STATUS AND ISSUES OF CORAL REEFS

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Coral reefs have traditionally been regarded as "oases in the desert", self-contained ecosystems that maintain diversity in nutrient-poor waters by recycling. But this has changed. The scientists invited to speak at the 1999 meeting of the U.S. Coral Reef Task Force in Maui emphasized as a consensus of the group that coral reefs cannot be understood or managed in isolation. Degradation of coral reefs can occur far from concentrations of humans. The growth rates of corals can be negatively correlated with the discharge of rivers 280 km away (Dodge and Lang 1983). The sediments from river plumes can travel 250 km along a coast before turning offshore and reaching the reef (Wolanski 1982). The influence of dust from the Sahara Desert on coral reefs of the western Atlantic is being investigated by the USGS in Florida (Shinn et al. 2000). The magnitude and extent of human influence is changing rapidly. The Mississippi River now carries 10 times the concentration of nitrates and phosphates that it did in the late 1960s (Hallock et al. 1993). The concentration of nitrates has doubled and the concentration of phosphates increased eight-fold in regions of deforestation in the Amazon Basin (Hallock et al. 1993). Each Year, 75 billion metric tons of soil are removed from land, and over the past 40 years, one-third of the Earth's arable land has been lost by erosion (Pimentel et al. 1995). The long-term effects of changes in land use on coral reef structure and health require collaborative studies among institutions such as those between USGS, the State of Hawaii, and Universities of Hawaii and Washington (Ogston et al. 2002). The bottom line is - coral reefs can no longer be understood or managed in isolation.

Coral reefs have always been a dynamic mosaic system of varying states of recovery from damaging events such as hurricanes, outbreaks of crown-of-thorns starfish, sea level changes, and lava flows from volcanoes. In the past two or three decades, however, some large areas of reef in the Caribbean and Pacific have not recovered. They have shifted to an alternative state, from coral-dominated to macroalgal-dominated communities. This phase shift is often attributed to ecosystem overfishing, the harvesting of the fish assemblage to the level below which the coral-reef ecosystem is not able to recover. The most prevalent form of ecosystem overfishing is the reduction of populations of herbivorous fishes to below the level at which they can keep the algae grazed down enough to allow recruitment of reef-building corals. Once the herbivorous fishes or urchins are unable to keep the algae under control, the algae dominate the space and the coral assemblage is excluded.

Coral reef fisheries were once rich and productive when managed by the local residents with traditional techniques. Coral reefs were once the main source of protein of islanders. In the 1970s, the shoreline fishery of American Samoa yielded an average of 18 metric tons per km^2 per year, with catches as high as 26.6 mt km^{-2} yr^{-1} (Wass 1982). The mean harvest of reef fishes from some small islands in the Philippines in the 1970s ranged from 11.4 to 16.5 mt km^{-2} yr^{-1} (Alcala and Luchavez 1982). The Nassau grouper in the western Atlantic formerly gathered in spawning aggregations of up to 100,000 individuals (Smith 1972) with individuals reaching a weight of 50 pounds (22.7 kg) or more. Until about 30 years ago, the Nassau grouper was a major component of subsistence and commercial fisheries in the western Atlantic (Sadovy 1993). Reef-associated fishes marketed for food include about 180 species in the Caribbean and nearly 300 species in the Pacific.

The stocks of reef fishes have undergone major deterioration since the 1970s. As modern technology such as scuba, nightlights, chemicals and explosives made the fishes easier to catch, the landings of reef fishes briefly increased up to 15 fold (Page 1998). But the technology eliminated natural refuges for the breeding stocks, and as fishing became more effective, the stocks began to plummet in the late 1970s and early 1980s. In Guam, the catch per unit effort dropped 78% in 12 years (Birkeland 1997). In American Samoa, the drop was 75% in 14 years (Craig 1994). The catches from Pedro Banks near Jamaica declined by 82% in 15 years (Koslow et al. 1998). The Nassau grouper dropped 15-fold in 14 years in Bermuda (Sadovy 1993), and spawning aggregations of the species disappeared from Bermuda, Puerto Rico and Hispaniola. Nassau grouper is now considered no more than an "incidental catch" in many areas, and most individuals captured are juveniles (Sadovy 1993). The breeding stock of fishes is like capital in the bank, and commercial, recreational and subsistence fishing before the introduction of advanced technology was analogous to living off the interest. The introduction of technology was like a key to the vault. For a brief period there was richness, but once the capital was spent, there was no more interest on which to live. The more accessible the fish became, the fewer fish there were. It should be noted that Australia (Queensland, Great Barrier Reef), all of French Polynesia, American Samoa, and many villages of Samoa all wisely prohibit the use of scuba for spearfishing.

Until a few decades ago, the breeding stocks of coral reef fishes were also protected in many areas by traditional management. Village-level controls were effective in Hawaii, Palau, American Samoa and some other communities because the traditional system emphasized social controls, peer pressure, and a strict, locally enforced code of conduct in fishery management. A village in Hawaii that currently operates under a similar system maintains sustainable fisheries yields and a fish biomass that equals the biomass in some officially designated no-take reserves (Friedlander et al. 2002). When villages or local clans or communities have been permitted to manage their own resources and exclude outsiders, they have been motivated to manage for the future. In order to maximize and sustain the yield to their village, they developed management strategies based on the reproductive biology of the reef fish species, protecting them during periods of spawning when they were most vulnerable, but harvesting them when needed. These traditions were broken down when well-meaning government agencies attempted to develop the local economy by opening access to everyone. The breakdown of local management systems effectively eliminated another refuge for breeding stocks of reef fishes.

Scientists and government agencies are now largely convinced of the benefits of local management, but the economic pull of markets such as Hong Kong, Singapore, Tokyo and (locally) Honolulu has made it impossible to manage the reefs in isolation. The live reef fish trade for restaurants rapidly became a billion dollar industry by 1992. After the stocks of Napoleon wrasse and groupers were depleted in the Philippines and Indonesia, stocks were intensively harvested further east in the Marshall and Solomon Islands. Ships from Hong Kong are already fishing as far away as the Galápagos.

Two responsibilities we have are to regain the fisheries yield of times past and to allow recovery of coral-reef systems by eliminating ecosystem overfishing. The coral-reef fish stocks have generally dropped considerably because new technology and the demise of traditional local management fisheries yield have eliminated the natural reserves for breeding stock. The reestablishment of community-based management may be a feasible method to resolve this problem with government support in isolated areas. But most of the tropical world cannot be managed in isolation because of the economic pull of the large urban markets of the Pacific, such as Hong Kong and Tokyo and, in Hawaii, Honolulu. Therefore, marine reserves for breeding stock is an alternative. The U.S. Coral Reef Task Force set 20% as the amount of coral reef area in U.S. waters that should be set aside as reserves. This may be politically more realistic, but 20% is likely too small to be effective. Fisheries models indicate that at least 50% of the coral reefs should be set aside (Polacheck 1990, DeMartini 1993, Roberts 1997, Guénette et al. 1998, Lauck et al. 1998, Palumbi 2001) in order to regain the fisheries and sustain the reef community.

Some fishermen do not recognize the problem or accept regulations unless they are allowed to fish the stock down to levels of severe depletion. This approach should not be followed for coral reef fishes because their life histories and behavioral traits may not permit the stock to recover if severely overfished. Groupers are an example. The aggregated spawning behavior of the groupers in predictable locations in space and time make them especially vulnerable to abrupt overharvesting with long-term effects. The spawning aggregation of groupers in the Denges Channel in Palau was collected by a Taiwanese fishing boat in 1986 and has not yet recovered.

Some other coral reef resources are also particularly vulnerable and warrant management under the Precautionary Principle being followed. A fishery resource was discovered at Haputo Reef off NW Guam in 1967 and fished down to assess the abundance of fishes and monitor recovery. A total of 3,322 kg were caught in 1967 (Ikehara et al. 1970), but apparently the stocks have still not recovered after 34 years. Over a hundred tons of pearl oysters were collected from Pearl and Hermes Reef in 1927, and the pearl oysters have not returned for 75 years. Additional examples of failure to return following overfishing on coral reefs can be found in Birkeland (2001).

The National Environmental Protection Council Act of 1994 in Australia states that lack of full scientific certainty that serious or irreversible environmental damage will occur cannot be used as a reason for postponing measures to prevent environmental degradation. With the Precautionary Principle, the onus is on the extractor to prove that the proposed practice will not endanger the sustainability of the resource. The Ecosystem Principles Advisory Panel of the NMFS advocated the precautionary approach in their Report to Congress. Whether a law or a guiding principle, precaution is necessary for managing coral reefs because of the vulnerability of some of the resources to permanent loss if mismanaged, also because it is our goal to restore fisheries to a high sustainable yield, and especially because the prevention of ecosystem overfishing is a tangible means for facilitating local recovery of coral reefs from some of the other factors impacting coral reefs. We forgive previous generations for what would now be considered unwise actions because they did not have the technology and knowledge base that we now have available to effectively predict the results of their actions. Now that we have these improved tools for decision making, we may not be forgiven by the next generation if we wastefully harvest resources until they are gone, simply because it is politically easier.

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