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REEF CHECK: THE FIRST STEP IN COMMUNITY-BASED MANAGEMENT

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The Reef Check program was initially designed to carry out a snapshot global assessment of coral reef health. In 1997–98, the protocol was used to survey more than 400 reefs in over 40 countries. The results have been useful for tracking coral reef changes, such as overfishing, and the 1998 bleaching and mortality event, on national, regional and global scales. Reef Check has proven very effective in building up community support for conservation and management of reefs. Now, many user groups are using the method for repeated monitoring of reef health with and without scuba. The methods are flexible and robust, and can easily be adapted to long-term monitoring by increasing temporal and spatial replicates to create a suitable sampling design in the area of interest. In each area, additional indicator organisms can also be added to the core protocol to provide data on socioeconomically or biologically important organisms. For many areas of the world, the ideal monitoring program will include a large number of broad-brush Reef Check surveys carried out by the local community, as well as a smaller number of more detailed surveys using methods such as those in the Survey Manual for Tropical Marine Resources. Participants in the Reef Check network can compare their results locally, regionally and globally. By increasing the number of sites surveyed using a standard methodology, there is a proportional increase in the chance of detecting subtle changes in reef health at all scales.

Coral Reef Monitoring and Management on a Global Scale

Terrestrial systems such as forests and agricultural lands have long been managed with a goal of sustainable production of resources, and more recently, to achieve biodiversity conservation goals. In contrast, in most parts of the world, coral reefs have been considered self-replenishing resource systems that could serve as a continuous source of wild stocks without need of management. In the few areas such as Micronesia, where there is a history of coral reef management, the traditional systems typically broke down decades ago, and only recently have experienced a renaissance (Johannes, 1997).

Prior to the advent of scuba, the results of centuries of exploitation of coral reefs lay invisible beneath the sea (Hodgson, 1997). Since the 1960s, increasing numbers of recreational divers have been exposed first-hand to coral reefs. The films of Jacques Cousteau brought reefs into the living room of millions of homes and he was one of the first to warn of changes and threats due to pollution and other impacts. Over the past 30 yrs, there have been increasing anecdotal reports of reef degradation, but only scattered scientific evidence. There was a critical need for a survey that could quickly measure coral reef health on a regional and global scale.

In 1997, the first Reef Check global survey of coral reefs was designed and carried out during a period of 2.5 mo. Over 350 reefs in 31 countries and territories were surveyed by volunteer scientists and recreational divers using a single standardized method. The results revealed the extent to which increasing populations of humans have been damaging coral reefs at an unprecedented rate (Hodgson, 1999). Most high-value fish and shellfish

species such as grouper and lobster were simply missing from the majority of reefs. A major new finding was that overfishing was much worse at far more locations than expected, and particularly bad at many reefs remote from cities. The reef corals themselves were in reasonably good condition except in the Caribbean where algae were replacing corals. The survey confirmed anecdotal reports from scientists, fishermen and recreational divers, of declining coral reef health. Subsequent global surveys in 1998 and 1999 reconfirmed the previous results, and demonstrated the importance of having a global network of monitoring stations in order to track the effects of an unprecedented global bleaching and mortality event that was particularly severe in the Indian Ocean (Wilkinson et al., 1999).

Starting in 1996, the UN-supported Global Coral Reef Monitoring Network (GCRMN) carried out the critically important work of raising the awareness of governments around the world about the importance of coral reefs and encouraging government agencies to get involved in monitoring. In 1998, the two programs were formally linked under the International Coral Reef Initiative (ICRI) umbrella, with GCRMN focusing on assisting government monitoring efforts and Reef Check addressing community-based work through non-governmental organizations.

When considering the term 'community-based management', a broad definition is most useful for Reef Check. Such a definition includes a diverse set of potential communities who care about reefs such as the local villagers, foreign dive tourists, surfers, fishermen etc. Typically, these communities consist of stakeholders who have an incentive and willingness to participate in active monitoring and management of the reefs.

Are volunteers really suited for these tasks? Wells (1995) has assessed the use of volunteers and non-professionals in reef assessment and monitoring and concluded that they do an excellent job if assigned to tasks appropriate for their skill levels. Reef Check was 'purpose-built' for this assignment.

Governments and private groups regularly monitor many activities unrelated to coral reefs. Weather, stock and commodity prices, fresh water levels, and tides are all monitored and reported frequently. Although hundreds of millions of people depend on coral reefs for their daily food supply (Hatziolos et al., 1998), it is only now that we are beginning to realize the importance of monitoring the quantity and quality of such natural resources. Without monitoring natural capital assets, it is very difficult to determine how much 'interest' can be used in a sustainable way. The lack of monitoring has allowed damage to continue undetected at many coral reefs and made it difficult to judge the effectiveness of management efforts such as the establishment and operation of marine parks. In the future, it is likely that people will look back at the late 20th century and wonder how humans could have been so foolish as to not track the status of their natural resources.

Clearly, if coral reefs are going to continue to serve as economic and biodiversity resources, a major shift is needed in the activities of governments, private groups and individual citizens, towards actively monitoring and managing coral reefs. To do this, effective mechanisms are needed at the local and national levels that also will contribute to coral reef management at regional and global scales. To implement a global coral reef monitoring and management scheme, the following tasks must be completed:

- Establish a global network of coordinators for information transfer and training
- Provide a tool-box of methods for education, monitoring and management
- Provide funds and trained staff for implementation

- Build government and public support so that effects are lasting

Each of these four areas has been targeted by Reef Check and progress has been made as described below.

Global Network

Reef Check has established a network of volunteer national coordinators with shared goals of coral reef monitoring and management in over 60 countries and territories in all tropical seas. This network is comprised of non-governmental organizations, individual scientists, divers and others who are concerned about reefs. Thus the network includes many people who are highly motivated to carry out reef monitoring and management and (in contrast to most scientists) who are experienced community organizers. The network members interact formally at meetings and regional training sessions, and informally over the internet. This network provides the core framework that will allow replication and expansion of Reef Check teams in new countries and in new areas of countries where the program is already operating.

Methods

Progress also has been made towards creating a 'tool-box' of methods for monitoring reefs. The Reef Check methods were designed to meet two goals: (1) to enable a non-scientist with a high school education to be trained in a short period to obtain accurate, meaningful data that could be comparable on a global scale, and (2) that focuses on human impacts to coral reefs. The methods have been published on the web and improved following a review by many coral reef scientists and other specialists. The use of the web allows anyone with access to view and download the methods and other training materials including color photos of indicator organisms. Since the internet is not accessible in many parts of the world, normal print-outs of the training materials are available for free from Reef Check. The latest version is available at: www.ReefCheck.org.

Although an effort was made to ensure that Reef Check methods were compatible with others, particularly those used by GCRMN, they represent a major step forward in the development of rapid, community-based monitoring methods and differ in major ways from any other previous methods. Reef Check methods differ from others because they:

- Are based almost entirely on counting (not measuring)
- Can easily be carried out without scuba, thus can be used by villagers in developing countries to monitor shallow reefs
- Are ecologically holistic, including algae, fish and invertebrates
- Include organisms selected based on market value and ecological role
- Include an assessment of fishing and other human activities
- Produce a relatively small amount of accurate, meaningful and statistically comparable data
- Produce data that are directly relevant to reef management
- Produce data that are nationally, regionally and globally comparable
- Include separate packages for different biogeographic regions that allow intra-regional comparisons
- Require minimal training time (typically a few hours as compared with the several days required to train other methods)
- Are much faster than most methods (half day per reef)
- Are designed for non-scientists who may be experienced recreational divers or villagers who are marine naturalists (e.g., fishermen) so the pool of potential data collectors is huge

To achieve the goal of relying on non-scientists to gather accurate data, the methods are based upon counting easily recognized key indicator organisms using broad taxonomic categories—typically family level. Organisms with global distributions were selected to allow for comparability among sites anywhere in the world. Two sets of indicator organisms were chosen to allow intra-regional comparisons, one for the Indopacific and another for the Caribbean. Subsequently, additional sets were designed for other locations including: E. Pacific, Hawaii and the Red Sea. To achieve the goal of collecting valuable information about human effects on reefs, high priced organisms were selected that are at the top of the target list for fishermen or aquariumfish collectors such as lobsters, giant clams, grouper, snapper, parrotfish, humphead wrasse, or butterfly fish. The full list of organisms is given in Table 1.

Funding and Training

Since 1998, the Reef Check program has actively carried out fund-raising activities, as well as seeking collaboration with other programs involved in coral reef monitoring. As a result, Reef Check has been able to offer training of trainers workshops, often in collaboration with GCRMN, in many countries. So far, funds have been raised to support training and monitoring activities in Asia, Melanesia, and the Caribbean. In addition, cooperative training has been carried out with numerous regional and national programs and projects including UNEP (Caribbean, Indian Ocean and Asia), SPREP (Pacific), COREMAP (Indonesia), CRMP (Philippines) and CPACC (Caribbean). A continuing challenge is to raise more funds for core operations and seed funding for new community teams, and to test self-financing mechanisms such as certification programs.

Scientific Results

The results of the study form the first synoptic database available on coral reefs from all oceans using a single method. While ReefBase contains ecological data from thousands of reefs, comparisons are problematic due to differences in methodology and timing. By using one method in all locations, it is possible to compare reefs from anywhere. In addition, the abundance of the indicator organisms, along with the live/dead coral cover ratio provides one objective definition of coral reef health. Based on this definition, the results indicate that most reefs are suffering from overexploitation of high-value edible species, and that few sites, regardless of how remote or whether they are designated as a marine park, are in good condition. The few hundred sites available so far are adequate for a broad brush assessment of regional and global reef health. Researchers are encouraged to use them for further, more detailed investigations. As additional years of data are built up, trends should become apparent, and the value of the database will increase.

The majority of scientists and managers are less interested in the condition of reefs on a global than a local scale. The 1998 global bleaching and mortality event, however, demonstrated the importance of having a global monitoring network to track global changes on reefs (Wilkinson et al., 1999). Reef Check results suggested that coral reefs may act as the "canary in a coal mine." Apparently coral reefs are quite sensitive to relatively small changes in global temperature. The political issue of greenhouse gas emissions reduction now includes coral reefs.

Table 1. Reef Check Indicator organisms for overfishing (OF), dynamite fishing (DF), cyanide fishing (CF), aquarium fish collecting (AF), organic pollution (OP) and curio collection (CC).

Organism	Indicator for					
	OF	DF	CF	AF	OP	CC
Global						
Lobster		x				
Grouper (>30 cm)	x	x	x			
Fleshy algae		x				
Hard coral				x	x	
Dead coral					x	x
Recently broken coral — estimate area			x			
Sponge						x
Banded coral shrimp *Stenopus hispidus*					x	
Long-spined black sea urchins *Diadema* spp.		x				x
Butterfly fish	x		x	x		
Sweetlips — Haemulidae		x	x	x	x	
Snapper — Lutjanidae		x	x			
Trash (describe type and size)						
Indo-Pacific region						
Barrimundi cod *Cromileptes altivelis*	x	x	x	x		
Humphead wrasse *Cheilinus undulatus*		x	x	x		
Bumphead parrotfish *Bolbometopon muricatum*	x	x	x			
Giant clams *Tridacna* spp.		x			x	
Edible holothurians (2 species)		x				
Crown-of-thorns starfish *Acanthaster planci*					?	
Triton shell *Charonia tritonis*					x	
Pencil urchin *Heterocentrotus mammilatus*					x	
Caribbean region						
Nassau Grouper *Epinephalus striatus*		x				
Parrotfish (>20 cm)	x					
Pencil urchin *Eucidaris* spp.			x			
Triton shell *Charonia variegata*						
Flamingo tongue *Cyphoma gibbosum*			x			
Gorgonians (sea fan, sea whip)	x	x				

At present, it is difficult to judge the success or failure of coral reef management efforts anywhere due to the lack of long-term monitoring programs. As more sites are added to the Reef Check network, the results will help managers to judge the success or failure of management efforts at a variety of scales.

Developing Community Awareness and Stewardship For Reefs

Over the past 20 yrs, there have been many calls to conserve coral reefs from scientists and prominent environmentalists. These calls generally have not been heeded because they were typically made at meetings attended by other scientists, who already were supporters of this concept. Scientists were not doing a good job of communicating their message to the general public or to governments. In contrast, when the public collaborate with scientists in fundraising, organizing communities, and training and surveys, their awareness is raised about the value of reefs, threats to reef health and solutions to these problems. Press events serve to spread this message to a wider audience and cement the feelings of the core groups involved. Thus, the public relations aspect of Reef Check–PR for reefs–is an extremely important part of the program.

CHALLENGES AHEAD.—A major challenge in 1998 was the growing demand to use Reef Check for more than just a one-time annual assessment. Most coral reefs are located in developing countries, and few of these countries have the financial resources or capacity to implement highly technical, detailed monitoring programs. Such programs have, after all, only recently been implemented in a few developed countries. Many coral reef countries could benefit from establishing a relatively modest monitoring program first, using core Reef Check methods, adapted to local requirements, and then adding more detail as needed. To meet this need, additional guidelines were drafted for those teams wishing to use the core methods for long-term monitoring (Hodgson, 1999). At the same time, an agreement was reached with GCRMN that all GCRMN training would start with Reef Check methods.

The next step in methods development will be in the area of interactive reef management. Interactive management can be accomplished by using technological solutions such as the internet and CD-ROM to supply management advice. There has been little progress in this area. Active coral reef management is a relatively new topic and, outside of Australia, Florida and a few other locations, there is little long-term experience. What is now needed is a set of management methods that can be included in an Action Plan menu for reef managers. This is not as complicated as it may sound, because the list of management options available to reef managers is short. A web-based interactive management system will provide managers anywhere with the tools to do their job. Given a certain set of results, the manager can query the expert system and a number of management options would be presented.

Clearly, this high-tech solution to reef management will not be directly useful to villages without electricity, let alone computers. But by placing this information in the hands of local coordinators, whether government or NGO personnel, a delivery mechanism could be established that can reach the village level.

An invaluable outcome of community participation in the monitoring program is the development of a strong feeling of stewardship for coral reefs among individuals from diverse areas of society. As public support spreads for coral reef conservation and management, this puts pressure on government leaders to develop their own programs and to support private sector programs that share this goal. An extra benefit is that scientists who volunteer to serve as Reef Check trainers come into contact with the general public and enhance their status in the community. Through this 'win-win' process, the general public gains a greater appreciation of basic and applied science and the role of marine scientists, which could lead to support for higher government funding for science. It also helps to stimulate the interest of academic scientists in solving applied problems which have been undervalued in academia.

Participation in Reef Check is the first step in community-based management of reefs. It provides communities (e.g., tourist divers, villagers, government officials) with the information and tools needed to make management decisions. When combined with an integrated coastal management plan and more detailed monitoring results from government programs, sufficient information will be available to effectively manage reefs.

Conclusions

A number of lessons have been learned over the past five yrs of developing the Reef Check program. The concept and methods of Reef Check work well both to stimulate public awareness about coral reefs and to produce high quality scientific data that are useful for broad brush assessments of coral reef health at the local, national, regional and global scales. The monitoring may serve as an early warning system such that if problems are detected, more detailed monitoring can be implemented.

The problems facing coral reefs are generally the same everywhere in the world; overfishing, destructive fishing, sewage and industrial pollution and sedimentation. The solutions are similar, but need to be adapted to match the local conditions in each area.

Monitoring and management have costs, and neither developing nor developed countries are willing to commit resources to fund large monitoring networks using detailed methods typically employed in ecological research. In places where coral reef monitoring has been established and tested within an integrated coastal management framework, a model is emerging that works well in both developing and developed countries. This model involves two (or more) tiers of monitoring methods, with less detailed, community-based methods such as Reef Check used at many sites, and more detailed methods such as those promoted by GCRMN used at a smaller number of sites. Reef Check is a win-win solution to the problem of insufficient resources because the heavy volunteer component reduces the level of government funding required. Public participation produces many positive benefits, including increased public awareness, support for conservation and reef science. It also opens a much needed channel for reef scientists and managers to communicate with the public.

Coral reef management involves managing both coral reefs and people. Very few developed and even fewer developing countries are in a position to design effective national coral reef monitoring and management plans. A great deal of assistance will need to be provided to most countries for these much-needed plans.

Monitoring programs have been and are still being designed by academic scientists, with little input from managers, and without respect to a management plan. There is a risk that such plans will produce a lot of data of great interest to scientists, but of little use to managers. Monitoring programs should be developed adaptively, in the context of serving management needs as defined by the local communities. Reef Check, by focusing on human effects on reefs, provides one definition of coral reef health that is holistic (includes invertebrates, fish, and algae), allows comparison with other reefs around the world and is relevant to management of human activities on reefs.

The Reef Check methods should retain flexibility. While it is important that the core methods retain stability, users are encouraged to add indicator organisms and other parameters so that the methods can be matched to local management needs. This also ensures a proper balance between asking too much of volunteers, and allowing them to become bored due to typically low numbers of indicator organisms recorded.

In an ideal world, international and local funding agencies and governments would notice that community groups are taking the initiative to try to reverse the trend in declining reef health, and they would offer assistance and funds. In reality, it will take a long time for this new paradigm in coastal monitoring and management to be accepted and supported.

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