Title

Report on the Survey of Coastal Reefs

Subtitle

Report on the Coral Reef Studies
North-western Coastal and Offshore Waters

SAREC Marine Science Programme
Contract No: SAREC/CE -02 /03

(extended through SAREC/CE-07)

Coral Reef Research Programme

National Aquatic Resources Agency
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Title of Project: Survey of Coastal Reefs

Institute where research was carried out: National Aquatic Resources Agency

Chief scientific investigator and co-investigators: Arjan Rajasuriya, Dr. Olof Linden.

Period : 1991 to 1995

No. of Research assistants/Technical assistants

Research Assistant
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Participation of personnel from Sweden

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Dr. Ron Johnstone, Stockholm University
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Mr. Carl Wachtmeister, Stockholm University

Description of research carried out (summary)

This study was conducted by the National Aquatic Resources Agency from 1991 to 1995 with the aim of investigating the biota and the status of coastal and offshore reefs along the northwestern coast of Sri Lanka. One of the aims of the study was to developing a management plan for coral reefs in the north-western coastal waters. Three locations, Bar Reef, Kandakuliya, Talawila were selected for the study as these locations include extensive coral and sandstone reefs. Mampuri located south of Talawila was surveyed in 1994.

Results of the studies have been reported by Rajasuriya, (1993), Öhman et al. (1993, 1997), Rajasuriya et al (1995) and Rajasuriya, Ohman and Johnstone (in press). Scientific investigations under this project led to the creation of the Bar Reef Marine Sanctuary which is the second and the largest marine protected area in Sri Lanka. Twelve species and three genera of stony corals were added as new records of stony corals for Sri Lanka. A new species of Damsel Fish to science was collected and described from the Kandakuliya reef.

Papers published in international journals

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Rajasuriya, A., De Silva, M.W.R.N., and Ohman, M.C. 1995. Coral Reefs of Sri Lanka: Human Disturbance and Management Issues. Ambio, Vol. 24, No. 7-8, pp. 428 - 437.

Rajasuriya, A. and White, A.T. 1995. Coral Reefs of Sri Lanka: Review of Their Extent, Condition and Management Status. Coastal Management, Vol. 23, pp. 77 -90

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Öhman, M., Rajasuriya, A and Olafsson, E. 1997. Coral Reef Fish assemblages in the north western Sri Lanka, distribution patterns and influences of fishing practises. Environmental Biology of Fishes, Vol. 49, 45 - 61.

Papers accepted for publication (in press)

Rajasuriya, A., Ohman, M.C. and Johnstone, R. Coral and Sandstone reef habitats in north-western Sri Lanka; patterns in the distribution of coral communities. (Hydrobiologia).

Ohman, M.C. and Rajasuriya, A. Relationship between habitat structure and fish assemblages on coral and sandstone reefs. (Environmental Biology of Fishes).

Papers presented at conferences and seminars

Rajasuriya, A. 1993. Present Status of Coral Reefs in Sri Lanka, pp. 410-416, Proc. of the colloquium on Global Aspects of Coral Reefs, Health, Hazards and History, 420p., University of Miami, USA.

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Rajasuriya, A. 1994. Three Genera and Twelve Species of Stony Corals New to Sri Lanka (Abs.). Paper presented at the 2nd Annual Scientific Sessions of the National Aquatic Resources Agency.

White, A.T., Fouda, M. M. and Rajasuriya, A. 1997. Status of Coral Reefs in South Asia, Indian Ocean and Middle East Seas (Red Sea and Persian Gulf). Proc. 8th International Coral Reef Symposium, 1: 301 - 306.

Reports

Rajasuriya, A. 1990. Protection of the Bar Reef from Further Degradation: Declaration of a Marine Sanctuary. NARA report to Department of Wild Life Conservation. National Aquatic Resources Agency (NARA), Sri Lanka.

Documentary

A video film was produced on the *Coral Reefs of Sri Lanka and Their Management Issues* through this project.

INTRODUCTION

Northwestern coastal waters of Sri Lanka contain the most extensive coral reef habitats in the country (White and Rajasuriya, 1995). Early scientific investigations on corals and coral reefs in the northwestern waters had been carried out at the turn of the century by Professor Herdmann (Bourne 1902). More recently, Swan (1983) reported on the occurrence of large coral formations in the northwestern coastal waters of Sri Lanka. Subsequent investigations revealed that these large coral formations are located at Vankalai, Silavathurai, Arippu and the Bar Reef along the Sri Lankan coast of the Gulf of Mannar (Rajasuriya, 1993). Several less extensive coral patches occur at Kandakuliya and Talawila (Rajasuriya et al., 1995). De Silva and Rajasuriya (1989) reported on the status of coral reefs at Kandakuliya and Talawila based on a survey carried out by them 1985 - 1986.

This study was conducted by the National Aquatic Resources Agency from 1991 to 1995. The primary aim was to investigate inshore and offshore reefs along the northwestern coast to determine the types of habitats, the biota, their status and to develop a management plan for coral reefs in the north-western coastal waters. Three locations, namely the Bar Reef, Kandakuliya and Talawila were selected for the study as these locations include extensive coral and sandstone reefs. Mampuri was later included in the surveys during 1994. Although more extensive coral formations occur at Silavathurai, Vankalai and Arippu, these could not be investigated due to the ongoing conflicts in the area.

Results of the surveys and investigations were reported by Öhman et al. (1993, 1996); Rajasuriya et al (1995); Rajasuriya and White,(1995); Rajasuriya (1993); Öhman and Rajasuriya (in press); Rajasuriya, Öhman and Johnstone (in press). The scientific investigations under this study also led to the creation of the largest marine protected area in Sri Lanka at the Bar Reef in 1992.

METHODS

Study sites

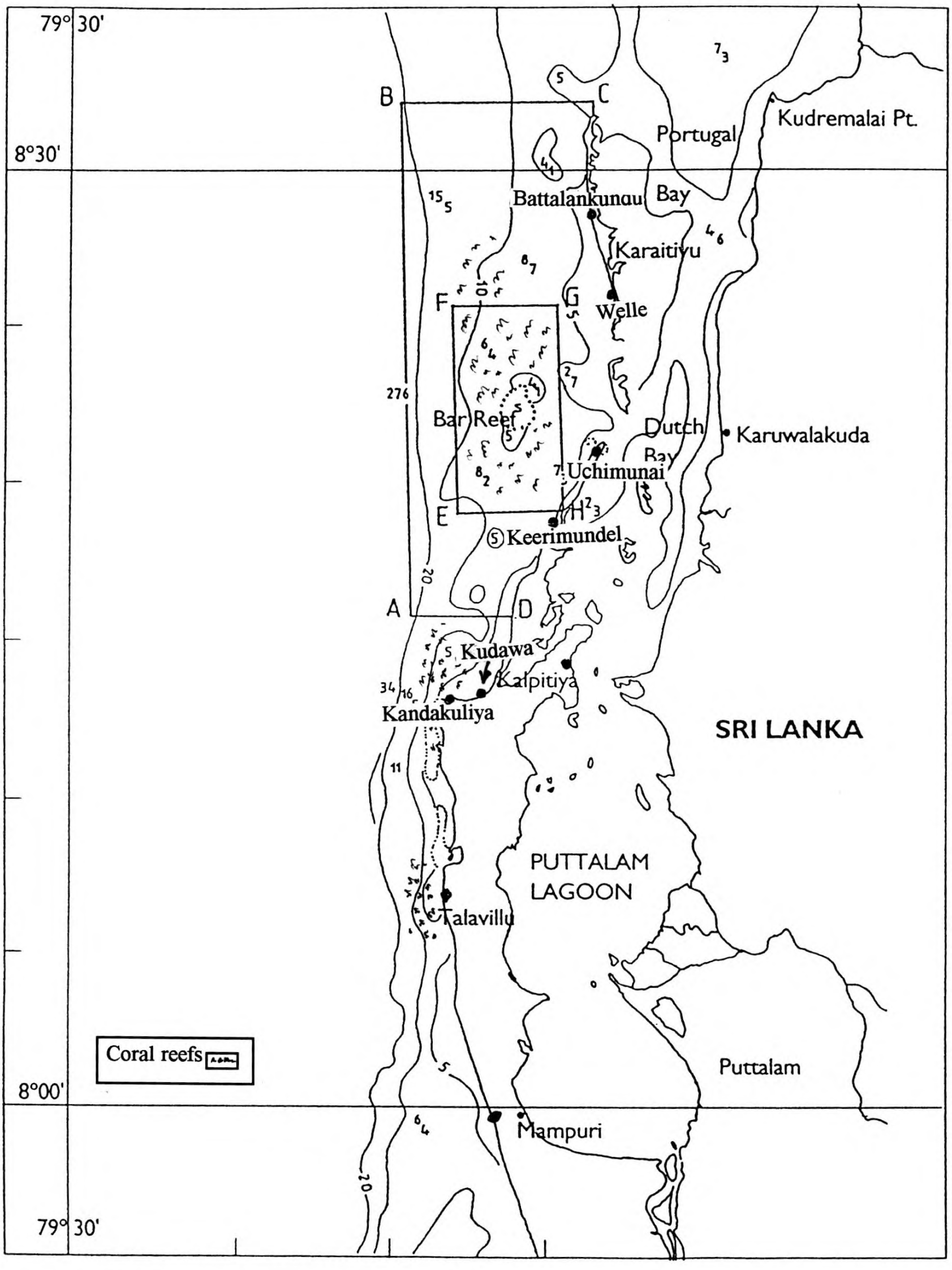
The study sites were located in the northwestern coastal and offshore waters. They included the Bar Reef, Kandakuliya reef, Talawila reef and Mampuri reef (Fig.1). All of the reefs studied were continental shelf patch reefs of coral and sandstone (Öhman et al. 1993, 1997; Rajasuriya et al. 1995). Their distribution was irregular and were located at varying distances from the shore. Coral reef habitats in the study area occur offshore at Bar Reef and nearshore at Kandakuliya and Talawila. Surveys did not reveal any significant coral outcrops at Mampuri. Sandstone reefs were common at all locations within the entire study area. The furthest sandstone reef habitats from the shore were located at an approximate distance of 12 km offshore and at a depth of 32m. Most of these formations are the predominant substrate for the formation of coral reefs (Rajasuriya et al., 1995).

Survey methods

A visual survey using the Manta Tow Technique was conducted initially at the study sites by towing a snorkel diver behind the boat (Done, et al. 1982, and Kenchington, 1978). This technique was used in order to survey large areas within a relatively short period. Rapid visual surveys were also conducted using scuba diving equipment which provided information on the locations of individual patch reefs, different habitat types and on the general status of reefs.

It was apparent from the initial surveys that coral reef habitats and sandstone reef habitats could be further separated into distinct habitats based on their structure. These were characterized as the Shallow Reef Flat (SRF), Shallow Patch Reef (SPR), Deep Reef Flat (DRF), Porites Dome Habitat (POD) for the coral reefs and as the Structured Sandstone Reef (SSR) and Flat Sandstone Reef (FSR) for the sandstone reefs. A third category was identified among the coral reef habitats at kandakuliya as the Disturbed Shallow Reef (DSR) where large scale damage has occurred as a result of human activities.

Figure 1 Map showing the Bar Reef Marine Sanctuary. ABDC = buffer zone; EFGH = core area.



Thereafter these habitats were investigated in detail using the Line Intercept Transect Technique (Marsh, et al. 1984., English, et al. 1994). According to this technique a 50 m fiberglass tape was laid at randomly selected points within each predetermined habitat type. Different components of the substrate that intercepted the tape were measured to the nearest centimeter and recorded on an underwater slate. Substrate components thus recorded included live and dead coral cover, coral rubble, soft coral, sponges, algae, sand and sandstone. The structural complexity (changes in depth as a result of topographical variations) of each transect was measured as the extra length required to cover the 50 m transect by laying a weighted line under the stretched tape that followed the contour of the reef. In addition the depth and the changes of bottom profile was measured for each metre on the transect line. Positions of the Line Intercept transects were recorded by using a hand held position fixing unit (Geographical Positioning System).

Abundance and diversity of fish around each transect was recorded within an area of 500 m^2 (5 m on either side of the 50 m transect line) (English, et al. 1994). Other invertebrates were also recorded within the transect area. In addition special emphasis was given to record the abundance of *Acanthaster planci* and other organisms that are known to affect the health of a reef system. A total of 53 transects were studied from the Bar Reef to Talawila from 1991 to 1992. Results were reported by Ohman, Rajasuriya and Linden (1993). A further 83 Intercept Line Transects were studied in 1993 and 1994 within the Bar Reef Marine Sanctuary and at Kandakuliya. Results from the studies in 1993 and 1994 are reported by Ohman, Rajasuriya and Olafsson (1997); Ohman and Rajasuriya (in press) and by Rajasuriya, Ohman and Johnstone (in press).

In order to determine the distribution patterns of reef fish and the influences of fishing practices 135 species of reef fish and species groups in 19 families were counted within the transects. Based on published material and field observations they were divided into eight broad trophic categories determined by their preferred feeding habits. This information was correlated with habitat information to determine the relationships of modified habitat structures due to fishing and reef fish assemblages (Ohman, Rajasuriya and Olafsson, 1997).

All corals and fish species were identified to the generic level and to the specific level where possible. Corals that could not be reliably identified in the field were collected for identification in the laboratory. Other invertebrates were also recorded in a similar manner.

The reef studies were complemented with information collected from fishermen, fisheries cooperative societies as well as ornamental fish collectors in the area. The coastline was also examined for the effect of natural phenomena such as coast erosion and the impact of human activities such as garbage disposal, construction etc.

RESULTS

Ecological factors

The north-western coastal area has a tropical equatorial climate with a relatively uniform temperature (30° to 34° C) and seasonal rainfall depending on the southwest and northeast monsoons. The marine environment is influenced mainly by the southwest monsoon from May to September. Comparatively the influence of the northeast monsoon (November and December) is less than that of the southwest monsoon. Surface current patterns vary throughout the year, northerly currents prevail from February to mid-November whilst southerly currents are common from mid-November to late January. Nearshore circulation may not follow the above patterns due to localised effects as a result of reef formation and other coastal processes. Seasonal changes along the coastline was also observed, mainly at kandakuliya and north of kandakuliya where changes appear to be natural seasonal occurrences.

Swan (1983) has pointed out that the coastline at Kandakuliya and northwards along the Kalpitiya Peninsula is generally unstable. The erosion at Kandakuliya has now buried part of the fringing reef that existed in the 1985 when Rajasuriya and De Silva survyed the area in 1989. Water clarity is also dependent on the south-west monsoon when the visibility is generally low (< 5m) due to wave action and sediment input through several rivers (Deduru Oya, Kala Oya and Aruvi Aru) in the area. The water clarity, however, is high (> 20 m) during the non-monsoon period (November to April).

Site Descriptions

Bar Reef

Bar Reef is a group of patch reefs located approximately between 2 and 8 km offshore (Fig. 1). It has two major habitat types namely, coral reef habitats and sandstone habitats. Relatively large coral reef habitats occur in three groups, namely the eastern group central group and the northwestern group. Their approximate distances from the shore were 2, 6 and 8 km respectively. Sandy areas with small scattered coral colonies were present between the larger patch reefs. All coral reef habitats were limited to shallow water where the maximum depth is about 10 m. Coral patches varied in size from a few metres to more than a couple of hundred metres across, many were joined together to form much larger complex patterns. The coral habitats were characterized as the Shallow Reef Flat (SRF), Shallow Patch Reef (SPR), Deep Reef Flat (DRF) and the Porites Dome Habitat (POD).

The sandstone habitats were found from a depth of 10 m to more than 30 m and were widespread in the study area. Sandstone habitats were categorized as the Structured Sandstone Reefs (SSR) and the Flat Sandstone Reefs (FSR). The SSR occurred as a discontinuous band 5 to 10 m in width with a relatively high relief up to 4 m. The FSR was characterized by having depressions about 1 m in depth and 3 to 5 m in diameter that were approximately 10 m apart. These depressions harboured large moray eels and groupers together with cleaner shrimps (*Lysmata amboinensis* and *L. debelius*).

Coral reef habitats were dominated by both large and small monospecific stands of *Acropora, Montipora* and *Echinopora*. The sandstone habitats and intermediate habitats of sandstone and coral supported low coral cover but was high in species diversity compared to coral habitats. Common coral genera at such habitats were *Acropora, Montipora, Echinopora, Pocillopora, Porites, Goniopora, Goniastrea, Platygyra, Leptoria, Favia, Favites, Montastrea, Oulophyllia, Fungia, Cycloseris, Hydnophora* and *Turbinaria.* A total of 125 species of stony corals divided among 54 genera have been recorded for the Bar Reef (Table 10).

Diversity of fish and other organisms was very high at the Bar Reef. A total of nearly 300 species of reef and reef associated species belonging to 51 families were recorded. The more abundant species groups belong to the families of Acanthuridae, Pomacentridae, Caesionidae, Labridae, Scaridae, Siganidae and Haemulidae. Other species that are relatively common belong to the families of Serranidae, Lutjanidae, Mullidae, Lethrinidae, Carangidae, Sphyraenidae, Clupeidae, Chaetodontidae, Pomacanthidae, Gobiidae, Blennidae, Balistidae and Nemipteridae. A total of 34 species of butterfly fish (Chaetodontidae) and seven species of angelfish (Pomacanthidae) have been recorded. *Chaetodon semeion* (Dotted Butterfly fish) which is known only from the Bar Reef is probably the rarest butterfly fish in Sri Lanka. In addition several species of rare butterfly fish (*Chaetodon bennetti, C. unimaculatus, C. rafflesi C. triangulum*) have been recorded. Spiny lobsters are also an important resource, three species (*Palinurus versicolor, P ornatus* and *P pencillatus*) have been recorded for Bar Reef.

In the shallow coral areas of Bar Reef the live coral cover was about 80 % (Fig.2) while the average number of coral genera per transect was only 2 (Fig.3). Coral rubble covered about 4% (Fig.4) on average per transect, while the topographic relief was about 7 m per 50 m of transect. The average number of fish per transect was 31 including 8 species of butterfly fish. A resident school of about six Black tip reef sharks (*Carcharinus melanopterus*) were present among the shallow coral patches. White tip sharks were rare (*Triaenodon obesus*) and a few sightings were recorded during the surveys.

Upto 1993 the Bar Reef was in excellent condition and the average live coral cover was about 80% in the coral areas (Ohman, et al., 1993). Subsequent investigations in 1993 and 1994 revealed that sections of the reef has been severely affected by the Crown of Thorns Starfish (*Acanthaster planci*) infestations (Rajasuriya. De Silva and Öhman, 1995). The density of the starfish populations were very high where a maximum number of 39 specimens were counted within 500 m^2 during investigations in 1994 (Rajasuriya and Rathnapriya, 1994).

Kandakuliya Reef

Kandakuliya and Kudawa (Kandakuliya North) fishing villages are situated about 15 km. south of the Bar Reef. Kandakuliya is the larger of the two villages and is densely populated. A fringing reef occur nearshore about 500 m south of the village.

This reef extends towards the sea in a north-westerly direction and joins a shallow coral reef about one to two kilometers away in front of the Kudawa fishing village situated about 700 m north of Kandakuliya (Fig.1). Both the nearshore reef south of Kandakuliya and the shallow reef in front of Kudawa are dominated by corals belonging to Acroporidae, Poritidae and Faviidae families. Seawards of the shallow coral reef is an extensive sandstone reef. Structurally these sandstone reefs are similar to the sandstone substrates at the Bar Reef and occur as discontinuous bands approximately parallel to the shoreline.
The relief of the reef varies from less than a meter in some areas up to 3 m, where a large underwater ridge occurs at a depth of 18 m (4 km offshore) in front of the Kandakuliya village.

The following habitat types were identified at Kandakuliya. The Shallow Reef Flat (SRF), Structured Sandstone Reef (SSR), Flat Sandstone Reef (FSR) and the Disturbed Shallow Reef (DSR) where considerably large areas have been damaged due to destructive fishing practises (Ohman et al. 1993).

Coral species diversity was higher on Kandakuliya reefs than at the Bar Reef. The nearshore reef and the shallow coral reefs were dominated by corals of the Family Acroporidae, Poritidae and Faviidae. *Pocillopora damicornis* and *Pocillopora verrucosa* were the other dominant species in the shallow areas. *Montipora aequituberculata* and *Montipora digitata* were also present. Deeper sections of the coral reef and the sandstone reefs supported a much greater species diversity. The dominant species belong to the families of Faviidae, Dendrophylliidae, Poritidae, Fungiidae, Mussidae, Siderastreidae, Pectiniidae and Merulinidae. One hundred and eight species of hard corals divided among 51 genera have been identified at Kandakuliya.

Live coral cover at Kandakuliya was found to be only about 22% (Fig.2) during the studies from 1990 to 1992. This was attributed to the damage caused by bottom-set nets to catch spiny lobsters and reef fish (Ohman et al, 1993). The same area surveyed in 1985 by Rajasuriya and De Silva, reported that the live coral cover was as high as 75% (Rajasuriya and De Silva, 1988). In some patch reefs the amount of coral rubble was very high (upto 80%), however, the average percentage of coral rubble per transect was about 20% (Fig.4). Regeneration of coral colonies in damaged areas was visible during surveys in 1994 and the early colonizers were *Pocillopora damicornis, Pocillopora verrucosa, Acropora hyacinthus* and *Galaxea fascicularis.*

On average 8 coral genera were recorded per transect (Fig.3) and the mean number of fish was 27 per transect. An average of 2 species of butterfly fish were recorded per transect. The fish species diversity and abundance was low at Kandakuliya, compared to Bar Reef. The common species belonged to the families of Serranidae, Lutjanidae, Acanthuridae, Haemulidae, Lethrinidae, Carangidae, Mullidae, Caesionidae and Sphyraenidae. The topographic relief was 6 m for 50 m of transect line.

Although *Acanthaster planci* was not sighted in the shallow areas, a few were recorded from the sandstone ridges at a depth of 15 to 20 m. Densities within an area of 500 m^2 varied from 1 to 5.

An area of about 100 m² consisting only of *Diaseris fragilis* (Fungiidae) was found at a depth range of 18 to 21 m at Kandakuliya. This is the only location where an aggregation of Fungid corals have been found in Sri Lanka. A species of damselfish (*Chrysiptera kuiteri*) new to science was collected and described from the deep sandstone reefs of Kandakuliya (Allen and Rajasuriya, 1995).

Talawila Reef

The Talawila reef is located about 500 m from the shore and from the fishing village at Talawila. The dominant families of coral were Faviidae, Poritidae and Oculinidae. Small patches of branching and tabulate *Acropora* was present towards the northern section of the reef. A total of 90 species divided among 43 genera have been listed for Talawila.

Reef habitat types at Talawila were the Shallow Reef Flat (SRF), Structured Sandstone Reefs (SSR) and Flat Sandstone Reef (FSR). The Talawila reef supports a live coral cover of about 59% per transect (Fig.2) (Ohman, et al, 1993). The soft coral averaged about 2% while the mean fish species richness per transect was 29 including 4 species of butterfly fish. The average number of coral genera was 11 (Fig.3) and the topographic relief was 8 m.. Coral rubble at this site was less than 1% per transect (Fig.4). Although bottom set nets have been used extensively on the Talawila reef, the damage caused to the reef structure was relatively low due to the fact that the predominant types of coral belonged to the massive growth forms where net entanglement is relatively low. However damage to the northern section of the reef was visible where the dominant coral genera were *Acropora* and *Pocillopora*. A sandstone reef similar to the Kandakuliya sandstone reef exists in the deeper areas although the relief was much lower (1 to 2 m). The Crown of Thorns starfish (*Acanthaster planci*) was not recorded at the Talawila reef.

Mampuri

The fishing village of Mampuri is located south of Talawila (Fig 1). In size the fishing village was comparable to the kandakuliya fishing village where most of the dwellings were semi-permanent and was put up only during the non-monsoon periods. The sea conditions at Mampuri was very similar to Kandakuliya and Talawila. The reefs were sandstone with a superficial live coral cover. The dominant habitat was the Structured Sandstone Reef (SSR). Structural complexity of the high sandstone ridges found in the deep zones of the Bar Reef and Kandakuliya (at a depth of 20 to 25 m) were found much closer to the shore (about 1 to 2 km offshore) at Mampuri. The relief was up to 3 m and the sandstone ridges contained many cracks and grottoes. The deeper areas (15 m and beyond) consisted of flat sandstone reefs. The diversity of hard corals was high although large coral patches were not found in the area. The diversity of hard corals were 78 species divided into 44 genera.

Coral genera recorded for Mampuri were *Favia, Favites, Platygyra, Goniastera, Turbinaria, Acropora, Montipora* and *Echinophyllia*. Live coral cover was 1% to 5% at the depth range of 5 to 12 m. In the deeper areas live coral cover was less than 1%.

Fish were abundant in several sections of the reef where the relief was high (average 3 m), but the abundance was low in other sections. The common reef fish species belonged to the families of Caesionidae (Fusiliers), Haemulidae (Sweetlips), Acanthuridae (Surgeon fish), and Pomacentridae (Damsel fish). In addition there were groupers (Serranidae), angelfish (Pomacanthidae), butterflyfish (Chaetodontidae), blennies (Blennidae) and gobies (Gobiidae).

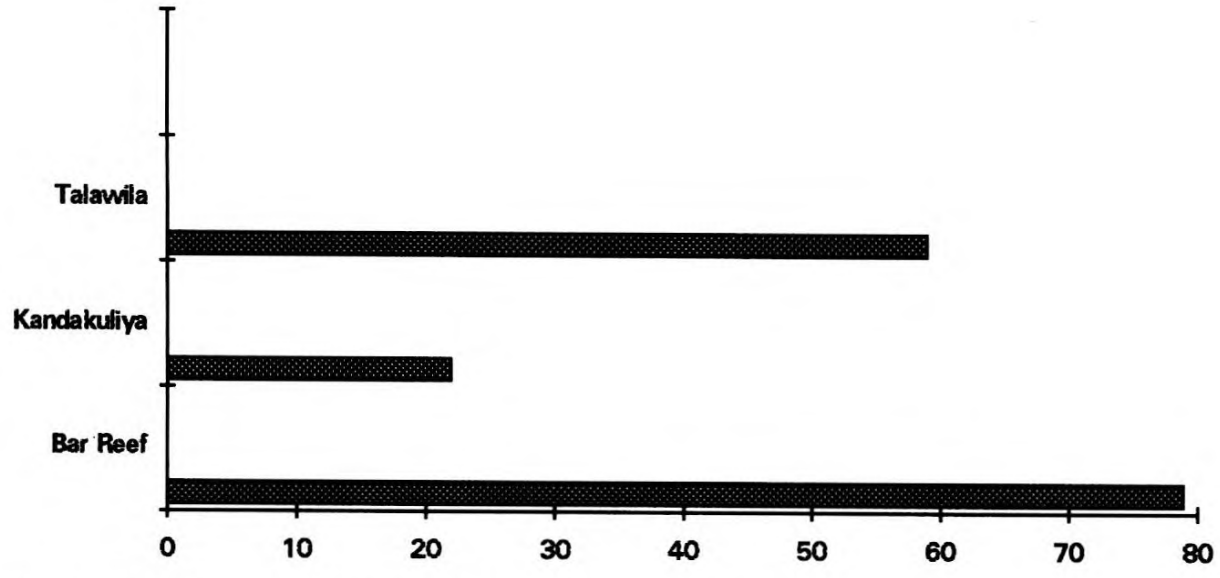


Fig. 2 Percentage of live coral cover per transect

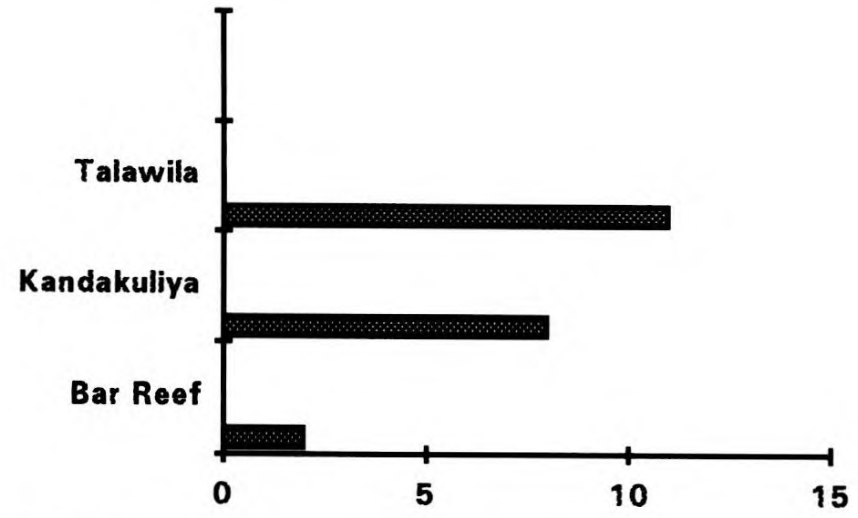


Fig. 3 Coral genera richness per transect

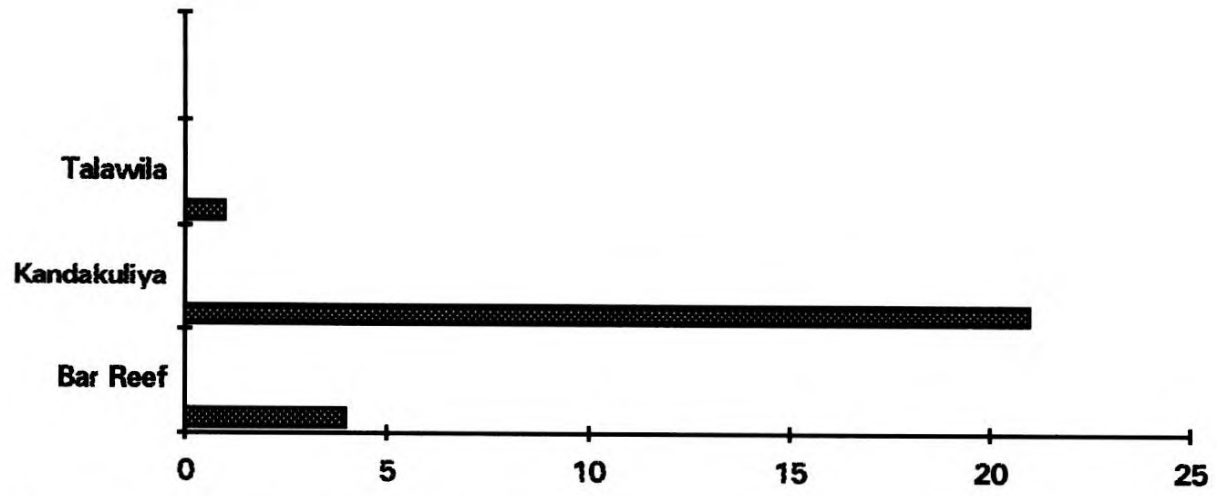


Fig. 4 Percentage of coral rubble per transect

Table 1. The percentage cover of the ten most common coral genera on coral habitats at Bar Reef, Kandakuliya and Talawila

BAR REEF

Coral Genera	Growth form	Percentage
Acropora	Branching & Plate	89
Echinopora	Foliaceous	8
Montipora	Foliaceous	2
Pocillopora	Branching	< 1
Psammacora	Columnar	< 1
Galaxea	Sub-massive & Encrusting	< 1
Porites	Massive	< 1
Pachyseris	Plate & Laminar	< 1
Leptastrea	Massive	< 1
Oulophyllia	Massive	< 1

KANDAKULIYA

Coral Genera	Growth form	Percentage
Porites	Massive	36
Acropora	Branching	24
Favites	Massive	8
Favia	Massive	6
Turbinaria	Foliaceous	6
Goniopora	Massive	5
Galaxea	Sub-massive & Encrusting	2
Pocillopora	Branching	2
Platygyra	Massive	1
Hydnophora	Massive & Encrusting	1

TALAWILA

Coral Genera	Growth form	Percentage
Favia	Massive	29
Porites	Massive	24
Galaxea	Sub-massive & Encrusting	13
Favites	Massive	8
Acropora	Branching & Plate	7
Goniopora	Massive	5
Platygyra	Massive	4
Montipora	Foliaceous & Laminar	3
Echinophyllia	Foliaceous & Encrusting	1
Hydnophora	Massive & Encrusting	1

Source: Ohman, Rajasuriya and Linden, 1993.

Three genera (*Blastomussa*, *Stylophora* and *Anacropora*) and twelve species (*Blastomussa merleti, Stylophora pistillata, Anacropora forbesi, Montipora digitata, Pavona maldivensis, Pachyseris speciosa, Fungia paumotensis, F. fungites, F. moluccensis, Polyphyllia talpina, Leptoseris explanata* and *Tubastrea micrantha)* of stony corals new to Sri Lanka were discovered as a result of the present study (Rajasuriya, 1994).

OTHER MARINE LIFE

Several larger forms of marine life were present in the area. Sea turtles were frequently encountered among coral patches of the Bar Reef. Green Turtles (*Chelonia* mydas)and the Olive Ridley Turtles (*Lepidochelys olivacea*) have been recorded from the Bar Reef and Kandakuliya reefs. A Hawksbill Turtle (*Eretmochelys imbricata*) was recorded among the catch in one of the fishing boats at Kandakuliya. Turtles are also killed in large numbers at Kandakuliya. Drift gill nets could be the main type of fishing gear responsible for the trapping of sea turtles.

Large schools of Spinner Dolphins (*Stenella longirostris*) and Smaller pods of Bottlenose Dolphins (*Tursiops truncatus*) were encountered regularly on the outer reef areas of Bar Reef and Kandakuliya. They were frequently sighted about 10 km offshore. Black-tip Reef Sharks (*Carcharinus melanopterus*) were also common. Occasionally Whale Sharks (*Rhyncodon typus*) were sighted over the sandstone reefs at a distance of about 10 km from the shore.

Bottlenose Dolphins (*Tursiops truncatus*) and the rare Indo-Pacific Humpback Dolphins (*Sousa chinensis*) were present within the Puttalam Lagoon during the months of February and March.
Several species of sea gulls, terns and waders were also common along the coastal areas especially close to the northern sections of Puttalam Lagoon.

FISHING ACTIVITIES

The main economic activity in the Kalpitiya Peninsula is fishing for finfish and crustaceans and trading in fish products such as dry fish. Fishing is concentrated in the Puttalam lagoon and in the coastal waters as well as around reefs. There are several fishing villages along the coastal belt. The largest is at Kandakuliya, the others are at Mampuri, Talawila to the south of Kandakuliya and Kudawa, Keerimundel, Uchimunai on the northern section of the Peninsula. In addition there were four villages on the Karativu Island (north of Kalpitiya peninsula) called Welle, Palliyawatte, Battalankundu and Karaduwa. (Fig. 1).

Most of the fishermen in the villages north of Keerimundel were migratory fishermen. They were mainly migratory fishermen from Negombo and Chilaw.

Except for the fishermen from Kandakuliya, Kudawa, Talawila and Mampuri, fishermen from all other villages previously mentioned, engage in fishing activities in the lagoon as well as in the sea. For them fishing in the sea is a seasonal occupation. The majority use bottom-set nets to catch spiny lobsters from November to January and may use gillnets up to May or June. However a smaller group of fishermen continue to use bottom-set nets throughout the year. Most fishermen in the area are opportunistic and many possess different types nets and use them depending on the seasonal availability of fish, crabs, shrimps and lobster.

Drift gillnets are an important fishing technique in the area. Target species will depend on the type of net used and the size of its mesh. The Indian Mackerels (*Rastrelliger kanagurta*) caranx species, scombrids, lethrinids and lutjanids are all caught with the same kind of net. The nets are laid over sandstone reefs at a depth range of 10 to 12 m.

Gillnets are also used to catch species of herring, sardinella, flying fish and smaller scombrids. These nets are generally used above sandstone reefs (below 12 m). Gillnets with smaller mesh sizes are used among coral reefs to catch half beaks (Hemiramphidae) and needlefish (Belonidae).
Fishing is mainly carried out from 18 to 20 foot fibreglass boats with out-board motors. The major types of gear used in the area for selected species is listed in table 1.

Large numbers of sea cucumber are also harvested from the northwestern coastal waters. Traditionally this activity was limited to Puttalam lagoon and was carried out by snorkel divers. Recently scuba divers have begun to harvest sea cucumbers in very large numbers from the coastal reefs and sandy areas among reefs.

Table 2. The main types of fishing gear used in the Area

Type of gear	Depth	Target Species
Drift Gillnet, mesh size 2 in. Set from surface downwards to a depth of about 10 m.	Laid over sandstone reefs at a depth range of 10 to 12 m.	Carangidae, Lutjanidae, Lethrinidae, Scombridae, Indian Mackerels,
Drift Gillnet, mesh size 1.5 in. Set in mid water, where the net does not reach the surface nor does does it reach the substrate.	Laid over sandstone reefs at a depth range of 12 m and beyond.	Scombridae, Sardinella spp. Exocoetidae, Belonidae.
Gillnet, mesh size 3.5 in. Set at different depths keeping the net at the required depth using surface floats.	Laid over sandstone reefs at a depth range of 14 to 25 m.	Scombridae, Sharks, Barracuda, Carangidae.
Bottom-set net, mesh size 2 to 2.5 in. between two layers of larger mesh size or single layer of 3 in. mesh size.	Laid directly on the reef, usually on sandstone reefs at a depth range of 8 to 15 m. Sometimes on coral reefs in depths of 5 to 6 m.	Spiny Lobsters and all types of reef fish.
Bottom-set net, sharks and rays, mesh size of 18 in.	Usually laid beyond the reef areas on soft bottoms.	Sharks and bottom dwelling rays.
Trammel net, having three layers with 3/4 in. mesh between two layers of a larger mesh (size 6 in.)	Laid vertically to trap reef fish that pass between coral patches, sometimes laid on the substrate of sandstone and coral.	All types of reef fish and spiny lobsters.

Table 2 cont.

Type of gear	Depth	Target Species
Hand lines	Coral and sandstone reefs	All types of reef fish and semi-pelagic species.
Long line	Outer reef area over a depth of more than 20 m and beyond.	Semi pelagic and pelagic species.
Trawl nets	Over deep sand stone reef areas and on soft bottoms.	All types of bottom dwelling species.
Beach seines	Nearshore areas	All types of inshore species such as Sardines, Herrings etc.
Castnets	Nearshore	All types of inshore species.
Scuba diving equipment	Reef and sandy/silty habitats	Sea cucumber, Chanks

ORNAMENTAL FISH COLLECTION

Ornamental fish collection at Kandakuliya and Talawila started in the late 1980's. This activity was expanded to include the Bar Reef area relatively recently. The majority of collectors were outside the Kalpitiya area. Collecting is carried out during the non-monsoon months from November to April. Generally their operational bases are makeshift huts on the beach. Each group of collectors may have up to 10 divers with their assistants such as compressor operators, boat operators etc. During 1995 there were approximately 8 groups diving from Kudawa to Mampuri. However, diving activities was not allowed in 1996 due to the prevailing security situation in the area.

Scuba divers collect fish in deeper waters, the average operational depths varied between 20 to 30 m. The main target species were deep water reef shrimps such as the scarlet shrimps (*Lysmata debelius*) painted shrimps (*Lysmata amboinensis*) and juvenile and sub-adult angelfishes (Pomacanthidae). In addition they collect various species of butterflyfish (Chaetodontidae), clown fish (Pomacentridae), wrasses (Labridae), anthids (Serranidae) and Gobies (Gobiidae) etc. Occasionally butterfly fish are collected from the shallow coral reef areas using "Moxy nets" which is detrimental to coral habitats.

Collecting Techniques

Collection was carried out by using handnets and moxynets. The handnet is used to catch fish in more flat and open terrain such as on sandstone reefs, and the moxynet is used in habitats among coral patches where it is difficult to collect with handnets. Whilst the handnet is a non-destructive collecting technique the moxynet causes considerable damage to the reef structure of coral habitats. A diver using the moxynet chases fish into a patch of coral and covers the area with the net. Then the diver uses a metal rod to break the corals within, and to drive the fish out of their hiding places. Most butterfly fish, angel fish, surgeonfish and wrasses in shallow coral areas were collected using this technique.

In shallow coral areas fish were also collected during the night. Only a single circular net about 8 inches in diameter was used. The smaller size of the net permits the diver to insert the net among coral branches and under overhanging ledges. Butterfly fish were the main target species during the night. Although a careful diver can collect fish in the night without damaging the corals, often divers stand on the coral or break them to have access to fish hiding among branches.

Reef shrimps, *Lysmata debelius* and *L. amboinensis* live together with moray eels in holes in the reef usually at a depth range of 22 to 30 m. The shrimps serve a similar function to cleaner wrasses where they pick off parasites from the skin of eels and groupers and other large fish living in the holes. The shrimps are collected using a small circular net with a long handle about 1 m in length.

Deep water corals such as the *Plerogyra sinuosa, Euphyllia ancora, E. divisa, Catalaphyllia jardinei* and *Goniopora stokesi* were collected from the sandstone reefs until the implementation of the ban on export of live corals from Sri Lanka by the Department of Wild Life Conservation in 1993. Although a large number of species are exported from Sri Lanka, mainly the high value species are collected from the Kalpitiya area. A total of 57 species of fish including 17 species of butterfly fish were targeted. These include 2 species of fish (*Chaetodon semeion* and *Labroides bicolor*) that are listed as protected organisms in the Fauna and Flora Protection Ordinance of Sri Lanka. Table 2. lists the species of ornamental fish and invertebrates collected from the area.

Table 3. Species of ornamental fish and invertebrates collected from the study area

FISH SPECIES

Scientific Name	Common Name
Acanthurus pyroferus (Juv)	Mimic surgeonfish
Acanthurus leucosternon	Powder blue surgeonfish
Naso lituratus	Orange-spine unicornfish
Balistoides conspicillum *	Clown triggerfish
Peudobalistes fuscus ® ✪	Jigsaw triggerfish
Chaetodon falcula	Double saddle butterflyfish
Chaetodon kleinii	Klein's butterflyfish
Chaetodon octofasciatus	Eight banded butterflyfish
Chaetodon bennetti ® ✪	Bennett's butterflyfish
Chaetodon unimaculatus *	Teardrop butterflyfish
Chaetodon madagascariensis *	Madagascar butterflyfish
Chaetodon rafflesi *	Raffle's butterflyfish
Chaetodon semeion ® ✪ ✸	Golden butterflyfish
Chaetodon collare	Brown butterflyfish
Chaetodon auriga	Threadfin butterflyfish
Chaetodon lunula *	Racoon butterflyfish
Chaetodon xanthocephalus *	Yellow head butterflyfish
Chaetodon meyeri *	Meyer's butterflyfish
Chaetodon triangulum *	Triangular butterflyfish
Forcipiger flavissimus	Long nose butterflyfish
Heniochus pleurotaenia *	Indian bannerfish
Heniochus monoceros *	Masked bannerfish
Dascyllus trimaculatus	Threespot damselfish
Amphiprion nigripes	Teak clownfish
Amphiprion clarkii	Clark's clownfish
Amphiprion sebae	Yellowtail clownfish
Anampses lineatus	Deepsea wrasse
Anampses sp	wrasse
Cirrhilabrus sp	Fighter wrasse
Coris formosa	Clown coris
Halichoeres leucoxanthus	Yellow wrasse

Table 3. Cont.

Labriodes bicolor ® ✪ ✸	Bicolor cleaner wrasse
Novaeculichthys taeniurus	Dragon wrasse
Parachelinus sp	Flasher wrasse
Pomacanthus imperator	Emperor angelfish
Pomacanthus annularis	Bluering angelfish
Pomacanthus semicirculatus	Koran angelfish
Apolomichthys xanthurus	Cream angelfish
Centropyge eibli	Eibl's angelfish
Centropyge flavipectoralis	Yellowfin pygmy angelfish
Ptereleotris evides	Arrow-dart goby
Ptereleotris heteropterus	Tail-spot dart goby
Nemateleotris magnifica *	Red fire goby
Nemateleotris decora ® ✪	Purple fire goby
Valenciennea helsdingeni	Blacklined sleeper
Valenciennea puellaris	Orange spotted sleeper
Valenciennea strigata	Golden headed sleeper
Solenostomus sp	Ghost pipefish
Rhinomuraena quaesita *	Ribbon eel
Cephalopholis miniatus	Jewel grouper
Variola louti *	Moontail bass
Pseudanthias squamipinnis	Anthias
Pseudanthias dispar	Dispar anthias
Rabaulichthys stigmaticus	Spotfin anthias
Pogonoperca punctata	Spotted soapfish
Pterois antennata	Spotfin lion fish
Pterois miles	Scorpion/lion fish
Synchiropus marmoratus	Marbled dragonet

INVERTEBRATES

Scientific Name	**Common Name**
Lysmata debelius	Scarlet shrimp
Lysmata amboinensis	Painted shrimp
Cerianthus sp	Sand anemones
Radianthus sp	Anemones
Stoichactis sp	Bulb tipped anemones
Chicoreus palmarosa	Palmarosa
Cyprea sp	Cowries
Conus sp	Cones

Very rare ®
Rare *
Vulnerable ✪
Listed as protected in the Fauna and Flora Protection Ordinance ✸

CONCLUSIONS

The diversity of coral genera, topographic relief and the proportion of coral rubble for the coral reefs at Bar Reef, Kandakuliya and Talawila were significantly different. The richness of coral genera on the shallow coral areas of Bar Reef dominated by branching forms of *Acropora,* and foliaceous forms of *Montipora* and *Echinopora* was the lowest at 2 genera per transect. The Kandakuliya reef had more coral genera than the Bar Reef at 8 genera per transect and the Talawila reef at 11 genera per transect was the highest in the study area for the true coral reefs. However the deeper areas of the Bar Reef which consists of sandstone and coral contains a much higher coral generic diversity than kandakuliya or Talawila. However transects conducted at an average depth of 9 to 14 m revealed that the Bar Reef supports an average of 13 coral genera per transect.
The Bar Reef had a 4% coral rubble in the shallow areas and this appeared to be the impact of *Acanthaster planci* rather than from fishing activities.

The Shallow coral areas of the Kandakuliya reef has been devastated by the use of bottom-set nets where coral rubble amounted to 20% as against the live coral cover which was only 22%. However, regeneration of first colonizers were noticed during site investigations in 1994.

The abundance of fish and their diversity was clearly an indication of the health of the reefs. The species diversity of fish was highest in the Bar Reef while Kandakuliya and Talawila had lesser numbers. The abundance of butterfly fish followed the same pattern as that of live coral on the reefs. The Bar Reef also had the highest number of butterfly fish species (34) as compared to Kandakuliya and Talawila.

The study indicated that of the four locations studied, the Bar Reef was the least affected by anthropogenic activities while the Kandakuliya reef was the most damaged as a result of fishing pressure especially with the use of destructive fishing gear. The Shallow coral areas of the Kandakuliya reef has been devastated by the use of bottom-set nets where coral rubble amounted to 21% as against the live coral cover which was only 22%. However, regeneration of first colonizers were noticed during site investigations in 1994. These were mainly species of *Pocillopora, Galaxea* and *Acropora.* The Talawila reef was moderately affected, however, as it contains mostly massive corals belonging to the family Faviidae the damage caused by bottom-set nets was relatively low.

The increasing human population of the area is a growing problem. Fishermen who formally used to migrate between the east coast and west coast with the change of monsoons, are now unable to do so due to civil unrest in the country. In addition refugees from the Mannar Island and other northern parts have settled down in the Kalpitiya area and are beginning to compete for the same resources as the local residents. Further, they are also starting to use the same destructive fishing techniques that have damaged the Kandakuliya and Talawila reefs. If present trends in fishing activities continue the sensitive reef habitats will be affected negatively. Therefore fishing activities in the area needs proper management.

MANAGEMENT RECOMMENDATIONS

The absence of management strategies for the utilization of reef resources has led to the overall degradation of reefs within the north-western coastal waters. In the mid 1980's resource surveys carried out by De Silva and Rajasuriya (1989) indicated that the Kandakuliya reef was in a relatively healthy state. They recommended that this area be managed before irreversible damage occurs to the environment due to the use of destructive fishing methods and uncontrolled harvesting. The same locations surveyed during this study indicated that severe reef damage has occurred due to the use of bottom-set nets on shallow coral reefs (Ohman et al, 1993).

The expanding population in the area is a critical factor that cause damage to the reefs. Fishing communities at Kandakuliya, Kudawa, Keerimundel as well as the villages in Karativu island continue to expand every year. This expansion takes place without any planned development and fishermen are now beginning to move into the Bar Reef area as the resources are depleted in adjacent fishing grounds. Similarly the numbers of ornamental fish collectors increase each year. In the mid 1980's, ornamental fish collection was carried out at Kandakuliya only by a few divers who visited the area for a week or two. This pattern has now changed where a number of well organized scuba divers operate throughout the season systematically harvesting the resources in a limited area. Similar situations have occurred in many reef areas in Sri Lanka.

An example of this type of harvesting can be seen on the reefs off Colombo where an abundant population of spiny lobster in the 1960's and 1970's was nearly wiped out by harvesting with scuba equipment. In addition the Bar Reef has been severely damaged by *Acanthaster planci* in 1993 and 1994. Main issues associated with resource utilization and the cause of reef damage are listed in table 3 and 4 respectively.

Table 4. Resource utilization and main issues

Main issues	Impact	Causes
• Increased fishing pressure	• Resource depletion	• Over- exploitation of adjacent fishing grounds
• Increased number of fishermen	• Habitat destruction	• Displacement of fisher families in areas of civil unrest and inability to migrate to the east coast during the southwest monsoon.
		• Fishermen moving in to areas where resources are plentiful.
• Use of destructive fishing methods e.g. bottom-set nets	• Severe reef damage and resource depletion	• Use of highly efficient fishing gear for making maximum profit on a common access resource
		• Lack of adequate fishery regulations and implementation.
• Uncontrolled collection of ornamental species	• Resource depletion	• Over exploitation of adjacent / former fishing grounds and increased number of collectors
• Use of destructive collecting techniques	• Habitat destruction	• Occurrence of species not found in other areas as well as abundant resources in a common access fishery

Table 4. Cont.

• Large scale habitat destruction due to *Acanathaster planci* predation	• Total destruction of coral reefs	• Causes of *Acanthaster planci* infestations is unknown
• Sedimentation	• Damage to coral reefs	• Increased sediment load from Puttalam Estuary, Deduru Oya and other rivers, could be due to mangrove and sea grass bed destruction and unplanned land use practices. • Coastal erosion.

Table 5. Major causes of reef degradation

Main issues	Causes	Impacts
• Reef and environmental degradation	• Use of bottom-set nets	• Habitat destruction
	• Use of gillnets near reefs	• Habitat destruction
	• Use of Moxy nets to catch ornamental fish	• Habitat destruction
	• Uncontrolled harvesting	• Resource depletion
	• Anchor damage	• Habitat destruction
	• Crown-of Thorns starfish	• Habitat destruction

It is now apparent that if current trends continue the resources will be severely depleted and the balance of the system will be negatively affected. Therefore it is extremely important to safeguard at least the area that is at present relatively undegraded and to manage the resources. The Bar Reef will be the ideal location for conservation management as it contains a large coral reef habitat and extensive sandstone habitats. Therefore it is ideally suited to maintain breeding populations of finfish and other species.

The Bar Reef was declared a Marine Sanctuary on 3 April 1992 under sub-section 2 of section (2) of the Fauna and Flora Protection Ordinance (Chapter 469), as amended by Act No. 44 of 1964 and Act No. 1 of 1970, of the Department of Wild Life Conservation. The extent of the Bar Reef Marine Sanctuary is 306 .7 m^2 between the northern seaward boundary at (8° 32.00' N , 79° 40.75' E) and the southern seaward boundary at (8° 16.00' N, 79° 40.75' E). The landward boundary borders the northern section of the Kalpitiya Peninsula and the Karativu Island to the north. (Fig. 1). The extent of the true coral area is approximately 25 km^2 and about another 50 km^2 contained scattered coral patches. The other areas within the sanctuary consists of sandstone reefs and sandy patches.

Recommendations to control destructive activities

The Bar Reef is sufficiently large to maintain a viable breeding population of fish and other organisms and can serve as a breeding and nursery grounds that can support and sustain fisheries activities in adjacent areas as well. For the well being of the whole system it is important to manage human activities within the sanctuary. In order to achieve this status the sanctuary has to be zoned for selected activities. The Bar Reef Marine Sanctuary contains a Core Zone of approximately 70 km ^{2} and about 236 km ^{2} of Buffer Zone. While the core zone supports most of the true coral reefs, the buffer zone contains extensive areas of sandstone and sandy areas. It also includes patches of seagrass beds as well as areas of Padina, Caulerpa and other marine algae.

Table 6. Recommended control measures to limit human activities within zones of the Bar Reef Marine Sanctuary.

Activity	Core area	Buffer area
• Bottom-set nets	• not allowed	• not allowed
• Gillnets (surface)	• not allowed	• Allowed with permit
• Gillnets (Bottom-set)	• not allowed	• not allowed
• Angling	• not allowed	• Allowed with permit
• Ornamental fish collection	• not allowed	• Allowed with permit
• Moxy nets to catch ornamental fish	• not allowed	• not allowed
• Boat anchoring	• only at designated points	• only at designated points
• Collection of Spiny Lobsters	• not allowed	• not allowed
• Collection of Sea Cucumber	• not allowed	• Allowed with permit
• Collection of molluscs and other invertebrates	• not allowed	• Allowed with permit
• Recreational diving	• Allowed with permit	• Allowed with permit
• Glass bottom boat	• Not allowed	• Not allowed
• Spear fishing	• not allowed	• not allowed
• Trolling	• not allowed	• Allowed with permit
• Trawling	• not allowed	• not allowed

Crown of Thorns starfish Eradication Programme

The Crown of Thorns Starfish (*Acanthaster planci*) is a major predator of live coral and has destroyed large tracts of living coral in the Bar Reef. Most of the destroyed coral species are the branching *Acropora* and the foliaceous *Echinopora* and *Montipora* spp. However very large coral domes of *Porites* have also been completely destroyed. These large colonies of 3 to 5 metres in diameter may be several hundred years old as species of *Porites* are among the slowest growing species of reef building corals.

Currently there are only two techniques of eradication that have been employed in the Great Barrier Reef where Crown of Thorns starfish are a major problem. One method is to physically remove the starfish and the other is to inject substances poisonous to the starfish by hand held syringes. Both techniques require manpower as divers are needed to carry out the above operations. It is recommended that a national programme be established under the NARA/ Department of Wild Life Conservation to control the Crown of Thorns Starfish. This can be achieved by utilising the services of free lance divers such as the ornamental fish collectors and other volunteer divers. Funding mechanisms for such activities needs to be established. A possible funding source could be the Global Environmental Facility where funds are specially allocated for the management of protected areas.

Institutional Responsibilities for management

The Bar Reef Marine Sanctuary has been declared under the Fauna and Flora Protection Ordinance of the Department of Wild Life Conservation, therefore the primary responsibility in management of the sanctuary lies with this department (Dayaratne, Linden and De Silva, 1997). The Provincial Council also has responsibilities towards managing their natural resources through the Provincial Environmental Authority which needs to function through the Divisional Secretariats within each section of the province. The Bar Reef is within the jurisdiction of the Kalpitiya Divisional Secretariat. Table 7 identifies various departments and organizations that are responsible for the management of the sanctuary and to control human activities within the area.

Table. 7. Issues, remedial action and the responsible Institutions for action.

Issues	Action needed	Organization
• Fishing within the sanctuary	• Prohibit all extractive uses within the Core Zone. • Demarcate zones and boundaries with markers. • Enforce sanctuary regulations • Issue licenses to all users, and prevent unauthorized use • Create zones within the sanctuary, provide maximum protection to the core area. • Establish Bar Reef Marine Sanctuary Authority under the DWLC with NARA, CCD, MFARD, PC, PEA, DS, NGOs.	• DWLC, MFARD, NARA, CCD, PC, DS, Local NGOs

Table 7. Cont.

• Colonization by fishermen	• Take steps to limit the numbers of fishermen in the area. Determine the carrying capacity of the area and limit the number of settlers	• MFARD, Local authorities to enforce, Provincial Council (PC) and Divisional Secretary (DS).
	• Identify fishermen and their children who could be weaned out of the fishing industry and offer them alternative employment	• MFARD, Central government to provide better educational facilities and introduce alternative sources of income.
	• Provide a good education to the younger generation of the fisher families to promote them to take up other employment	• MFARD, DS, PC, NARA, NIE, CCD, Local NGOs to carryout educational programmes on resources, value of resources in terms of the well being of the community, need to limit extraction.
	• Set a ceiling to the number of divers that can operate in the area.	• DWLC, MFARD, PEA.
	• Introducing a licensing system and limit the number of licenses.	• MFARD
• By catch of other species such as murex shells, sponges, starfishes etc.	• Educate the fishermen • Identify types of gear that bring in these species and try to modify • Devise a scheme to purchase these organisms (Live) and reintroduce into non-fishing areas.	• MFARD, NARA, DWLC, CCD, PC, DS, FS, NGOs.
• Use of destructive fishing techniques	• Ban all destructive fishing techniques	• MFARD, DWLC, NARA, PEA.
• Unsustainable harvesting	• Set quotas and size limitations	• MFARD

Table 7. Cont.

• *Acanthaster planci* and reef destruction	• Carry out an eradication programme with assistance from NGOs. Formulate a programme to remove *Acanthaster* periodically.	• MFARD, NARA, DWLC, NGOs, FS.
• Lack of awareness	• Organize an awareness programme on value of reefs with the aid of audio visual material	• DWLC, NIE, NARA, MFARD, NGOs, DS, PEA, FS.

DWLC : Department of Wild Life Conservation
NARA : National Aquatic Resources Agency
CCD : Coast Conservation Department
MFARD : Ministry of Fisheries and Aquatic Resources Development
PC : Provincial Council
PEA : Provincial Environmental Authority
DS : Divisional Secretariat
NIE : National Institute of Education
NGO : Non Governmental Organization
FS : Fisheries society

Table 8. Requirements for management of the sanctuary

- Park Rangers and Officers
- Boats and out board motors
- Park headquaters at kalpitiya and guard posts.
- Vehicles
- Boundary demarcation
- Demarcation of zones
- Educational center with audio visual equipment
- Audio visual educational material
- Mooring buoys
- Sign boards

Table 9. Long term monitoring and Research needs

Research needs	Organization
• Monitor the status of the reefs	• NARA
• Monitor the abundance of reef fish	• NARA
• Determine species diversity and abundance	• NARA
• Monitor the fish catches from the buffer zone	• NARA, MFARD, DWLC
• Socio economic studies	• NARA, local NGO's, PC.
• Monitor *Acanthaster planci* populations and impact on reefs	• NARA, MFARD
	• NARA, DWLC

Table 10. LIST OF CORAL SPECIES IN THE NORTHWESTERN COASTAL WATERS

Corals	Bar Reef	Kandakuliya	Talawila	Mampuri
Family: Acroporidae				
Acropora aculeus	x	x	x	x
Acropora anthocercis	x	x	-	x
Acropora cytherea	x	x	-	-
Acropora danai	x	-	x	-
Acropora divaricata	-	x	-	-
Acropora humilis	x	-	-	-
Acropora hyacinthus	x	x	x	x
Acropora formosa	x	x	x	x
Acropora millepora	x	-	-	-
Acropora microphthalma	x	x	x	-
Acropora nobilis	x	x	x	-
Acropora robusta	x	x	x	x
Acropora secale	x	-	-	-
Acropora solitariyensis	x	-	x	-
Acropora valenciennesi	x	x	-	-
Acropora yongei	x	-	-	-
Montipora aequituberculata	x	x	x	x
Montipora danae	x	-	x	x
Montipora foliosa	x	x	x	x
Montipora millepora	-	x	x	-
Montipora monasteriata	x	x	x	-
Montipora undata	x	x	x	x
Montipora digitata	x	x	x	-

Table 10. cont.

Montipora verrucosa	x	x	x	x
Astreopora gracilis	x	x	x	x
Anacropora forbesi	x	-	-	-
Family: Astrocoeniidae				
Stylocoeniella guentheri	x	x	x	x
Family: Agariciidae				
Pavona minuta	x	x	x	-
Pavona varians	x	x	x	x
Pavona decussata	x	-	x	-
Pavona venosa	x	-	-	-
Pavona maldivensis	-	x	-	-
Gardineroseris planulata	x	x	x	x
Leptoseris papyracea	x	x	-	x
Leptoseris mycetoseroides	x	x	x	x
Leptoseris explanata	x	x	x	x
Pachyseris rugosa	x	x	x	x
Pachyseris speciosa	x	x	x	x
Family: Caryophylliidae				
Paracyathus sp	x	-	-	-
Euphyllia sp	x	x	-	x
Euphyllia ancora	x	-	x	x
Catalaphyllia jardinei	x	-	-	-
Plerogyra sinuosa	x	x	-	x
Family: Dendrophylliidae				
Heteropsammia cochlea	-	-	-	x
Tubastrea micrantha	x	x	x	x
Tubastrea sp	x	x	-	x
Dendrophyllia sp	x	x	x	x
Turbinaria peltata	x	x	x	x
Turbinaria sp	x	x	x	x
Family: Faviidae				
Favia favus	x	x	x	x
Favia maxima	x	x	x	x
Favia pallida	x	x	x	x
Favia veroni	x	x	-	-

Table 10. cont.

Favia rotundata	x	x	x	-
Favia speciosa	x	x	x	x
Favia spp.	x	x	x	x
Favites abdita	x	x	x	x
Favites chinensis	x	x	x	x
Favites pentagona	x	x	x	x
Favites flexuosa	x	x	x	x
Favites spp.	x	x	x	x
Montastrea curta	x	x	x	-
Montastrea valenciennesi	x	x	x	x
Diploastrea heliopora	x	x	-	x
Plesiastrea versipora	x	x	x	x
Goniastrea pectinata	x	x	-	-
Goniastrea retiformis	x	x	x	x
Goniastrea aspera	x	x	x	x
Platygyra lamellina	x	x	x	x
Platygyra sinensis	x	x	x	x
Platygyra daedalea	x	x	x	x
Platygyra pini	x	x	x	x
Leptoria phrygia	x	x	x	x
Leptastrea purpurea	x	x	x	x
Leptastrea transversa	x	-	-	-
Cyphastrea chalcidicum	x	x	x	x
Cyphastrea serailia	x	x	-	-
Echinopora lamellosa	x	x	x	-
Oulophyllia crispa	x	x	x	x
Family: Fungiidae				
Cycloseris costulata	x	x	x	-
Cycloseris cyclolites	x	x	-	-
Cycloseris patelliformis	x	x	x	x
Diaseris distorta	x	x	x	x
Diaseris fragilis	x	x	x	x
Fungia (Danafungia) *danai*	x	x	-	-
Fungia (Ctenactis) *echinata*	x	x	x	-
Fungia (Verrilofungia) *repanda*	-	x	-	-
Fungia (Pleuractis) *scutaria*	x	x	x	x
Fungia paumotensis	x	x	x	-
Fungia moluccensis	x	-	-	-
Fungia fungites	x	x	-	-
Podabacia crustacea	x	x	x	x
Polyphyllia talpina	x	x	x	x
Sandalolitha robusta	x	x	-	-
Zoopilus echinatus	x	x	-	-

Table 10. cont.

Family: Mussidae				
Acanthastrea echinata	x	x	x	x
Australomussa rowleyensis	x	x	-	-
Symphyllia radians	x	x	x	x
Symphyllia agaricia	x	x	x	-
Symphyllia cf. recta	x	x	-	-
Symphyllia cf. valenciennesi	x	x	-	x
Symphyllia sp	x	-	x	x
Lobophyllia sp	x	x	x	-
Cynarina lacrymalis	x	x	-	x
Family: Merulinidae				
Hydnophora exesa	x	x	x	x
Hydnophora microconos	x	x	x	-
Hydnophora sp	x	x	x	-
Family: Oculinidae				
Galaxea cf. astreata	x	x	x	x
Galaxea fascicularis	x	x	x	x
Family: Pectiniidae				
Mycedium elephantosus	x	x	x	x
Echinophyllia aspera	x	x	x	x
Echinophyllia sp	x	x	-	-
Family: Poritidae				
Porites spp	x	x	x	x
Goniopora stokesi	x	x	x	x
Goniopora sp	x	x	x	x
Alveopora verriliana	x	-	-	-
Alveopora fenestrata	-	x	-	-
Alveopora sp	x	-	-	-
Family: Pocilloporidae				
Pocillopora damicornis	x	x	x	x
Pocillopora verrucosa	x	x	x	x
Pocillopora eydouxi	x	x	x	-
Pocillopora sp	x	x	-	-
Stylophora pistillata	x	x	x	-

Table 10. cont.

Family: Siderastreidae				
Coscinaraea columna	x	-	-	x
Coscinaraea sp	x	x	x	x
Pseudosiderastrea tayamai	x	x	x	x
Family: Thamnastreidae				
Psammacora contigua	x	x	x	-
Family: Milleporidae				
Millepora platyphyllia	x	x	x	-
Millepora exesa	x	x	-	x
Millepora sp	x	x	x	x
Family: Stylasteriidae				
Distichopora violacea	x	x	x	x

Total	**Bar Reef**	**Kandakuliya**	**Talawila**	**Mampuri**
Total no of Families	17	17	17	17
Total no of Genera	54	51	43	44
Total no of species	125	108	90	78

Table 11. LIST OF REEF FISH SPECIES RECORDED IN THE STUDY AREA

Family	Genus	Species
Acanthuridae	*Acanthurus*	*lineatus*
Acanthuridae	*Acanthurus*	*leucosternon*
Acanthuridae	*Acanthurus*	*bariene*
Acanthuridae	*Acanthurus*	*bleekeri*
Acanthuridae	*Acanthurus*	*nigricauda*
Acanthuridae	*Acanthurus*	*mata*
Acanthuridae	*Acanthurus*	*triostegus*
Acanthuridae	*Acanthurus*	*pyroferus*
Acanthuridae	*Acanthurus*	*xanthopterus*
Acanthuridae	*Acanthurus*	*tennenti*
Acanthuridae	*Acanthurus*	*dussumieri*
Acanthuridae	*Acanthurus*	*tristis*
Acanthuridae	*Acanthurus*	*thompsoni*
Acanthuridae	*Acanthurus*	*nigrofuscus*
Acanthuridae	*Acanthurus*	*leucocheilus*
Acanthuridae	*Acanthurus*	*blochii*
Acanthuridae	*Acanthurus*	*spp.* (unidentified)
Acanthuridae	*Ctenochaetus*	*striatus*
Acanthuridae	*Ctenochaetus*	*strigosus*
Acanthuridae	*Ctenochaetus*	*binotatus*
Acanthuridae	*Naso*	*lituratus*
Acanthuridae	*Naso*	*annulatus*
Acanthuridae	*Naso*	*tuberosus*
Acanthuridae	*Naso*	*unicornis*
Acanthuridae	*Naso*	*brachycentron*
Acanthuridae	*Naso*	*hexacanthus*
Acanthuridae	*Naso*	*brevirostris*
Acanthuridae	*Zebrasoma*	*scopas*
Acanthuridae	*Zebrasoma*	*veliferum*
Apogonidae	*Apogon*	*robustus*
Apogonidae	*Apogon*	*novemfasciatus*
Apogonidae	*Apogon*	*aureus*
Apogonidae	*Apogon*	*spp.* (unidentified)
Apogonidae	*Apogon*	*nigrofasciatus*
Apogonidae	*Apogon*	*bifasciatus*
Apogonidae	*Apogon*	*endekataenia*
Apogonidae	*Archamia*	*fucata*
Apogonidae	*Cheilodipterus*	*quinquelineatus*
Apogonidae	*Cheilodipterus*	*lineatus*
Apogonidae	*Cheilodipterus*	*macrodon*
Apogonidae	*Cheilodipterus*	*artus*
Apogonidae	*Sphaeramia*	*spp.*
Aulostomidae	*Aulostomus*	*chinensis*
Balistidae	*Abalistes*	*stellatus*
Balistidae	*Balistapus*	*undulatus*
Balistidae	*Balistoides*	*viridescens*
Balistidae	*Balistoides*	*conspicillum*

Table 11. Cont.

Balistidae	*Melichthys*	*indicus*
Balistidae	*Pseudobalistes*	*fuscus*
Balistidae	*Pseudobalistes*	*flavimarginatus*
Balistidae	*Rhinecanthus*	*aculeatus*
Balistidae	*Rhinecanthus*	*rectangulus*
Balistidae	*Rhinecanthus*	*verrucosus*
Balistidae	*Sufflamen*	*fraenatus*
Balistidae	*Sufflamen*	*bursa*
Balistidae	*Sufflamen*	*chrysopterus*
Blennidae	*Aspidontus*	*taeniatus*
Blennidae	*Cirripectes*	*spp*
Blennidae	*Ecsenius*	*bicolor*
Blennidae	*Ecsenius*	*spp.*
Blennidae	*Exalias*	*brevis*
Blennidae	*Meiacanthus*	*smithii*
Blennidae	*Plagiotremus*	*rhinorhynchus*
Blennidae	*Salarias*	*spp.*
Caesionidae	*Caesio*	*caerulaurea*
Caesionidae	*Caesio*	*cuning*
Caesionidae	*Caesio*	*xanthonota*
Caesionidae	*Pterocaesio*	*chrysozona*
Caesionidae	*Pterocaesio*	*tile*
Caesionidae	*Pterocaesio*	*marri*
Callionymidae	*Synchiropus*	*marmoratus*
Callionymidae	*Synchiropus*	*stellatus*
Carangidae	*Alectis*	*indicus*
Carangidae	*Carangoides*	*ferdau*
Carangidae	*Caranx*	*melampygus*
Carangidae	*Caranx*	*sem*
Carangidae	*Caranx*	*ignobilis*
Carangidae	*Caranx*	*lugubris*
Carangidae	*Caranx*	*sexfasciatus*
Carangidae	*Caranx*	*heberi*
Carangidae	*Caranx*	*spp.* (unidentified)
Carangidae	*Elagatis*	*bipinnulata*
Carangidae	*Gnathanodon*	*speciosus*
Carangidae	*Scomberoides*	*lysan*
Carangidae	*Scomberoides*	*commersonianus*
Carangidae	*Trachinotus*	*blochii*
Carangidae	*Trachinotus*	*bailonii*
Carcharhinidae	*Carcharhinus*	*melanopterus*
Carcharhinidae	*Triaenodon*	*obesus*
Chaetodontidae	*Chaetodon*	*auriga*
Chaetodontidae	*Chaetodon*	*vagabundus*
Chaetodontidae	*Chaetodon*	*decussatus*
Chaetodontidae	*Chaetodon*	*citrinellus*
Chaetodontidae	*Chaetodon*	*ephippium*
Chaetodontidae	*Chaetodon*	*meyeri*
Chaetodontidae	*Chaetodon*	*xanthocephalus*
Chaetodontidae	*Chaetodon*	*plebeius*
Chaetodontidae	*Chaetodon*	*melannotus*

Table 11. Cont.

Chaetodontidae	*Chaetodon*	*rafflesi*
Chaetodontidae	*Chaetodon*	*trifascialis*
Chaetodontidae	*Chaetodon*	*trifasciatus*
Chaetodontidae	*Chaetodon*	*lunula*
Chaetodontidae	*Chaetodon*	*falcula*
Chaetodontidae	*Chaetodon*	*collare*
Chaetodontidae	*Chaetodon*	*lineolatus*
Chaetodontidae	*Chaetodon*	*bennetti*
Chaetodontidae	*Chaetodon*	*kleinii*
Chaetodontidae	*Chaetodon*	*gardneri*
Chaetodontidae	*Chaetodon*	*guttatissimus*
Chaetodontidae	*Chaetodon*	*madagascariensis*
Chaetodontidae	*Chaetodon*	*octofasciatus*
Chaetodontidae	*Chaetodon*	*semeion*
Chaetodontidae	*Chaetodon*	*oxycephalus*
Chaetodontidae	*Chaetodon*	*triangulum*
Chaetodontidae	*Chaetodon*	*ornatissimus*
Chaetodontidae	*Chaetodon*	*unimaculatus*
Chaetodontidae	*Forcipiger*	*longirostris*
Chaetodontidae	*Forcipiger*	*flavissimus*
Chaetodontidae	*Hemitaurichthys*	*zoster*
Chaetodontidae	*Heniochus*	*acuminatus*
Chaetodontidae	*Heniochus*	*monoceros*
Chaetodontidae	*Heniochus*	*pleurotaenia*
Chaetodontidae	*Heniochus*	*singularis*
Chaetodontidae	*Heniochus*	*diphreutes*
Cirrhitidae	*Cirrhitichthys*	*pinnulatus*
Cirrhitidae	*Cirrhitichthys*	*oxycephalus*
Cirrhitidae	*Cirrhitichthys*	*bleekeri*
Cirrhitidae	*Paracirrhites*	*forsteri*
Cirrhitidae	*Paracirrhites*	*arcuatus*
Dasyatidae	*Dasyatis*	*kuhlii*
Dasyatidae	*Taeniura*	*lymna*
Dasyatidae	*Taeniura*	*melanospilus*
Diodontidae	*Diodon*	*hystrix*
Exocoetidae	*Exocetus*	*spp*
Fistularidae	*Fistularia*	*spp.*
Gerridae	*Gerres*	*spp*
Gobiidae	*Amblygobius*	*phalaena*
Gobiidae	*Amblygobius*	*spp.*
Gobiidae	*Cryptocentrus*	*spp.*
Gobiidae	*Eviota*	*spp.*
Gobiidae	*Gibiodon*	*spp.*
Gobiidae	*Valenciennea*	*strigata*
Gobiidae	*Valenciennea*	*puellaris*
Gobiidae	*Valenciennea*	*helsdingeni*
Haemulidae	*Diagramma*	*pictum*
Haemulidae	*Plectorhinchus*	*ceylonensis*
Haemulidae	*Plectorhinchus*	*gibbosus*
Haemulidae	*Plectorhinchus*	*vittatus*

Table 11. Cont.

Haemulidae	*Plectorhinchus*	*schotaf*
Haemulidae	*Plectorhinchus*	*obscurum*
Haemulidae	*Plectorhinchus*	*spp.*
Holocentridae	*Myripristis*	*adustus*
Holocentridae	*Myripristis*	*berndti*
Holocentridae	*Myripristis*	*murdjan*
Holocentridae	*Myripristis*	*melanostictus*
Holocentridae	*Neoniphon*	*sammara*
Holocentridae	*Neoniphon*	*opercularis*
Holocentridae	*Sargocentron*	*spiniferum*
Holocentridae	*Sargocentron*	*caudimaculatum*
Holocentridae	*Sargocentron*	*diadema*
Kyphosidae	*Kyphosus*	*vaigiensis*
Kyphosidae	*Kyphosus*	*cinerascens*
Labridae	*Anampses*	*lineatus*
Labridae	*Anampses*	*caeruleopunctatus*
Labridae	*Bodianus*	*diana*
Labridae	*Bodianus*	*neilli*
Labridae	*Bodianus*	*axillaris*
Labridae	*Cheilinus*	*chlorourus*
Labridae	*Cheilinus*	*undulatus*
Labridae	*Cheilinus*	*trilobatus*
Labridae	*Cheilinus*	*fasciatus*
Labridae	*Cheilinus*	*bimaculatus*
Labridae	*Cheilio*	*inermis*
Labridae	*Choerodon*	*anchorago*
Labridae	*Cirrhilabrus*	*spp*
Labridae	*Coris*	*frerei*
Labridae	*Coris*	*africana*
Labridae	*Epibulus*	*insidiator*
Labridae	*Gomphosus*	*caeruleus*
Labridae	*Halichoeres*	*nebulosus*
Labridae	*Halichoeres*	*leucoxanthus*
Labridae	*Halichoeres*	*argus*
Labridae	*Halichoeres*	*hortulanus*
Labridae	*Halichoeres*	*marginatus*
Labridae	*Halichoeres*	*scapularis*
Labridae	*Halichoeres*	*zeylonicus*
Labridae	*Halichoeres*	*timorensis*
Labridae	*Halichoeres*	*margaritaceus*
Labridae	*Hemigymnus*	*fasciatus*
Labridae	*Hemigymnus*	*melapterus*
Labridae	*Hologymnosus*	*annulatus*
Labridae	*Hologymnosus*	*doliatus*
Labridae	*Labrichthys*	*unilineatus*
Labridae	*Labroides*	*dimidiatus*
Labridae	*Labroides*	*bicolor*
Labridae	*Macropharyngodon*	*ornatus*
Labridae	*Novaculichthys*	*taeniourus*
Labridae	*Paracheilinus*	*mccoskeri*

Table 11 cont.

Labridae	*Pseudocheilinus*	*hexataenia*
Labridae	*Stethojulis*	*trilineata*
Labridae	*Stethojulis*	*strigiventer*
Labridae	*Stethojulis*	*interrupta*
Labridae	*Stethojulis*	*sp.*
Labridae	*Thallasoma*	*amblycephalum*
Labridae	*Thallasoma*	*purpureum*
Labridae	*Thallasoma*	*hardwicke*
Labridae	*Thallasoma*	*jansenii*
Labridae	*Thallasoma*	*lunare*
Labridae	*Thallasoma*	*quinquevittatum*
Labridae	*Xyrichtys*	*spp.*
Lethrinidae	*Gnathodentex*	*aurolineatus*
Lethrinidae	*Lethrinus*	*harak*
Lethrinidae	*Lethrinus*	*ornatus*
Lethrinidae	*Lethrinus*	*nebulosus*
Lethrinidae	*Lethrinus*	*lentjan*
Lethrinidae	*Lethrinus*	*variegatus*
Lethrinidae	*Lethrinus*	*spp.* (unidentified)
Lethrinidae	*Monotaxis*	*grandoculus*
Lutjanidae	*Lutjanus*	*lutjanus*
Lutjanidae	*Lutjanus*	*ehrenbergi*
Lutjanidae	*Lutjanus*	*rivulatus*
Lutjanidae	*Lutjanus*	*lunulatus*
Lutjanidae	*Lutjanus*	*argentimaculatus*
Lutjanidae	*Lutjanus*	*bohar*
Lutjanidae	*Lutjanus*	*spp.* (unidentified)
Lutjanidae	*Macolor*	*niger*
Microdesmidae	*Gunnelichthys*	*spp.*
Microdesmidae	*Nemateleotris*	*magnifica*
Microdesmidae	*Nemateleotris*	*decora*
Microdesmidae	*Ptereleotris*	*evides*
Microdesmidae	*Ptereleotris*	*heteroptera*
Microdesmidae	*Ptereleotris*	*zebra*
Microdesmidae	*Ptereleotris*	*monoptera*
Mobulidae	*Manta*	*birostris*
Mullidae	*Mulloidichthys*	*vanicolensis*
Mullidae	*Mulloidichthys*	*flavolineatus*
Mullidae	*Parupeneus*	*indicus*
Mullidae	*Parupeneus*	*bifasciatus*
Mullidae	*Parupeneus*	*macronema*
Mullidae	*Parupeneus*	*cyclostomus*
Mullidae	*Upeneus*	*tragula*
Muraenidae	*Echidna*	*nebulosa*
Muraenidae	*Gymnomuraena*	*zebra*
Muraenidae	*Gymnothorax*	*javanicus*
Muraenidae	*Gymnothorax*	*flavimarginatus*
Muraenidae	*Gymnothorax*	*undulatus*
Muraenidae	*Gymnothorax*	*nudivomer*
Muraenidae	*Gymnothorax*	*meleagris*
Muraenidae	*Gymnothorax*	*favagineus*

Table 11 cont.

Muraenidae	*Rhinomuraena*	*quaesita*
Muraenidae	*Siderea*	*grisea*
Muraenidae	*Siderea*	*picta*
Myliobatidae	*Aetobatus*	*narinari*
Nemipteridae	*Scolopsis*	*vosmeri*
Nemipteridae	*Scolopsis*	*xenochrous*
Nemipteridae	*Scolopsis*	*bilineatus*
Nemipteridae	*Scolopsis*	*bimaculatus*
Ophichthydae	*Myrichthys*	*colubrinus*
Pempheridae	*Pempheris*	*oualensis*
Pempheridae	*Pempheris*	*vanicolensis*
Pempheridae	*Pempheris*	*schwenkii*
Pinguipedidae	*Parapercis*	*clathrata*
Pinguipedidae	*Parapercis*	*hexophthalma*
Pomacanthidae	*Apolomichthys*	*xanthurus*
Pomacanthidae	*Centropyge*	*multispinis*
Pomacanthidae	*Centropyge*	*flavipectoralis*
Pomacanthidae	*Centropyge*	*eibli*
Pomacanthidae	*Pomacanthus*	*annularis*
Pomacanthidae	*Pomacanthus*	*imperator*
Pomacanthidae	*Pomacanthus*	*semicirculatus*
Pomacentridae	*Abudefduf*	*vaigiensis*
Pomacentridae	*Abudefduf*	*septemfasciatus*
Pomacentridae	*Abudefduf*	*sordidus*
Pomacentridae	*Amblyglyphidodon*	*leucogaster*
Pomacentridae	*Amphiprion*	*clarkii*
Pomacentridae	*Amphiprion*	*sebae*
Pomacentridae	*Amphiprion*	*nigripes*
Pomacentridae	*Chromis*	*dimidiata*
Pomacentridae	*Chromis*	*cinerascens*
Pomacentridae	*Chromis*	*opercularis*
Pomacentridae	*Chromis*	*ternatensis*
Pomacentridae	*Chromis*	*viridis*
Pomacentridae	*Chromis*	*atripectoralis*
Pomacentridae	*Chrysiptera*	*leucopoma*
Pomacentridae	*Chrysiptera*	*kuiteri*
Pomacentridae	*Chrysiptera*	*biocellata*
Pomacentridae	*Chrysiptera*	*unimaculata*
Pomacentridae	*Chrysiptera*	*glauca*
Pomacentridae	*Dascyllus*	*trimaculatus*
Pomacentridae	*Dascyllus*	*aruanus*
Pomacentridae	*Dascyllus*	*carneus*
Pomacentridae	*Dascyllus*	*reticulatus*
Pomacentridae	*Neoglyphidodon*	*bonang*
Pomacentridae	*Neopomacentrus*	*azysron*
Pomacentridae	*Neopomacentrus*	*cyanomos*
Pomacentridae	*Plectroglyphidodon*	*dickii*
Pomacentridae	*Plectroglyphidodon*	*lacrymatus*
Pomacentridae	*Pomacentrus*	*coelestis*
Pomacentridae	*Pomacentrus*	*similis*

Table 11. Cont.

Pomacentridae	*Pomacentrus*	*proteus*
Pomacentridae	*Pomacentrus*	*philippinus*
Pomacentridae	*Pomacentrus*	*nagasakiensis*
Pomacentridae	*Pomacentrus*	*chrysurus*
Pomacentridae	*Stegastes*	*nigricans*
Pomacentridae	*Stegastes*	*lividus*
Pseudochromidae	*Pseudochromis*	*fuscus*
Pseudochromidae	*Pseudochromis*	*sp.*
Rhinobatidae	*Rhyncobatus*	*spp.*
Scaridae	*Chlorurus*	*sp.*
Scaridae	*Scarus*	*atrilunula*
Scaridae	*Scarus*	*rubroviolaceus*
Scaridae	*Scarus*	*spp.* (unidentified)
Scaridae	*Scarus*	*ghobban*
Scaridae	*Scarus*	*russelii*
Serranidae	*Aethaloperca*	*rogaa*
Serranidae	*Cephalopholis*	*argus*
Serranidae	*Cephalopholis*	*formosa*
Serranidae	*Cephalopholis*	*miniata*
Serranidae	*Cephalopholis*	*sonnerati*
Serranidae	*Cephalopholis*	*sexmaculata*
Serranidae	*Cephalopholis*	*boenack*
Serranidae	*Cephalopholis*	*nigripinnis*
Serranidae	*Chromileptis*	*altivelis*
Serranidae	*Diploprion*	*bifasciatum*
Serranidae	*Epinephelus*	*caeruleopunctatus*
Serranidae	*Epinephelus*	*fuscoguttatus*
Serranidae	*Epinephelus*	*merra*
Serranidae	*Epinephelus*	*hexagonatus*
Serranidae	*Epinephelus*	*fasciatus*
Serranidae	*Epinephelus*	*longispinis*
Serranidae	*Epinephelus*	*tukula*
Serranidae	*Epinephelus*	*undulosus*
Serranidae	*Epinephelus*	*quoyanus*
Serranidae	*Epinephelus*	*microdon*
Serranidae	*Epinephelus*	*tauvina*
Serranidae	*Epinephelus*	*faveatus*
Serranidae	*Epinephelus*	*flavocaeruleus*
Serranidae	*Epinephelus*	*malabaricus*
Serranidae	*Epinephelus*	*rivulatus*
Serranidae	*Grammistes*	*sexlineatus*
Serranidae	*Plectropomus*	*leopardus*
Serranidae	*Plectropomus*	*maculatus*
Serranidae	*Plectropomus*	*laevis*
Serranidae	*Pogonoperca*	*punctata*
Serranidae	*Pseudanthias*	*evansi*
Serranidae	*Pseudanthias*	*ignitus*
Serranidae	*Pseudanthias*	*squamipinnis*
Serranidae	*Pseudanthias*	*cooperi*

Table 11. Cont.

Serranidae	*Pseudanthias*	*bimaculatus*
Serranidae	*Rabaulichthys*	*stigmaticus*
Serranidae	*Variola*	*louti*
Siganidae	*Siganus*	*javus*
Siganidae	*Siganus*	*lineatus*
Siganidae	*Siganus*	*canaliculatus*
Siganidae	*Siganus*	*virgatus*
Siganidae	*Siganus*	*stellatus*
Tetraodontidae	*Arothron*	*hispidus*
Tetraodontidae	*Arothron*	*nigropunctatus*
Tetraodontidae	*Arothron*	*stellatus*
Tetraodontidae	*Canthigaster*	*solandri*
Tetraodontidae	*Canthigaster*	*valentini*
Tetraodontidae	*Canthigaster*	*bennetti*
Torpenididae	*Torpedo*	*spp.*
Trichonotidae	*Trichonotus*	*setiger*
Trichonotidae	*Trichonotus*	*sp.*
Zanclidae	*Zanclus*	*cornutus*

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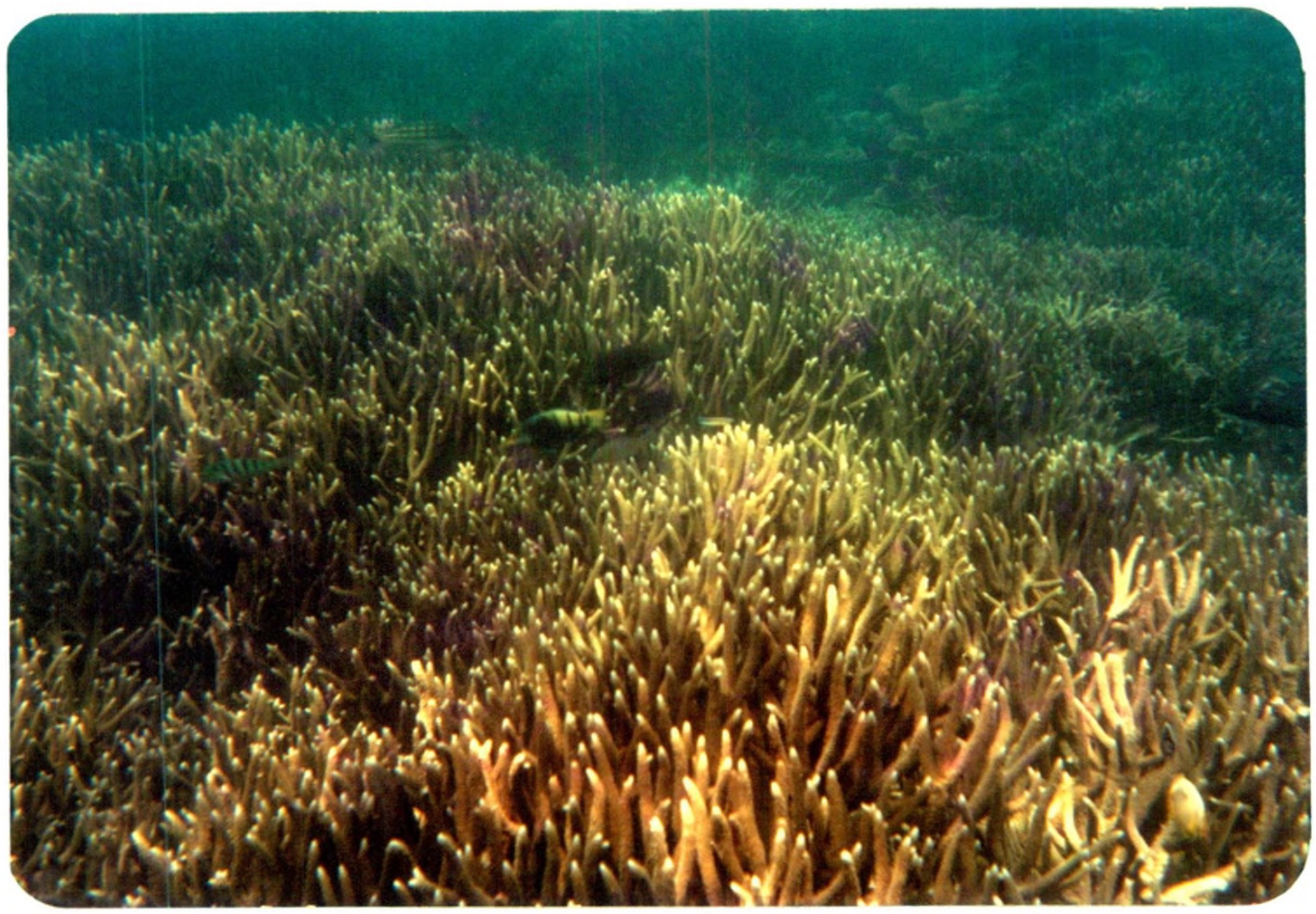
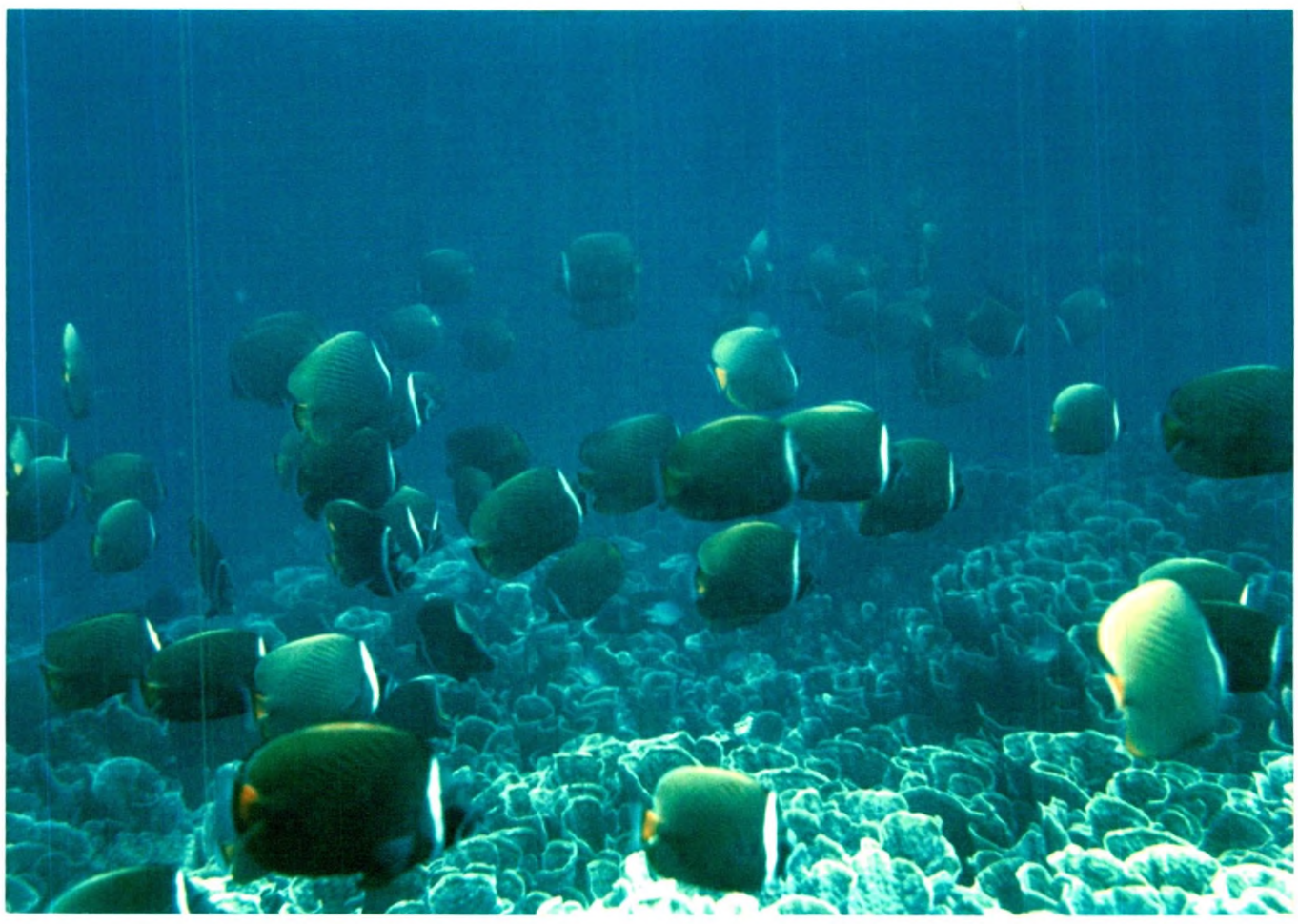
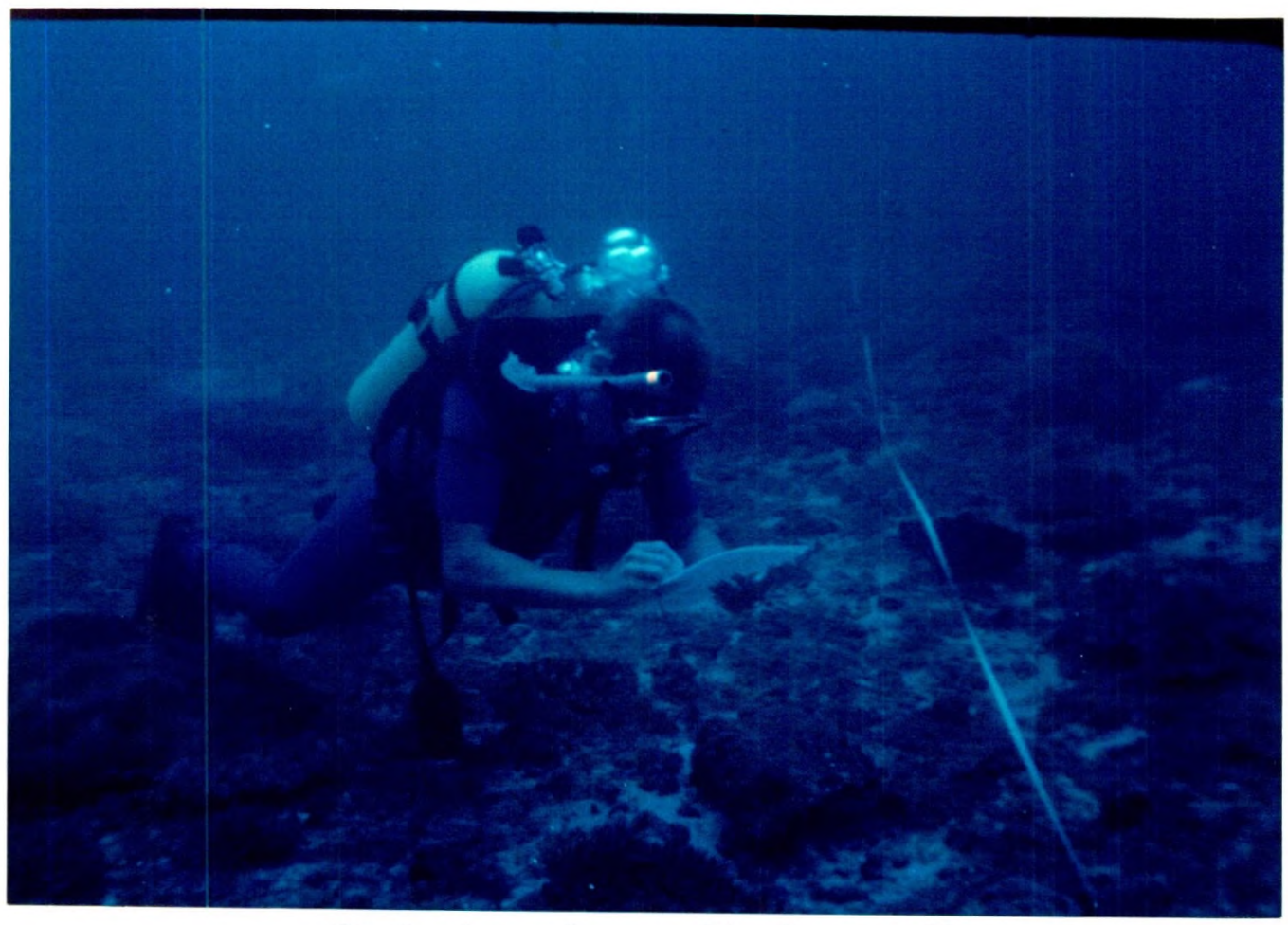


Undamaged sections of the Bar Reef



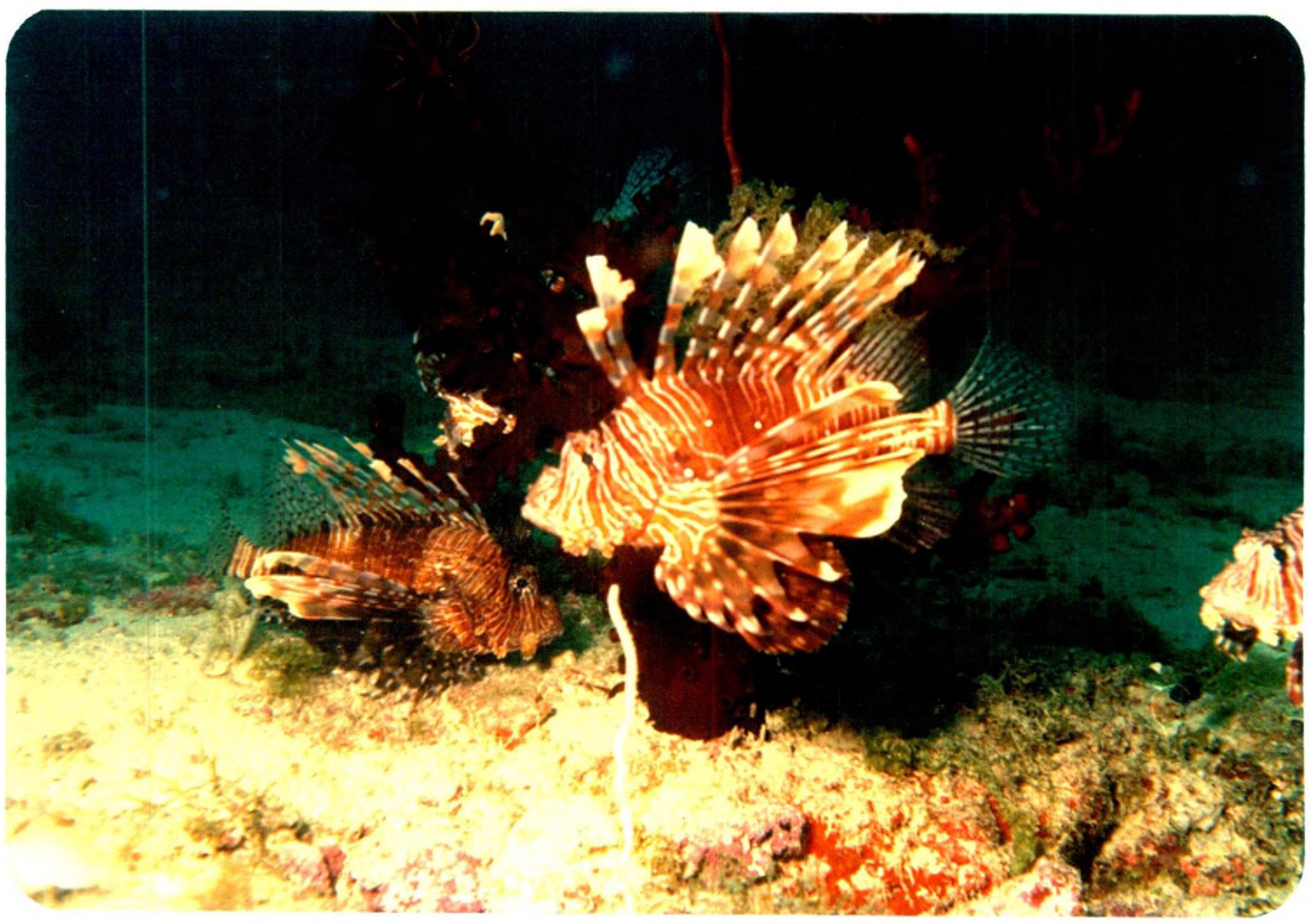
Shoal of *Chaetodon collare*, important for the ornamental fish trade

Interviewing fishermen



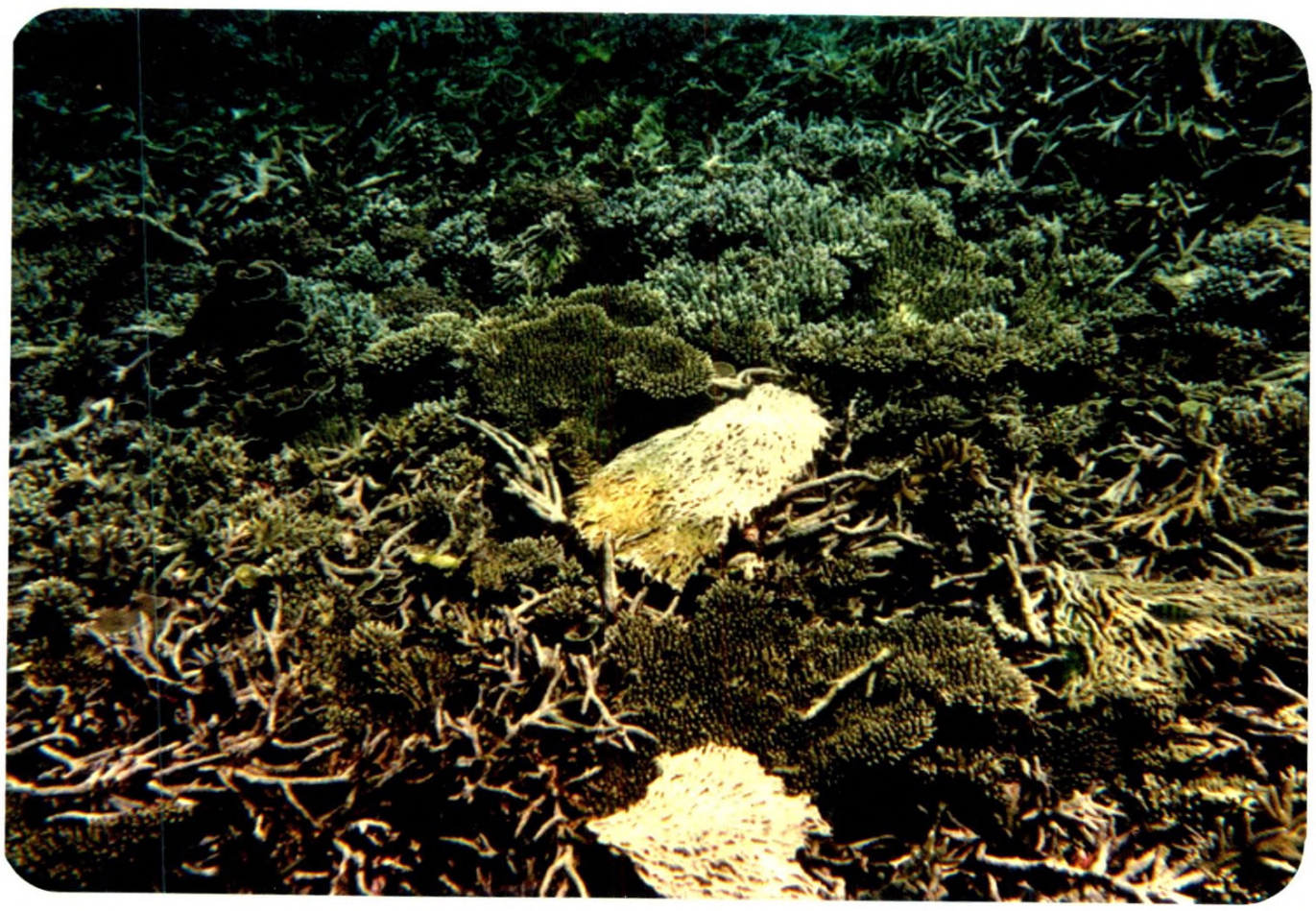
Conducting underwater Line Intercept Transects

Structured sandstone reef habitat



Flat sandstone reef habitat

Ornamental fish collectors using a moxy net



Damaged coral due to bottom set nets

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