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ABUNDANCE AND COMMUNITY STRUCTURE OF REEF BUILDING CORALS IN LAKSHADWEEP ISLANDS, INDIA

BY

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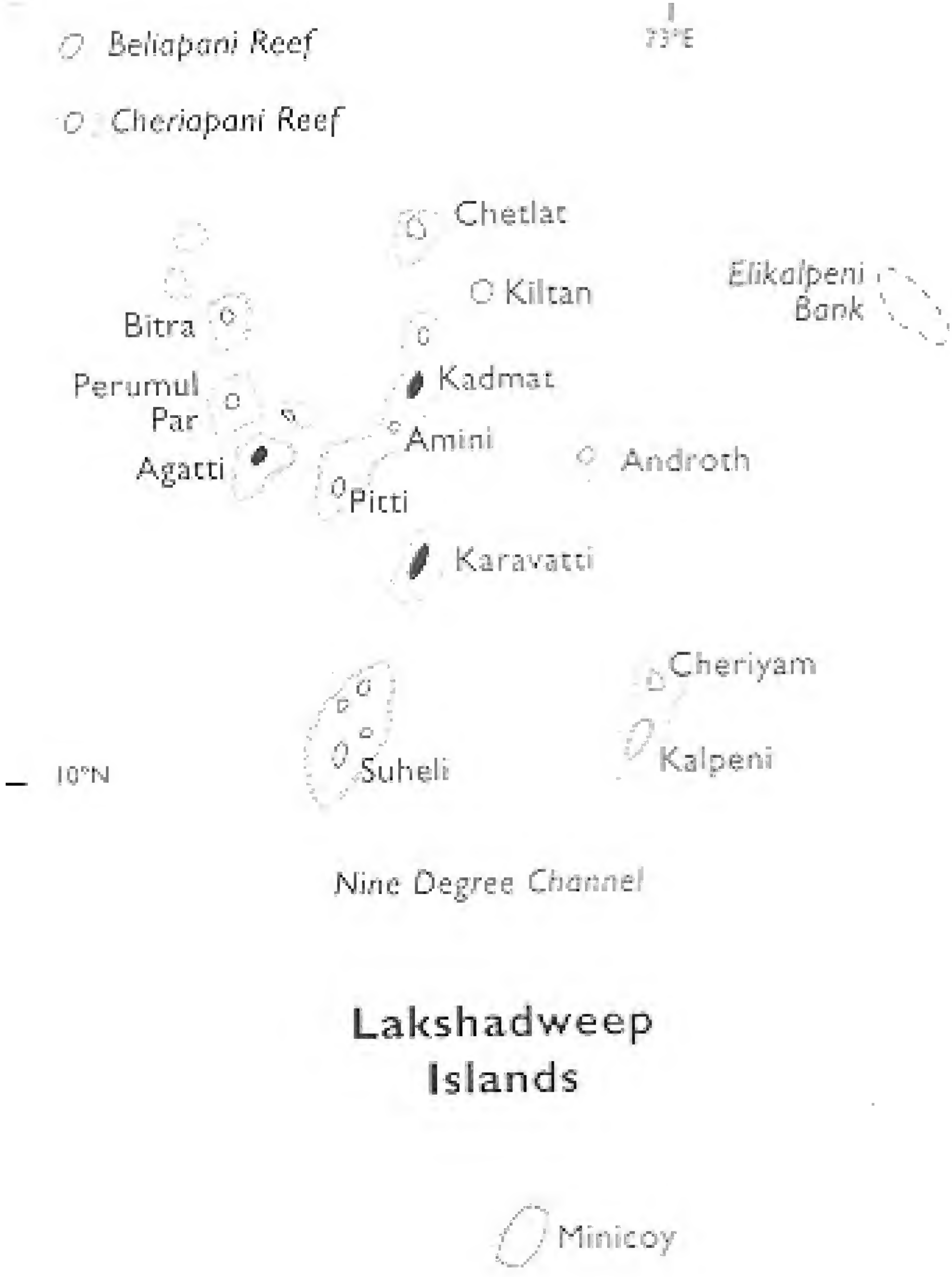

Figure 1. Map showing the surveyed islands (■) at Lakshadweep Archipelago

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ABSTRACT

Coral reefs were surveyed at three islands (Kavaratti, Kadmat and Agatti) of Lakshadweep during February 2005 using the Line Intercept Transect method. The percent coverage of coral in all the three islands was good (55%), dominated by *Acropora* spp. (33 %) of the live coral cover. Twenty three genera of corals are reported with two new records for the Lakshadweep islands. No apparent bleaching and crown-of-thorns starfish (COTS) related mortality of coral was observed in the three islands. The abundance and distribution of corals and associated biota were recorded along with the characterization of the benthic communities at these sites.

INTRODUCTION

The Lakshadweep Archipelago (71˚-74˚ E longitude and 8˚-12˚30' N latitude) consists of 12 coral atolls with 36 islands, 3 reefs and 5 submerged banks situated at the northern end of the Laccadive-Chagos ridge, 225-450 km west off the Kerala coast (Fig.1). These islands vary in size from 0.1sq.km (Bitra) to 4.8 sq. km (Androth) and are surrounded by 4,200 sq. km of lagoon, raised reefs and banks. The population on the 10 inhabited islands ranges from 100 on Bitra Island to 10,000 on Kavaratti. All inhabited Lakshadweep islands are protected by an outer reef which encloses a shallow lagoon with the exception of Androth, which is exposed on all sides (Jones and Kumaran, 1980); the coastline of Lakshadweep islands is 132km (Wafar, 1999).

The islands receive heavy southwest monsoonal rain ranging between 156 and 225 cm/year with most of it falling between June and September (Pillai, 1971) with air temperatures ranging between 20.1˚ to 32.9˚C. The lagoons have surface seawater temperatures of 22° to 28° C, salinities of 36 to 39.4 ppt, and oxygen levels between 1 and 15 ml/l (Girijavallaban et al., 1989). The reefs enclose the islands in extensive lagoons and protect them from storm and other disturbances of the sea. The island complexes around India, in contrast, show healthy reef growth and support high species diversities.

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Central Marine Fisheries Research Institute (CMFRI) made a study of the marine fauna of Lakshadweep in 1989. Then in 1998, Department of Science and Technology, Lakshadweep (DST), Lakshadweep in association with the Global Coral Reef Monitoring Network (GCRMN South Asia) undertook the first Reef Check survey in India, at Kavaratti and Kadmat Islands, Lakshadweep (Rajasuriya et al., 1999; Arthur, 1999; Koya, S.I. and Wafar, per. com.). Various other agencies and individuals (Rajasuriya and Karunarathna, 2000; DOD, 2001; Callum, 2002; Anon., 1991) have given some preliminary hot spot assessment/conservation points from different perspectives.

The present study focuses on: 1) determination of the abundance and distribution of coral associated reef biota and 2) characterization of the reef habitat along with the inventory resources.

MATERIALS AND METHODS

Description of the Study Areas

Kavaratti. Kavaratti (Fig. 2), the capital island situated at 10°33' N and 72°38' E and 404 km from Cochin, has a land area of 3.63 sq. km. At the northern end, the lagoon is shallow and the coral growth is found to be healthier. Kavaratti is the most centrally located island in this archipelago.

At Kavaratti, the southwestern atoll, shows excessive deposits of silt at some areas which resulted in dead colonies at the top portion of the lagoon reef. The three spots selected at Kavaratti are Dolphin Centre (Northwest), West Entrance, and Wind Mill (South). During the survey at Kavaratti, the tide and visibility were good (16-19 m).

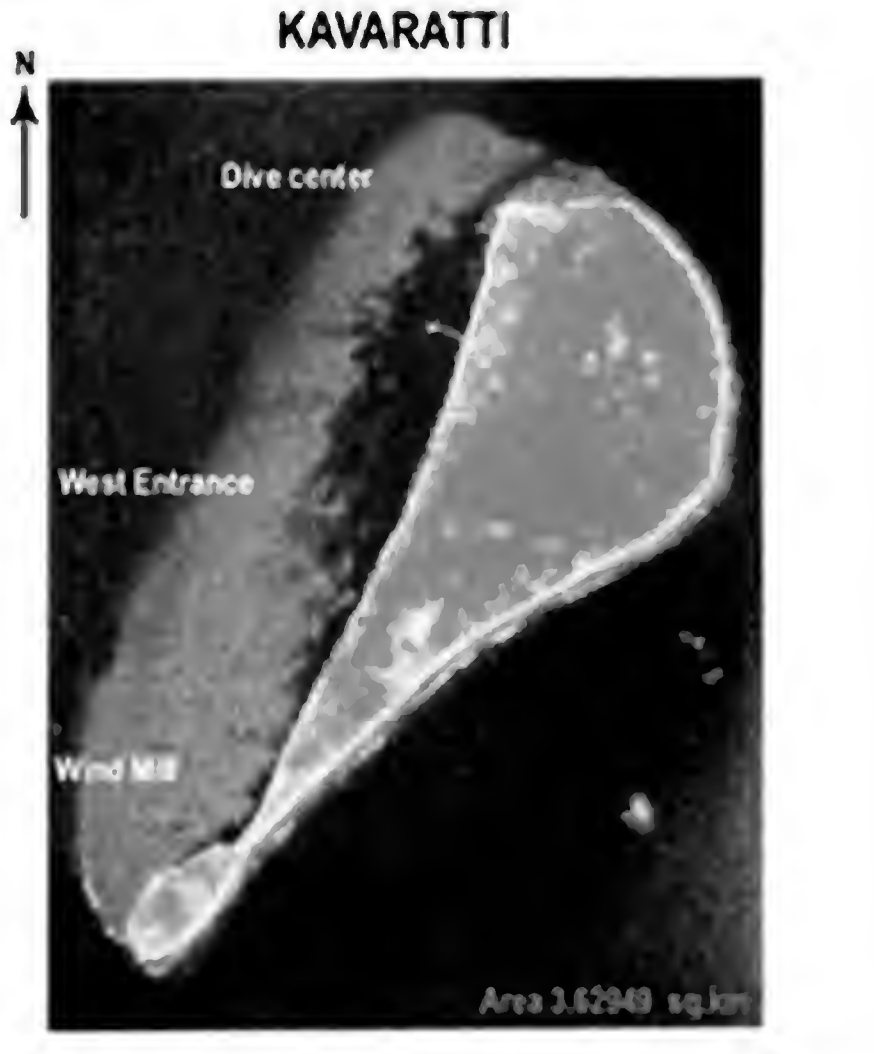

Figure 2. Location of transects at Kavaratti island, Lakshadweep.

Kadmat. Kadmat (Fig. 3), located at 11°13' N and 72°47' E, is 407 kms from Cochin. It has a land area of 3.12 sq. km and is 8 kms long and 550 m wide at the broadest point. It is the longest island and has a very large lagoon on the western side with abundant coral growth. The three spots selected were: Ship Wreck (Northwest), Main Entrance (West) and Tourist Hut (South). Mostly, the sea was calm with good visibility to 18 m during diving at Kadmat.

Agatti. Agatti (Fig. 4) is located at 10°51' N 72°11' E and 459 kms from Cochin. It has a land area of 2.7 sq.km: 6 kms long and 1 km wide. Three spots selected were: Main Entrance (Northwest), West Entrance, and Japanese Garden (Southeast). The weather was quite windy and cloudy during the survey at Agatti. Visibility was observed to 20 m.

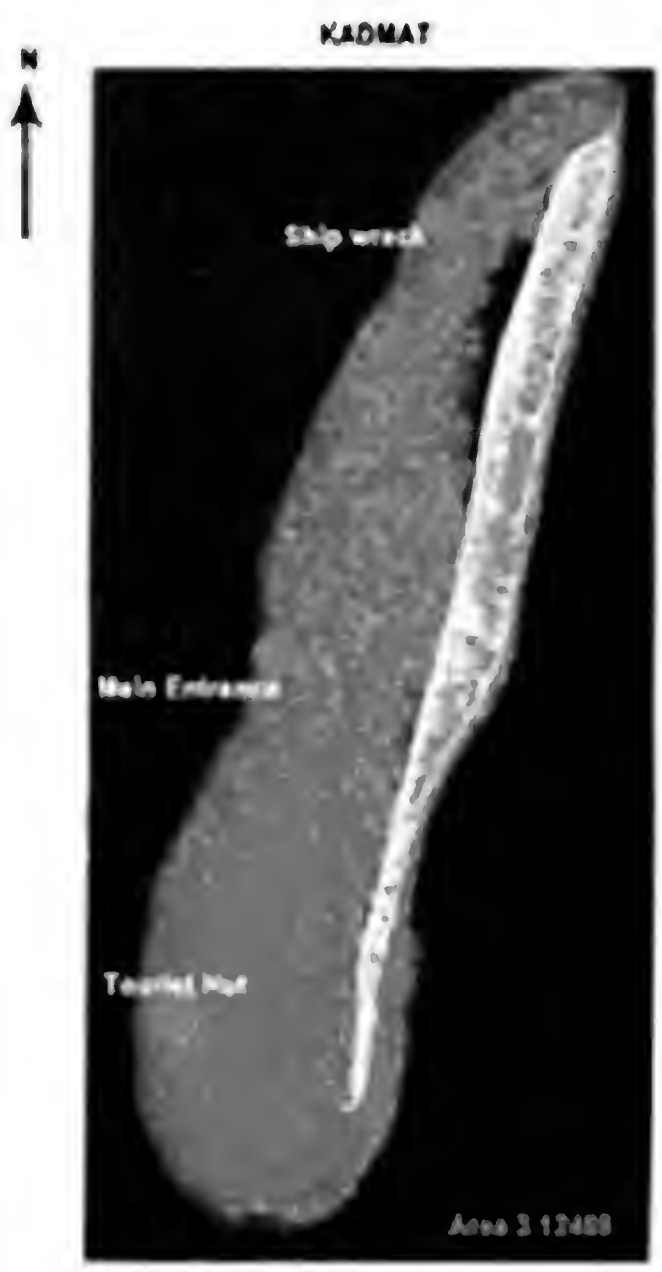

Figure 3. Location of transects at Kadmat island, Lakshadweep.

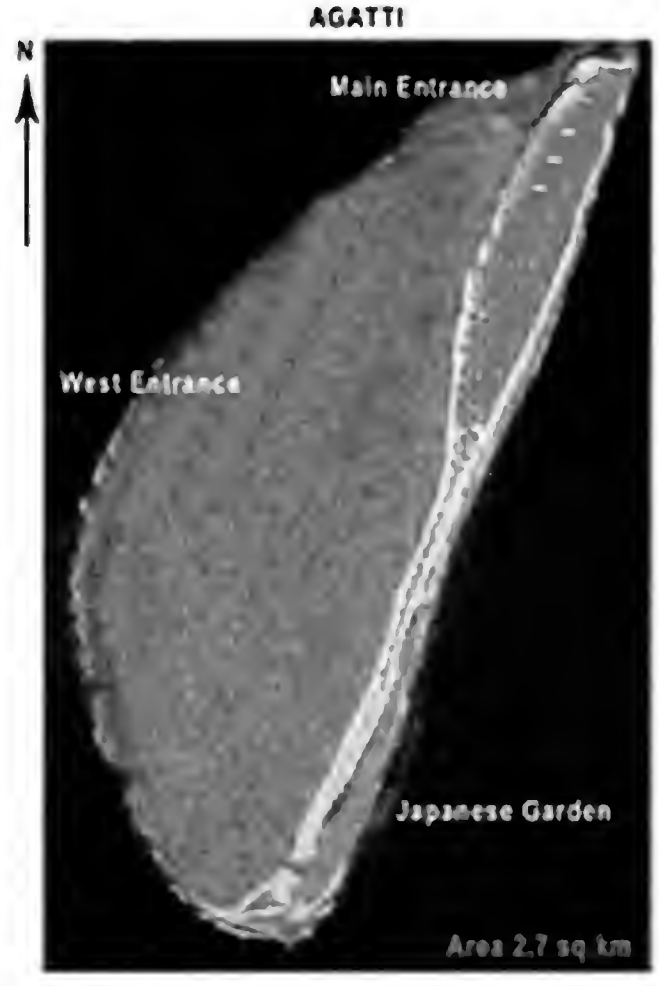

Figure 4. Location of the transects at Agatti island, Lakshadweep.

Methodology

Three spatially distinct areas (< 2 km^2) in each of the three islands were selected to record the coral percent coverage and diversity. Sampling was conducted using SCUBA on the outer reef crest using Line Intercept Transects (LIT) at depths ranging

from 4 to 10 m. LIT was used to calculate the percent coverage of both living and non-living benthos. Two spatially distinct sites were surveyed in each area. At each site, at least two LIT were conducted. Data suggested that two surveys in three different sites in each island would be adequate for determining the abundance of the most common species within the desired precision (20%). Two transects of 20 m were placed parallel to depth contour at each site. To account for intra-site variation, transects were laid in representative areas of the substrate at a distance separated by 10 to 30 m, such that surveys were distributed over approximately 150 m to 250 m of each reef. The intercepts of all underlying coral species, characterization of dead and live coral (massive / submassive / branching / digitate, mushroom and foliose), soft coral, sponge, macro algae and sand were recorded to the nearest 1 cm along each transect.

RESULTS

Biodiversity and Status of Coral Reefs/Ecosystem

This study found mean live coral cover for the three islands to be 53.5%, 53.6% and 58% and for dead coral surface to be 27.3%, 25.8% and 24.1% at Kavaratti, Kadmat and Agatti respectively. The average relative abundance of each category of benthos is given in Tables 1-3.

For the purpose of easy understanding, the variations in percentage cover encountered under the transects for the benthic biota are grouped in 5 main categories: hard corals, total algae, soft corals, other invertebrates and rubble, which shows the dominance of hard corals and algae in all the three surveyed islands (Figs. 5-8). The summary of observed benthic coverage under transects (n =18) was averaged and recorded in Table 4. Twenty-one genera of corals were recorded in the three surveyed islands of Lakshadweep (Table 5). The average bottom coverage at Kavaratti, Kadmat and Agatti shows both tabular and branching *Acropora* dominance (9.6% and 9.1%) with a greater diversity followed by massive and encrusting corals (8.5% and 7.5%) of the

Table 1. The average relative abundance of each category of benthos at each survey area in Kavaratti island (mean is ± 1 SD).

Sl. No.	Benthos	Dolphin Dive Centre (Northwest)	West Entrance	Wind Mill (South)	Mean
1.	Live coral	52.5	54.5	53.5	53.5 (1.0)
2.	Dead coral	25.0	27.0	30.0	27.3 (2.5)
3	Coralline algae	15.5	10.0	9.0	11.5 (3.5)
4	Macro algae	1.0	1.0	3.5	1.8 (1.4)
5	Turf algae	1.5	1.0	0.0	0.8 (0.8)
6	Algal assemblage	1.0	5.0	1.0	2.3 (2.3)
7	Halimeda	0.0	0.0	1.0	0.3 (0.6)
8	Zoanthids	1.5	2.5	2.0	2.0 (0.5)
9	Others	2.4	2.4	2.5	2.4 (0.1)

Table 2. The average relative abundance of each category of benthos at each survey area in Kadmat island (mean is ± 1 SD).

Sl. No.	Benthos	Ship Wreck (Northwest)	Main Entrance (West)	Tourist Hut (South)	Mean
1	Live coral	50.5	44.5	66.0	53.6 (11.1)
2.	Dead coral	27.5	34.5	20.5	27.5 (7.0)
3	Coralline algae	14.0	14.5	6.0	11.5 (4.8)
4	Macro algae	2.5	0.0	3.0	1.8 (1.6)
5	Turf algae	1.0	3.0	2.5	2.2 (1.0)
6	Algal assemblage	0.5	0.0	0.0	0.2 (0.3)
7	Halimeda	0.5	0.0	0.0	0.2 (0.3)
8	Zoanthids	0.5	0.5	0.5	0.5 (0.0)
9	Others	1.5	1.4	1.5	1.5 (0.1)

Table 3. The average relative abundance of each category of benthos at each survey areas in Agatti island (mean is ± 1 SD).

Sl. No.	Benthos	Main Entrance (Northwest)	West Entrance	Japanese Garden (Southeast)	Mean
1.	Live coral	62.5	59.0	52.5	58.0 (5.1)
2.	Dead coral	21.5	23.0	28.0	24.1 (3.4)
3	Coralline algae	12.0	14.0	15.5	13.8 (1.8)
4	Macro algae	2.5	0.0	0.0	0.8 (1.4)
5	Turf algae	0.0	1.5	2.0	1.2 (1.0)
6	Algal assemblage	0.0	0.0	0.0	0.0
7	Halimeda	0.0	0.0	0.0	0.0
8	Zoanthids	1.6	1.5	1.9	1.7 (0.2)
9	Others	2.4	2.3	1.5	2.1 (0.5)

non-*Acropora* spp. The highest live bottom coverage was coralline algae with an average for the three islands of 12.3%.

Species of *Acropora* dominated in all the three islands followed by *Fungia*, *Porites*, *Montipora*, *Pavona, Goniopora*, *Favites*, *Favia, Astreopora*, *Pocillopora, Psammocora, Stylophora, Goniastrea* along with two new records of *Siderastrea* (Kavaratti and Agatti) and *Seriatopora* (Kavaratti) (Table 5). *Leptoria* and *Symphillia* are new records to the three islands (Kavaratti, Kadmat and Agatti); *Goniopora* and *Stylophora* are new records to Kavaratti and Agatti whereas *Goniastrea, Astreopora, Montipora* and *Millepora* are new to Agatti and *Favia* is new to Kadmat and Agatti.

Table 5. Inventory of coral species observed and their occurrence in the survey areas of Lakshadweep (See Fig. 1- 4 for location of sites); species in xx represent a new record to that particular island and species in caps are a new record to Lakshadweep; – represents no observaions at the particular site.

Table 4. Summary of observed benthic coverage (mean % cover) by site.

Site details and Benthos	Kavaratti Island	Kadmat Island	Agatti Island	Pooled data
Habitat	Outer Lagoon	Outer Lagoon	Outer Lagoon	-
Depth (m)	4-9	3-9	4-10	3-10
Visibility (m)	16-19	18	20	16-20
No. of transects (n)	6	6	6	18
Acropora				
branching	6	9.2	12.2	9.1
encrusting	3.3	1.2	2.5	2.3
submassive	7.4	7.2	4.9	6.5
digitate	5.7	4.1	6.7	5.5
tabular	8.9	10.1	9.9	9.6
Non-Acropora				
branching	0.5	0.6	1.9	1.0
encrusting	9.6	8.2	4.8	7.5
foliose	0.6	1.5	0.0	0.7
massive	7.2	7.9	10.4	8.5
submassive	2.2	0.5	0.0	0.9
Mushroom coral	1.4	1.5	2.5	1.8
Heliopora	0.3	0.2	1.0	0.5
Millepora	0.4	1.4	1.2	1.0
Total coral cover	53.5	53.6	58.0	55.0
Sponges	0.3	0.5	0.3	0.4
Soft coral	0.1	0.5	0.1	0.2
Zoanthids	2	0.5	1.7	2.1
Algae				
Coralline algae	11.5	11.5	13.8	12.3
Macro algae	1.8	1.8	0.8	1.5
Turf algae	0.8	2.2	1.2	1.4
Algal assemblage	2.3	0.2	0	0.8
Halimeda	0.3	0.2	0	0.2
Total algal cover	16.7	15.9	15.8	16.1
Rubbles/silt/sand	0.1	1.5	0.0	0.4
Dead coral	27.3	27.5	24.1	26.3

Stress tolerant *Porites* sp. is common in all the study areas. Encrusting corals are healthy and unaffected by the anomalous temperature while largely unaffected tabular and massive *Favia* are also observed in the survey (55% healthy coral) (Figs. 9-21).

The condition of reefs surveyed varied from healthy to heavily impacted by natural and anthropogenic factors. Of these, siltation and cyclone damage appeared to be important. Degradation of dead coral through bioerosion and wave action has led to increased sand and rubble formation, increasing stress through abrasion and suffocation, which was observed in most of the surveys (Figs. 20 and 21).

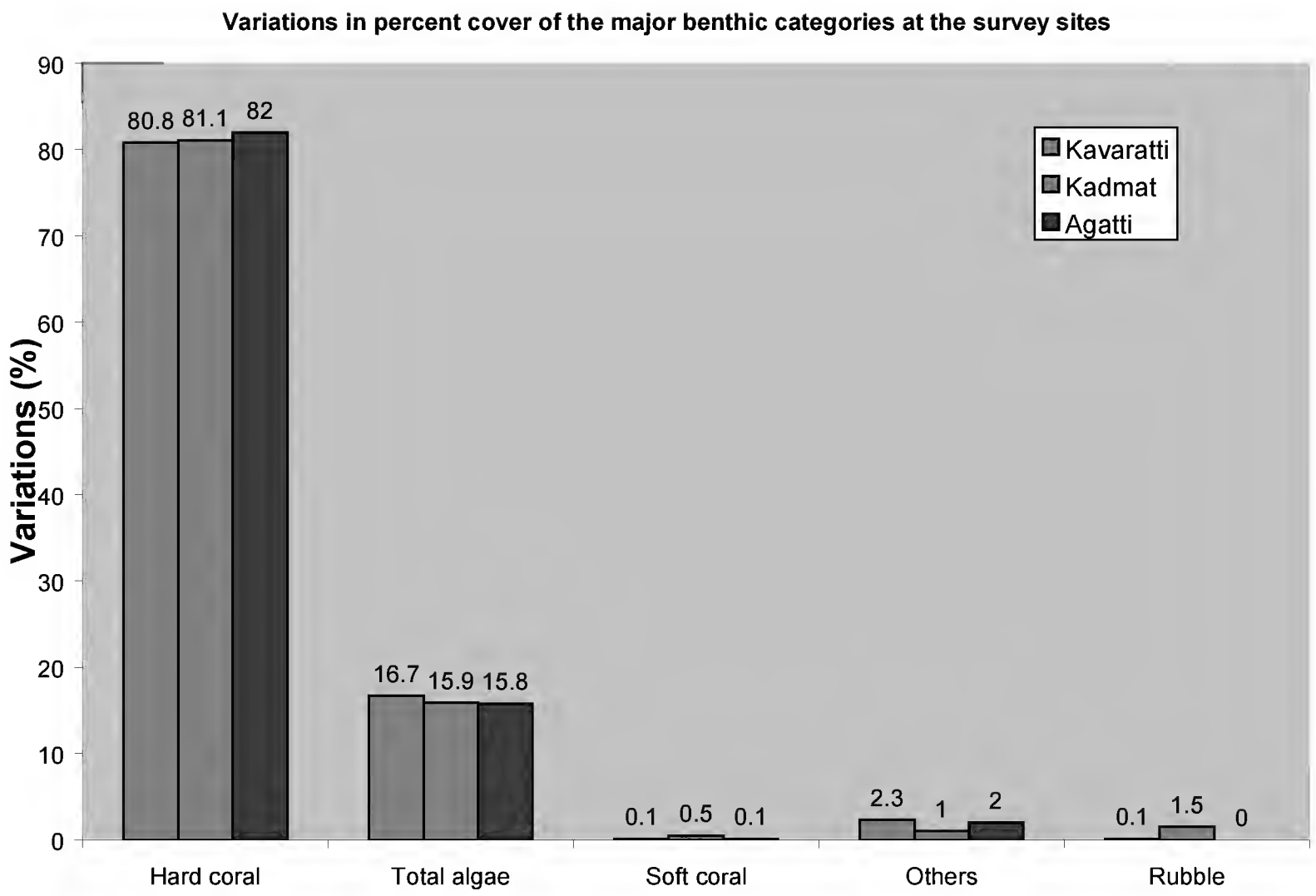

Figure 5. Variations in percentage cover of the major benthic categories at the survey sites..

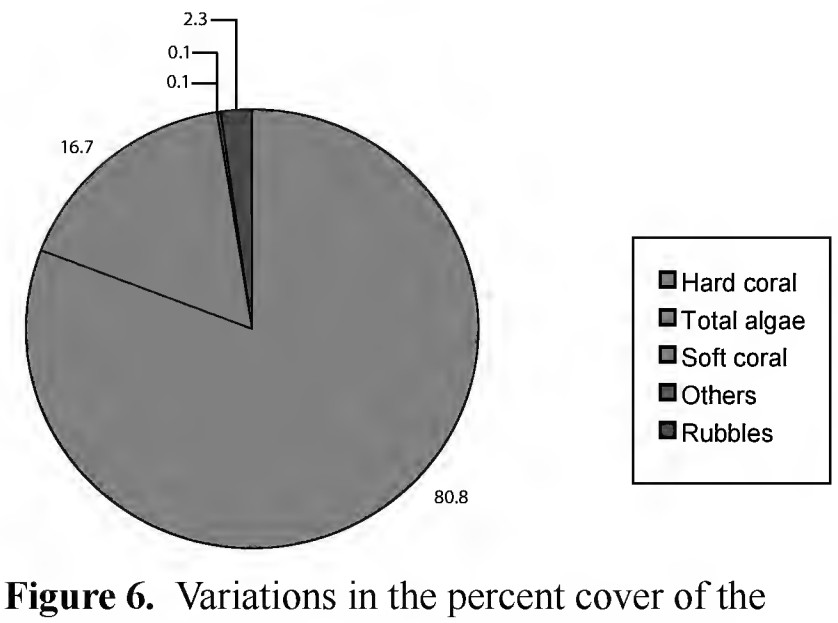

Figure 6. Variations in the percent cover of the major benthic categories at Kavaratti Island.

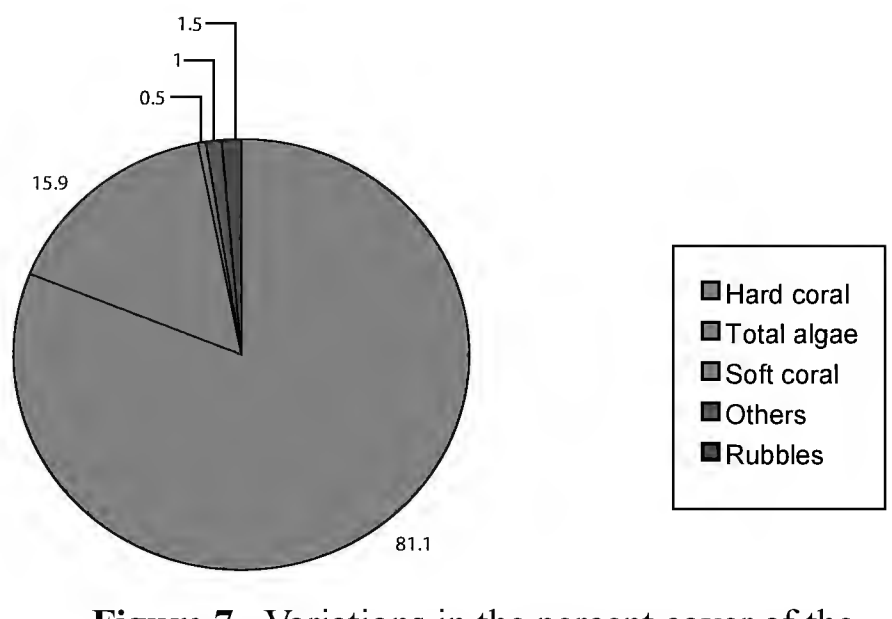

Figure 7. Variations in the percent cover of the major benthic categories at Kadmat island.

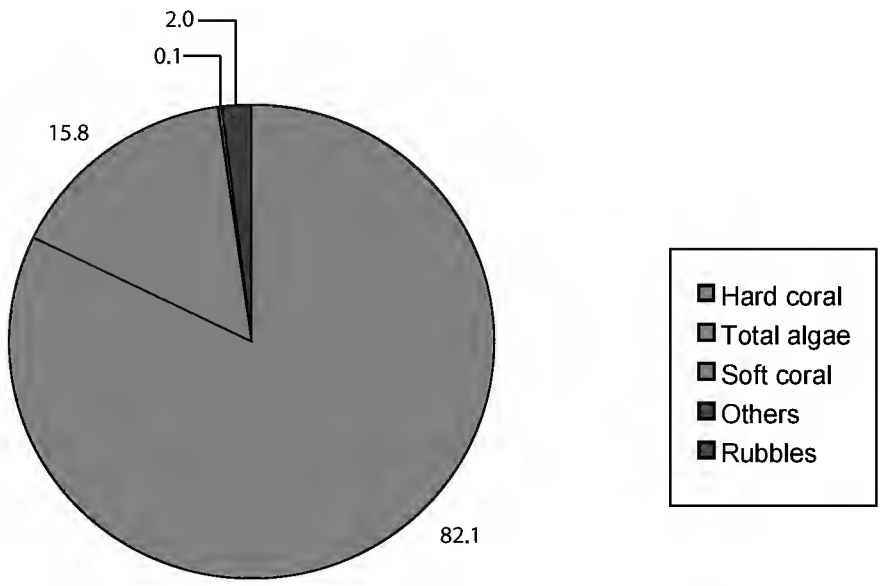

Figure 8. Variations in the percent cover of the major benthic categories at Agatti island.

Table 5. Inventory of coral species observed and their occurrence in the survey areas of Lakshadweep (See Fig. 1- 4 for location of sites); species in xx represent a new record to that particular island and species in caps are a new record to Lakshadweep; – represents no observaions at the particular site.

Genus	Kavaratti Island	Kadmat Island	Agatti Island
Acropora branching	x	x	x
Acropora tabular	x	x	x
Acropora digitate	x	x	x
Acropora encrusting	x	x	x
Acropora submassive	x	x	x
Astreopora	x	x	xx
Pocillopora	x	x	x
Montipora	x	x	xx
Porites	x	x	x
SIDERASTREA	xx	-	xx
Psammocora	x	x	-
Stylophora	xx	x	xx
SERIATOPORA	xx	-	-
Hydnophora	x	x	x
Leptoria	xx	xx	xx
Symphyllia	xx	xx	xx
Goniastrea	x	x	xx
Pavona	x	x	-
Favia	x	xx	xx
Favites	x	x	x
Goniopora	xx	x	xx
Turbinaria	-	x	x
Fungia	x	x	x
Heliopora	x	x	x
Millepora	x	x	xx

Figure 9. Reef crest of Kavaratti.

Figure 10. An *Acropora* and *Pocillopora* colony along with red calcareous algae at Kavaratti.

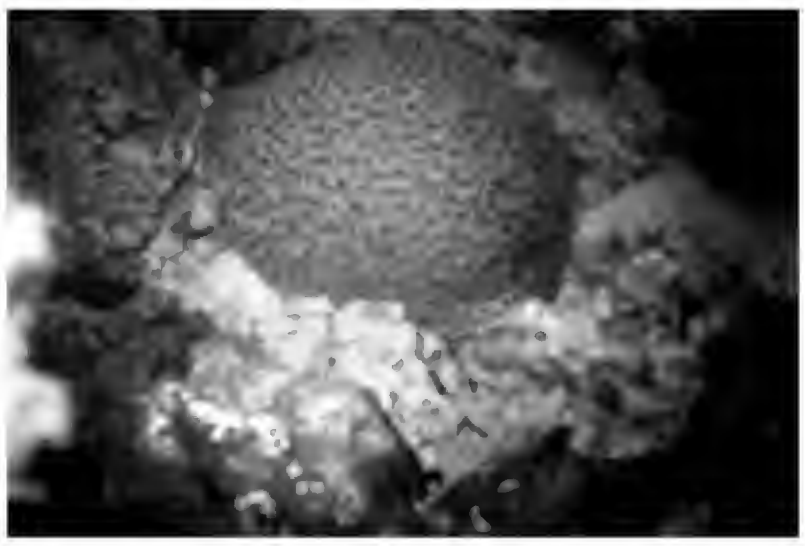

Figure 11. A brain coral at Kadmat.

Figure 12. An Indian cushion starfish at Kadmat.

Figure 13. View of live coral covers at Kadmat island.

Figure 14. Reef fishes among Acropora tabular at Kavaratti island.

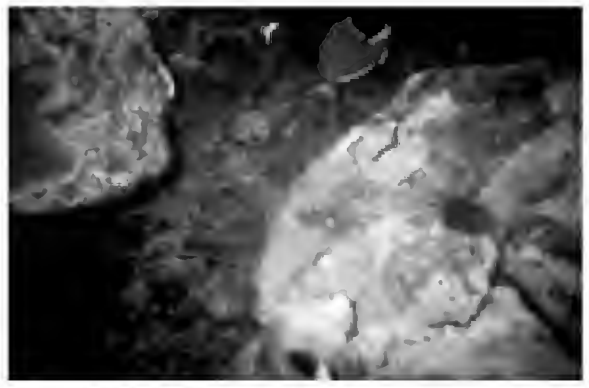

Figure 15. Red calcareous coralline algae along with a surgeon fish at Kadmat.

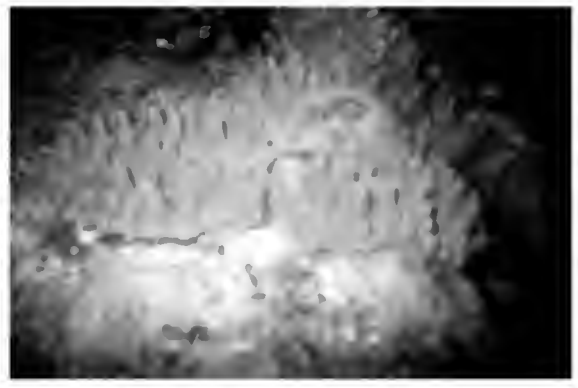

Figure 16. A soft coral colony at Agatti island (Japanese garden).

Figure 17. Close up of live massive *Favia* among coralline algae.

Figure 18. Coralline algae (pink area) and *Acropora digitata* under LIT at Kavaratti..

Figure 19. Dead coral coverage with sand at Kadmat.

Figure 20. Recolonisation of *Acropora digitata* among the dead corals at Kavaratti.

Figure 21. *Stylophora pistillata* in the midst of dead corals at Agatti.

Coral Reef Resources

Hard corals of 105 species among 37 genera and 603 species of fish have been recorded including both reef dwelling and oceanic species (Pillai and Jasmine, 1989). Over 600 species of marine fishes were reported from Lakshadweep (Heere, 1941; Jones, 1986; Tikader et al, 1986; Venkateswarlu, 1984). Marine ornamental fishes are discussed by Emmanuel et al., 1996.

In the present survey, the major benthic animals other than the corals observed were polychaetes, clams, barnacles, starfishes, sea anemones, sea cucumbers, sponges, octocorals (dominated by alcyonians and nephthids rather than gorgonids) (Fig. 16) and black corals. Large varieties of coral reef fishes included squirrelfish, parrotfish, butterflyfish, surgeonfish, triggerfish, damselfish, clownfish, eels, wrasses, emperors, snappers, groupers, barracudas, porcupine fishes, sharks and rays. Crustaceans such as crabs and shrimps, molluscan shells and echinoderms (*Indian cushion star*, Fig. 12) are regularly seen around the three islands.

Even though the study was initiated during February 2005, after the December 2004 tsunami along the west coast of India, no apparent impact was seen in the study areas.

DISCUSSION

It is evident from this study that 53.6% of the live coral cover observed in Kadmat island in February 2005 are healthy indeed. However an earlier report (Rajasuriya, et al., 1999), from the same study area, exceeded 80-90% before April 1998 with subsequent drastic reduction to 5% later (between September 29th to October 21st) in 1998 due to *El Nino*. After 1999 these reefs showed a pronounced resilience and they rapidly recovered (Wafar, 1999, Rajasuriya, *et. al*. 1999, Arthur, 1999, Pet-Soede et al., 2000 and Pillai and Venkataraman, 2000).

Post *El Nino* re-colonization could be attributed to the fact that the environment is relatively free from anthropogenic pressure. Therefore the ability of corals to recover from natural disaster in short period is evident. In another study, where corals were successfully transplanted in Kavaratti (Fig. 2), the waters are less polluted compared to mainland India (Mary, Unpublished 2005).

This observation points out the need for a comprehensive understanding of different components involved in the rapid re-colonization of the reefs. As of today there is no such survey of other associated faunal assemblage in the study area. Future research should orient in collecting information on the different communities such as benthic, to clearly understand the factors responsible for rapid recovery.

Also since there is no previous information on the benthic communities off Kavaratti and Agatti island and so time comparative studies are not possible. It is hoped that this study of the distribution of reef communities along the three islands of Lakshadweep will provide a basis for comparison to similar assessments in the future so that any major changes can be related to natural or anthropogenic environmental stresses.

Studies focusing of the coral reefs in Lakshadweep Islands are essential because (i) the reefs are atoll type, (ii) faster recovery rates after bleaching and (iii) can narrow down to the most influencing factors for successful resurrection of dead/bleached corals.

RECOMMENDATIONS

This study could not determine changes, if any, in the community structure and fish census because of the methodological inconsistencies with previous studies. However, the present study provides the basic information with which further long term monitoring can be compared. The recommendations and the priority areas for immediate action are:

1. The need for strict and sustained reef monitoring is stressed in all the islands of Lakshadweep at a broader level to keep track of any mortality, recovery and to detect the changes in the functioning of reef and associated biota.
2. A comprehensive study on fish abundance should be done in all the islands.
3. A scientific study on the major threats in all the islands should be done.
4. Assessment of the biodiversity and other baseline parameters can be done for all islands.
5. The promulgation of representative species such as coral reefs, seagrass beds, mangroves, marine sponges, octocorals, marine turtles, marine mammals, endangered marine species etc. alongwith the environments and systems from all islands should be emphasized.
6. Training of marine scientists in coral reef research and SCUBA diving should be encouraged.
7. Mapping of the areas for reef biota can be done.

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