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Coral Reef of the Red Sea

Background:

The Red Sea contains some of the world's most unique and diverse marine and coastal habitats. The natural coastal resources have supported populations for thousands of years, and nourished the development of a maritime and trading culture linking Arabia and Africa with Europe and Asia. The Red Sea is one of the most important repositories of marine biodiversity in the world. It's relative isolation has given rise to an extraordinary range of ecosystems, biological diversity and endemism, particularly among reef fishes and reef-associated organisms.

The coral reefs of the Red Sea are comprised of more than 200 species of scleractinian corals, representing the highest diversity in any section of the Indian Ocean. The warm water and absence of fresh water runoff provide suitable conditions for coral reef formation adjacent to the coastline. In the northern Red Sea the coast is fringed by an almost continuous band of coral reef, which physically protects the shoreline. Further south the shelf becomes much broader and shallower and the fringing reefs gradually disappear and are replaced with shallow, muddy shorelines. Coral reefs become more numerous in the offshore parts of this coast.

Although many reef areas in the Red Sea are still in a pristine state, threats are increasing rapidly and reefs are being damaged by coastal development and other human activities. Major threats include: landfilling and dredging for coastal expansion; destructive fishing methods; damage by the recreational SCUBA diving industry, shipping and maritime activities, sewage and other pollution discharges; lack of public awareness, and insufficient implementation of legal instruments that affect reef conservation.

What are the Coral Reefs?

Coral reefs are centres of marine biodiversity. Reefs are constructed by a host of reef-building (hermatypic) coral species, but also are home to ahermatypic, or non-calcium carbonate depositing corals such as soft corals, black corals and gorgonians. Much like their terrestrial counterparts the tropical rainforests, reefs combine a host of micro-habitats and a diverse array of life-forms that are still being discovered and described. Coral reefs are distributed throughout the tropics, and large proportions are located in developing countries.

Coral reefs are made up of numerous coral colonies. These colonies are made up of thousands of minute coral polyps each of which secretes a calcium carbonate skeleton. The deposition rate for individual coral species varies, but is generally considered to range between 0.1 mm and 10.0 cm per year. The accumulation of these skeletons over an enormously long period of time results in massive, three dimensional geological structures. The actual living tissue however, is only a very thin layer lining the surface. Coral polyps feed by filtering plankton, aided by tentacles tipped with stinging-cells (nematocysts); they also receive organic matter through their symbiotic relationship with minute algae (dinoflagellates) called zooxanthellae. These small algal cells use sunlight to photosynthesise carbonates and water into organic matter and oxygen, both of which are used by the polyp.

Coral reefs support complex food and energy webs that are inter-linked with nutrient inputs from outside sources (such as those brought with ocean currents and run-off from nearby rivers) and from the reef itself (where natural predation and die-off recirculate organic matter). These complex webs mean that any effect on one group of individuals will ultimately impact another, and single disturbances can have multiple effects on reef inhabitants. For example, the complete eradication of the giant Triton *Charonia trinis* through overfishing usually results in outbreaks of Crown-of-Thorns starfish *Acanthaster planci*. This in turn leads to massive coral mortalities as the starfish reproduce and feed on the coral polyps. Habitats and food sources for reef fishes are then reduced leading to declines in the population of larger predatory fishes. The following sections provide a brief review of human disturbances and their general effects on coral reefs.

Coral Reef and Human Disturbance

Collection of corals:

Corals have been mined for construction purposes in several countries including Sudan and Saudi Arabia, broken into manageable sizes or crushed for the manufacture of cement and lime.

Corals are also collected for use in the ornamental trade as curios, souvenirs, or as jewellery. The aquarium industry is also responsible for the coral collection, either for direct sale as live colonies or through the process of fish collecting.

The removal of coral colonies decreases the shelter and niche areas available to numerous other reef inhabitants. Juvenile stages of fishes that seek shelter among the branching species of corals, and worms and ascidians that take up residence on massive life-forms, are deprived of protection and refuges and may become prey to other reef organisms. Furthermore, removal of entire colonies reduces the overall structural stability of the reef, and increases rates of erosion from wave damage.

Destructive Fishing:

Destructive fishing pressures are taking their toll on coral reefs. Today this is done with the use of home-made explosives composed of fertiliser, fuel and fuse caps inserted into empty beer bottles. Blast-fishers hunt for schooling fish such as sweetlips and fusiliers, which aggregate in groups in the open or hide under large coral heads. The bombs are usually dropped into the centre of an area judged to have many fish and after the bomb has exploded the fishermen use dip nets to collect the stunned and dying fish.

Blast fishing also damages corals. Lightly bombed reefs are usually pockmarked with blast craters, but many reefs in developing countries have been reduced to a continuous band of coral rubble instead of a reef crest and upper reef slope. The blasts change the three-dimensional structure of reefs, and blasted areas no longer provide food or shelter to reef inhabitants. Further, once the reef structure has been weakened or destroyed by blast fishing it is much more susceptible to wave action and the reef is unable to maintain its role in coastline protection. Larvae do not settle on rubble and thus replenishment and rehabilitation is minimal. The recovery of such areas has been measured in decades, and only then with complete protection and cessation of fishery pressure of any kind.

One of the most destructive fishing methods involves the use of cyanide. An aqueous solution of sodium cyanide or other chemical is squirted at fish to stun them, after which they are collected and sold to the live-fish trade. In the process of stunning the fish, the cyanide affects corals, small fish and invertebrates. A solution, which is narcotising to large fish, is often lethal to smaller ones. Cyanide has also been shown to limit coral growth, cause diseases, bleaching, and ultimately, in many coral species, leads to death.

Also among destructive fishing practices are normal trawl and purse fishing operations, when these take place close to or over reefs. Trawlers try to operate close to reefs to take advantage of the higher levels of fish aggregated around them, but often end up with their trawls caught on the reefs. Many of these then have to be cut away and discarded, becoming further entangled, breaking corals and smothering others. Spearfishing may also damage corals if fishermen trample and break coral to get at fish that disappear into crevices.

Discharges:

Mankind also has an impact on corals through the uncontrolled and often unregulated discharge of a number of industrial and domestic effluents. Many of these are 'point-source' discharges that affect localised reef areas, rather than causing broad-scale reef mortality. Discharges may release chemicals that are debilitating, toxic, or lead to a change in the environmental conditions. The release of fluids high in organic matter or nutrients, such as sewage or abattoir refuse can lead to a phenomenon known as eutrophication. Plague quantities of algae may grow, stimulated by the high nutrient levels. When these die, the bacteria that cause decomposition can deplete the water of oxygen to such an extent that it becomes impossible for corals and other animals to survive. Untreated and partially treated sewage is often discharged where fringing reefs are located close to shore, such as the reefs that fringe the length of the Red Sea. Raw sewage can also result in tumours on fish, and erosion of fins from the high concentrations of bacteria that develop.

Petroleum hydrocarbons from the oil industry have also caused widespread damage to coral reefs. The levels of oil and its derivatives in the marine environment (many of which are persistent carcinogens) have been correlated with coral diseases in the Red Sea, especially Black Band Disease. Drilling activities frequently occur near reefs, such as along the Saudi Arabian shoreline in the Arabian Gulf. Drilling mud can suffocate reefs and it also contains compounds that disrupt growth and cause diseases. Discharges result in an increase in diatoms (algae) and a decrease in marine fauna in their vicinity.

Many millions of tonnes of oil are transported through the region each year. Oil spills affect coral reefs through smothering, resulting in a lack of further colonisation, as occurred in the Gulf of Aqaba in 1970 when the coral *Stylophora pistillata* was found not to re-colonise oil-contaminated areas. There have been more than 20 oil spills along the Egyptian coast since 1982, some which have smothered and poisoned corals and other organisms.

Industrial effluents also impact coral reefs and their associated fauna and habitats. Discharge of heavy metals may give rise to elevated levels of lead, mercury or copper in bivalves and fish, or elevated levels of cadmium, vanadium and zinc in sediments. Larval stages of crustaceans and fish are particularly affected, and effluents often inhibit the growth of phytoplankton, resulting in a lack of zooplankton, a major food source for corals.

The outflow from desalination plants is typically 5-10 ºC higher in temperature and up to 3-10 ppt higher in salinity than normal seawater. These discharges may also include chorine and anti-scaling chemicals. The higher temperatures decrease the water's ability to dissolve oxygen, slowing reef processes, and usually result in localised bleaching of coral colonies. The higher salinity of the discharges increases coral mucus production and results in the expulsion of zooxanthellae and eventual bleaching and algal overgrowth. Often these waters are also chlorinated and contain compounds that are non-biodegradable and circulate in the environment for years. These compounds are absorbed by phytoplankton and then by filter-feeding corals. Through the complex food webs on the reef these compounds concentrate in carnivorous fishes, which may become poisonous to mankind.

Many airborne particles are also deposited over coral reefs, such as fertiliser dust, or dust from construction activities. At Ras Baridi, on the Red Sea coast of Saudi Arabia, a cement plant operating without filtered chimneys discharges more than 100 tonnes of partially processed cement over the nearby coral reefs each day. The reefs are now smothered by over 10 cm of fine silt.

Solid Waste Dumping:

Plastics, metal, wood, rubber, and glass can all be found littering coral reefs. These wastes are often non-biodegradable, or persist over long periods of time, causing damage which is primarily of a physical nature. Solid wastes damage coral colonies at the time of dumping, and thereafter through movements with natural tidal and surge action.

Construction:

Construction activities include coastal reclamation works, port development, dredging, and urban and industrial development. Commercial and residential property development in Jeddah have filled in reef lagoon areas out to the reef crest and bulldozed rocks over the reef crest for protection against erosion and wave action. 'Landfill' activities of this type generally result in increased levels of sedimentation as soil is nearly always dumped without the benefit of screens or silt barriers. Coral polyps, although able to withstand moderate sediment loading, cannot displace heavier loads and perish through suffocation.

The development of ports and marinas also involves dredging deep channels through reef areas for safe navigation and berthing, and damages reefs through the direct removal of coral colonies, sediment fallout, and disruption of the normal current patterns on which the reefs depend for nutrients.

Port Activities:

Port activities can have adverse effects on nearby reefs through spills of bulk cargoes and petrochemicals. Fertilisers, phosphates, manganese and bauxite are often loaded and offloaded using massive mechanical grabs which spill a little of their contents on each haul. In Jordan, the death of corals was up to four times higher near a port that had frequent phosphate spills compared to control sites. The input of these nutrients inhibits calcification and increases sedimentation. Algal blooms also develop through input of nutrients (nitrogen and phosphorous compounds), limiting light penetration and depleting dissolved oxygen.

Recreation:

The recreation industry has caused small but significant localised damage to coral reefs. Flipper damage by SCUBA divers is widespread, but certain activities, such as underwater photography, finds divers breaking corals to get at subjects and trampling reef habitats in order to get *the perfect shot*.

Anchor damage from boats is another problem at tourist destinations. Experiments have proven that repeated breakage of corals, such as caused by intensive diving tourism, may lead to substantially reduced sexual reproduction in corals, and eventually lower rates of re-colonisation. In the northern Red Sea, another popular diving destination, efforts are underway to install permanent moorings to minimise the damage to reefs from anchors.

Indirect Effects:

Most anthropogenic effects and disturbances to coral reefs are easily identifiable. Blast debris and lost fishing nets can be seen. Pollutant levels and sediment loads can be measured. However, many other man-made or induced problems have indirect impacts on coral reefs that are both problematic to link directly to coral mortality and difficult to quantify. Agricultural practices and logging, for instance, contribute to coral reef degradation through the runoff of sediment, fertilisers and pesticides. These result in the smothering of corals, limited larval settlement and localised nutrient enrichment.

Global warming, resulting from the Greenhouse effect and the build-up of carbon dioxide in the atmosphere, might also kill corals. The extensive coral-beaching event that took place in 1998, which was particularly severe in the Indian Ocean region, is accepted as having been the result of a rise in sea surface temperature. Bleaching of coral colonies occurs through the expulsion of zooxanthellae as coral polyps become stressed by adverse thermal gradients.

Coupled with global warming is sea level rise; this is predicted to be 25 cm by the year 2050. If not matched by coral growth, this will mean that corals will be submerged deeper and will not receive the levels of sunlight required for photosynthesis by the zooxanthellae. Additionally, the ability of coral reefs to protect coastlines from erosion will be lost if the waves are able to wash over the newly submerged reefs.

The Future:

Mankind has contributed to the widespread destruction of corals, reef areas and their associated fauna through a number of acute and chronic pollutant discharges, destructive processes, and through uncontrolled and unregulated development. These effects are more noticeable where social and traditional practices have changed with a lack of infrastructure, finances, and educational resources. Destructive fishing pressures and the development of coastal industry affects reefs throughout their geographic range. If mankind is to be the saviour of coral reefs in the coming millennium, there is going to have to be a change in fishing practices, and adherence to development and shipping guidelines and regulations, and integrated coastal management programmes that take into account the socio-economic status of people, the environment, and developmental needs.