

Coral Reefs at Risk: Challenges and Solutions
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Presentation notes: CLIMATE CHANGE AND CORAL REEFS
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- I. Climate change background – a reef perspective
 - A. Climate change is not new; climate has changed between glacial conditions and interglacials (like the present) many times over the past several million years.
 - B. The past several thousand years have had an atypical climate even before humans modified it – it is warmer, with higher atmospheric CO₂ and higher sea levels than all but a few percent of the past 4 million years (or more).
 - C. The long-term average natural condition for geologically modern coral reefs is a tropical surface temperature 1-2°F lower than the recent past (and even lower temperatures at higher latitudes), with about two thirds of the present day atmospheric CO₂ concentration, and sea level ~125-250 feet below present.
 - D. The human-caused increase in atmospheric CO₂ and the increasing temperature and variability is rapidly moving the environment outside of the ‘envelope’ of natural evolutionary experience.

- II. Reef Stress – causes, understanding, and trends
 - A. The ‘coral reef crisis’ is well documented – the incidence of disease and bleaching is increasing in frequency and geographic extent, and reef ‘health’ is declining.
 - B. There are at least two clear and well-documented global-scale, climate-related present and/or future reef stress factors:
 1. High temperature – ‘hot-spot’ temperature excursions, especially when coupled with high light and calm water, are a major factor in bleaching and related mortality. This is demonstrated in laboratory, mesocosm, and the field, but understanding of the mechanisms remains elusive.
 2. Reduced surface ocean calcium carbonate saturation state – rising atmospheric CO₂ causes the surface ocean water to become more acid, making it more difficult for some organisms to precipitate their carbonate mineral skeletons. This is understood in principle and demonstrated in lab and mesocosm, but difficult to verify in the field.
 - C. Local and regional human-induced stresses have taken a heavy and accelerating toll on reefs over the past half-century; nutrient loading, contamination, overfishing, sedimentation, and direct destruction have all been factors in general, but with large geographic variations and a variety of combinations.
 - D. Humans have a very limited understanding of, and almost no predictive ability for, the tolerance limits and stress response mechanisms of corals and reef systems. This is particularly true with respect to synergistic interactions of multiple stresses.
 - E. At a global level, the major stress sources will continue to increase; on a time scale of decades, CO₂, temperature, and population (especially coastal zone population) are virtually certain to continue to rise.

- III. The Dilemma for Reef-related Humans
 - A. The situation is bad and will certainly get worse.
 - B. We have essentially no near-term ability to control or reduce the large-scale stresses.
 - C. We know how to alleviate or prevent most (but not all) local, human-induced stresses, but:
 1. Financial and human resources available are very limited compared to the need;
 2. The measures required can generate economic hardship and political resistance;
 3. Solutions need to be regional because of the interconnectedness of marine systems; and

4. We have not yet developed reliable and objective techniques for assessing where a given reef is on the continuum from healthy to threatened to sick to mortally ill.

- IV Triage – the science and art of resource allocation in coping with disaster
- A. The battlefield concept is to sort casualties according to medical capabilities to help them while sustaining the system (society in general or the military unit).
 1. In an ‘open’ (or civilian) situation, priority is given to seriously injured but recoverable cases, with reduced attention to the mortally and the superficially wounded.
 2. In a ‘closed’ (e.g., isolated battlefield) situation, priority shifts to the less seriously wounded, who can be returned to duty quickly to sustain the system.
 - B. The coral crisis is a ‘closed’ situation – planet-wide attack with no prospects of reinforcements. Priority should be on protecting the healthy and treating the less seriously impacted reefs.
 - C. Application of the priority system will depend on the distribution of problems, resources, and societal values at the local and political jurisdiction level. This will ensure attention to a diversity of reef systems and problems.
 - D. There is need for some large-scale global coordination to make sure that some vital need does not ‘fall through the cracks’ between local efforts.
 - E. With the exception of Australia and some of the US Pacific territories, most of the less serious casualties and better prospects are in developing countries with fewer resources.

- IV. Criteria for sorting and prioritization
- A. Candidates for reduction of, or protection against, local stresses should consider global threats as well as the feasibility of effective action at the local scale.
 - B. Some of the considerations are scale-dependent; others are applicable at all scales:
 1. Distance from population centers is an important criterion – recognizing that oceanographic or biological distance is not always the same as map distance.
 2. Oceanic reefs or reefs remote from major land masses have important advantages in being subject to a reduced number and variety of types of stresses.
 3. Reliable water motion (flushing by both waves and currents) is important – it promotes calcification, and tends to break down the thermal stratification that leads to bleaching.
 4. At regional scales, the high tropical latitudes deserve particular attention as the best short-term compromise between lethal temperatures expanding from the tropics and inhibitory saturation state reductions progressing from higher to lower latitudes.

- V. Critical needs
- A. Regional coordination to ensure that local/national efforts reinforce each other, rather than occurring in biological isolation or generating socioeconomic conflicts.
 - B. Rapid development and dissemination of a scientifically-based, management-oriented literature on development and application of the triage concept. *Most current management and planning literature is compulsively optimistic and focused on human dimension issues and local problems to the exclusion of large-scale, long-term environmental issues. **
 - C. Establishment and (probably international) support of research sites and facilities that permit studies of relatively healthy, unimpacted reefs. *Many marine labs and study sites are in areas so degraded that field research on stress-response physiology and ecology is done on moribund systems and stressed individuals rather than those that should be protected. **

** italics indicate editorial opinion based on scientific interpretations*