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Coral Reefs of Sri Lanka: Review of Their Extent, Condition and Management Status

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Abstract

Sri Lanka, with 17 million people and a coastline of about 1,585 km, has nearshore coral reefs of varying quality along about 2 percent (up to 32 km) of the linear coast. Reefs are mostly of fringing type in nearshore waters or patch reefs on rocky substratum varying distances from the shore on the continental shelf. True coralline reefs are few and most with their general locations known, have been surveyed. The most extensive reefs occur off the northwest and east coast up to and around the Jaffna Peninsula. At two locations along the western coast, offshore barrier reefs of good condition occur as well as on two submerged ridges off the southeast coast (Great and Little Bases). Sixty-five coral genera (171 species) and 35 species of butterflyfish are recorded from Sri Lankan reefs.

Reef condition is generally poor and declining in nearshore waters. The only relatively pristine reefs are offshore patch or barrier type reefs located away from population centers in a few locations. Sedimentation and coral mining are damaging many nearshore reefs while the use of explosives and bottom-set nets in fishing are damaging offshore reefs in specific sites. Impacts from tourist activities are relatively minor except in several popular tourist locations.

Although institutions and laws are sufficient in theory to manage and protect the reefs in Sri Lanka, there is little effective action by authorities in the field. One of two legally protected coral reef areas, Hikkaduwa Marine Sanctuary, is part of a Special Area Management planning and implementation process which is addressing the broad issues surrounding the protection of coral reefs in the sanctuary. This participatory and locally-based management process is a first for Sri Lanka. Bar Reef, the second marine protected area and most pristine in the country, is scheduled for similar management planning in 1995.

Introduction--The Sri Lankan Situation, Past and Present

This paper reviews the extent, condition and management status of coral reefs in Sri Lanka in the context of the larger coastal zone, its resources and management. The various data presented, organized in a manner to highlight management status and needs of coral reefs, is not being reported for the first time. Rather, this paper reviews and analyzes from a new perspective the existing information generally available in Sri Lanka but not in the international literature.

Sri Lanka is a large island located about 40 km off the southeast coast of India in the Indian Ocean. It has a coastline of about 1,585 km, or probably more than 2000 km if the shoreline of lagoons, bays and inlets are added (GSL 1985). The country's land area is 65,610 sq km and is inhabited by about 17 million people. Its maritime area is more than three times larger, with 230,000 sq km within the Exclusive Economic Zone. It is surrounded by a continental shelf covering 31,000 sq km and ranges from 9 to 45 km with an average depth of 66 m (Cooray 1967). There are fringing coral reefs and seagrass beds of varying condition along the southwest, southeast and northeast coasts (Figure 1). About 45 river basin estuaries and 40 lagoons, many of which are lined with mangroves, cover about 160,000 ha (Samarakoon and Pinto 1986). The open coast has over 300 km of beaches and sand dunes used by tourists, fishermen and local residents (GSL, 1985; Lowry and Wickremeratne 1989; Olsen et al 1992).

The coastal region as defined by the 67 Assistant Government Agent divisions with a coastal boundary and referred to by Olsen et al (1992) supports 32 percent of the country's total population on 24 percent of its land area and contains 66 percent of the urban land, 67 percent of the country's industry and 80 percent of the tourism infrastructure. Marine fisheries contribute up to 65 percent of the animal protein consumed by the population. Coastal fisheries classified as within 40 km of the shore constitute over 90 percent of the marine fish production and employ more than 78,000 people (Sadacharan and Lowry 1987). All of Sri Lanka's coral reefs and sea grass beds, within 25 to 30 km from the shore, contribute to fisheries production. More recently, coral reefs have been utilized for the export of ornamental marine organisms and to earn much needed foreign exchange from tourism (Olsen et al 1992; Baldwin 1991).

Environmental conditions of coastal waters around Sri Lanka are suitable for coral reef formation only in areas where high turbidity in the vicinity of river mouths or high wave energy is absent. Consequently, nearshore reefs are not extensive, constituting only about 2 percent (up to 32 km) of the shoreline in linear extent (Swan 1983). The areal extent of nearshore reefs and offshore reefs has not been mapped although the reef locations are generally known.

Traditionally, fishing in coastal and reef areas has been confined to non-destructive methods such as hand lines and beach seines. However, within the past two to three decades reef use has increased tremendously, resulting in severe reef degradation. A major cause is the rapid increase of the population in coastal districts which has demanded more fish production and use of more efficient fishing methods (De Silva 1985a; Olsen et al 1992). Increasing incidence of blast fishing; use of small mesh nets, set nets and non-selective fishing gear on reefs are damaging the habitat and causing overexploitation (ICRMP 1986). Further unregulated collection of ornamental fish and invertebrates have contributed to reef damage and overharvesting of selected organisms (Wood 1986).

Historically, and even at present, reefs have been used for lime production to provide a base material for mortar and plaster in building construction, to improve the soil quality in agriculture and in the ceramic and cement industries (Hale and Kumin 1992). Relic coral rock is mined from inland deposits and from the nearshore reefs. Although coral mining from the sea is illegal, it continues in some areas due to the demand for and high price of lime. Coral mining has caused large scale reef destruction along the south and southwest coast and a few sites in the east have also been heavily mined in the past (Premeratne 1984; Hale and Kumin 1992).

Infestations of Acanthaster planci on reefs in the Gulf of Mannar and near Trincomalee in the east have damaged many patch reefs in the past (De Bruin 1972). Deforestation and poor land use practices have increased the input of suspended material into coastal waters. Impacts on water quality and coral reefs from discharge of untreated waste products from factories, hotels and cities are increasing particularly along the southwest coast of Sri Lanka (De Silva 1985a; De Silva and Rajasuriya 1985; Baldwin 1991).

Reef Research

Coral reefs in Sri Lanka have only been studied by a few researchers during this and last century. Published reports by Ridley (1883), Ortmann (1889), Bourne (1905), Gardiner and Cooper (1907), De Bruin (1972), Mergner and Scheer (1974), Pillai (1972), Salm (1981), Scheer (1984) and Rajasuriya and De Silva (1988) provide species lists and information on the location of reefs. Pillai (1972), for example, recorded a total of 90 species of stony corals divided among 39 genera. The physiographic zonation and ecological conditions of the fringing reefs at Hikkaduwa were studied by Mergner and Scheer (1974) and later Scheer (1984) recorded 40 coral genera for Sri Lanka. More recently Rajasuriya and De Silva (1988) updated the checklist of stony corals which contain a total of 171 species divided among 65 genera of which 64 species and 15 genera were new records for Sri Lanka. The new records were based on research conducted by the National Aquatic Resources Agency (NARA).

Hoffman (1976), De Silva (1981, 1983 and 1985a and b), De Silva and Rajasuriya (1985), Salm (1981) and Ohman et al (1993) discuss the status of reefs in Sri Lanka and in South Asia and their needs for management. An overview of the exploitation of coral reef fishes for the aquarium trade was completed in 1985 by Wood (1986) and the IUCN has published a volume on the conservation status of all marine ecosystems and species (Pernetta 1993) but which has little new data beyond the above references.

In addition, several surveys have been conducted by the Coast Conservation Department (CCD) and the Coastal Resources Management Project on the problems of coral mining and coastal erosion (CCD 1990; ICRMP 1986; Herath 1990; Premeratne 1984; Hale and Kumin 1992).

Types and Locations of Coral Reefs

Reefs within the coastal waters of Sri Lanka are found mainly as nearshore fringing reefs and patch reefs on the continental shelf (Figure 1). They are located mostly on the bathymetric contours formed by changes in sea levels in the past and on consolidated marine substrates. The majority are confined to within the 30 m bathymetric contour. Based on coral cover and composition they can be divided into

three major groups, namely true coral reefs (where underlying substrate is generally not visible), beach rock (where coral growth is superficial and sparse) and rocky habitats. Beach rock is widespread in Sri Lanka and is exposed along the shores in the intertidal zone and also occurs offshore as reefs.

True coralline reefs are few and their exact extent has not been mapped. The main known occurrence of coral formations is shown on Figure 1 based on various surveys by NARA from the northwest to the south coast. Coral reefs occur around the Jaffna Peninsula in the north, from Trincomalee to Kalmunai in the east coast, from Tangalle in the south to Akurala in the southwest. Coral reefs in the northwest are found from Mannar Island southwards to the Kalpitiya Peninsula. At three locations along the western coast (at Vankalai, Silavathurai and Bar Reef), barrier type reefs are present. Corals have also colonized two underwater ridges called the Great and Little Bases off the south eastern coast of the island. Elsewhere, corals provide a superficial cover on reefs of beach rock and rocky sandstone substrates.

Reef system diversity

A high diversity of corals and other reef organisms are recorded for Sri Lanka. A total of 171 species of stony corals divided among 65 genera have been recorded, one species new to the Indian Ocean (Zoopilus echinatus) was discovered on the sandstone reefs at Kandakuliya (De Silva and Rajasuriya 1986). Common reef building corals in Sri Lanka belong to the families of Acroporidae, Faviidae, Poritidae, Pocilloporidae, Agariciidae, Caryophylliidae, Mussidae, Merulinidae and Oculinidae (Rajasuriya and De Silva 1988). Fungid corals are rare in nearshore reefs but are found in depths greater than 15 m. They are common in the northwestern areas. Common soft coral genera are Sarcophyton and Dendronephthya. There are few records for other reef invertebrates common in Sri Lanka except that five species of spiny lobster (Panulirus spp.) are found.

The 35 species of Butterflyfish recorded for Sri Lanka is high by world standards for butterflyfish richness. Nine of these species, recorded as rare in Sri Lankan waters are: Chaetodon unimaculatus, C. bennetti, C. ephippium, C. rafflesi, C. ornatissimus, C. guyotensis, C. semeion, Chelmon rostratus and Parachaetodon ocellatus (Rajasuriya 1993).

Over 300 species of reef and reef associated fish have been identified belonging to 62 families. In addition, offshore patch reefs are frequented by Whale sharks (Rhyncodon typus) and five species of sea turtles (Chelonia mydas, Caretta caretta, Eretmochelys imbricata, Lepidochelys olivacea, and Dermochelys coriacea). Dolphins are also sighted, especially in the northwest area over offshore reefs. Frequently sighted species are Bottlenose dolphins (Tursiops truncatus) and Spinner dolphins (Stenella Longirostris) (Rajasuriya 1991a and b).

Reef Condition and Status

Surveys on substrate cover of the most important reefs of the country have shown that the reefs of best condition are associated with the barrier type reefs off the northwest coast at Kalpitiya (Bar Reef) and on the Little and Great Basses ridges off the southeast coast. Live hermatypic coral cover on these reefs surpasses 50 percent in some areas (Figure 2). Many other nearshore reefs around the country have a low percentage of living coral and high percent of sand or rocky substrate in relation to living substrates (Rajasuriya and De Silva 1988) (Figure 2). Exceptional reefs off the southwest coast occur at Hikkaduwa, Unawatuna Bay and Weligama Bay (Rajasuriya 1991b). Although extensive fringing and true coral reefs occur off the northeast and east coasts, few surveys have been made in the past ten years due to political conflicts. Studies which quantify reef condition beyond basic substrate cover have not been done.

Most coral reefs in Sri Lanka have been severely degraded from human induced damage described in the following section. In addition, coral reefs on the northwest and the east coasts are under threat from periodic infestations of the Crown-of-Thorns starfish (Acanthaster planci).

The status of investigated locations, causes of reef degradation and potential threats are summarized in Table 1.

Human and Natural Impacts on Reefs

The most significant human induced impact on the reefs of Sri Lanka is the increasing amount of sediments pouring into the ocean from erosion due to deforestation, poor agriculture practices and construction. This sediment, when

churned by heavy wave action on the south coast facing the Indian Ocean and moved in longshore currents impact most nearshore coral reefs during at least some parts of the year (Ekaratne 1989; Ohman et al 1993).

A second and possibly equally important impact on reefs stems from the historical and continued coral mining along parts of the south and eastern coastlines (Hale and Kumin 1992; Herath 1990; Simmons 1993). This removal of reef rock from dead and living reefs has removed large areas of reef habitat and caused increasing coastal erosion along those stretches of coast where it is most prevalent. The quantities of coral collected for lime production in 1984 from living and dead reefs is shown in Table 2. This problem has not been easy to address because of the economic benefits accruing to the more than 5,000 people on the south coast directly or indirectly employed by coral mining and processing. Coral miners can earn up to \$US100 per month, a wage significantly higher than most other employment opportunities available to such people with little education in most coastal areas (Hale and Kumin 1992).

In addition to these large scale impacts, reefs are utilized for a variety of commercial purposes. Because most reefs are easily accessible, common uses are fishing, collection of live marine organisms for the aquarium industry and for tourism. In 1985, about 25,000 to 30,000 boxes of ornamental marine fish and invertebrates were exported valued at about \$US2 million. Fishing with explosives, use of indiscriminate nets and hand collection while diving are increasingly common in areas where law enforcement is not a threat. Corals within reef lagoons are often damaged due to boat anchoring and the discharge of waste oil into the sea from fishing or tourist boats. Glass bottom boats used for viewing corals contribute to reef damage within the Hikkaduwa Marine Sanctuary (De Silva and Rajasuriya 1985; Nakatani et al 1994).

Coastal waters in Sri Lanka are the main dumping ground for solid wastes and sewage from cities, towns, hotels and industries located in the coastal areas. A cottage industry on the south that produces coconut fiber products requires calm back waters of fringing reefs to season the fiber. This activity reduces the oxygen present in the water causing pollution.

Natural impacts on reefs are primarily related to high wave action at certain times of the year on the south, southeast and southwest coasts. Infestation of the Crown-of-Thorns starfish has caused considerable damage to the reefs in the northwestern and eastern coasts (De Bruin 1972; De silva 1985a). A summary of all human and natural factors causing impacts on coral reefs in Sri Lanka is shown in Table 3.

Laws and Institutions Governing Coral Reef Management

In Sri Lanka there are numerous government departments, agencies and authorities functioning under different ministries that control activities within coastal areas. The government institutions responsible for the development, management and conservation of resources within the coastal zone, the marine environment and with specific jurisdiction over coral reef resources are shown in Table 4.

Legislation which directly controls the management of coral reefs is the Coast Conservation Act No. 57 of 1981, its amendment of 1988 and the national Coastal Zone Management Plan it authorizes; the National Environmental Act No. 47 of 1980 and its amendment of 1988; the Fauna and Flora Protection Ordinance No. 2 of 1937 and its amendments of 1937, 1938, 1970 and 1972; Fisheries Ordinance No. 24 of 1940 and amended in 1973; and the National Aquatic Resources Research and Development Agency Act No. 54 of 1981 (CCD 1990).

Protected Areas and Management Efforts

Protection of the marine environment for sustainable development has been a stated national policy and priority since the creation of NARA and CCD in the early 1980s. Environmental problems were first addressed in specific terms in the Coastal Zone Management Plan (CCD 1990) approved by the Cabinet of Ministers and by the National Environmental Action Plan of 1991 under the coordination of the Central Environmental Authority. In addition, a more recent policy document, Coastal 2000: A Resource Management Strategy for Sri Lanka's Coastal Region (Olsen et al, 1992), has been accepted by the government as a guide for management of coastal resources in the country. This document calls for a decentralized and participatory approach to management of resources including coral reefs.

Although an Inter-Ministerial Committee formed by NARA in the early 1980's identified more than 20 marine and coastal sites around the island to be declared as reserves or sanctuaries, only two which contain coral reefs are legally protected. These sites are the Hikkaduwa Marine Sanctuary (declared in 1979) on the southwest coast and the Bar Reef Marine Sanctuary (1992), off the northwest coast. They have been declared as marine sanctuaries under the Fauna and Flora Protection Ordinance of the Department of Wild Life Conservation. However, these sanctuaries are declarations only since sanctuary regulations have proved difficult to implement. Unregulated fishing and other prohibited activities such as collection of marine organisms for export continue within the sanctuaries. Lack of proper enforcement strategies, staff to enforce the sanctuary regulations, adequate funds and concerted public awareness programs are some of the major constraints in the implementation of the marine sanctuaries.

In 1992, the Hikkaduwa Sanctuary became the focus of an intensive Special Area Management (SAM) project which is addressing, through participatory planning and implementation, the contributing causes of deterioration of the sanctuary coral reef. This SAM process is an experiment for Sri Lanka which, if successful, can later be applied in other coral reef areas of the country (White and Samarakoon 1994).

Efforts to stop coral mining, for example, through law enforcement, have been partially successful but appear to not be a permanent solution to the problem. Coast Conservation officials have tried to educate police to increase enforcement, have passed amendments to the Coast Conservation Act allowing for confiscation of equipment used in coral mining, have offered relocation of miners to new development areas inland and have considered several other initiatives ranging from simple regulation to more comprehensive economic development activities. Although coral mining has been reduced somewhat in the major mining areas, the larger socioeconomic context in which poor people need income from readily available limestone is beyond the scope of simple enforcement actions or local development alternatives organized by government authorities.

Discussion and Recommendations for Management

Although rigorous research on the coral reefs of Sri Lanka has not been undertaken, it is apparent that the current status of reefs in the country is not good. It is also clear that research in the near future should focus on management action and community involvement rather than narrow baseline studies which are not integrated and linked with conservation problems and their solutions (White et al 1994). This is evidenced by the continuing impacts of human related activities which are degrading reefs in Sri Lanka at an ever increasing rate (Ohman et al 1993).

Coral mining, which seems to present a continuous challenge to management authorities, will require a larger, more comprehensive and development oriented solution. Although many efforts have been made to improve enforcement, to educate communities and officials and to look beyond simple approaches, coral mining continues and in more covert ways than in the past. It is becoming apparent that short of strict and vigilant enforcement, the only other alternative is a comprehensive and integrated approach to management of coastal resources which includes developing substantial and real economic alternatives which compete favorably with the benefits currently derived from coral mining.

Since many of the coral reefs along the nearshore areas of Sri Lanka are being degraded by various impacts beyond the immediate control of government or nongovernment organizations, it is suggested that efforts to protect and manage coral reef resources be focused on those areas where conditions are still conducive to success. The following recommendations are put forth with the intention of directing future management efforts towards more productive outcomes:

1. The legally declared marine sanctuaries of Hikkaduwa and Bar Reef, and the proposed sanctuaries of Unawatuna and Great and Little Basses (recommended by NARA) should be given prime consideration for active management which embodies the collaboration of national and local government with active participation of the community user groups of the area. This can build on the Special Area Management approach started in 1992 in Hikkaduwa (White and Samarakoon 1994). Traditional law enforcement will not work in these areas as has been shown in the past.

2. Coral mining needs to be addressed through a comprehensive economic program which removes the market for limestone. This can be accomplished by making inland limestone more accessible to the present coral miners and by allowing some imports of cement to supplement the market (Herath 1990; Hale and Kumin 1992). In addition, viable economic alternatives in the immediate coastal zone need to be developed along with the disincentive of improved law enforcement.
3. The increasing incidence of physically destructive fishing methods such as use of explosives can be dealt with through education campaigns against such practices and improved law enforcement as a deterrent.
4. A standardized and expanded coral reef monitoring and documentation program to be implemented under the guidance of NARA with collaboration of Universities and NGOs interested in coastal conservation is needed to provide current information on the status of the resource and its management.

Table 1. Reef location, status and cause of damage or threat (for undegraded sites)

Location*	Status	Causes of Damage or Threats
Bar Reef	Undegraded	Destructive fishing, Crown of Thorns star fish, ornamental fish collection, boat anchors
Kandakuliya	Heavily degraded	Destructive fishing, boat anchors, ornamental fish collection
Talawila	Degraded	Destructive fishing, boat anchors, ornamental fish collection
Chilaw	Partially degraded	Destructive fishing
Negombo	Degraded	Destructive fishing, sedimentation
Colombo	Degraded	Destructive fishing, pollution, silt, ornamental fish collection
Ambalangoda	Degraded	Destructive fishing, sedimentation
Akurala	Degraded	Coral mining, destructive fishing
Hikkaduwa	Degraded	Boat anchors, glass bottom boats, pollution, siltation, ornamental fish collection, reef walking, oil
Galle	Degraded	Destructive fishing, ornamental fish collection, blast fishing, pollution, oil, sedimentation
Unawatuna	Partially degraded	Ornamental fish collection, boat anchors, pollution, reef walking
Weligama	Degraded	Ornamental fish collection, boat anchors, oil from boats, silt
Polhena	Degraded	Pollution due to coconut fibre seasoning, ornamental fish collection, sedimentation
Tangalle	Partially degraded	Ornamental fish collection, reef walking, destructive fishing
Great & Little Basses	Undegraded	Unregulated fishing and diving for spiny lobsters, destructive fishing
Batticaloa & Trincomalee	Partially degraded	Destructive fishing, ornamental fish collection, coral mining, Crown of Thorns, boat anchors

* Locations shown on Figures 1 and 2. (De Silva 1985a; Rajasuriya and De Silva 1988; Rajasuriya 1991 a and b; Ohman et al 1993)

Table 2. Coral collected for lime production from Sri Lanka's southwestern coastal area in 1984

LOCATION OF CORAL COLLECTED	AMOUNT (tons)	TOTAL HARVEST (percent of total)
Relic reefs on land		
* inland of the coastal zone	7,532	42
* within the coastal zone	2,868	16
Coral rubble on the beach		
* within the coastal zone	5,377	30
Live coral at sea, from the reef		
* within the coastal zone	2,282	12
TOTAL	18,059	100

Source: Hale and Kumin 1992.

Table 3. Human and natural factors impacting reefs in Sri Lanka and their relative importance and extent

FACTORS	RELATIVE IMPORTANCE (1 high to 5 low)	EXTENT
HUMAN CAUSED		
Sedimentation from poor landuse practices and construction	1	Pervasive in nearshore areas
Coral mining in beach and marine waters	1	Many sites on southwest coast
Destructive fishing methods		
Blast fishing	2	Site specific
Bottom set nets	2	in many areas
Tourism related activities		
Boat anchors	4	Few sites
Collection by tourists	5	Few sites
Pollution		
Oil from boats	3	Pervasive near harbors
Seasoning of coconut fiber	4	Few areas
Collection of ornamental fish and reef organisms	2	Many reefs
NATURAL CAUSED		
Crown of Thorns starfish	3	Localized in a few reef areas
Wave action from storms	4	Southeast, south and southwest

Sources: ICRMP, 1986; De Silva, 1985a; Nakatani et al 1994; Ohman et al 1993.

Table 4. Principal government agencies with authority and jurisdiction in Sri Lanka's coastal zone*

Responsibilities of key agencies are summarized as follows:

**** Coast Conservation Department (CCD):** Planning, development and regulatory jurisdiction from 2 km seaward to 300 meters landward, with extended authority where inland waterbodies meet the sea. Responsible for building shoreline protection structures. Issues permits for coastal development activities on the basis of their location, impact on the coastal zone and applicable policies of the CZM Plan.

**** Central Environmental Authority (CEA):** Principal coordinating agency for environment-related activities. Establishes national environmental standards. Responsible for coordinating the National Environmental Action Plan, and overseeing Sri Lanka's environmental impact assessment process.

**** Ministry of Fisheries and Aquatic Resources:** Management authority over fishery resources and the development of the fishery industry.

**** Department of Wildlife Conservation (DWLC):** Manages national parks and protected areas, responsible for endangered species and trade in wildlife including marine areas and species.

**** National Aquatic Resources Agency (NARA):** National research agency for all aquatic resources and management thereof.

Urban Development Authority (UDA): Planning and regulatory authority over building specifications within one kilometer of the coastline.

Ceylon Tourist Board: Planning authority for tourist facilities and development.

Ceylon Fisheries Harbors Corporation: Responsible for fishery harbor development.

Ports Authority: Supervises port development and management.

National Drainage and Water Supply Board: Responsible for drinking water and sewer facilities.

* There are thirty-two government agencies that have jurisdiction over coastal areas and resources in Sri Lanka.

** Those agencies with direct authority over coral reef resources management or with research interest (NARA)

Source: Adapted from Hale and Kumin (1992)

References

- Baldwin, M. (ed.) 1991. Natural Resources of Sri Lanka, Conditions and Trends. Report prepared for the Natural Resources, Energy and Science authority of Sri Lanka, sponsored by the United States Assistance for International Development, Colombo, 290 pp.
- Bourne, G.C. 1905. Report on solitary corals collected by Professor Herdman, at Ceylon in 1902. Rep. Govt. Ceylon Pearl Oyster Fish. Gulf Mannar (Suppl.), 29: 187-242.
- Coastal Conservation Department (CCD) 1990. Coastal Zone Management Plan. CCD and Coastal Resources Management Project of the University of Rhode Island, Colombo, pp. 81.
- Cooray, P.G. 1967. An introduction to the geology of Ceylon. Spolia Zeylanica, 31:1-324.
- De Bruin, G.H.P. 1972. The 'Crown of Thorns' starfish Acanthaster planci (Linne) in Ceylon. Bull. Fish. Res. Station, Sri Lanka (Ceylon), 23 (1 and 2): 37-41.
- De Silva, M.W.R.N. 1981. Status of coral reefs of Sri Lanka, Singapore and Malaysia. Coral Reef Newsletter International Union for the Conservation of Nature, 3:34-37.
- De Silva, M.W.R.N. 1983. Status of South-Asia Coral Reef Resources, Utilization and Problems of Management, Report prepared for ESCAP/UN.
- De Silva, M.W.R.N. 1985a. Status of the Coral Reefs of Sri Lanka, Proceedings of the Fifth International Coral Reef Congress, Tahiti, Vol 6, p. 515-518.
- De Silva, M.W.R.N. 1985b. A Strategy for the Rational Management of Coral Reefs, Proc. Symp. Endangered Marine Animals and Marine Parks, Vol. 1: 440-447
- De Silva, M.W.R.N. and A. Rajasuriya 1985. Management plans for the proposed marine park at Hikkaduwa. Paper presented at 41st Annual Sessions of Sri Lanka Association for Advancement of Science, 9-13 December, Colombo.
- De Silva, M.W.R.N. and A. Rajasuriya 1986. Geographical extension of the range of the Fungid coral genus Zoopilus to the Indian Ocean. 42nd Annual Session Sri Lanka Association for the Advancement of Science, Report.
- De Silva, M.W.R.N. and A. Rajasuriya 1989. Collection of marine invertebrates of Sri Lanka (Phase I) Tangalle to Kalpitiya as part of the zoological survey of Sri Lanka. Report of survey supported by the Natural Resources Energy and Science Authority (NARESA) of Sri Lanka and the Swedish Agency for Research Cooperation with Developing Countries (SAREC) with NARA, Colombo.
- Ekaratne, S.U.K. 1989. Status of Sri Lankan Coral Reefs. Report for workshop to establish funding priorities for management of biologically diverse ecosystems, Bangkok, Thailand, Dept. of Zoology, University of Colombo, Sri Lanka.
- Gardiner and Cooper 1907. Description of the Percy Sladen Trust Expedition to the Indian Ocean in 1905. Trans. Linn. Soc. London (Zoology), 12, 1-155, 111-175.
- Government of Sri Lanka (GSL) 1985. Second Interim Report of the Land Commission.

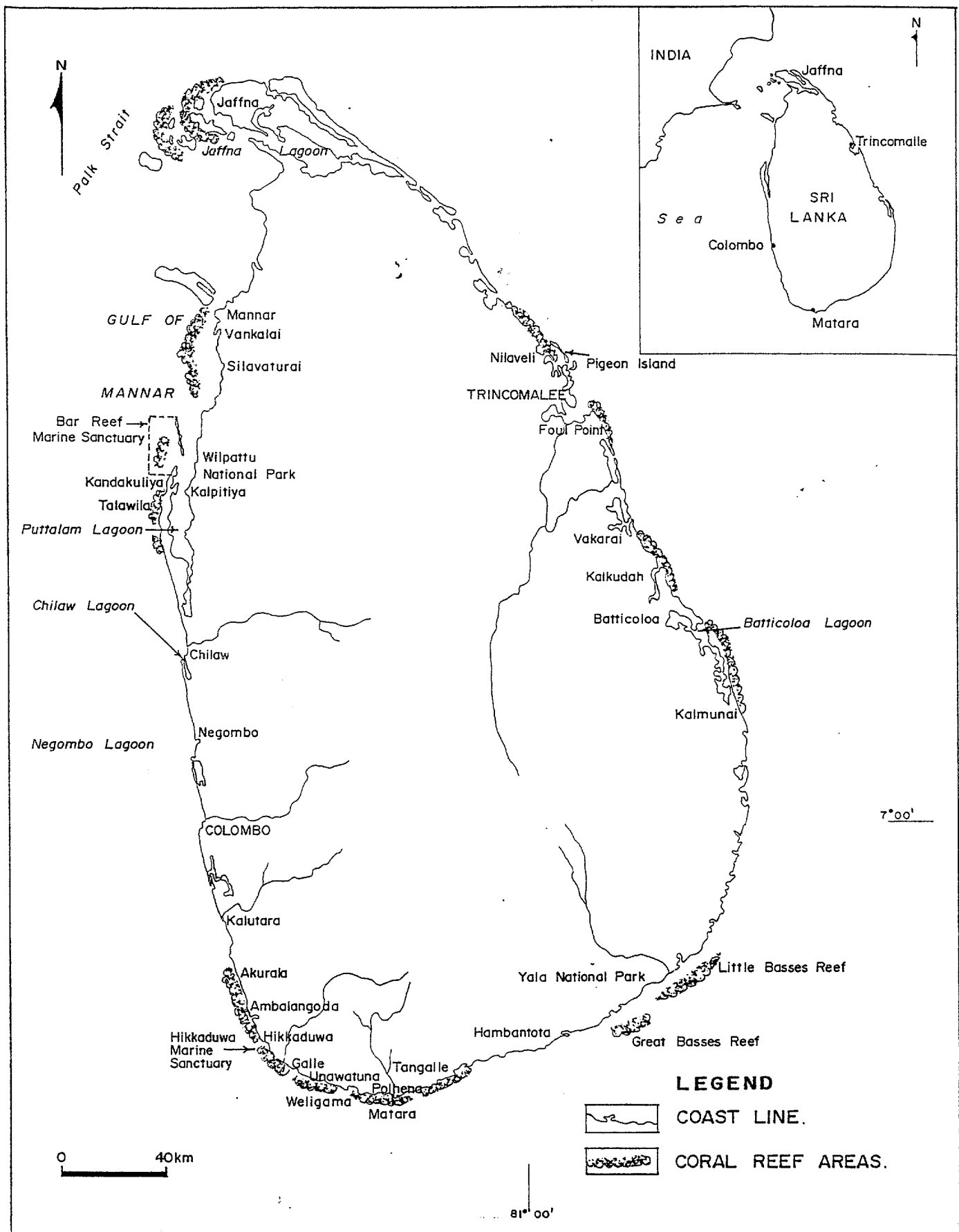
- Hale, L.Z. and E. Kumin 1992. Implementing a Coastal Resources Management Policy, The Case of Prohibiting Coral Mining in Sri Lanka. Coastal Resources Center, The University of Rhode Island, 30 pp.
- Herath, J.W. 1990. The coral and shell industry of Sri Lanka. Sri Lanka German Technical Cooperation and Coast Conservation Department, Colombo, 43 pp.
- Hoffmann, T.W. 1976. Coral exploitation on the East Coast. Multiple illegal activities. Loris 16:94-96.
- International Coastal Resources Management Project (ICRMP) 1986. The Management of Coastal Habitats in Sri Lanka. Report of a workshop at the Sri Lanka Foundation Institute, May 12-15, 36 pp.
- Lowry K. and H.J.M. Wickremeratne 1989. Coastal Area Management in Sri Lanka, Ocean Yearbook 7, p. 263-293.
- Mergner, H. and Scheer, G. 1974. The physiographic zonation and ecological conditions of some South Indian and Ceylon coral reefs. Proceedings of the 2nd International Coral Reef Symposium, Brisbane, Australia, (2):3-30.
- Nakatani, K., Rajasuriya, A., Premaratne, A. and A.T. White (eds.) 1994. The Coastal Environmental Profile of Hikkaduwa, Sri Lanka. Coastal Resources Management Project, Colombo, Sri Lanka 70 p.
- Ohman, M., Rajasuriya, A., and O. Linden 1993. Human Disturbances on Coral Reefs in Sri Lanka: A Case Study. AMBIO Vol. 22, No. 7, November, pp. 474-480.
- Olsen, S., Sadacharan, D., Samarakoon, J.I., White, A.T., Wickremeratne, H.J.M., and M.S. Wijeratne 1992. Coastal 2000: A Resource Management Strategy for Sri Lanka's Coastal Region, Volumes 1 and 2. Coastal Resources Management Project and CCD, Sri Lanka, pp. 81 and 21.
- Ortmann, A. 1889. Boebachtungen an Steinkorallen von der Sudkuste Ceylons. Zool Jb., (syst.), 4(3): 493-590.
- Pernetta, J.C. 1993. Marine Protected Area Needs in the South Asian seas Region Volume 5: Sri Lanka, IUCN, Switzerland, 67 pp.
- Pillai. C.S.G. 1972. Stony corals of the seas around India. Proceedings of the First International Symposium on Corals and Coral Reefs, p. 191-216.
- Premaratne, A. 1984. Socioeconomic survey of those engaged in the coral mining industry in the southwestern coastal zone from Ambalangoda to Dikwella. Coast Conservation Department, Colombo.
- Rajasuriya, A. 1991a. Survey of Coral Reefs off Kalpitiya Peninsula, Report from the Swedish Agency for Research Cooperation with Developing Countries (SAREC) and the National Aquatic Resources Agency (NARA) Marine Science Project. NARA, Colombo.
- Rajasuriya, A. 1991 b. Locations and condition of reefs along Sri Lanka's coast. Proceedings Seminar on Causes of Coastal Erosion in Sri Lanka, pp. 203-210.

- Rajasuriya, A. 1993. Distribution of Butterflyfish (Family Chaetodontidae) on Reefs in the West Coast of Sri Lanka. Paper presented at the Annual Scientific Sessions, National Aquatic Resources Agency.
- Rajasuriya, A. and M.W.R.N. de Silva 1988. Stony Corals of Fringing Reefs of the Western, South-western and Southern Coasts of Sri Lanka. Proceedings of the 6th International Coral Reef Symposium, Australia, Vol. 3, p. 287-296.
- Ridley, S.O. 1883. The coral faunas of Ceylon with descriptions of new species. Ann. Mag. Natural History, 11(6): 250-262.
- Sadacharan D. and K. Lowry 1987. Managing Coastal Fisheries Conflicts in Sri Lanka, Paper delivered at Coastal Zone '87, Seattle.
- Salm, R.V. 1981. Coastal Resources of Sri Lanka, India and Pakistan: Description, Use and Management. In. U.S. Fish and Wildlife Service, pp. 250.
- Samarakoon, J.I. and L. Pinto 1986. Synthesis report for information on coastal habitats in Sri Lanka, CCD, Colombo.
- Scheer, G. 1984. The distribution of reef-corals in the Indian Ocean with a historical review of its investigation. Deep Sea Research, 31 (6-8): 885-900.
- Simmons, M. 1993. Mining is Ravaging the Indian Ocean's Coral Reefs, New York Times, August 8, Section 1, p. 3.
- Swan, B. 1983. The Coastal Geomorphology of Sri Lanka--an Introduction. University of New England, Armidale, New South Wales. Dept. of Geography. Research Series in Applied Geography and the National Museum of Sri Lanka.
- White, A.T. and J.I. Samarakoon 1994. Special Area Management for Coastal Resources: A First for Sri Lanka. Coastal Management in Tropical Asia, No. 2 (March), pp. 20-24, Colombo.
- White, A.T., Hale, L.Z., Renard, Y. and L. Cortesi (eds) 1994. Collaborative and Community-Based Management of Coral Reefs. Lessons from Experience, 130 p., Kumarian Press, Inc., USA.
- Wood, E. 1986. Exploitation of Coral Reef Fishes for the Aquarium Trade, Report prepared for the Marine Conservation Society, U.K., sponsored by the World Wildlife Fund U.K., 118 pp.

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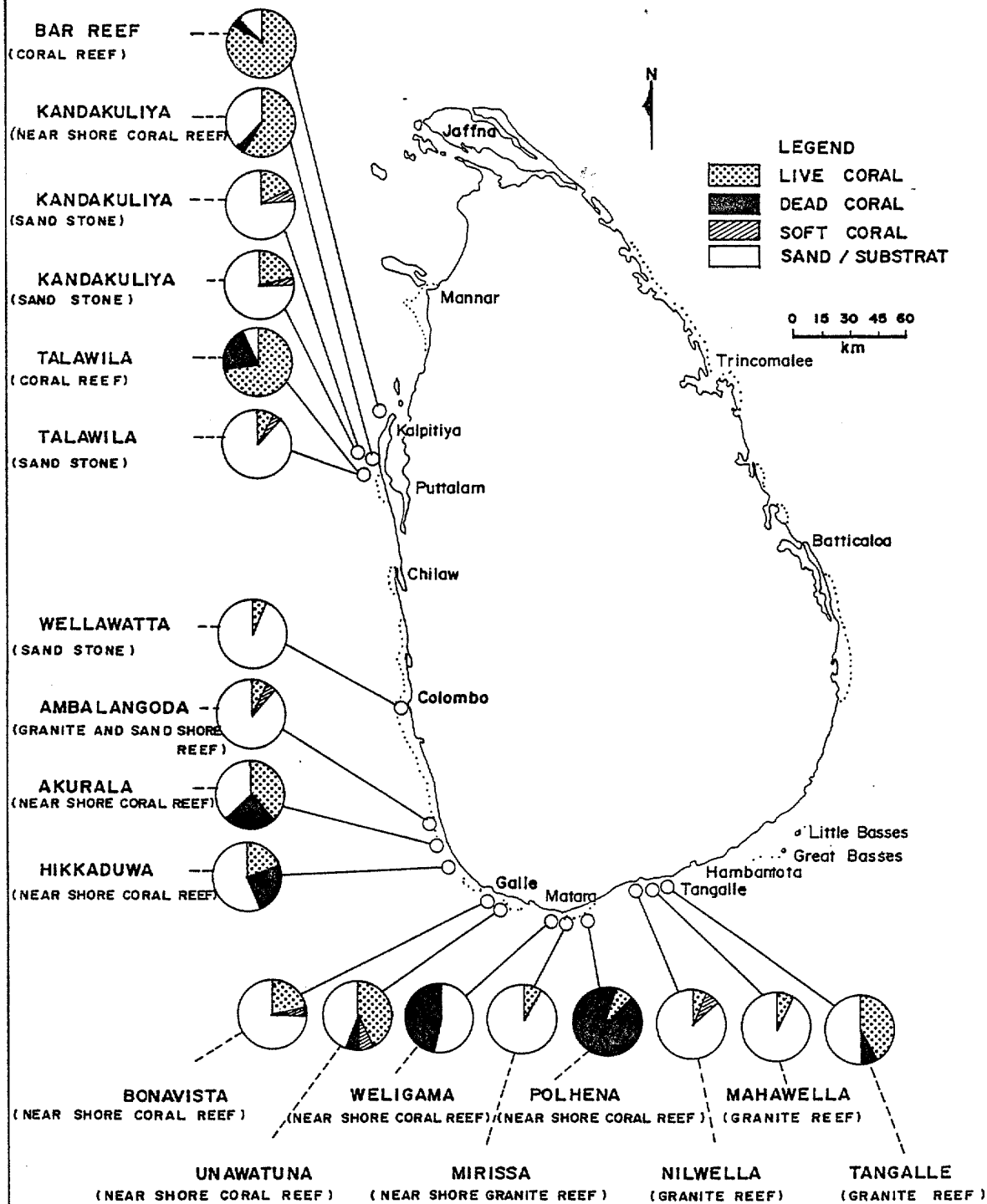
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Figure 1. Important recorded coral reef locations in Sri Lanka surveyed by NARA



Source: NARA

Figure 2. Percent substrate cover of coral reef sites investigated by NARA along the Sri Lankan coast.



Source : NARA, De Silva and Rajasuriya (1989)
Rajasuriya (1991a and b)