



Appendix E

Benthic Survey of Fringing Coral Reefs of Victor Islet, Round Top and Flat Top Islands



**PORTS CORPORATION
QUEENSLAND**

Port of Hay Point Apron Areas and Departure Path Capital Dredging

Benthic Survey of the Fringing Coral
Reefs of Victor Islet, Round Top and Flat
Top Islands



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- A Summary ranked abundance for Victor Islet, Round Top and Flat Top Islands (Sites 1-6)
- B List of Plant and Invertebrate Species
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1. Introduction

1.1 Location

The Port of Hay Point is located in the Shire of Sarina on the Central Queensland coast approximately 40 km south of Mackay as shown in Figure 1. The Port of Hay Point is Queensland's largest coal export port exporting close to 80 M t of coal in 2004 with export volumes planned to increase significantly in the next 5 years.

1.2 Proposed Capital Works

The port expansion program involves the capital dredging of approximately 9 million m³ of material from the apron areas adjacent to the terminal berths and the creation of a departure path. Future maintenance works over a 5 year period are expected to generate up to a further 5 million m³ of material. The proposed works involve the disposal of material at a spoil ground approximately 5 km to the north of the port facilities. Disposal of dredged material is expected to occur in a proposed new spoil ground extending seaward from the existing spoil disposal ground.

1.3 Impacts Associated with Dredging and Disposal of Sediment

1.3.1 Turbid Plumes

Dredging and the disposal of fine sediments can cause sediment plumes to become suspended within the water column. Tidal and other currents may then cause the plume to migrate away from the original point source. Sediment plumes increase the turbidity of the water and thus reduce the amount of available light to organisms that rely on photosynthetic processes. Such organisms may be sensitive to the migration of sediment plumes, especially in deeper water where light penetration is already limited at the seabed.

While the larger dredged sediment particles do not mobilise any great distance, finer particulates may migrate several kilometres. Migration of finer sediments has been observed previously at Hay Point during maintenance dredging activities. Hydrodynamic plume modelling undertaken as part of the Port of Hay Point EIS (GHD 2005) predict elevations in turbidity adjacent to nearby fringing coral reefs including those surrounding Victor Islet, Round Top and Flat Top islands.

As sediment plumes migrate, particles may fall out of suspension and deposit on the seabed. This creates a deposition footprint that may extend past the boundary of the spoil ground. While benthic organisms deal with moderate rates of sediment deposition as a normal phenomenon in shallow coastal waters, inordinate elevation in this rate may lead to smothering and mortality (Skilleter, 1998). Modelling of the proposed dredging program predicts a low rate of deposition, being between 0.5 and 2.0 mm per month with dredging expected to occur over a sixth month period.

1.3.2 Benthic Habitats

The Queensland Department of Primary Industries and Fisheries (QDPI & F) and CRC Reef Research Centre have completed surveys investigating the diversity and distribution of benthic habitats at Port of Hay Point (Rasheed *et al.* 2004) and adjacent Mackay Harbour (Rasheed *et al.* 2001). Rasheed *et al.* (2004) surveyed benthic habitats to assess the location and suitability for the proposed departure path and disposal ground. Key ecological communities identified during these studies include seagrass, algae and benthic invertebrate populations. No hard coral communities were surveyed over the areas targeted by this survey. Rasheed *et al.* (2001) conducted similar surveys of benthic habitats within the vicinity of the Mackay Harbour, several kilometres to the north of Hay Point. Apart from deeper soft sediment habitats, these surveys also identified the presence of hard coral fringing reef communities surrounding Flat Top and Round Top islands.

1.4 Scope of Investigation

1.4.1 Overview

Following additional information requests from GBRMPA, GHD have been commissioned by PCQ to survey and assess fringing reef habitats surrounding Victor Islet and Flat Top, Round Top Islands (see Figure 1). It is expected that dredging activities will create sediment plumes that will migrate outside the port boundaries. Of specific interest is the migration of sediment plumes towards Round Top and Flat Top Islands to the north of the port and Victor Islet to the south (see Figure 1). These islands, all of which are located within the Great Barrier Reef Marine Park, have each been designated as habitat protection zones. While each island is known to be fringed by coral reef communities, the extent and condition of these reefs has not previously been documented. The present survey provides the first detailed assessment of the diversity, abundance and condition of these fringing reefs, for the purpose of determining the likely sensitivity of these habitats to the effects of light attenuation and sediment deposition. The survey will also act as a baseline assessment for any future monitoring that may be required during the construction and post-construction phases of the port development.

1.4.2 Survey Locations

Round Top Island is situated 9 km north of the port facilities in the Port of Hay Point and 4 km to the northwest of the proposed disposal ground. This continental island covers 19 ha, rising to a height of 72 m. The island is characterised by steep sloping cliffs on the eastern side of the island and a gentler slope on the western side (see Figure 1). Continuation of the slope gradient on either side of the island extends down past the low tide watermark as rocky reef until the hard substrate changes to a soft sediment substrate where the seabed slope then levels out. Fringing reef flat is delimited by the prevailing bathymetry surrounding Round Top Island.

Flat Top Island lies 1 km to the north west of Round Top Island. Flat Top Island is 17 ha in size, located approximately 12 km from the Hay Point terminal and 5 km from



the disposal ground (see Figure 1). The formation of Flat Top is very similar to that of Round Top Island, with deeper, steeply sloping cliffs and bathymetry along its eastern side. Unlike Round Top, Flat Top Island exhibits a gently sloping reef flat (~3 m LAT) along its western and northern shores, covering an area of approximately 14 ha.

Victor Islet lies approximately 8 km south of the port facilities in the Port of Hay Point and 3 km from the mainland. Victor Islet is the smallest of the three islands in size, at approximately 7 ha (see Figure 1). The topography of Victor Islet is very different to both Flat Top and Round Top Islands, reaching a height of less than 10 m. The reef flat at Victor Islet extends out to 1 km at the island's southern end, and occupies an area of approximately 45 ha. Shallow water depths (-1 to -3 m LAT) surround the island representing a significant variation to both Round Top and Flat Top Islands.

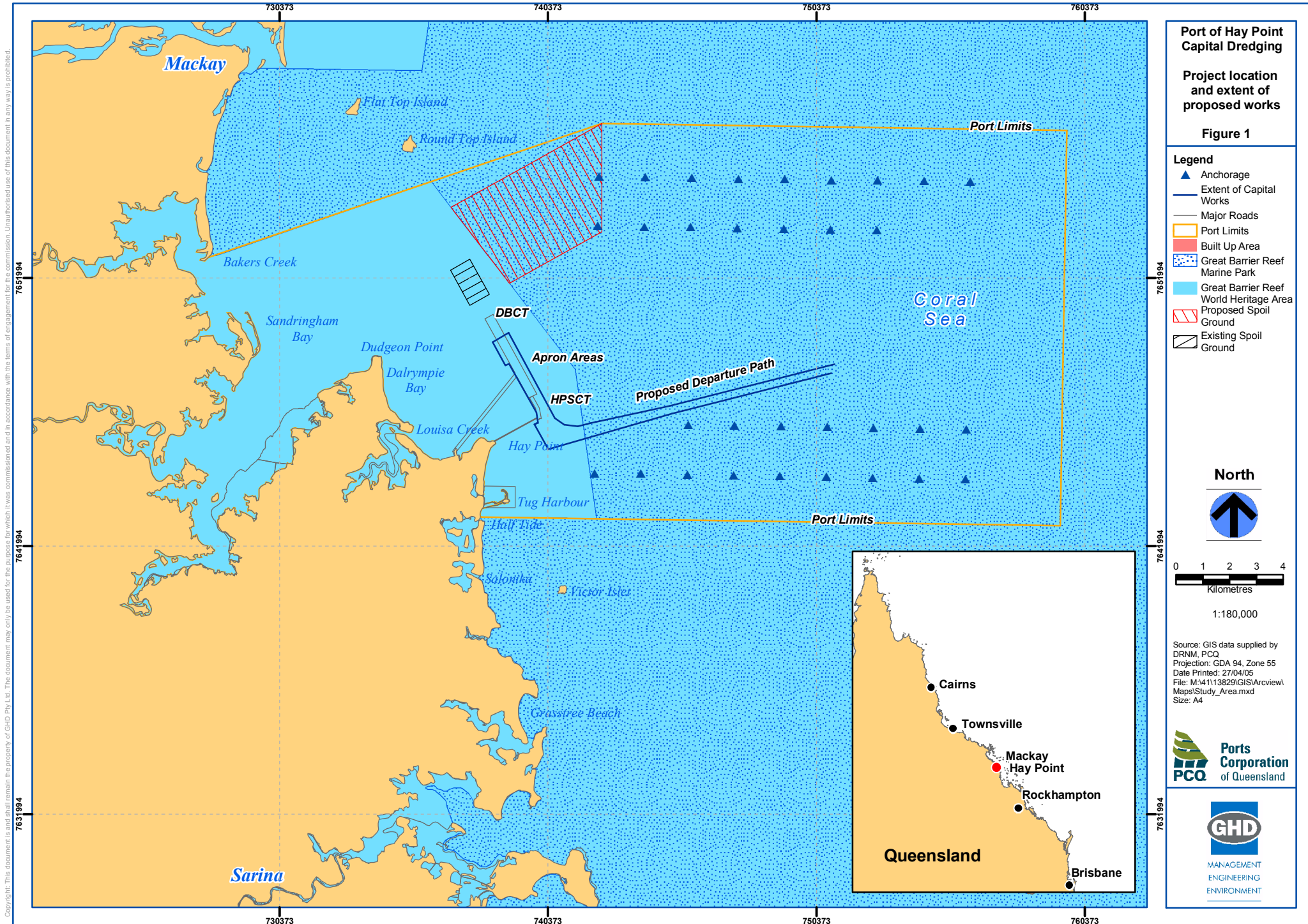


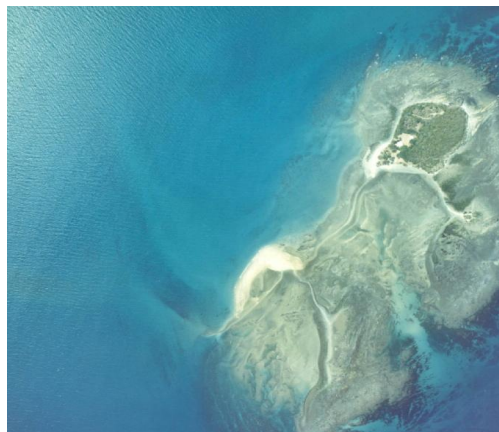
Figure 2 Victor Islet, Flat Top and Round Top Islands



a. Flat Top Island, south eastern shore



b. Round Top Island, south eastern shore



c. Victor Islet (Note enlarged reef flat)



d. Round Top (left) and Flat Top (right)



e. Flat Top Island, eastern shore



f. Coal loading at the Port of Hay Point

2. Methodology

2.1 Introduction

Line intercept surveys were undertaken to provide an assessment epibenthic habitats of the fringing reef adjacent to Victor, Round Top and Flat Top Island. The key objective of the survey was to assess the cover, abundance and diversity of epibenthic fringing reef communities at the three survey locations.

2.2 Survey Period

Surveys were conducted over a 3-day period between May 14 - 16, 2005. The conditions experienced during the survey enabled excellent video footage to be recorded and accurate analysis to be undertaken (see Figure 3). Each island required between 6-8 hrs of shallow water diving to complete the survey.



Figure 3 Video survey of benthic biota

2.3 Site Locations

Surveys were conducted at Victor Islet, Round Top and Flat Top islands. Six sites were surveyed at each island, with 4 replicate transects undertaken at each site. A total of 18 sites consisting of 72 transects provided the survey of approximately 1,440 m of the seabed.

Distribution of the six survey sites in the near shore benthic habitats surrounding Victor Islet were restricted due to vessel access and depth. Attempts were made to establish a site within the narrow channel that separates Victor Islet from an adjacent sand and rocky reef system. While this would have provided coverage between sites V4 and V3, shallow depths and narrowness of the passage precluded the safe survey of these reaches by the vessel. The area that remained unsurveyed was, according to visual inspection, predominantly sand and rubble substrate. The sites established at Victor Islet provided assessment of similar depth regimes to those of Round Top and Flat Top Islands, and provided a comparison between 'front' (windward) and 'back' (leeward) conditions.

Table 1, Figure 4, Figure 5 and Figure 6 present the location of each survey site.

Table 1 Survey design and site locations

Location	Sites	Position (UTM WGS 84)
Flat Top	F1	55 K 733603 7658917
Flat Top	F2	55 K 733502 7658549
Flat Top	F3	55 K 733340 7658105
Flat Top	F4	55 K 732999 7657940
Flat Top	F5	55 K 732547 7658511
Flat Top	F6	55 K 732946 7658683
Round Top	R1	55 K 735298 7657438
Round Top	R2	55 K 735442 7657118
Round Top	R3	55 K 735576 7656892
Round Top	R4	55 K 735346 7656611
Round Top	R5	55 K 734951 7656666
Round Top	R6	55 K 734962 7657030
Victor	V1	55 K 741409 7641088
Victor	V2	55 K 741424 7640500
Victor	V3	55 K 741361 7639688



Location	Sites	Position (UTM WGS 84)
Victor	V4	55 K 740522 7640449
Victor	V5	55 K 740853 7640881
Victor	V6	55 K 741081 7640757



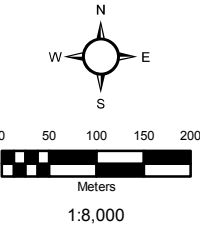
**Port of Hay Point
Capital Dredging**

**SURVEY SITE
LOCATIONS FOR
FLAT TOP
ISLAND**

Figure 4

Legend

+ Dive site location



Source: GIS data supplied by
SunMap, DNRM, Field Data
Projection: GDA94, Zone 55
Date Printed: 27/06/05
File: g4113829\GIS\Arcview\Maps
Flat_Top_dive.mxd
Size: A4



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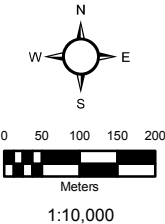
**Port of Hay Point
Capital Dredging**

**SURVEY SITE
LOCATIONS FOR
ROUND TOP
ISLAND**

Figure 5

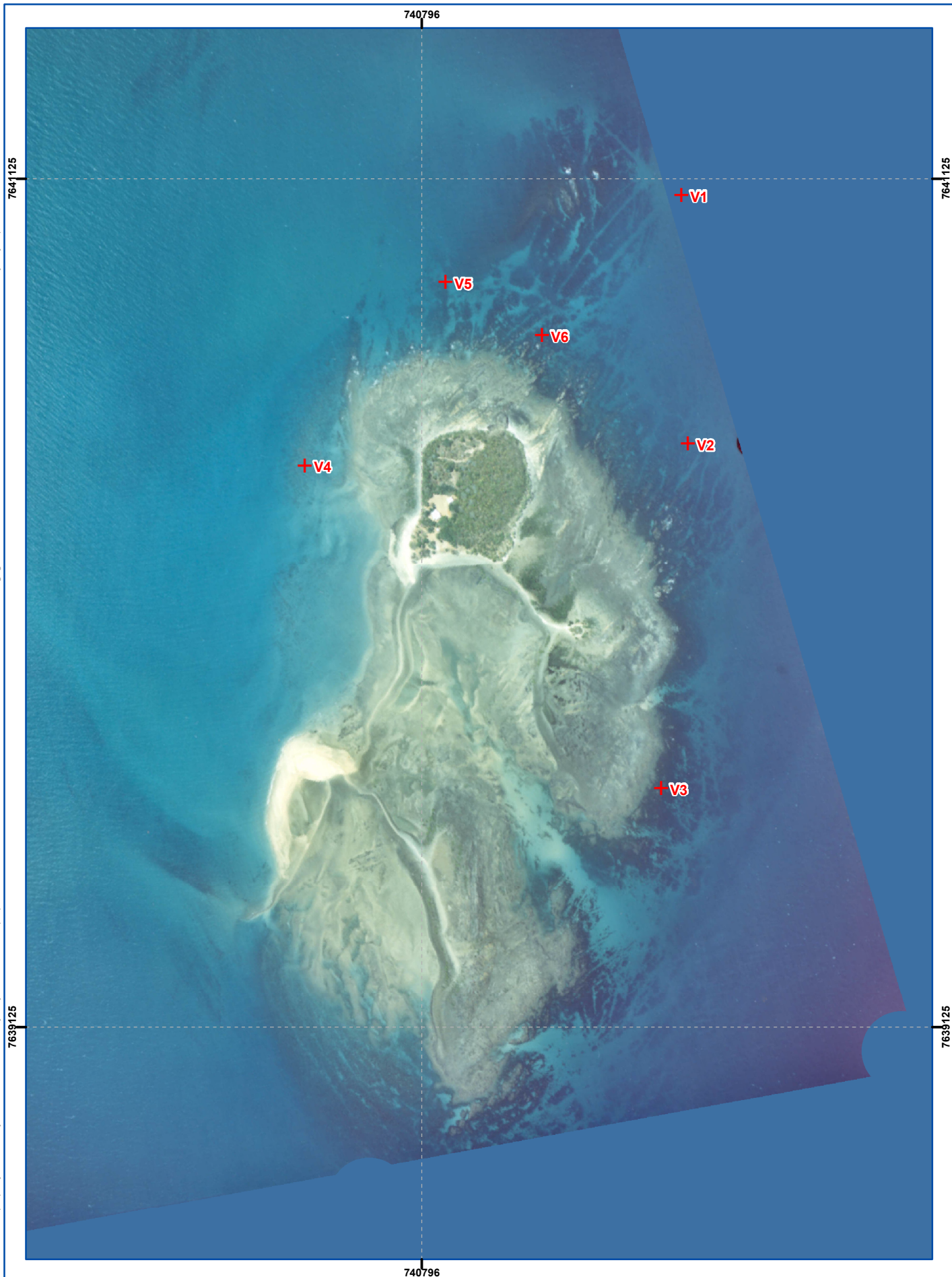
Legend

+ Dive site location



Source: GIS data supplied by
SunMap, DNRM, Field Data
Projection: GDA94, Zone 55
Date Printed: 27/06/05
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Round_Top_dive.mxd
Size: A4

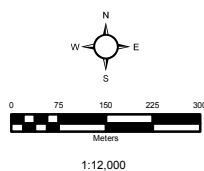




Source: GIS data supplied by
SunMap, DNRM, Field Data
Projection: GDA94, Zone 55
Date Printed: 27/06/06
File: g41113829/GIS/Arcview/Maps
Victor_dive.mxd
Size: A4

Legend

+ Dive site location



**Port of Hay Point
Capital Dredging**

**SURVEY SITE LOCATIONS FOR
VICTOR ISLET**

Figure 6

2.4 Survey Methods

2.4.1 Line Transect Survey

Fringing reef benthic communities were surveyed on SCUBA surrounding the three islands using line transect methods. These methods are favoured by the Great Barrier Reef Marine Park Authority to determine change in the long-term condition of marine environments (Kaly *et al.*, 1993; Mapstone *et al.*, 1989).

Four 20 m, randomly positioned line intercept transects were run within a narrow depth stratum along about approximately 80 m of reef to measure cover of the major benthic reef organisms at each site. The survey tapes were laid on the substratum and the length of intercept with the tape of all benthic organisms directly beneath it measured. Intercept lengths for all colonies of a species or benthic group were totalled, and converted to a percentage cover measurement. In addition, the benthic community, approximately 50 cm wide along the tape was recorded using a vertically held high definition digital video camera (Sony TRV-950 digital video camera with Amphibico underwater housing). This video footage provides a permanent record for archive, and allows an improved appreciation of overall ecosystem condition.

2.5 Data Analysis

Survey data has been analysed according to the following approaches, where relevant.

Reef Structure

Description of survey sites including depth, structure and formation.

Species List

Species lists were compiled for most marine groups at each location during the approximate four-five hours of underwater time taken to survey each island. Species lists were not made for small turfing algae or for small cryptic groups such as marine worms. The following organisms or groups of organisms were recorded: *Sargassum* spp. and other macroalgae; turfing algae; seagrasses; sponges; hydroids; all hard corals identified to species level (or to growth form if more appropriate); all soft corals. These techniques have been used in many other surveys of fringing and offshore reefs in the Great Barrier Reef (GBR) region.

In addition to keeping a detailed list of all fish species seen, an estimate of the abundance of each species was also made.

A photographic record was made of most benthic organisms encountered during these surveys.

Depth Stratification

The depth at each site was recorded by electronic depth gauge and used to identify changes in community composition with depth.

Analysis of Variance

Analysis of variance (ANOVA) is a test of statistical significance to determine similarities or differences between test groups. This is accomplished by partitioning the total variance into the component that is due to within mean variation (measurement error) and the components that are due to differences between means. These latter variance components are then tested for statistical significance, and if significant, the null hypothesis of no differences between means is rejected and the alternative hypothesis that the means are different from each other is accepted. Patterns in benthic organism abundance were investigated using two-way analysis of variance techniques, looking at differences between the three island locations, and between sites within each location (see Table 2).

Table 2 Benthic cover analysis of variance design

Source of variation	Degrees of freedom	Fixed/Random	Denominator
Location	2	F	Site (location)
Site (location)	15	R	error (t)
error (transects)	72	R	

Notes:

Locations: Victor Islet, Round Top Island, Flat Top Island
Six sites in each location
Four transects in each site

Orientation

Tests for the effect of orientation (windward and leeward) on observed benthic abundance has been tested using ANOVA.

Diversity

System diversity is estimated by considering the factors of species richness (S) and evenness (E). The diversity indices Shannon-Weiner or Simpson Index take into account both measures of richness and evenness, generating a single measure that expresses the diversity of a community.

For this project the Simpson's Index (**D**) has been applied. As a measure of diversity, Simpson's Index provides the probability that two individuals randomly selected from a sample will belong to the same species or surveyed category. With this index, 0 represents infinite diversity and 1, no diversity. For ease of interpretation, Simpson's Index may also be expressed as **1-D** (the probability that two randomly selected individuals belong to different species).

Rank Abundance

Data tables and graphs are used to define abundance between sites and relative dominance of species. Curves that extend furthest to the right have the highest number of species while curves with the steepest slopes have the least species evenness.

3. Results

3.1 Reef Structure

The reefs around all three island locations were not true coral reefs but were rather rocky reefs with a thin veneer of reef forming corals in some places. On the exposed east faces of the islands the reefs had a solid, continuous rock structure, while on the more sheltered west and north facing sides the reefs were composed of rock boulders and rubble interspersed with sand patches.

At all three locations the reefs were shallow, with the rock reef reaching the sand substratum at a maximum depth of less than 8 m below AHD. Victor Islet was the shallowest reef structure with depths to the sand at the six sites ranging from 2 – 4 m below AHD. Round Top Island had the deepest reefs with depths to the sand ranging from 2 – 7.5 m below AHD, while Flat Top was intermediate between these two with depths ranging from 3 – 5.5 m below AHD. The depth ranges of the surveys, corrected to zero AHD, are shown in Table 3.

Table 3 Depth range in metres of the benthic surveys at each site

Site:	Victor	Round Top	Flat Top
Site 1	1.5-3 m	4-6 m	2-4 m
Site 2	2.5-4 m	2.5-5 m	2.5-5.5 m
Site 3	0-2.5 m	3.5-6.5 m	2.5-5 m
Site 4	0-1.5 m	3.5-7.5 m	2.5-3.5 m
Site 5	2.5-3 m	2.5-4 m	2-4 m
Site 6	0.5-1.5 m	0.5-2 m	1-3 m

3.1.1 Depth Stratification

There was little depth stratification in the benthic communities at Victor and Flat Top Islands because the depth range of the reefs was less than 5 m. There was a low level of stratification at Round Top where the depth range was around 8 m, although this was not quantitatively documented. Observations suggested that there were more *Acropora* corals in shallow water (<3 m), and more gorgonians and hydroids in deeper water (>6 m) compared to the surveyed depth strata.

3.1.2 Orientation

Sites were established during these surveys to represent conditions along the 'front' (windward) and 'back' (leeward) sides of the island. Survey results indicate significantly lower abundance of hard corals and sponges along those sites situated at the back of both Round Top and Flat Top Islands (ANOVA: $p < 0.05$) (see Table 4). No

significant difference in the distribution of biota between front and back sites was demonstrated for Victor Islet.

Table 4 ANOVA comparison between epibenthic family groups and their relative abundance at leeward and windward survey sites

Location	Hard Coral	Soft Coral	Macroalgae	Turf Algae	Sponges	Hydroids
Round Top Island	0.010(B)	0.833	0.385	0.173	0.315	ND
Flat Top Island	0.154	0.646		0.611	0.004(B)	0.139
Victor Islet	0.281	0.847	0.526	0.378	0.934	0.423

Note:
Shading indicates significance
B =
ND =

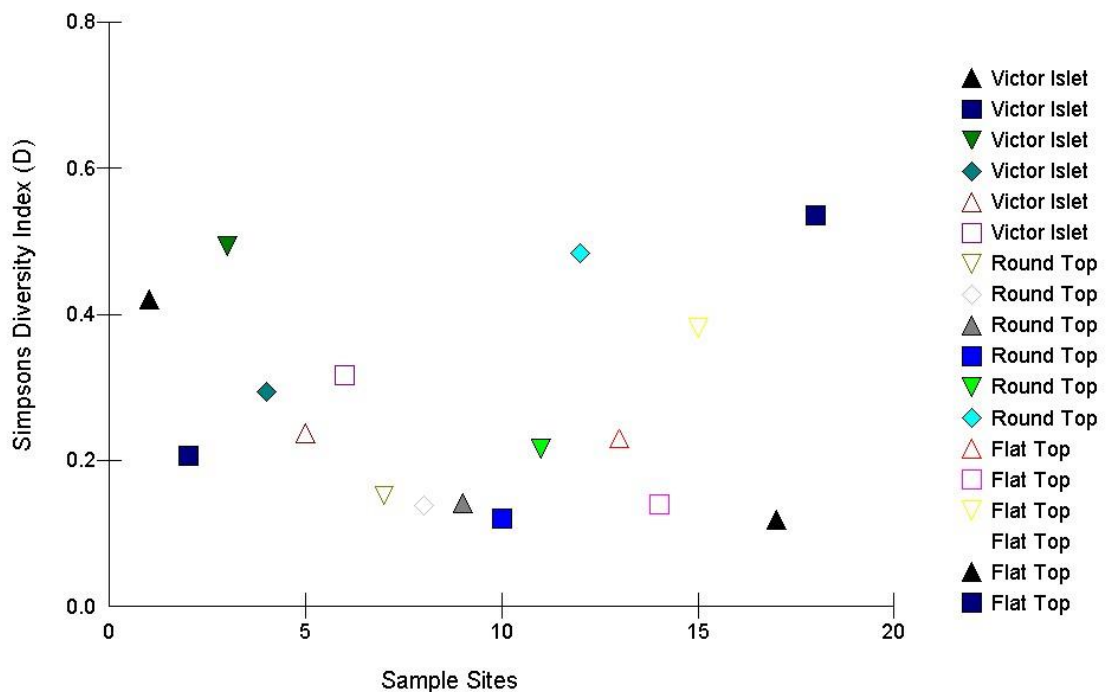
3.2 Diversity

Round Top Island recorded typically higher diversity than either Victor Islet or Flat Top Island (see Table 5 and Figure 7).

The lowest recorded diversity was identified from sites 4 and 5 at Flat Top Island. These sites were dominated by turfing algae, soft corals, hydroids, and scattered hard corals.

Table 5 Simpson's Diversity Index (D)

Location	1	2	3	4	5	6
Round Top Island	0.152	0.138	0.142	0.120	0.215	0.483
Flat Top Island	0.230	0.140	0.381	0.689	0.119	0.535
Victor Islet	0.420	0.206	0.493	0.293	0.237	0.316



Note:
Graph markers relate to species rankings as listed in Table 5

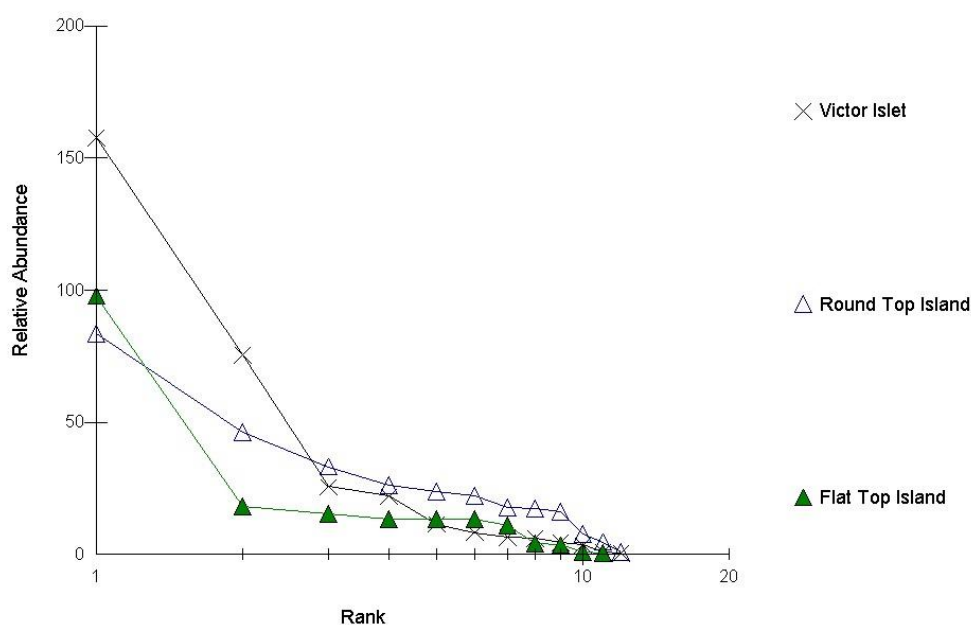
Figure 7 Simpson's Diversity Index (D)

3.3 Rank Abundance

Sargassum sp (macroalgae) dominated the observed benthic assemblage at Victor Islet, with more than double the abundance compared with turfing algae (see Table 6). *Turbinaria* sp. was the most abundant hard coral represented at all survey island sites, followed by *Montipora* sp. The occurrence of hydroids at Flat Top Island exceeded all hard coral and soft coral species. Although both Victor Islet and Flat Top Island out ranked Round Top Island for key dominant species, Round Top maintained greater overall community abundance for 9 of the 12 benthic categories. Detailed abundance summaries for each site are provided within Appendix A and summarised in Table 6 and Figure 8.

Table 6 Pooled rank abundance

Victor Islet	Ranked Abundance	Round Top Island	Ranked Abundance	Flat Top Island	Ranked Abundance
Macroalgae	157.9	Turf Algae	83.5	Turf Algae	97.8
Turf Algae	75.6	<i>Turbinaria</i>	46.4	Hydroids	18.0
<i>Turbinaria</i>	25.6	<i>Siderasterid</i>	33.2	<i>Turbinaria</i>	15.3
<i>Montipora</i>	22.0	<i>Montipora</i>	26.1	Soft Coral	13.4
<i>Siderasterid</i>	11.5	<i>Acropora</i>	23.7	<i>Siderasterid</i>	13.3
<i>Faviid</i>	8.3	Soft Coral	22.2	<i>Faviid</i>	13.3
Sponges	6.4	<i>Faviid</i>	17.9	<i>Poritid</i>	10.8
Soft Coral	6.0	<i>Poritid</i>	17.3	Sponges	4.1
<i>Poritid</i>	4.6	Macroalgae	16.2	Macroalgae	3.5
<i>Acropora</i>	3.5	Sponges	7.8	<i>Montipora</i>	0.9
<i>Pocillopora</i>	0.9	<i>Pocillopora</i>	4.7	<i>Acropora</i>	0.4
Hydroids	0.7	Hydroids	0.9	<i>Pocillopora</i>	0.0



Note: Graph markers relate to species rankings as listed in Table 6.

Figure 8 Pooled relative abundance of key benthic biota

Table 7 Abundance summary for benthic organisms in all survey sites at Victor Islet

Location	Hard Coral	Pocillo-pora	Acropora	Montipora	Poritid	Siderasterid	Faviid	Turbinaria	Soft Coral	Macroalgae	Turf Algae	Sponges	Hydroids
Site 1	5.1	-	-	-	-	2.2	0.7	2.2	0.7	29.5	13.6	0.6	0.2
Site 2	17.5	-	-	-	0.6	5.0	3.2	8.2	1.4	17.1	12.8	2.1	0.1
Site 3	3.7	-	-	-	0.8	0.7	0.3	1.9	-	40.7	18.4	0.4	-
Site 4	27.3	0.5	2.1	20.3	1.8	0.2	1.5	0.6	3.1	27.6	5.4	0.3	-
Site 5	12.4	-	-	0.8	0.5	0.9	2.1	7.8	0.4	15.1	6.4	2.1	0.2
Site 6	11.7	0.4	1.4	0.9	0.9	2.5	0.5	4.9	0.4	27.9	19.0	0.9	0.2
Grand mean	12.9	0.2	0.6	3.7	0.7	1.9	1.4	4.2	1.0	26.3	11.5	1.1	0.1

Note:

Mean percent coral cover derived from four transects

Table 8 **Abundance summary for benthic organisms in all survey sites at Round Top Island**

Location	Hard Coral	Pocillo-pora	Acropora	Montipora	Poritid	Siderasterid	Faviid	Turbinaria	Soft Coral	Macroalgae	Turf Algae	Sponges	Hydroids
Site 1	20.7	-	1.5	0.8	3.3	3.4	2.1	8.8	8.2	2.8	12.9	1.3	0.2
Site 2	44.4	2.6	13.2	7.5	1.3	8.1	3.6	7.9	2.8	-	14.9	1.8	-
Site 3	52.0	0.8	6.4	6.2	3.2	14.0	5.0	16.0	2.0	0.5	8.8	1.7	0.3
Site 4	39.8	0.3	1.9	9.8	5.4	5.8	4.2	10.6	7.3	1.2	10.5	1.2	-
Site 5	17.4	0.8	0.7	1.8	4.0	1.8	2.7	2.7	1.7	0.9	15.3	1.6	0.2
Site 6	1.1	0.2	-	-	0.1	0.1	0.3	0.4	0.2	10.8	21.1	0.2	0.2
Grand mean	29.2	0.8	4.0	4.4	2.9	5.5	3.0	7.7	3.7	2.7	13.9	1.3	0.1

Note:

Mean percent coral cover derived from four transects

Table 9 Abundance summary for benthic organisms in all survey sites at Flat Top Island

Location	Hard Coral	Pocillo-pora	Acropora	Montipora	Poritid	Siderasterid	Faviid	Turbinaria	Soft Coral	Macroalgae	Turf Algae	Sponges	Hydroids
Site 1	5.6	-	-	-	0.5	1.4	-	3.6	1.3	-	3.5	1.3	9.2
Site 2	28.2	-	-	-	4.2	9.8	7.1	7.1	4.9	-	11.0	0.9	3.6
Site 3	11.2	-	-	-	3.2	1.2	4.4	2.2	1.5	-	24.6	1.2	2.2
Site 4	3.1	-	0.1	-	1.7	0.3	0.7	0.3	1.8	1.2	36.0	0.1	1.1
Site 5	1.9	-	-	-	0.6	-	0.3	1.1	3.1	-	1.1	0.4	1.6
Site 6	4.1	-	0.3	0.9	0.6	0.6	0.8	1.0	0.8	2.3	21.6	0.2	0.3
Grand mean	9.0	-	0.1	0.1	1.8	2.2	2.2	2.5	2.2	0.6	16.3	0.7	3.0

Note:

Mean percent coral cover derived from four transects

3.4 Benthic Communities

3.4.1 Victor Islet

Figure 9 shows a cross section of the typical species recorded at sites surrounding Victor Islet. Reef communities range in width from approximately 55 m to approximately 675 m when measured from the seaward edge of the inter-tidal area to open substrate.

Benthic communities around Victor Islet were dominated by macroalgae, with over 25% mean cover (see Table 7 and Figure 12). *Sargassum* was the most abundant algal species with a mean of almost 24% cover, but *Hormophysa triquetra*, *Cystoseira trinodis* and *Halimeda* sp. also occurred. Turfing algal species covered another 12% of the substratum around Victor Islet, with *Lobophora variegata* the dominant species.

Hard corals were not abundant at most sites around Victor Islet with a mean of only 13% cover (see Table 7 and Figure 12). However, abundance at the site level was variable with very significant, almost order of magnitude differences, among sites (see Table 10 and Figure 13). Classification of hard coral cover is provided in Figure 14.

Silt tolerant *Turbinaria* spp. corals were the dominant hard coral group with a mean of over 4% cover, but acroporids, siderasterids and faviids were also present. Acroporids were rare except at site 4 where explanate *Montipora* species covered over 20% of the substratum, and corymbose and staghorn *Acropora* species a further 2%. Pocilloporid and poritid corals were uncommon as were all other coral groups. Hard coral diversity was low with a total of only 41 species being recorded during approximately four hours of observations (Appendix B).

Soft corals were not common on the Victor Islet reef covering a mean of only 1% of the substratum. Encrusting *Briareum* soft corals were the most frequently encountered species, but *Sinularia*, *Sarcophyton*, *Lobophytum* and four species of gorgonians also occurred. A variety of sponge species also covered around 1% of the substratum on this reef with hydroids and ascidians forming an even smaller part of the benthic community.

A number of mobile invertebrate species were present in the Victor Islet reef community, including a single species of seastar, several crinoid species, the black holothurian *Holothuria atra* and several species of nudibranchs. Overall, algal and invertebrate diversity was low with only 82 species recorded, including all hard and soft corals and other benthic and mobile invertebrates (Appendix B).

Figure 9 Representative photographs of Victor Islet reef communities



a) Macroalgae, especially Sargassum (brown) and Halimeda (green) dominated the benthic community on Victor Islet fringing reefs with a mean cover of over 26%.



b) Hard corals only covered about 13% of Victor Islet reefs with Turbinaria (bottom and left) and faviids (centre) both common.



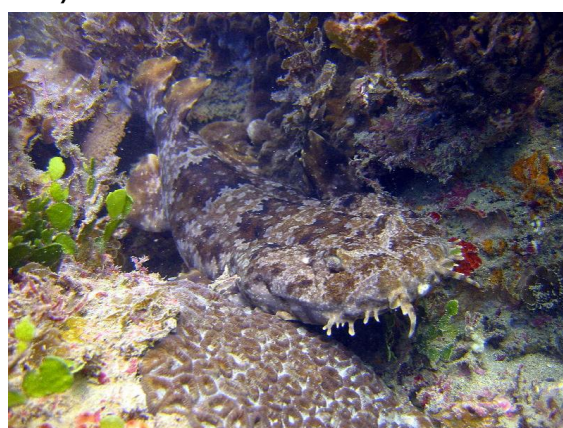
c) Victor Islet reef were shallow, reaching the sand in only 2-4 m depth. Turbinaria hard corals, Sarcophyton soft coral (centre top) and Sargassum near the reef/sand border



d) At site 4 on Victor Islet explanate Montipora corals (foreground) covered 20% of the substratum amongst the Sargassum macroalgal forest. Bengal sergeant fish (top centre).



e) The scalyfin *Parma microlepis* (centre) was a southern fish species common on these three fringing reefs. Turbinaria and faviid corals are also shown (foreground).



f) The well camouflaged ornate wobbegong *Orectolobus ornatus* was also relatively common on these reefs. Green Halimeda algae (left) and faviid coral (foreground)

3.4.2 Round Top Island

Figure 10 shows a cross section of the typical species recorded at sites surrounding Round Top Island. Reef communities range in width from approximately 55 m to approximately 190 m when measured from the landward edge of the inter-tidal area to open substrate.

Macroalgae were not common in most Round Top Island sites with a mean cover of less than 3%, this being significantly lower than macroalgae cover recorded around Victor Islet. *Sargassum* was most abundant on the protected western facing rubble site, where this species covered over 10% of the substratum, but was rare elsewhere. Turfing algae, mainly *Lobophora variegata*, covered a mean of almost 14% of Round Top Island reef substratum. Round Top Island benthic communities were dominated by hard corals with a mean cover of almost 30% (see Table 8 and Figure 12). Hard coral cover was significantly higher than on the other two islands (Table 10). As was the case on all three islands the site variability was high, with site cover ranging from 1% to over 50% and strongly significant differences between sites (see Table 8 and Figure 12). Coral cover was highest on the more exposed eastern face of the island and lowest on the protected west facing rock rubble reefs. Silt tolerant *Turbinaria* spp. corals were also dominant on this island, accounting for 26% of hard coral cover. Acroporids, siderasterids, faviids and poritids were also common (see Table 8). Hard coral diversity was higher on Round Top than on the other two survey islands but was still relatively low compared with other GBR fringing reefs with only 61 species being recorded during this survey (Appendix B). Classification of hard coral cover is provided within Figure 15.

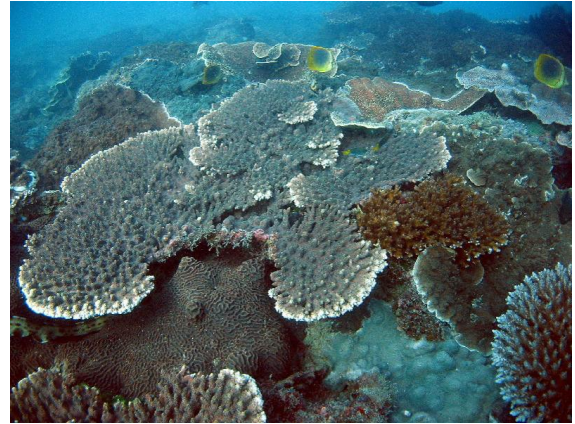
Soft corals were moderately common on this reef, covering a mean of almost 4% of the substratum (Figure 10 and Table 8). The genus *Sinularia* was the most abundant soft coral group but *Sarcophyton*, *Briareum*, *Dendronephthya*, *Lobophytum* and seven species of gorgonians were also present. Sponges covered a mean of 1.3% of these reefs, with the large orange-brown cup sponge *Xestospongia testudinaria* forming a prominent part of the benthic community. Hydroids and ascidians were also present in the benthic community but at covers of less than 0.1%.

Overall algal and invertebrate diversity, including a similar suite of mobile invertebrates to that recorded on Victor Islet, was also relatively low on Round Top Island with a total of only 107 species being encountered during this survey.

Figure 10 Representative photographs of Round Top Island reef communities



a) Hard corals covered almost 30% of the substratum on Round Top Island. A number of species of *Acropora* corals dominated some shallow water areas of this reef.



b) A distinctive *Acropora solitaryensis* colony (centre left) with *Pocillopora* (centre right), *Psammocora* (bottom right) *Montipora* (right) and *Platygyra* (bottom left) on Round Top.



c) Four species of *Turbinaria* on Round Top, along with *Platygyra* (lower left) and *Acropora* corals. *Turbinaria* spp. corals were the dominant coral group on all the islands.



d) *Turbinaria* corals on Round Top with *Montipora* and *Goniopora* (bottom left). Three gold-striped butterflyfish can be seen on the centre left, with chinese demoiselles behind.



e) Several species of gorgonians were common on deeper sections of Round Top reefs, including *Ctenocella* sp. (centre), *Junceella* sea whips (right) and *Eplexaura* sp. (bottom).



f) Macroalgae only covered a mean of 3% of Round Top Island reefs and were only common at site 6. *Sargassum* sp. on the rubble bank at site 6, with *Padina* alga (centre).

3.4.3 Flat Top Island

Figure 11 shows a cross section of the typical species recorded at sites surrounding Flat Top Island. Reef communities range in width from approximately 10 m to approximately 300 m when measured from the landward edge of the inter-tidal area to open substrate.

Macroalgae were rare around Flat Top Island with a few patches of *Sargassum* recorded on the more sheltered west facing rubble reef sites (see Table 9). There was significantly lower cover of macroalgae on Flat Top and Round Top Islands than on Victor Islet. The brown turfing alga *Lobophora variegata* was more common than on the other two islands, although the combined turf cover of 16% on Flat Top Island reefs was not significantly higher than on the other two islands.

Hard corals were most abundant on the east facing sites, and site differences were significant (see Table 10) but the mean cover of 9% was much lower than on adjacent Round Top Island (see Figure 12 and Table 9). Coral cover on Flat Top and Victor was significantly lower than on Round Top Island (see Table 10). *Turbinaria* spp., siderasterids, faviids and poritids all accounted for about 20% of hard coral cover, while pocilloporids, *Acropora* and *Montipora* were all rare on Flat Top Island. Hard coral diversity was very low and only 33 species were recorded during the surveys around this island. Classification of hard coral cover is provided within Figure 16.

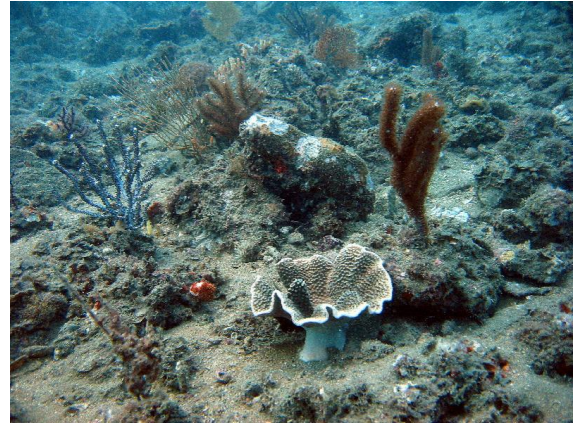
Soft corals covered over 2% of the substratum, with the dominant group being 11 species of gorgonians. *Sinularia*, *Sarcophyton*, *Briareum* and *Dendronephthya* soft corals were also recorded on these reefs. A distinctive feature of the Flat Top Island reefs was the relative abundance of hydroids, ascidians and bryozoans in the benthic community. Although not all these organisms were recorded along the survey transects, observations suggested that the combined cover of these groups was more than that of hard corals. At least six hydroid species were present covering a mean of 3% of the substratum, and hydroid cover on Flat Top was significantly higher than on the other two islands (Table 10). Although not recorded in the transects, 11 species of ascidians and at least four species of bryozoans probably covered similar areas of the substratum to hydroids around this island.

Mobile invertebrates were a distinctive feature of Flat Top Island reefs, especially crinoids and three species of filter feeding holothurians. Although hard coral diversity was low the diversity of other invertebrate groups was relatively high and the overall number of algal and invertebrate species recorded during this survey was 104 (Appendix B). A summary of major differences between the reefs around these three islands is shown in Table 11.

Figure 11 Representative photographs of Flat Top Island reef communities



a) Hard corals only covered 9% of Flat Top reefs (faviid colony centre), but hydroids (right) and ascidians (left) were relatively common. Scribbled angelfish were also common.



b) Eleven species of gorgonian fans were recorded on Flat Top reefs while *Turbinara* spp. was the dominant hard coral group (bottom centre).



c) Eleven species of ascidians were recorded on Flat Top (red and blue) along with bryozoans (underneath and below seastar) and many other filter feeding invertebrates.



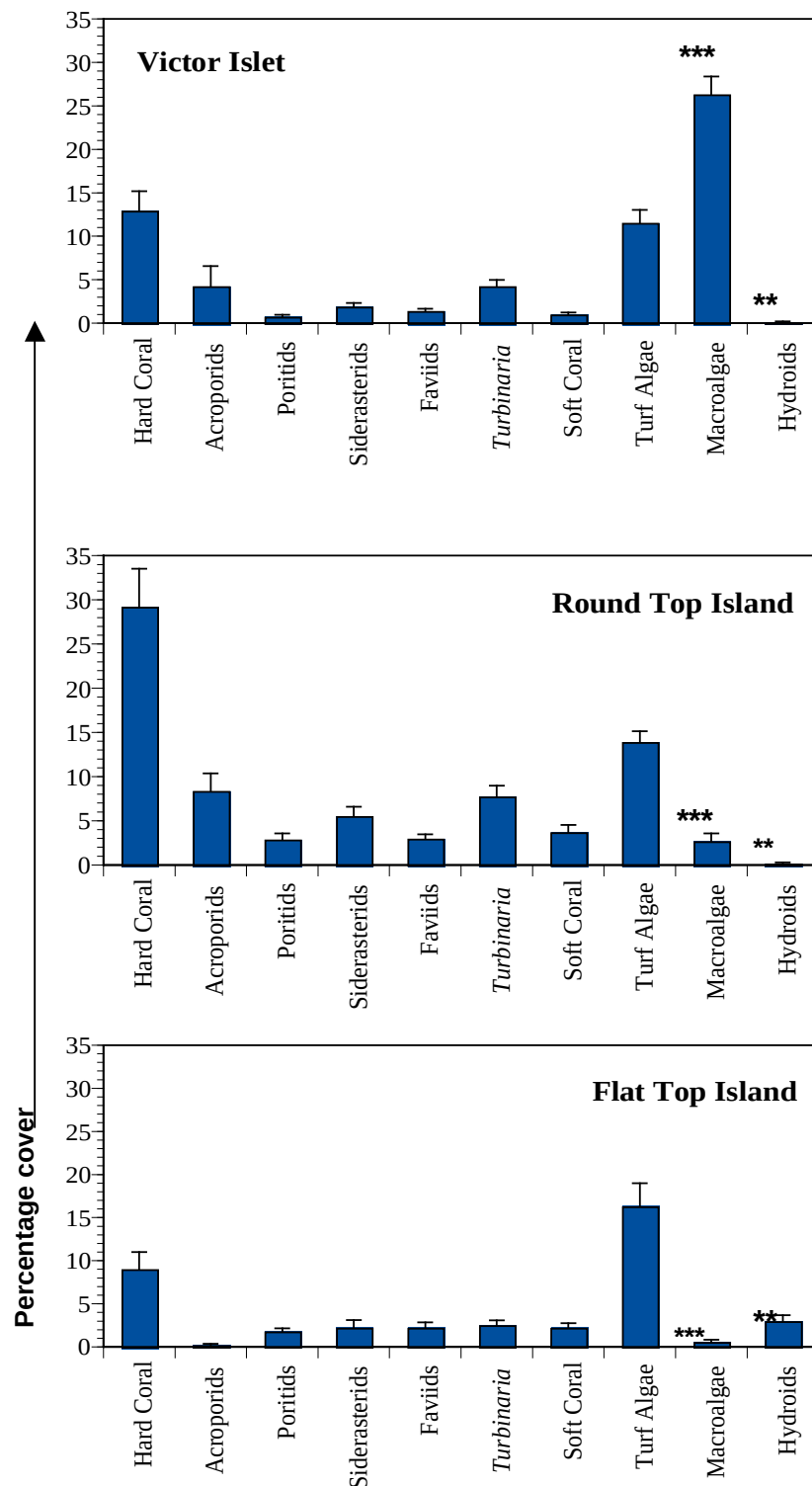
d) Filter feeding crinoids were common on Flat Top as was the red gorgonian *Melithaea* sp.



e) The colourful filter feeding holothurian *Pseudocolchirus violaceus* was common on Flat Top Island as was the brown disc-shaped alga *Lobophora variegata* (lower left and right).



f) Bar-cheeked coral trout *Plectropomus maculatus* were common on all three islands. A few large *Porites* massive coral colonies were also present on all islands.



Note:

Graphs show grand mean benthic cover from six sites of four 20 m transects spaced around each island. Asterisks indicate benthic groups with significant location differences. Error bars are standard errors.

** = $p < 0.01$, *** = $p < 0.001$

Figure 12 Cover of the major groups of benthic organisms

Table 10 Fringing reefs ANOVA results

Family/Group	Location	Site (L)
Macroalgae	***	***
Turf Algae	NS	***
Hydroids	**	***
Total hard coral	*	***
Acroporidae	NS	***
Poritidae	NS	*
Siderasteridae	NS	***
Faviidae	NS	***
<i>Turbinaria</i> spp.	NS	***
Total soft corals	NS	***

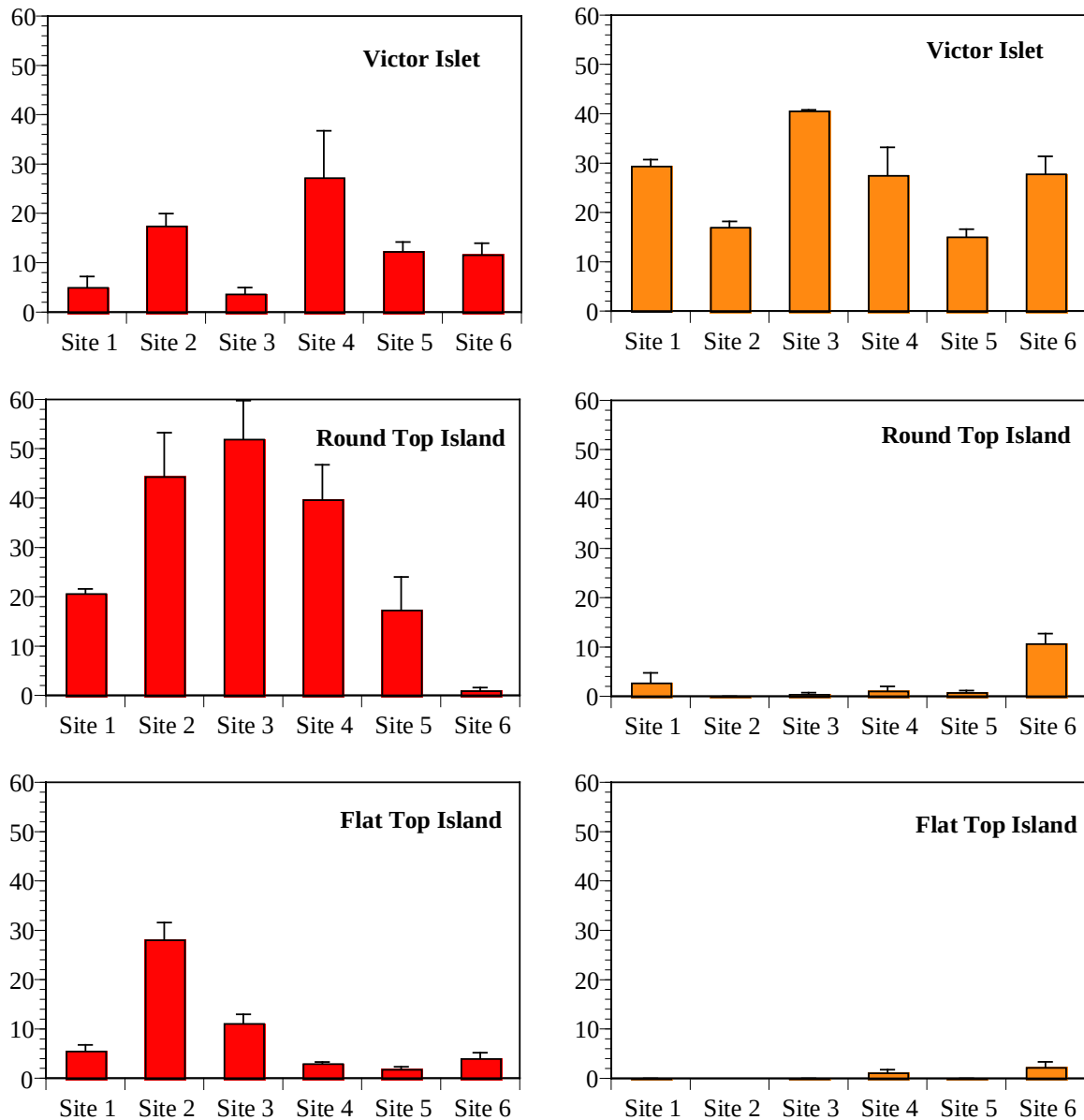
Note:

NS = not significant; * $0.05 > p > 0.01$; ** = $0.01 > p > 0.001$; *** = $p < 0.001$

Table 11 Comparison of reef communities

Feature	Victor	Round Top	Flat Top
Maximum reef depth	4 m	8 m	5.5 m
Benthic diversity	82	107	104
Hard coral diversity	41	61	33
Macroalgae abundance	high	very low	very low
Hard coral abundance	low	high	low
Acroporid abundance	medium	high	low
Gorgonian abundance	low	medium	high
Filter feeder abundance	low	low	high
Filter feeding holothurians	absent	absent	common
Fish diversity	35	57	42

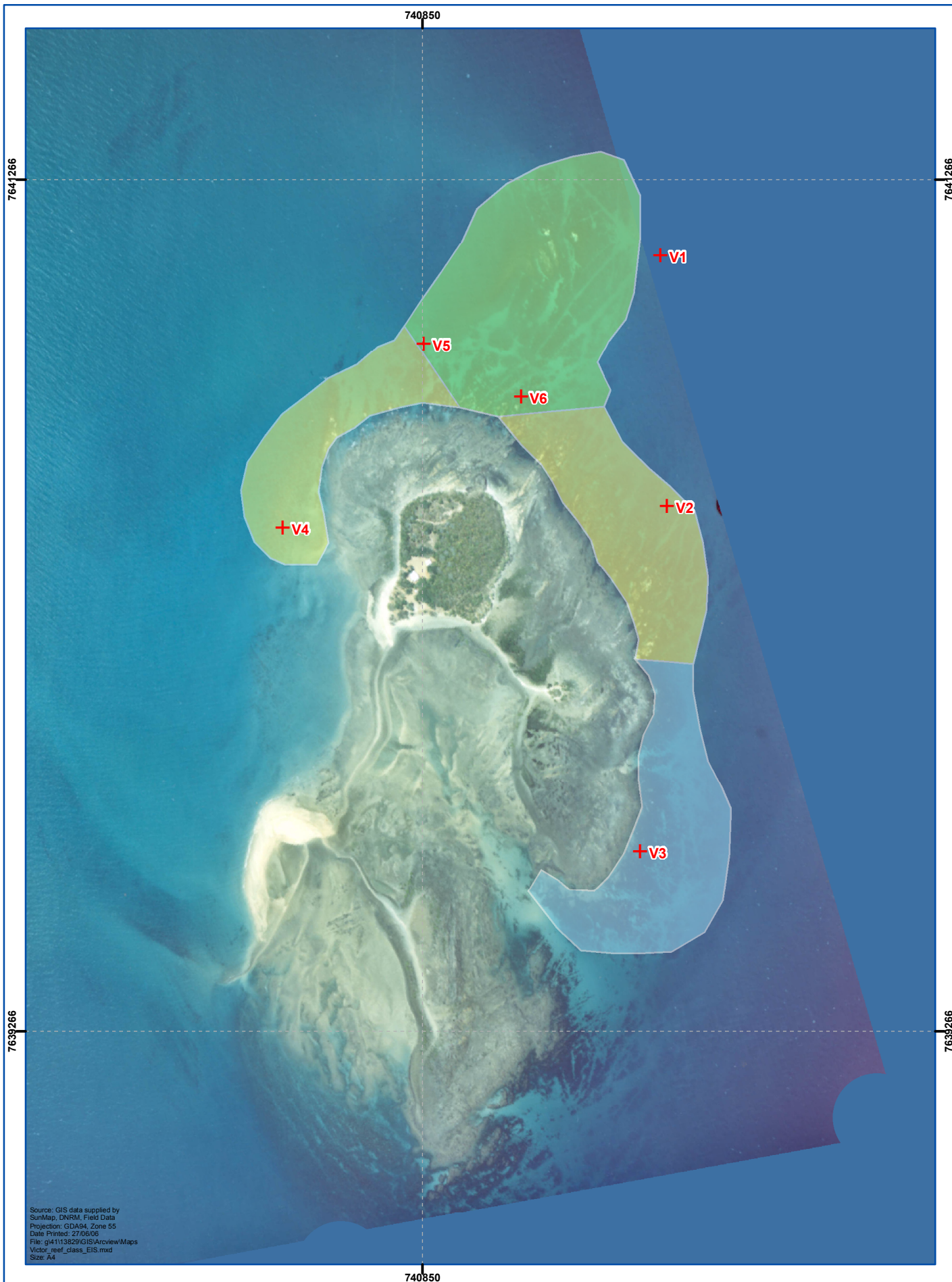
Hard Coral Macroalgae



Note:

Graphs show site means at each island for mean total percentage hard coral cover (red) and macroalgae (orange) from four 20 m transects at each site for the three islands surveyed. Error bars are standard errors.

Figure 13 Variability at the site level



Source: GIS data supplied by
SunMap, DWRM, Field Data
Projection: GDA94, Zone 55
Date Printed: 27/06/06
File: g41113829GIS\Arcview\Maps
Victor_reef_class_EIS.mxd
Size: A4

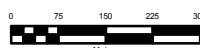


Legend

+ Dive site location

Hard Coral Cover (%)

< 5	10 - 30
5 - 10	> 30

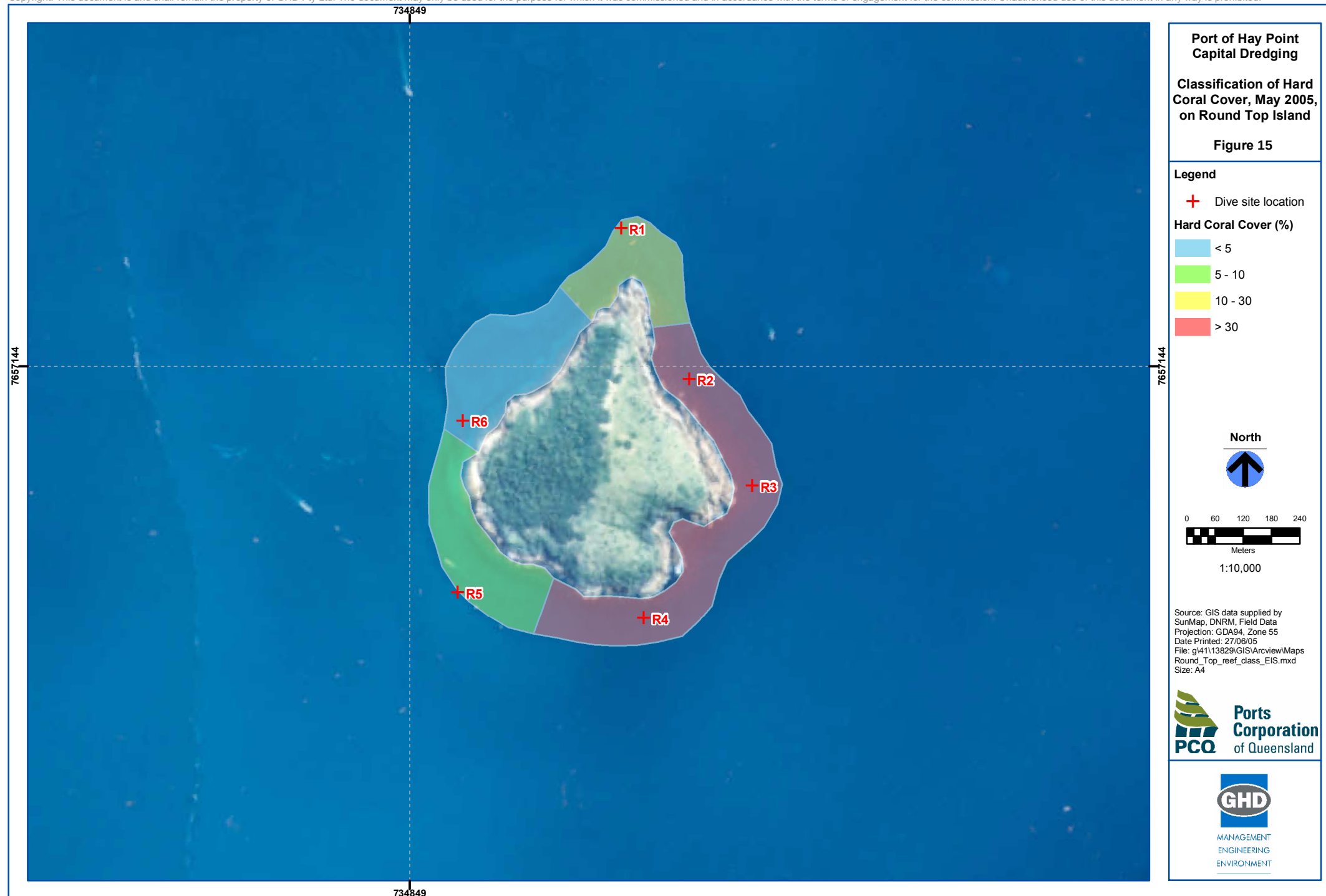


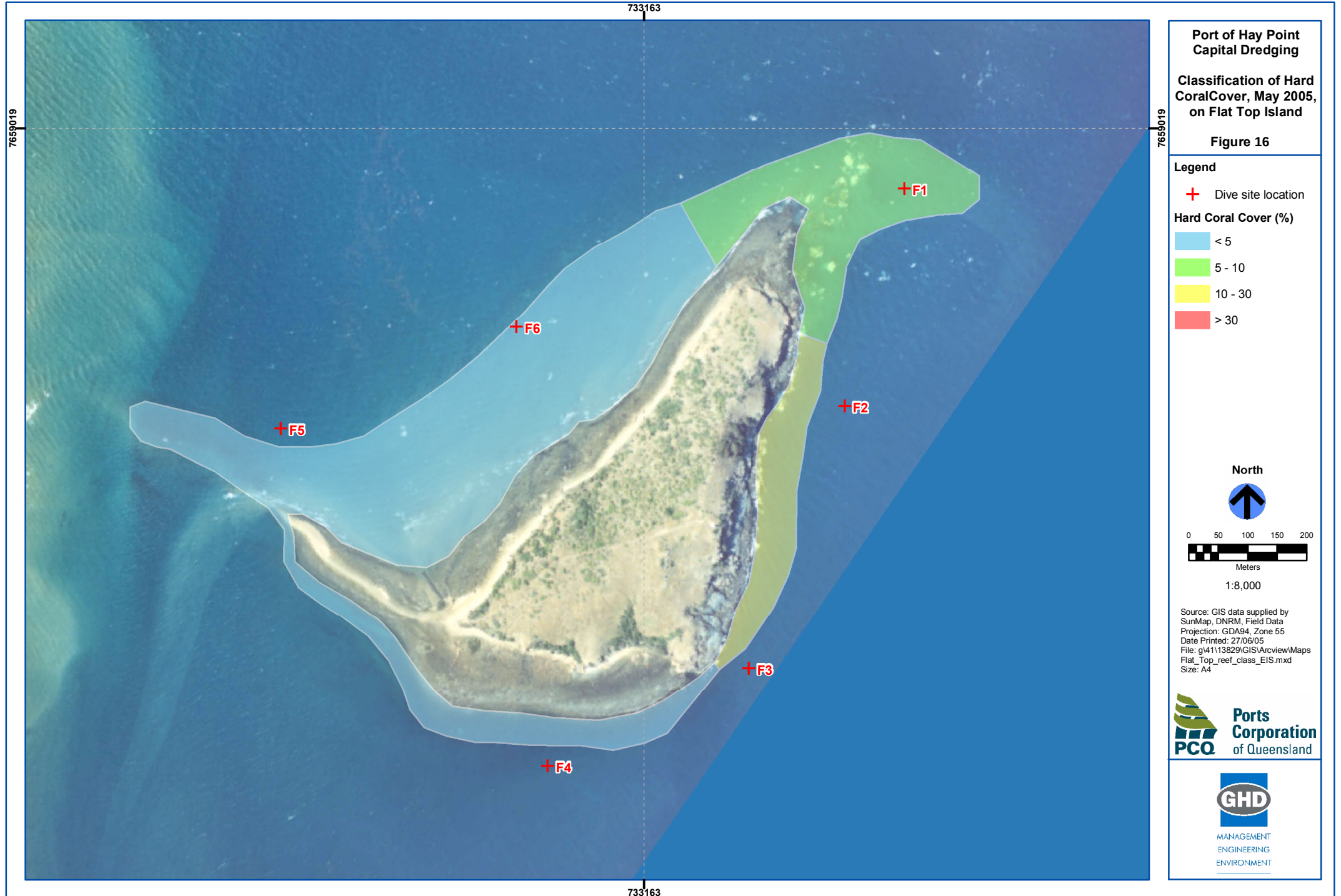
1:12,000

**Port of Hay Point
Capital Dredging**

**Classification of Hard Coral
Cover, May 2005, on Victor Islet**

Figure 14





3.5 Coral Species

The coral communities around these islands had many unusual features. The normally uncommon coral genus *Turbinaria* was the dominant coral group with six species represented including the common species *T. frondens*, *T. stellulata* and *T. peltata*. Pocilloporids were only represented by a single species *Pocillopora damicornis* that was only found commonly on Round Top Island. *Acropora* species were also only common on Round Top Island with only 14 species represented in this normally very diverse genus. This included some unusual species such as *A. solitaryensis* and *A. glauca* that are usually only common on reefs to the south of the GBR region. Several other commonly recorded coral species included *Acanthastrea lordhowensis* and *A. hillae*, which are usually found on reefs south of the GBR region. Massive *Porites* colonies were not common on these reefs and the largest encountered were only between 1-2 m diameter. The most abundant poritids were members of the genus *Goniopora* and the majority of these colonies were small, being less than a metre in diameter. Siderasterid corals are normally rare on GBR coral reefs but on these islands, this group was second in overall abundance to *Turbinaria* spp. A species of *Psammocora* was the most abundant representative in this group with a grand mean cover over the three islands of almost 3%.

A number of coral groups that are usually common on all fringing reefs were notably absent or very rare on the Hay Point island reefs. This included all fungiid corals, most agariciids (a single small *Pavona varians* colony was recorded), most pectiniids, most merulinids and the genus *Echinopora*.

Very few coral colonies over 1 m in diameter were encountered during this survey suggesting that historical disturbance has been high in this area.

3.6 Fish Communities

Fish communities around the three islands were similar and were generally typical of silty inshore reefs of the southern GBR region (Appendix C). Fish diversity was very low, ranging from 35 species recorded on Victor Islet to 57 on Round Top. Many normally diverse groups were absent or represented by a single species, including emperors, goatfishes, hawkfishes, parrotfishes, blennies, surgeonfishes, rabbitfishes, triggerfishes, leatherjackets and pufferfishes. Only 15 fish species were common around these islands (see Table 12 and Appendix C).

There were a number of unusual features of the fish community of these islands. Several fish species that are normally rare were common on all three islands, including the scribbled angelfish *Chaetodontotopplus duboulayi*, the scalyfin *Parma microlepis* and the goldlined coris *Coris aurilineata*. Also unusually abundant on these islands were the two wobbegong species *Eucrossorhinus dasypogon* and *Orectolobus ornatus*. Mullers coralfish *Chelmon muelleri*, a species that is only occasionally seen on the GBR, and is restricted to very silty inshore areas, was relatively common on Flat Top Island. The spotted tuskfish *Choerodon vitta* is another fish species that is normally only recorded from very silty locations and

was common around all three islands. The blackstripe coris *Coris pictoides* is a fish that is normally found on reefs to the south of the GBR but was recorded on Victor Islet during this survey.

Table 12 List of common fish species recorded at the three islands

Family	Scientific name	Common name	Abundance
Serranidae	<i>Plectropomus maculatus</i>	Bar-cheeked coral trout	C
Apogonidae	<i>Apogon cavitiensis</i>	Cavite cardinalfish	C
Lutjanidae	<i>Lutjanus carponotatus</i>	Stripey	A
Lethrinidae	<i>Lethrinus laticaudis</i>	Grass emperor	C
Chaetodontidae	<i>Chaetodon aureofasciatus</i>	Gold-striped butterflyfish	A
Pomacanthidae	<i>Chaetodontoplus duboulayi</i>	Scribbled angelfish	A
Pomacentridae	<i>Abudefduf bengalensis</i>	Bengal sergeant	C
	<i>Chromis nitida</i>	Barrier reef chromis	A
	<i>Neopomacentrus bankieri</i>	Chinese demoiselle	A
	<i>Parma oligolepis</i>	Scalyfin	A
	<i>Pomacentrus australis</i>	Australian damsel	C
Labridae	<i>Pomacentrus. wardi</i>	Wards damsel	A
	<i>Choerodon cyanodus</i>	Blue tuskfish	A
	<i>Choerodon vitta</i>	Spotted tuskfish	C
	<i>Coris aurilineata</i>	Goldlined coris	C
	<i>Pseudolabrus guentheri</i>	Gunthers wrasse	A

Note:

Abundance is the overall estimated abundance from all three islands: Abundant (A) - many seen on every dive; Common (C) - up to 10 seen on every dive

3.7 Reptiles

Two reptile species were recorded in this area during the survey. The olive seasnake *Aipysurus laevis* was common around all three islands (see Figure 17). A single green turtle *Chelonia mydas* was seen on Victor Islet.

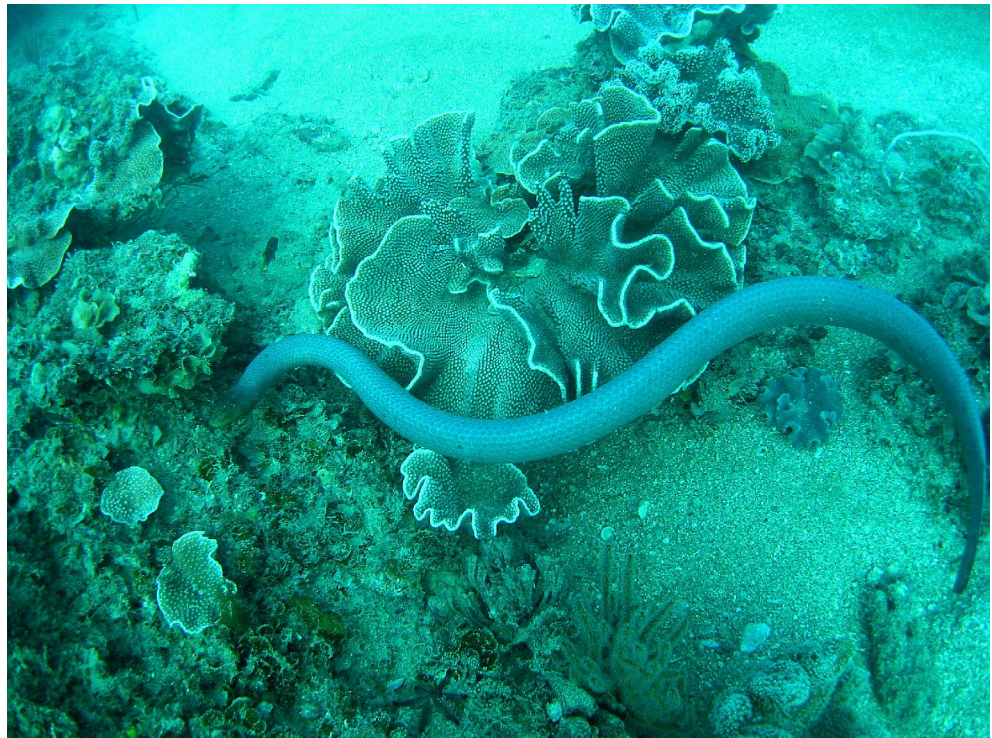


Figure 17 Olive seasnake recorded at Round Top Island

4. Discussion

4.1 Relationship Between Benthic Communities and Physical Conditions

The Hay Point area is a harsh environment for corals and other reef organisms to live in. The tidal range during spring tides is between 6 – 7 m and currents are strong, resuspending fine silt. The three islands are fully exposed to the predominant SE winds: wave action also resuspends sediment and causes turbid water conditions. This survey was carried out in a neap tide, low wind situation with underwater visibility ranging from 5 – 10 m, but these conditions were probably unusual. There were a number of features of the marine communities around these three islands that suggested the water conditions were normally extremely turbid.

Many of the common fish species encountered during this survey are only found on very silty coastal or near-shore reefs. The complete absence of the common coral trout *Plectropomus leopardus*, and the rarity of parrotfishes, surgeonfishes and emperors are also typical features of very turbid reefs (A.M. Ayling personal observations). The low fish diversity is also indicative of very silty inshore conditions (Ayling and Ayling 1999, Williams 1982).

Many of the coral species in this area were also typical of very turbid reefs including *Turbinaria* spp., *Duncanopsammia axifuga*, *Plesiastrea versipora*, *Goniastrea palauensis*, *Moseleya latistellata* and *Trachyphyllia geoffroyi* (Veron 2000). Other common corals from these three islands are usually only common where turbid conditions are normal, especially *Cyphastrea* spp. and explanate *Montipora* species. The low coral species diversity of these islands is also normal for very silty coastal or near-shore reefs (Ayling *et al.* 1998).

These features suggest that the marine communities of these islands are very silt tolerant and well adapted to low light, turbid water conditions.

Shallow exposed coastal reef areas such as these are also susceptible to physical extremes, including cyclonic and storm wave action, freshwater inundation and high water temperatures (Berkelmans and Oliver 1999, Ayling and Ayling 1997, 2004). This probably leads to regular disturbance and damage of the reef communities. The absence of large coral colonies on these reefs does indicate that frequent disturbance is a feature of the study area.

4.2 Comparison to Other Inshore Reef Sites

4.2.1 Coral Communities

A comparison of coral cover on the three Hay Point island reefs with other fringing reef areas in the GBR region is interesting (Table 13). Hard coral cover on these reefs was generally lower than that recorded during previous fringing reef surveys from the GBR region, with the exception of those other reefs that lie within the area

between Mackay and Port Clinton where the maximum tide range is greater than 5 m. Van Woesik (1992) surveyed a large number of sites within this area and recorded coral cover values ranging from 5.3% around Percy Isles to 41% around Prudhoe Island. Most reefs in this area were algal dominated. Coral cover on the reefs of Victor Islet and Flat Top Island was at the low end of that recorded on other strong tide area reefs but Round Top Island was at the high end of this range. Coral cover from the Keppel Islands to the south of this strong tide area is comparable to that from the other fringing reefs to the north of this area (Table 13). Hence, it is likely that the strong tidal currents and resulting silt movement are the major factor responsible for the low coral cover in this area, rather than lower sea temperatures.

Table 13 Summary of hard coral cover on GBR fringing reefs

Region	Date	Latitude°S	No. sites	Hard coral cover	
				mean	sd
Cape Flattery ¹	Feb 1996	14.9	5	46.2	12.2
Cape Tribulation ²	Jan 2004	16.0	12	49.3	25.9
Cairns Section Nth ³	Jan 1995	16.5	34	81.0	7.5
Frankland Islands ²	Mar 2005	17.2	6	35.6	17.2
Magnetic Island ⁷	Jan 2003	19.2	26	34.9	17.2
Middle Reef ⁴	Aug 1993	19.2	5	74.6	3.9
Hamilton Island ⁷	Sep 2001	20.3	16	51.1	21.2
Sir James Smith Gp. ⁶	1991	20.7	56	22.0	na
Keswick Is. ⁵	Oct 2001	20.9	18	26.8	na
Flat Top Is. ⁸	May 2005	21.2	6	9.0	9.7
Round Top Island ⁸	May 2005	21.2	6	29.2	21.1
Victor Islet ⁸	May 2005	21.3	6	12.9	11.1
Northumberland Is. ⁶	1991	21.5	20	11.7	na
Shoalwater Bay ⁹	Dec 1995	22.3	34	37.8	16.2
Keppel Islands ⁶	1991	23.2	8	54.3	na

Note:

Figures show grand mean percentage cover from groups of 20 m line transects.

1 Ayling *et al.* 1997;

2 Ayling and Ayling 2004;

3 Ayling and Ayling 1995a;

4 Kaly *et al.* 1993; 5 Ayling and Ayling 2002;

6 Van Woesik 1992;

7 A.M. Ayling 2005;

8 This study;

9 Ayling *et al.* 1998.

na = not available.

Turbinaria spp. is usually only a major component of the coral community on fringing reefs in very turbid situations (K. Anthony personal communication, A.M. Ayling personal observations). On more normal fringing reefs this group accounts for less than 5% of overall coral cover. In previous surveys the highest component of these corals has been recorded at Cape Flattery (8% of coral cover), Shoalwater Bay islands (17% of coral cover) and Magnetic Island (25% of coral cover). For the three Hay Point islands the *Turbinaria* component accounted for 28% of hard corals, the highest level that has been recorded in available results.

Biodiversity, recorded as the number of coral species encountered at each location, was also lower on these Hay Point island reefs than on most other GBR region fringing reefs. A combined total of only 67 species were recorded over 12 hrs of diving compared with:

- » 87 species recorded over 25 hrs of diving in the Shoalwater Bay region (Ayling *et al.* 1998);
- » 92 species recorded during 8 hrs of diving in the Cape Flattery area north of Cooktown (Ayling *et al.* 1997);
- » 131 species recorded during 2 hrs of diving around Dent Island in the Whitsunday Group of Islands (Ayling and Ayling 1995b);
- » 120 species from 30 hrs of diving on 17 Cairns Section fringing reefs (Ayling and Ayling 1995a);
- » 90 species recorded from the Keppel Islands by Van Woesik (1992); and
- » 143 species from 10 hrs of diving around Cape Tribulation fringing reefs (Veron 1987).

The number of coral species at each Hay Point island was also low (33-61), comparable with the low diversity recorded in Shoalwater Bay from 18 island reefs where the diversity ranged from 23-58, but much lower than the 131 from one location at Dent Island and 93 from one location at Hamilton Island (Ayling and Ayling 1995c).

Another feature of the reefs around these three Hay Point islands was the common presence of a number of southern species that are common on fringing reefs south of the GBR region and on southern reefs such as Lord Howe Island, but normally rare on the GBR. A similar situation was recorded on Shoalwater Bay island reef corals by Ayling *et al.* (1998) and for Shoalwater Bay fish communities by Ayling and Ayling (1999). The Hay Point reefs also share with Shoalwater Bay the complete absence of a number of coral and fish groups that are usually common on reefs in other areas.

The Hay Point reefs were generally similar to those surveyed around islands in Shoalwater Bay in late 1995 (Ayling *et al.* 1998). The Shoalwater Bay islands also did not support true coral reefs but were rock reefs and rock rubble banks, had low coral diversity, supported southern coral species, exhibited large between location differences (range of coral cover from 8 – 67%) and had a large *Turbinaria* spp. component. However, the Hay Point island reefs differed in having a lower mean

coral cover and having a large component of siderasterid corals. Although the mean coral cover on these Hay Point islands was lower than on the 18 Shoalwater Bay islands surveyed in 1995, these differences are probably not significant. Near-shore reefs have suffered two severe bleaching episodes since 1995 that has probably reduced coral cover on Shoalwater Bay reefs since the surveys were made. The Shoalwater Bay surveys were made in two sites per island on the most exposed face of each island. Selecting the three most east facing sites from each Hay Point island gives a mean coral cover of 25%, well within the 1995 Shoalwater Bay range.

4.2.2 Fish Communities

Reef fish diversity and abundance on the Hay Point island reefs was also similar to that on the Shoalwater Bay island reefs (Ayling and Ayling 1999). Surveys in Shoalwater Bay recorded between 27 and 42 fish species per island location compared to 35-57 for the three Hay Point islands. However, the Shoalwater Bay surveys only covered three sites per island and did not include any non-transect search time. The overall diversity from the Shoalwater Bay surveys was 97 fish species from 16 days of diving compared to 71 species from three days diving on the Hay Point islands. This diversity compares well with the 103 species recorded from Cape Tribulation fringing reefs over a three year study (Ayling and Ayling, 1991) and the 96 species recorded on Dent and Hamilton Islands in the Whitsunday Group in 1995 (Ayling and Ayling, 1995b), but is much lower than the 400-800 fish species known from offshore GBR reefs. Low diversity fish populations are typical of GBR inshore fringing reefs (Williams, 1982).

The majority of the fish species we recorded are widely distributed throughout the GBR region. A number of these are either only found on these turbid coastal or inshore reefs, or are only common on these reefs, including *Chaetodontoplus duboulayi*, *Abudefduf bengalensis*, *Parma oligolepis*, *Neopomacentrus bankieri*, *Halichoeres dussumieri*, *Choerodon cephalotes*, and *Acanthurus grammoptilus*. Another group of species only occurs on the offshore reefs south of about Mackay but is found on coastal reefs throughout the GBR region, notably *Choerodon graphicus*, *C. vitta*, *Coris aurilineata* and *Pseudolabrus guentheri* (Ayling and Ayling 1999). In the reef communities we investigated there were no southern sub-tropical species such as the 20 or so (5% of total) reported by Trinski *et al.* (1993) during a survey in Shoalwater Bay that concentrated on non-reef habitats.

4.2.3 Filter Feeding Communities

Flat Top Island benthic communities were unusual, having a high cover of non reef-forming filter feeding organisms such as hydroids, bryozoans, ascidians and gorgonians. Although a few sites have been reported previously from the GBR region with moderate filter feeding benthic cover, eg Blind and Connor Rocks in Shoalwater Bay (Ayling *et al.* 1998), Flat Top Island is unique in having a low macroalgal and hard coral cover combined with relatively high filter feeding organism cover.

4.3 Conclusions

Epibenthic biota and fish assemblages surveyed around Victor Islet, Round Top and Flat Top Islands are representative of reef communities adapted to extended periods of elevated natural turbidity. Significant tidal currents (spring tides) and periodic elevations in sea state result in a near shore environment exposed regularly to elevated suspended sediment loads. Seasonal freshwater inundation, elevated water temperatures and periodic cyclonic and storm exposure define Victor Islet, Round Top and Flat Top Islands as habitats of physical extremes. The presence of sediment tolerant species (coral, fish and algae) outlines the resilience of these communities to natural turbidity flux, while the absence of larger coral colonies suggests that frequent disturbance events may be considered a natural feature of the study area.

Results of modelling undertaken as part of the Draft Environmental Impact Statement (EIS) for the project indicate that the process of dredging and spoil disposal for the new apron and departure path, is likely to produce sediment plumes that migrate towards Round Top Island and Victor Islet. An assessment of the impacts that episodic elevations in suspended sediment these plumes may cause will be undertaken as part of the Draft EIS.

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Appendix A

Summary ranked abundance for Victor Islet, Round Top and Flat Top Islands (Sites 1-6)

Victor Islet 1	Abundance	Victor Islet 2	Abundance	Victor Islet 3	Abundance	Victor Islet 4	Abundance	Victor Islet 5	Abundance	Victor Islet 6	Abundance
Macroalgae	29.5	Macroalgae	17.1	Macroalgae	40.7	Macroalgae	27.6	Macroalgae	15.1	Macroalgae	27.9
Turf Algae	13.6	Turf Algae	12.8	Turf Algae	18.4	Montipora	20.3	Turbinaria	7.8	Turf Algae	19.0
Siderasterid	2.2	Turbinaria	8.2	Turbinaria	1.9	Turf Algae	5.4	Turf Algae	6.4	Turbinaria	4.9
Turbinaria	2.2	Siderasterid	5.0	Poritid	0.8	Soft Coral	3.1	Faviid	2.1	Siderasterid	2.5
Faviid	0.7	Faviid	3.2	Siderasterid	0.7	Acropora	2.1	Sponges	2.1	Acropora	1.4
Soft Coral	0.7	Sponges	2.1	Sponges	0.4	Poritid	1.8	Siderasterid	0.9	Montipora	0.9
Sponges	0.6	Soft Coral	1.4	Faviid	0.3	Faviid	1.5	Montipora	0.8	Poritid	0.9
Hydroids	0.2	Poritid	0.6	Pocillopora	0	Turbinaria	0.6	Poritid	0.5	Sponges	0.9
Pocillopora	0	Hydroids	0.1	Acropora	0	Pocillopora	0.5	Soft Coral	0.4	Faviid	0.5
Acropora	0	Pocillopora	0	Montipora	0	Sponges	0.3	Hydroids	0.2	Pocillopora	0.4
Montipora	0	Acropora	0	Soft Coral	0	Siderasterid	0.2	Pocillopora	0	Soft Coral	0.4
Poritid	0	Montipora	0	Hydroids	0	Hydroids	0	Acropora	0	Hydroids	0.2

Round Top 1 Abundance		Round Top 2 Abundance		Round Top 3 Abundance		Round Top 4 Abundance		Round Top 5 Abundance		Round Top 6 Abundance	
Turf Algae	12.9	Turf Algae	14.9	Turbinaria	16.0	Turbinaria	10.6	Turf Algae	15.3	Turf Algae	21.1
Turbinaria	8.8	Acropora	13.2	Siderasterid	14.0	Turf Algae	10.5	Poritid	4.0	Macroalgae	10.8
Soft Coral	8.2	Siderasterid	8.1	Turf Algae	8.8	Montipora	9.8	Faviid	2.7	Turbinaria	0.4
Siderasterid	3.4	Turbinaria	7.9	Acropora	6.4	Soft Coral	7.3	Turbinaria	2.7	Faviid	0.3
Poritid	3.3	Montipora	7.5	Montipora	6.2	Siderasterid	5.8	Montipora	1.8	Pocillopora	0.2
Macroalgae	2.8	Faviid	3.6	Faviid	5.0	Poritid	5.4	Siderasterid	1.8	Soft Coral	0.2
Faviid	2.1	Soft Coral	2.8	Poritid	3.2	Faviid	4.2	Soft Coral	1.7	Sponges	0.2
Acropora	1.5	Pocillopora	2.6	Soft Coral	2.0	Acropora	1.9	Sponges	1.6	Hydroids	0.2
Sponges	1.3	Sponges	1.8	Sponges	1.7	Macroalgae	1.2	Macroalgae	0.9	Poritid	0.1
Montipora	0.8	Poritid	1.3	Pocillopora	0.8	Sponges	1.2	Pocillopora	0.8	Siderasterid	0.1
Hydroids	0.2	Macroalgae	0	Macroalgae	0.5	Pocillopora	0.3	Acropora	0.7	Acropora	0
Pocillopora	0	Hydroids	0	Hydroids	0.3	Hydroids	0	Hydroids	0.2	Montipora	0

Flat Top 1	Abundance	Flat Top 2	Abundance	Flat Top 3	Abundance	Flat Top 4	Abundance	Flat Top 5	Abundance	Flat Top 6	Abundance
Hydroids	9.2	Turf Algae	11.0	Turf Algae	24.6	Turf Algae	36.0	Soft Coral	3.1	Turf Algae	21.6
Turbinaria	3.6	Siderasterid	9.8	Faviid	4.4	Soft Coral	1.8	Hydroids	1.6	Macroalgae	2.3
Turf Algae	3.5	Faviid	7.1	Poritid	3.2	Poritid	1.7	Turbinaria	1.1	Turbinaria	1.0
Siderasterid	1.4	Turbinaria	7.1	Turbinaria	2.2	Macroalgae	1.2	Turf Algae	1.1	Montipora	0.9
Soft Coral	1.3	Soft Coral	4.9	Hydroids	2.2	Hydroids	1.1	Poritid	0.6	Faviid	0.8
Sponges	1.3	Poritid	4.2	Soft Coral	1.5	Faviid	0.7	Sponges	0.4	Soft Coral	0.8
Poritid	0.5	Hydroids	3.6	Siderasterid	1.2	Siderasterid	0.3	Faviid	0.3	Poritid	0.6
Pocillopora	0	Sponges	0.9	Sponges	1.2	Turbinaria	0.3	Pocillopora	0	Siderasterid	0.6
Acropora	0	Pocillopora	0	Pocillopora	0	Acropora	0.1	Acropora	0	Acropora	0.3
Montipora	0	Acropora	0	Acropora	0	Sponges	0.1	Montipora	0	Hydroids	0.3
Faviid	0	Montipora	0	Montipora	0	Pocillopora	0	Siderasterid	0	Sponges	0.2
Macroalgae	0	Macroalgae	0	Macroalgae	0	Montipora	0	Macroalgae	0	Pocillopora	0



Appendix B

List of Plant and Invertebrate Species

List of Plant and Invertebrate Species Encountered During the Surveys of Victor Islet, Round Top and Flat Top Islands

Small turfing and encrusting algae not recorded. Worms and other cryptic species not recorded. Site Key: V – Victor Islet; RT – Round Top Island; FT – Flat Top Island. X = species present at that site. Numbers indicate the number of species recorded at that site in a particular genus

Species:	V	RT	FT
TOTAL NUMBER SPECIES:	82	107	104
ALGAE:			
<i>Halimeda</i> sp.	X	X	X
<i>Sargassum</i> sp.	X	X	X
<i>Hormophysa triquetra</i>	X		
<i>Cystoseira trinodis</i>	X		
<i>Lobophora variegata</i>	X	X	X
<i>Padina</i> sp.			X
SEAGRASSES:			
<i>Halophila spinulosa</i>			X
<i>Halodule uninervis</i>		X	
SPONGES:			
<i>Aplysilla sulphuria</i>	X		
Agelasiid yellow sponge			X
<i>Acanthella klethra</i> orange sponge			X
Axinelliid brown sponge	X		
Brown crumbly sponge	X		
Black poeciloscerid sponge			X
<i>Cliona</i> sp. red boring sponge			X
Callyspongiid white tube sponge	X	X	X
Calcareous white net sponge			X
<i>Ciocalyptra</i> sp.			X
<i>Coelocarteria</i> sp.			X
<i>Cinachyra</i> sp.	X	X	X
Dictyoceratid orange sponge		X	
<i>Gelloides</i> sp. orange net sponge		X	
Halicionid yellow sponge		X	

Species:	V	RT	FT
<i>Haliclona</i> sp. red sponge	X		
Haplosclerid grey sponge	X		
<i>Hyattella intestinalis</i>	X		X
<i>Ircinia</i> sp. grey sponge	X	X	X
<i>Microciona</i> sp. red sponge			X
<i>Turpios</i> sp. coral killing sponge	X	X	X
<i>Xestospongia testudinaria</i>		X	
HYDROIDS:			
<i>Lytocarpus philippinus</i>	X	X	X
<i>Sertularia</i> sp.	X	X	X
Hydroid 1	X	X	X
Hydroid 2	X		X
Hydroid 3			X
Hydroid 4			X
ANEMONES:			
Coralliomorpharian colonial anemone		X	X
<i>Entacmaea quadricolor</i>	X		
HARD CORALS:			
Pocilloporidae			
<i>Pocillopora damicornis</i>	X	X	X
Acroporidae			
<i>Montipora</i> spp.	4	5	2
<i>Acropora nobilis</i>		X	
<i>A. formosa</i>		X	
<i>A. microphthalma</i>	X		
<i>A. tenuis</i>		X	
<i>A. glauca</i>	X	X	
<i>A. cytherea</i>	X	X	
<i>A. latistella</i>		X	
<i>A. nasuta</i>		X	
<i>A. hyacinthus</i>		X	

Species:	V	RT	FT
<i>A. valida</i>	X	X	
<i>A. divaricata</i>		X	
<i>A. solitaryensis</i>	X	X	X
<i>A. vughani</i>		X	
<i>Acropora</i> sp.	X		
<i>Astreopora myriophthalma</i>		X	
Poritidae			
<i>Porites</i> massive	1	2	1
<i>P. lichen</i>		X	
<i>Goniopora</i> spp.	3	5	3
<i>Alveopora</i> spp.	1		2
Siderasteridae			
<i>Psammocora contigua</i>		X	
<i>P. superficialis</i>	X	X	X
<i>Pseudosiderastrea tayami</i>	X	X	X
<i>Coscinarea columna</i>	X	X	
Agariciidae			
<i>Pavona varians</i>		X	
Oculinidae			
<i>Galaxea astreata</i>		X	X
Pectiniidae			
<i>Echinophyllia orpheensis</i>	X	X	
Mussidae			
<i>Acanthastrea echinata</i>		X	
<i>A. lordhowensis</i>	X	X	X
<i>A. hillae</i>	X	X	X
<i>Lobophyllia hemprichii</i>		X	
Merulinidae			
<i>Hydnophora exesa</i>	X	X	X
Faviidae			
<i>Favia speciosa</i>	X	X	X

Species:	V	RT	FT
<i>F. favus</i>	X	X	
<i>F. rosaria</i>	X	X	
<i>Favia</i> sp.		X	
<i>Favites flexuosa</i>	X	X	
<i>F. abdita</i>		X	
<i>Goniastrea palauensis</i>	X	X	X
<i>Platygyra</i> spp.	3	3	3
<i>Leptastrea purpurea</i>		X	X
<i>Cyphastrea serailia</i>	X	X	X
<i>C. microphthalma</i>	X	X	X
<i>Plesiastrea versipora</i>	X	X	X
<i>Moseleya latistellata</i>	X	X	X
Trachyphylliidae			
<i>Trachyphyllia geoffroyi</i>			X
Caryophylliidae			
<i>Euphyllia ancora</i>	X		X
Dendrophylliidae			
<i>Turbinaria peltata</i>	X	X	X
<i>T. frondens</i>	X	X	X
<i>T. mesenterina</i>	X	X	X
<i>T. stellulata</i>	X	X	X
<i>T. patula</i>		X	
<i>T. bifrons</i>		X	
<i>Duncanopsammia axifuga</i>	X	X	X
NUMBER HARD CORAL SPECIES:	41	61	33
SOFT CORALS:			
<i>Sinularia</i> sp.	X	X	X
<i>Sarcophyton</i> sp.	X	X	X
<i>Carijoa</i> sp.			X
<i>Lobophytum</i> sp.	X	X	X
<i>Dendronephthya</i> sp.	X	X	X

Species:	V	RT	FT
<i>Capnella</i> sp.		X	X
<i>Briareum</i> sp.	X	X	X
<i>Junceella</i> sp.	X	X	X
<i>Dichotella</i> sp.			X
<i>Melithaea</i> sp.	X	X	X
<i>Menella</i> sp.		X	X
<i>Eplexaura</i> sp.	X	X	X
<i>Paralexaura</i> sp.			X
<i>Astrogorgia</i> sp.			X
<i>Echinogorgia</i> sp.			X
<i>Sansibia</i> sp.		X	X
<i>Alertigorgia</i> sp.			X
<i>Ctenocella</i> sp.		X	
<i>Subergorgia</i> sp.		X	X
<i>Echinomuricea</i> sp.	X		
BRYOZOANS:			
<i>Triphylozoon</i> lace 'coral'	X	X	X
Vitaticellidae orange bush bryozoan	X		X
Unknown leafy bryozoan		X	X
Small branching bryozoan	X	X	X
MOLLUSCS:			
<i>Casella</i> sp. blue/yellow nudibranch		X	X
<i>Chromodoris</i> sp. 1 nudibranch	X	X	X
<i>Chromodoris</i> sp. 2 nudibranch	X	X	X
<i>Chromodoris</i> sp. 3 nudibranch		X	
<i>Phyllidia</i> sp. yellow/black nudibranch		X	X
ECHINODERMS:			
<i>Linkia multifora</i> small seastar	X	X	X
<i>Holothuria atra</i> black holothurian	X	X	X
<i>Pentacta crassa</i> small grey holothurian			X
<i>Pseudocolchirus violaceus</i> red/blue			X

Species:	V	RT	FT
<i>Synapta</i> sp.			X
Tube dwelling holothurian			X
Crinoids – feather stars	2	3	3
ASCIDIANS:			
<i>Phallusia julinea</i>		X	X
<i>Cnemidocarpa stolonifera</i>		X	X
<i>Styelidae</i> green/yellow colonial			X
<i>Eusynstyela</i> red colonial	X		X
<i>Clavelina moluccensis</i> blue colonial	X		X
<i>Didemnum</i> sp. 1 red white			X
<i>Didemnum</i> sp. 2 grey blue	X	X	X
<i>Didemnum</i> sp. 3 green white			X
<i>Aplidium</i> sp. 1 yellow green			X
<i>Aplidium</i> sp. 2 pink			X
<i>Distaplia</i> sp. white compound			X
<i>Polycitor</i> orange dome compound		X	



Appendix C

List of Fishes and Other Vertebrates

List of Fishes and Other Vertebrates Seen During the May 2005 Hay Point Island Fringing Reef Surveys.

A number of small secretive fish species were probably not recorded. Site Key: V – Victor Islet; RT – Round Top Island; FT – Flat Top Island. A rough estimate of abundance is given using four categories: Abundant (A) - many seen on every dive; Common (C) - up to 10 seen on every dive; Occasional (O) - only 5-10 individuals seen in total; Rare (R) - only 1-2 individuals seen in total.

Family	Species	V	RT	FT
TOTAL FISH SPECIES:		35	57	42
FISHES:				
Orectolobidae	<i>Eucrossorhinus dasypogon</i>	-	R	-
	<i>Orectolobus ornatus</i>	O	O	O
Hemiscylliidae	<i>Chiloscyllium punctatum</i>	-	-	R
	<i>Hemiscyllium ocellatum</i>	R	R	R
Dasyatidae	<i>Taeniura lymma</i>	R	R	R
	<i>Dasyatis kuhlii</i>	-	R	-
Holocentridae	<i>Sargocentron rubrum</i>	-	R	R
Scorpaenidae	<i>Pterois volitans</i>	-	-	R
Platycephalidae	<i>Platycephalus</i> sp.	-	R	-
Centropomidae	<i>Psammoperca waigiensis</i>	-	R	-
Serranidae	<i>Cephalopholis boenak</i>	-	O	R
	<i>Epinephelus cooides</i>	-	-	O
	<i>E. quoyanus</i>	R	O	C
	<i>Plectropomus. maculatus</i>	C	C	C
	<i>Diploprion bifasciatum</i>	R	C	C
Pseudochromidae	<i>Ogilbyina novaehollandiae</i>	R	O	R
	<i>Pseudochromis fuscus</i>	-	O	-
Apogonidae	<i>Apogon cavitiensis</i>	C	C	C
	<i>A. cookei</i>	-	-	O
	<i>Archamia biguttata</i>	-	O	-
Carangidae	<i>Caranx</i> sp.	-	R	-
Lutjanidae	<i>Lutjanus carponotatus</i>	A	A	C
	<i>L. fulviflamma</i>	-	R	-

Family	Species	V	RT	FT
	<i>L. lemniscatus</i>	-	R	O
	<i>L. russelli</i>	O	-	-
	<i>L. sebae</i>	-	-	R
Caesionidae	<i>Caesio cuning</i>	O	O	-
Haemulidae	<i>Diagramma pictum</i>	-	-	O
	<i>Plectorhynchus flavomaculatus</i>	O	R	R
Lethrinidae	<i>Lethrinus laticaudis</i>	O	C	C
Nemipteridae	<i>Pentapodus paradiseus</i>	-	R	-
	<i>Scolopsis monogramma</i>	-	O	-
Mullidae	<i>Upeneus tragula</i>	O	O	-
Pempheridae	<i>Pempheris schwenkii</i>	-	O	-
Kyphopidae	<i>Kyphosis vaigiensis</i>	-	O	-
Ephippidae	<i>Platax pinnatus</i>	R	-	-
Monodactylidae	<i>Monodactylus argenteus</i>	-	C	-
Chaetodontidae	<i>Chaetodon aureofasciatus</i>	A	A	C
	<i>C. rainfordi</i>	-	R	-
	<i>Chelmon rostratus</i>	O	-	-
	<i>C. muelleri</i>	-	R	O
	<i>Coradion chrysozonus</i>	-	O	-
Pomacanthidae	<i>Chaetodontoplus duboulayi</i>	C	A	A
	<i>Pomacanthus sexstriatus</i>	-	O	R
Pomacentridae	<i>Abudefduf bengalensis</i>	O	C	A
	<i>Chromis nitida</i>	A	A	C
	<i>Neopomacentrus bankieri</i>	A	A	A
	<i>Parma oligolepis</i>	C	A	A
	<i>Pomacentrus australis</i>	C	A	C
	<i>P. wardi</i>	A	A	C
Sphyraenidae	<i>Sphyraena flavicauda</i>	-	-	C
Labridae	<i>Choerodon cyanodus</i>	A	A	A
	<i>C. cephalotes</i>	-	-	R
	<i>C. graphicus</i>	-	R	R

Family	Species	V	RT	FT
	<i>C. schoenleinii</i>	O	O	C
	<i>C. vitta</i>	C	C	C
	<i>Coris aurilineata</i>	C	C	C
	<i>C. pictoides</i>	R	-	-
	<i>Halichoeres nigrescens</i>	O	O	O
	<i>Hemigymnus melapturus</i>	-	R	-
	<i>Pseudolabrus guentheri</i>	A	A	A
	<i>Thalassoma lunare</i>	-	R	-
Scaridae	<i>Scarus ghobban</i>	O	O	R
Gobiidae	<i>Cryptocentrus</i> sp. 1	C	C	C
	<i>C.</i> sp. 2	-	-	O
	<i>Valenciennea</i> sp.	-	R	-
Microdesmidae	<i>Ptereleotris microlepis</i>	-	R	O
Acanthuridae	<i>Acanthurus grammoptilus</i>	-	R	-
Siganidae	<i>Siganus margaritiferus</i>	O	C	-
Balistidae	<i>Abalistes stellatus</i>	-	R	-
Tetradontidae	<i>Arothron manilensis</i>	R	R	-
REPTILES:				
Olive sea snake	<i>Aipysurus laevis</i>	C	C	C
Green turtle	<i>Chelonia mydas</i>	R	-	-



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