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FINAL REPORT

LONG TERM MONITORING PROGRAM FOR MARINE BENTHOS IN THE VICINITY OF KESWICK ISLAND DEVELOPMENT (WHITSUNDAY ISLAND GROUP): BASELINE SURVEY

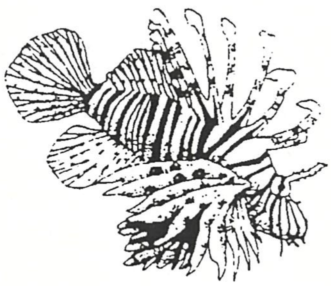
Prepared by

SEA RESEARCH

for

THE GREAT BARRIER REEF MARINE PARK AUTHORITY

April 2002



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CONTENTS

LIST OF TABLES

LIST OF FIGURES

Long Term Monitoring Program for marine benthos in the vicinity of Keswick Island Development (Whitsunday Island group): Baseline Survey

Draft report to the Great Barrier Reef Marine Park Authority from:
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1. INTRODUCTION

A residential development is currently being constructed on the southeast end of Keswick Island (approximate position 20° 55'S, 149° 24'E) by Keswick Island Pty Ltd (figure 1). Most of the terrestrial earthworks for this project have been completed but construction of coastal and marine infrastructure is expected to begin in the first half of 2002. Stage 1 of these works will comprise a reclaimed runway extension, commercial boat harbour and an associated barge ramp. A Code of Environmental Practice has been prepared by the Great Barrier Reef Marine Park Authority (GBRMPA) and the Queensland Environmental Protection Authority to guide the conduct of these works.

Potential impacts associated with the works that are of main concern to the GBRMPA include:

- The introduction of sediment into the water in sufficient quantity to settle on and smother marine organisms or to increase turbidity to the extent that sunlight reaching marine organisms is reduced.
- Physical damage to marine organisms from poor use of machinery.
- Pollution from spillage of fuel, oil or other pollutants.

A core component of the Code of Environmental Practice is an Environmental Monitoring Program (EMP), which includes a Reactive Monitoring and Management Program (RMMP) and a Long Term Monitoring Program (LTMP). The purpose of the LTMP is to detect and document any effects of the development on the benthic communities of the area, particularly corals. The GBRMPA has asked Sea Research to conduct the dry season baseline of the LTMP for marine benthos (especially corals) in the vicinity of the Keswick Island Development. We suggested that the baseline be based around sites of five permanent 20 m line intersect transects, with 6 sites set up within the potential impact areas of Horseshoe and Basil/Arthur Bays, and 12 control sites set up in four other fringing reef bays. It should be pointed out that while the stage 1 coastal and marine construction has not started, extensive earthworks have been carried out to develop roads and grassed residential blocks. Anecdotal evidence suggests that there has been considerable entry of run-off sediment from these earthworks onto the Horseshoe Bay reef flat. There has also been a residence on Saint Bees for many years with associated infrastructure. Because of these factors the current project does not represent a true undisturbed baseline picture of these fringing reefs. There may have been an unknown level of previous disturbance from the above factors.

* yes
*

This document presents the results of the first dry season baseline for the LTMP and discusses the nature of the observed fringing reef benthic communities in comparison with other fringing and offshore reef areas.

2. METHODS

2.1 Benthic Transects

Keswick Island is situated some 30 km northeast of Mackay (figure 1). The Keswick Island Long Term Monitoring Program Baseline Survey was carried out between the 15-19th October 2001. Coral cover was surveyed along permanently marked 20 m long intersect line transects. Previous trials have showed that there was no advantage in extending these transects longer than 20 m (Mapstone et al. 1992), and all programs we have been involved with have used 20 m transects (Ayling and Ayling 1991, 1995, 1998a, 2001a). These transects were positioned haphazardly, running as straight as possible and approximately parallel to the reef edge. They were marked using one metre lengths of 12 mm reinforcing rod driven into the reef substratum at 5 m intervals along the transect line. Our experience has shown that this method provides reliable marks that can be relocated over a period of at least five years (Ayling and Ayling 1998b).

The following organisms or groups of organisms were surveyed along the line intersect transects: all hard corals down to species level where possible but to structural groupings where reliable field identification was not possible eg. *Porites* spp. massive; total cover of fire corals (*Millepora* spp.); all soft corals to generic level where possible; total sponges; total area of substratum covered by turfing algae; total area covered by *Sargassum* and other macroalgae. The intersect lengths in cm of all the above organisms with the transect line were recorded for conversion to percentage cover measurements. Our experience has shown that line intersect transects are more accurate than video transects on fringing reefs where macroalgae are present (Ayling and Ayling 1998a). Comparative studies using both methods along the same transects have shown that line intersect transects, as carried out by Sea Research, are as accurate as video transects in non-algal benthic communities, and more accurate than video where macroalgae are present (Ayling and Ayling 1998a).

2.2. Sampling Design

This study was based around sites of five 20 m transects with the transects at each site run within an area approximately 50 x 15 m in a depth range from 2-5 m below low water springs level. We established three sites regularly spaced in each of six Bays around Keswick and St. Bees, with three sites in each potentially impacted Bay and three sites in each of four control Bays. This gave a total of 18 sites of five transects (table 1).

2.3. Analysis.

Spatial patterns in the baseline data were tested using analysis of variance techniques (table 2). Post hoc comparisons of means were made using Newman-Keuls tests at the 0.05 probability level.

Table 1. Design of the Proposed Monitoring Program.

Status	Impact						Control											
Bay	Horseshoe			Basil/ Arthur			Victor			Singapore			Homestead			Turtle		
Site no.	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Transects	5x	5x	5x	5x	5x	5x	5x	5x	5x	5x	5x	5x	5x	5x	5x	5x	5x	5x

Table 2. Baseline Benthic Cover Analysis

With 6 impact sites and 12 control sites. Bay has 6 levels

Source of variation	df	Fixed/ Random	Denominator
Bay	5	F	Site (B)
Site (B)	12	R	error
Error	72		

A repeated measures analysis of variance will be used to test the significance of any changes in benthic cover in subsequent re-surveys that might be caused by the development (table 3). The terms of interest in this analysis will be Time and the Time x Bay interaction. If coral cover decreases in either impact Bay it may cause an overall significant decrease in cover with time. However, such a decrease is more likely to give rise to a significant Time x Bay interaction as coral cover in the other bays either stays the same or increases due to normal coral growth.

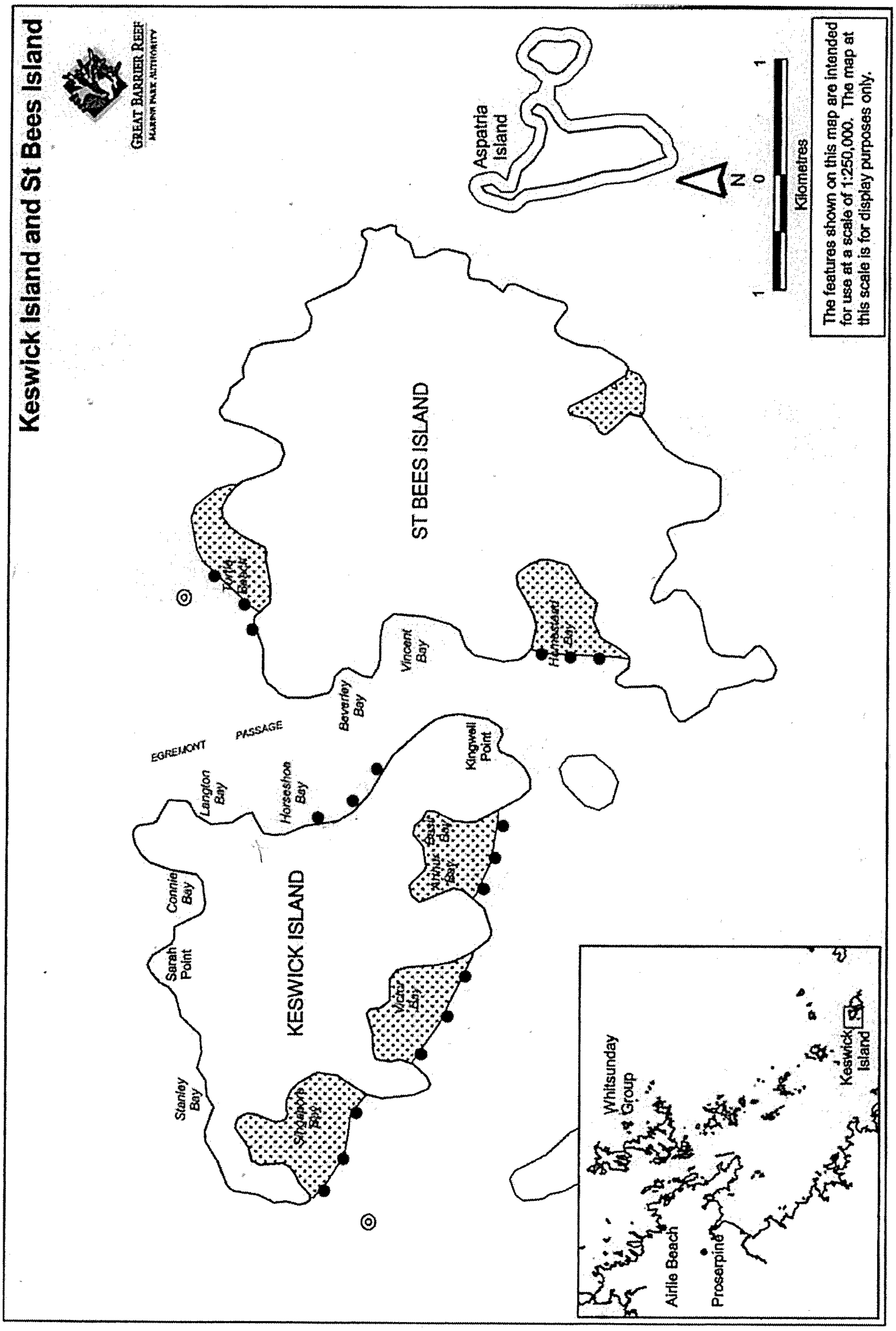
Table 3. Temporal Changes in Benthic Cover Analysis.

Summarises the design for the repeated measures analysis of variance: df assumes comparison of two time periods.

Source of variation	df	Denominator
Between Transects:		
Bay	5	Site (B)
Site (B)	12	error (s)
error (s)	72	
Within Transects:		
Time	1	S x T(B)
B x T	5	S x T(B)
S x T(B)	12	error (T)
error (T)	72	

Figure 1. Map of Keswick and Saint Bees Showing the Study Sites.

Approximate site positions are indicated by black circles in the survey bays.



3. RESULTS

3.1. Physical Environment of the Study Area.

Keswick and Saint Bees Islands are within the big-tide area of the Queensland coast that centres on Broad Sound. Between the southern Whitsunday Islands and Port Clinton mean spring tide rise and fall is over 4 m, peaking at over 6 m in Broad Sound. For Keswick/Saint Bees the mean spring tide range is 4.1 m. This compares with 1.6 m for the Cape Tribulation area, 2.3 m around Magnetic Island, 3.1 m at Hamilton Island, and 3.4 m at the Keppel Islands to the south of the big-tide area.

As a result tidal currents around Keswick and Saint Bees can be quite strong, running at 2-3 knots around the islands and over 4 knots through the narrow passage between the two islands. Our observations suggested the fringing reefs were mostly out of the direct currents and current speed along the edge of the reef slope was usually less than half a knot. Current turbulence stirs up fine bottom sediments and underwater visibility during spring tides can be very poor. Our visit coincided with high spring tides and a rise and fall range for Mackay Outer Harbour of almost 6 m. In these conditions underwater visibility ranged from 3-6 m, and deteriorated to 1-2 m when wind chop stirred up reef flat sediments. Local dive operators who use the area suggested that visibility during neap tide calm sea conditions can exceed 10 m.

Most of the fringing reefs around these islands were sheltered within bays, with the reef flat filling the bay and the reef slope running across the entrance. The reef flat was mostly sandy, with low algal covered carbonate substratum along the outer edge. Some hard corals occurred along the outer edge of the reef flat. The reef slope was narrow and in most cases fell to a sandy substratum over a horizontal distance of less than 10 m. With the exception of the reef along Vincent Bay on the St Bees side of the channel that was not surveyed, the reef slope reached a maximum depth of only 4-6 m below low spring tide level. The Vincent Bay reef dropped steeply to about 20 m

The reef flat in Horseshoe Bay was relatively narrow, being only 20-30 m across, and in many places this reef fell almost vertically to the sandy floor. In most bays the reef flat was at least 500 m across, and the reef slope more gentle. The reef slope was widest in Homestead Bay where *Acropora* thickets extended out some distance over the soft substratum. The reef slope along much of Turtle Bay was not continuous, but was broken into a series of steep sided reef patches surrounded by sand or rubble.

3.2. Benthic Communities of the Study Area.

The benthic communities were not the same in the six bays surveyed around Keswick and Saint Bees Islands. There were significant differences in the abundance of hard and soft corals, and the algal groups, as well as differences in the composition of the hard coral community (table 4-6, figures 2-9). Overall hard coral cover was highest in Homestead Bay, lowest in Victor Bay and similar in the other four bays (figure 2). Coral cover in Homestead Bay was over 46%, twice the mean from the other five bays (23% cover). Over 70% of hard coral cover in this bay was *Acropora* spp., mainly staghorn growth form species, compared to a mean of only 13% of hard coral cover in the other five bays. *Acropora* spp. cover in Homestead Bay was more than an order of magnitude greater than the mean from the other bays (32% vrs 3%). Both *Acropora* spp. and pocilloporid cover were significantly higher in Homestead Bay than in the other bays (table 5). The cover of faviids, agariciids and poritids was nominally lower in Homestead than in the other bays but these differences were not significant (table 5).

Horseshoe Bay had similar overall coral cover to three of the other bays (excluding Homestead and Victor: figure 2) but had some community composition differences to all other bays. Cover of the coral groups Poritidae, Merulinidae, Pectiniidae and total soft corals was significantly higher in Horseshoe than in the other five bays, while the cover of *Montipora* spp. was significantly lower (table 5).

Although overall coral cover in Victor Bay was significantly lower than in the other bays the benthic composition was similar to all bays except Homestead and Horseshoe (table 5).

The reefs of these bays were all algal dominated, with the exception of Homestead Bay. Macroalgae and turfing algae accounted for a combined cover of between 26 and 51% (figures 8, 9), greater than the overall hard coral cover in all but Homestead Bay. In all except Homestead Bay coral cover was very patchy, with large algal dominated areas interspersed with clumps of hard corals. The cover of *Sargassum* and other macroalgae was significantly higher in Singapore Bay compared to the other bays (table 4, 6; figure 8), while algal turf cover was significantly higher in Basil/Arthur and Victor Bays than in the other four bays (table 4, 6; figure 9).

Soft corals were significantly more abundant in Horseshoe Bay (16% cover) than in the other bays (grand mean 3.7% cover)(table 4, 6; figure 7). Encrusting soft corals were most abundant, followed by *Sinularia* spp and *Sarcophyton* spp.

In summary, Homestead Bay reefs stood out as strongly different from those in the other survey bays, being dominated by extensive stands of *Acropora* corals along the full length of the bay. Horseshoe Bay reefs were also somewhat different from the other bays, with a steeper reef slope, more massive corals such as *Porites*, *Pectinia* and *Lobophyllia*, and more soft corals (table 7).

3.3. Power of the Tests.

The techniques of Cohen (1988) were used to find the power of the interaction term to detect a change in overall coral cover in Horseshoe Bay with 80% power and a probability level of 0.1. This suggested that the minimum change that could be detected with 80% power is a relative decrease of 36% (effect size index – f = 0.395; u = 5; n' = 13). This is within the guidelines set by the GBRMPA for coral cover levels of 25% in their Project Brief for the LTMP. However, this assumes that the transects used to detect change are random and the power of fixed transects to detect change is much greater. Setting random decreases to coral cover in the Horseshoe Bay transects, and setting relative changes in the other bays to plus or minus less than 5% and maintaining the same standard errors, showed that a relative decrease of less than 10% at Horseshoe Bay gave a Bay x Time interaction significant at a probability level of less than 0.0001.

Table 4. Analysis of Variance Results for the Major Benthic Groups.

Significance of analyses for the factors Bay and Site (Bay) are shown.
Note: NS - not significant; * - 0.01<p<0.05; ** - 0.001<p<0.01; *** - p<0.001.

Benthic Group	Bay	Site (Bay)
Sargassum (macroalgae)	**	***
Turf algae	***	NS
Total hard coral	***	NS
Pocilloporids	*	*
Acropora spp.	***	**
Montipora spp.	*	*
Poritids	*	NS
Agariciids	NS	*
Pectiniids/Merulinids	*	NS
Faviids	NS	*
Turbinaria	NS	NS
Total soft coral	*	***

Table 5. Significance of Benthic Cover Differences Among Bays.

Covers of the indicated benthic groups in the underlined ranges of Bays were not significantly different at the 0.05 probability level using the Newman-Keuls post-hoc test. Bay abbreviations: Hoe = Horseshoe; BA = Basil/Arthur; Sng = Singapore; Vic = Victor; Ttl = Turtle; Hsd = Homestead.

	High →					Low
Sargassum	Sng	Ttl	BA	Vic	Hoe	Hsd
Turf algae	BA	Vic	Sng	Ttl	Hsd	Hoe
Total hard coral	Hsd	Ttl	BA	Hoe	Sng	Vic
Pocilloporids	Hsd	Sng	Ttl	Hoe	BA	Vic
Acropora spp.	Hsd	BA	Sng	Ttl	Hoe	Vic
Montipora spp.	BA	Vic	Sng	Ttl	Hsd	Hoe
Poritids	Hoe	Tttl	Sng	BA	Vic	Hsd
Agariciids	Ttl	Hoe	Vic	BA	Sng	Hsd
Pectin/Merulinids	Hoe	Ttl	Sng	BA	Hsd	Vic
Faviids	Tttl	BA	Hoe	Vic	Sng	Hsd
Turbinaria	Ttl	BA	Sng	Hsd	Vic	Hoe
Total soft coral	Hoe	Ttl	BA	Sng	Hsd	Vic

Table 6. Summary of Cover of the Major Benthic Groups in the Survey Bays.

Figures show means from three sites of five 20 m permanent line intersects in each bay, with the standard error beneath in brackets.

Benthic category	Hoe	BA	Vic	Sng	Ttl	Hsd
Sargassum spp.	9.1	13.8	12.7	24.0	16.4	6.1
	(1.0)	(1.8)	(2.2)	(2.7)	(2.2)	(1.3)
Turf algae	18.2	37.3	36.3	23.7	23.2	20.0
	(1.6)	(2.3)	(2.4)	(2.5)	(1.7)	(2.9)
Total hard coral	23.7	24.8	16.4	22.7	26.6	46.4
	(1.5)	(2.5)	(1.3)	(2.3)	(2.5)	(4.4)
Pocilloporids	0.9	0.6	0.4	1.5	1.1	4.0
	(0.2)	(0.2)	(0.2)	(0.5)	(0.4)	(1.0)
Acropora spp.	2.5	5.8	0.7	3.1	2.6	32.7
	(0.7)	(2.5)	(0.3)	(1.5)	(1.1)	(5.4)
Montipora spp.	0.8	7.4	6.4	6.1	4.3	4.1
	(0.3)	(1.4)	(1.1)	(0.8)	(0.9)	(1.2)
Poritids	8.8	4.7	3.8	5.6	7.1	2.8
	(1.2)	(0.9)	(0.8)	(1.0)	(1.0)	(1.0)
Acariciids	1.6	1.0	1.0	0.5	2.2	0.3
	(0.6)	(0.3)	(0.4)	(0.3)	(0.5)	(0.2)
Pectiniid/Merulinids	3.1	0.5	0.4	0.7	1.7	0.4
	(1.2)	(0.2)	(0.2)	(0.3)	(0.7)	(0.2)
Faviids	2.7	2.8	2.6	2.5	3.9	0.7
	(0.7)	(0.6)	(0.5)	(0.6)	(0.7)	(0.2)
Turbinaria spp.	0.3	0.9	0.3	0.7	1.0	0.6
	(0.1)	(0.4)	(0.2)	(0.3)	(0.5)	(0.3)
Total soft coral	16.0	3.4	2.7	3.0	6.8	2.9
	(2.8)	(0.6)	(0.9)	(0.6)	(1.7)	(1.0)

Table 7. Summary of Differences Between Survey Bays.

Bay	Physical differences	Benthic community
Homestead	• wide reef flat	• high overall coral cover • very high *Acropora* cover • high pocilloporid cover
Horseshoe	• narrow reef flat • steep reef slope	• high poritid cover • high pectiniid/merulinid cover • high soft coral cover • low *Montipora* cover
Victor	• wide reef flat	• low overall coral cover • high algal turf cover
Basil/Arthur	• wide reef flat	• high algal turf cover
Singapore	• wide reef flat	• high *Sargassum* cover
Turtle	• broken reef flat	

Figure 2. Abundance of Total Hard Coral in the Survey Sites.

Graph shows mean percentage cover from five 20 m line intersect transects at each site. Error bars are standard errors. Bays with significantly higher or lower coral cover than the rest are marked with an asterisk: *

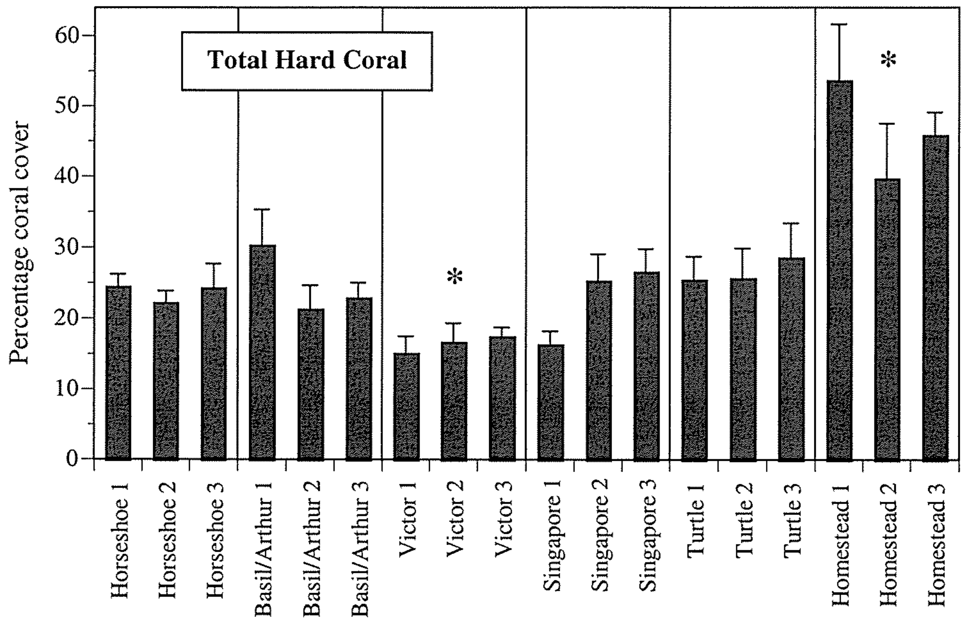


Figure 3. Abundance of Pocilloporid Corals in the Survey Sites.

Graph shows mean percentage cover from five 20 m line intersect transects at each site. Error bars are standard errors. Bays with significantly higher or lower coral cover than the rest are marked with an asterisk: *

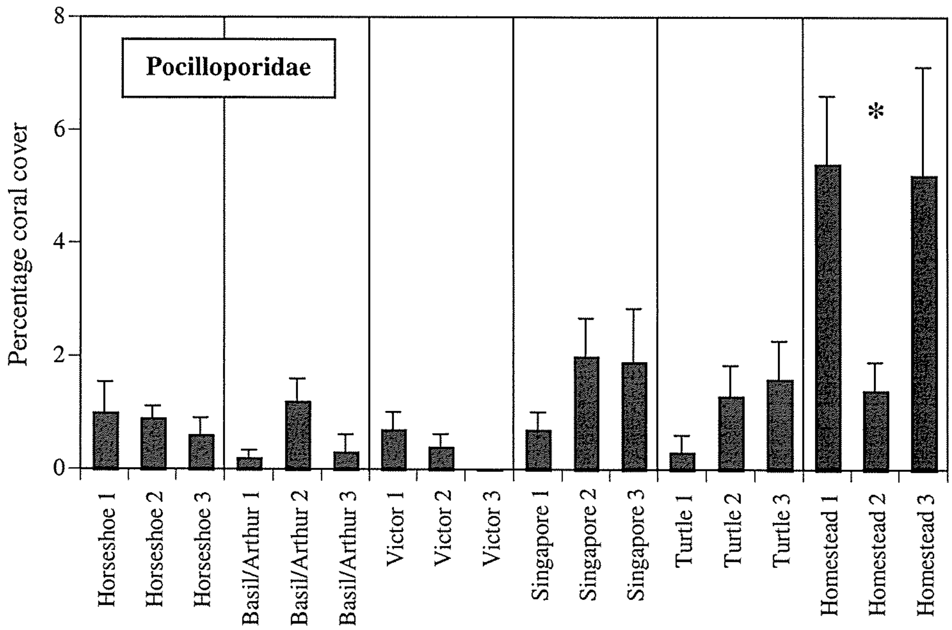


Figure 4. Abundance of *Acropora* spp. Corals in the Survey Sites.

Graph shows mean percentage cover from five 20 m line intersect transects at each site. Error bars are standard errors. Bays with significantly higher or lower coral cover than the rest are marked with an asterisk: *.

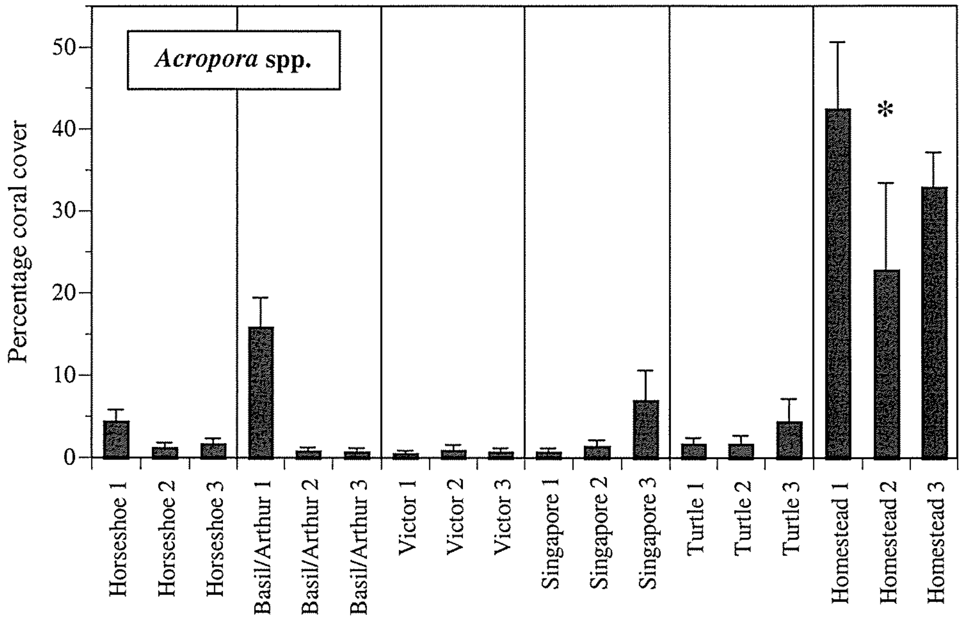


Figure 5. Abundance of *Montipora* spp. Corals in the Survey Sites.

Graph shows mean percentage cover from five 20 m line intersect transects at each site. Error bars are standard errors. Bays with significantly higher or lower coral cover than the rest are marked with an asterisk: *

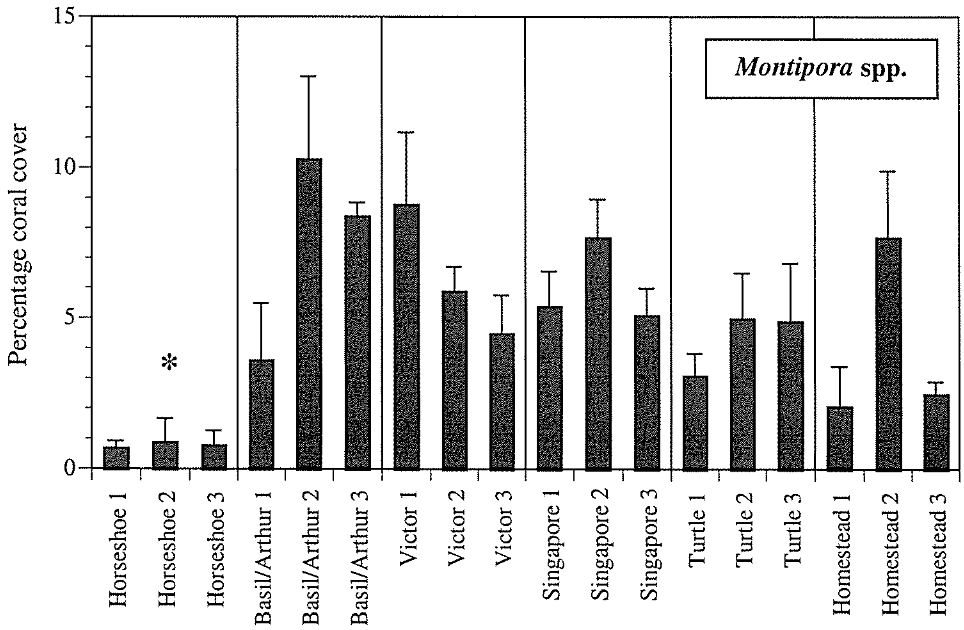


Figure 6. Abundance of Poritid Corals in the Survey Sites.

Graph shows mean percentage cover from five 20 m line intersect transects at each site. Error bars are standard errors. Bays with significantly higher or lower coral cover than the rest are marked with an asterisk: *

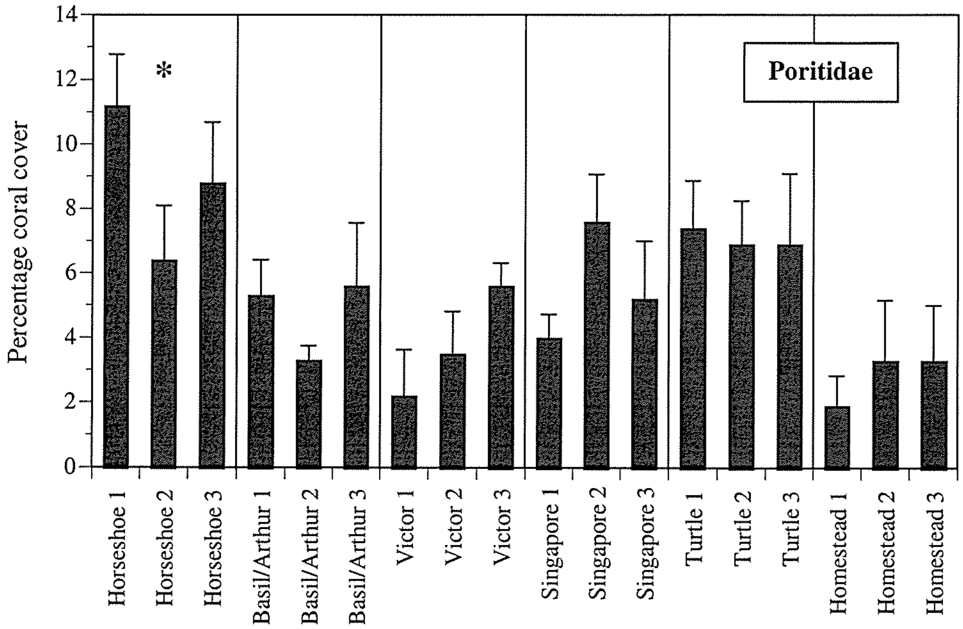


Figure 7. Abundance of Total Soft Corals in the Survey Sites.

Graph shows mean percentage cover from five 20 m line intersect transects at each site. Error bars are standard errors. Bays with significantly higher or lower coral cover than the rest are marked with an asterisk: *

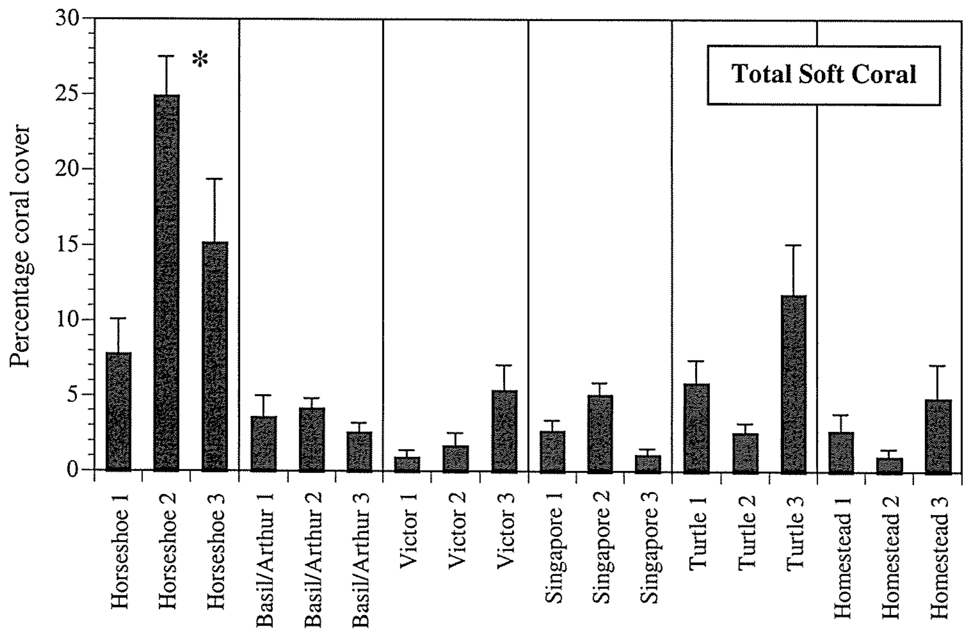


Figure 8. Abundance of *Sargassum* spp. Macroalgae in the Survey Sites.

Graph shows mean percentage cover from five 20 m line intersect transects at each site. Error bars are standard errors. Bays with significantly higher or lower algal cover than the rest are marked with an asterisk: *

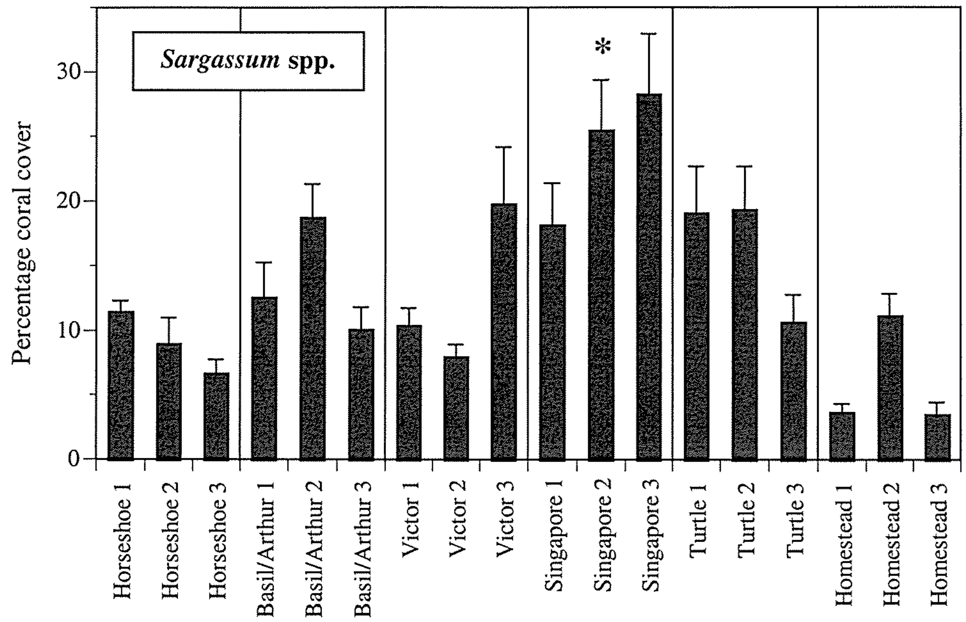
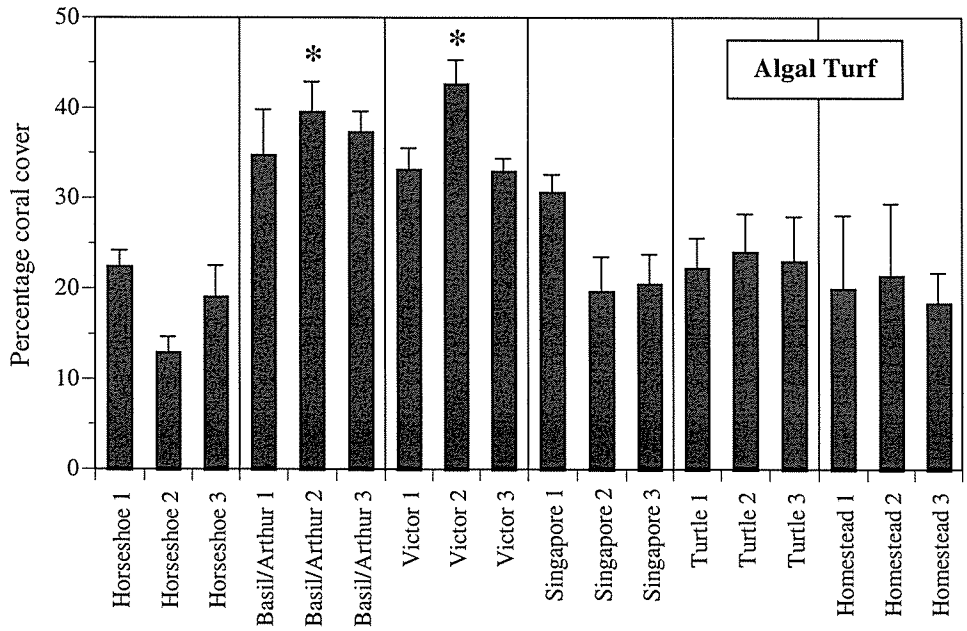


Figure 9. Abundance of Algal Turf in the Survey Sites.

Graph shows mean percentage cover from five 20 m line intersect transects at each site. Error bars are standard errors. Bays with significantly higher or lower algal turf cover than the rest are marked with an asterisk: *



4. DISCUSSION

The reef slope of most of the fringing reefs around Keswick and Saint Bees Islands (Keswick) supported only moderately rich hard coral communities, with around 23% mean overall coral cover. Most coral colonies were small to medium sized (less than a metre) and aesthetics were generally poor. The reefs were dominated by macroalgae and turfing algae and the distribution of hard corals was rather patchy. Cover of *Acropora* spp. corals was usually low, and the reefs were dominated by a mixture of poritid, faviid and *Montipora* spp. corals. An exception to all this was Homestead Bay where coral cover was twice that in the other five bays, and over 70% of coral cover was *Acropora* spp. The reason for this dramatic difference was not clear. Homestead is probably the most protected bay as far as the prevailing SE winds are concerned but Horseshoe is also protected from wind in this quarter and coral cover in the latter bay was very different from that in Homestead. Homestead is still open to strong winds from the SW to West and has no other physical characteristics that are not shared by many of the other bays. It is possible that some combination of historical events has led to the present marked differences between Homestead and the other bays. The reefs fringing the small bay on the tip of Kingwell Point (figure 1) were also *Acropora* dominated and appeared to be similar to those in Homestead Bay. We had a quick look at these reefs but did not carry out any surveys as they are rated as deserving special protection and are within a no anchoring zone. This bay is more exposed than Homestead and is very similar in aspect to Basil/Arthur Bay

Keswick fringing reefs are at the lower end of the coral abundance scale when compared to the latest available surveys from other GBR fringing reefs (table 8). Coral cover around Keswick was similar to that on the cyclone, crown-of-thorns and bleaching damaged reefs around Snapper and the Frankland Islands. Overall coral cover was also similar to that recorded ten years ago on reefs in the Sir James Smith Group 20 km to the north of Keswick (Van Woesik 1992). Coral cover was lower than Keswick Island only in the Northumberland Island Group 50 km further south and much closer to Broad Sound (Van Woesik 1992). Coral cover around all other fringing reefs was much higher than around Keswick Island (table 8).

The cover of acroporids was much lower around Keswick/St. Bees than on most other fringing reefs (table 8). This difference was most pronounced if Homestead was excluded from the Keswick data. Acroporids accounted for only 12% of total hard coral cover in the five survey bays excluding Homestead, but made up 56% of total hard coral cover on the other fringing reef locations for which data was available. Outside Keswick/St. bees the lowest acroporid cover was in the Frankland Islands where this group made up 23% of hard corals. This island group had suffered extensive bleaching and crown-of-thorns damage to coral communities over the past four years that had markedly reduced acroporid cover (Ayling and Ayling 2001a). In spite of this damage, acroporids on the Frankland reefs accounted for about twice the percentage of hard corals as did acroporids on Keswick Island (excluding Homestead Bay). This difference is clearly not an environmental effect of the general Keswick region or acroporids could not reach the levels that they have in Homestead Bay. The acroporids in this bay were healthy and not obviously stressed. Instead, this difference probably reflects some feature of the history of coral growth and disturbance on Keswick/St. Bees. It seems likely that there have been recent (past decade) impacts in most sites that have reduced the expected high acroporid cover.

Many natural disturbances, such as bleaching episodes, cyclones and *Acanthaster* outbreaks have a disproportionate effect on acroporid and pocilloporid cover compared with other coral groups (Ayling and Ayling 2001a, Done et al. 1986, Fisk and Done 1985, Harriott 1985, Moran et al. 1987).

Table 8. Summary of Hard Coral Cover on GBR Fringing Reefs.

Figures show grand mean percentage cover from groups of 20 m line transects. [1] Ayling et al. 1997; [2] Ayling and Ayling 2001a; [3] Ayling and Ayling 2001b; [4] Ayling and Ayling 2001c; [5] Ayling et al. 1998; [6] Van Woesik 1992; [7] This study. na = not available.

Region	Date	Latitude °S	No. sites	Hard coral cover mean	Hard coral cover se	Acroporid cover
Cape Flattery[1]	Feb 1996	14.9	5	**46.2**	2.4	18.9
Cape Tribulation[2]	Dec 2001	16.0	12	**50.1**	3.4	37.4
Snapper Island[2]	Dec 2001	16.3	6	**27.3**	4.2	18.3
Frankland Islands[2]	Dec 2001	17.2	6	**23.5**	2.7	5.5
Magnetic Island[3]	Sep 2001	19.2	26	**39.5**	1.8	15.5
Hamilton Island[4]	Sep 2001	20.3	6	**51.4**	3.2	36.4
Sir James Smith Gp. [6]	1991	20.7	56	**22.0**	na	na
Keswick Island[7]	Oct 2001	20.9	18	**26.8**	1.4	12.9
Northumberland Is. [6]	1991	21.5	20	**11.7**	na	na
Shoalwater Bay[5]	Dec 1995	22.3	34	**38.4**	1.4	22.3
Keppel Islands[6]	1991	23.2	8	**54.3**	na	na

A comparison of Keswick/St. Bees fringing reef coral cover measurements with those recorded on offshore reefs is interesting (table 9). Coral cover recorded on northern offshore reefs since the mid 90s that have been damaged by crown-of-thorns and cyclones over recent decades, was about equal to that from Keswick Island. However, coral cover on reefs offshore from Keswick Island (Mackay and Pompey data from table 9) was almost twice that recorded on the inshore island fringing reefs. These offshore reefs have not been badly damaged for at least the past decade (A.M. Ayling personal observations). Although a breakdown of the offshore data into coral groups is not possible our observations suggest that acroporids accounted for well over 50% of hard corals from the Mackay and Pompey offshore regions (A.M. Ayling personal observations).

Coral communities in the Keswick/St. Bees sites that are likely to be affected by terrestrial and marine construction at the Keswick development site are not rich in terms of level of coral cover, with a grand mean cover of less than 25%. These reef communities are also algal dominated and aesthetically poor. The dominant corals from these sites, such as poritids, faviids and pectiniids, are all relatively resistant to many impacts such as sedimentation, bleaching, freshwater inundation, crown-of-thorns grazing and cyclone damage (Ayling and Ayling 1991, 2001a Done et al. 1986, Fisk and Done 1985, Harriott 1985, Moran et al. 1987; Van Woesik et al. 1996). As a result of these features it should be possible to avoid any construction related stresses through the application of effective but not overly restrictive management practices. If any deleterious effect does occur on the fringing reefs adjacent to the development the power of the monitoring design to detect such change is good. A reduction in coral cover at the impact sites of 5-10% should be detected with adequate power assuming that the control sites remain stable, or increase in coral cover.

Table 9. Comparative Coral Cover on Offshore Reefs

Grand mean coral covers from: [1] data from AIMS long term monitoring program (personal communication from W. Oxley); [2] data from Bramble Reef replenishment area survey (Ayling and Ayling 1996); [3] data from CRC Effects of Fishing survey (A.M. Ayling and D. McB. Williams unpublished data).

Region	Date	No. survey reefs	Total no. sites	Hard coral cover (%) mean
GBR (AIMS reefs)[1]	1993-94	34	102	**23**
Offshore Townsville[2]	Aug 1995	7	84	**29**
Lizard Island area[3]	Oct 2000	6	36	**15.6**
Townsville offshore[3]	Oct 2000	6	36	**23.8**
Mackay offshore[3]	Nov 2000	6	36	**50.2**
Pompey reefs[3]	Nov 2000	6	36	**44.4**

We have heard undocumented reports that there has already been sediment run-off from terrestrial earth works on Keswick Island onto the Horseshoe Bay reef and this may already have had an influence on the environment of the area. The corals of the area looked healthy at the time of our study. However, we did notice that a strong NE wind combined with a low spring tide on one of our survey days stirred up fine sediments along the Horseshoe Bay reef, reducing underwater visibility to less than 1 m. While this is a frequent occurrence on many coastal and island fringing reefs we have visited we are not sure if it is normal around Keswick or whether it results from the recent introduction of fine terrestrial sediment into the environment from the anecdotal run-off mentioned above.

The high water temperatures experienced along much of the Queensland coast during January and February 2002 also affected Keswick/St. Bees. Many of the corals on the Keswick fringing reefs were bleached during this high temperature episode (personal communication from Paul Marshall of the GBRMPA). This bleaching may cause mortality of corals on the Keswick reefs, and we would suggest that it is important to establish the extent of this effect before the area is disturbed by the Keswick development. Differential mortality of corals in the survey Bays resulting from this bleaching could confound the ability of the monitoring program to detect construction impacts. A second baseline before an~~d~~y substantial activity would resolve this problem.

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APPENDIX 1. Position of the Survey Sites: as derived from a hand held GPS.

Bay	Site	Latitude S	Longitude E
Horseshoe	Site 1	20° 54.900	149° 25.110
	Site 2	20° 54.789	149° 25.025
	Site 3	20° 54.628	149° 24.995
Basil/Arthur	Site 1	20° 55.470	149° 24.612
	Site 2	20° 55.455	149° 24.720
	Site 3	20° 55.482	149° 24.777
Victor	Site 1	20° 55.275	149° 24.205
	Site 2	20° 55.148	149° 24.129
	Site 3	20° 55.038	149° 23.982
Singapore	Site 1	20° 54.868	149° 23.636
	Site 2	20° 54.716	149° 23.540
	Site 3	20° 54.666	149° 23.353
Turtle	Site 1	20° 54.364	149° 25.813
	Site 2	20° 54.314	149° 25.868
	Site 3	20° 54.275	149° 26.138
Homestead	Site 1	20° 55.820	149° 25.680
	Site 2	20° 55.737	149° 25.679
	Site 3	20° 55.919	149° 25.641