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STATUS OF CORAL REEFS IN PALK BAY

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INTRODUCTION

Palk Bay is the sea between southeast of India and northwest of Sri Lanka, separated by Pamban Pass from Gulf of Mannar in the South and extends up to Kodiakarai coast in the North. The bay is characterized by a shallow basin with an average depth of 9 m. There is a well defined fringing reef which runs parallel to the shore, at the south west of the Palk Bay, extending 7.46 km from 09° 17' 14.8" N; 079° 11' 16.4" E at the East near Pamban to 09° 17' 34.4" N; 079° 06' 57.8" E towards the west of the bay, with the width varying from 200 m to 600 m at different places, and occurring at a maximum depth of 4 m. The lagoon is 1 -2 m deep, sandy with molluscan shells and pieces of disintegrating corals (Pillai, 1969). Described by the same author, a narrow channel divides the reef at mid-length in to eastern and western portions, locally called Kathuvallumuni reef and Vellapertumuni reef respectively. Beyond this reef to the west and extending northward are dense seagrass beds, which sustain the high productivity of this basin. There are also patchy occurrence of corals in this basin, occurring from southwest of the Rameswaram Island to its North.

Many scientific studies on Hydrology, physicochemical parameters, fauna and flora of Palk Bay are available, as reviewed by Venkataraman *et al.,* 2007. Information with respect to scleractinian corals are available for the fringing reef as early as 1969 (Pillai, 1969), and lately in 2007 (Venkataraman *et al.,* 2007). These works, though studied scleractinian diversity, especially Pillai's (1969) with species composition data (number of colonies in a perpendicular transect from the shore, a measure of benthic cover of coral species and other status assessment parameters were not covered. The coral patches around Rameswaram Island had not also been covered in these studies. Bio-physical status assessments (% benthic cover of life-forms) were made in these reefs, along the assessment of bleaching in 2002, however lacking in species-wise cover data (Kumaraguru *et al.,* 2003). Given this, a base-line information on coral status, based on diversity, species-wise cover, and other bio-physical categories has been made for the first-time in these reefs in 2010 and monitoring assessments in 2013. The report presented here is the status of these reefs based on the study as mentioned above and an analysis of change in terms of scleractinian species diversity and composition from Pillai's (1969) and Venkataraman *et al.,* (2007) work and available bio-physical data.

STUDY AREA AND METHODS

Seven stations in the fringing reef in the south west of the Palk Bay and 3 stations in the patch reefs in the East of Palk Bay have been marked (Fig.1), and bio-physical status assessed in October 2010 and subsequently in March 2013. The assessed parameters (hereafter mentioned as bio-physical categories) include, hard corals diversity, species-wise cover, live coral cover (LC), dead coral cover (DC), dead coral cover encrusted with turf algae (DCTA), coralline algae (COR), calcareous algae (CA), macro algae (MA),

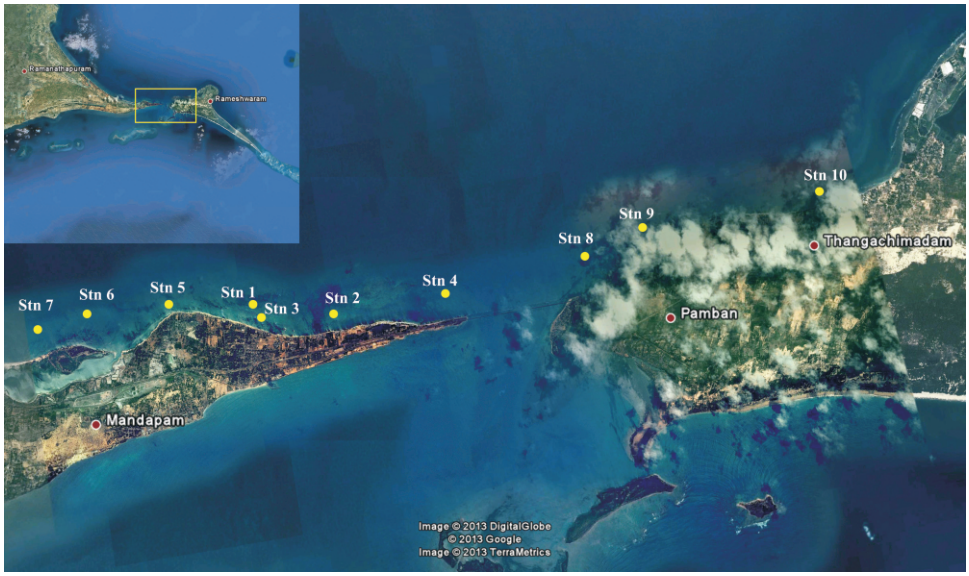

Fig. 1 : Map showing the monitoring stations in Palk Bay.

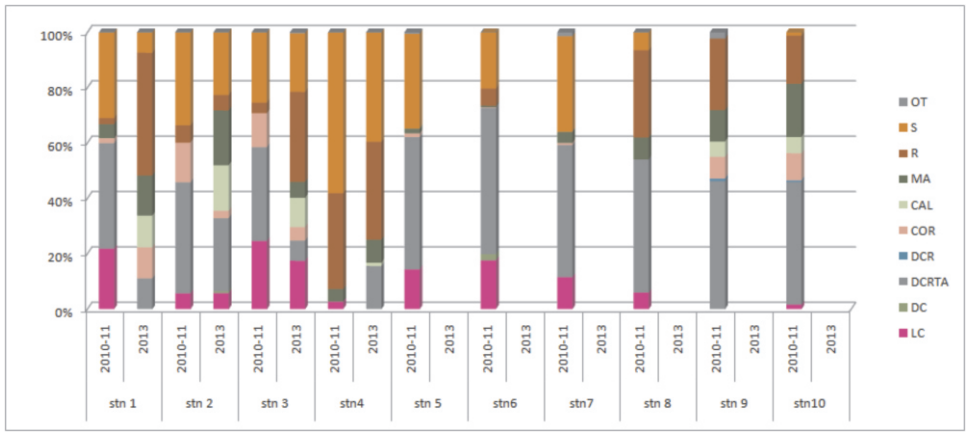

Fig. 2 : Station-wise comparison of life-form categories between 2010 and 2013

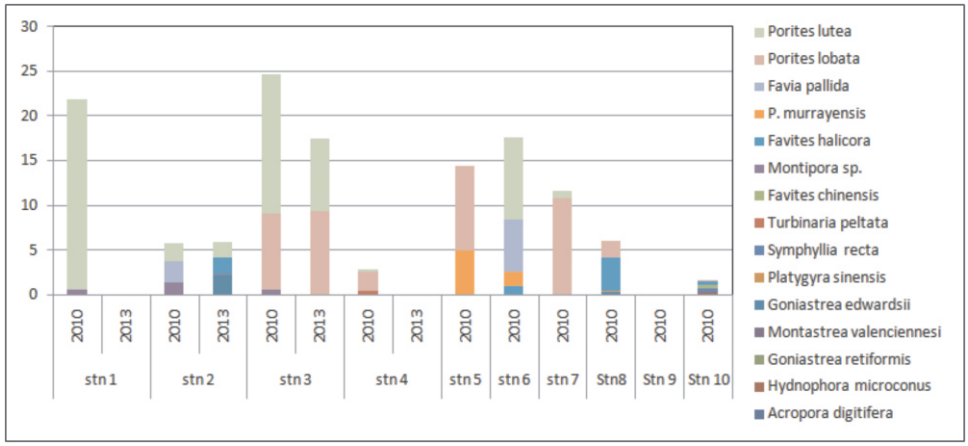

Fig. 3: Average species - wise benthic cover at the transects.

Table 1 : Summary Results

Life-form categories	2010	2013
LC	9.89 ± 8.73	5.83 ± 8.42
DC	0.19 ± 0.91	0.22 ± 0.63
DCR	0.08 ± 0.39	0.00 ± 0.00
DCTA	41.28 ± 20.80	16.31 ± 10.52
COR	4.06 ± 5.55	4.48 ± 4.28
CAL	0.94 ± 2.70	10.65 ± 6.77
MA	5.34 ± 8.29	12.88 ± 7.37
FA	0.47 ± 1.29	0.00 ± 0.00
R	15.92 ± 19.46	26.85 ± 19.02
S	21.69 ± 18.31	22.67 ± 12.52
OT	0.16 ± 0.45	0.06 ± 0.16

Table 2 : Average and station-wise live cover values and diversity indices for the years 2010-11 and 2013 and Pillai, 1969.

	LC		S		D		H'		E	
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
stn 1	21.9	0.0	2	--	0.94	--	0.13	--	0.18	--
stn2	5.7	5.83	3	4	0.21	0.19	1.08	1.14	0.98	0.82
stn3	24.65	17.5	3	2	0.50	0.47	0.74	0.69	0.67	1
stn4	2.75	0.0	3	--	0.36	--	0.73	--	0.67	--
stn 5	14.33	*	2	*	0.51	*	0.65	*	0.93	*
stn6	17.66	*	4	*	0.1	*	1.07	*	0.77	*
stn7	11.6	*	2	*	0.87	*	0.24	*	0.35	*
stn 8	5.97	*	4	*	0.38	*	0.9	*	0.65	*
Stn 9	0.0	*	--	*	--	*	--	*	--	--
stn 10	1.63	*	9	*	1.07	*	1.85	*	0.84	*
Ave ±	**9.89	**5.83	3.5 ±	3.0 ±	0.31 ±	0.33 ±	0.82 ±	0.92 ±	0.67 ±	0.91 ±
stdev	± 8.73	± 8.42	2.2	1.4	0.59	0.2	0.51	0.32	0.26	0.12
Pillai , 1969	--		15		0.25		1.9		0.7	

S - Total No. of species; D - Simpson's Dominance Index; H' - Shannon diversity index ; E - Shannon's Evenness Index

* surveys in these stations are not completed for the year 2013

** Calculated incorporating data from all the transects

filamentous algae (FA), coral rubbles (R), sand (S) and others (OT) which include, soft corals, octocorals and other sessile benthos such as echinoderms and mollusks. The dead coral cover recorded in this study is of recently dead corals and were not encrusted with turf algae or sediment. At each station, three 20 m transects were laid at the fore-reef area (depth of 2 - 4 m) and the data collected employing Line Intercept Transect (LIT) as per English *et. al*., 1997. Species diversity was estimated both within and outside the transects; for which specimens of *Scleractinians* were photographed *in-situ* using underwater digital cameras with the macro option for identification up to species level.

RESULTS

The % cover of life-form categories summarized for the Palk Bay reefs in the years 2010 and 2013 are presented in Table 1. The average LC cover observed during both the

Table : 3. List of species recorded under the diversity studies during 2010 (I) and 2013 (II)

		stn 1		stn 2		stn 3		stn 4		stn 5		stn 6		stn 7		stn8		stn 9		stn 10	
No.	Scleractinian species	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	
1	**Montipora monasteriata* (Forskal, 1775)	*		*	*	*			*												
2	*Acropora Formosa* (Dana, 1846)															*					
3	*Acropora gemmifera* (Brook, 1892)															*				*	
4	*Acropora digitifera* (Dana, 1846)															*		*		*	
5	*Hydnophora microconus* (Lamarck, 1816)															*		*		*	
6	**Turbinaria Peltata* (Esper, 1794)							*													
7	*Turbinaria frondens* (Dana, 1846)																	*			
8	*Symphyllia recta* (Dana, 1846)																	*		*	
9	*Favia speciosa* Dana, 1846															*					
10	***Favia tragrum (Esper, 1797)*																			*	
11	***Favia albidus* Veron, 2000																			*	
12	**Favia pallia* (Dana, 1846)			*								*									
13	***Favia lizardensis*															*					
14	*Favia rotumana* (Gardiner, 1899)															*					
15	*Favites pentagona* (Esper, 1794)																	*			
16	*Favites halicora* (Ehrenberg, 1834)				*							*				*		*		*	
17	***Favites russeli* (Wells, 1954)																			*	
18	*Favites complanata* (Ehrenberg, 1834)																			*	
19	*Favites vasta* (Klunzinger, 1879)																			*	
20	*Goniastrea edwardsii* Chevalier, 1971				*											*		*			
21	*Goniastrea retiformis* (Lamarck, 1816)															*		*		*	
22	*Goniastrea aspera* Verrill, 1905																			*	
23	*Platygyra sinensis* (Milne Edwards and Haime, 1849)															*		*		*	

		stn 1		stn 2		stn 3		stn 4		stn 5		stn 6		stn 7		stn8		stn 9		stn 10	
No.	**Scleractinian species**	I	II	I	II	**I**	**II**	I	II	I	II	I	II	I	II	I	II	I	II	I	
24	*Platygyra deadalia* **(Ellis and Solander, 1786)**															*					
25	***Montastrea colemani* Veron, 2000**															*				*	
26	*Montastrea valenciennesi* **(Milne Edwards and Haime, 1848)**															*				*	
27	*Pleasiastrea versipora* **(Lamarck, 1816)**																	*		*	
28	***Leptastrea aequalis* Veron, 2000**															*					
29	*Leptastrea purpurea* **Dana, 1846**																	*		*	
30	*Cyphastrea micropthalma* **(Lamarck, 1816)**															*				*	
31	*Porites lobata* **Dana, 1846**					*	*	*		*				*		*		*		*	
32	*Porites lutea* **Milne Edwards and Haime, 1860**	*		*	*	*	*	*				*		*		*		*			
33	*Porites murrayensis* **Vaughan, 1918**									*		*				*		*		*	
34	*Goniopora minor* **Crossland, 1952**																			*	
	Total Number of species recorded at each station in 2010 and 2013.	2	0	3	4	3	2	3	1	2	- -	4	- -	2	- -	20	- -	14	- -	20	- -
	Total number of species recorded (combined number from the two observations for each station)		2		5		3		4		2		4		2		20		14		20

- - not assessd

** Previous distribution records are not available for the species in Gony.

* Photographs were not seemed for these species in the present study.

observations indicate the 'poor' status, as per Gomez and Yap (1998), of the reefs, with the reduction in cover from 2010 – 2013. In tandem, the algal covers (both macro and calcareous algae) increased from 2010 to 2013. As the significant observation indicating further degradation, dead corals covered with turf algae (DCTA) (comprised mostly of *Acropora* tables) – the dominant category in the observation in 2010, were disintegrated into rubbles, and was observed as the dominant category in 2013.

The station-wise comparisons between 2010 and 2013 (Fig. 2) confirm the overall trend: there is obvious reduction in the live coral cover (Stn. Nos. 1, 3 & 4), and increases in rubbles (Stn. Nos. 1 , 3 & 4) and macro algae and calcareous algae (1, 2, 3 & 4), which indicate continuing degradation of these reefs. The life-form categories between stations exhibit variations in live coral cover (Figure 2 & Table 2). The stations assessed in east-side of the Palk Bay (Stn. Nos. 8, 9 & 10) had low live coral cover, which could attributable to the patchy occurrence of corals, where they had not formed a well defined reef. Other notable variations are the absence of sand cover in the stations 8, 9 and 10, which could again be attributable to the benthic structure in these stations.

The list of station-wise occurrence of species recorded in the diversity surveys is presented in Table 3. A total of 34 species under 15 genera have been recorded in the 2010 and 2013 surveys. Interestingly, six species have been recorded newly for this reef area. The number of species recorded ranged from 0 to 20, with numbers >14 in the stations 8, 9 and 10, which fall in the patchy coral occurrences in the southeast of the Palk Bay. On the contrary very low numbers of species were recorded from the fringing reef in the mainland shore. The species-wise cover of scleratinian corals estimated in the transects showed 'stress tolerators', as per Edinger and Risk (2000), forming the major cover and also being reported from more number of stations (Fig. 3). The diversity indices estimated for the species recorded within the transects for the Palk Bay reefs showed variations between stations, with some stations exhibiting high diversity indices(*H'* and *E*) and lower dominance indices, while *vice versa* in majority of the stations (Table 2). Stations which exhibited high dominance (*D*) with low diversity and evenness (*E*) indices in the first assessment (2010) showed a reduction in live coral cover in the latest surveys (e.g., stn 1). On the other hand, stations which exhibited high diversity (*H'*) and evenness (*E*) indices with low dominance (*D*) indices showed an increase in coral cover (e.g, stn 2). Nevertheless, decrease in coral cover was observed in most of the stations assessed conforming to the former scenario.

DISCUSSION

Lack of quantitative data (e.g. % coral cover), in the studies of Pillai (1969) and Venkataraman *et al.,* (2007) may deter from comparison of reef health to the present status. Nonetheless, a rough estimate of the colony sizes over a perpendicular transect from Pillai's (1969) study, characterize this reef to having fair to good cover i. e., >25% (Gomez and Yap, 1988) during that period. The estimates by Kumaraguru *et al.,*(2003), in August 2002, after the recovery from the bleaching event in April - June 200, showed the live cover of 32.9 – 42.9%. Thus, there is definitely a notable decline in reef health from the past and from the observations between 2010 and 2013 in the present study, which is shown by the increase in algal covers, and the disintegration of the intact DCTA (*Acropora* tables) in to rubbles, between 2010 and 2013, The reasons for which could be a combination of local to climate change related to stressors.

Though observations of bleaching are available for Gulf of Mannar for the 1998 event (Arthur, 2000; Venkataraman, 2000), the reefs of Palk Bay have not been observed during that time. The report of bleaching in these reefs for the event in April – June 2002, showed a bleached cover of 35.5 – 47.1%, with a live coral cover ranging from 6.5 – 9.9 % (Kumaraguru *et al.,* 2003). The corals however recovered in August 2002 with a sharp increase in live coral cover, of 32.9 – 42.9 %, with bleaching mortality ranging from 2.7 – 4.5%

(Kumaraguru *et al.,* 2007). This shows the impact of bleaching as minimal for that particular event, lack of monitoring in these reefs, however is a handicap to pointing the reasons for declining coral health which could be attested by the absence of bleaching information for the 2010 mass bleaching event. The very low LC cover reported in this study is the result of that event is not clear. However the observations of the present study being carried out in October 2010, well after the bleaching event in May, suggest the reduced coral cover may be due to bleaching related mass mortality than any other mortality event.

Scleratinian species composition and diversity studied by Pillai (1969) and Venkataraman *et al.,* (2007), pointed out zonation of species for the fringing reef (however, indistinct in comparison to other reef structures) as per lagoon, shore-ward reef, reef crest and sea-ward reef zones. In Pillai's (1969) observation, encrusting and massive types of 10 – 20 cm sizes formed majority in the shore-ward side, the reef crest lacking corals, and the shore-ward reef comprising mostly of ramose forms of 30 – 40 cm in greater diameter. Similar species composition was observed again by Venktataraman *et al.,* (2007) for the fringing reef, with the shoreward reef dominated by *Favia pallida* and *Leptastrea transvera*, in the reef crest the occurrence being rare, and the reef slope dominated by branching forms of *Pocillopora, Acropora* and *Montipora.* Though the zonation of species could be viewed in the dead skeletal forms as DCTA in the present study (observations in 2010), the same could not be viewed in the latest observation (2013), owing to the disintegration of the ramose forms in to rubbles. The species richness too remarkably declined from the 63 species under 22 genera in Pillai's (1969) and 61 species under 22 genera in Venkataraman *et al.*'s (2007) to 34 species under 15 genera in the present study (Table 3), with the absence of many prominent species from the both the former studies. The species-wise covers (Fig. 3) estimated further pointed out the dominance of 'stress tolerators' which is not of the reported species composition the previous studies. The diversity indices too show a decline in the present study from the 1969 observation (calculated from the number of colonies listed per species in Pillai's (1969) publication; Table 2) which could be attributable to the changes in community structure in relation to the climate change issues and the persistent local stressors such as sedimentation, sewage and industrial effluents in to the reef, and over exploitation of resources.

Studies have indicated that community patterns of coral species in bleached reefs are manipulated by thermal tolerence in species (Done, 1999; Coles and Brown, 2003: Loya *et al.,* 2001), similarly noting that sediments reduced coral settlement and algal turfs inhibited coral settlement (Birrell *et al.,* 2005), thus validating the possible causes of changed community structure in Palk Bay. Most remarkably in the present monitoring observations (i.e., 2010 to 2013), the stations exhibiting low diversity indices in combination with high dominance indices – where a few stress tolerant species dominating the reef, have proceeded to a reduction in coral cover (e.g., Stn. 1) is an obvious sign of overall coral decline.

The six new records of coral species in this study however is a significant observation, with the species observed being not of very common occurrence. Though this might indicate the coral seeding from elsewhere and recruitment, the previous diversity studies did not cover the patch reefs around Rameswaram in their diversity assessment could be one reason these species were not reported earlier.

SUMMARY

The fringing reef along the mainland shore and the patch reefs surrounding Rameswaram Island in Palk Bay were assessed for status of reef health, based on scleractinian diversity, species-wise cover, and other bio-physical categories, in 2010 and monitored subsequently in 2013. The live coral (LC) covers indicated the poor status of the reefs, in comparison with the past reports. The reasons for decline however are not clear given the absence of monitoring reports especially for

the large-scale bleaching event in 2010. The LC cover regressed again i.e., from 2010 to 2013, observed in tandem with the increase in algal covers and the disintegration of intact dead corals covered with turf algae (DCTA) in to rubbles (R), indicating further degradation of reef health. Diversity studies showed reduction in species richness from >60 species in the previous studies to 34 species in the present study. Species-wise cover and diversity indices showed dominance of species (by stress tolerators) with low diversity and evenness. The combination of climate change related mortality events and continuous local scale factors are deduced as reasons for the coral decline in these reefs. The patch reefs in Palk Bay being assessed for the first time for scleractinian diversity and not covered in the previous studies, resulted in to six coral species being new records from these reefs.

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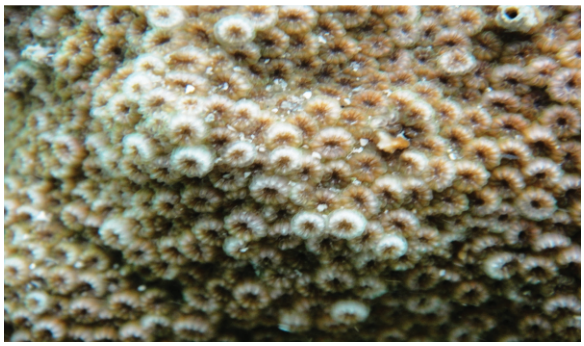
Plate 1

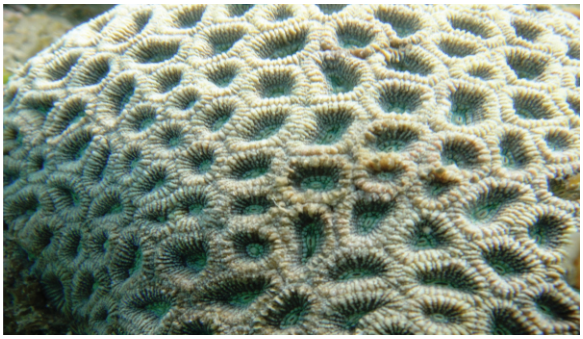
Acropora digitifera

Acropora formosa

Acropora gemmifera



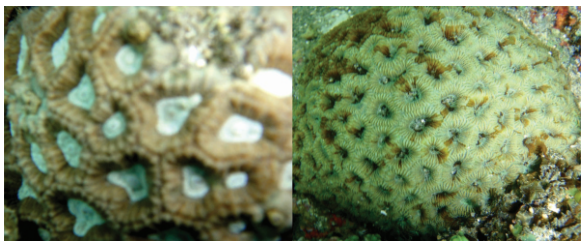
Cyphastria micropthalma



Favia albidus

Favia lizardensis

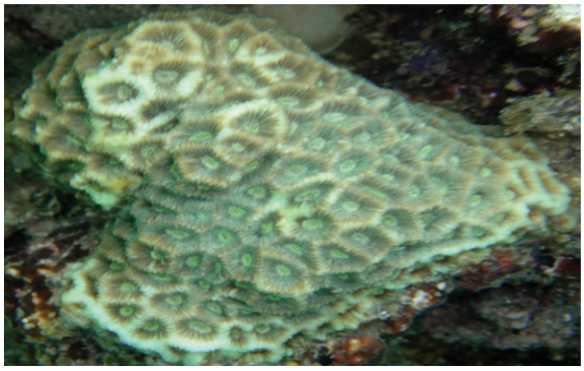
Favia rotumana *Favia speciosa*



Favia veroni *Favites complanata*

Plate 2

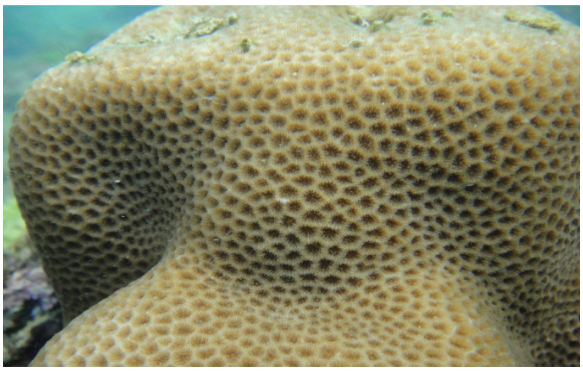
Favites halicora



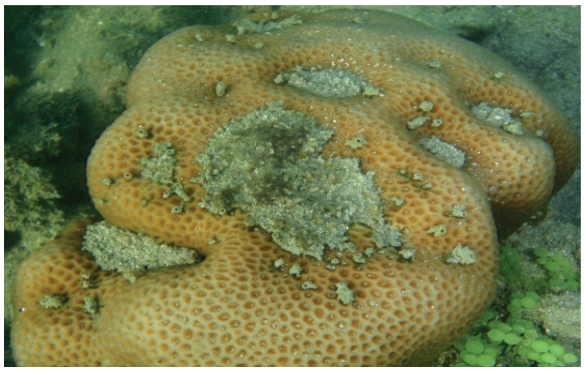
Favites pentagona

Favites russeli

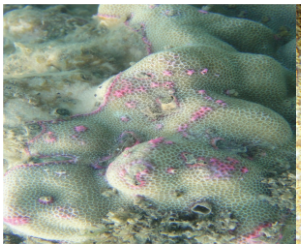
Favites vasta



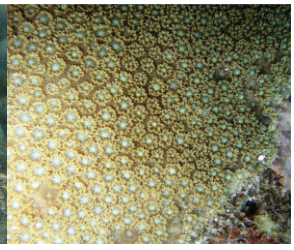
Goniopora aspera



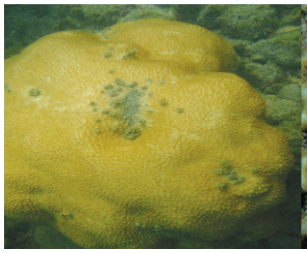
Goniopora edwardsii



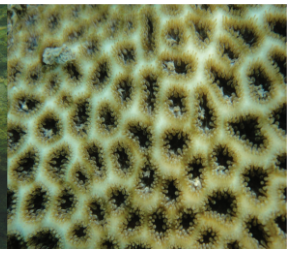
Goniastrea retiformis



Goniopora minor



Hydnophora microconus

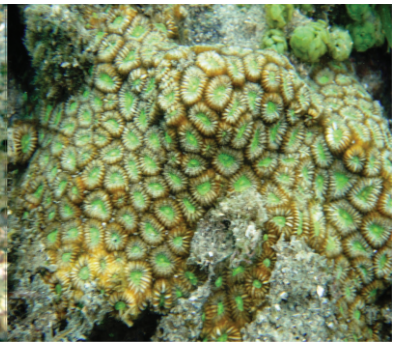


Lepastrea aequalis

Plate 3

Leptastrea purpurea

Montastrea valenciennesi

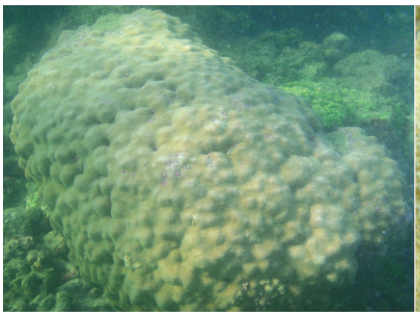


Montastrea colemani

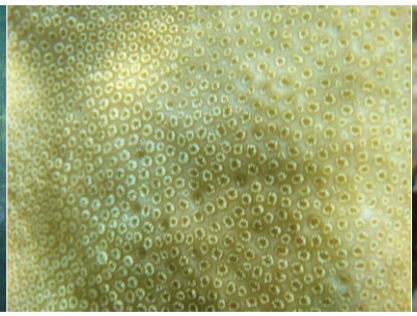
Platygyra deadalia

Platygyra sinensis

Pleasiastrea versipora



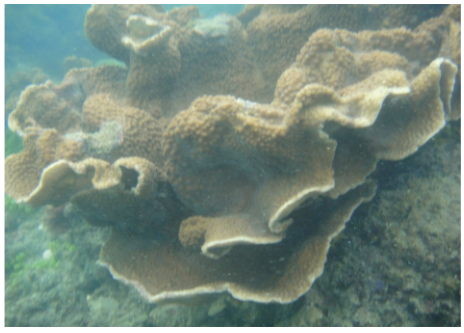
Porites lobata



Porites lutea

Porites murrayensis

Symphyllia recta



Turbinaria frondens

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