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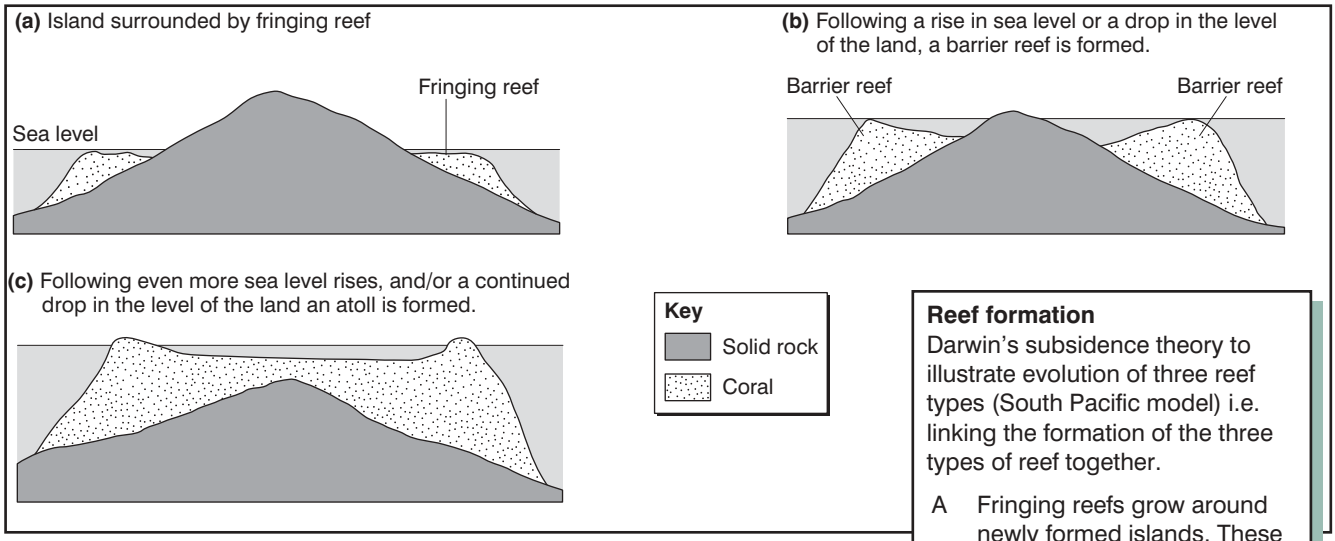
CORAL REEFS

Figure 1: Formation of fringing reefs, barrier reefs and atolls



Reef formation
Darwin's subsidence theory to illustrate evolution of three reef types (South Pacific model) i.e. linking the formation of the three types of reef together.

A Fringing reefs grow around newly formed islands. These islands subside, or sea level rises relative to land.
B If the process is slow the reef will grow upwards to form a larger barrier reef separated from the island by a deeper lagoon.
C When the island disappears beneath the sea an atoll forms. Corals can continue to grow on the outside to keep the reef on the surface. On the inside, where the land used to be, quiet water with increased sedimentation prevails.

Introduction

Coral reefs are one of the most biologically diverse ecosystems, rivalled only by the tropical rainforests in this respect. Corals themselves are marine animals, and almost a thousand coral species currently exist. However, human activities are threatening their future.

With the majority of the world's population living in coastal regions, many people depend on living coral reefs for food, and protection from storm surges and erosion, as well as the additional benefits of medical research, tourism and aesthetic beauty. Coral reefs contribute about 25% of the total fish catch in LEDCs, providing food for one billion people in Asia alone. Human activities, such as those associated with global warming, are threatening coral reefs. Increasing sea temperatures stress corals and cause damage, including bleaching.

The development of coral

All tropical reefs began life as polyps – tiny, soft animals, like sea anemones – which attach themselves to a hard surface in shallow seas where there is sufficient light for growth. As they grow, many of these polyps exude calcium carbonate, which forms their skeleton. As they grow and die, these colonies of 'rock'-forming corals create reefs.

Tropical reefs can grow at rates of under 2.5–60 cm/year, forming huge structures over incredibly long periods of time, making them the largest and oldest living systems on Earth. For example, the 1,250-mile Great Barrier Reef was formed over five million years.

Polyps have growing inside them small algae, zooxanthellae. The algae receive shelter and food from the polyp, while the polyp also gets some food via photosynthesis. Algae need sunlight to live, and obviously photosynthesis (conversion of light energy from the sun into food) cannot occur in darkness, hence corals only grow where the sea is shallow and clear.

Threats to coral

The main threats to coral include:

- coral bleaching and global climate change
- diseases of corals and other reef organisms
- plagues of predators like the crown-of-thorns starfish (COTS) and other damaging organisms such as the sea urchin
- invasive species which have been introduced onto new coral reefs.

Figure 2: Zoning in an atoll

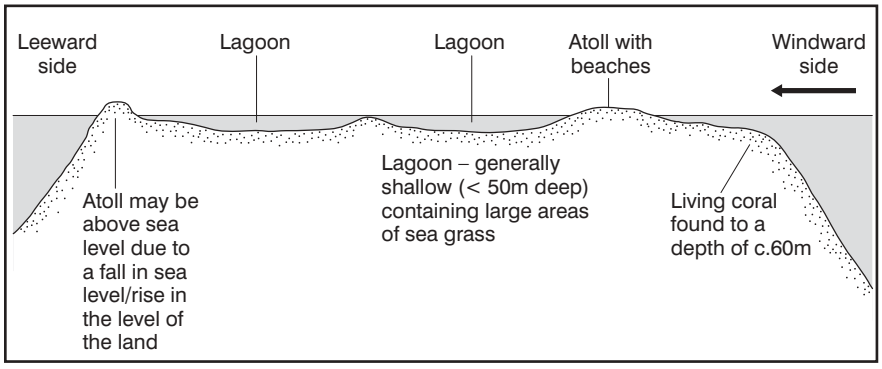
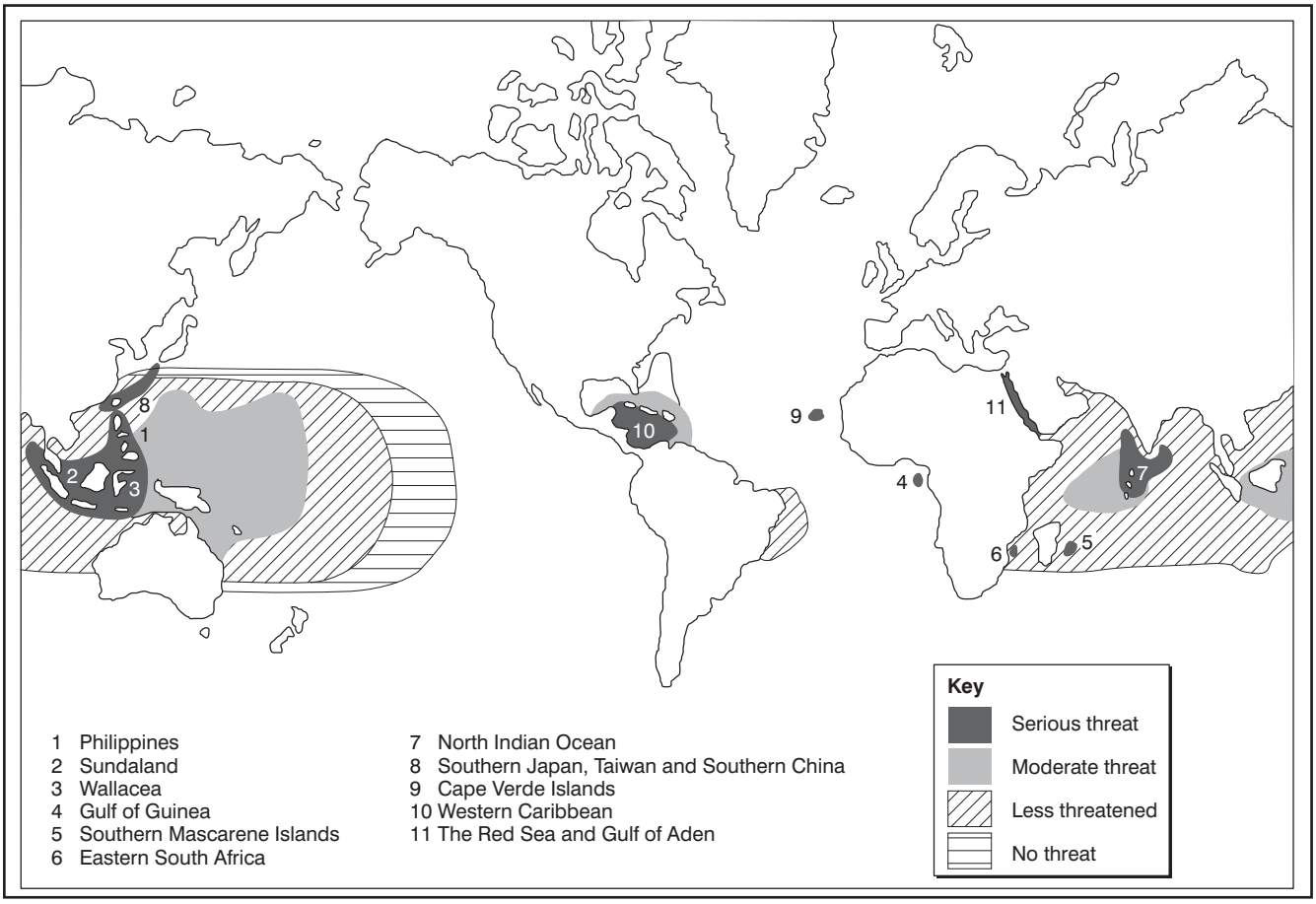


Figure 3: The coral reef hotspots, ranked by degree of threat



These threats are in addition to natural stresses that have always affected coral reefs such as storms, freshwater inundation and seismic and volcanic events. Direct human pressures on reefs have, until recently, been the dominant factors damaging coral reefs through a range of stresses, many of the which can co-occur:

- The delivery of pollution from unsustainable land-based human activities such as deforestation, poorly regulated agriculture, and urban and industrial development resulting in the release of excess amounts of sediments and nutrients. This is exacerbated by the release of nutrients and other pollutants from untreated or poorly treated sewage and industrial and agricultural wastes.
- Over-fishing and over-exploitation of coral reef fisheries and coral rock and sand resources. Within the last two decades there has been an increase in damaging fishing activities involving the use of home-made bombs, cyanide and other damaging practices such as muro ami that involves dropping weighted rocks onto corals to drive fish into set nets.
- Modification and engineering practices such as building of ports, airports and groynes on coral reefs, including the practice of 'reclamation', which pours sediments onto shallow areas, displacing sea area in exchange for increased terrestrial area.
- Coral mining involves live coral being removed from reefs for use as bricks or road-fill, while sand and limestone is made into cement for new buildings. Corals are also removed from their habitats to be sold as souvenirs to tourists and exporters.
- Pollution from oil, gas, industrial and urban waste, sewage, and agrochemicals from farming is poisoning reefs. These toxins are dumped directly into the ocean or carried by river systems from sources upstream.
- Some pollutants, such as sewage and runoff from farming, increase the level of nitrogen in sea water, causing an overgrowth of algae, which smothers reefs by cutting off their sunlight.
- Construction (both along coasts and inland), mining, logging and farming along coastal rivers can all lead to erosion. Valuable topsoil and other sediments are washed by rain into rivers and end up in the ocean where they smother corals by depriving them of the light needed to survive. Additionally, developments (piers and other structures) are occurring directly on top of coral reefs.
- Careless boating, diving, snorkelling and fishing can also damage coral reefs. Substantial damage has been caused by people touching the reefs, stirring up sediment, collecting coral, or dropping anchor on the corals.

These newer global threats (bleaching, disease and predators) are increasing rapidly in frequency and severity, coincidentally with direct human disturbances. Coral disease has caused major disruptions to coral reefs in the Caribbean with a range of human disturbances potentially implicated, and there are now increasing reports of similar disturbances from the Indo-Pacific region. Evidence linking severe coral bleaching and mortality to increasing rates of global climate change attributed to rising levels of anthropogenic greenhouse emissions is growing stronger.

Coral bleaching

Coral lives in a symbiotic relationship with algae called zooxanthellae. Zooxanthellae live within the coral animal tissue and carry out photosynthesis providing energy not only for themselves, but for the coral as well. Zooxanthellae give the coral its colour. When environmental conditions become stressful, zooxanthellae may leave the coral, leaving the coral in an energy deficit and without colour, a process that is referred to as coral bleaching. If the coral is re-colonised by zooxanthellae in a timely manner, the coral will likely recover. If not, the coral may die. Coral bleaching can be caused by increases in temperature of as little as 1–2°C above average annual maximum temperatures.

In 1998 there was extensive and intensive bleaching affecting the majority of coral reefs around Puerto Rico and the US Caribbean. In the southwest region a large number of coral colonies bleached completely (100% of living surface area) down to 40 m deep. Maximum temperatures measured during 1998 in several reef localities ranged from 30.15°C (20 m deep) to 31.78°C at the surface.

The 1998 episode was the largest coral bleaching and mortality event ever recorded on coral reefs globally, with major effects in the Arabian/Persian Gulf, Eastern Africa, throughout the Indian Ocean, in Southeast Asia, parts of the western Pacific and the Caribbean and Atlantic region. Overall, it was estimated that 16% of the world's area of coral reefs was severely damaged.

In the wider Caribbean region, there was moderate to severe coral bleaching in 1998, but generally there were low levels of mortality. At one site on Barbados, approximately 20% of bleached corals did not survive, but there were complicating factors, notably hurricane damage.

Coral and diseases

There has been a worldwide increase in reports of diseases in marine organisms including fish, sea urchins, shellfish, sponges, marine mammals, and corals. Since the 1990s, coral diseases have increased in number, affecting over 150 species from the Caribbean and Indo-Pacific alone. The rate of discovery of new diseases has increased considerably, with more than 29 coral diseases now described. Coral diseases can potentially produce severe population declines, threaten biodiversity, and shift the structure of reef communities by challenging the resilience of these systems.

Stress appears to lower a coral's resistance to disease and thus affects its ability to survive. Because elevated temperature is a coral stress, global climate change may also result in increasing incidence of coral disease. It is possible that proximity to human population centres may increase the likelihood of infection. Stress is often associated with increased susceptibility to disease and many studies have suggested a correlation between elevated sea temperatures, sedimentation, and pollution. Disease outbreaks are nearly impossible to manage because the connectivity of the marine environment increases the speed of disease transmission and renders standard response such as quarantine and vaccines ineffective. Preventing nutrient runoff into coastal areas by managing water quality could be one important management technique.

For some reason, the Caribbean appears to have experienced a far higher incidence of disease to coral reef organisms than reefs of the Indo-Pacific (at least 82% of Caribbean coral species are susceptible to disease, compared to 25% of Indo-Pacific corals). Several hypotheses have emerged: the Caribbean is semi-enclosed, hence the reefs are in relatively close contact due to the circulation of water; there are higher concentrations of nutrients and possibly pollutants because of the large volumes of waters flowing in from major rivers e.g. Amazon and Mississippi; and the reefs have been isolated from the others for millions of years. The region also has a higher population of scientists regularly monitoring the reefs for problems.

In the 1930s, there was a major disease outbreak that devastated the sponge industry. This seems to have been repeated in the 1990s when commercial sponges to the west of Florida were virtually eliminated. But the most dramatic and devastating diseases have been to corals and sea urchins.

Populations of the sea urchin were virtually obliterated when a disease killed over 95% of them throughout the Caribbean during 1983–84. This emphasised a major difference between coral reefs in the Caribbean, where urchins are the major grazers on algae, and elsewhere where the major grazers are fishes. The disease that killed these urchins probably originated near the Caribbean entrance to the Panama Canal and spread to the south-east and north from this point. The major impact on the reefs, however, was a massive explosion in fleshy algae, causing many corals to be smothered. Thus this disease outbreak had far-reaching consequences which were still evident in 2004; 20 years after the death of the urchins the populations have only recovered to about 4% of their original status and the coral cover is still depleted.

Predator plagues

Predator plagues such as COTS are increasingly reported around areas of human activities, with two strong hypotheses advanced:

- the plagues may be initiated and certainly exacerbated by either over-fishing of key starfish predators, and/or
- increases in nutrient runoff from the land favours the planktonic stages of the starfish.

The increasing frequency of COTS outbreaks continues despite decades of scientific study in the Pacific and Australasia and the cause of these plagues remains unclear. The negative effects of COTS are exacerbated by many other impacts including pollution, fishing pressures, sedimentation, river runoff, global climate change and associated coral bleaching events. These synergistic pressures lead to widespread, large-scale losses of coral cover and biodiversity. The highest densities of COTS in recent years have been on coral reefs in Tanzania and Kenya.

Invasive species

The most likely causes of invasive species introduction are:

- ballast-water exchange for cargo ships travelling long distances between ports releasing gametes, larvae, or juvenile individuals into new systems; and
- aquaria-related incidents whereby individuals import specimens from all over the world and release them into the wild after a time in captivity.

Since Indo-Pacific live rock is exported widely, the risk of introducing Pacific organisms to the tropical Atlantic is high.

Strategic planning in St Lucia

A 1998 survey showed that 65% of coral reefs in the Caribbean are in danger, and the coral reefs along St. Lucia's west coast are no exception. Protecting reefs makes sound economic sense as well as environmental sense. With this in mind, the St. Lucia government including the Department of Fisheries, the Department of Tourism, local tourist organisations and the Soufriere Regional Development Foundation have begun to take action to prevent the further destruction of this valuable natural resource.

The Soufriere Marine Management Area

In 1986 six areas were declared as marine reserves and another three areas were created as fishing priority areas. The Soufriere Marine Management Area is a 12 km stretch of coastline. The SMMA is attempting to manage St Lucia's marine resources in a sustainable way, although it is not always easy. SMMA's activities include:

- Scientific research on the natural resources of the region.
- Regular monitoring of coral reefs, water quality and other environmental factors and resources.
- Provision of public information and sensitisation.
- Provision of facilities for users of the SMMA e.g. moorings.
- Co-ordination of economic activities related to the SMMA and its resources.

Global assessment of coral reefs

About one-fifth of the world's coral reefs are so damaged they are beyond repair. While the percentage of reefs recovering from past damage has risen, 70% of the world's reefs are threatened or have already been destroyed, up from 59% in 2000. Almost half of the reefs severely damaged by coral bleaching in 1998 are recovering, but other reefs are so badly damaged that they are unrecognisable as coral reefs.

The destruction of reefs is cause for economic, as well as ecological, concern, especially for the communities that depend on coral reefs for the fish they provide and the revenue they draw as tourist attractions.

The 2004 State of the World's Coral report says the main causes of reef decline are climate change which causes bleaching, poor land management practices which damage the reefs with sediments, nutrients and other pollutants, over-fishing and destructive fishing practices, and coastal development. Increased water temperatures have already been blamed for the single most destructive event for corals, the 1998 bleaching.

The most damaged reefs are in the Persian Gulf where 65% have been destroyed, followed by reefs in South and Southeast Asia where 45% and 38%, respectively, are considered destroyed. There are also recent reports that many reefs in the wider Caribbean have lost 80% of their corals.

The percentage of recovering reefs has increased compared to the last global assessment. Most of the recovered reefs are in the Indian Ocean, part of the Great Barrier Reef off the coast of Australia and in the western Pacific, especially in Palau. In 2004, Australia increased protection of the Great Barrier Reef from 4% to 33% and 34% of Ningaloo Reef Marine Park was made off-limits to fishing.

The Status of Coral Reefs of the World: 2004 report documents how human activities continue to be the primary cause of the global coral reef crisis. The report details many new initiatives aimed at reversing this degradation such as by conserving the biodiversity, the economic value and beauty of coral reefs. The report recognises that the major stresses to coral reefs are: natural forces that they have coped with for millions of years; direct human pressures, including sediment and nutrient pollution from the land, over-exploitation and damaging fishing practices, engineering modification of shorelines; and the global threats of climate change causing coral bleaching, rising sea levels and potentially threatening the ability of corals to form skeletons in more acid waters.

Conclusion

At the World Conservation Union's (IUCN) meeting in Australia (2005) it was claimed that up to 20% of the world's reefs had been destroyed and that a further 50% could be lost by 2050. The IUCN called for more marine parks, which could help protect coral by decreasing over-fishing, mining and other destructive processes. Given the diversity within coral reefs, their protection is as important as that of the tropical rain forests.

Focus Questions

1. Describe, and account for, the threats that face coral reefs. Distinguish between physical and human threats.

2. To what extent are the coral reefs of the world salvageable? Can they be conserved, or are the threats too great?