

Conservation of Coral Reefs

C. M. YONGE

Formerly Scientific Coordinator IBP/PM, Edinburgh, Scotland

The effect of man on the terrestrial fauna and flora of oceanic islands and particularly on coral atolls with their initially very restricted terrestrial life has frequently been devastating. Less is known about the effects on submarine life, particularly on the hermatypic animals and plants responsible for the formation and maintenance of coral reefs. But, as biological agents often directly responsible for the creation of land masses and for their continued existence, they are fundamentally important. It is true to say that the continued maintenance of such land areas depends on the activities of the excessively thin covering of living matter which is responsible, with, in the scleractinian corals, the highly significant aid of symbiotic plant cells (zooxanthellae), for the secretion of the reef framework. If this thin covering of living matter is extensively damaged, calcification must cease and the reef framework begin to disintegrate under the combined erosive action of physical and biological agents.

We are not concerned solely with atolls, i.e., with isolated islands formed exclusively by coral growth, but also with volcanic and continental islands surrounded by fringing reefs and in some of the larger, such as New Caledonia, with off-shore barrier reefs. Both fringing and barrier reefs occur along continental coasts, notably the Great Barrier Reef which stretches for over 1200 miles off the northeast coast of Australia. The presence of these fringing and barrier reefs is often crucial to the protection of adjacent coasts and harbors.

The reef framework is formed largely of hermatypic (i.e., reef-building) corals consisting largely of Scleractinia with a few Hydrozoa and Octocorallia and consolidated on the exposed upper surfaces by coralline algae. This framework with the wide variety of environments it brings into being—on exposed and sheltered sides, on the upper surface or crest, and in crevices within itself—provides the physical basis for a complex ecosystem or series of ecosystems. Both as the builders of the framework and as constituents of the ecosystem, the members of this calcifying fauna and flora exist in a state of easily disturbed balance. Even without any apparent influence by man there are many accounts of apparently degenerating or receding reefs indicating a normally precarious balance.

Stoddart (1968) has provided a valuable account of man's often catastrophic effects on every aspect of the ecology of atolls beginning with the building of airfields and culminating in the events of the Second World War and the subsequent testing of atomic and hydrogen bombs. His paper covers every aspect of atoll ecology,

including the land fauna and flora and the human population and, with its important list of references, should be consulted.

Following in part Stoddart's treatment of the subject, the major man-made hazards to reefs, including the ecosystems of which they are a part, comprise the following.

Geomorphological changes. These are brought about by the construction of major civil or military installations with consequent alterations in submarine topography. Particularly in atolls where the free flow of water into and out of the central lagoon is essential the effects may be devastating with the lagoon becoming a sediment trap and life largely destroyed by lack of oxygen and accumulation of sediment and final production of H_2S . Only previous surveys and consequent planning so that water movements are not impeded can prevent such effects. While damage will inevitably be caused during the period of construction, recovery will take place if the flow of water has not been permanently impeded.

Pollution. With increased population, sewage pollution, can become serious and also industrial and thermal pollution in continental areas such as southern Queensland and off Kingston (Jamaica); Puerto Rico, where petrochemical works have been constructed, and other areas in the Caribbean. Not only may reefs be destroyed by pollution but imbalance produced. Certain organisms may be encouraged. Increased populations of echinoderms and of the green alga, *Enteromorpha*, appear to be associated with sewage contamination. There is some concern about the possible effect of oil pollution should the active prospecting for oil in the sedimentary deposits below the southern end of the Great Barrier Reef prove successful. Pacific islands have also experienced major radio-active pollution.

Mining of coral rock. Ever-increasing demand for lime and, where this occurs with it, phosphate presents a major problem which again has concerned the Great Barrier Reef and is even threatening the Palau Islands. Here also careful survey of the probable effect of mining is essential if living reefs are not to be destroyed either directly or else indirectly by the smothering effect of the sediment produced by such mining.

Dynamiting and poisoning of fish. Although usually officially forbidden, these methods of fishing are widely employed. They result in extensive destruction of the environment and every possible means should be employed to stop their use.

Indiscriminate collection. Over wide regions of the Pacific the more spectacular members of the marine fauna, especially Mollusca but including coral colonies, are being collected by tourists and, more important, by the local population for sale to dealers in such "merchandise". There are warehouses and stores in the Philippines and doubtless elsewhere with immense accumulations of shells obtained from all over the Pacific and Indian Oceans. Crated giant clams (*Tridacna gigas*) are exported all over the world. Reef fishes are extensively collected for the aquarium trade and in certain areas the effect is becoming apparent.

Because the larger and more striking species are so conspicuous they are easily found. At the apex of the food chain in many cases, they are not abundant, indeed often rare, and can be, and probably are being, exterminated in many regions. Apart from the loss of most interesting members of the fauna, there is a disruption in the balance of the ecosystem. It is suspected—although as yet by no means proved—that the great increase in the numbers of the “crown of thorns” starfish, *Acanthaster planci*, (see Goreau, 1963; Barnes and Endean, 1964; Barnes, 1966; Chesher, 1969) along the Great Barrier Reef and also at Guam and elsewhere is due to tourist collections of the conspicuously large trumpet shell, *Charonia tritonia*, which is the only known predator on this starfish. Certainly in areas where it was formerly rare this very large starfish is now excessively common. It spreads over and consumes reef building corals, liquifying the tissues by means of digestive enzymes secreted by the walls of the extruded stomach and is doing enormous damage. Whatever the factor or factors responsible for this population explosion it provides a striking example of the effect of imbalance within the ecosystem.

The speed with which these larger molluscs may be locally exterminated is indicated by the rate at which they disappeared from the reefs around Addu Atoll in the Indian Ocean following the establishment of the R.A.F. staging post on that island (Stoddart, 1968). It is already apparent that amongst the regulations that will have to be made when the research station is established in Aldabra (Indian Ocean) by the Royal Society must be one preventing collection of shells for other than scientific purposes.

Divers. A further danger comes from the destruction of coral reef fishes by divers and underwater fishermen generally. These fishes are highly territorial and the larger ones in particular are very easy to exterminate locally.

Conclusions

Coral reefs are almost certainly by no means as securely based as they may superficially appear to be. All modern reefs have grown to their present form since the last Ice Age and in many cases represent no more than a veneer over the surface of the Pleistocene reefs that were then destroyed. Both the reef framework and the ecosystems are in a state of delicate balance which may be very easily upset with unpredictable results. There is every reason for pressing for the most careful initial surveys before any major engineering, mining or drilling operations are undertaken; for scrutiny of all possible sources of pollution and for the rigorous control of collecting upon the reefs and of the destruction by underwater fishermen of coral reef fishes.

While such measures should be taken as widely as possible the fullest measures of conservation can only be applied in relatively restricted areas with the establishment of marine parks and areas designated as of special scientific interest. Fortunately, this need is beginning to be realized and suitable regulations are now in force in areas where tourism is being developed, such as the Great Barrier Reef of

Australia, the Bahamas and in Kenya, while they are proposed elsewhere.

Literature cited

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