Panel Four

Marine Information and Education

Session Chair: Marea E. Hatziolos, World Bank

ReefBase: Status and Plans

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ReefBase is a global database on coral reefs and their resources that serves as the official database of the Global Coral Reef Monitoring Network. It is a joint project of the International Center for Living Aquatic Resources (ICLARM), the World Conservation Monitoring Centre (WCMC), and the University of Rhode Island. Its major activities are the extraction of data from existing publications and the production of standardized digital maps of the world's coral reefs. Increasingly, ReefBase has become a host system for data from prior and ongoing field data collection activities. Objectives include the investigation, definition, and analysis of coral reef ecosystem health at global, regional, and national levels. The ReefBase Aquanaut System involves training scuba divers to collect ecological information about coral reef health through an international certification system. The Rapid Assessment of Management Parameters (RAMP) system is an integration of field protocol and database structure aimed at social, cultural, and economic analyses relevant to coral reef uses. Ongoing ReefBase activities include the estimation of coral reef fish harvest and coral reef area and, in collaboration with the World Resources Institute, the determination of probable levels of reef degradation by country. ReefBase is released annually on CD-ROM. The current version, ReefBase 2.0, has information on over 7,000 coral reefs and serves as a vital tool for facilitating coral reef management at all scales.

Background

It is widely believed that many, if not most, of the coral reefs of the world are in various states of degradation (UNEP/IUCN 1988, Wilkinson 1992, Ginsburg 1994, Jameson and others 1995, Maragos and others 1996, Eakin and others 1997). This decline in the quality of reef resources has serious consequences for tens of millions of dependent people, particularly those who fish on coral reefs (McManus 1996, 1997). However, it has been difficult to assess the extent of the degradation and its effects with any reasonable degree of certainty. Indeed, even the locations and global coverage of coral reefs are poorly known (Pennisi 1997). Recent debates on the global warming issue have clearly demonstrated that effective, long-term action on the part of the governments and intergovernmental bodies of the world must be based on high-quality scientific evidence and analysis (see Knowlton, these proceedings, pp. 183–87).

The development and implementation of management strategies for specific reefs has often been inhibited by the difficulty of gaining access to relevant information. Most coral reefs are in developing countries, and most of the policymakers and managers tasked with protecting coral reefs have little access to major coral reef publications because of a paucity of reasonable libraries in these countries. In cases where useful biophysical and socioeconomic information has been gathered for a particular reef, this informa-

tion has often deteriorated in filing cabinets, been lost on unreadable computer media, or been reported in publications with little or no distribution in the countries from which the data originated.

ReefBase is a project for which a primary objective is to consolidate and distribute information on the coral reefs of the world through a user-friendly database to a wide audience. It directly addresses the need for information on the status of coral reefs and their dependent peoples, and facilitates coral reef management at local, national, regional, and global scales.

History

The idea for ReefBase was a response in 1988 to requests from the media for information on the global status of coral reefs (McManus and Ablan 1996, 1997). While very useful and relatively well substantiated information existed for rates of loss of the world's rain forests, no such information was available for coral reefs. In 1992, ReefBase was a priority topic in an international workshop on coral reef research needs held at the Australian Institute of Marine Science (Munro and Munro 1994, Froese 1994). The project was initiated with two years of funding from the European Commission beginning in late 1993. It involved ICLARM in database design and implementation, and the World Conservation Monitoring Centre in digitizing maps of coral reefs from around the world. Initial planning efforts included international workshops in the United Kingdom and Luxembourg, and a planning meeting on socioeconomic aspects at the University of Rhode Island in 1994.

By early 1995, the database had progressed enough to produce major inputs for the "State of the Reefs Report" (Jameson and others 1995). These included maps showing the locations of most of the shallow reefs of the world, and several point maps illustrating the distributions of major sources of reef degradation, including blast fishing, cyanide fishing, coral bleaching, sedimentation, and pollution. The report served as the background document for the global workshop of the International Coral Reef Initiative (ICRI) held in the Philippines in mid-1995.

The ICRI resulted in a "Framework for Action," which was endorsed by acclamation initially by representatives of 39 countries, and later through regional workshops by at least 85 countries. Others involved in the development of the framework included the World Conservation Union (IUCN) and major funding agencies such as the World Bank and the Asian Development Bank. Among the priority actions called for in the framework were the strengthening of efforts to provide for the dissemination of information to facilitate reef management.

ReefBase 1.0 was released in mid-1996 (McManus and Ablan 1996), and was followed a year later by ReefBase 2.0 (McManus and Ablan 1997).

Coverage

ReefBase 2.0 contains information on over 7,000 coral reefs, including ecological information on corals and fish communities for 2,700 reefs, coral reef fisheries and mariculture activities for 2,500 reefs, reports of stresses affecting 2,000 reefs, dive tourism information for 850 reefs, and descriptions of management practices and legislation for 500 marine protected areas. The 196 standard digital maps from the WCMC maps include most of the charted reefs of the world in global, regional, and subregional maps, and many selected reefs in detail. Linked to particular coral reef records are 883 aerial, underwater, and terrestrial photographs of reefs, showing their uses and misuses. Indexes include information on over 1,600 coral reef experts, monitoring programs, and institutions involved in coral reef research. A dictionary defines 191 terms related to coral reef studies. The reference section includes over 6,500 references on coral reefs from conference proceedings, technical reports, and informal articles.

Nearly half of the structure of the database is devoted to the Rapid Assessment of Parameters (RAMP) system. The RAMP system was developed to provide an integrated system for the collection, storage, and retrieval of information on the cultural, sociological, legal, and economic

factors affecting people associated with coral reefs. The system was designed primarily by Dr. Richard Pollnac of the University of Rhode Island. The variables are linked in a hierarchical system and chosen so as to facilitate multivariate analyses of factors relevant to management decisions regarding the reefs.

Because charted reefs tend to be those that represent hazards to navigation, they generally omit the large areas of coralline ecosystem existing below 10 meters depth scattered across the shelves and subsurface sea mounts of the tropics. In order to estimate the extent and location of these areas, Dr. Joanie Kleypas of the National Center for Atmospheric Research determined where reef corals were likely to grow around the world, based on a variety of environmental parameters (Kleypas 1995, 1997). One of the resulting REEFHAB maps (the most conservative) is available in ReefBase 2.0 as a global map into which the user can zoom for greater detail.

The ECOPATH system is a standardized approach to ecosystem modeling that permits the calculation of a wide range of useful ecosystem parameters and facilitates meta-analytical studies leading to generalizations about ecosystem structure and dynamics. At least five coral reefs around the world have been modeled using the system. The current version of the model, ECOPATH 3.0, is included on the ReefBase CD-ROM as a tool for coral reef researchers. Included as well are the parameters to allow the researcher to reconstruct and experiment with each of the published ECOPATH models of coral reefs.

Distribution

Approximately 500 copies of the ReefBase CD-ROM are distributed each year. About half of these are donated to developing country research institutions, and the others are sold at cost. In addition to the CD-ROMs, several key tables from ReefBase have been made accessible through the Internet. More of the database will be put onto the Internet as software advances facilitate the conversion to Internet-compatible formats.

Facilitating Current Management

ReefBase is designed to make optimal use of the vast body of information that has been or is being gathered on coral reefs around the world. Needs addressed by ReefBase include data archaeology, archiving, repatriation, distribution, standardization, meta-analysis, and gap identification.

Data archaeology is the locating and reintroduction to science of data sets from previous research efforts. ReefBase provides a focal point for data archaeological efforts, including, for example, the digitization of data from mimeographed reports from the 1970s and earlier. All data in ReefBase are archived on CD-ROM. The reproduction in hundreds of copies and continual upgrading to new software and hardware requirements helps to ensure continued accessibility in terms of decades.

A major problem in past studies of coral reefs has been related to the fact that much of the research on reefs has been accomplished by expatriates. The resulting data and reports have often been relatively inaccessible to researchers from the developing country with jurisdiction over the reefs. ReefBase provides such researchers with access to this data in a very usable, quantitative, and standardized form. The combined distribution of data via CD-ROM and Internet far exceeds the original data distribution for most of the included studies, in which data were usually confined to a few diskettes, disk drives, computer tapes, and reports of very limited circulation.

Standardization is approached in two ways in ReefBase. First, researchers read through all reports, converting data into standard units wherever possible, while screening for probable reporting errors. In some cases, substantial data sets are recalculated from raw data. Second, ReefBase as a project is involved with the standardization of methodologies for collecting data. This activity was a response to numerous requests for guidance on what type of data ReefBase needed from people planning trips to coral reefs. This led to the development of the ReefBase Aquanaut Survey Method (McManus and others 1997) described below, and the

RAMP protocol described above. ReefBase personnel are routinely consulted by groups developing reef-sampling standards. The presence of the database tends to encourage the development and widespread acceptance of data-collecting standards. Standardization, the quantitative nature of the database, and features built into the system to produce data tables from user-friendly queries all contribute to the acquisition of information through meta-analysis. These features also facilitate the identification of critical data gaps and needs, thus providing a basis for prioritizing research efforts and preventing redundant research.

ReefBase has an "encyclopedic aspect," in which it provides information about individual reefs to those who would develop improved management strategies or conduct further research. In many cases, existing data on a reef are relatively inaccessible to reef managers. For example, a manager concerned that a recent construction project may be damaging a coral reef through siltation may not be aware of studies showing that high levels of silt from deforestation were present long before the construction project. ReefBase makes this type of information available, including quantitative data about the problem whenever possible. Without this information, managers must either commission new studies or base their decisions on inferences from factors such as the presence of deforested hillsides. In all such cases, the lack of access to prior studies limits understanding of trends over time, thereby lowering the certainty of management predictions. Where previous studies exist, ReefBase makes the data accessible to those who must evaluate trends affecting the reef as a basis for informed management. Because of the early stage of research on coral reef ecosystem health, analysis of trends in variables such as hard coral cover is often the only reliable indicator of the state of a given reef and of the need for corrective management action.

The "summary aspect" of ReefBase is equally important. The maps of reefs and of stresses affecting reefs produced by ReefBase for the "State of the Reefs" report (Jameson and others 1995) strongly influenced those developing the Framework for Action of the International Coral Reef Initiative. The locations of reefs compiled and carefully verified in ReefBase provided a basis for the calibration of the REEFHAB model described above, which in turn plays a major role in discussions concerning the role of the oceans in global warming. ReefBase has provided information for recent reports summarizing the status of coral reefs (Maragos and others 1996, McManus 1997, Eakin and others 1997). These in turn provide a basis for the prioritization of funding for coral reef conservation.

Reef Ecosystem Health Studies

Ecological studies of coral reefs began prior to 1800, and became particularly prominent after the first publication of Charles Darwin's paradigmatic study on reefs (Darwin 1851). However, most coral reef research has been focused on basic concerns such as niche interactions and the description of general biogeochemical cycling. Applied and strategic research has focused principally on fisheries (Munro 1983, Johannes 1981, Munro and Williams 1985, Polunin and Roberts 1996, McManus 1997), and specific degradative problems such as sedimentation and organic pollution (Johannes 1975, Johannes and Hatcher 1986).

Recent concern about the global environment has led to the rise of the field of ecosystem health, which focuses specifically on the status of ecosystems with respect to human use and management (Rapport and others 1981, Costanza and others 1992). This field is concerned with managing ecosystems from a holistic, pragmatic view, analogous to that of modern medical practice. A good definition of a state of ecosystem health is "one whose parameters do not vary outside predetermined limits from a predetermined level within a given period of time" (Jakarta Mandate 1997).

The relevance of the holistic, health approach to the management of coral reefs can be seen in the recent debates concerning coral reef degradation in Jamaica. Hughes (1994) reported that coral cover in coral reefs of northern Jamaica had declined from mean values of greater than 50 percent to current values of less than 5 per-

cent over the previous decade. This change was explained principally in terms of :

- The reduction of populations of herbivorous fish through overfishing
- The destructive effect of a hurricane
- The proliferation of macroalgae
- The subsequent proliferation of herbivorous sea urchins
- The rapid decline of sea urchin populations
- The dominance of reef substrate by macroalgae, which prevents the settlement of corals.

Some of the assumptions of the explanation were later challenged. In particular, some researchers have suggested that fisheries may have had less to do with the overgrowth by algae than organic pollution from the highly populated coastline of Jamaica (for example, Hodgson 1994, Ogden 1994). The general feasibility of the Hughes conclusions, as well as the alternative explanations, highlights the need for management-oriented studies of coral reefs to treat the system holistically. Thus, a coral reef ecosystem health approach is warranted.

The ecological components of ReefBase have been designed specifically to facilitate progress in coral reef ecosystem health by providing a basis for the identification of the predetermined levels and limits called for in the Jakarta Mandate. An example is the recent analysis of 205 well-studied reef slopes showing that 40 percent is a reasonable expected value for hard coral cover on reef slopes among a given (large) set of reefs (McManus and Ablan forthcoming). As data matrices in ReefBase are filled in over time, increasing efforts will be directed toward applying multivariate analysis to the development of functions relating variables to healthy versus degraded coral reefs. Ultimately, parsimonious sets of variables will be recommended for monitoring and use in the identification of reefs under stress, based on such functions. This will also greatly facilitate the development of corrective action plans, the evaluation of their effectiveness, and the implementation of adaptive management (McManus and others 1988).

The need for blocks of "solid" data (nonsparse matrices—those with more data than missing values) necessitates action beyond the passive activity of summarizing existing reports. Coral reef studies have involved researchers with substantially different objectives using a very wide variety of approaches. Data needed for reef health analyses should cover a limited range of variables and be gathered under a limited number of standards. Thus, ReefBase has been active in collaborating in the implementation of the Global Coral Reef Monitoring Network (GCRMN). It has also produced the ReefBase Aquanaut Method described above, which permits nonspecialists as well as scientists to gather data compatible with the standard methods of the GCRMN.

Current and Future Activities

The continual development of ReefBase involves the conduct of associated research projects designed to generate new information from a variety of data sources. Research associated with ReefBase 3.0 (to be distributed in July 1998) includes country-level estimates of coral reef fish production, coralline area, and coral reef degradation.

Past estimates of global, regional, and national fish production from coral reefs have generally been based on estimates of reef area multiplied by catch rates per unit of area (Munro and Thompson 1973, Smith 1978, Munro 1996). Fish statistics reported to and by the United Nations Food and Agriculture Organization (U.N. FAO) have often involved general categories, such as "grouper," which do not indicate the catch by species and give little other indication of the habitat source. ReefBase is currently weighting the reported categories by proportion expected from reefs, to arrive at estimates of coral reef fish production at global, regional, and national scales. A set of regional experts is reviewing the weightings and they are being adjusted as appropriate. The resulting estimates will be useful in a variety of policy decisions concerning fishery production and coral reef management.

The REEFHAB model described above provides estimates of reef area geographically around the world. However, the assignment of these coralline areas of the ocean shelf to individual countries requires analysis within the

framework of the International Law of the Sea. This process is ongoing, and will result in estimations of reef area by country based on the predictions of the model and the estimation of shelf area of responsibility of each country.

A major objective of ReefBase is to provide a basis for the assessment of coral reef degradation by country and region. Doing so empirically requires very large amounts of data, because of the extreme variability of coral reefs and of the types of studies currently available to provide the data. Thus, reliable empirical predictions are expected to be possible only after a few more years of research (depending on levels of funding, the activity levels of the GCRMN and Aquanaut program, and other factors). However, the 2,000 reefs for which stresses have been reported do provide a basis for calibrating and refining models designed to determine the likelihood of stress problems on large scales. Thus ReefBase is collaborating with the World Resources Institute in the development of a global situation report based on factors such as distances from population centers, fishing pressure, likely levels of sedimentation, and other variables. The variables are interrelated in a Geographic Information System (GIS) and adjusted with respect to known stress reports. The procedure incorporates multiple consultations with regional and tropical experts.

The growth of the GCRMN is being accompanied by a rising concern for the establishment of regional and national databases. All aspects of ReefBase are provided in the public domain, including the structure and code. ReefBase makes these available to minimize the labor and cost involved in establishing new databases. Advice and training in database development are also available from ReefBase.

A recent effort within ReefBase is the development of a set of recommended standards for the processing of satellite imagery for inclusion in the database. With assistance from the government of the Netherlands, ReefBase is reviewing and testing existing analytical approaches for inclusion. The resulting product will incorporate the suggestions and contributions of a set of remote sensing experts from around the world.

Conclusions

ReefBase is far more than a traditional database. It is a set of research initiatives designed to facilitate the evaluation and management of coral reefs. It is an effective means of data archaeology, archiving, repatriating, standardizing, and distributing that facilitates a wide range of coral reef investigation, including meta-analysis across sets of coral reefs. More important, it is a physical end product of the efforts of coral reef scientists, managers, and users around the world that returns information in value-added form. This physical entity then serves as a rallying point for enhanced, targeted efforts in the conservation and management of coral reefs.

Note

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Coral Reefs: Harbingers of Global Change?

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Evolution produces a very few new species every million years. If we are to assume that nature can cope with our feverish developments, it is probable that mankind would be submitted to the fate of the dinosaurs. Destruction is quick and easy. Construction is slow and difficult.

—J. Y. Cousteau, 1973

Coral reefs form in the tropical, equatorial waters of the world's oceans and are the marine analogs of tropical rain forests. They are the oldest, most diverse and productive ecosystems in the sea. Coral reefs are a reservoir for much of the ocean's biodiversity, providing an estimated 10 percent of the world's fisheries, and their productivity fuels intense biogeochemical activity linking them to the global carbon cycle. Complex reef structures house some of nature's most amazing creatures while protecting miles of coastline from the full fury of the sea.

Coral reefs develop to their greatest expression in clear tropical waters under extremely nutrient-poor conditions. Abundant solar energy fuels photosynthetic activity, which is transferred to the food web by a host of grazing herbivores (animals that eat plants). This lush development of reefs under extreme oligotrophic conditions created a "paradox of reef" among scientists until the role of symbiosis was fully recognized. Now we know that the high productivity of reefs results from the evolution of many symbiotic associations, mainly coral-algal (zooxanthellae), that increase the retention of limiting nutrients, primarily nitrogen and phosphorus. Reef corals are functionally both animals and plants. Ironically, the same intricate patterns of survival that have developed over an immense span of evolutionary time make the reef vulnerable to changes in environmental conditions, especially temperature, sediment, and nutrient concentrations.

Anthropogenic stresses are thought to be contributing to the decline in coral reef ecosystems, notably in the Caribbean and the western Atlantic. Driven by the engine of ever-increasing human population, more and more land has been converted from its natural state. Generally, terrestrial ecosystems tend to be conservative and export little in the way of nutrients, carbon, and sediments. But, agriculture, urbanization, and deforestation reduce the capacity of terrestrial ecosystems to trap and retain materials. Development has altered the ecological characteristic of watersheds, overloading rivers with sediments, and nutrients, and adding toxic chemicals. Simple runoff has become an effluent that can have a significant deleterious influence on water quality. The addition of fertilizers, organic carbon, and urban and commercial dumping further enriches the watershed's effluent as it flows into the sea. When these ecological variables pass some threshold, the species composition of the reef community becomes reorganized.

The addition of sediments or nutrients triggers a set of ecological processes that alter the

selective pressures facing corals. In disturbed areas, increased loading of sediments and nutrients often co-occur, making it difficult to isolate their individual effects. Generally, increased sediment and nutrient loading favor the growth of macroalgae over corals. Suspended sediments reduce light levels to the corals and coat their soft tissue surfaces. Algae strip nutrients from the water column, quickly enabling them to grow faster than stony corals.

Excess sediment, coarse or fine, smothers coral tissue, impeding diffusive gas exchange through the tissues while also reducing the amount of light available for photosynthesis. Since corals work best when their surfaces are sediment-free, their metabolic efficiency diminishes. Energy spent on housekeeping is not available for prey capture, growth, or reproduction. As the sediment load increases, the tissues cannot maintain their status and tissue death occurs. Microbes quickly claim the freshly exposed skeleton, which is followed by a successional process ending with an algal turf or macroalgal community. Tissue losses increase when, through fishing and collecting, levels of herbivory are reduced or at least altered. Such reefs change from coral gardens to algal-covered rocks, in precisely the type of trend that is one of the key problems facing coral reef ecosystems in the Caribbean and western Atlantic today.

Curiously, luxuriant reefs can be found naturally in areas with high sediment loading, such as could be found near the mouths of tropical rivers along the north coast of Jamaica. The difference is that these reefs developed under these conditions rather than being subject to dramatic environmental shifts after becoming established. Reef corals that have developed under one set of conditions may not possess the necessary flexibility in their physiology or genetic makeup to cope with the added stress of rapid environmental change.

The death rate of coral tissue from sediment necrosis increases when algae grow in close proximity to corals. Macroalgae can shade coral tissue, causing bleaching and eventually tissue necrosis. Large algal colonies can also abrade the soft coral tissue as they wave in the surge. Microalgal filaments at the edge of corals form effective sediment dams that prevent corals from clearing sediment off their surface, slowly suffocating the live tissue. This process, termed edge damage, is a functional disease and appears to be a significant source of coral tissue mortality. Additionally, any lesion increases susceptibility to opportunistic pathogens that can kill a colony in less than 1/100 of the time it takes to grow. In the Florida Keys in 1974, I observed the process on reefs that had increased amounts of fine sedimentation. The condition became much more prevalent after the mass mortality of *Diadema antillarum* greatly reduced levels of herbivory. Today, throughout the Florida Keys and the Bahamas, almost anything that lives on hard substrate is being overgrown by algae. It is abundant, almost metastatic, on the outer reefs of Key Largo. Molasses Reef, the most heavily visited reef in the world, has thick ruglike algal mats, while Carysfort Reef has mats with finer filaments. Both types of algal communities trap sediments and the finer particulate organic snow, which shade, smother, and rather quickly kill coral tissue.

The reefs in many parts of the Caribbean and western Atlantic are showing signs of decreasing vitality; coral cover is decreasing while algae are increasing. Coral regeneration is slowing, and the increased levels of algal biomass may be, in part, responsible for reduced levels of coral larvae settlement. Signs of stress appear most evident on coastal reefs near population centers. In the Florida Keys, one of the most dramatic sites, I am frequently asked which single factor is responsible, sediments or nutrients? My perspective is that the factor may actually be the accumulation of a series of nested stresses that are as local as the fisherman; as regional as the landowner, sugarcane field, or village; and as global as deforestation in Amazonia, the ozone hole, and the greenhouse effect. Each factor compounds the rest, a synergy leading toward death for the reef.

Locating the sources of increased levels of nutrients and sediments, and other stressors, has proved as elusive as defining the nested levels of stress. In the Florida Keys, the effluent of cities, towns, farms, a watershed too vast to control, slowly bleeds into the sea through canals, rivers,

and coastal bays. The origin can be either a steady and well-defined point source stream or an effluent that seeps from the land with each rainfall. Both push sediments, nutrients, and contaminants into the sea. More of it upwells from injected sewage; some leaches from shallow septic tanks, urban lawns, agricultural lands, or vacant lots. Some washes into the sea along the west and east coasts of Florida, the Everglades, the Mississippi, and lands that are farther downstream. Bits and pieces from a diffuse array of sources contribute to a pervasive level of adverse stress for the reef.

The changes we are witnessing in reefs are echoes of the increased levels of harmful algal blooms in coastal waters, beach closings, and the general global decline in fisheries. The impact of man is extending into the seas. Watershed effluent, runoff from increasingly urbanized landscapes, an unprecedented manipulation by humans, is thought to be responsible for increased levels of nutrients and sediments, but the definitive data are not yet in. The data are elusive because reef community metabolism has evolved to rapidly take up and sequester the very nutrients signal we are trying to detect. Increases in algal biomass are thought to reflect increased nutrients but do not constitute proof. Carbonate sediments are almost as hard to follow, so at this time we are left with correlation rather than causality. It is my belief that the declining vitality of reefs is a metric for the health of the oceans, analogous to the coal miner's canary in the cage. They are the fragile harbingers of change warning us of declining oceanic health.

Coral reefs, rain forests, and human civilization are the three most complex communities on earth. The first two are the most productive natural communities, while humanity, is rapidly encroaching on the entire planet. Reefs are the oldest, having existed since there were organisms with skeletons in the sea. Modern coral reefs date from about 250 million years before the present. Like rain forests, these communities have evolved an ecological logic that allows them to flourish and persist on a planet that is forever changing.

Over enormous spans of evolutionary time, very sophisticated relationships emerge and form the core of biodiversity. The most elaborate ecosystems tend to be found in places that are old, benign, predictable, and frequently rich in solar energy. These ecosystems are very proficient at elemental recycling, so that the living portions of the habitat are richer in nutrients than their surrounding soils or seas. Both reefs and rain forests develop to their highest expressions in habitats that seemingly cannot support luxuriant growth. The soil of rain forests is extremely poor, and the clear, warm tropical seas that bathe reefs have nutrient levels at or below the minimum level of detection. In this case, more is not always necessarily better.

Human civilization is undergoing an unprecedented population expansion coupled with an economy driven by consumption and profit, as opposed to efficiency and recycling. Humans treat biological resources like agricultural systems in which net production is maximized rather than managed for sustainable yields. Such systems are inherently unstable. They require a constant input of nutrients, very little of which are sequestered in the standing stock, or "body," of the ecosystem. They grow at the expense of other systems and greatly increase the entropy of surrounding areas. But since the earth is finite, this approach cannot continue without increasingly severe degradation of the biosphere.

One long-range vision for the future of humanity suggests that the incorporation of the logic of natural systems into our mode of living might, perhaps, enable civilization to persist as long as coral reefs and rain forests. Given humanity's commerce-driven dominance of ecosystems, the environmental and long-term costs of economic activities need to be reflected in market prices. We must change our present practices, lest we leave only our wastes for future generations.

The very first diving expedition of *Calypso* was to the Red Sea, beginning the modern study of coral reefs using the Aqualung. It was there that Jacques Cousteau became astounded and entranced by the splendor and the extravagant beauty of the coral world. In time, his concern grew for the careless destruction that our unchecked technological development is spread-

ing into the oceans. His legacy to us is a greater understanding and appreciation for the marvels of life.

Recommendations for the World Bank

Recognizing that coral reefs may be indicators of oceanic health and that their decline may forebode the decline of the oceans, the World Bank should assume a leadership role in the global conservation of coral reefs for a sustainable future by undertaking the following:

- Establish an international interdisciplinary working group composed of scientific, technical, and policy experts to ascertain the state of knowledge of coral reef ecosystems and make recommendations concerning their sustainable future.
- Establish collaborations with international space agencies to develop a global capability to map and monitor the distribution of coral reef communities, to ascertain their health and identify potential hazards to their future.
- Support a climate of stimulation for existing activities and fund scientific programs on the health and vitality of coral reef ecosystems, and support efforts to implement sustainable fisheries practices at all levels.
- Recognize the dynamics of population growth in coastal areas and focus attention on protecting the ecology of the land-sea margin and watersheds of coastlines and rivers. Address land-based sources of marine pollution, including nutrient and chemical inputs, soil erosion, and forest and agriculture practices.
- Support the development of an industrial/technological ecology focused on both remediation and an end to pollution of the seas, and develop new environmental management techniques integrating ecology, economics, technology, and social sciences ("Ecotechnie") with the goal of significantly reducing pollution in coastal areas, remediating ecological harm, protecting human health, and enhancing human welfare.
- Expand support for small-scale projects designed to eliminate destructive fishing (such as the use of cyanide and dynamite), implement reef surveys and monitoring activities, and protect reefs from physical harm. Work at the national and international level to address fisheries that exploit children, and implement certification programs for aquarium fish to ensure they are caught in a nonharmful manner. Explore the use of microcredit loans for small-scale entrepreneurial activities to promote the sustainable use of coral reef resources.
- Ensure that the knowledge and means for management are transferred to tropical developing nations where most of the world's reefs are located, and assist in developing the capacity of local communities to manage and use these resources in a sustainable manner.
- Support the establishment of marine protected areas and particularly sensitive sea areas (PSSAs) to ensure the conservation of marine biodiversity.
- Support the full implementation of the Jakarta Mandate on Marine and Coastal Biodiversity, and the development of a Protocol on Marine Biodiversity Conservation to the Convention on Biological Diversity.

The Global Coral Reef Monitoring Network: Communities, Governments, and Scientists Working Together for Sustainable Management of Coral Reefs

Clive Wilkinson
Global Coral Reef Monitoring Network

Bernard Salvat
GCRMN Scientific and Technical Advisory Committee

The declining status and health of coral reefs around the world stimulated the formation of the Global Coral Reef Monitoring Network (GCRMN), a component of the International Coral Reef Initiative (ICRI).

Formation of the GCRMN

The GCRMN was established under sponsorship by the Intergovernmental Oceanographic Commission of UNESCO (IOC), the United Nations Environment Programme (UNEP), and the World Conservation Union (IUCN) and is co-hosted by the Australian Institute of Marine Science (AIMS) in Townsville and the International Center for Living Aquatic Resources Management (ICLARM) in Manila.

The GCRMN commenced in March 1996, when the IOC appointed a coordinator using U.S. State Department funds. The GCRMN is governed by the sponsors, hosts and ICRI forming the Management Group. Advice is provided by a widely representative GCRMN Scientific and Technical Advisory Committee (STAC), with the chair sitting on the Management Group. The first major task was to produce a "Strategic Plan," which is available at this meeting.

GCRMN Strategies

The GCRMN will develop partnerships with local users and other stakeholders, government departments, scientists, and resource managers to implement a global program of reef monitoring. The GCRMN will function as an association of independent networks (or nodes), within regions based on the UNEP Regional Seas Programme. The size and composition of nodes will depend on the number of countries, geographical range, distance, language, culture, religions, and political affiliations. Central coordination will diminish to a role of preparing reports and assisting in funding nodes.

Regional nodes will identify major stakeholder groups to train and involve in local area monitoring, as well as conducting country-wide monitoring. Specific emphasis will be placed on involving fisher cooperatives, women's organizations, and schools. The objectives of the monitoring are twofold: to gather data on the status and trends in coral reefs, and to raise awareness amongst all stakeholders, as well as decision-makers, on the current rates of reef destruction and causes. These objectives feed directly into the ICRI programs of integrated management and capacity building.

GCRMN Regions and Nodes

Regions and nodes will be effectively independent with their own budgets and reporting, coordinated through a central office, usually the UNEP regional office. Nodes will be staffed by a coordinator and staff able to train in biophysical and socioeconomic monitoring, plus be responsible for in-country monitoring. Each node will

produce annual reef status reports, based on data from participating countries, and ensure the wide dissemination of reports. The regions are:

- *Middle East.* Countries bordering the Red Sea and the Persian Gulf, which held their first ICRI Regional Workshop in September 1997.
- *Western Indian Ocean and Eastern African States.* The ICRI Regional Workshop in the Seychelles, April 1996, recommended a Western Indian Ocean node to assist Comoros, Madagascar, Mauritius, Reunion, Seychelles, based in Mauritius and supported by the Indian Ocean Commission; and an Eastern African node assisting Kenya, Mozambique, Tanzania, South Africa (and possibly Eritrea, Somalia) hosted by the Kenya Marine Fisheries Research Institute in Mombasa.
- *South Asia.* One node for India, the Maldives, Sri Lanka (Bangladesh, Pakistan) was designated at the Maldives ICRI Regional Workshop, November 1995. The node is supported by the Department for International Development, UK, and hosted at IUCN and SACEP in Colombo, with Jason Rubens appointed as the interim regional coordinator.
- *East Asian Seas.* Five countries (Indonesia, Malaysia, the Philippines, Singapore, and Thailand) will be independent nodes. One node is planned for Cambodia, Myanmar, and Vietnam; another node is envisaged for North Asia, with the Okinawa Coral Reef Conservation and Research Center of Japan assisting China, the Republic of Korea, and Hong Kong (China). These were decided at two ICRI regional workshops—Bali, March 1996, and Okinawa, February 1997.
- *Pacific.* Six nodes will serve the countries and states within the South Pacific Regional Environment Programme (SPREP). These were decided at the GCRMN meeting in Fiji in July 1997. The nodes are Hawaiian—for Hawaii, U.S. Line, U.S. Phoenix and Wake Islands, based at the University of Hawaii, the East-West Center, and the Bishop Museum; Polynesian—at the Ecole Pratique des Hautes Etudes/Centre de Recherches Insulaires et Observatoire de l'Environment (EPHE/CRIOBE) station on Moorea, assisted by the government of French Polynesia and Université Française du Pacifique, to include the Cook Islands, Tokelau, Niue, Wallis, and Futuna; Northwest Pacific—based at the University of Guam and the Guam Coastal Management Program and incorporating Palau, the Federated States of Micronesia, and the Northern Marianas; Central Pacific—based in the Marine Studies Center, University of the South Pacific, in Suva, Fiji, and including American Samoa, Samoa, and Tonga; Pacific Atoll—based in the USP Atoll Research Unit in Kiribati for the Marshall Islands, Nauru, and Tuvalu; Melanesian High Islands—for New Caledonia, Papua New Guinea, the Solomon Islands, Vanuatu, and Australia, hosted probably at ICLARM in Honiara.
- *Caribbean and Tropical Americas.* There will be many nodes based on the expertise within the CARICOMP network of interacting marine institutes, with some coordination through the UNEP regional offices in Jamaica.

GCRMN Program and Progress

- *Planning.* Initial interagency support has been obtained to establish the GCRMN and fund coordination. The Strategic Plan, Biophysical Manual, and Protocols are being distributed. A manual of social, cultural, and economic parameters is currently being drafted. The GCRMN Pilot Monitoring Project is under way with more than 50 institutes or individuals signifying interest. A manual for tourist and volunteer divers is being planned by the East-West Center in Hawaii, to include existing projects like Aquanaut and Reef Check.
- *Negotiation.* More than 80 governments participated in the six ICRI Regional Workshops; most requested participation in the GCRMN. These workshops determined the problems for their coral reefs and established action priorities. Many scientists and resource managers participated and are willing to assist.

- *Node formation.* Approximately 16 nodes in four regions have been formed around strong centers; approximately 12 remain to be designated. Coordinators have been selected for most nodes and funding is assured for the establishment of the South Asian node, and five independent country nodes in Southeast Asia will seek their own funding. Funding proposals are being developed for the others.
- *Training.* Initial training has started in the Western Indian Ocean, South Asia, Southeast Asia, and the Pacific. Full training should commence within nine months in most regions. Likewise the socioeconomic manual will be simultaneously tested in all regions.
- *Devolution.* The next step, after country monitoring has started, is to train and involve communities in monitoring their resources, with the view toward developing local management plans.
- *Reporting.* The GCRMN will produce two reports (results of pilot and initial regional monitoring, and assessments by expert scientists and resource managers) for the International Year of the Ocean and presented at ITMEMS, an international coral reef management conference in November 1998. A major status report will be presented at the International Coral Reef Symposium in Bali, 2000. Specific reports by communities and countries should commence by June 1998.
- *Over to ICRI.* GCRMN country and community activities will constitute the basis to achieve ICRI goals of integrated management and capacity building.

Specific Anthropogenic Problems and Solutions

The ultimate cause of coral reef degradation derives from greater use of resources by increasing populations, which are driven to overexploitation by poverty and a lack of control over these resources. Solutions to these problems operate at a larger scale than the GCRMN; but we intend to assist in tackling the direct causes of most coral reef degradation. In this paper, we consider two levels of anthropogenic damage:

- That which can be controlled by communities (localized overfishing; damaging fishing; overharvesting of sand and rock; immediate pollution by sediment, sewage, agricultural and small industrial effluents)
- Large-scale impacts imposed on reefs from outside the system (catchment area pollution, oil and large-scale industrial pollution, global climate change and sea level rise).

The GCRMN is focused on the first—assisting communities in developing awareness of the problems facing coral reefs and educating users about the connections between human activities and reef damage. The impacts listed below that are directly controllable by local communities are marked ($). Solutions to some of these are treated in detail elsewhere in these proceedings.

- Sediment pollution:
  - Deforestation ($)
  - Stripping of mangroves ($)
  - Coastal and catchment development ($)
- Poor agricultural practices:
  - Dredging for mariculture ponds ($)
  - Dredging for ports
  - Land reclamation
  - Dumping of spoils at sea
  - Mining in the catchment area
  - Coastal mining (for example, tin dredging)
- Nutrient pollution:
  - Runoff from cleared land ($)
  - Sewage wastes ($)
  - Agricultural wastes and fertilizers ($)
  - Intensive animal husbandry ($)
  - Intensive mariculture, such as shrimp ponds ($)
  - Wastes from food and paper industries
- Overfishing:
  - With fine mesh traps and nets ($)
  - Fishing with spearguns ($)
  - Commercial fishing with compressed air ($)
  - Destructive fishing—nets and trawlers($)
  - Cyanide fishing ($)
  - Poison, such as bleach ($)
  - *Muro ami* fishing ($)
  - Blast, or dynamite ($)
  - Anchor damage ($)
- Engineering: building of groins, harbors, and walls; building of airports, ports, marinas.

Sediment and nutrient pollution can be controlled by integrated management of watersheds directed by local populations and assisted by central government. Many developmental and agricultural practices can be managed to reduce sediment loss, such as clearing land during the dry season, green tillage, building bund walls around coastal developments. Nutrients can be reduced by the target application of fertilizer, use of sewage wastes in agriculture, installation of basic sewage treatment for towns and agricultural industries, sustainable stocking rates for grazing. The development of crops requiring less fertilizer is needed for coastal communities.

Combating overfishing and damaging fishing practices will require coordinated action to reduce poverty by providing alternative employment through industries like tourism. Fishers are usually the poorest of the poor. The reliance on wild-caught fish must be reduced by improved mariculture and cage culture, using larvae and juveniles caught in traps or nets or on artificial reefs.

Above all are the major efforts required to reduce population growth, combat poverty, provide alternative employment, ensure that local people have greater control over their resources, and improve information, awareness, and education into the causes of problems and possible solutions. This will require some funding, but at low levels (for example, US$3 million to 5 million) across the globe. The GCRMN is specifically targeted at providing communities with the information and understanding necessary to take greater control of these resources, but by pursuing the goals, the GCRMN will form networks and provide them with some tools to tackle the larger problems.

Marine Information Management and Environmental Education

Janine M. H. Selendy
HORIZON Communications

To effectively and expeditiously protect and preserve coral reefs, marine information and environmental education efforts must be undertaken, reaching people throughout the world to heighten awareness of problems and dangers and to provide answers: solutions that can be and are being undertaken from environmentally sound fishing and extraction practices to controls on trade and tourism. To help achieve this goal, on the 15th of October, HORIZON Communications, a not-for-profit international research, film production, and development organization based at Harvard and Yale Universities in the United States, is launching its CORAL REEF ODYSSEY: QUEST FOR SURVIVAL project. This effort, consisting of television programs, books, and other multimedia materials, is designed to help increase public understanding of the importance of coral reefs, of the threats to their survival, and of the efforts that can be and are being undertaken to protect them.

HORIZON is embarking on a new symbiotic relationship between research and the media. The ODYSSEY, will take audiences on a research expedition through the major coral reef ecosystems of the world with a group of dedicated marine biologists led by Dr. Walter Adey, Director of the Marine Systems Laboratory of the Smithsonian Institution. The quest will be threefold: (1) to find new organisms which may be a source of future medicines and other biochemical products, both addressing the newly growing practice of bioprospecting and necessary precautions to avoid hurting the reefs and showing how environmentally friendly bioprospecting is benefiting local communities without harming the reefs; (2) to heighten public appreciation of the beauty and complexity of these extraordinary ecosystems and of the interdependence of man and coral reefs; and (3) to provide examples of successful reef protection and management practices.

The many problems confronting the reefs will be played against the story of efforts to protect and preserve these fecund oases of biodiversity. The media coverage will reach people throughout the world.

Environmental education needs to be culturally and politically sensitive and to reach children as well as adults. Television and all media available in a region should be employed, along with hands-on training of local people who are or can be involved in protective measures. Whenever possible, local participation in the media coverage itself should be factored into information packages. This can be done without much extra expense by adding segments produced by and with local individuals depicting their situations. Adding material to existing educational videos can be achieved using simple camcorders. In order to make their additions to the productions particularly effective, integration of their segments into the body of existing tapes should be done. This can be achieved by providing them with special edits of the

ODYSSEY, for example, in which blank sections are left into which they can cut a segment produced locally. In regions where they do not have access to cameras and video equipment, the equipment and training could be provided, adding to learning skills and direct involvement in preservation efforts. HORIZON has had a long experience in creating documentaries composed of detachable segments which can be seen in sequence or can be worked into news programs, reaching audiences not only through major broadcasters such as PBS, but also appearing in whole or part in major news programs on ABC in the United States and in Burkina Faso, China, Germany, Lebanon, Mexico, Pakistan, Peru, Poland, Thailand, and other countries.

The World Bank can benefit fisheries and coral reefs around the world by encouraging research, education, and environmentally sound consumer demand. It can play a very meaningful and effective role by incorporating, as part of the Bank's long-range ecological objectives, support for education, disseminating knowledge of successful models of conservation with profitable development. Thus, the Bank can help provide a foundation of knowledge on which people can act. What better resource to focus on than coral reefs, where the stakes are so high and the promising initiatives so compelling.

The fact that the diversity of coral reef life has great scientific and economic potential needs to be spread in environmental education. The work of Dr. William Fenical of the Scripps Institution of Oceanography serves as such a model, representing the promise of medicines from coral reef organisms and of market incentives. In the Bahamas, successful bioprospecting work begun under Dr. Fenical is under way. There a treelike gorgonian, *Pseudopterogorgia elisabethae,* is being harvested by local fishermen who carefully cut only a few branches from the gorgonian, which then regenerates. Substances derived from the branches are used by a major cosmetic company and are being studied for use of its powerful anti-inflammatory properties. The Bahamian government is receiving hundreds of thousands of dollars in export taxes from this resource.

Uneducated Consumers

Tourism is a rapidly growing industry throughout the coral reef areas of the world. Uncontrolled or inadequately controlled tourism is resulting in coral reef destruction, often by unwary divers who mean no harm. Education and controls are essential. In Bonaire, a wonderfully successful coral reef preservation effort, and an excellent example of effective ecotourism, is working and has been under way for more than 20 years. Videos are employed to teach divers the do's and don'ts before they can receive their diving permits. The production of the ODYSSEY will commence this month with filming of the Bonaire effort, including how this ecotourism effort came about and why the ecotourism effort is so successful, not only in terms of protecting the reefs, but also in economic terms.

Environmental education and marine information management need to address boaters, pleasure fishing, reef treasure hunters, amateur and professional archeologists, other explorers, and pleasure divers. There is vital interdependency between fisheries and coral reefs about which not many people seem to be aware. *Time* magazine of August 11, 1975, provides a good example of how major media coverage can help. Its article on fisheries draws attention to their fragility, helping to increase public awareness of fish losses from excessive catches. The article presents startling facts about fish popular among chefs in the United States, such as the orange roughy. They grow extremely slowly, live for more than 100 years, and take 25 years to reach sexual maturity. The consumer sitting in a restaurant may never have thought about the fact that consuming an orange roughy was encouraging overfishing and depletion.

Time offered a section on "What Consumers Can Do," providing lists of what is OK to eat sparingly and what is not OK to eat. For example, the grouper, a resident reef fish which is easily caught, is being targeted in many tropical waters. They are most often taken at a crucial point in their life cycle—when they gather by the thousands to spawn. *Time* reports: "In some places, fishermen have wiped out nearly an entire generation of reproducing adults in just a

few seasons." Many have heard of a single grouper commanding a price of $10,000 in Southeast Asia, where the economic boom is generating wealth that is too often encouraging plundering of such resources. Mass education is needed to alert people to the consequences. Grouper in the Caribbean are facing imminent danger, according to some marine scientists. They are concerned that there will be uncontrolled poaching of grouper during their forthcoming spawning season, wiping them out. This situation needs attention. Media can alert people and inform them about actions they can take, such as avoiding catching and consuming grouper.

Recommendations for Future Actions

1. Sustainable Practices and Private Entrepreneurs

People who are drawn into poisoning and dynamiting for fish need to be educated about alternatives. Daniel Pelicier of Mauritius provides an excellent example of environmentally friendly aquarium collection, in both his techniques and his reasoning. By sharing knowledge of his approach in the media, he will heighten awareness of how one can make immediate money while providing for long-term availability of resources.

2. Bank Staff and Policymakers

Media can help alert people to illegal and harmful fishing and extractive practices and can be very effective in bringing about major policy decisions. If the world knows about what is being done, the force of the public can make the difference. For instance, it could be tremendously helpful for the media to bring to attention the loss of fisheries and coral reefs along the heavily populated coasts of Indonesia. Professor Paul Dayton of the Scripps Institution of Oceanography says that 112 million Indonesians living along the seaboard depend on fish. "Pirates have destroyed their entire resource." Can pirating be stopped? It may go on if there is not enough of a public outcry. That outcry comes from knowledge of the cause. People recognize that illegal taking of fish and destruction of coral reefs is theft. It is theft from local communities and from their livelihoods, theft from the interdependent species that are hurt or killed: theft from our global capital. When the message gets out that our global capital is being lost to pirates on the coast of Indonesia, people will wake up and realize that it affects them, whether halfway around the world or on the Indonesian coast. It puts the situation in a perspective that everyone can relate to. Hence, it generates action. Similarly, it is important that the World Bank take into account not only local and regional considerations when financing a development, but also global capital. Will the development cause depletion of global capital? Will the development harm or destroy global capital with pollutants? Will the development have negative long-term consequences on our global capital? The Bank's new "outplacement" policy begun by President Wolfensohn benefits both the Bank staff who can expand their knowledge and experience and the organization with which they are collaborating. It could be made more liberal with time and Bank resources.

3. Reef Managers

The World Bank and other entities could help with the establishment and operation of training programs with education and certification of coral reef managers, using media to illustrate problems and best practices. There needs to be more power of enforcement than now exists in many areas, and stronger infrastructure from which to work. Effective education programs incorporating visual material for coral reef reserve managers can help to effectively and quickly generate an understanding of the long-term consequences of failure to enforce the controls over poaching or other harmful activities. A striking example of conservation enforcement was presented in the *Economist* of September 20, 1997, one I am not advocating: In order to help the black rhinos in Zimbabwe, their national parks "are protected by a new and fiercer force. If guards and game rangers come across anybody who might be a poacher, they now have the right to shoot first and ask questions later."

The *Economist* states, "Its effect was immediate—and salutary."

4. Educators

Educators in various fields should incorporate an understanding and appreciation of the biodiversity of coral reefs and of the interdependent relationships of fisheries and coral reefs, mangroves, and sea grasses. Symbiotic relationships showing caring, understanding, and mutual protection and support provide striking examples which can be effectively incorporated into education and marine information management programs. The images and stories of symbiotic anemones and clown fish, gobies and pistol shrimp, symbiosis crabs on sea feathers, porcelain crabs with their delicate translucent plankton nets, and many other magnificent examples will make people better understand the complexities of coral reefs. Interdisciplinary studies need to be fostered to increase understanding of coastal related influences on coral reefs such as agricultural runoffs, sewage, and industrial processes that cause pollutants.

5. Scientists

Members of the scientific community can build on knowledge of interconnected influences causing reef degradation and destruction such as weakened conditions due to toxins and increased algal blooms leading to newly emerging viruses and death. Scientists, fishermen, and coral reef communities can all play an essential role by sharing knowledge of spawning and breeding grounds, knowledge of crucial times for corals and fish, such as fertility cycles, breeding grounds needing protection, and symbiotic relationships between various species of fish and corals. To provide an understanding of long-term consequences, this information then needs to be made widely available through all multimedia forms, reaching into even the smallest community.

To further facilitate local and regional coral reef protection efforts, HORIZON, in collaboration with the United Nations Environment Programme, Development Programme, Population Fund, UNICEF, the International Development Research Centre of Canada, and Harvard and Yale Universities, will be sharing solutions in easily accessible case studies on its "Solutions Site" on the HORIZON Web page. We welcome participation in this site, for which case studies will be checked for applicability and feasibility by HORIZON's Scientific Review Board, Coral Reef Advisory Board, and other experts. The information will be made available in newsletters and other means as well as on the Internet. Please visit HORIZON's Web page for more information on the CORAL REEF ODYSSEY: http://www.yale.edu/horizon and to share your ideas with us in our guest book.

Discussion

Stephen Colwell, Coral Reef Alliance: There are dozens, actually hundreds, of organizations that are not here today, all of whom have participated in getting out the very information we are talking about [the International Year of the Reef], and the reason I'm saying this is that there's often people who are saying, "We need to create this or that." A lot of it is out there, a lot of it is done. It's important to tap into that so that we don't spend all of our time creating, and we put a lot of resources into distribution. There are exhibits, like the Smithsonian Tropical Research Institute's, Nuestros Arecifes, which is going through the Caribbean; there are NOAA's programs this year, which they have done for "52 Stories," which has been picked up by newspapers around the world; there are Web sites. In fact, if you look at the International Year of the Reef Web site, you can see hundreds of people in over 50 countries have set these things up. And you should tap into those, particularly since 1998 is the Year of the Ocean. We really have a chance to use this momentum. I was taking a shuttle to the airport in New York, and had the cab driver say, "Oh, coral reefs, aren't they really in trouble? Really bad things are happening in Indonesia, right? " It's out there—we can build on it, particularly with all the resources that the panel and other people have developed, I think we have an obligation right now to carry this momentum through to 1998.

John McManus: Thank you, Steve. You have broadened the picture—that was extremely important. We're also very supportive of ReefCheck—a very successful move to get a lot of people in the water in a hurry to get some sort of immediate feedback about coral reefs, but also to get a lot of people involved in looking at coral reefs. There's going to be a press conference [October, 16, 1997], in Hong Kong about the initial results. I was actually one of the people on the first ReefCheck. They have the advantage that you can train somebody in three hours and get them in the water, and gather some sort of information. And we have just agreed that ReefCheck will be seen as some sort of a two-level thing. After ReefCheck—if people want to go through three or four days training at the Aquanaut program, then that becomes stage two. There's a number of other volunteer programs around the world that we're very happy about including the reef program with fish watching, so there's lot of things going on around the world.

Silvia Earle: I wanted to quickly respond to something that Janine [Selendy] was alluding to, which I guess you could sum up with just referring to the distillation of this Black Sea Conference, which was a curious mix of religion, environment, scientists, economists. It was really something—the idea being trying to pull people together from various disciplines that normally don't talk to one another, and to see if we

could find the common ground. I had the fun of trying to come up with some of the essence of what it was all about. And it seemed to me that you could say that some of the things you learn as a little kid about "doing to others what you would have them do unto you"—this is the ethic that we grow up with no matter what culture we come from. And no matter what culture we come from there are certain guidelines for living, such as "thou shalt not kill, and thou shalt not steal." And as you were saying, Janine, about theft of things that go beyond taking things from one another's backyard. In a sense, this is our backyard, but we haven't yet quite extended the ethic to an environmental ethic of "thou shout not kill the environment upon which you and your neighbors depend. You shall not steal from the future generations by killing the environment upon which we all depend." And I think that is one of the things at the end of this discussion, whatever else we go away with, if we can come together with a new ethic of caring, a new understanding that the Napoleon wrasse—even if it's worth $10,000, once as a gourmet feast—if left in the ocean as a part of that system can be worth $10,000 month after month—a priceless value. In fact, you can't put a price tag on its value as part of the system—what it generates in income, but also what it generates in terms of the health which we cannot replace.

Richard Jordan, Inter-Faith Partnership, UNEP Regional Office, North America: I, too, was on the Black Sea, and I mentioned a term in Japanese: *Mottainai,* which means "humble sense of awe," and that certainly was put forth very well in the videos. But what I would like to do in building upon what Clive [Wilkinson] and Jack [Sobel] mentioned, in building on your partnerships and outreach to other organizations and networks, please include the religions. Religions are extremely good at developing and spreading this idea of the humble sense of awe, and I can certainly tell you that the Inter-Faith Partnership at UNEP, which has existed for 10 years, will certainly disseminate the results of this conference, and will perhaps help you in doing that. Thank you.

Clive Wilkinson: Thank you very much for that comment, and I'd like to talk with you afterward about that. Certainly in areas where I'm familiar, the local priest is a very important person in the community to get the message across about conservation of protecting reefs. And we're hoping in the year 2000, at the International Coral Reef Symposium, to hold a special symposium on the role of religion in conserving coral reefs, and I've been talking to Graham Kelleher about that, so please talk to me later.

Barbara Ornitz, Shellman and Ornitz: I want to address this to Jack [Sobel] and to Phillip [Dustan], because we had a meeting about this the other day. When we talk about the power of one, we—each of us in this room sitting in Washington, D.C., today—can do something, and I want wanted to let you know, and ask Jack and Phillip how they feel about this? There are some letters on my exhibit table that deal with three pieces of legislation—resolutions that are now sitting in the Senate and Congress. It's the first time that we've had, in principle, the proposal for stewardship for coral reefs that our Congress is looking at. My question—the letters are out there. Each one of us can sign one of these letters; we can send it to our senators, we can send it to our congressmen, and we can say, "We are exercising our power to ask you to support reefs." One of the resolutions deals with just a general stewardship call. The second resolution deals with cyanide and dynamite fishing practices as we have been talking so much about in this conference. And the third deals with funding—for projects for science and monitoring, community work—which we have also been talking about. So I guess my question would be: these are beginnings, but we—each of us—can take the step to sign onto these letters and send them on, and I would ask the panel members, particularly Jack and Phillip, if you would endorse that, or if you have comments about that, and then I would urge you to please pick up these letters and send them in.

Phillip Dustan: I think, unequivocally, I endorse that, and I know the people I have spoken to within the Cousteau Society endorse the idea.

I'm going to take the letter back and take it to my child's preschool and get the little kids to write letters, too, because my son wants to form an earth-saver's club.

I'd like to make one other comment about this that hasn't really come up—here we are at the World Bank—the value of the world's ecological goods and services, the kinds of things that reefs do for us has been valued at $33 trillion. That should make any banker take notice. And that's stuff we don't have to pay the world to do; it just does it for us. So maybe somewhere that should find its way into this educational process. It is an extremely conservative figure.

Marea Hatziolos: We have used that figure to try and educate our own senior management.

Jack Sobel: If I could just also comment on that—a couple of thoughts. First of all, we [Center for Marine Conservation] certainly endorse that. We think that taking personal action, whether you're a government person, whether you're an NGO representative, whether you're a scientist, whether you're a fisher—is really important. When I first came to Washington, D.C., I worked on "the Hill" [the U.S. Capitol], and the one thing that the Hill really convinced me of is that democracy does work if people participate. And writing letters and contacting your representatives and government makes an enormous difference. The other thought I have is that, in an international setting like this, I think it's still worth supporting that, but we shouldn't forget that there's a lot of people here who are not Americans, but there are similar [issues]—the same role of letter writing and individual participation is important. And because there's a fair number of people here who in one way or another are leaders in various communities, it's not just important to take personal action in terms of writing your own letter, but you have much greater impact if people go beyond that and encourage others, particularly when they have opportunities to speak publicly in open forums, to encourage other people to do that. I think you can really multiply your impact—in not only taking individual action, but also encouraging others to do the same.

Alexander Stone, Reef Keeper International: I would just put two things on the table for consideration at your work. One with regards to public awareness: we think it's real important to undertake focused awareness efforts that reach coastal user groups. And by that I mean the owners and managers of the reef that have outfalls that are dumping the sewage into the water. How do we target, or create public awareness efforts so we make sure we are getting the right message to that kind of a person? Or to the cab driver in the U. S. Virgin Islands that asks me: "Well, what's the big deal with those rocks that out there?" or the maid in Cozumel that tells me her family has lived in Cozumel for generations, and never has had the chance to look at a coral reef. How do we get to them? That's question, or point number 1. Point number 2 has to do with reef monitoring efforts. Particularly, I am addressing this to Clive [Wilkinson] and to John [McManus]: [inaudible]…we want to connect with you. And somehow we have spent a year wanting to connect, and we're still not touching. So I'm saying, let's develop some sort of a process to do that, because time continues to roll long and our reef monitoring efforts are growing and so are yours, and we don't want them to be too divergent for too long. Thanks.

Clive Wilkinson: I think the point is the power of one. I have salary until next February. John [McManus] is running out of money. We need a few more "ones" to make a team. But one thing you said about communication—I want to make one point; it is an anecdote that Jim Porter from the University of Georgia made. He was appearing before the Congress, or the Senate or some committee, and he had his best scientific presentations—graphs, histograms, pie diagrams—the lot. And they nodded [fell asleep]. And then he showed some before and after photographs. "Gee, it's that bad? We didn't realize it was that bad!"…So, we've got to learn to communicate.

John McManus: Yes, I'll just quickly add to that. What we've been doing with other groups is that we've been putting a bit of the onus on the other group, because especially initially, we had to be very cautious not to look like a threat to other

groups. There were some groups that were nervous, so we've been more responsive than we have been aggressive toward getting information. The other problem is that there is only one of me, and Sheila Vergara, who is our team leader is out there, and her job is to figure out what we do at what time, and who actually puts it in, so please communicate directly with her if you have any trouble getting responses back from me.

Jack Sobel: It also sounds like, perhaps, taxi drivers are a particularly important constituency for us to reach out to [laughter]. I say that partly in joking, but the Reverend Bill Ballentine, for people who have worked on no-take marine reserves, has been one of the most forceful and effective advocates for reserves—in New Zealand and elsewhere—makes a point of wherever he goes, and I've traveled with him some and seen him do this—to talk with to everybody. And he, too, points out taxi drivers, because they talk to a lot of people. And it's the one-to-one thing of talking to taxi drivers; he doesn't limit it to there, he also he spends a fair amount of time in bars, and in bars he also reaches out to the bartender, and the person sitting next to him. And I think that is another way—there are a lot of constituencies. And the point I made earlier about who are the stakeholders? Everyone is a stakeholder in coral reef conservation. Some of them realize it already; some of them don't. And I think we need to reach out to a much broader and much more diverse group of people than we have so far been successful in reaching out to.