Endangered Species UPDATE

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THE UNIVERSITY OF MICHIGAN
School of Natural Resources

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Reefs and the Greenhouse Effect: Will Coral Go with the Flow ?

by
Lauren Wenzel

Introduction

Recent evidence suggests that coral reefs may be more immediately threatened by global warming than terrestrial systems. Coral reefs are sensitive to small changes in sea surface temperature, light availability, and other environmental factors. Despite their rapid growth and wide geographic range, such specializations make reef ecosystems vulnerable to global change. Many scientists agree that rising atmospheric concentrations of CO_2 and other greenhouse gases — produced by industrialization and changing land use — will cause the average earth surface temperature to rise. In 1990, the International Panel on Climate Change (IPCC) estimated that the direct and indirect effects of increased atmospheric concentrations of greenhouse gases will warm the earth by about 3° Celsius by the end of the next century. Among the impacts of global warming will be a rising sea level, due to the expansion of warmer oceans and the partial melting of glacial and polar ice. Recent estimates, by the IPCC and the National Academy of Sciences, of expected sea level rise range from 65 cm to 1.5 meters by 2099. These increases correspond to average annual rates of 5-14 mm/year, compared with a historic rate for the past century of 1.2-1.4 mm/year (Gornitz, et al, 1982). Other expected impacts include increased seawater temperature, possible changes in ocean currents, and increased frequency and intensity of tropical storms. I will explore how these changes may affect coral reef ecosystems.

Coral reefs are among the earth's most diverse and productive ecosystems, occurring in warm shallow waters (between 30° N and 30° S) that are uninfluenced by major upwellings or freshwater inflows. Reef-building (hermatypic) corals rely on sunlight for the survival of their symbionts, the photosynthetic algae that live inside coral polyps. These algae, called zooxanthellae, provide corals with oxygen, carbon and essential nutrients; receiving shelter, CO_2 and nitrogenous wastes in return (Bunkley-Williams and Williams, 1990). Hermatypic corals receive up to 98% of the photosynthetically fixed carbon produced by zooxanthellae, potentially meeting up to 100% of the animals' respiratory requirements. This partnership enables corals to produce their calcium carbonate skeletons 2 to 3 times faster than they could alone. The efficiency of this relationship creates a highly productive ecosystem despite relatively nutrient poor tropical waters. At depths of 30 meters, reef fisheries annually yield an average 43 tons per square mile, and yields of 65 tons per square mile have been recorded in American Samoa (US OTA, 1987). Coral reefs are also extraordinarily diverse ecosystems. About 500 species of hermatypic corals are distributed throughout the Indo-Pacific; and about 70 in the Caribbean, with eight genera common to both regions (Sheppard and Wells, 1988). Together with corraline algae species and zooxanthellae, corals form a habitat for thousands of fish and invertebrate species. The diversity within reef ecosystems is a result of specialization, both in terms of food and microhabitat. This diversity and productivity, the highest in the marine world, has prompted ecological comparisons with tropical rainforests.

The economic value of coral reefs —primarily fisheries production, tourism, and coastal protection — is enormous, particularly in the developing world. Reef fish account for a significant portion of marine fish catch: 8 to 10% in the Philippines and 20% in Sabah, Malaysia (Sheppard and Wells, 1988). Atoll inhabitants are even more dependent, relying on reef species for over 90% of their protein requirements. In Kosrae, Belau (S. Pacific), over 500 fish species have been recorded — 200 of them eaten locally (US OTA, 1987). Reef fish are preyed on by migrating pelagic species, which comprise the bulk of the world's commerical fisheries. In addition, coral reefs are also the basis of coastal tourism in many tropical countries. Finally, reefs provide critical protection from storms for many tropical islands and coasts. For low lying atolls such as the Marshall Islands, Kiribati, the Maldives and Tuvalu, reefs are the key to national survival.

A Caribbean coral reef — Photo by Yonat Swimmer

Rising Seas

Reefs grow in clear, warm, shallow waters, thriving between 0 and 30 m; they do not grow below 45 m (Wells and Edwards, 1989). Histories of ancient reefs reveal that in past periods of rapid climate change, some reefs were able to grow quickly enough to keep up with rising seas; others could not and were submerged. Research on the Great Barrier Reef reveals that most reefs were innundated during the warming that followed the last ice age 8000 to 9000 years ago, when sea levels were rising by 7 to 10 meters every thousand years. The waters surrounding the Great Barrier Reef reached modern sea levels about 6500 years ago, and reefs, growing by about 7 to 8 meters each thousand years, were gradually able to "catch up" (Hopley and Davies, 1986). Whether modern reefs "keep up", "catch up", or "give up" (i.e. drown) (categories proposed by Hopley and Davies) depends, of course, on the respective rates of sea level change and reef growth. Both are difficult to measure or predict precisely.

Researchers examining tide gauges for the past 30 to 50 years have found an average annual global sea level rise of 1 to 2.4 mm/year, perhaps a sign that the impacts of global warming are already being felt. In the early 1980s, climate researchers estimated a global temperature increase of 1.5 to 4.5° C could cause sea levels to rise by 144 to 216 cm by 2100, (13.1 to 19.6 mm/year). However, three groups of climate modellers — members of the American Geophysical Union, Australia's CSIRO, and Germany's Max Planck Institute for Meteorology — have recently independently downscaled their best estimates of sea level rise to approximately 30 cm by 2050 (4 to 5 mm/year) because glacial melting is assumed to be minimal in the short term (through 2050). Although vertical growth rates for some reef species have reached 14 mm/year, most scientists' maximum estimates for overall reef growth converge around 10 mm/year (Buddemeier and Smith 1989). Intermediate growth rates range from 4 to 6 mm/year, while many slow growing reefs, such as those on some Pacific atolls, accumulate at rates of only 1 to 3 mm/year (Wells and Edwards, 1989). Within the reef, branching corals may show rapid growth of up to 14 mm/yr in favorable conditions, while most corraline algae grow slowly, at rates of only 1.2 mm/yr (Hopley and Davies, 1986). Vertical growth rates for many species decline with depth, due primarily to changes in light availability. In experiments on Enewetak atoll, for example, Buddemeier notes that *Porites lutea* grows 2.5 times faster at 4 meters than at 30 m. In their research on surviving and submerged reefs in the Hawaiian archipeligo, Grigg and Epp (1989) conclude that reefs below a "critical depth" cannot continue to grow upwards, and ultimately drown. These depths are determined by rates of coral growth, changes in sea level, erosion, and subsidence or uplift of the foundation.

On an ecological time scale, net reef growth is influenced by rates of bioerosion, caused by boring species such as sponges, barnacles and bivalves, and grazers such as parrotfish and sea urchins. In Barbados, conditions favorable to these species have resulted in a net loss of calcium carbonate on some fringing reefs. Changing environmental conditions that favor such species could affect reef growth rates, and their ability to keep up with rising seas. Much evidence suggests that reef growth will not keep pace with sea level rise in the long term.

As Buddemeier and Smith (1988) point out, the range of uncertainties of sea level rise and coral growth overlap. Much depends on the degree and rate of sea level rise. However, even a conservative estimate of 5 mm/year over the next century and beyond, corresponding to revised estimates of sea level rise, will eventually submerge many slow growing reefs over a period of centuries. In the South Pacific, researchers fear that even if reefs are able to keep pace with rising seas, atolls will still suffer a net loss of sand due to increased erosion from waves and storms, unmatched by increased rates of sediment production.

Warmer Seas?

Estimates of sea surface temperature increases depend not only on at-

Endangered Species UPDATE

A forum for information exchange on endangered species issues
January/February 1991
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Alice Clarke and Joel Heinen...Editors
Dr. Terry Root............Faculty Advisor
Jon Jensen.......................Staff Advisor

Instructions for Authors:
The Endangered Species UPDATE welcomes articles related to species protection in a wide range of areas including but not limited to: research and management activities for endangered species, theoretical approaches to species conservation, and habitat protection and preserve design. Book reviews, editorial comments, and announcements of current events and publications are also welcome.

Readers include a broad range of professionals in both scientific and policy fields. Articles should be written in an easily understandable style for a knowledgeable audience. Manuscripts should be 10-12 double-spaced typed pages. For further information, contact the editors at the number listed below.

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Hawksbill Turtle
(*Eretmochelys imbricata*)
Photo by Yonat Swimmer

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mospheric models, but also on complex models of ocean currents. The sea surface temperatures measured by satellites are for open water areas (usually slightly cooler than reefs), are often on too large a geographic scale to be useful for assessing local impacts, and are influenced by cloud cover. Despite difficulty in using these data to understand reef conditions, satellite data have revealed that global sea surface temperatures have already begun gradually warming by 0.1° C per year (Strong, 1989). Atmospheric temperature data measured by satellite, on the contrary, showed no warming trend over the past decade. Estimates of the impact of global warming on sea surface temperatures vary. One model, developed by the Goddard Institute for Space Studies, predicts that a doubling of CO_2 will increase sea surface temperatures by 2.3 to 4.8° C. Such an increase could have a devastating affect on coral reefs.

Coral polyps are extremely sensitive to temperature. Reefs grow best between 26 and 27° C and temperatures below 23° or above 29° slow calcification dramatically (Miller and Veron, 1990). Many researchers now believe that the mass bleaching, or loss of color due to destruction of zooxanthellae cells, which ocurred in the Caribbean in 1987 and 1989, was due to temperatures up to 1° C above normal (Bunkley-Williams and Williams, 1990). Observations of bleaching in the Caribbean confirm that all incidents occurred during periods of elevated water temperature and were not caused by pathogens, changes in salinity, or local environmental stresses (Goreau, 1990).

Although expulsion of zooxanthellae takes place naturally, allowing corals to dispose of old or dead cells, the mass expulsion by bleached corals is a sign of physiological stress. One explanation of bleaching is that higher temperatures increase rates of photosynthesis in zooxanthellae, causing them to produce too much oxygen, a toxicant to most organisms. When oxygen levels become intolerable, corals expel their symbionts. This explanation is supported by observations in the Caribbean that zooxanthellae taken from coral hosts that had bleached showed a dramatic increase in oxygen production with temperature (Sandeman, 1988). Another theory is that corals stressed by high temperatures fail to provide algae with enough nutrients to survive. Studies around the Florida Keys, Hawaii, and Enewetok atoll have shown that corals exposed to seawater above 30° C lost their zooxanthellae permanently and died (Ghiold, 1990). Reefs on wide shallow shelves, having little circulation with open ocean waters, may be more vulnerable to bleaching incidents. Also at risk are high latitude reefs, which seem to be more sensitive to elevated temperatures than reefs at lower latitudes. Although many bleached corals eventually recover, repeated or prolonged bleachings may cause coral death. Caribbean corals bleached during 1987 and 1988 failed to grow or reproduce for 10 months, due to slow recovery and difficulty in feeding. Bunkley-Williams and Williams (1990) predict that global bleaching cycles will occur every 3-4 years, gradually becoming more intense, and that the next cycle will begin in 1991 or 1992. Mass bleaching could also occur if the warming the ocean surface layer causes dramatic shifts in ocean currents, a potential impact predicted by some atmospheric-oceanic models.

Over the past decade, sea surface temperature records for Jamaica, Florida, and the Bahamas show an average temperature rise of 0.4 to 1° C; a similar trend has been observed in Hawaiian waters. These regional effects cannot be linked conclusively to global warming. Other explanations include bleaching as a response to a periodic atmospheric-oceanic event, or a result of cumulative environmental and anthropogenic stresses. However, pollution alone cannot explain the bleaching episodes of 1987 and 1990, which affected many areas remote from human populations. Mass bleaching is widespread and non-species specific: in 1987 and 1988, bleaching events occurred worldwide, affecting most species of reef-building corals (Goreau, 1990).

Warmer seas could also cause changes in current tropical storm patterns. One model developed at MIT predicts that an increased sea surface temperature of 2.3 to 4.8° C could increase the intensity of tropical storms by up to 60% (Emanuel, 1987). Warmer oceans may also increase storm frequency, and would enable tropical storms to form at higher latitudes. Reefs can be devastated by tropical storms, both through the direct impact of wave action (particularly on branching corals) and through the increased sedimentation and freshwater runoff from land. As the number and intensity of future storms increases, reefs already stressed by pollution and overexploitation may be less able to recover from catastrophic damage.

Reefs and the Carbon Cycle

The oceans are an enormous reservoir for carbon, containing 50 times more than the atmosphere and 20 times more than the biosphere, but how much is stored in reefs? Until recently, the amount of carbon stored in reefs was not considered globally significant, and was not included in global carbon budgets. There are two major pathways for carbon in coral reef systems: calcification, and organic carbon production and consumption. CO_2 fixed by photosynthesis roughly equals that produced by respiration for reef systems and is not considered to be a significant global reservoir. Corals transform CO_2 from respiration and bicarbonate absorbed from seawater into calcium carbonate skeletons. Calcium carbonate is also produced by many red and green algae species and by reef animals such as foraminifera, sponges, and molloscs. The rates at which reefs produce calcium carbonate vary with species and environmental conditions, but are directly proportional to rates of photosynthesis, suggesting that light is the primary limiting factor (Chalker, 1983). This does not seem to be due to increased fixation of organic carbon, which is found in reef skeletons and sediments only in small amounts. Rather, increased photosynthesis may create conditions favorable for growth by increasing the removal of phosphates, which inhibit calcification (Miller and Veron, 1990).

Based on measurements of calcification rates for different reef types on the Great Barrier Reef and elsewhere, Kinsey and Hopley suggest a composite

(Continued on UPDATE page 4)

reef growth rate of 1.46kg/m²/year. They estimate that the 617,000 km² of reefs worldwide currently produce 900 million tons of calcium carbonate a year, representing a sink for 111 million tons of carbon a year, or 2% of present industrial CO_2 emissions. Kinsey and Hopley predict that a sea level rise of 0.2 to 1.4 meters over the next 50 to 100 years will cause a burst of growth on fringing reefs and reef flats, doubling the global annual production of reef carbonates (to 1800 million tons), and increasing after several centuries to 3000 million tons. Such growth would represent an increase in carbon absorption to 4% and ultimately 9% of industrial CO_2 emissions (Kinsey and Hopley cited in Pain, 1990). These estimates of the future of reefs as a "sponge" for CO_2 are dependent on assumptions that reefs form a net carbon sink and that they will grow rapidly as sea levels rise— assumptions disputed by Fujita (pers. comm. 1990). If large amounts of carbon are released during the production of calcium carbonate, reefs will serve as a buffer, rather than as a sink, for carbon in the short term.

While reefs do not currently play a major role in the carbon cycle, they may become important for two reasons. First, though relatively small, the inorganic carbon in reefs and sediments is stored for centuries, far longer than that in the atmosphere or other parts of the biosphere. Second, deterioration of reefs could create an additional large source of CO_2. If widespread bleaching occurs, for example, a decline in photosynthesis, coupled with a constant rate of respiration, could create a potential source of 1.6 gigatons of carbon a year as CO_2, roughly 25% of current industrial emissions (Fujita, pers. comm. 1990). Such an extreme scenario is unlikely, since bleached corals would either recover, causing photosynthetic rates to increase, or die, causing respiration rates to fall; the figures do illustrate the magnitude of carbon stored within reefs and the potential of degraded reefs to exacerbate global warming.

Summary and Conclusion

Coral reefs, with their extreme sensitivity to environmental change, could be the first major casualties of global warming. Already, reefs worldwide are affected by local stresses, including overfishing, chemical and nutrient pollution, coral mining, and increased siltation due to erosion from deforestation. Reefs growing in these conditions may be less able to cope with stresses brought on by climatic change than those living in the relatively pristine environment of 10,000 years ago. Areas that could be particularly threatened by climate change impacts include: (1) reefs already under considerable stress from human activities (such as those in Jamaica or the Philippines); (2) reefs on large shallow shelves having limited circulation with open ocean waters and a tendency to have warmer temperatures (such as the Florida Keys and the Bahamas); (3) reefs at high latitudes, which grow more slowly and are more sensitive to higher temperatures than those at lower latitudes; and (4) other slow growing reefs, which may be unable to recover from bleaching, storm damage and other climate-related stresses, or to keep up with rising seas.

Recent observations of worldwide coral bleaching, massive sea urchin death in the Caribbean, and crown-of-thorns starfish predation on corals illustrate the serious impacts associated with disruptions of reef systems. While the precise impacts of the expected warming are unknown, they are likely to compound current stresses. Coral bleaching alone, according to Goreau, has had a more severe impact on Jamaica's reefs than 40 years of hurricanes, overfishing, poor sewage treatment, soil erosion, and shoreline development. The severe and widespread damage to coral reefs caused by bleaching illustrates the sensitivity of corals to even a slight increase in seawater temperature likely to occur with global warming. The deterioration of coral reefs, a serious conservation problem in itself, will compound pressures on other coastal ecosystems by reducing storm protection for biologically rich mangroves and seagrass beds. Even if reefs thrive in the greenhouse in the short-term, as Kinsey and Hopley suggest, their long term chances are mixed. Sea level rise — even at the relatively slow rate of 5 mm/year — would eventually drown many slow growing reefs. Dying reefs, in turn, could become a major new source of carbon emissions. While the debate continues about whether a conclusive warming "signal" can be detected in the marine environment (similar to the debate being waged about terrestrial impacts), reefs may already be facing the stresses of a warmer world.

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Book Review

Wetland Creation and Restoration: The Status of the Science

edited by Jon A. Kusler & Mary E. Kentula

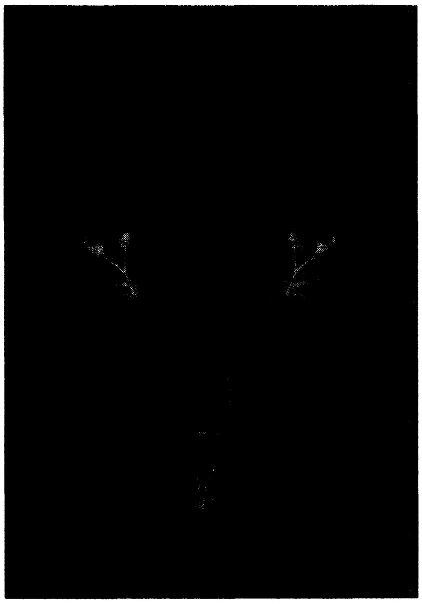
Despite wide recognition of their diverse environmental functions and economic benefits, the rapid and substantial loss of wetlands continues. Addressing the urgent need to stem this loss, the National Wetlands Policy Forum recommended that the nation adopt the short-term goal of no net loss of wetlands, and a long-term goal of increasing wetland resources nationwide.

The restoration and creation of wetlands will play an increasingly important role if we hope to offset continuing losses and eventually to increase wetland acreage. Questions remain, however, as to how well restored or created wetlands compensate for the destruction of existing, naturally functioning wetlands. *Wetland Creation and Restoration: The Status of the Science* begins to address these questions by identifying and discussing the related scientific issues.

The 591-page status report is the first major publication on the topic resulting from research initiated by the U.S. Environmental Protection Agency. The report is intended to evaluate the adequacy of available information and help set priorities for research; it describes various methods of restoring and creating wetlands, and discusses associated probabilities of success.

The status report is divided into two sections. Part One, "Regional Review," consists of fifteen papers describing restoration and creation in specific geographic areas and wetland types within the U.S., with an overview paper on research needs authored by members of the National Wetland Technical Council. The papers in the Regional Review summarize and evaluate available information and recommend research priorities. Each paper includes a short abstract, an extensive reading list, and an appendix of ongoing or completed projects related to the topic. The project profiles contain summaries of goals, evaluations of project success and significance, as well as a list of contacts and reports. A standard format facilitates comparison.

The amount and quality of information available varies significantly by



region and topic, a fact recognized by the editors in the report's introduction. Although many wetland types and regions of the U.S. are represented, papers addressing coastal and estuarine projects on the eastern seaboard predominate. The disparate amount of information reflects the need for additional research in specific areas, notably regarding inland, freshwater wetlands.

Part Two, "Perspectives," includes twelve papers covering a range of topics of general application. Topics include: wetlands evaluation, information needs for planning, wetland and vegetation dynamics, wetland restoration and water quality, wetlands and the urban environment, and options for mitigation.

One paper offers a standardized terminology to alleviate the confusion that exists about specific terms applied to the topic. The definitions for restoration and creation suggested in this paper, however, are not consistently followed throughout the report and little distinction is made between the terms, despite very different scientific, management, and policy implications.

The status report focuses on technical and scientific issues critical to improving the success rate of restoration and creation projects, intentionally avoiding broader policy questions that arise. In an attempt to eliminate the possible policy bias of agencies involved in wetland management, paper authors were drawn primarily from academia or private consulting firms rather than government agencies. Authors were selected because of their expertise in particular areas of wetland science or their active involvement in a specific aspect of wetlands creation or restoration.

In the executive summary, the editors briefly touch on policy and policy-science questions which wetland managers often encounter. The last section of the summary, entitled "Recommendations for Wetland Managers," highlights fourteen items to consider when including restoration and creation in management strategies. Among these recommendations is a warning that such proposals must be viewed with great care, particularly where promises are made to "restore" or "recreate" a natural system in exchange for a permit to destroy or degrade an existing natural system. This statement suggests that creation and restoration should not diminish or displace wetland preservation efforts.

Wetland Creation and Restoration is the most comprehensive source to date on the science. The papers are well documented and present useful technical information. The executive summary provides a good overview for those with more management-oriented interests. Noteworthy for its compilation of information and extensive literature citations, this book is an important reference for anyone involved in wetlands protection and management.

Reviewed by Nancy Fishbein, Research Fellow, Land & Wildlife Program, World Wildlife Fund and The Conservation Foundation, Washington, DC.

Opinion

Conservation of Marine Resources

by Yu Man Lee

Oceans cover 71 percent of the earth's surface and occupy a volume of almost 1.5 billion cubic kilometers. The Pacific Ocean alone is 25 percent larger than all of the world's land surface combined. All phyla and most classes of animals are represented in marine environments. However, the conservation of marine systems has not been given the same attention as that of terrestrial systems; U.S. protected areas are almost exclusively on land, thereby ignoring coasts and the outer continental shelf that represent 43 percent of the nation's public lands. The first national park was established in 1872 and the National Park Service in 1916. The first marine reserves were established only 60 years ago; they have become more prevalent in the United States only in the last 20 years since the authorization of the National Marine Protection, Research, and Sanctuaries Act in 1972.

Research into marine systems has been fairly extensive, but development and application of ecological theory for marine conservation have been neglected. Fewer documented extinctions of marine, as compared to terrestrial, organisms and a tendency to ignore degradation of the seas have led to a perceived lack of urgency regarding marine conservation. The direct application of terrestrial conservation principles to marine systems has also caused setbacks. Simultaneously, degradation of the marine environment, through human-induced habitat destruction and fragmentation, overexploitation, and linked extinctions, has increased dramatically; issues of marine conservation have become crucial.

Nature reserves have played an integral role in terrestrial wildlife conservation. Similarly, the designation of marine reserves and protected areas is crucial to marine conservation; the general criteria for these reserves correspond to those for terrestrial reserves, focusing on diversity, naturalness, representativeness, uniqueness, and effectiveness as a conservation unit. However, distinct and intricate abiotic and biotic characteristics of marine systems create special concerns for the design of effective marine reserves; the ocean is immense and inter-connected, and includes both open and coastal, components.

While terrestrial ecosystems are bounded essentially by the structure and composition of vegetation and soils and by physiography, marine ecosystem boundaries are determined by dynamic circulation pattern. Oceans are structured horizontally and vertically. Horizontal structures include barriers formed by continents and marine landforms (e.g. seamounts) and by differences in density, temperature and salinity of different water masses. These barriers, and atmospheric trade winds, influence the horizontal circulation patterns of ocean surface waters. Vertical structures involve temperature, density, salinity and light gradients. Daily and seasonal vertical circulation of water is driven by changes in density that are caused by changes in temperature and salinity. In addition, the land and sea form a continuum and grade into one another in marshlands, estuaries, reefs, beaches and rivers. Thus, ecosystem boundaries in marine systems may be more subtle and difficult to determine than those on land. The great mobility of marine organisms adds to the complexity; genetic diversity is greater in many marine species than in terrestrial species, possibly because the former are more widespread. Marine organisms are also sensitive to abiotic and biotic fluctuations in the marine environment since they are in direct contact with water.

The size, diversity and complexity of marine environments highlight the need for an ecosystem, rather than a species, approach to marine protection. In the terrestrial environment, the largest tree species may be preserved by simply protecting several tracts of land and even small reserves can preserve a great number of small organisms that can exist at high densities within limited space. In the marine environment, preservation of even small organisms requires an extensive area due to dispersal of lifeforms by ocean currents.

Knowledge, as well as lack of knowledge, of the exact interactions among marine organisms and between marine organisms and their habitat also make a strong case for protection and management of whole marine ecosystems. For example, commercial fisheries are slowly adopting an ecosystem-level approach by defining management units based on natural physical boundaries and by managing for all marine species, not just those of commercial importance. A case study on the conservation of walrus effectively identified critical habitats by collecting data on walrus' biology and socioeconomic, legal, and jurisdictional activities/policies in the area. These examples show that critical areas of marine reserves should encompass entire ecological units, comprised of communities, habitats, and adjacent land areas, as much as possible, although they rarely do. Core areas and marine reserves, in general, should be located in areas of high species richness (high diversity), such as coral reefs and other tropical shallow marine environments, and in areas that act as sources for potentially colonizing populations. Marine protected areas need to **incorporate adjacent land areas** within their boundaries or in management plans due to the strong physical links between marine and terrestrial environments. Such an ecosystem-level approach to management is critical for conserving our marine resources.

Yu Man Lee is a senior in the School of Natural Resources, University of Michigan, Ann Arbor, MI 48109-1115.

Bulletin Board

Rain Forest Data Base

The New England Tropical Forest Project is developing a database to facilitate networking and cooperation among organizations involved in the tropical forest and indigenous rights movement. There will also be a media database for action alerts. Intended to be available by the end of the year, these databases will be computerized and published. For institutional listings and further information, contact the New England Tropical Forest Project, P.O. Box 73, Strafford, Vermont 05072; (802) 765-4337.

Endangered Vertebrates Bibliography

Sylva Baker. 1990. Endangered Vertebrates: A Selected, Annotated Bibliography, 1981-1988. Garland Publishing, Inc. NY.

This bibliography provides readers with a list of publications which identify endangered, threatened, vulnerable, rare, or recently extinct vertebrates and/or which contain natural history information regarding these species. Over 900 citations are included, organized by major taxonomic groups. The work is indexed by common and scientific names, as well as by authors and geographic areas. A list of organizations concerned with endangered species is also included.

UPDATE Abstracts

Looking for information in the Endangered Species UPDATE? Our publication is abstracted and indexed in **Environment Abstracts** published by Bowker A & I, New Providence, NJ. Environment Abstracts is prepared monthly and has an annual index.

Hybrid Vigor: Center For Plant Conservation Joins Missouri Botanical Garden

The Center for Plant Conservation has joined forces with the Missouri Botanical Garden in a cooperative agreement which will help the Center fulfill its mission to save endangered plant species in the US. The Center will continue to manage its innovative endangered plant program and the Garden will provide the resources of a large and stable horticultural research institution. The Center's new address is: Center for Plant Conservation, Missouri Botanical Garden. PO Box 299, St Louis, MO 63166.

Florida Native Plant Conference

The Florida Native Plant Society's 11th Annual Spring Conference will be held May 3-5 at the University of Central Florida. The conference theme is "Florida's Native Plants - What, Why, and Where". For information contact Stephen Beidler, Florida Native Plant Society, PO Box 1393, Lady Lake, FL 32159.

Internships Available

The Atlantic Center for the Environment is offering internships to students, high school through graduate school, for the summer of 1991 in New England, Canada, Scotland, and the Caribbean. To receive an application, write Julie Early, Director of Program Operations, ACE, 39 South Main St, Ipswich, MA 01938.

Bulletin board information provided in part by Jane Villa-Lobos, Smithsonian Institution.

Announcements for the Bulletin Board are welcomed.

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