

MEMORANDUM TO THE PRESIDENT

From: J.C. Ogden

Subject: Maintaining Diversity in Our Oceans

PROBLEM

The cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea-fisheries, are inexhaustible; that is to say that nothing we do seriously affects the number of fish. And any attempt to regulate these fisheries seems consequently . . . to be useless.

The unintended irony of these words, written by Thomas Henry Huxley in a paper presented at The Great International Fishery Exhibition in London in 1884, is a clarion cry for the future of the oceans.¹ At that time, the population of the world was slightly more than one billion, and the oceans were perceived as mysterious and limitless. The H.M.S. Challenger was two years into its epic four-year voyage of discovery, which laid the foundation of modern oceanography and marine science and brought back the first outlines of the ocean's vastness and sketches of its endlessly fascinating animals and plants. However, even then, human beings had drastically reduced populations of the great whales and other marine mammals and turtles—some to extinction.² Now, more than a century later, it is said that humans know more about the surface of the moon than about the oceans. But this knowledge is sufficient to understand that the relentless growth of human populations to the present 6 billion is exerting a tremendous influence on the oceans, fundamentally changing their biological diversity and threatening a critical part of the Earth's life support system.

Three recommendations address this alarming decline in marine biological diversity:

- Institute a comprehensive program of ocean resource management and protection based on zoning within the U.S. exclusive economic zone (EEZ);
- establish an integrated monitoring and assessment program encompassing the U.S. EEZ to continuously track the status and trends of key indicators of ocean health; and
- establish an intergovernmental scientific panel within international agencies and conventions that is similar to the Intergovernmental Panel on Climate Change (IPCC) to periodically assess global ocean health and make recommendations on mitigation.

BACKGROUND

What is Biodiversity?

Biological diversity has been the cornerstone of biology since the first century, when Roman naturalist Pliny first described different animals and plants, and it has been a preoccupation of biologists since the 18th century Swedish botanist, Carl Linnaeus, began systematically to name and catalog them.³ The apparently simple question, Why are there so many different kinds of plants and animals? drives much of the modern science of ecology. In the past three decades, there has been increasing anxiety about the accelerating worldwide loss of biodiversity, including habitat destruction, species extinction, and loss of genetic material and its potential impact upon human dependencies on the environment.

In the 1980s, benchmark meetings of experts heralded a crisis of species extinction largely associated with tropical deforestation.⁴ The United Nations Conference on the Environment and Development (UNCED), held in Rio de Janeiro in 1992, developed the Convention on Biological Diversity with more than 150 signatory nations to date pledging conservation action. Because there was no perceived crisis of extinction in the oceans, they were not featured in the convention. However, the collapse of fisheries and the destructive effect of fishing

on ocean habitats, the increasing pollution of relentlessly expanding coastal populations, the global decline of coral reefs, and evidence of global warming in the oceans have raised the alarm and pointed to the need for priorities in research, management, and conservation.⁵

The key to understanding marine biodiversity is the salient feature of oceanic life—planktonic larva, which drifts on ocean currents for as little as a few days to as much as a year before settling to begin adult life. Consequently, most marine populations are widely distributed. However, in other areas, such as those in the tropics, the range of tree or bird species may be encompassed within only a few square miles. Modern techniques using genetic markers, combined with satellite observations of currents and water masses and satellite-tracked drifters, have shown great promise in working out patterns of dispersal—surely a key to the design of effective conservation and management strategies. However, scientists now know enough to realize that successful marine resource management and conservation will have to work on local, regional, and, ultimately, global scales.

The oceans cover more than 71 percent of the Earth and, taking depth in account, contain more than 99 percent of the space available for life. Although oceans have fewer species than the terrestrial environment, they contain about twice the phyla (higher order diversity) as land does, with species much more evenly spread among them.⁶ In contrast, more than 90 percent of terrestrial diversity is in only two phyla—insects and flowering plants. Just as in the era of the Challenger expedition, the oceans remain remote, difficult to visualize, and poorly understood. For example, deep-sea sediments contain a great biodiversity, yet the total area that has been sampled is the equivalent of only a few tennis courts. Similarly, coral reefs, often called “the rainforests of the sea,” are well known in only a few locations.

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How much human disturbance can an ecosystem tolerate? This question is at the center of conservation efforts and attempts to live sustainably with nature. It also lies on the frontier of current ecological research, including indicators of ecosystem functioning, such as plant production and the cycling of essential nutrients in disturbed versus undisturbed sites, comparative studies of sites arrayed along clines of increasing biodiversity, and microcosm experiments.

Other studies look at replacements and adjustments of species numbers and distributions through contemporary and geologic time using well known and well preserved fossil species assemblages. Introductions of nonnative species, such as zebra mussels in the Great Lakes and comb jellies in the Black and Azov Seas principally by ballast-water transport, are accidental “experiments” that have resulted in significant declines of native species and important resources. Some species, called “keystone species” contribute disproportionately to the structure and dynamics of the ecosystem. Identification of these species may provide an indicator of ecosystem health and an early warning to implement intensive conservation efforts in advance of a collapse.⁷

Coral bleaching, a physiological response of corals and their symbiotic algae to high water temperature, was first noted on coral reefs of the greater Caribbean Sea and Florida in 1987. This was the same year that the U.S. Congress began to address global warming. Since then, coral bleaching has been noted periodically all over the world, often associated with El Niño, but always with prolonged elevated seawater temperatures. The 1997–98 El Niño—the largest this century—coincided with the largest, most coherent, and most damaging coral bleaching event in history. All through the world’s tropics, corals bleached and unprecedented amounts of coral died. Since 1987, coral bleaching has been a hypothetical early warning signal of global warming in the oceans. The 1997–98 event, combined with recent evidence of warming of the core temperature of the ocean, is great cause for alarm and concern for the future of the most diverse and most beloved shallow-water ecosystem.⁸

Marine ecosystems are major national capital assets. In addition to providing valuable goods, such as fisheries and minerals, they provide critical life support services, such as diluting, dispersing, and metabolizing the effluents of society, thus purifying waters for recreation. The value of a healthy ocean is difficult to overestimate. At a national level, economic evaluation of ecosystem services can guide policy decisions on inevitable development versus environment tradeoffs. For example, Florida’s ocean policy estimates an annual economic value of \$105 billion to ocean-related industries and tourism. Recent attempts to put a monetary value on global ecosystem services have stimulated much discussion and more comprehensive and ultimately more useful ways to evaluate the importance of nature.⁹ Finally, it is important to acknowledge that the value of nature to human society might be even more fundamental. E. O. Wilson, Pellegrino

Research Professor in Entomology at Harvard University, has argued that people have an innate response to biodiversity that links us to our evolutionary origins and stands at the core of humanity and a sense of well-being.¹⁰

Everything We Do on Land Ends Up in the Ocean

Ahupua'a—from ridgetop to reef—was the ancient Hawaiian scheme for managing human activities from the watershed to the sea, recognizing the inextricable link between them. The coastal seascape—including the watershed (100 meters above sea level) and the coastal ocean and continental shelf (200 meters below sea level)—is the meeting place of the three great provinces of land, sea, and air. It is where 60 percent of the human population lives and it accounts for about 25 percent of global production of plant material, the basis of all food chains, and 90 percent of fish catch. An estimated 80 percent of marine pollution originates from land runoff and atmospheric sources. During the past 100 years of relentless population growth, the seascape's capacity to disperse, dilute, and metabolize the waste products and effluents of human society and its insults to the land has been gradually exceeded. The consequences include damaged coastal economies, pollution, increased frequency and virulence of harmful algal blooms, dead zones off major river mouths, human health concerns, and diseases of marine organisms.¹¹

South Florida is a case in point. In 1988, the Everglades National Park sued the state of Florida for discharging nutrient-laden water from the Everglades Agricultural Area into the northern reaches of the park, allowing nonnative plant species to displace the famous river of grass. Downstream, the development of the management plan of the new Florida Keys National Marine Sanctuary targeted declining water quality in the Everglades ecosystem and Florida Bay as a critical impact on contiguous sanctuary waters. The sanctuary plan identified the limitation of freshwater delivery to Florida Bay by decades of freshwater canalization and drainage as the cause. The resolution of these two problems, currently in progress in the Everglades Restoration Project, is the largest effort in U.S. history to restore the functioning of a natural system. In partnership with Florida, it involves a commitment of billions of dollars in property acquisition and drainage engineering to restore more natural freshwater flow through the greater Everglades ecosystem and into the shallow marine waters surrounding the Florida peninsula.¹²

In the west, “shuttling as they do like silver threads between upland and ocean . . . , salmon tightly stitch the interlock between continent, torrent, and tide binding everything humans do to land and water.”¹³ One has only to look at the reasonably healthy economics and management of the Alaska salmon fishery, where the human population is low, the seascape is relatively undisturbed, and rivers run free of dams, to realize what has been lost in Washington, Oregon, and California. There, disruption of streams and rivers by dams and deforestation, overfishing, and unintentional release of Atlantic salmon and their pathogens from aquaculture are driving genetically distinct Pacific salmon populations to the brink of extinction.

Overfishing

The unfortunate history of fishing is overfishing. The principal reasons are politics and greed. The United States spends approximately \$500 million annually on fisheries research and management and has worked out the fisheries-related aspects of the life histories of most commercially important species. Nevertheless, the United States does not effectively manage most of these fisheries.¹⁴ The 1976 Magnuson Fisheries Conservation and Management Act eliminated competition from foreign fishing fleets by establishing eight regional fishery management councils charged with developing management plans for fishery resources and an EEZ of 200 miles. Unfortunately, the act was unclear about overfishing and encouraged the National Marine Fisheries Service and the councils to achieve a vague standard called optimum yield. The shifting definition of optimum yield allowed maximum sustainable yield, another uncertain standard, to be exceeded because of economic and social considerations, driving some fisheries to collapse. The councils mixed the problems of fisheries management with local and regional politics and commerce, shifting emphasis from sustainability to commercial development of hard-pressed fish species and, given frequent disasters, switching effort to underexploited species that become the disasters of the future.

Fish are wildlife. Overfishing causes declines in marine biodiversity and the results recall the history of settlement and development of the land. The development of agriculture required the removal of large land predators, such as bears, wolves, and cats, causing drastic increases in populations of deer and other grazers, which, in turn, disrupted natural and cultivated areas. Overfishing of large

predators similarly changes the functioning of marine ecosystems. For example, the shift from reef-building corals to overgrowth by algae on many coral reefs has been attributed to overfishing and associated human disturbances. In the open ocean, fishing first eliminates the larger top carnivore and then gradually moves down the food chain, changing the functioning of ocean ecosystems in ways that humans do not yet understand.¹⁵

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Fishing gear damages biodiversity. For example, trawl fishery has been compared to catching squirrels by cutting down forests. Bottom trawl nets scour and destroy an estimated global area of fish habitat the equivalent of 150 times the area of forests cut annually worldwide, and a great proportion of the catch—the so-called by-catch—is discarded.¹⁶

The 1996 reauthorized Magnuson Act (renamed the Magnuson-Stevens Sustainable Fisheries Act) addresses the earlier problems of sustainable fisheries and mandates that fisheries management councils use a precautionary approach to evaluate the impact of loss of essential fish habitat (EFH), manage fisheries using ecosystem principles, and mitigate damages. Unfortunately, the act has a fundamental policy flaw in that fisheries management is too narrow in scope to provide the basis for managing the ocean ecosystem implicit in the EFH and ecosystem provisions.

In response largely to concerns of fisheries management, various types of marine protected areas have captured the imagination of policy makers, resource managers, scientists, and the general public as simple, familiar, and demonstrably effective ways of managing fisheries and protecting marine biodiversity. In the years since the National Marine Sanctuaries Act of 1972, 12 marine sanctuaries have been designated. The Florida Keys National Marine Sanctuary (FKNMS), created by Congress in 1991, is one of the largest and the only one with a comprehensive management plan. The plan uses zoning to separate potentially conflicting human activities and implements fully protected, fishing prohibition zones, sometimes called “no-take reserves.”¹⁷

Most people are astonished to learn that the total area of fully protected marine habitat in the United States is approximately 50 square miles. The Dry Tortugas Marine Reserve, to be designated as part of the FKNMS in late 2000 after extensive public discussion, will quadruple this area. This tiny and insignificant level of protection stands in stark contrast to land areas in which more than 700 national parks and 93 million acres of national wildlife refuges have been designated, protecting, in total with other areas, approximately 5 percent of the U.S. land area. Clearly U.S. marine sanctuaries are too small and the areas that they protect are tiny and fragmented.

In May 2000, anticipating broad public support, President Clinton ordered the development of a national system of ocean conservation zones centered on fully protected marine reserves with the ultimate goal of protecting 20 percent of U.S. coastal waters. Networks of fully protected marine reserves will support traditional fisheries

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management by supplying new recruits to the surrounding harvested areas and will enhance fishing in adjacent areas by movement of adults. In addition, the reserves will function as reference or control areas to evaluate the environmental cost of fishing and help to inform manage-

ment. But the greatest benefit of marine reserves will be the protection of the marine biodiversity.¹⁸

The decline of global fisheries has caused aquaculture to double in the past 15 years, currently accounting for approximately 20 percent of global fisheries production. This attempt to make up for the enormous production potential of wild fishes through fish farming is doomed to failure. More than 220 species of finfish and shellfish are grown in aquaculture, and the collateral damage to the environment has been huge. For example, much of the world's 50 percent decline in mangrove forests can be attributed to the relentless pursuit of the economic potential of shrimp culture. Aquaculture ponds and the culture of nonnative species have caused the introduction of diseases into already stressed native populations. Finally, the most widely consumed aquacultured species are fed a significant portion of their diet on fish meal and oil from wild-caught fishes, further stressing the

natural system. Sustainable aquaculture is feasible but not on the industrial scale that has characterized much of the recent growth in aquaculture.¹⁹

RECOMMENDATIONS

Establish Comprehensive Management and Protection of Marine Biodiversity in the United States

The pressures on the shallow marine ecosystems in the United States to provide commerce, recreation, and resources and to receive, process, disperse, and dilute the effluents of a complex modern human society are increasing. With the exception of ownership, the United States uses the coastal ocean in much the same way they use the land, and the conflicts between commerce, recreation, development, resource exploitation, and conservation are expensive, contentious, politically sensitive, and very familiar. The recent rapid implementation of marine protected areas has pointed to the need for more comprehensive zoning of the oceans.

The U.S. EEZ is 130 percent of the U.S. land area. It contains most of the country's marine biodiversity and the myriad physical, chemical, and biological linkages that zoning must address. The EEZ is a logical, legally defensible, and ecologically meaningful geographic area in which comprehensive management and protection have the best chance to achieve sustainable balance of resource use and conservation. Zoning brings one of the most familiar tools that has been used on land to separate potentially conflicting human activities and uses—that of the landscape (or land-use) plan, into the ocean. Within the EEZ, humans have the opportunity to step back and assess, with the best available knowledge, the distribution of and threats to coastal ocean biodiversity. The data and information to do this is abundantly available from federal, regional, and state sources. For example, it is not well known that the U.S. EEZ was completely mapped with multibeam sonar in the 1980s. In addition to providing critical information on the distribution of resources, this imagery provides a powerful way for the public to see ocean regions as essentially similar to the land. Armed with this information, the United States can implement a process leading to a seascape (or ocean-use) plan, based upon comprehensive zoning within the EEZ, that will start a whole new course of protection and use of coastal marine resources.

The ocean-use plan, based on zoning, has several immediate benefits. It is familiar and can be put into positive terms. In contrast, concentrating on bottom-up implementation of fishing prohibition zones or no-take marine reserves one at a time targets only one user group and makes the process unduly contentious. However, if the bottom-up efforts are nested within a national commitment to sustainable use of marine biodiversity, all stakeholders—not only fishers—will have a role. The function of marine protected areas will be much clearer and the pain and the benefits will be shared. The ocean-use plan logically links the coastal ocean to the land, a goal that is often stated as basic to coastal ocean management but is rarely achieved.

Finally, a key difference between land and sea is that zoning in the sea is inherently more flexible. The ocean is not owned and zones can be established and moved in response to increased understanding and changing exigencies. The geographically broader approach and the potential flexibility of an ocean-use plan help to deal with a vexing question: How much of a larger area zoned for multiple uses should be fully protected from all human disturbances? The figure of 20 percent has been widely discussed, but there is little scientific justification for it. It seems to be big enough to provide significant protection, yet it is not so big as to be politically impossible to achieve. The implementation of a network of fully protected areas, combined with a scientific monitoring plan, will provide, over time, the key information to answer this question. In other words, adaptive management of the coastal ocean will be inherently easier than management on land.²⁰

Establish an Integrated Coastal Ocean Observing System

The great variability, short time scale, and small geographic scale of oceanographic events in the coastal seascape demand state-of-the-art continuous, in situ monitoring equipment, and better access to more refined remote sensing and satellite imagery. For example, there are at present no sensors to monitor the inorganic ions of phosphorus and nitrogen, which are key indicators of pollution of coastal seas. In addition, satellite sensors have not generally been designed for maximum utility in the coastal ocean where most management problems are.

After the 1982–83 El Niño, the United States, in cooperation with France, Japan, and Taiwan, began a 10-year program to build a vast ocean observing system known as the Tropical Atmosphere-Ocean (TAO) Array of 70 buoys span-

ning the Pacific Ocean. The buoys measure critical surface and subsurface parameters that are telemetered to the National Oceanographic and Atmospheric Administration's (NOAA) Pacific Marine Environmental Laboratory. The TAO Array allowed ocean scientists to accurately predict the 1997–98 El Niño—something that had never before been done.

Following on this success, initial blueprints have been prepared for a national integrated ocean observing system. The data, critical to weather prediction, safer marine operations, and prediction and mitigation of natural disasters, will be among the most valuable for human health and safety in the world.²¹ The program will also create opportunities for entrepreneurs. Imagine a nightly weather report including ocean conditions: Temperature gradients, wave fronts, algal blooms, wind patterns, and other key information will be set into motion in full color and become as important to the average person in the United States as cloud patterns and radar images of rain intensity and storm cells are today.

Establish an Intergovernmental Panel on Ocean Health

The reports of IPCC have been extremely influential in directing the energy and atmospheric policies of many nations and have driven demonstrable improvement in human damage to the atmosphere. There is a need for an IPCC-like process directed at marine systems.

In international waters beyond the EEZ, the nations of the world collect a great deal of data and information to inform national programs. Sometimes these data are gathered together in a global summary. For example, the UN Food and Agriculture Organization collects and publishes fishery statistics from every fishing nation. These statistics present a grim recent history of fisheries worldwide but are not widely known. Similarly, vast amounts of water quality data critical to understanding the dynamics of the ocean system are collected every year by maritime nations and filed away, largely unused. Taken together, all of these data provide important information on ocean health.

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An Intergovernmental Panel on Ocean Health, integrating the information from developing international ocean observing systems, could be as influential as IPCC is on

greenhouse gases on national policies involving fishing, waste disposal, mining, energy, and shipping. The United States, having much to gain from comprehensive ocean protection and management, has the power to lead such a development.²²

Conclusions

Biodiversity is the key to the maintenance of the world as we know it This is the assembly of life that took a billion years to evolve. It . . . created the world that created us. It holds the world steady. (E. O. Wilson)²³

Ocean ecosystems are major capital assets and a healthy ocean is a key to the economic and social future of the United States. National polls taken over the past few years clearly show that public awareness of the oceans is growing rapidly and that people are frustrated with our inability to manage and conserve marine biodiversity. The political will is present to support bold new initiatives. A comprehensive long-term program based on zoning the EEZ, developing the scientific and management infrastructure to monitor and manage it, and extending experience in partnership with the maritime nations to the global oceans is an idea commensurate with the scale of these emerging problems. It will not be easy, but the approach demystifies the oceans and lends itself readily to phased timing, partnerships with coastal states and nations, and public education and participation. Stewardship of the last great frontier on Earth will strengthen our global leadership and emerging traditions of environmental sensitivity and do no less than sustain human survival and quality of life.