

Management and Conservation Options for Indian Coral Reefs

M.V.M. WAFAR
National Institute of Oceanography
Dona Paula, Goa 403 004, India

Abstract

Coral reefs are the most specialized, diverse and productive of all tropical marine ecosystems. In the recent years, they are being increasingly subjected to exploitation and human interference. These have resulted in degradation of many reefs, and there is a global need for environmental protection of the reefs. This paper, therefore, describes the distribution of coral reefs in the Indian seas, the state of exploitation of their resources, the damages associated with such practices, and the options for management of the reefs. The approaches proposed for management of Indian reefs are: (1) decision on the need for management, (2) preparation of a use and impact analysis chart, to evaluate the type of management approach needed, (3) preparation of management plan by identifying zones for various uses, and formulating control and regulatory measures for extractive and non-extractive uses, (4) implementation of the management plan, and (5) planning for crisis management. These elements of protective management are examined with respect to the Lakshadweep group of islands, taken as an example.

INTRODUCTION

Tropical seas are well known for the greater diversity of fauna and flora, as well as a greater degree of specialization in structure, organization and functioning of their constituent ecosystems. Among the latter, coral reefs command the greatest importance by virtue of their biological productivity, the largest diversity of resident fauna and flora, complexity of trophic organization and finally the resources, both organic and inorganic, that are of direct economic importance. Aesthetically, they are the most beautiful, and constitute the only environment that is as colourful and attractive to a common man as a well managed terrestrial botanical garden or park (Wafar 1988).

Like every ecosystem, coral reefs are subject to damages from natural causes as well as man-made changes wherever the reefs are located close to human settlements and when there is a direct dependence of the local population on reef resources. While instances of extensive natural damages are few and far in between, intentional, but quite often unintentional, destruction of the reefs has been increasing incessantly in the last few decades, directly as a consequence of increase in the rate of exploitation of reef resources. The gravity of the situation is evident from the ever-growing literature on the damages to reefs associated with human activities in, near, and around the reefs, and the concomitant recognition that reefs are more susceptible to such impacts than thought of so far (Salvat 1987). Coupled with a global awareness of environmental protection, however, there is a growing interest in the conservation and protective management of the reefs world-wide, and in fact, several

countries have already proposed and/or implemented various measures and legislations for conservation of the reefs. Such measures, though, cannot have a universal application and instead, must reflect, in each reef area, a balance between the magnitude of the resources, the rate of their exploitation, the extent of the dependence of the local population on reef resources, and of the possibilities of generating a greater revenue from non-destructive uses of reef than by destructive uses. These considerations form the basis of this communication which attempts to discuss the options for conservation of Indian reefs.

REEF FORMATIONS IN INDIAN WATERS

A proper assessment of the reefs – areal coverage, diversity of coral species, resources and the present state of their exploitation – is a pre-requisite for formulation of acceptable conservational measures. In two earlier papers (Wafar 1986, 1988), these have been dealt with in detail, but are summarized here briefly (see also Table 1).

TABLE 1. Summary of major Indian coral reefs, exploited resources and present status

Geographical area	Reef area (km ²)	Number of known coral genera and sub-genera	Potential fish yield (million tons per year)	Exploited resources	Present state of the reefs
Gulf of Mannar	100	26 + 4	0.001-0.0015	Coral blocks, debris, algae, shells	over-exploitation
Gulf of Kutch	1000	20 + 1	0.01-0.015	Coral sands	Overexploited and degraded
Lakshadweep	4200	28 + 9	0.04-0.06	Coral collection	Under-utilized
Andaman	11000	25 + 8	0.11-0.17	Shell collection	-do-
Nicobar	2700	42 + 9	0.03-0.04	Shell collection	-do-

(a) *Palk Bay*: The reef here is of the fringing type, and extends from 79°08' to 79°20' E along 9°17' N. This is one of the few Indian reefs (Fig. 1) where detailed studies on coral and associated fauna and flora, productivity and ecological structure have been carried out. Coral fauna comprises of 63 species under 21 genera. Resources exploited from this reef are shells and souvenir corals, particularly of the ramose type.

(b) *Gulf of Mannar*: Fringing reefs occur around a chain of 20 islands from Tuticorin (8°48' N; 78°9' E) to Shingle island (9°14' N; 79°14' E). Only few of the northern most and southern most islands have been subjected to detailed studies. Coral fauna from 4 northern islands belong to 88 species under 26 genera. Systematics of corals from other reefs are not known. Exploited resources are principally coral blocks and coral debris. Trap and drift-net fishing is also carried out near the islands. Chank and pearl fishing are important activities near the Tuticorin region. Holothurians, marine algae and molluscan shells are harvested in large quantities, almost throughout the year.

(c) *Gulf of Kutch*: Reef formations are fringing or patchy around a chain of islands from Okha to Jodhya. Coral diversity is lowest of all Indian reefs, with only 26 species under 20 genera. Ramose corals are totally absent. Exploited resources are mainly coral sands dredged for use in a cement factory, with an estimated 0.6 to 1 million tonnes removed annually. No other resource appears to be intensively exploited.

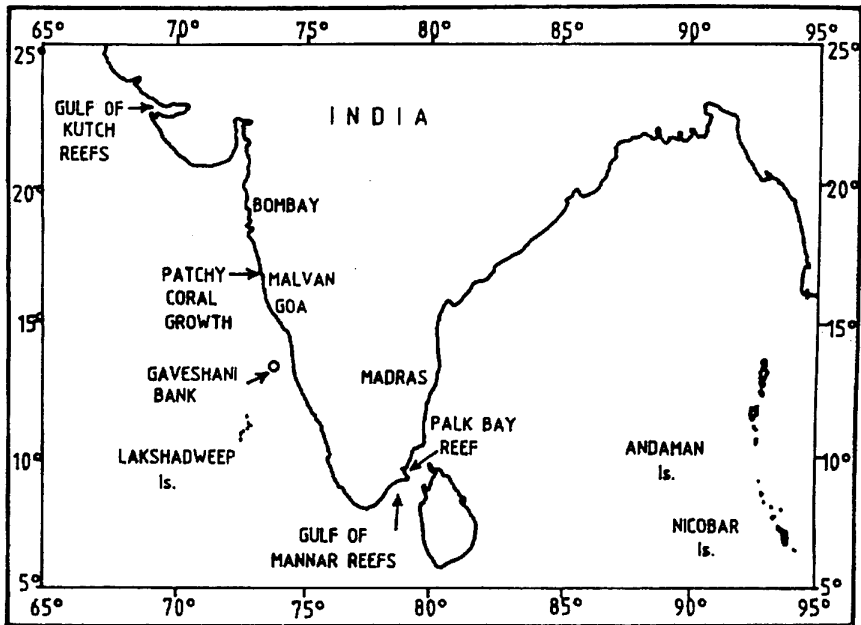


Fig. 1. Locations of occurrence of reef-building corals and reef formations in the Indian seas.

(d) *Lakshadweep islands*: Reef formations ($8-12^{\circ}$ N; $71-74^{\circ}$ E) are mainly atolls, with a low-lying island on the east, a broad, well-developed reef on the west, with a lagoon in between, connected to the open ocean by one or several channels. In addition, 3 reefs, the top of which lie just below mean sea level, and 5 submerged banks (mean depth 40 m), also have living coral cover. The number of coral species known is 70 under 28 genera. These records are limited to Minicoy only, and the actual number of coral species in all islands together may be much higher. No single resource is exploited intensively. However, collection and trade in souvenir corals was a main activity of resource exploitation in Kavaratti atoll until recently. Efforts to develop harvesting of ornamental fishes on a commercial scale are now on.

(e) *Andaman islands*: Reef formations are of fringing type around these islands ($10^{\circ}30' - 14^{\circ}$ N; $92-93^{\circ}$ E). About 70 species of corals under 25 genera are known from these reefs. Exploited resources are principally molluscan shells (*Trochus*, *Turbo*) for use in handicrafts, and ramose corals for souvenir collections.

(f) *Nicobar islands*: These islands ($6^{\circ}30' - 9^{\circ}30'$ N; $93-94^{\circ}$ E) also have vast fringing reefs. A total of 42 coral genera are known from these reefs. As with Andaman reefs, molluscan shells are the main exploited resources.

Isolated occurrences of corals are known from central west coast of India and the submerged banks in the Arabian Sea, but these do not sustain any resource that can be exploited commercially.

DAMAGES CAUSED BY EXTRACTIVE USES

Coral mining

Corals constitute the single, most-intensively exploited resource from the reefs, especially those of Gulf of Mannar and Gulf of Kutch. In Gulf of Mannar, mining of corals is mainly from the eastern and northern shores of the islands which are protected from wave action (Rajendran & David 1969). Quarrying is more intensive along the northern most islands, with an estimated removal of about 25,000 tonnes a year (Pillai 1973), which continued through the eighties (Silas *et al.* 1985). As the mining is done only manually, it is confined to waters less than 1 m deep, and consequently, destruction of live coral cover is great, and occasionally by as much as 100 per cent (Pillai 1973). Similarly, coral mining near Tuticorin results in an annual removal of about 15,000 tonnes of coral blocks and 10,000 tonnes of coral debris (Venkataramanujam *et al.* 1981). Localised removal, at instances, is so great that one or two islets, which were previously emerged, now are fully submerged (Silas *et al.* 1985). Harvesting of other reef resources such as shells, holothurians, seaweeds, and fishing near the reefs have contributed to further degradation of the reefs. These damages are given in detail by Silas *et al.* (1985).

In the Gulf of Kutch, extraction of calcareous sand for use as raw material in a cement factory is the major form of reef resource exploitation. The removal, estimated to be at between 0.6 and 1 million tonnes, has destroyed live coral cover to the extent of 50 per cent (Rashid 1985), mainly through increase in turbidity and deposition of thick layers of silt on corals.

Coral removal in the Andaman, Nicobar and Lakshadweep islands is mainly for local needs, such as building construction or laying of roads, and no commercial industry exists in these islands. However, increased localised exploitation, associated with population pressure, in smaller islands, such as Kavaratti and Minicoy, has led to serious shore erosion.

Shell and coral collection

Collection of molluscan shells for local trade and export is a major activity in the Gulf of Mannar, Andaman and Nicobar islands. In the Gulf of Mannar, in the region of Rameswaram and Tuticorin, shells like cowries, cones, volutes, murices, strombids etc. are collected on a commercial scale, and sold locally or exported. Near Tuticorin, collection of chank shells is as much of economic importance as that of smaller ornamental shells. In Andaman and Nicobar islands, *Turbo* and *Trochus* are the two genera intensively collected, apart from a variety of cowrie shells.

Along the mainland coast, collection of ramose corals for sale to tourists is a lucrative business. Corals of the genera *Acropora* and *Pocillopora* are particularly preferred as they are the most decorative, and fetch a high price. The corals are usually collected from Gulf of Mannar reefs but are sold even at far-away tourist spots like Cape Comorin or Madras.

In the Lakshadweep islands, coral collection was rampant in the last decade, resulting in a total loss of ramose corals from the lagoons of many islands, especially Kavaratti. Sale of corals was through a Government-sponsored handicrafts emporium, but most of the corals were collected to be given away as gifts or souvenirs to visitors from mainland. Now there is a total ban on removal of corals, and this ban appears to be implemented seriously. However, collection and sale of corals continue in the Andaman islands.

Selective removal of ramose corals affects the zonation and creates an imbalance in the ecosystem. For example, the Kavaratti lagoon, abundant with many species of *Pocillopora* and *Acropora*

only 10 years ago, is now totally devoid of these two genera, except for a small patch of *Acropora* in the southern end of the lagoon. Consequently, the rocky substrates within the lagoon are overgrown with algae, thus depriving sites for new coral settlement. Secondly, it deprives the habitat of reef fishes which are associated with these coral colonies; most of these fishes have economic value as ornamental fishes. Thirdly, the reef growth or recovery is seriously reduced, since the ramose forms precipitate calcium at rates several times greater than the massive forms do.

Fishing

Potential food fish yield from coral reefs is in the range of 10-15 tonnes $\text{km}^{-2} \text{yr}^{-1}$, and for the Indian reef areas, including lagoons, coralline shelves and submerged banks, it is about 0.2 million tonnes yr^{-1} (Wafar 1986). Present exploited yield is, though, hardly a fraction of this, and much of it is only for sustenance, the reasons being the uneven topography which precludes use of large gears, and the remoteness of many reef areas. Nevertheless, even artisanal fishing is attendant with serious damage to reefs. For example, in Kiltan, fishing is done by covering corals with small nets and breaking off the branched corals to drive out the resident fishes (Pillai 1988). This is a common practice in many other reef areas also, and the reported scarcity of food fishes may not necessarily be due to over-exploitation, but be due to habitat destruction. Fishing by lines or harpoons is least damaging to the reefs. Destructive procedures of fishing by poisons or dynamite do not exist, since these products are not readily accessible to common fisherman.

Aquarium fishes constitute a potential resource from the reefs. The present import value of world trade in ornamental marine fish and invertebrates is around 20-40 million US\$ (Wood 1985). Commercial exploitation of aquarium fishes from Indian reefs was non-existent until recently, when the Lakshadweep Administration arranged for a survey of stock of aquarium fishes in these islands, and entrusted harvesting of these fishes to commercial collectors. No perceptible damages due to this activity are yet evident, but I can predict at least two major damages. The first will be a large scale habitat destruction — I have seen islanders unconcernedly breaking large ramose colonies to pieces just to get a few small ornamental fishes. Incentive in the form of hard cash from commercial operators will only accelerate this form of habitat destruction. The second will be a tendency to collect only high value and rare fishes, leading to over-exploitation and decimation of some fish stocks.

Scientific collections

Overzealous and uncontrolled collection by students and scientists have caused damages to some reef areas. The best known example is the Kurusadai island in Gulf of Mannar, visited by student groups for the past several decades. Now the reef is practically dead, and it is perhaps the only reef in that region, that is heterotrophic (Balasubramanian & Wafar 1974). Another example is the Pirotan island in the Gulf of Kutch, but now the collections are banned in these two islands. However, the Lakshadweep reefs are becoming open to visits by student groups, and it is only a matter of time before irreparable damage is done. Though there is a ban on coral removal, scientific collections are exempt, but no rules exist to regulate them.

Damages associated with natural causes

Known natural physical causes affecting the reefs are hurricanes, catastrophic low tides, unusually low or high temperatures, etc. among which hurricanes are the most important (Brown & Howard

1985). Among the biological causes, noteworthy is the *Acanthaster planci* infestation, and bacterial infection. None of these, however, has at any time been responsible for serious damage to reefs. *A. planci* has been recorded from Minicoy, but its density (2-3 per km² reef area) is only that of a natural population (Murty *et al.* 1979). Jagtap (1987) recently reported a density of 1.4 *A. planci* per m² from Agathi, but this is an overestimate, since it exceeds the accepted density for outbreak proportions, (Moran 1986), yet no damage to corals has been noticed then or since then.

Damages due to developmental activities

These are of isolated instances. In the Palk Bay reef, effluents from a fish meal plant at Mandapam were responsible for coral bleaching in some parts of the reef. In Gulf of Mannar, there was a progressive disappearance of live coral reefs inside the Tuticorin harbour and surrounding areas due to increased ship movement, oil spillages, and increase in marine based industries (Silas *et al.* 1985). In the high islands of Andamans, widespread deforestation has resulted in soil erosion, washing off sediments by river run-off and massive siltation on the fringing reefs. In Port Blair, Mayabandar and other areas, effluents from timber factories have been responsible for large scale mortality of reef corals (Whitaker, cited in Wells 1988).

Two facts emerge on summing up of the above information. The first is the absence of baseline information on parameters such as diversity, live coral cover etc. that will serve as reference to assess the degradation of a reef, from any of the Indian reefs. The only exception is the transect survey by Pillai (1969) of the Palk Bay reef, but it has not been made use of at all to follow the changes in this reef during the last two decades. The second is the absence of any follow-up studies where damages to reefs have been noticed. In the absence of the latter, it will be neither possible to conclude whether a reported damage is only instantaneous or chronic and evolving, nor plan and enforce appropriate conservation measures.

MANAGEMENT OPTIONS

Options for management of reefs and their resources are several. With respect to extractive uses, they can vary from a restriction on the type of resource exploited and fixing a quota for their exploitation, through regulations of the periods of use and recovery and prohibition of unacceptable extractive procedures, upto the drastic measure of a total ban on all exploitations. With respect to developmental activities, they vary from efforts to minimise the impact of such activities on reef biota to a total ban. As far as non-extractive uses are concerned, the options lie in the regulation of tourist traffic, developmental activities related to a sustenance of tourism, and control of recreational activities on a reef. The applicability of these measures, however, would vary as a function of the health of the reef, level of exploitation, and the degree of economic dependance of the local population on reef resources. The logical steps would therefore be (1) decide whether management is needed; (2) if so, prepare a check-list of uses and impacts; (3) formulate plans for management; (4) suggest measures of implementations, and (5) prepare contingent plans for crisis management. The following discussion covers these aspects with reference to Lakshadweep reefs, taken as an example.

(1) Is management needed? The answer is 'yes' and the reasons are: (a) areal coverage is low, being less than a few percent of Indian reefs area; (b) species diversity is low, with only 28 genera, as against the 50 known from Indian waters and 88 from Indo-Pacific; (c) most of the reefs are already

subject to exploitation and human interference, (d) some are already visibly degraded, and (e) there exists a great potential for shifting from extractive to non-extractive uses without economic loss.

(2) Table 2 provides a check-list of possible uses a reef can be put into, whether these exist in the Lakshadweep reefs, and if so, what is their extent and impact. As is evident, this list covers almost all uses other Indian reefs are, and can be expected to be, subjected to, but is open to addition, should there be any specific local use.

TABLE 2. Check-List of the uses of the Lakshadweep reefs and the nature of the damages

Use category	Existent or not	Level of use	Nature of damages
<i>(A) Living resources</i>			
(1) Commercial fishing within reef area	N.E.		
(2) Commercial fishing in offshore waters	Yes	High	Over-exploitation of live bait fishes from reefs
(3) Subsistence fishing in reef areas	Yes	Moderate	Habitat destruction
(4) Recreational fishing	N.E.		
(5) Commercial coral collection	Yes	High in certain reefs	Live coral cover loss: habitat destruction for aquarium fishes
(6) Commercial shell collection	Yes	Modest	No perceptible damage
(7) Aquarium fish collection	Yes	Infantile	Possible large-scale live coral cover loss: over-exploitation of selected species
(8) Aquaculture	N.E.		
(9) Turtle hunting	Yes	Modest	Damage to recruitment
(10) Bird hunting	Yes		
(11) Plant harvesting-terrestrial	Yes	High	Pollution
(12) Plant harvesting-marine	N.E.		
(13) Other resources	N.E.		
(14) Destructive fishing methods	N.E.		
<i>(B) Non-living resources</i>			
(1) Oil and gas mining	N.E.		
(2) Lime-stone mining	N.E.		
(3) Extraction of construction material	Yes	Moderate to high	Shore erosion; habitat destruction
(4) Other minerals	N.E.		
<i>(C) Developmental activities</i>			
(1) Industries and discharge of effluents	Yes	Low	Pollution
(2) On-shore mining	N.E.		
(3) Dams/river flow modifications	N.E.		
(4) Harbour/Navigational works (dredging, blasting, filling etc)	Yes	Moderate to high	Erosion, topography changes, habitat destruction
(5) Domestic sewage	Yes	Less	No visible damage

TABLE 2. (Contd.)

Use category	Existent or not	Level of use	Nature of damages
(6) Industrial sewage	N.E.		
(7) Reclamation	N.E.		
(8) Solid waste dumping	Yes	Less	Dumping of dredged material on reef kills corals
(9) Research and development	Yes		Recommendations for management
(10) Offshore navigation and oil spills	Yes		Occasional mortalities of reef biota
<i>(D) Non-extractive uses</i>			
(1) Resident tourism	Yes	Modest	No visible damage
(2) Sea-borne tourism	Yes	-do-	-do-
(3) Air-borne tourism	N.E.		
(4) Water sports (SCUBA etc.)	Yes	Localised	No visible damage
(5) Reef walking	Yes	-do-	-do-
(6) Construction activities related to tourism	Yes	modest	-do-

N.E. = Non-existent

Use and impact analysis, thus, is a powerful tool in planning management approaches. For example, in the Lakshadweep islands, a major part of extractive and developmental activities are attendant mainly with habitat destruction whereas non-extractive uses are less developed. This is an ideal situation where a shift can be made to non-extractive uses with more economic gains and low damage to reefs. The simple example is the more employment generation, such as reef guides, small boat operators, diving assistants, gear technicians etc., associated with tourist visits, which manpower would otherwise go to extractive uses with damage to reefs. Already, some small boat operators at Kavaratti realize that towing glass bottom boats for tourists is much more gainful than fishing in the reefs. However, reef exploitation for sustenance cannot totally be banned, and hence a management plan should strike a balance between these two. At this stage, zoning plans, which provide for a number of zones, with defined objectives, for particular users, become indispensable.

(3) A zoning plan seeks to provide for conservation of the environment and for the reasonable use of the reef, and it integrates into the concept of the marine park. Actually, it is a spatial partitioning of the reef for one or multiple uses, consistent with the maintenance of the ecosystem. There is no definite list as to what should be the zones, but the following, adopted from Kenchington & Hudson (1984) and Great Barrier Reef Marine Park Authority's plans, should satisfy all of the user requirements and conservation.

Biological zones: where ecosystems, habitat, processes and genetic diversity are protected.

Species zones: where particular animal and/or plant species is protected.

Sustainable yield harvest zones: where exploitation is allowed at a sustainable level using ecologically-sound methods.

Fisheries management zones: where particular fish stocks are monitored and catch levels are controlled.

Water quality control zones: where potential or existing forms of pollution are closely monitored and controlled.

Tourism management zones: where recreational uses of an area are allowed which are consistent with its carrying capacity.

Scientific research zones: where ecologically-sound research is allowed in relatively undisturbed areas.

Education zones: where instructional activities are permitted for the benefit of students, public and the tourists.

Cultural zones: where cultural activities or monuments are preserved.

Replenishment zones: heavily used area which are closed for all activities to allow depleted fish and other resource stocks to recover.

Reef appreciation zones: small area on heavily used reefs reserved for public appreciation and enjoyment, free from fishing and collecting.

Actual zoning and management would vary with the nature and state of the reef, and on the results of use and impact analysis. For example, an atoll like Kavaratti, already heavily disturbed, needs to have larger conservation and replenishment zones (lagoon and inner reef areas), medium to small size recreation and appreciation zones (reef flat, outer reef slope), and smaller extractive use zones. On the other hand, an atoll like Bitra, least disturbed as it is, can have larger extractive use zones, with smaller ones reserved for monitoring and research.

Adoption of the zoning plan implies a control which is in the form of restrictions on the level of extractive use, quota for harvest, entry and accessibility, etc. Let us examine these with respect to the aquarium fish industry in Lakshadweep which is beginning to develop. The controls required are:

- Marking off the reef areas for this use. This shall not cover more than 10 per cent of the whole reef, so as to provide for other users.
- Licence may be issued to only one operator for each island, considering that the reef area is not greater than a few km² in each case. The permit is subject to the condition that the operator has all infra-structural facilities for holding the aquarium fishes without mortality prior to shipment.
- Permit may be issued to one operator to employ not more than 5 field collectors, a figure that is again related to the size of the reef. This is also subject to the field collectors being instructed properly on the collecting techniques least destructive to the reefs.
- Banning of all destructive fishing methods (poison, dynamite) with provision of penalties for infringements.
- Listing of the species that can be caught, and the quotas for the numbers and size of fish in each species. These are to be determined based on species occurrence and abundance surveys and the biology of individual fishes. As a general rule, upto 40 per cent of the fish can be allowed to be harvested in one season. This figure is tentative, and is based on the consideration that recolonization of the vacant territories by fish from adjacent zones, and new recruitment can easily replenish the stock (Randall 1987).
- Ban on entry of other users in this zone.
- Closure of fishing for any one species when it corresponds with the spawning season of the fish.

(4) Six elements are fundamental to the effective implementation of the management plan (Kenchington & Hudson 1984). These are: training, education, surveillance, enforcement, monitoring and review. The following description defines the objectives of each element, and identifies the authority on whom the responsibility can be vested (These are again with reference to the Lakshadweep).

Training: to ensure that those who must implement the plan understand it and the approaches to achieve it. (Authority: Administrator, Director of Science and Technology cell, Director of Fisheries).

Education: to appraise the users of the area, of the existence of the management plan, and of their rights and responsibilities. (Authority: Director of Science and Technology, Director of Fisheries and the Society for the Promotion of Recreational Tourism, SPORTS).

Surveillance: to monitor the use of the reef and guard against infringements. (Authority: Director of Fisheries, SPORTS).

Enforcement: to follow-up infringements, and prevention of their repetition. (Authority: preferably the marine park staff, if existing, failing which, Director of Fisheries).

Monitoring: to monitor the state of the managed reef, and record the impact of its use. (Authority: Science and Technology cell, in association with National laboratories having the means and expertise for this).

Review: to revise and improve the plan at pre-determined intervals. (Authority: Administrator, Directors of Science and Technology and Fisheries, National laboratories and National agencies concerned with reefs).

(5) A crisis is an event that cannot be precisely anticipated, but its nature can approximately be. With respect to Lakshadweep, it can be a severe storm, cyclone, unusual low/high tides, shipwreck followed by oil or toxic waste spills, marine accident etc. Since such events leave little time for evolving plans to counteract, contingency planning is a must and should form part of any management plan. For example, there was a shipwreck at Kiltan island in 1974, resulting in an oil spill of about 3000 tonnes and causing a severe mortality of corals and other organisms, but there was neither a contingent plan, nor any effort to remove the oil afterwards by any agency (Qasim *et al.* 1974). Thus, crisis management plans, with safety of life and protection of environment and property as immediate priorities, clear lines of responsibility and co-ordination, and provisions for follow-up actions, must be drawn and incorporated in the overall plans.

CONCLUSIONS

The above discussion on management pertains to one reef area only and covers only broad aspects, because exploitation of resources and the consequences vary from one reef area to another, requires a plan to be evolved specifically reflecting the local uses and impacts. Undoubtedly, there will be a lot of finer elements to be taken care of, but this exercise is worth the effort, because there is a growing amount of evidence in India, and elsewhere, that reefs are degrading fast, and unless a management is enforced, there will always be a tendency to look for short term profits from excessive and destructive harvest, disregarding the long-term adverse consequences these may entail.

REFERENCES

- Balasubramanian, T. & M.V.M. Wafar. 1974. Primary productivity of some fringing reefs of south-east India. *Mahasagar-Bulletin of the National Institute of Oceanography* 7: 157-164.
- Brown, B.E. & L.S. Howard. 1985. Assessing the effects of "stress" on reef corals. *Advances in Marine Biology* 22: 1-63.
- Jagtap, T.J. 1987. Distribution of algae, seagrasses and coral communities from Lakshadweep islands, eastern Arabian sea. *Indian Journal of Marine Sciences* 16: 256-260.
- Kenchington, R.A. & B.E.T. Hudson. 1984. *Coral Reef Management Handbook*. UNESCO-ROSTSEA, Jakarta, Indonesia.

- Moran, P.J. 1986. The *Acanthaster* phenomenon. *Oceanography and Marine Biology Annual Review* 24: 379-480.
- Murty, A.V.S., G. Subbaraju, C.S.G. Pillai, V. Josanto, P. Livingston & R. Vasanthakumar. 1979. On the occurrence of *Acanthaster planci* (The crown-of-thorns) at Minicoy atoll. *Marine Fisheries Information Service* (T and E series), Cochin, India 13: 10-12.
- Pillai, C.S.G. 1969. The distribution of corals on a reef at Mandapam (Palk Bay), S. India. *Journal of the Marine Biological Association of India* 11: 62-72.
- Pillai, C.S.G. 1973. Coral resources of India with special reference to Palk Bay and Gulf of Mannar. pp.700-705. In: *Symposium on Living Resources of the Seas Around India*.
- Pillai, C.S.G. 1988. Corals and coral reefs of Lakshadweep. pp. 55-57. In: S.N. Dwivedi & P. Chaturvedi (eds.) *Island Development: Technology options*. IAAS Publication.
- Qasim, S.Z., P.N. Nair & P. Sivasdas. 1974. Oil spill in the Laccadives from the oil tanker "Transhuran". *Mahasagar-Bulletin of the National Institute of Oceanography* 7: 83-89.
- Rajendran, A.D.I. & K. David. 1969. A preliminary under-water survey of the extent of the coral reefs in and around some of the islands in the Gulf of Mannar. pp. 231-238. In: C. Mukundan & C.S.G. Pillai (eds.) *Proceedings of the Symposium on Corals and Coral Reefs*. Marine Biological Association of India.
- Randall, J.E. 1987. Collecting reef fishes for aquaria. pp. 29-39. In: B. Salvat (ed.) *Human Impacts on Coral Reefs: Facts and Recommendations*. Antenne Museum, E.P.H.E., French Polynesia.
- Rashid, M.A. 1985. Gujarat's Gulf of Kutch — A marine paradise. pp. 467-474. In: E.G. Silas (ed.) *Proceedings of the Symposium on Endangered Marine Animals and Marine Parks*. Marine Biological Association of India.
- Salvat, B. (ed). 1987. *Human Impacts on Coral Reefs: Facts and Recommendations*. Antenne Museum E.P.H.E., French Polynesia.
- Silas, E.G., S. Mahadevan & K. Nagappan Nair. 1985. Existing and proposed marine parks and reserves in India — A review. pp. 414-428. In: E.G. Silas (ed.) *Proceedings of the Symposium on Endangered Marine Animals and Marine Parks*. Marine Biological Association of India.
- Venkataramanujam, K., R. Santhanam & N. Sukumaran. 1981. Coral resources of Tuticorin (S. India) and methods of their conservation. *Proceedings of the Fourth International Coral Reef Symposium* 1: 259-262.
- Wafar, M.V.M. 1986. Corals and coral reefs of India. *Proceedings of the Indian Academy of Sciences (Animal Sciences/Plant Sciences) Supplement* 19-43.
- Wafar, M.V.M. 1988. Coral reef ecosystems of the Indian islands. pp.47-54. In: S.N. Dwivedi & P. Chaturvedi (eds.) *Island Development: Technology Options*. IAAS Publication.
- Wells, S. 1988. *Coral Reefs of the World*. Vol. 2. *Indian Ocean, Red Sea and Gulf*. International Union for Conservation of Nature.
- Wood, E. 1985. *Exploitation of Coral Reef Fishes for the Aquarium Trade*. Marine Conservation Society, Ross-on-Wye, Herefordshire, U.K.