats.

Coral habitats are defined as special zones because they need special management attention. To date, Nova Scotia's deep-sea coral habitats have been inadequately mapped for the special coral management zone to be fully defined. Within the wild seas conservation vision map (Figure 1), the continental slope between 200 and 1,000 meters deep is identified as a coral protection zone. Recent research has shown that not all of this area is suitable for corals, but also that there are other places where corals and other large fragile formations, such as biogenic reefs (reefs created by living organisms), exist. Structurally complex and mature marine habitats that grow slowly over centuries should be treated the same way as old-growth forest should be treated on land: they should be strictly protected—left alone for their intrinsic value and for the habitat that is created for multitudes of other organisms.

CONSERVATIONISTS INCREASINGLY recognize the need to address the intersection between marine and terrestrial protected area system planning, especially at the coast. Ecological interrelationships along the coast, in intertidal areas, and along the continuum from sea to land and from marine to freshwater aquatic systems warrant special planning attention. Not only are coastal areas often subject to intense pressures from human settlement and other activities, they are often biologically dynamic, productive, and rich areas such as estuaries and other intertidal zones. Maintaining connectivity along waterways is vital to sustain ecological processes such as migration and other life-cycle needs; species such as catadromous and anadromous fish require a healthy interface between marine, freshwater aquatic, and terrestrial systems. For example, conservation of estuaries of major salmon rivers is critical if imperiled Atlantic salmon are to survive and thrive.

The wild lands conservation vision identifies aquatic/marine zones around islands, headlands, bays, lakes and rivers. Approximately 2500 square kilometers, including areas below the high-tide mark, are identified as aquatic/marine protection zones. The near-shore aquatic/marine protection zones are areas identified primarily for their value to aquatic or marine organisms, or for organisms that require an interface between marine, freshwater aquatic, and terrestrial realms. These zones are primarily around islands, headlands, bays, and intertidal rivers and in marine areas adjacent to terrestrial core areas. Areas selected were those known to be particularly sensitive or significant in their own right, or with relatively little human development. In some cases, these zones were also identified for their role as connectivity zones between core areas located near the coast, and between coastal and inland areas, such as along riparian corridors. Connectivity zones are linkage or corridor areas designed to permit large-scale and long-term ecological processes, such as to facilitate movement of animals (migration, breeding, foraging), plant propagules (seeds, pollen, pollinators), and essential abiotic resources such as water and nutrients.

Our work represents a conceptual basis for a long-term (100-year) marine-terrestrial biodiversity conservation plan and illustrates the appropriate scale—both spatially and temporally—for addressing landscape- and seascape-level ecological goals and the complex challenges that accompany them. The wild lands and wild seas visions were not intended as final



coral polyps, pen-and-ink by D. D. Tyler

conservation plans, but rather as the preliminary, ecological foundation for a conservation strategy for the province. Additional information and collaborative processes are necessary to develop a more refined conservation vision, and economic, social, and political considerations must be incorporated. Nevertheless, they represent an important first iteration of a common vision created by scientists, managers, and advocates with wide-ranging experience and knowledge of biodiversity conservation in the province and its surrounding seas.

SUBSEQUENT TO THE wild seas and wild lands vision workshop, a longer-term project was initiated by the School for Resource and Environmental Studies at Dalhousie University in Halifax to further refine the conservation plans. Coarse-filter and fine-filter criteria of representation, special elements, and focal species were applied in the terrestrial realm, in order to identify core areas, connectivity zones, and compatible-use areas. Aquatic and coastal areas in particular need further attention and integration, especially in identifying interconnections in the interface between terrestrial, aquatic, and marine processes. For the marine protected areas system design, we are applying the three-track, terrestrial-based approach in the reverse order, identifying: first, important habitats for a suite of focal species; second, special elements, such as hotspots of diversity or unique geological features; and third, representative samples of each biogeographic zone (Table 1).

Selecting a suitable suite of marine focal species is a challenge because of the high level of uncertainty surrounding marine species and their roles in the ecosystem. Marine focal species include:

- keystone, umbrella, indicator, vulnerable, and flagship species;
- species from both benthic and pelagic marine realms;
- species that inhabit each of the broad habitat types found in the region (i.e., bank, basin, channel/canyon, and slope); and,
- species from each of the major species groups (i.e., fish, invertebrates, marine mammals, and seabirds).

An example of a focal species for the Scotia-Fundy region is the North Atlantic right whale (*Eubalaena glacialis*), which is a vulnerable, umbrella, and flagship species. The right whale is a mammal species of the pelagic realm that prefers basin habitats. They are long-distance migrants and congregate each summer in a key feeding area in the Bay of Fundy. This critical habitat component could be protected as part of a "stepping stone" approach to functional connectivity for this species. Protecting this area could also help conserve sympatric species (organisms with overlapping ranges) with smaller habitat area requirements and less charismatic appeal, such as plankton. Some protection has already been achieved in the area by moving a shipping lane, and further actions are being considered.

Special elements include hot spots of rarity and diversity, critical habitat areas, sensitive ecosystems, and other species and places of high conservation value. An example of a special element in the Scotia-Fundy region is the Gully, the largest submarine canyon on the East Coast of North America. The Gully is the only place in Canada and one of only two places in the world with resident populations of northern bottlenose whales (*Hyperoodon ampullatus*) and is believed to contain the most diverse assemblage of deep-sea coral species in the region.

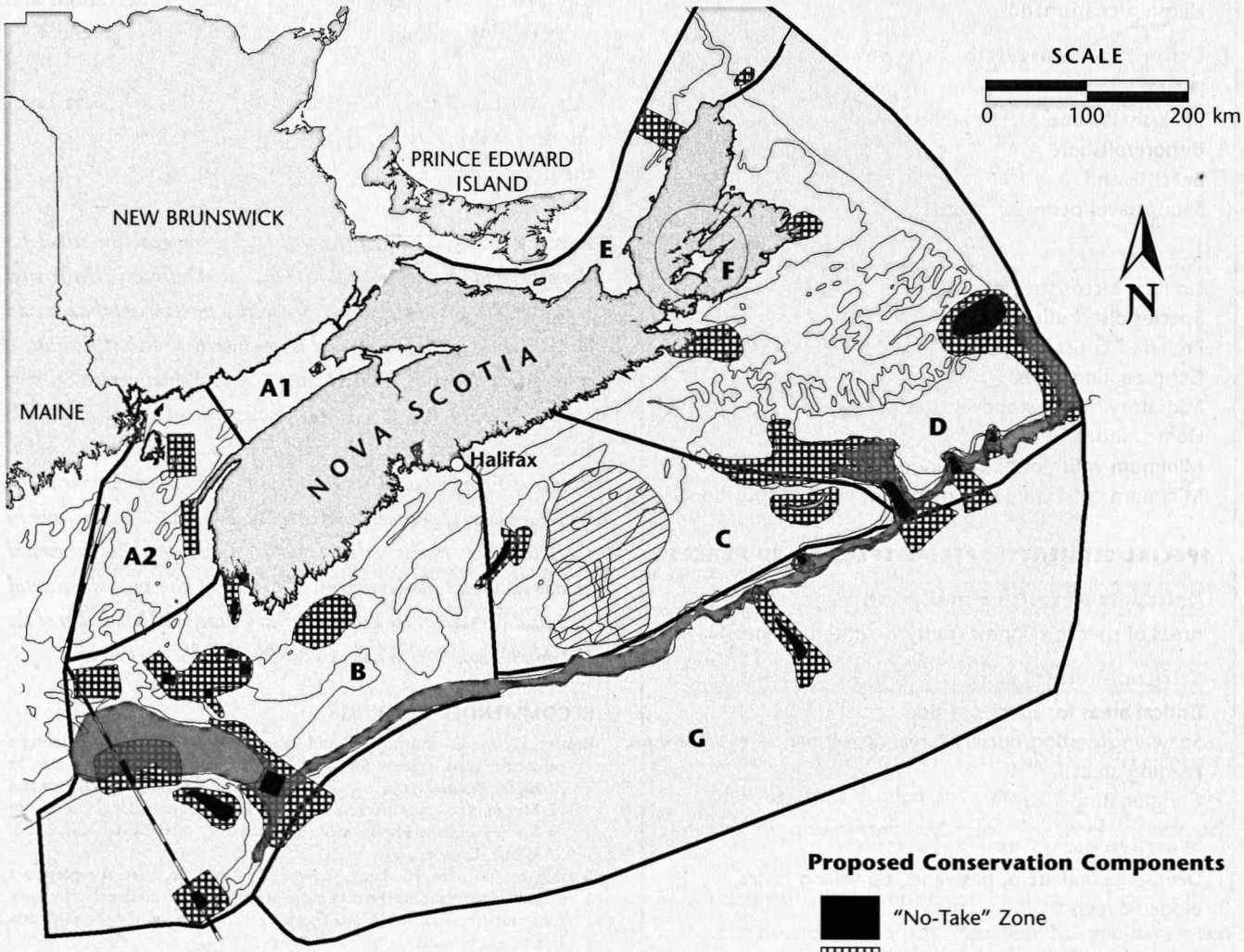
Important habitat for focal species and special element occurrences are being mapped in a computer-based Geographic Information System and overlaid with WWF Canada's seascapes classification map. Representative samples will be selected in each seascape in which less than 12% of its area has been identified as focal-species habitat and/or special elements. Together, consideration of focal species, special elements, and representative samples of natural seascapes will serve to identify priority areas for conservation. More refined MPA boundary delineation and connectivity will include consideration of ocean currents and interrelationships between marine, terrestrial, and freshwater aquatic systems.

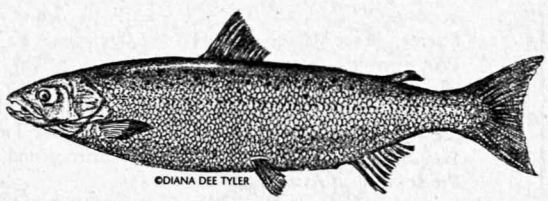
WWF Canada is also working in the Scotian Shelf/Gulf of Maine region with the Conservation Law Foundation (CLF) of New England as part of an international marine conservation initiative to establish an ecologically representative network of MPAs from Cape Cod to Cape Breton. In 2000, a WWF Canada report outlined a marine habitat classification framework based on enduring physical characteristics of marine ecosystems, which was then applied to the Scotian Shelf region to produce a map of physical habitat types (or seascapes). WWF has since refined the seascape classification and expanded the study area to include the Gulf of Maine. The WWF/CLF team is currently working toward defining conservation targets such as the percentage of each seascape to be protected to meet habitat representation goals. Early in 2003, at a peer-review workshop, scientists will critique the seascapes classification and the overall MPA network planning framework.

While significant progress has been made in marine conservation planning in Nova Scotia and the surrounding region

Figure 1. Wild Seas: A Marine Biodiversity Conservation Vision for Nova Scotia

The wild seas vision is a result of the Nova Scotia Wild Lands and Wild Seas Mapping Workshop, held in Dartmouth, NS, May 8–9, 1999. Experts were asked to identify and map important marine conservation components on a 1:1,000,000 scale oceanographic chart. Seven marine management units were defined: **A1** and **A2)** Inner and outer Bay of Fundy; **B)** Southwestern banks and basins; **C)** Central banks and basins; **D)** Eastern banks and basins; **E)** Eastern Laurentian shallows; **F)** Bras d'Or inland sea; and **G)** Deep abyssal plain. Within these management units, potential marine protected areas are identified, along with "no-take" zones. In addition to these areas, two large distinctive zones are defined as special management areas due to their sensitivity and importance for larval recruitment and deep water coral habitat.





Atlantic salmon, pen-and-ink by D. D. Tyler

Table 1. System planning components for marine conservation

FOCAL SPECIES: HABITAT AREA FOR VIABLE POPULATIONS OF NATIVE/FOCAL SPECIES

Focal species types

Keystone/functionally important
Umbrella
Habitat quality indicator
Management indicator
Flagship/charismatic

Enduring feature/habitat types

Pelagic/Benthic
Bank/shelf/slope/canyon/channel
Inshore/offshore
Beach/island
Sand/gravel/bedrock/mudflat

Considerations

Limiting factor/stressor
Species distribution
Preferred/critical habitat
Congregating areas
Migratory routes/stopover sites
Home range
Minimum width of home range
Minimum critical area for minimum viable population

SPECIAL ELEMENTS: SPECIAL SPECIES AND PLACES

Hot spots of rarity and diversity

Areas of species richness (rarity-weighted richness)

Critical habitat areas

Critical areas for species at risk
Spawning/nesting/nursery/larval recruitment areas
Feeding areas
Congregating area

Sensitive ecosystems

Deep-sea coral areas, gas vents, upwelling zones, biogenic reefs

REPRESENTATION: ECOSYSTEM DIVERSITY

Typical/enduring features

Benthic and pelagic habitat types (WWF Canada's seascapes classification)

Special unique places

Unique features
Unique assemblages of species

over the past decade, there is still much to be done. Nevertheless, the preliminary wild seas vision and ongoing refinements provide an ever-clearer picture of the scale and ecological considerations for biodiversity conservation over time. Although the long-term health of marine ecosystems is the goal, significant threats exist for species and processes in the immediate future. Additional integration and cooperation among marine and terrestrial planners and activists is also essential to address the complex and interrelated processes at the interface of land and sea. Together we can define a common vision and precise prescriptions for conservation, and work toward a sustainable future for Nature and people. ☾

ACKNOWLEDGMENT We would like to thank Robert Long and the Wildlands Project for providing GIS assistance and the figure on page 85.

Karen Beazley, Ph.D., *is an assistant professor at the School for Resource and Environmental Studies at Dalhousie University, Halifax, Nova Scotia, Canada. She teaches environmental ethics and protected areas management, and is co-editor with Robert Boardman of* Politics of the Wild: Canada and Endangered Species *(2000).* **Marty King, B.A.,** *is a conservation intern at WWF Canada–Atlantic Regional Office, Halifax, Nova Scotia, and a Master of Environmental Studies student at Dalhousie University on temporary leave of absence.* **Martin Willison, Ph.D.,** *is a professor in the Biology Department and the School for Resource and Environmental Studies at Dalhousie University. He is also active in environmental organizations such as the Ecology Action Centre, and is president of the Canadian Parks and Wilderness Society–Nova Scotia chapter.*

RECOMMENDED READING

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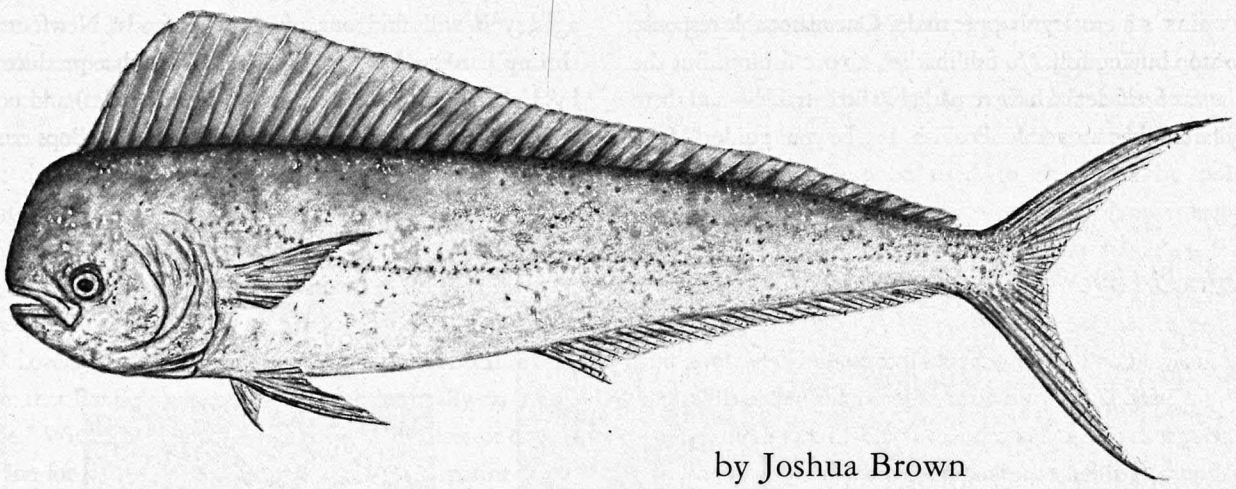
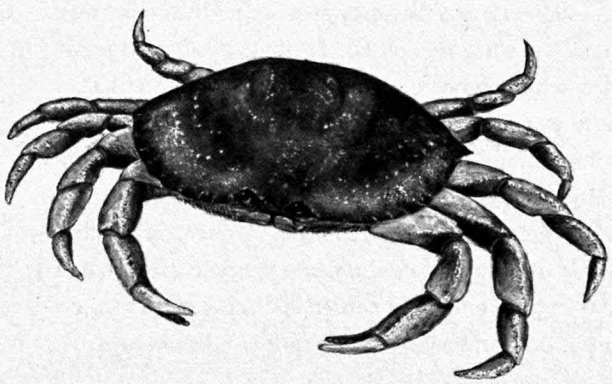
EcoFish, Inc. Trolls the Waters of Consumer Conscience



by Joshua Brown

The cod fishery...and probably all the great sea fisheries, are inexhaustible; that is to say, that nothing we do seriously affects the number of the fish.

THOMAS HUXLEY, Inaugural Address, Fisheries Exhibition, London, 1883



mahimahi and Dungeness crab, watercolors by Todd Telander

IN 1895, A LONGLINE FISHERMAN off the coast of Massachusetts hauled in a cod over six feet long, weighing 211 pounds. A record breaker but not much different from the 50 and 100 pounders that were often pulled up from Georges Bank and the Gulf of Maine in the nineteenth century. Yet those halcyon days when hundreds of schooners heavy with cod set anchor in Gloucester and New Bedford were, really, closing chapters in a 500-year harvesting free-for-all.

Today, Atlantic cod (*Gadus morhua)* average less than 10 pounds, as a commercial species they are nearly extinct, and large parts of the fishery appear to be at the edge of permanent ecological collapse. Cod are not the only Atlantic species in deep trouble. Haddock, salmon, halibut, pollock, flounder, red snap-

per, most shrimp, and many other American dinner-table favorites have received a red designation from the National Audubon Society's Living Oceans Program for having "significant problems" (see sidebar). Recent research makes clear that "even seemingly gloomy estimates of the global percentage of fish stocks that are overfished are almost certainly too low" (Jackson et al. 2001). Thomas Huxley was wrong.

So what's a grocery shopper to do? One reasonable response is to stop buying fish. No fish market, no overfishing. But the sea lanes of self-denial have remarkably little traffic—and there may be another answer: let EcoFish, Inc. be your guide. "Many people don't know which species are in trouble or how they were caught," explains Henry Lovejoy, president and founder of this Portsmouth, New Hampshire company. "We've done this homework for you. Our goal is to provide high-quality seafood from sustainable fisheries to those consumers in this country that care, which is a rapidly growing group."

More than 1,000 natural food stores in the United States now carry EcoFish. Inside quick-frozen vacuum-sealed packages, you will find one of seven seafoods: Newfoundland shrimp harvested with cone-shaped nets that produce little bycatch (the incidental capture of other species) and none of the pollution of farm-raised shrimp; Chinese scallops raised in

Seafood Lover's Almanac

Usually, I don't take my books into the grocery store, but the *Seafood Lover's Almanac* sometimes makes the trip. This elegant volume mixes buyer's guide, natural history, cookbook, nutrition column, and ecological status report about dozens of marine creatures that people like to eat.

Opening to the "Comrades in Armor" chapter, it is clear that not all shellfish are harvested equal. Consider the entry on oysters. Along the outer margin of the page is a graded strip of color, like a piece of litmus paper. Japanese Pacific, European, and Olympia oysters are placed in the green zone at the top; accompanying text explains that they are well managed with abundant habitat. American oysters fall in the middle yellow zone; they are depleted and hampered by water pollution—but are making a comeback in some locations. Dredged oysters find themselves at the bottom, in the red; their harvest causes massive underwater damage. Peering at the mute, glistening trays in the seafood department, it can be hard to know what to choose, what to avoid; this Fish Scale is my guide.

Flipping the page, I learn that, in the wild, one oyster creates a microecosystem in itself: "other shellfish, mud worms, barnacles, boring sponges, snails, hydroids, sea squirts, and numerous other creatures live among, on, and even inside oysters." A sidebar, "How They're Caught," explains that in the Chesapeake Bay, the days of tong and rake harvesting were easier on oyster populations, but have been mostly replaced by destructive dredges. "On Eating Them" describes how to read oyster shells to distinguish dredged from net-grown varieties. Another box tells me that three ounces of oyster contain 100 calories, 35 grams of fat, and 45% of one's daily iron requirement. A cartoon of an oyster carrying a "be my valentine" balloon introduces a tiny essay that demurs on the question of oysters' efficacy as an aphrodisiac—but does warn people with compromised health to avoid eating raw oysters. Returning home, the final page of the oyster section rewards with a recipe for Brazilian bouillabaisse.

The National Audubon Society's Living Oceans Program has distilled an ocean's worth of research into the *Seafood Lover's Almanac*. Fortunately, they have presented it with such flair, pleasing page design, and delicious artwork that more than just committed conservationists can be seen carrying this book in their shopping carts. —**Joshua Brown**

open-ocean lantern nets suspended in the water column to avoid the habitat devastation caused by bottom trawling; Monterey Bay squid, cut into calamari rings—short-lived, fast-growing, early to mature, year-round breeders taken at night with bright lights and seine nets to minimize bycatch; Pacific halibut from the still-thriving Alaskan long-line fishery, which has a strict quota system (Pacific halibut, like many Pacific fishes, are in far better shape than their Atlantic brethren); wild Alaskan coho salmon caught on trolling lines from what appear to be still healthy stocks of fish (unlike most of the ecologically disastrous farmed salmon sold in the U.S.); albacore tuna from the abundant west coast troll fishery that avoids dolphin bycatch; and Ecuadorian mahimahi mostly caught by villagers in canoes with hook-and-line.

From among the hundreds of seafoods available worldwide, these few pass muster with the EcoFish Seafood Advisory Board.* "Our advisors are independent of the company," Lovejoy notes. "They volunteer their time because they believe that EcoFish is a business model that really can bring change." With six members ranging from the director of conservation for the New England Aquarium to a marine scientist with the World Wildlife Fund, the board provides expert advice on fish populations, government management plans, harvesting methods, and other measures of a fishery's health.

Lovejoy then goes out and buys the approved products directly from fishermen—avoiding the traditional seven layers of distribution in the seafood market. "In Alaska many of the boats we buy off of are family fishing boats—mom, dad, kids, working hook-and-line—usually no more than 12 lures in the water, brought in by hand," Lovejoy remarked. "It's sad how the global glut of cheap farm salmon has driven many of these hard-working families out of business." EcoFish's streamlined business model allows the company to pay more than other buyers in the Alaskan salmon fishery with a goal of supporting not only a healthy fishery, but also traditional fishing communities.

Lovejoy knows the messy entrails of industrial fishing. Having spent 10 years exporting lobsters before starting EcoFish, he has often traveled overseas to the largest seafood markets in the world. "You still see huge volumes of highly threatened fish, like the bluefin tuna, coming off the coast here in New England and flying into Tokyo," he said. "Every day, warehouses full of bluefin tuna are for sale. A lot of them are very small, the size of a football. As soon as you start removing breeding stock from a fishery that is already threatened, the writing is on the wall."

As part of its effort to rewrite this sad tale, EcoFish has committed 25% of its profits to marine conservation, as an investment in communities and organizations that support sustainable fishing. This commitment may soon yield real money: 2002 will be the first year (after only two years in business) the four-person company shows a profit, growing from $1 million in sales in 2001 to $2 million last year. While Lovejoy would like to be doing $50 million in annual sales in 5 to 10 years, he gets most excited about how his little business might be used to shape public policy. "Through our product, we can make a large impact in educating the public about the need for MPAs [marine protected areas]. We can put a postcard to Congress in every box of fish."

THOMAS HUXLEY'S words may come back as a perverse kind of truth: "nothing we do seriously affects the number of the fish"—because the fish will have been fished to death. For the more than one billion people who depend on seafood as their sole source of protein, the decrease in global catches since the 1980s—despite greater fishing effort—is ominous. Will efforts like EcoFish help to turn the tide of overfished, overcapitalized, and poorly regulated global fishing? The answer would seem to depend on whether Henry Lovejoy is correct that, "ultimately the force for change in marine conservation is the consumer." ☾

Joshua Brown is Wild Earth*'s assistant editor and a freelance writer. Though he gets seasick just thinking about big boats, he enjoys eating clam chowder at his dryland home in Burlington, Vermont.* ⇦ *For more information about EcoFish, Inc., visit www.ecofish.org or call 877-214-3474.*

SOURCES AND RECOMMENDED READING

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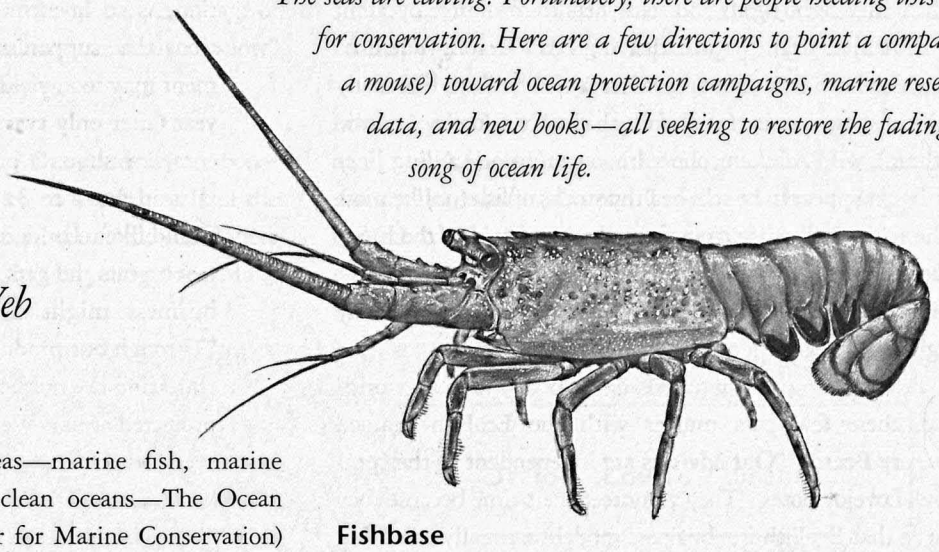
* In addition to these seven products, chefs can receive overnight delivery of Oregon Dungeness crab, farm-raised striped bass, Prince Edward Island blue mussels, sablefish, and farm-raised rainbow trout. EcoFish has also recently launched a retail program for fresh seafood.

A Marine Resources Sampler

The seas are calling. Fortunately, there are people heeding this call for conservation. Here are a few directions to point a compass (or a mouse) toward ocean protection campaigns, marine research data, and new books—all seeking to restore the fading song of ocean life.



On the World Wide Web

The Ocean Conservancy

➤ www.oceanconservancy.org

With four major program areas—marine fish, marine wildlife, ocean ecosystems, and clean oceans—The Ocean Conservancy (formerly the Center for Marine Conservation) develops regional conservation campaigns from offices in Anchorage, Maine, San Francisco, Florida, the U.S. Virgin Islands, and Washington, D.C. See their *Health of the Oceans* report and *Blue Planet Quarterly.*

SeaWeb

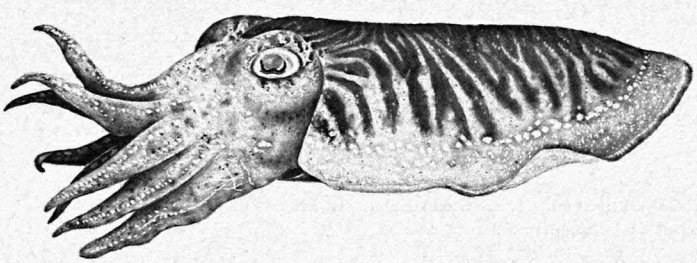
➤ www.seaweb.org

Seeking to raise awareness of the world's oceans, SeaWeb programs include Seafood Choices Alliance, SeaWeb Aquaculture Clearinghouse, a marine reserves campaign, and "Caviar Emptor," a campaign to protect and restore critically endangered beluga sturgeon and other threatened Caspian Sea sturgeon.

Woods Hole Oceanographic Institution

➤ www.whoi.edu

The largest independent oceanographic institution in the world, Woods Hole scientists and students explore the seas from their famous research vessels and deep-sea submersibles.



Fishbase

➤ www.fishbase.org

Containing records on virtually all known fish, this database gives background information on more than 25,000 marine and freshwater species. The site also provides a guide to learning and teaching ichthyology, the opportunity to upload your own fish observations and photos, a "fish tour," and more.

Oceana

➤ www.oceana.org

Opening with a video clip of bottom trawling destruction, Oceana's website introduces this international advocacy group's legal and policy efforts, including pending cases in their Ocean Law Project. Oceana has offices in Washington, D.C., Alaska, and Los Angeles.

Marine Stewardship Council

➤ www.msc.org

The Marine Stewardship Council's global certification program recognizes well-managed fisheries and harnesses consumer preference for seafood products bearing the MSC label of approval.

Surfrider Foundation

➤ www.surfrider.org

This grassroots organization's work to protect our oceans, waves, and beaches is mostly carried out by 60 chapters located along the East, West, Gulf, Puerto Rico, and Hawaiian coasts. Their bimonthly publication, *Making Waves*, is available online.

California rock lobster and cuttlefish, watercolors by Todd Telander

Scripps Institute of Oceanography

➤ http://sio.ucsd.edu

Part of the University of California, San Diego, and one of the preeminent academic institutions in the world, Scripps is home to hundreds of marine conservation research efforts.

NOAA

➤ www.noaa.gov

Like a treasure chest, the National Oceanographic and Atmospheric Administration's website opens onto a wealth of information from tide charts to weather information, fisheries laws to oil spill updates, historical navigation maps to research requests.

Pew Oceans Commission

➤ www.pewoceans.org

This commission has gathered a group of American leaders—from Leon Panetta to Jane Lubchenco—to develop marine policy recommendations. See their useful library of online reports.

Marine Conservation Biology Institute

➤ www.mcbi.org

Founded by biologist Elliott Norse in 1996, MCBI provides scientists, the public, and decision-makers with scientific and policy information. Their campaigns have focused critical attention on bottom trawling and the need for marine protected areas.

New Books on Ancient Waters

In a Perfect Ocean: The State of Fisheries and Ecosystems in the North Atlantic Ocean

by Daniel Pauly and Jay Maclean, 2003, Island Press, $50

The first in a series by leading marine scientists, *In a Perfect Ocean* provides an empirical portrait of 14 large Atlantic ecosystems—and details Pauly's assessment that we are "fishing down the food web."

Eye of the Albatross: Visions of Hope and Survival

by Carl Safina, 2002, Henry Holt & Co., $27.50

The albatross, "a great symphony of flesh, perception, bone, and feathers," takes Safina on an exploration of remote portions of Hawaii and into the lifeways of numerous other sea creatures. A reflective offering from the author of the acclaimed *Song for the Blue Ocean*.

Listening to Whales: What the Orcas Have Taught Us

by Alexandra Morton, 2002, Ballantine Books, $26.95

A personal memoir and scientific account of recording the movements and sounds of orcas—the mammals commonly known as killer whales. Received an honorable mention for the National Outdoor Book Award.

Seal Wars: Twenty-Five Years on the Front Lines with the Harp Seals

by Paul Watson, 2002, Sea Shepherd Conservation Society, $21

Sadly, the slaughter of baby Canadian harp seals continues. *Seal Wars* chronicles the efforts of Captain Paul Watson and the Sea Shepherd Conservation Society to protect these extraordinary animals, even at great personal risk.

Reef Life

by Andrea and Antonella Ferrari, 2002, Firefly Books, $24.95

As part of an excellent series of general-interest, photo-illustrated field guides (including *Turtles and Tortoises* and *Sharks), Reef Life* provides detailed entries on more than 300 species.

Marine Reserves: A Guide to Science, Design, and Use

by Jack Sobel and Craig Dahlgren, 2002, Island Press, $55

No-take reserves—areas of the sea where all consumptive use of marine life is prohibited—may be the last, best chance for ocean biodiversity. This management guide provides case studies and principles for design and siting.

Great Waters: An Atlantic Passage

by Deborah Cramer, 2001, Norton & Co., $27.95

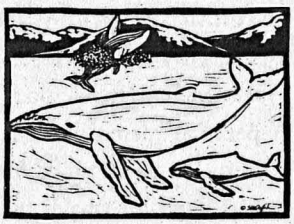
With a scientific voyage from Massachusetts to Barbados as background, Cramer takes on the ambitious task of telling the story of the whole Atlantic Ocean—from water molecules to global tide dynamics—and some of its lesser-known residents.

To Touch a Wild Dolphin: A Journey of Discovery with the Sea's Most Intelligent Creatures

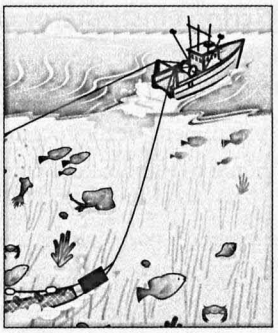
by Rachel Smolker, 2001, Nan A. Talese/Doubleday, $26

The author and a team of fellow scientists spent 15 years studying the lives of dolphins at Monkey Mia, a remote beach on the west coast of Australia. In this personal account, Smolker provides insight into dolphin society, offers portraits of the individual animals she became close to, and chronicles her many interactions with these beloved creatures.

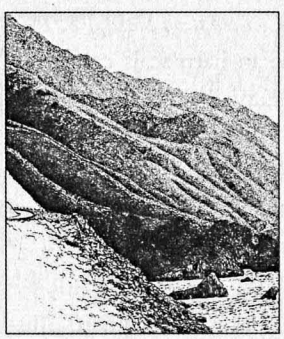
[ARTISTS THIS ISSUE]



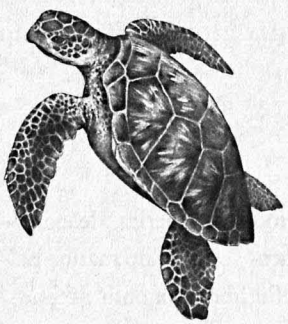
Suzanne DeJohn
(pages 18, 21, 22)
Singing Dog Press
2073 N. Cambridge Rd.
Jeffersonville, VT 05464
802-644-2852
suzanned@garden.org



Joe Shoulak
(page 36)
Joe Shoulak Graphics
joecalif1@aol.com
510-450-0298



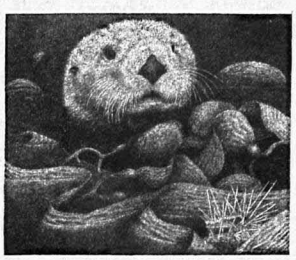
Gus diZerega
(pages 54, 57, 58)
Dept. of Politics
Whitman College
Walla Walla, WA 99362
509-527-5175
dizerega@whitman.edu
www.dizerega.com

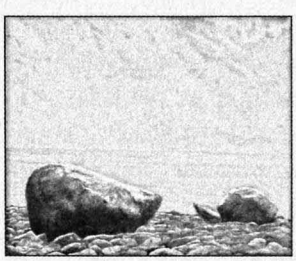


Todd Telander
(pages 6, 7, 64, 65, 71, 73, 87, 90)
915 Calle Conquistador
Taos, NM 87571
505-751-4029
todd@telanderart.com
www.telanderart.com

Richard Ellis
(inside back cover)
richellis@nyc.rr.com

D. D. Tyler
(front cover, 10, 11, 12, 24, 25, 27, 34, 35, 49, 76, 81, 83, 85)
Tyler Publishing
P.O. Box 243
Augusta, ME 04332
207-622-7379
tylerpub@aol.com





Barrie Mottishaw
(page 68)
8012 Waring Ave.
Los Angeles, CA 90046
323-655-2704
barrie@nibs.com

David Williams
(page 2)
2520 Ashley Ct.
Raleigh, NC 27607
919-829-9129
davidtw@ipass.net

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BACK ISSUES

Thirty back issues are available, beginning with our spring 1991 edition. For a more complete listing, visit www.wildlandsproject.org. Order online or use the reply form insert in this issue. See form for additional publications.

Summer 2001 • Dave Foreman on cornucopianism, Tom Butler on Smart Growth and Sapsuckers, David Olson calls for conservationists to speak with one voice, Long-Nosed Bats and White-Winged Doves, saving the sagebrush sea, Lyanda Haupt delights in the Winter Wren, Cascades Conservation Partnership, battling invasive fungi and insects, genetically engineered trees, Farming with the Wild, Eco-Labeling, wilderness restoration forum, U.S. population stabilization

Fall/Winter 2001–2002 (combined issue) • ***Citizen Science*** Thomas Fleischner on natural history, Reed Noss considers whether citizen scientists are amateur naturalists, Rick Bonney suggests citizens collecting data help science, profiles of projects that monitor birds, mammals, fish, butterflies and more; Foreman on Early Awareness of Extinction, Biological Crusts, Sonoran Jaguars, Restoring Scotland's Caledonian Forest, Doug Scott examines words of the Wilderness Act, a lament for Florida, Pedaling Conservation Biology Across America, Saving School Trust Lands

Spring 2002 • ***Extinction or Recovery?*** Causes and Processes of Extinction by Dave Foreman, A Fleet of Arks by Scott Russell Sanders, Quantifying the Biodiversity Crisis, Learning from the Rocky Mountain Locust, Passenger Pigeon Lice Rediscovered, Wolves & the Ecological Recovery of Yellowstone, Canebrakes, Threats to the Black-Tailed Prairie Dog and A Plan for Conservation, California Condors in Arizona, Moral Meaning of & Today's Fight for the Endangered Species Act, Wildlife Amendment Protects Private Lands

Summer 2002 • ***Deep Time*** Foreman on Paul Shepard, John McPhee helps us find our bearings, Evolution's Second Chance by David Burney et al., Connie Barlow says goodbye to the eternal frontier, Reuniting Pangaea by Yvonne Baskin, Jeff Bickart on Reclamation, Paul Shepard essay; Theodore Roszak on ecopsychology, Terrence Frest on native snails, Kathleen Dean Moore essay, Dean Bennett tells the story of Maine's Allagash Wilderness Waterway, a proposal for Pennsylvania's Allegheny National Forest, forum on federal recreation fees

Fall 2002 • Dave Foreman on overpopulation, Paul Hawken on Commerce and Wilderness, Jay Kardan on literary conservationists, John Elder descends into Darkness and Memory, interview with Mike Fay, John Terborgh asks whether the "working" forest works for biodiversity, Steve Stringham pleas for real science in grizzly recovery efforts, Lyanda Haupt encounters a One-Eyed Dunlin, Conserving Wildlands in Mexico, Benton MacKaye's Progressive Vision, Gary Nabhan's satire on bioregional infidels

BACK ISSUE BONANZA!

We're now offering a full set of back issues (less sold-out editions) for **$100** including shipping.

Call 802-434-4077 for more details or to order.

GATHERINGS

9th Annual Public Interest Law Conference The University of Florida College of Law's Environmental and Land Use Law Society will sponsor a conference focused on "Florida's Final Frontiers: Saving What's Left" on February 27–March 1, 2003 in Gainesville. Topics to be addressed include Land and Development, Water, Wildlife and Habitat, and Policy and Procedure. Lawyers, scholars, and representatives of public interest organizations, government agencies, and environmental groups will participate. Wildlands Project Chief Scientist Reed Noss will keynote. Visit http://grove.ufl.edu/~els for information.

Environmental Biology Conference "Interfaces in Environmental Biology," a day-long symposium sponsored by the University of Kentucky's Department of Biology and Tracey Farmer Center for the Environment, will be held on April 3, 2003 in Lexington. Wildlands Project Chairman Dave Foreman will keynote and Wildlands Project Chief Scientist Reed Noss will speak on Application of Science to Conservation. Other topics include Global Habitat and Atmospheric Change, Environmental Endocrine Disruptors, and Funding Trends and Opportunities in Environmental Biology. Visit http://biology.uky.edu/palmer/IEBsymposium.htm for information.

Natural and Cultural Resources Conference "Protecting Our Diverse Heritage: The Role of Parks, Protected Areas, and Cultural Sites" will be held April 14–18, 2003 in San Diego, California. This conference is jointly sponsored by the George Wright Society and Cultural Resources 2003, a program of the National Park Service that works to foster increased appreciation and stewardship of cultural resources. The George Wright Society Biennial Conference is the nation's largest interdisciplinary conference on protected areas. The gathering will include four plenary sessions, 90 concurrent sessions, a poster/computer demo/exhibit session, field trips, and special events. Wildlands Project Chairman Dave Foreman will keynote. Visit www.georgewright.org for details.

Conservation Biology Conference The 17th Annual Meeting of the Society for Conservation Biology will be held June 28–July 2, 2003 in Duluth, Minnesota on the shores of Lake Superior. The meeting's theme, "Conservation of Land and Water Interactions," will focus attention on water, forests, wetlands, the Great Lakes and other large lakes and rivers of the world, marine and coastal systems, and associated biodiversity issues. Visit www.d.umn.edu/ce/conferences/scb2003/home.htm for registration information.

Symposium and Celebration The Rocky Mountain Biological Laboratory in Crested Butte, Colorado will celebrate its 75th anniversary with an August 14–17, 2003 symposium highlighting the benefits of research in model ecosystems. The session will focus on research from the Gunnison Basin, but speakers experienced with other model organisms and ecosystems are invited to attend and present. Abstracts for oral presentations are due by March 15. Visit www.rmbl.org/modelecosystem/modelecosystems.html for details.

Same Continent, Different Priorities

THESE ARE HARD TIMES for conservation in the United States. The Bush Administration recently announced an administrative rule that will weaken the Clean Air Act. It unveiled the latest in a series of rollbacks in forest protection. In Yellowstone, it ignored overwhelming public opinion and will allow more snowmobiles to roar through America's first national park. In Texas, it has just authorized two new drilling projects in Padre Island National Seashore, home to the endangered Kemp's ridley sea turtle and 11 species of imperiled birds. Unfortunately, these and similar threats to America's natural heritage are likely to only get worse as the 108th Congress convenes in January and key senate posts change hands. Many creatures, from turtles to grizzly bears, will find their homes threatened by increased production of oil, gas, coal, and timber on public lands—*our lands*.

While conservationists in the United States are on the defensive, north of the border things couldn't be more different. Canada has just passed its own endangered species act. Prime Minister Jean Chrétien has declared combating global climate change a top priority for his government, which has ratified the Kyoto Protocol. This past October, the Canadians announced plans to create ten new national parks and five new national marine conservation areas over the next five years. These changes will expand Canada's park system by almost 50%, with the total new area spanning over 150,000 square miles, just slightly smaller than the state of California.

Equally important, the government will accelerate its actions over the next five years to improve the ecological integrity of Canada's 39 existing national parks, based on conservation biology principles. Clearly, cores and connectivity are well-understood concepts in the agency charged with preserving Canada's natural heritage. These actions follow guidelines outlined in the new Canada National Parks Act, perhaps the strongest law governing national parks in the world.

What are the lessons here? For one, we in the United States have a lot to learn from our neighbors to the north. All too often we in the American conservation community fail to look beyond our own borders for fresh approaches to conservation science and policy. (In addition to what the Canadians are doing at the national level, readers should also look closely at the exciting conservation work underway in Nova Scotia on page 80. This project, which the Wildlands Project helped launch several years ago and for which we continue to serve as a collaborative partner, is one of the most innovative attempts at integrating marine and terrestrial ecosystem planning currently underway anywhere.)

The second lesson is that politics matter—perhaps now more than ever. What has happened in Canada is no accident, but rather the end result of hard work by countless activists, researchers, agency staff, and ordinary citizens. Canadians too have unmet social needs, concerns about energy supplies, and their own set of economic problems, yet they have been able to see through the false tradeoffs between environment and economy and focus on what really matters: advancing public policies that can sustain wildlife and people in one of the grandest and wildest nations on Earth.

Finally, rather than feeling defeated by the current state of affairs in the United States, we should be energized by it. In spite of what we see and hear on the news, there are millions of Americans just like you and me who are passionately committed to protecting wild Nature. The Canadians have provided us with one model of what's possible; the rest is up to us. If we don't do the job of protecting our wild places, it won't get done, period.

~ **Leanne Klyza Linck**

Species Spotlight

text and illustration by Richard Ellis

Luring Prey in a Lightless World

WITH MOST HAVING gigantic heads all out of proportion to their tiny bodies, the deep-sea anglerfishes look like children's bad drawings of evil fishes. But few children would equip their fishes with fishing rods, and even fewer would permanently attach miniature males to the bodies of the relatively enormous females. Some globular, some elongated, some pear-shaped, the ceratioids are grotesquely formed creatures that are among the most fantastic of all the deep-sea fishes.

The deep-sea anglers are so-called because of their habitat and their fishing equipment. Each species is equipped with a lighted lure (illicium) that is a modified dorsal fin arising from the top of the head. These lures come in all shapes and sizes, from short, stubby little buttons to elaborate whiplike structures. The luminous tip of the illicium is known as the "esca"—Latin for "bait."

As far as we know, members of the genus *Linophryne* (which means "toad that fishes with a net") are unique in having two distinct lighting systems: the esca harbors luminous bacteria, while the multirayed chin barbel generates its own light (described as "intrinsic, extracellular luminescence" by Hansen and Herring in 1977).

Consider the tackle of *Linophryne arborifera,* a miniature ogre that is coal-black and about the size of a baby's fist, with a gigantic mouthful of frightful fangs. On the top of its head it sports a plumed lantern, and beneath its chin is a hanging garden (hence the name *arborifera*) of hanging filaments. This tiny sea monster is well equipped for attracting food in its lightless environment. ☾

Deep-Sea Anglerfish
Linophryne arborifera

KINGDOM	Animalia
PHYLUM	Chordata
CLASS	Actinopterygii
ORDER	Lophiiformes
FAMILY	Linophrynidae
GENUS	Linophryne
SPECIES	arborifera

World-renowned marine artist **Richard Ellis** *has had paintings selected by the Smithsonian Institution, created a 100-foot mural of Moby Dick for the New Bedford Whaling Museum, and written screenplays on whales for PBS. His many books include* Dolphins and Porpoises, Encyclopedia of the Sea, *and* Deep Atlantic, *from which this page is adapted. His newest book,* The Empty Ocean, *chronicles the decline of fish, marine mammals, and other sea life; it will be released by Island Press in May 2003.*

Thousands of seals are slated to die.

Who will stop the slaughter?

We will.

Please join us!

SEA SHEPHERD CONSERVATION SOCIETY

THE SEA SHEPHERD CONSERVATION SOCIETY, led by Captain Paul Watson, has opposed, documented, and exposed this inhumane annual hunt for over 25 years, saving thousands of seals from the brutal clubs and cruel kill tactics of the sealers. But the hunt continues…

In the spring of 2003, the Canadian government again intends to allow the needless killing of over 300,000 harp and hood seals on Canada's eastern coast—the largest mass slaughter of wildlife on the planet.

Captain Watson and Sea Shepherd will journey to the ice this spring, bringing cameras, celebrities, and the determination to STOP one of humanity's most shameful acts—the killing of baby seals.

We need your support to SAVE THE SEALS. Please call 310-456-1141 or 800-494-2537, or visit **www.seashepherd.org** to learn more and make an online donation with a credit card. You can also send your tax deductible contribution to:
Sea Shepherd Conservation Society, 22774 Pacific Coast Highway, Malibu CA 90265.

WILD EARTH
P.O. Box 455
Richmond, VT 05477