NEARSHORE CORALS OF THE COFFS HARBOUR REGION, MID NORTH COAST, NEW SOUTH WALES.

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ABSTRACT

The occurrence and distribution of hermatypic coral species in both the littoral and sublittoral areas at nearshore locations in the Coffs Harbour region were recorded and evaluated. Total species count for the area was 16 with the greatest abundance occurring on the sheltered, northern sides of headlands. Colonies displayed evidence of damage from interactions with macrophytes and from sand deposition.

INTRODUCTION

The Solitary Islands (29°30' to 30°15'S) immediately offshore from Coffs Harbour support the southernmost coral communities on the east coast of Australia (Veron, 1986). Early work by Veron *et al.* (1974) suggested a minimum hermatypic species count of 36 from 18 genera with more recent estimates increasing this to 56 species (Veron, personal communication). Coral diversity is highest at the outer and northernmost island, North Solitary, with a number of species having their only documented regional occurrence in sheltered areas at this location (Veron, 1974).

The presence of an apparent biogeographic mixing zone has been demonstrated in other areas of research such as fish (Pollard, 1981) and algal surveys (Chidgey, 1987; Millar, 1987) for both the offshore islands and the shallow nearshore environment. Results from these surveys support the hypothesis suggested by the coral data that the Coffs Harbour region represents an important area of overlap for tropical and temperate biotic elements and further suggest that a gradient of increasing tropical representation occurs from the nearshore region to the outer islands.

To date, little work has been done on the mainland coral communities of the region with the only published data resulting from Veron's earlier research (Veron, 1974; Veron *et al.*, 1974). The conclusions of those reports suggested a poor representation of hermatypic corals with only 7 species recorded from the sublittoral, with colonies restricted to two major headlands. Intertidal rock-pools in the area were found to be more diverse with a total of 11 hermatypic species.

The present paper documents more fully the presence and diversity of corals at major headlands within the Coffs Harbour region and discusses some of the environmental factors which have been observed to have an impact on these coral communities.

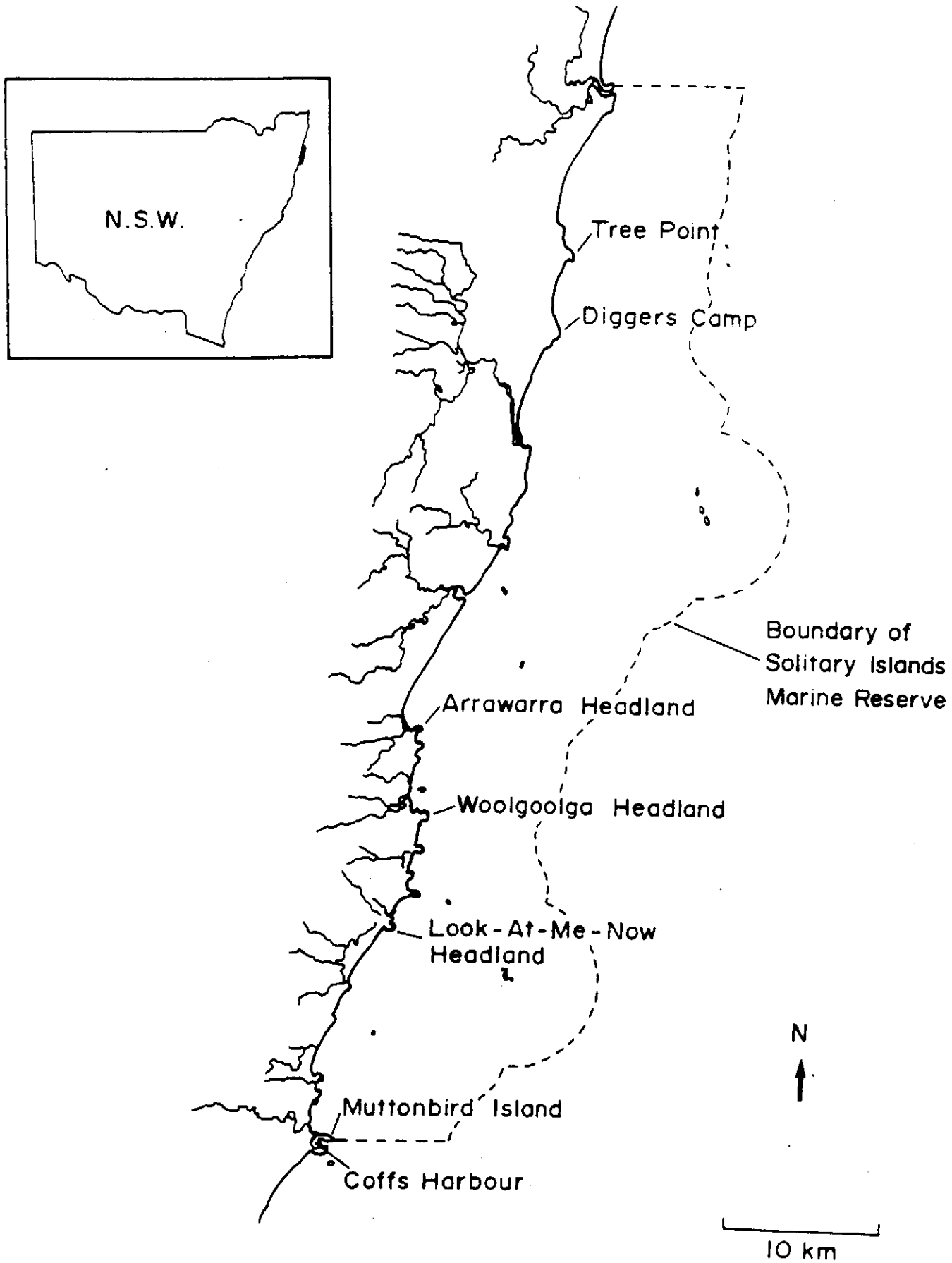
THE NEARSHORE ENVIRONMENT

The area surveyed for this paper is shown in Fig. 1 and encompasses the same stretch of coastline previously described by Veron *et al.* (1974).

The coastal area is characterised by rocky headlands and extensive sandy beaches. Without exception, the headlands examined for this study originate from metamorphic greywacke deposits. The local origin of these is primarily from the Coramba beds (mid-section) with representatives of Silurian deposits in the north and from the Brooklana beds in the south (Muttonbird Island) (Korsch, 1980; National Trust of Australia (NSW),1981). The rock is hard wearing providing a stable substrate for the attachment of epibiotic communities including corals. Projections of the rocky headlands into the sublittoral result in gutters and ridges extending in an easterly direction to various distances from the emerged shore. Benthic cover is dominated by algal macrophytes and in particular by the large brown algae *Sargassum* spp. and the kelp *Ecklonia radiata*. The fauna comprise a range of sessile species dominated by sponges, cnidarians and patches of the large ascidians *Pyura stolonifera* and *Herdmania*

Figure 1

Map of the Coffs Harbour region showing the locations where coral surveys were conducted.



momas which occupy extensive areas of available substrate (see Smith, 1988 for a review of the nearshore, shallow sublittoral communities).

Direction of sea-swell is predominantly from the southern to south-eastern quarter giving rise to the well described phenomenon of exposed (southern) and sheltered (northern) headland sides and representative biota (Dakin and Bennett, 1987; Carefoot and Simpson, 1985).

Little water clarity and temperature data are available for the region but the scant records suggest that nearshore temperature fluctuations are in the order of 17-27°C with a mean monthly range of 18-25°C (D. Currie unpublished data) compared to an offshore (surface) mean range of 20-26°C (Chidgey, 1987). Seasonal rainfall during the summer months produces turbid waters which stay close to shore, often remaining for periods of up to 2 months (pers. obs.).

METHODS

Within the area shown in Fig.1, preliminary reconnaissance surveys indicated major headlands and associated intertidal rock-platforms for further study. Sites were selected primarily on their possession of well developed intertidal rock-platforms with tide-pools and also for sheltered waters which would be conducive to coral establishment. These sites are shown in Fig. 1.

At each location, the full intertidal and sublittoral reef areas were surveyed at least twice over a period of two years (mid 1987 to mid 1989). Intertidal areas were examined at low tide and where necessary, larger pools were examined by snorkeling. Sublittoral sites were surveyed initially using a manta-tow to map areas of coral presence. These areas were subsequently studied using SCUBA and coral species were documented *in situ*.. Where taxonomic difficulties arose, small samples were removed, bleached in the laboratory and sent to Dr. J. Veron at the Australian Institute of Marine Science for identification.

RESULTS

The results are summarised in Tables 1 and 2. Table 1 indicates the headland characteristics in terms of length of northern side and maximum depth to the sand as well as the number of coral species recorded during the surveys. Table 2 gives an inventory of coral species by headland.

TABLE 1

Summary of site details for the locations surveyed.

Location	Length of northern side (m)	Maximum depth (at low tide) (m)	Number of coral species	
			Littoral	Sublittoral
Muttonbird Island	560*	11	5	12
Look-at-me-now Headland	340	7	4	1
Woolgoolga Headland	750	10	5	12
Arrawarra Headland	420	7	7	3
Diggers Head	440	7	8	3
Tree Point	Not applicable	10	11	8

(*excluding breakwall)

Table 2. Hermatypic corals recorded from each location.

	Muttonbird Island		Look-at-me-now Headland		Woolgoolga Headland		Arrawarra Headland		Diggers Head		Tree Point	
	Littoral	Sublit	Littoral	Sublit	Littoral	Sublit	Littoral	Sublit	Littoral	Sublit	Littoral	Sublit
Pocillopora damicornis		*				*				*		*
Acropora solitaryensis	*	*				*						
Goniopora lobata											*	
Psammocora superficialis		*	*		*	*			*		*	*
Coscinaraea mcneilli		*				*						
Acanthastrea lordhowensis	*	*	*		*	*	*		*		*	*
Favites abdita	*	*	*		*	*	*	*	*		*	*
Favites flexuosa		*					*		*		*	*
Goniastrea australensis		*			*	*	*	*	*	*	*	*
Montastrea curta							*		*		*	
Plesiastrea versipora	*	*				*						*
Cyphastrea seralia					*	*	*		*		*	
Turbinaria frondens		*				*					*+	
Turbinaria mesenterina	*	*	*	*		*	*	*	*	*	*	*
Turbinaria radicalis		*				*					*	

(+P.Harrison and B. Nudd pers. comm.)

Sublittoral

The most striking feature of coral distribution is the complete absence of colonies on the southern sides of the headlands. Headlands with extensive northern sides support the highest number of species and greatest cover, particularly where water depth exceeds 9m. As suggested by Veron (1974), Muttonbird Island and Woolgoolga Headland support the most coral species, but the count (16) is much higher then the 7 species recorded previously. In these locations, coral colonies are scattered but also occur in patches of up to approximately 10 x 10m interspersed by stands of macrophytes, in particular by dense kelp (*E. radiata*) forests. *Turbinaria mesenterina* is the dominant coral at all locations extending furthest into the macrophyte stands. Colony growth form for this species is as horizontal laminae with no tendency to vertical frond development as is the case in lower latitude reefs (Veron, 1986). *Pocillopora damicornis* is also abundant with colonies attaining diameters in excess of 1m in the sheltered regions. Branching is variable with most colonies showing the thick-branched form characteristic of the Solitary Islands and others in the more exposed locations, displaying a short branched, stunted growth form. Encrusting colonies of *Goniastrea australensis, Acanthastrea lordhowensis, Psammocora superficialis* and *Favites abdita* are common providing considerable cover at most localities and extending furthest into the shallower water, with patches present at a depth of 2m in the sheltered embayment at Muttonbird Island. *Acropora solitaryensis* is confined to the two longer headlands with large plate colonies, up to 1.5m across, growing in the deeper, sheltered sections of the northern sublittoral. Colony characteristics for this species are similar to those at the Solitary Islands with a tendency towards denser plates and fewer erect branches. The remaining species recorded from the sublittoral are uncommon, each with fewer than 8 colonies at the sites where they were present. The relative abundances of *Turbinaria radicalis* and *Favites flexuosa* were difficult to assess owing to the problems associated with distinguishing them from similar species of the same general *in situ* (see Veron, 1981, 1986 and this discussion).

At the two most diverse locations, coral abundance is greatest on the side of rocky gutters (Woolgoolga) and along the seaward edge of the deeper (8-9m) drop-offs (Muttonbird Island). At all locations, no living coral colonies were found adjacent to the rock/sand interfaces, colonies generally being located at least 1m above this zone.

The are a number of signs that the coral communities are under stress. Colonies in close proximity to macrophytes displayed evidence of abrasion from the algal fronds with areas of damaged and bleached skeleton in some cases overgrown by short growths of filamentous red algae. As *T. mesenterina* was more frequently observed adjacent to *E. radiata* stands, abrasive damage was more commonly observed in this species. This was usually characterised by both an uneven growing edge to the plate and also by sometimes substantial epiphytic growth.

The shape of *T. mesenterina* colonies is variable, generally comprising horizontal laminae with a raised outer edge. In colonies where the degree of edge lift is marked, pooling of sand and finer sediment occurs leading to smothering and death of the inner polyps. In some colonies the central area has not only become a sediment trap but also a settlement site for algae allowing the establishment of substantial epiphytic growth. Most colonies displayed some evidence of damage within the central area but in some cases, inward growth of coral tissue from surrounding unaffected sections of the colony has resulted in the damaged areas being at least partially overgrown by living polyps.

Few coral colonies are present at the base of rocky outcrops with available substrate occupied by algal species. Where corals are present, they are usually completely dead or with little living tissue. At these rock/sand interfaces, periodic changes in sand levels presumably resulting from heavy sea conditions, would appear to restrict the establishment of all but the opportunistic or rapidly growing biota.

Intertidal

Intertidal coral species are generally restricted to deep (>1m) rock-pools at the locations with the greatest degree of shelter. Thus although colonies of hermatypic species are present on the southern headland sides, they are associated with pools where the full force of the prevailing seas is ameliorated by the pool depth. This is evident particularly at Diggers Head where the majority of coral presence is confined to deep pools along the southern edge of the intertidal rock-platform.

A number of species not observed at any of the sublittoral locations are present in the intertidal pools. *Goniopora lobata*, a common member of the coral communities at the Solitary

Islands, is represented by a large colony in the extensive pools at Tree Point. At this site, a single colony covers a large area of vertical rock-wall at the edge of the pool where it is present. *Montastrea curta*, also absent from nearshore sublittoral communities, is less obvious with single, small colonies at each of the 3 sites from which it was recorded. The only intertidal record for *A. solitaryensis* was at Muttonbird Island. This single colony is stunted, bleached and very atypical in colony characteristics. *T. mesenterina* is extremely stunted and also paler than the sublittoral colonies, displaying a light brown colouration compared to the green of the sublittoral specimens.

Coral species richness is highest at Tree Point (11 species) where a large area of sheltered rock-pools provides suitable habitat for coral recruitment and survival.

Shading and overgrowth of colonies by macrophytes is evident at all locations. In pools at Arrawarra Headland seasonal variation in algal growth is such that algal cover (particularly of *Sargassum* spp.) fluctuates from approximately 10 to 100% secondary cover in winter and summer respectively. The resulting shading and also sediment trapping by the algal holdfasts are likely causal factors of patches of dead, encrusting corals at this location.

Significant stress resulting from sand deposition by heavy seas is also evident, particularly at Woolgoolga Headland where deep pools towards the eastern tip of the headland display sand covered skeletons with few patches of living polyps.

DISCUSSION

The distribution of corals at nearshore locations in the Coffs Harbour region is more widespread than previously documented, with most major headlands and associated reefs supporting some coral colonies. However, diversity is substantially less than for the offshore Solitary Islands where 56 hermatypic species have been recorded to date (Veron, pers. comm.).

TABLE 3

List of hermatypic coral species present at the headlands surveyed and their southern limit of distribution (for the mainland and nearshore islands).

Coral species	Limit of southern distribution	Reference
Pocillopora damicornis	Sydney, N.S.W.	Veron, 1986
Acropora solitaryensis	Solitary Islands, N.S.W.	" "
Goniopora lobata	Solitary Islands, N.S.W.	" "
Psammocora superficialis	Solitary Islands, N.S.W.	" "
Coscinaraea mcneilli	South-eastern Australia	" "
Acanthastrea lordhowensis	Solitary Islands, N.S.W.	" "
Favites abdita	Forster, N.S.W.	Personal observation
Favites flexuosa	Solitary Islands, N.S.W.	Veron, 1986
Goniastrea australensis	Forster, N.S.W.	" "
Montastrea curta	Solitary Islands, N.S.W.	" "
Plesiastrea versipora	South Australia	" "
Cyphastrea seralia	Sydney, N.S.W.	Veron, pers. comm.
Turbinaria frondens	Solitary Islands, N.S.W.	Veron, 1986
Turbinaria mesenterina	Syndey, N.S.W.	Veron, pers. comm.
Turbinaria radicalis	Solitary Islands, N.S.W.	Veron,1986

Mainland coral species numbers are higher than those found by Veron *et al.* (1974), but this is partly due to the splitting of taxa which has occurred since this earlier work, as well as the concentration of the earlier surveys on the island coral fauna. The present study also encountered considerable taxonomic uncertainty with some colonies. Although samples were

generally taken where identification was not immediately apparent, it was not practical to sample all "atypical" colonies for obvious destructive reasons (part of the survey was conducted as a basis for objective selection of sites to include in the Solitary Islands Marine Reserve). The nature of the habitats where corals grew introduced large variation into colony and even intracolony corallite morphology such that small samples sent away were not always confidently identifiable to species level (e.g. *Favites* spp.). The problems associated with variable coral colony morphology from marginal habitats and consequent identification difficulties are not unique to these high latitude communities and have been well documented for low latitude reefs (Veron, 1981, 1986). A good example of local variation is shown by the only intertidal colony of *A. solitaryensis* found within the study area which was essentially encrusting, bleached and with few obvious branches. Difficulties with identification typically arose with *Favites (abdita* vs *flexuosa)* and *Turbinaria (mesenterina* vs *radicalis).*

The coral communities are dominated by the same species previously documented by Veron *et al.* (1974) as being the most tolerant of shallow water and the effects of competition with algae at South West Solitary Island - *T. mesenterina, F. abdita, G. australensis* and *P. damicornis* but also include *A. lordhowensis* and *P. superficialis.* Other species present were generally in much lower abundance and restricted to the more sheltered, deeper locations. Encrusting growth forms dominate, presumably because this colony formation offers survival advantages in an environment where wave action is one of the most significant physical features. In addition, all the colonial hermatypic species that have an Australian distribution record further south than the Solitary Islands and are thus thought to be more resistant to temperate conditions, are represented in the nearshore communities (see Table 3 for southern distribution limits for species recorded during these surveys). Species which have not been found further south to date include *A. solitaryensis, G. lobata, P. superficialis, A. lordhowensis* and *M. curta.* Their presence in the marginal nearshore habitat suggests that they may be the more tolerant representatives of their genera occurring within the region. Conversely, *Coscinaraea mcneilli* is close to its northern limit of distribution with no current records further north than Byron Bay, N.S.W. (Veron, 1986).

From previous studies within Australia, a number of factors have been suggested as important determinants of community structure of high latitude reefs (Crossland, 1981; Johannes *et* al., 1983, Crossland *et al.,* 1984). These include competition with algae, turbidity, and nutrient regimes as well as low winter temperatures. It is likely that these factors, as well as stress associated with periodic heavy sedimentation, are also primary determinants of coral community structure at mainland locations in the Coffs Harbour region. Some evidence for this assertion is provided by the observations made during these surveys. However, more detailed, long-term data on variations in the community structure correlated with changes in these factors are required to gauge their respective importance.

The system of currents at Coffs Harbour may also contribute to the observed coral distribution. The outer islands are subject to warm water, with tropical origin resulting from both direct flow and eddies of the East Australian Current (EAC). The importance of these eddies for the provision of recruits of tropical biota has been implied for fish (Pollard, 1981; Hutchins and Swainston, 1986) and algae (Chidgey, 1987) as well as for corals (Veron *et al.,* 1974). Indeed, the presence of a wide variety of tropical biota, many of which are present only during the warmer months (e.g. fish, Hutchins and Swainston, 1986; and pers obs.) suggests that these currents are a regular source of recruits to the offshore and, to a lesser extent, nearshore communities. Zooplankton studies as far south as the south-western Tasman Sea confirm the presence of tropical species at the centre of warm-core EAC eddies (Tranter *et al.* 1983). In contrast, the nearshore waters appear to be bathed predominantly in water derived from southern N.S.W. (Cresswell *et al.,* 1983; Chidgey, 1987). This argument is developed by Chidgey (1987) who hypothesises that a cool water eddy produced by a combination of the departure of the EAC from the coastline at Cape Byron and wind-driven northerly coastal currents result in the difference between the nearshore and island flora.

The number of overgrown colonies and also those displaying damage through sedimentation and algal abrasion suggest that there may be considerable turnover in the nearshore environment, an observation which is supported by research on coral communities in marginal habitats elsewhere (Veron, pers. comm.).

Concern must be expressed for the future of the nearshore corals while the continuing development of the local coastal area results in increased transportation of silt and nutrients into coastal waters. This can only increase the stress on the relatively scant coral fauna, possibly

tipping the equilibrium in favour of algal communities as has been demonstrated elsewhere (e.g. Banner, 1974).

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