Coral Disease

Coral is a generic term for a group of simple organisms that belong to the phylum Cnidaria. Most often, the term is used to describe reef-building corals of the Order Scleractinia (Class Anthozoa). These organisms form single or multi-polyp colonies and are almost all symbiotic with single-celled plants called dinoflagellates or "zooxanthellae". These symbionts live within the cells of corals and are essential to the host. Corals form the structural elements of the dominant ecosystem of shallow tropical oceans. Recent surveys of coral reefs worldwide have revealed that a wide of factors is degrading reefs on a large scale. One of these factors is an apparent increase in the incident of disease. The causal agents for a large number of these diseases are currently unknown, however, most evidence points to a combination of physical (temperature, light) and biological agents.

Mass bleaching. Mass bleaching has been the most conspicuous coral disease to strike coral reefs over the past 20 years. Notably, there have been 6 major periods of mass bleaching (1979-80, 1982-83, 1987, 1991, 1994,1998). There are no reports of mass bleaching events prior to 1979. During these events, corals loose their characteristic brown colour over a period of several weeks and take on a brilliant white (bleached) appearance. The loss of brown colour is due to the reduction in the number of photosynthetic symbionts (zooxanthellae) that are essential for the health of the coral. Thousands of square kilometers may be affected in any single event, and events may stretch across several tropical oceans at once. Events last for 6-12 months but may have ramifications for coral reefs that may last years.

Individual corals may recover and regain their zooxanthellae. In many cases, however, corals suffer rates of mortality that may rise to as much as 80-100% of all corals dying after a bleaching event. Survivorship may be higher but is associated with reduced growth rates and reproductive capacity.

Global patterns. Coral reefs in almost every ocean have now been affected by mass bleaching. Mass bleaching events coincide with strong El Nino years. This association has been tracked to the sensitivity of reef-building corals and other symbiotic invertebrates like anemones and clams to increases in temperature and light. In 1994, mass bleaching in the central Pacific was triggered by the arrival of water that was 0.8^{o}C above the summer maximum. Three weeks later, most coral reefs from French Polynesia to Fiji were 40-80% bleached. This pattern has been seen in most events across the world over the past 20 years, with 80% of reports being associated with observations of warmer than normal conditions. The US agency, NOAA (National Oceanic and Atmospheric Administration), has used satellite measurements of sea temperature to predict every incident of bleaching during the 1998 event by tracking 1^{o}C positive temperature anomalies. For example, a February 10, 1998 advisory statement from NOAA predicted the bleaching event that occurred on the Great Barrier Reef (Australia) three weeks later. During this event, water that was 1^{o}C above the normal summer maximum led to wide spread bleaching on the Great Barrier Reef in which 80% of all reefs in the 2100 km long marine park ere affected.

Causal factors. While temperature is considered to be the primary variable associated with mass bleaching, several other factors appear to be important secondary factors. Changes in salinity and the quality of light accompanying temperature changes are important. There is some evidence that bleaching events are exacerbated by the doldrum conditions that usually accompany strong El Niño events. El Niño doldrum conditions are typified by clear skies and no wind leading to increased levels of both Photosynthetically Active Radiation (PAR) and Ultra-Violet (UV) radiation. Conditions of greater levels of PAR and UV radiation appear to increase the bleaching of corals in response to small increases in sea temperature. A salient observation is that bleaching will occur faster if corals are exposed to either PAR or UV light and will not occur if corals are left in the dark.

Mechanism: Mass bleaching is caused by a failure of the photosynthetic processes of the zooxanthellae that reside in corals. Recent work has shown that this is due to increases in temperature leading to a reduced capacity to process the excitation energy coming from the light reactions of photosynthesis and that the primary effect is that the zooxanthellae of corals become more sensitive to photoinhibition. This leads to an over-reduction of biochemical components within the light reactions, resulting from the fact that energy cannot be passed to the dark reactions of photosynthesis. Destruction of the chloroplast follows thereafter. Damaged zooxanthellae (and the host cell in which they reside) are quickly removed from the body of the coral polyp.

Pathogenic disease. The growth of human populations worldwide has meant many new pressures have been placed on coral reefs. On eof the most important factors has been the decline in water quality. Generally, corals grow best in the

warm, clear and low nutrient waters of tropical oceans. Increased development of the coastal zone in many tropical countries has led to increases in nutrient, sediment and heavy metal concentrations. These in turn have been shown to have a range of direct impacts on coral reef organisms. In addition to these, it appears that the incidence of pathogenic infections among corals has also increased, especially in densely populated areas like the Caribbean sea. Similar increases appear to be occurring among other coral reef organisms (e.g. sea urchins, gorgonians and coralline algae).

A number of diseases have been identified since the 1970s. While the specific pathogen in many of these disease remain undescribed, there appears to be a diversity of host pathologies that indicates that a range of microorganisms are involved. These organisms are thought to be either opportunistic species that have capitalized on the reduced health of corals or pathogens that have been recently introduced into the marine environment.

While there now over 20 different diseases have been described for corals, there are several main diseases that appear to be on the increase in several parts of the world.

Black band disease. Black band disease was first recorded in 1974 and is characterized by a thick black band of tissue that advances rapidly across infected corals. While infrequently seen, Black Band Disease has been reported in a number of outbreak situations. Empty coral skeleton is left behind as the band advances across the surface of infected corals – the total destruction of coral colonies taking less 60 days in many cases. Rutzler and Santavy (1983) have classified the primary infection as being due to pathogen called *Phormidium corallyticum*, which is blue-green alga or cyanobacterium. A range of other organisms including the blue-green alga or cyanobacterium *Spirulina* sp., various sulfur-oxidizing and sulfate-reducing bacteria, and other bacteria are associated with the band and cause the death of the underlying coral tissues through asphyxiation. Transmission of the disease is through contact of one colony with another. Red Band Disease and Brown Band Disease are similar diseases but appear to involve different consortia of pathogens.

White band disease. White Band Disease is typified by a loss of tissue that is visible as a band of bare white skeleton. White Band Disease has been reported on Caribbean, Australian and reef in the Red Sea. Despite persistent attempts, no pathogen has been identified as the causal agent and it is possible that this disease may have multiple causes. The impact of this disease has been major in some parts of the world. For example, up to 95% of the Acroporid (staghorn) corals have died in some part of the Caribbean sea. This disease is thought to have important ramifications for the diversity of coral species and is considered to be a major problem in many parts of the Caribbean.

Rapid wasting syndrome. This disease was first observed in the Dutch Antilles in December 1996 by Bak and associated. By 1998, this disease had been reported from the Florida Keys and many locations in Caribbean sea (e.g. Venezuela, Grenada, Mexico, Grand Cayman). Rapid wasting syndrome is typified by a rapid loss of tissue and destruction of the underlying coral skeleton. It is thought to be associated with parrot fish predation and an as yet unidentified fungus.

Tumors and growths. A persistent observation by many workers on coral reefs is that coral colonies frequently suffer abnormal growth forms. While rare, these abnormalities of either tissue of skeleton have attracted attention because of their similarity to human tumors and cancers. The intensity of ultra-violet radiation has been hypothesized as a causal agent. No causal agent, however, has been described for the tumors and outgrowths of corals.

Vibrio. A form of coral bleaching has been associated with a biological agent. While this agent is not responsible for the mass bleaching that has occurred on a global scale since 1979, it appears that a bacterium belonging to the genus *Vibrio* can cause symptoms that are similar to the coral bleaching caused by increased temperature. This disease has been reported among corals off the Mediterranean coast of Israel. Vibrio is agenus of aerobic rod-shaped and gram-negative bacteria which include the causal agent responsible for the human disease Cholera (Vibrio cholerae). The group also has extensive representation in marine ecosystems as both benign and symbiotic forms (e..g. luminescent forms are symbiotic with a range of fish and squids).

The role of human activity. The rapid increase in disease among corals over the past 20 years has implicated human activity. Humans have massively increased the sediment and nutrient loading of rivers, which is suspected to have played a major role in the decline of the health of organisms like corals. These changes to the rivers that flow into coastal areas adjacent to coral reefs are in turn linked to changes to the land use. The reduced health of corals is suspected to be leading to an increase in the susceptibility of corals to invasion by microorganisms. Changing land use has also led to the introduction of novel pathogens. For example, the fungus affecting

gorgonians (sea fans) throughout the Caribbean Sea has been identified as *Aspergillus sp.,* a terrestrial fungus that is unable to reproduce in sea water (Smith et al., 1996). Another hypothesis that has attempted to explain the rise in disease in the Caribbean sea is the increasing amount of dust blowing across the Atlantic from North Africa. This dust has been hypothesized to stimulate abnormal conditions under which corals then suffer or by introducing a range of terrestrial bacteria, viruses and fungal spores.

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