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SOME ECOLOGICAL FACTORS AFFECTING CORAL REEF ASSEMBLAGES OFF HURGHADA, RED SEA, EGYPT.

TAREK ABD EL-AZIZ AHMED MOHAMMED* AND MOHAMED ABD EL-WAHAB MOHAMED**

** National Institute of Oceanography and Fisheries, Red Sea and Suez & Aqaba Gulfs Branch, Hurghada Marine Research Station, Hurghada, Egypt.*
** Correspondence author: Dr. Tarek A. A. Mohammed. Researcher in the National Institute of Oceanography and Fisheries, Red Sea, Hurghada, Egypt.

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ABSTRACT

Three shallow reef sites were investigated during four seasons (Autumn, 2003, Winter, Spring and Summer, 2004) off the Marine Biological Station at Hurghada, Red Sea, Egypt. Thirty-eight scleractinian coral species were recorded at the studied sites. Generally, Twenty-six species were affected by more than one factor (such as high temperature, solar radiation, sedimentation and algae), while the last twelve species remained healthy.

The affected species (26 species) were divided into the following: five species were affected by combination of high temperature and direct exposure to solar radiation during the neap tide, eleven species only were affected by sedimentation and increasing algal cover and ten species were affected by high temperature, solar radiation, sedimentation and algae all together.

Coral bleaching and death in some cases were due to these factors. *Galaxea fascicularis, Seriatopora hystrix* and *Millepora dichotoma* were partially bleached but recovered during the high tide time within weeks. Few species such as *Acropora granulosa, Montipora venosa, Goniastrea pectinata* and *Porites solida* were completely bleached and could not recover but died. Repeated bleaching events in the future may expose corals to an increasingly hostile environment.

INTRODUCTION

Coral bleaching (whitening of corals due to loss of symbiotic algae and/or their pigments), in tropical ocean systems have widely been reported in the past two decades (Williams & Bunkley-Williams, 1990; Glynn, 1993; Brown, 1997). Moreover, coral bleaching has occurred in the Caribbean, Indian, and Pacific Oceans (Salvat, 1992; Gleason, 1993; Fagerstrom & Rougerie, 1994; Hoegh-Guldberg & Salvat, 1995).

Bleaching often occurs following periods of warming and doldrum conditions which have profound detrimental effects on seawater temperatures (*Lesser et al.,* 1990; Glynn, 1991 and 1993). Bleached coral colonies may also exhibit a decrease in photosynthesis and reproductive potential (Porter *et al.,* 1989; Szmant & Gassman, 1990). Lasker *et al*. (1984) found that bleaching is associated with drastic reductions in density of zooxanthellae and with atrophy and necrosis of animal tissue.

Much of the patchness in the temporal and spatial occurrence of bleaching is derived from the fact that the environmental triggers eliciting bleaching in the field are various (Glynn, 1993). For most studies, the key environmental variables remain poorly defined. Bijlsma *et al.* (1995) mentioned that the long-term predictions of sea temperature increase in the tropical oceans from 1 to 2˚C until the year of 2100; they also illustrated

* Corresponding author

that, this is the main factor responsible for extensive coral bleaching in the tropical oceans.

Macro-algae are a major component of many coral reef communities and are potentially main competitors with corals (Tanner, 1995 & 1997; Rajasuriya, 2002; Uku *et al*., 2002). Other factors causing bleaching are high solar irradiance and diseases (Barid & Marshall, 1998; Brown, 1997; Winter *et al*., 1998). Touristic development also plays a role in reduction and degradation of coral reefs primarily as a result of increasing sedimentation. Sediment particles smother reef organisms and reduce light available for photosynthesis (Rogers, 1990). Changes in sea level also threaten corals and cause degradation in Nicobar Islands (Kulkarini and Saxena, 2002) and in South Asia (Perks, 2002).

In the present study, four mass coral bleaching events recorded in the study area during the years 2003-2004. Therefore, it was aimed to illustrate (1) the different coral framework types, (2) the liability of coral reefs to bleaching, (3) water temperature and sea level changes, and (4) the sedimentation rates.

MATERIALS AND METHODS

I- The Study area

The area is situated off Marine Biological Station, 5Km north of Hurghada city along the Red Sea coast, (Fig.1). It includes three shallow reef sites namely Northern reef, Crescent reef and Southern reef, (Plate1: a, b & c). The three sites were invaded with gradual increase of algal cover, human activities (as snorkeling and fishing), sedimentation and direct exposure to solar radiation as well as temperature.

1-Northern Reef

This is circular shaped site containing fringing reefs extending parallel to the shore line for about 250 m and contains five small lagoons about 5 m long and 10 m wide inside the reef site. These lagoons have sandy bottoms inhabited by many coral species (*Acropora spp*., *Galaxea fascicularis, Stylophora pistillata* and *Platygyra daedalea)* (Edwards et. al., 1981; Ormond, 1981). The upper surface of this reef arises from the bottom to about 7- 8 m in the lee side and 9 m in the seaside.

2- The Crescent Reef

It is located 200 m offshore between the Northern reef and the Southern reef on sandy bottom. It is oblique to the shore having hump-shaped 40 m wide and 120 m long on a sandy bottom at depth 5-7 m (Edwards et. al., 1981; Gubbay & Rosenthal, 1982). It is dominated by low coral cover species (*Echinopora lamellosa, Platygyra daedalea* and *Galaxea fascicularis*). During high tide, the upper surface exists at depth of 1.2 m while during low tide time it exists at depth ranging from 0- 0.5 m.

3- The Southern Reef

It is situated at the end of tidal flat zone, 160 m offshore. It is about 80 m long and 120 m wide and covered with water (about 0.5 - 1.2 m depth) during high tide. Its reef edge well defined and sloping gently to sandy sea bed, at depth ranging from 5 – 9 m on the seaward. The most dominant coral species are *Echinopora gemmacea, Platygyra daedalea, Galaxea fascularis* and *Acropora hyacinthus*.

II- Methods

Coral bleaching have been detected using traditional small-scale survey technique {Line Intercept Transect (LIT)} method according to English *et al.* (1997). To estimate the percentage cover of corals in each site, the LIT was applied using nine transects at each site. Each transect of 20 m length. There was at least 2 m gap between the neighbour transects at different sites.

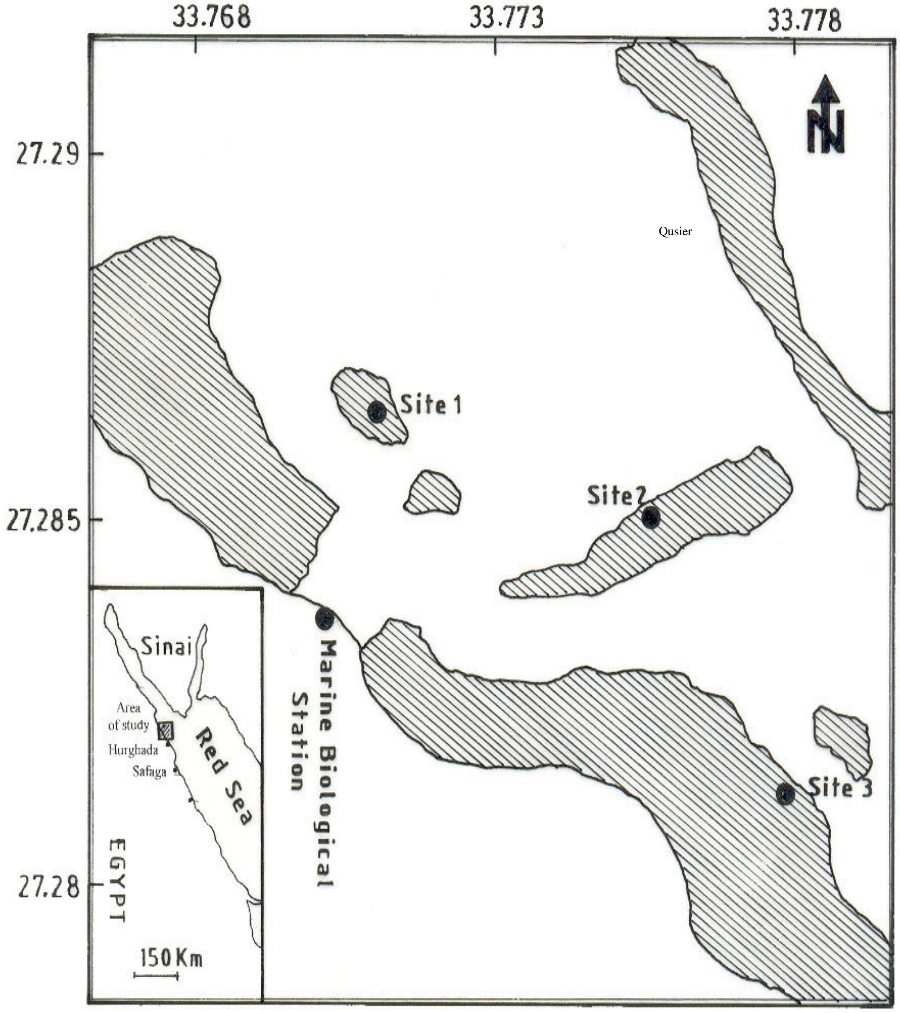

Fig. (1). Map showing the studied reef sites.

Other contents such as algae, sponges, sand, rocks and unknown dead corals were also estimated. At each site, the percentage cover of the living corals (as hard and soft) as well as number of coral species were calculated from the following formula:

Coral species were identified according to Sheppard and Sheppard (1991), Wallace (1999) and Veron (2000). Surface water temperature was measured seasonally during inspection of the investigated sites using a normal laboratory mercury thermometer and sedimentation rate was calculated according to Glynn (1993).

$$\text{Percentage cover} = \frac{\text{Intercepted length}}{\text{Transect length}} \text{ x } 100$$

RESULTS

A total of 38 species of hard corals were recorded at the three reef sites. Fifteen species namely (*Acropora humilis, A. cytherea, Galaxea fascicularis, Platygyra daedalea, Seriatopora hystrix, Stylophora pistillata, Echinopora gemmacea, Montipora venosa, Pocillopora verrucosa, Goniastrea pectinata, Porites solida, Millepora dichotoma, Montipora circumvalata, Favites flexosa* and *Acropora granulosa*) were affected by the combination of neap tide and exposure to solar radiation (Table 1). Twenty one species (*Acropora humilis, A. cytherea, A. hycinthus, A. clathrata*, *A. eurystoma, A. caenciennesi, A. valenciennesi, Anacropora forbesi, Echinopora lamellosa, E. gemmacea, Favia favus, Favites persi, Galaxea fascicularis, Goniastrea pectinata, Montipora columna, M. vennosa, M. stilosa, Platygyra daedalea, Porites solida, Stylophora pistillata* and *Seriatopora hystrix*) were affected by sedimentation and increasing of algal cover that cause coral bleaching and death in some cases (Table 2). Twelve species (*Acropora digitifera, A. nasuta, A. table, A. pharonis, A. squarrosa, Anacropora spinosa, Lobophyllia corymbosa, Echinopora fruticulosa, Favia pallida, Turbinaria mesentrina, Montipora calcarea* and *Fungia fungites*) were not affected and appeared in good conditions (Table 3).

Figure 2 shows the percentage cover of all taxa in the studied sites. The first site is dominated by assemblages of hard corals (65.48%) in descending order such as *Galaxea fascicularis, Seriatopora hystrix, Acropora humilis, Stylophora pistillata,* and *Acropora cytherea* followed by algae 10.53% (dominated by *Padina pavonia* and *Turbinaria turbinata*), dead corals 10.14% and soft corals 2.8% (dominated by *Lobophyton pauciflorum*). Other taxa such as rubbles, seagrass and sponges represent 11.05% of the total cover.

The second site is mainly covered with hard corals such as *Echinopora lamellosa, Galaxea fascicularis*, *Platygyra daedalea* and *Echinopora gemmacea* where they occupied 47.84% of the total cover, followed by the algae (*Turbinaria turbinata* and *Padina pavonia* are the dominant species) which formed 17.03% of the total cover. The dead corals occupied 11.15% of the total cover, followed by soft corals (*Sarcophyton sp., Sinularia sp.* and *Lobophyton sp.*) represented 6.53% of the total cover. Among the soft corals *Sarcophyton trocheliophorum,* is most dominant. Other taxa (sponges, seagrass and rubbles) form 17.45% of the total cover.

The third site is characterized by *Echinopora gemmacea*, *Platygyra daedalea*, *Galaxea fascicularis* and *Acropora hyacinthus* hard corals represented 51.67% of the total cover. Occupied the highest percentage cover. This site is more or less characterized by a consistent increase in algae such as *Padina pavonia* and *Hormophysa triquetra.* The percentage cover of algae amounted to 22.98%, of the total cover. Dead coral covered 11.81% followed by soft coral (7.07%) which show the same pattern as those of the second site. Among the soft corals, *Sarcophyton trocheliophorum* represent the highest forms. Taxa such as sponges, seagrass, and rubbles represented 7.47% of the total cover.

The combination between algal cover, direct exposure to solar radiation and high temperature during the neap tide for three to five days especially at daytimes may be considered to the bleached coral colonies (Tables 1 and 2). Many coral species which are partially bleached, (Plate1: d, e & f and Plate 2: a, b, c & d) could be recovered and its colour returned bright. From the field observation, the following species *Galaxea fascicularies*, *Seriatopora hystrix* and *Millepora dichotoma* were faster species that recovered within two to three weeks seasonally, while some coral species such as *Pocillepora damicornis* and *Favites flexuosa* have been completely bleached (Plate 2: e & f) and could not be recovered apparently due to the loss of zooxanthellae.

On the other hand, some coral species such as *Platygyra daedalea, Stylophora pistillata* and *Seriatopora hystrix* were degraded and eroded by the algal cover (Table 2). While other species such as *Acropora humilis, Galaxea fascicularis* and *Stylophora pistillata* were recovered and returned to their natural state when the algae were removed by the authors in field.

Eight algal species were recorded and calculated as percentage cover in the three sites. Generally, there is a consistent increase in algal cover in the study area during the last two years from 10.53% (according to Mohamed, 2003) to 21.98% (recorded by the authors). *Padina pavonia* is the most common algal species with highest percentage all over the studied sites especially at the third and first sites. While *Turbinaria turbinata* is dominant at the second site (Table 4).

Table (5) compares water temperature and sedimentation rate at the studied sites during the four seasons. The highest water temperature was recorded during summer. It ranged from 27.8 – 29.6 ˚C whereas during winter, it ranged from 18.6 – 20.3 ˚C. The reverse was true for sedimentation rate. It ranged from 0.0098 – 0.0205 gm. cm^{-2}/day during summer and from 0.0399 – 0.0503 gm. cm^{-2}/day during winter.

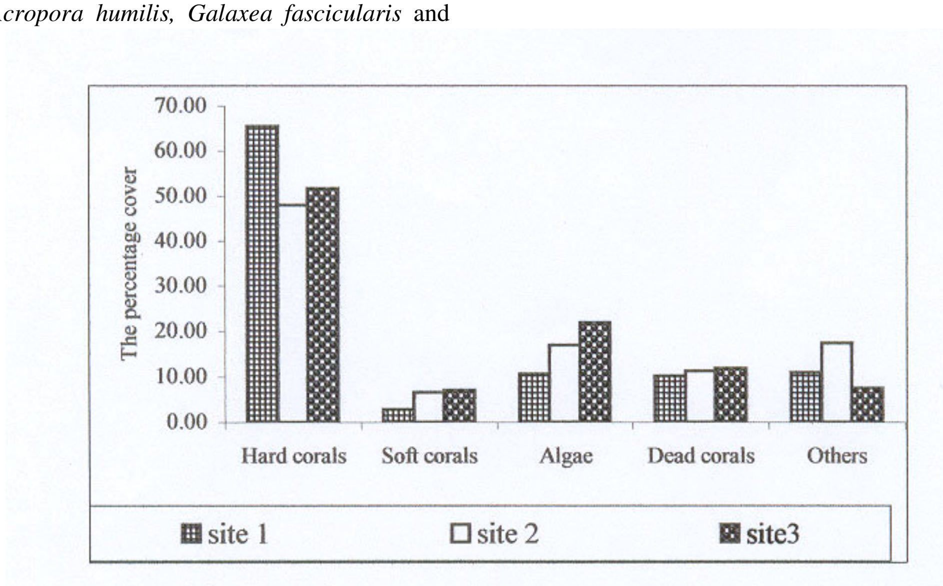

Fig. (2). The percentage cover of all taxa in the studied sites.

Table (1). Bleached coral species due to the direct exposure to solar radiation and high temperature during neap tide.

Site 1	Site 2	Site 3
Acropora granulosa **	*Acropora humilis* *	*Acropora humilis* *
Acropora humilis *	*Galaxea fascicularis* *	*Galaxea fascicularis* *
Galaxea fascicularis *	*Platygyra daedalea* *	*Goniastrea pectinata* **
Goniastrea pectinata *	*Seriatopora hystrix* *	*Platygyra daedalea* *
Platygyra daedalea *	*Stylophora pistillata* *	*Porites solida* **
Porites solida *	*A. cytherea* *	*Seriatopora hystrix* *
Seriatopora hystrix *	*Echinopora gemmacea* *	*Millepora dichotoma* *
Stylophora pistillata *	*Montipora venosa* **	*Montipora circumvalata* *
	Pocillopora verrucosa *	*Favites flexosa* *

* Corals are partially bleached and may recover. ** Corals are completely bleached and could not recover but died.

Table (2). Coral species that were affected by sedimentation and increasing algal cover.

Site 1	Site 2	Site 3
Galaxea fascicularis	*Galaxea fascicularis*	*Galaxea fascicularis*
Stylophora pistillata	*Stylophora pistillata*	*Stylophora pistillata*
Seriatopora hystrix	*Seriatopora hystrix*	*Platygyra daedalea*
Echinopora lamellosa	*Echinopora lamellosa*	*Acropora humilis*
Favia favus	*Montipora columna*	*A. cytherea*
Favites persi	*Platygyra daedalea*	*Porites solida*
Montipora columna	*Acropora humilis*	*Echinopora gemmacea*
Platygyra daedalea	*Porites solida*	*A. eurystoma*
Acropora humilis	*Echinopora gemmacea*	*A. caenciennesi*
Acropora cytherea	*Goniastrea pectinata*	*A. valenciennesi*
Porites solida	*A. hycinthus*	*Montipora vennosa*
Anacropora forbesi	*A. clathrata*	*Montipora stilosa*

Table (3). The coral species that still life and not affected at the studied sites.

Site 1	Site 2	Site 3
Acropora digitifera	---------	---------
A. nasuta	---------	---------
A. table	*A. table*	---------
A. pharonis	---------	---------
A. squarrosa	---------	---------
Anacropora spinosa	---------	*Anacropora spinosa*
Lobophyllia corymbosa	*Lobophyllia corymbosa*	*Lobophyllia corymbosa*
Echinopora fruticulosa	---------	---------
Favia pallida	---------	*Favia pallida*
Turbinaria mesentrina	---------	*Turbinaria mesentrina*
Montipora calcarea	---------	---------
Fungia fungites	*Fungia fungites*	*Fungia fungites*

---- not recorded

Table (4). The percentage cover of algal species at the studied sites.

Algal species	Site 1	Site 2	Site 3
Cystosera myrica	-	1.81	4.78
Cystosera trinode	1.02	-	-
Dictyosphaeria cavernosa	1.86	-	-
Halimeda copiosa	1.06	-	-
Hormophysa triquetra	-	2.35	6.32
Padina pavonia	3.47	4.3	7.83
Penicillus dumetosus	-	3.49	-
Turbinaria turbinata	3.12	5.08	3.05

Table (5). Seasonal range of water temperature (^{o}C) and sedimentation rate (gm.cm-2/day) at the studied sites.

Category		Autumn	Winter	Spring	Summer
Temperature (^{o}C)		19.9-24.8	18.6-20.3	23.5-26.9	27.8-29.6
Sedimentation rate (gm.cm-2/day)	Site 1	0.0199	0.0399	0.0295	0.0098
	Site 2	0.0301	0.0389	0.0344	0.0163
	Site 3	0.0457	0.0503	0.0381	0.0205

DISCUSSION

The present study found that bleaching of coral colonies at the studied sites was due to combination of light temperature and solar radiation during the neap tide. This result ties very well with the results of Brown *et al.* (1986), Brown (1997) and Winter et al. (1998) who state that high water temperature ranging between 29 – 31.6°C causes coral bleaching at La Parguera, northeastern Caribbean Sea. Also, Glynn (1984) and Lasker *et al.* (1984) illustrated that coral bleaching in the San Bals Island reefs was due to solar insulation in the shallow, semi-restricted areas. Perks (2002), Mohammed (2003) have also noted that climatic conditions (tides, high temperature, direct exposure to solar radiation and human activities such as fishing and aquatic sports) are factors controlling coral population.

The present study also indicated an increase in algal cover during the last two years from 10.53% - 21.98%. A possible explanation may be due to the overfishing of some grazers such as sea cucumber species, which was obvious over the last two years. Carpenter (1986), Hay (1991) and Tanner (1995) reported that macroalgae are a major competitors with coral communities. They found that grazers such as fish and sea urchin play a significant role in the distribution and abundance of most macro-algae species. Removal of grazers has a negative effect on coral environment which lead to an increase in algal cover and overgrowth on corals.

The highest sedimentation rate in winter compared with the less values recorded during summer indicated that sedimentation is dangerous to corals. Sedimentation ceases coral growth due to decrease in zooxanthellae, which leads to coral tissue lesions (Hubbard, 1986; Macintyre, 1988; Rogers, 1990). Mohammed (2003) showed that there is an initial rise of sedimentation rate (0.0104 – 0.0437 gm. cm^{-2}/day) off Hurghada area due to landfilling process (Table 6).

It may therefore be concluded from this study, the proximate factors responsible for bleaching coral colonies and death in some cases are high temperature and direct exposure to solar radiation during the neap tide. Moreover, sedimentation and increasing algal cover expose corals to a hostile environment.

Table (6). A comparison for sedimentation rate between the present study and Mohammed (2003).

Category	Autumn	Winter	Spring	Summer
Mohammed (2003)	0.0394	0.0437	0.032	0.0104
The present study	0.0199 – 0.0457	0.0399 – 0.0503	0.0295 – 0.0381	0.0098 – 0.0205

CONCLUSION AND RECOMMENDATIONS

1- There is a relation between coral bleaching and the combination of high temperature and direct solar radiation stress during the neap tide seasonally.
2- Sedimentation and increasing algal cover play an important role in coral growth, survival, abundance and degradation.
3- Some coral species such as *Galaxea fasciculamries*, *Seriatopora hystrix* and *Millepora dichotoma* have the ability to recover within weeks during the high tide.
4- Prevent the landfilling processes of the under construction tourstic projects along the Red Sea coast.
5- Putting strikes law to prevent fishing of seacucumber and collection of molluscs to conserve the balance of the marine environment.
6- Encourage the processes of coral transplantation especially in the damaged areas.

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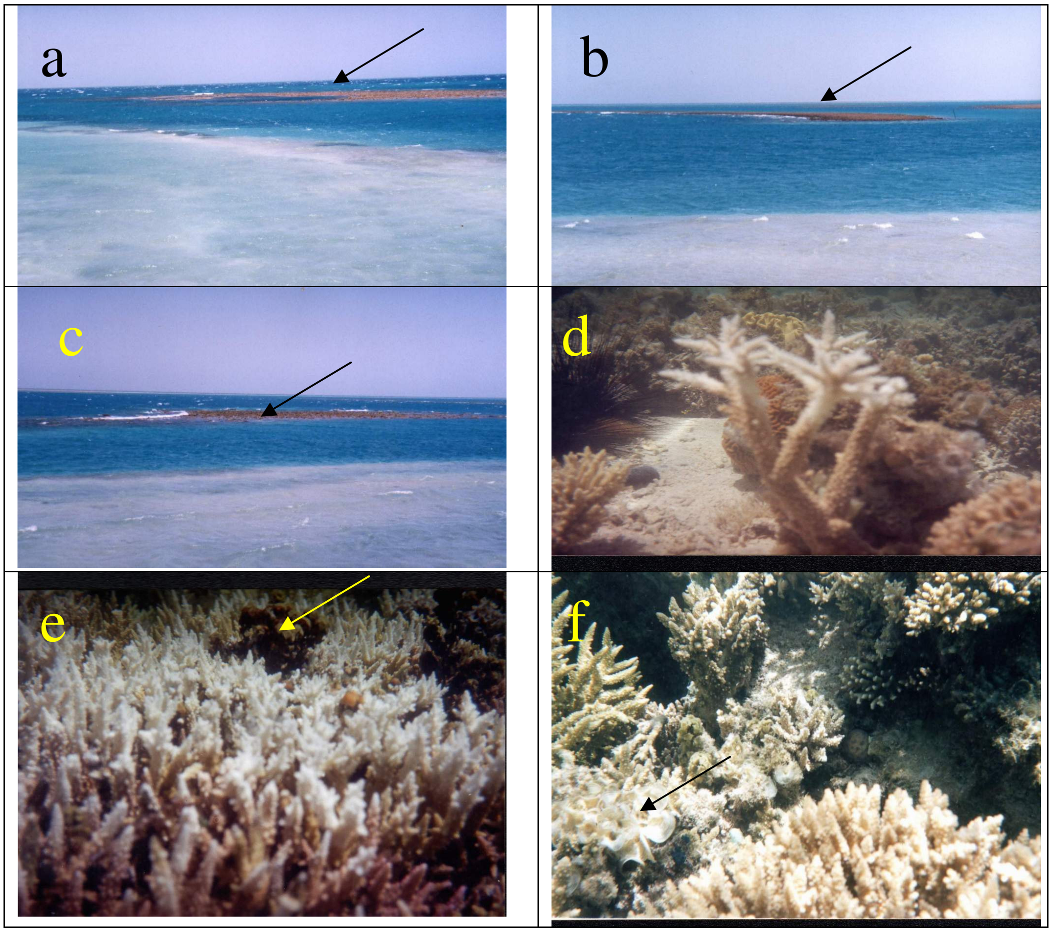

Plate 1:

a- Northern site.

b- Crescent site.

c- Southern site.

d- *Acropora valenciennesi.*

e & f- *Acropora* sp. with algal cover.

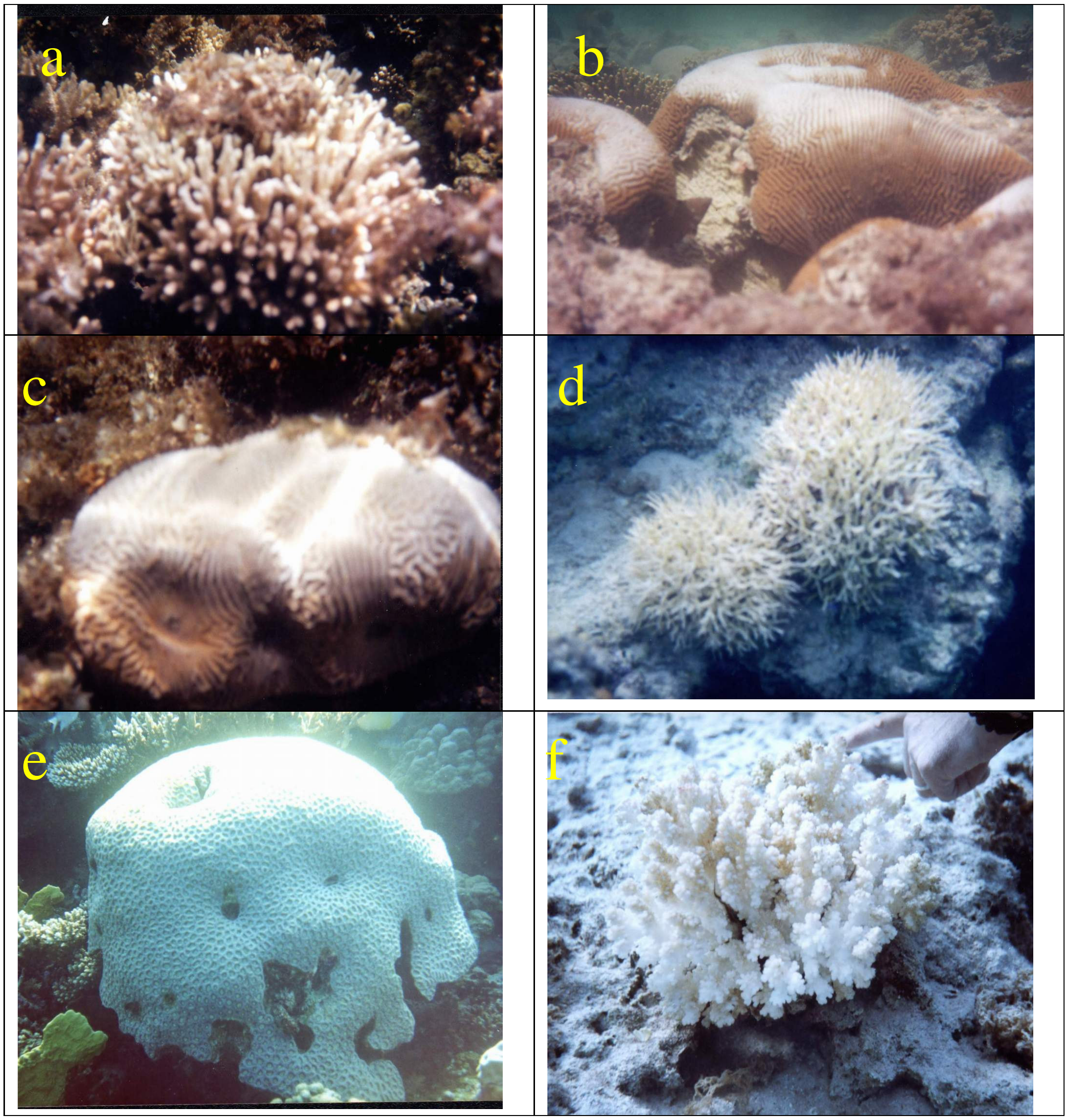

Plate 2:

a & b- *Stylophora* and *Platygyra* partially bleached and covered with algae.

c & d- *Platygyra* and *Seritopora* partially bleached.

e & f- completely bleached coral species.