Geo Factsheet

Number 118

CORAL REEFS – Ecosystem in Crisis?

Introduction

In the year 2000, 10% of the world's coral reefs were either totally dead or degraded beyond recovery. Unless action is taken in the next ten years this will rise to over 30% - indeed only 10% of all coral reefs are not at risk. Why is this and does it matter?

Table 1 The uses of coral reefs

*Coral reefs are of **great value** in many ways because they:*

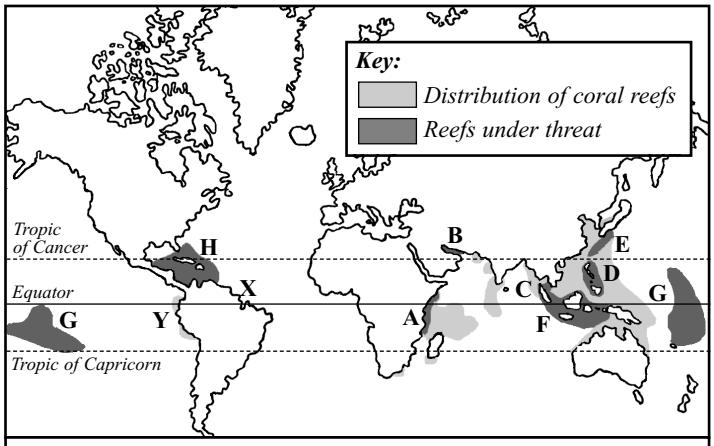
- *include some of the most **biologically rich ecosystems**. Whilst coral reefs only occupy 0.18% of the world's marine environments, the reefs are home to over 25% of all known marine fish. Coral reefs rival rainforests for their **biodiversity** i.e. the number of different species found within an area or ecosystem. Also many rare species live on reefs.*
- ***protect adjacent shorelines** from wave erosion and the impact of tropical storms – at much lower cost than artificial sea defences. These natural self-repairing breakwaters could become even more important if sea levels rise due to **global warming**. Healthy reefs will grow with rising sea levels.*
- *supply the basic **food needs** of many local communities. 109 countries have reef systems and 80% of these countries can be classified as LEDCs (less economically developed countries). A huge variety of fish and other species are caught using spears, traps and other 'native' methods.*
- *make a major contribution to **commercial fishing**. Globally 20% of animal protein consumed by humans comes from marine environments – with coral reefs providing 25% of this total **commercial** fish catch.*
- *are sources of **medicine**. Reef species may support new treatments for bacterial infections or possibly cancer, and corals are also used for bone grafts.*
- *contain resident fish and animals such as seahorses which are vital for the growing global **aquarium trade**. In the year 2000, 20 million seahorses were caught for this trade.*
- *are home to reef species which are used as **decorative objects**, for example shells and black corals, which are used for jewellery. This trade supports many 'native' craft industries around the world.*
- *provide coral which can be mined as a source of **lime** for cement. Many tropical countries lack alternative basic building materials.*
- *provide ideal habitats for **education** and **scientific research** because of their high biodiversity combined with their shallow water and easy accessibility.*
- *are major magnets to the world's **tourists**. In the year 2000 over 150 million people took a holiday in a coral reef area. 90% of the 109 countries with coral reefs have an established tourist industry. Many LEDCs such as those in the Caribbean derive over half the **Gross National Product** (GNP) directly from tourism.*

Many of these uses are conflicting; they are all growing and therefore are increasingly **unsustainable** as the coral reef ecosystems are being damaged or destroyed at a greater rate than they can 'self-repair'. Saving coral reefs has become just as important as saving the rainforests – hence in 1995 the International Coral Reef Initiative to promote sustainable reef management and in 1997 the International Year of the Coral Reef to promote public education on the state of the reefs and how best to manage them**.**

Coral reefs as ecosystems

Coral reefs are unique amongst marine ecosystems in that they are built up entirely by biological activity. Reefs are massive deposits of **calcium carbonate** ($CaCO_3$) produced primarily by corals *(Fig. 1).* Their distribution is controlled by what are known as **limiting factors**, i.e. if the factor is not present the reef does not form.

Fig. 1 Distribution of coral reefs.



Coral reefs - threats	
A: East Africa	*Coral mining for building materials, blast fishing, tourist trade and sedimentation.*
B: The Gulf	*Oil and industrial pollution, sedimentation.*
C: Thailand & Malaysia	*Tourist resorts, bucket dredging for tin, over-fishing.*
D: Philippines	*Blast fishing, coral mining, collection for tourist trade and use of poisons.*
E: Southern Japan Ryukyu Archipelago	*Destroyed by coastal development and sedimentation.*
F: Indonesia	*Destroyed by blast fishing, coral mining, tourist trade and coastal development.*
G: South Pacific	*Tourism, sedimentation from coastal development.*
H: Wider Caribbean	*Collection for tourist trade, coastal development, mangrove destruction/ sedimentation and damage by boat anchors*

Globally

- ***Temperature:*** No reefs develop where the mean annual temperature of the water is below 18°C. The best conditions for reef development occur in water temperatures between 23-25°C. Above 27°C causes problems for the health of the reef.
- ***Water depth:*** Most reefs grow in depths of 25m or less on the margins of continents or islands.
- ***Light:*** As light is needed for **photosynthesis** for the tiny algae (called **zooanthellae**) which live in corals and in return for a space to live, supply the corals with 98% of their total food requirements, coral reef growth is restricted to shallow waters.
- ***Salinity:*** Corals are marine creatures which are intolerant of water which is less than 30-32 psu, but surprisingly they will tolerate highly saline conditions such as those in the Red Sea or Persian Gulf.

Locally

- ***Sediment:*** Corals require clear, clean water as sediment clogs up their feeding mechanisms and reduces the light available for photosynthesis. Hence, almost always, there is a break in the reef across a river mouth.
- ***Wave action:*** As coral reefs thrive in well oxygenated water they prefer areas of strong wave action, but not too exposed to frequent storm conditions as waves destroy delicate corals.
- ***Exposure to air:*** Corals die if they are exposed to the air for too long, so for this reason the growth of reefs is limited to the level of the lowest tides.

Typical Exam Questions:

1. ***Describe and suggest reasons for the global distribution of coral reefs.***
2. ***Describe the general picture i.e. where the reefs are by latitude (tie this into global limiting factors.***
3. ***Discuss anomalies e.g. at X or Y where you would expect reefs to grow but they don't (clue: ocean currents – cool and warm).***

Types of coral reef

Generally, coral reefs can be grouped into one of three categories:

1. **Fringing reefs** such as those found around many Caribbean islands e.g. St. Lucia or Buccoo Reef, Tobago. These occur adjacent to a land mass and are separated from it by a narrow lagoon.
2. **Barrier reefs** such as the Great Barrier Reef are much larger and separated from the adjacent land mass by a deeper, larger lagoon.
3. **Atolls** such as those forming the Maldives are ring shaped reefs which enclose a lagoon rising out of very deep water far from land.

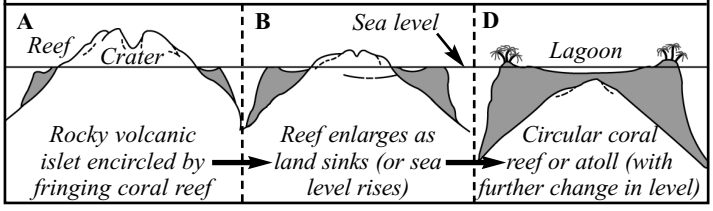
As coral requires shallow water to form in, explaining the formation of atolls is a challenge. *Fig. 2* shows a simple theory, first developed by Charles Darwin, which links the three types of reef into an evolutionary subsidence generated theory.

Fig. 2 The formation of reefs.

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.*



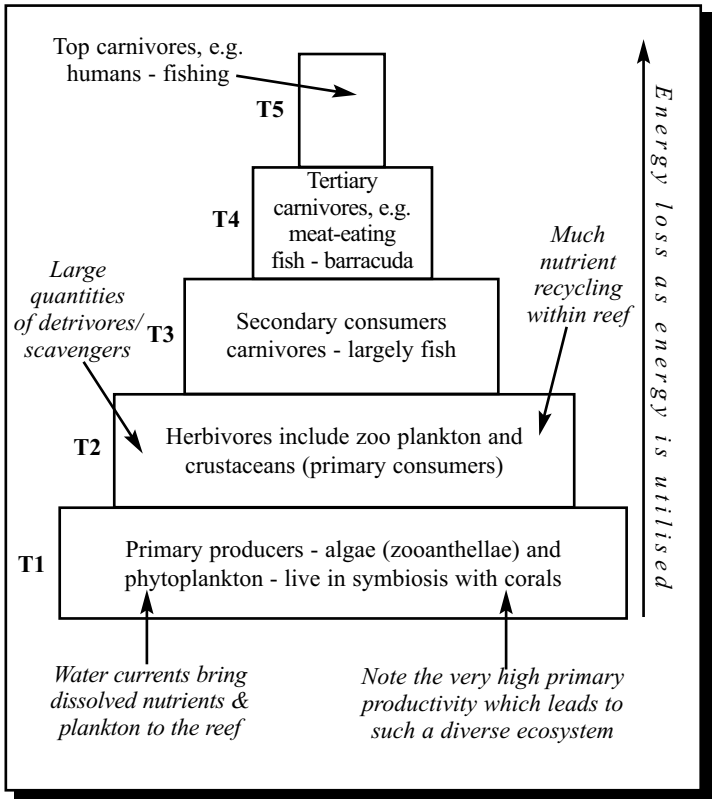
Exam Hint: Many exam questions require candidates to comment on the structure and functioning of a chosen named/location ecosystem.

1. ***Be sure to distinguish between the two. Structure is how the components are arranged within the ecosystem and functioning involves the operation of key processes such as energy flow and nutrient cycling.***
2. ***Learn a diagram such as the one shown below in Fig 3. It is simple to produce, can be adapted to show structure (via trophic levels) or functioning and also is well linked to a chosen named ecosystem.***

Note how the primary productivity of a coral reef is extremely high at between 1500-5000g c/m²/year, about 100 times higher than the surrounding waters. It is this enormous productivity which supports the whole ecosystem, and is the key to the high biodiversity. The diagram shows how nutrients are brought in from other areas such as the adjacent sea grass and mangrove swamps.

An alternative approach to structure would be to draw a diagram of Coral Reef Zoning in an atoll.

Fig. 3 Trophic Levels

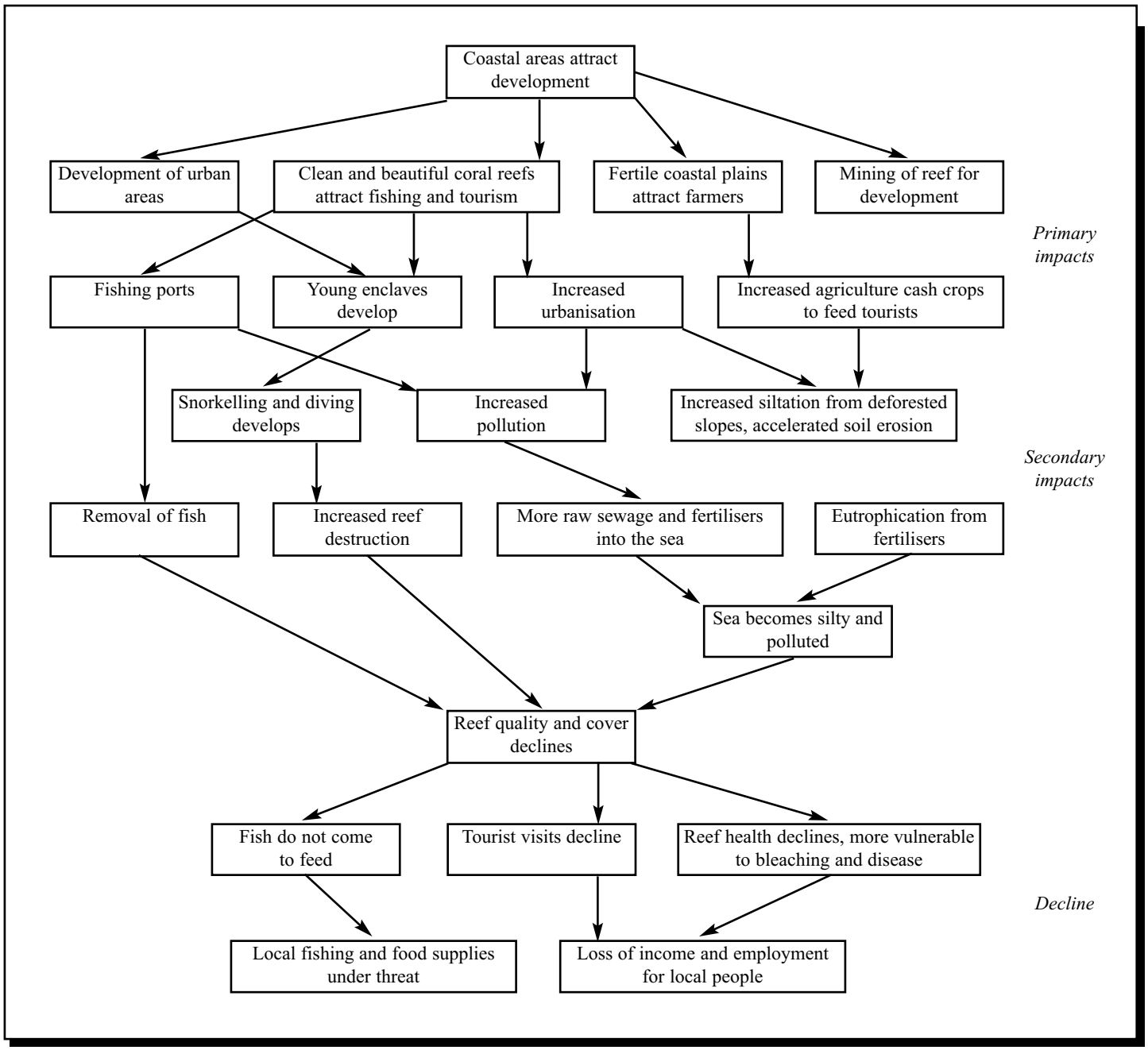


Reefs at risk – the causes

The world's coral reefs are under increasing threat. Of particular concern are the 15% of world reefs which qualify as **biodiversity hotspots** – i.e. very high ecological value, high-risk sites in the Philippines, Indonesia or the Caribbean.

At the root of the problem is the increasing population of the coastal areas both from natural increase (an average 2.5% - 3% per year in many LEDCs) and from migration to the coastal areas which are frequently areas of economic opportunity and employment (tourist development etc). The result is development which has both primary and secondary impacts as shown in *Fig 4 (on page 3)*.

Fig. 4 The impact of development on a coral reef ecosystem and the vicious circle of reef decline.



Natural causes of reef decline and destruction

Coral reefs thrive in temperatures between 23 and 25°C. As tropical oceans warm, either because of short term and localised El Niño impacts or longer term because of the impact of global warming, this can lead to corals going 'white' because of **bleaching**. When corals become stressed they expel the zooanthellae which colour their tissues and provide them with nutrients – so they die. '**Bleaching**' occurs when ocean temperatures rise by only 1-2°C. Increased coral reef stress leads to the onset of diseases such as white and black band disease.

Sometimes it is not the coral itself, but another organism's disease which has a knock - on effect. For example Long Spined Sea Urchins normally feed on the algae in the reef, controlling its levels. When the sea urchin population falls, as a result of disease, the uncontrolled growth of the algae overwhelms the coral, blocking out the light.

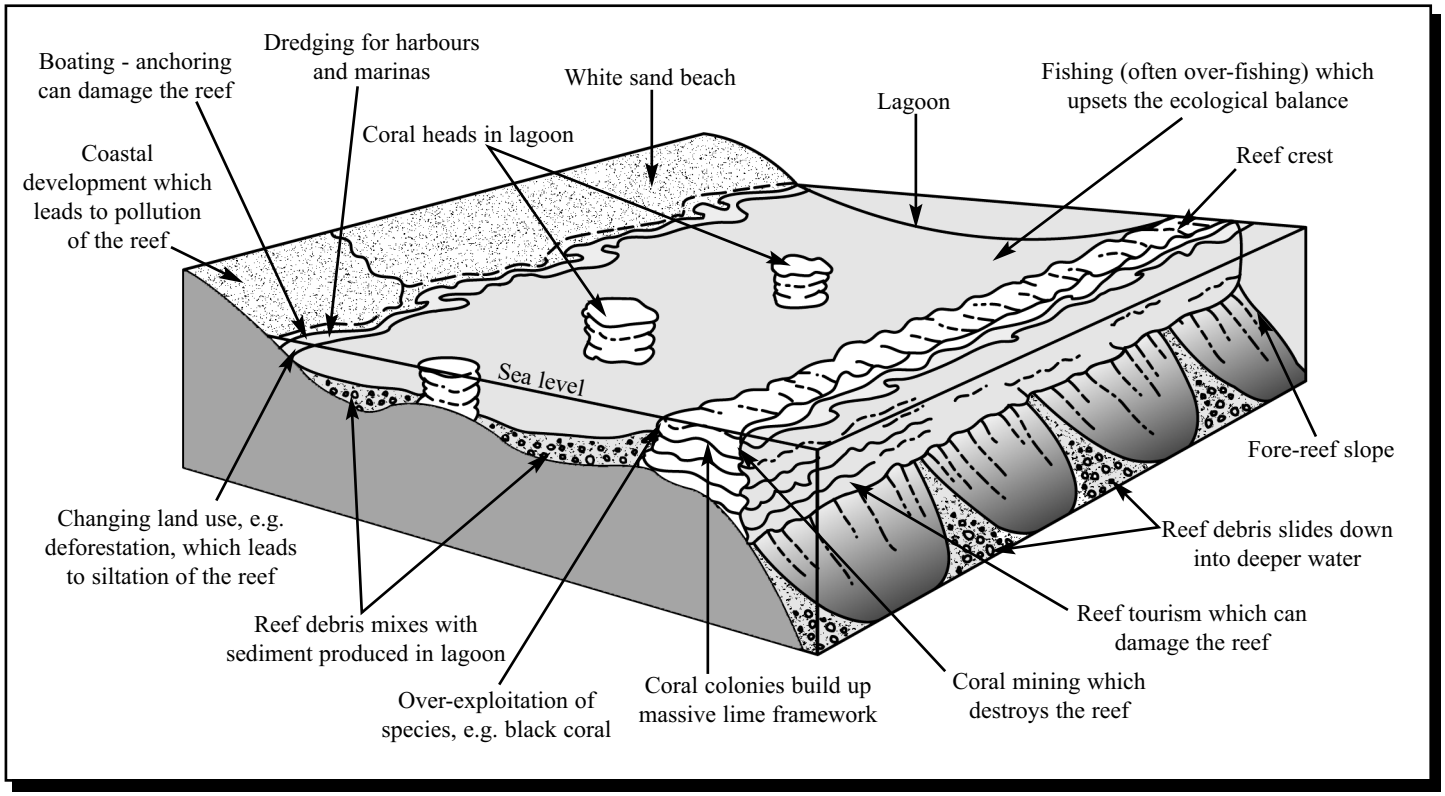
In some reef areas, notably the Great Barrier Reef in Australia, the starfish *Acanthaster* (known as Crown of Thorns) occurs in plagues, and can kill 80-90% of reef building corals.

Why do these plagues occur? Many people argue that enrichment from land run-off enabled huge numbers of these starfish to survive into adulthood, or that over-fishing has killed their natural predators.

Hurricanes can also generate storm waves to reduce coral reefs to rubble, as most reefs are in the hurricane belt (*Fig. 1*). However diseased and stressed reefs can be destroyed and eroded much more easily than healthy reefs. **Tropical storms** and hurricanes bring huge quantities of silt down from the deforested hillsides, as well as making the waters much less salty in localised areas, both factors causing damage to the coral. When Tropical Storm Debbie struck St. Lucia in September 1994, nearly 400mm of rain fell in 10 hours bringing down huge quantities of silt, especially from the bare area caused by the construction of the new West Coast Road from Castries to Soufrière. The Park Rangers had to use marine vacuum cleaners to collect all the silt from the coral!

***Note:** In all cases these natural factors became more damaging because of parallel human causes.*

Fig. 5 Human impacts on the reef



Human causes of reef destruction

Fig. 5 summarises the human activities which impact on coral reefs – some directly and some indirectly. Essentially these are activities which seek to exploit the value of the reef.

The real question is not whether these activities should occur but how they can be managed in a sustainable way, so that the coral reefs are conserved, or that badly damaged reefs can be given a chance to recover. Most recent research suggests that coral reefs can and do recover, especially from acute damage caused by a single event as opposed to less intense but prolonged disturbances (chronic damage).

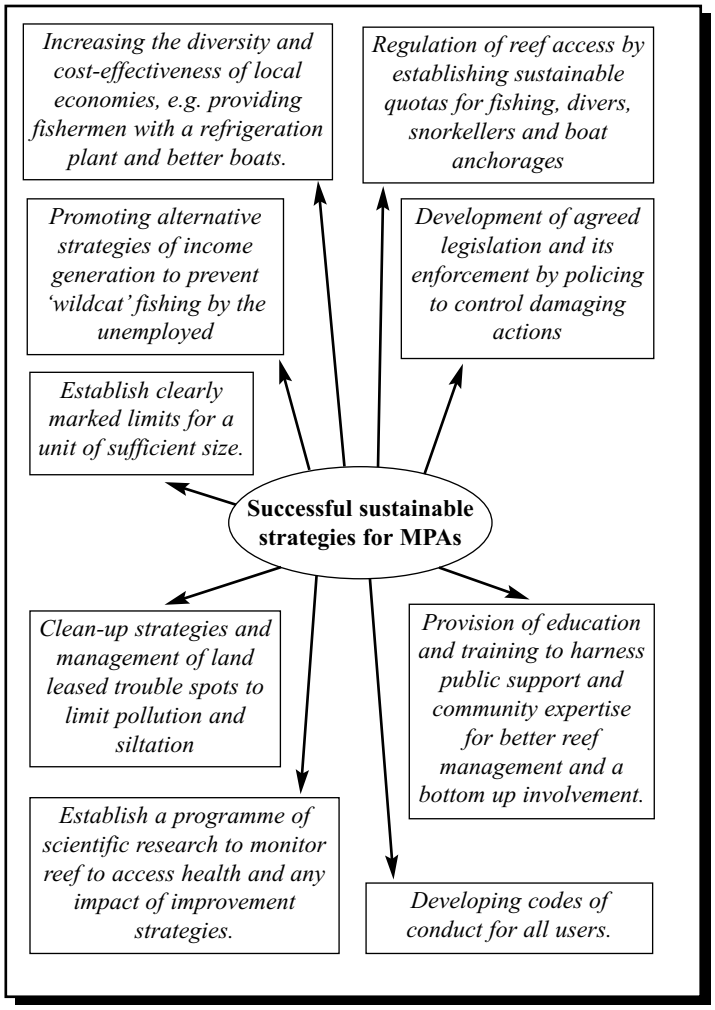
Reefs at risk – the solutions

International Agreements and Initiatives need careful monitoring. For example, as early as 1975 the Convention on International Trade in Endangered Species (CITES) included Black Coral on a list of species in which international trade should be restricted, but as it was such an important source of income via a highly lucrative jewellery trade, many local artisans were unconvinced of the need to control the exploitation to sustainable levels.

Coral reefs have to be seen as part of a wider coastal zone, the integrated management of which requires considerable co-ordination between government departments at a national scale.

The creation and successful development of Marine Protection Areas (MPAs) to conserve reef ecosystems is vital. At present there is no truly global network of MPAs. In 1998 there were nearly 500 marine protection areas in 70 countries, but at least 40 countries had no formal protection for their reefs. Many of the MPAs are small, frequently less than 1km^2 and are 'paper parks' – designated protected areas only by name. Some 60% of MPAs have ineffective or poorly conceived management plans. It is vital, as is the case with the Great Barrier Reef, which is seen as an example of good practice, to balance the conflicting needs of users such as tourists and fisheries yet at the same time to protect biodiversity. You can research SMMA (Soufrière Marine Management area – see the website list – another example of good practice).

Fig. 6 Strategies for the successful development of a Marine Protection Area.



Case study: Management of the Buccoo Reef and Bon Accord Lagoon Complex in South West Tobago

Traditionally use: *fishing, tourism (since 1930s).*

1973: *It was declared a Marine Reserve with restricted access.*

1990: *Management plans developed. Between 1973 and 1990 considerable damage was done to the reef and adjacent seagrass and mangrove areas.*

Causes of damage: *hurricanes, reef operators, tourists, sewage effluent, fertiliser run-off from agricultural holdings, silt from heavy storms*

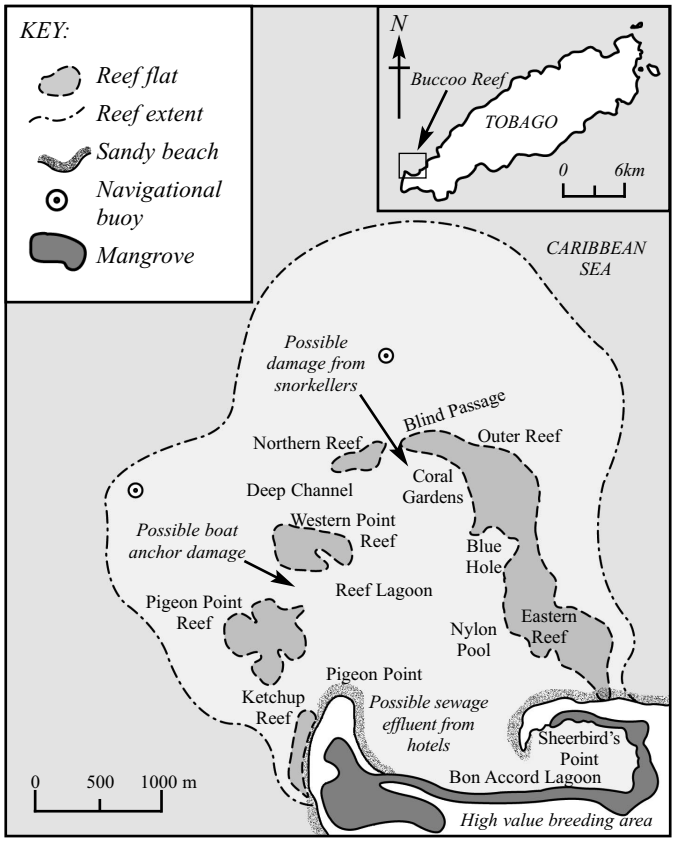
Problems included:

- *the failure to publicise and clearly demarcate the zoning plan of a scuba zone – anchorage area, snorkelling zone and a buffer zone.*
- *the failure to adequately police reef activities which caused damage.*
- *the limited training provided for the staff.*
- *the limited availability of equipment such as patrol boats.*

There was a lack of finance to support all these activities.

Exam Hint: In exam questions it is vital that you use an in-depth case study of a named reef system, e.g. Buccoo. If possible draw a simple sketch map such as the one shown in Fig. 7.

Fig. 7 Annotated sketch map of Buccoo Reef



To summarise, MPAs are created to:

- *prevent further habitat degradation by physical disturbance e.g. divers' feet*
- *prevent natural degradation from water pollution from shoreline development and waste disposal from boats*
- *prevent the overuse of reef resources, balancing exploitation with conservation.*

Exam Hint: Exam questions at AS are usually 1 side of extended writing worth 10 marks for which around 12 minutes of writing time are available.

1. ***'Examine the impact of human activities as <u>one</u> named located ecosystem' is a typical style of question.***
2. ***Draw a simple diagram such as Fig. 7 to locate your named reef.***
3. ***Go back and look at Fig. 4, which would be very appropriate as the main threats at Buccoo are traditional fishing and tourism as well as siltation and pollution. <u>Note</u> use named examples in the case study.***

Further research

A set of fact sheets on coral reefs is available from the Marine Conservation Society, 9 Gloucester Road, Ross on Wye, HR9 5BU.

Two useful books include:
Ecological Issues – the exploitation of Coral Reefs. British Ecological Society, 1996, ISBN 1 851 53 856 9 (available from Field Studies Council).
Coral Reefs - Ecosystem in Crisis? S Warn. Field Studies Council 2001.

Useful websites

Websites are numerous – search using the words *Coral Reef*!
http://www.coral.org/links.html (the Coral Reef Alliance) which gives details of other websites, publications, research etc.
http://www.reefcheck.org provides details of global reef monitoring.
http://www.smma.org.lc provides details of the Soufrière Marine Management area in St. Lucia – a very successful scheme.

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