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Abbot Bay marine habitat survey,
December 2002

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21 January 2003

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Title: Abbot Bay marine habitat survey, December 2002

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Issued by: Chris Ryan

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This report constitutes the Final report issued on 21 January 2003. This report supersedes any previous documents.

Chris Ryan

Director

Scientific Marine Pty. Ltd.

Executive Summary

- Scientific Marine were contracted by Lambert and Rehbein on behalf of Pacific Reef Fisheries to carry out field surveys and prepare a report on the marine habitat in the vicinity of a proposed prawn farm development near Abbot Bay, Queensland.
- This report presents information on the seagrass meadows and fringing reefs surveyed, together with some relevant background materials.
- Three species of seagrass were detected in the surveys, including *Halophila ovalis*, *Halophila spinulosa* and *Halodule uninervis*. *Halodule uninervis* could further be described as wide and thin leaved.
- Seagrass density was generally low in the area surveyed, apart from a small area due north of the mouth of the Elliot River.
- Live cover was low on the fringing reefs surrounding Camp Island. There was clear evidence of the effects of coral bleaching events and Crown-of-thorn starfish attacks.
- Diversity on the fringing reefs was generally low. Acroporid corals were by far the most common, followed by *Montipora spp.* and Favids.

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Introduction

Pacific Reef Fisheries has proposed the development of a prawn farm adjacent to Abbot Bay and the Elliot River. The proposed development would require the construction of an inlet and outfall pipe in Abbot Bay. With due consideration to the potential impact on the marine environment of such a development, Scientific Marine were commissioned by Lambert and Rehbein, on behalf of Pacific Reef Fisheries to investigate the marine resources of the area at risk.

Project Brief

Scientific Marine's brief was to:

Map the extent of the fringing reefs around Camp Island. Conduct visual surveys of fringing reefs for hard and soft coral cover, algae cover and other benthic fauna.

- Conduct marine habitat surveys of area potentially affected by discharges from outfall pipe. Report on presence/absence of seagrass, species present, basic density estimates (shoots/m²), epiphyte cover, bottom type and depth.
- Conduct intensive surveys of marine habitat affected by pipe footprint. Report on presence/absence of seagrass, species present, basic density estimates (shoots/m²), epiphyte cover, bottom type and depth.
- Conduct marine habitat surveys of the area between the mouth of the Elliot River and the inlet pipe. Report on presence/absence of seagrass, species present, basic density estimates (shoots/m²), epiphyte cover, bottom type and depth.

Study Site

Abbot Bay is a large shallow, exposed bay stretching between Cape Abbot and Cape Upstart, approximately 35 km north of Bowen (Figure 1). Guthalungra is the nearest township, situated where the Bruce Highway crosses the Elliot River. The proposed development is to be sited north of the Elliot River, with the inlet and outfall pipes approximately two and four km's north of the mouth.

Broadscale surveys in 1987 by the Queensland Department of Primary Industries (Queensland Fisheries Service - Northern Fisheries Centre) identified seagrass meadows as marked on Figure 1 (see Appendix 2 for the seagrass metadata). This study identified 35.4 km² of seagrass meadows in Abbot Bay, comprising seven species (Lee Long *et. al.*, 1993). As tropical seagrass meadows are subject to natural temporal changes, varying seasonally and between years (Mellors *et. al.*, 1993), the seagrass meadows shown in Figure 1 may have changed in the fifteen years since the QDPI survey.

Fringing Reefs have been previously identified by AUSLIG (under contract to the Great Barrier Reef Marine Park Authority) and are noted on Figure 1 (see Appendix 3 for the reef metadata).

The area potentially affected by construction of the pipes and outfall discharges are zoned "General Use" by the Great Barrier Reef Marine Park Authority.

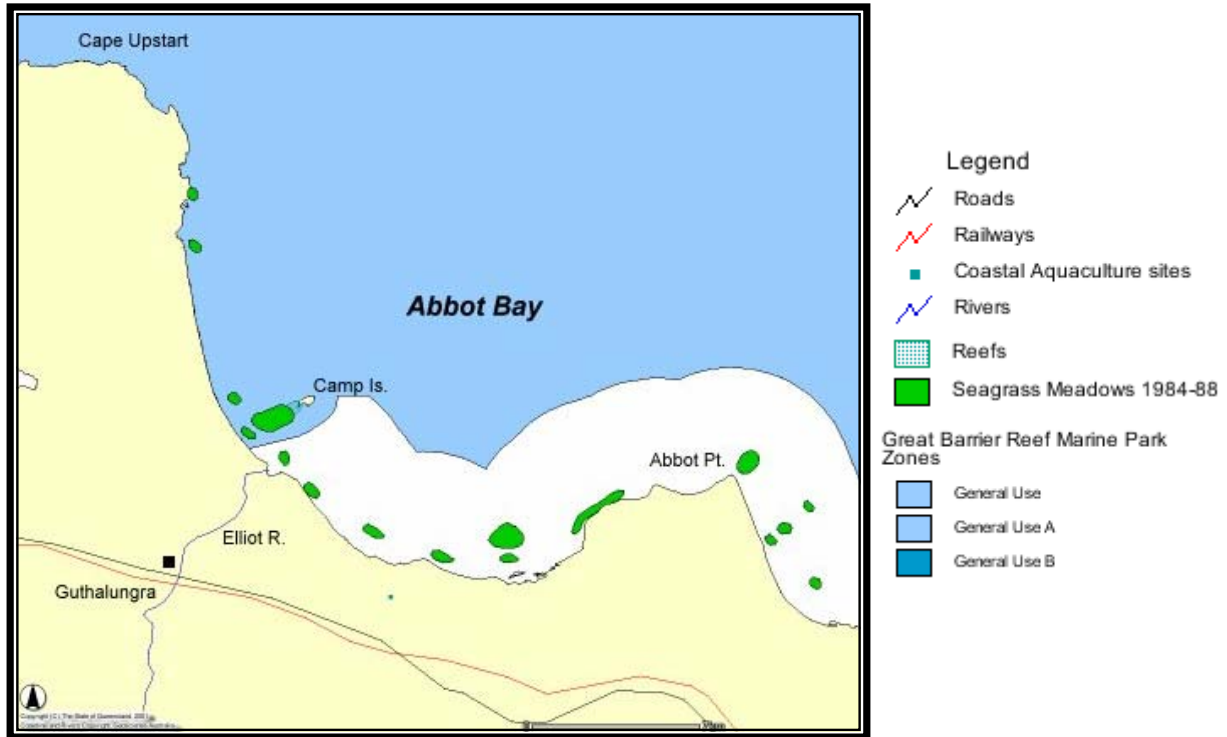


Figure 1: Abbot Bay, showing location of seagrass meadows (Lee Long *et. al.*, 1993)

Methods

Surveys of the marine habitat were carried out between 2 - 7 December 2002 and 12 - 13 December 2002. Access to Abbot Bay is by tide restricted boat ramps at the mouth of the Elliot River.

All depths are recorded as depth below chart datum.

Fringing Reefs

Three sites were randomly selected along the front (SE face) and three along the back of the fringing reef around Camp Island (see Figure 2). At each site, divers laid four 20m line intercept transects and recorded all live non-motile benthic cover, including hard and soft corals, algae, sponges, seagrass and corallimorphs. Corals (Veron, 1993) and algae (Mather and Bennett, 1993) were identified to genus level.

Seagrass Meadows

For the broadscale seagrass survey, a random stratified design based on the modelling of plumes from the pipe outlet was used (see Figure 2 and Appendix 1). Eight sites were randomly selected from within each zone (1 and 2), and eight further sites selected within 1 km of the outside edge of Zone 2. After further consultation, a further twelve sites (25 – 36) were randomly selected between the mouth of the Elliot River and the area already surveyed.

At each site, eight samples (20x20cm quadrats) were taken. The first sample was taken directly under the boat, and the remaining seven were located by divers swimming in a random direction, for a random distance (between 1 – 15 m). Data was recorded from each sample on seagrass species present, number of shoots, epiphyte cover, bottom type, other species present and the presence of dugong feeding trails. Seagrass was identified to species level (Lanyon, 1986).

Pipe footprint

The pipe footprints were located by taking a direct line to shore from the inlet and outlet positions given. Five sites on each track were randomly selected and surveyed (using methodology as above).

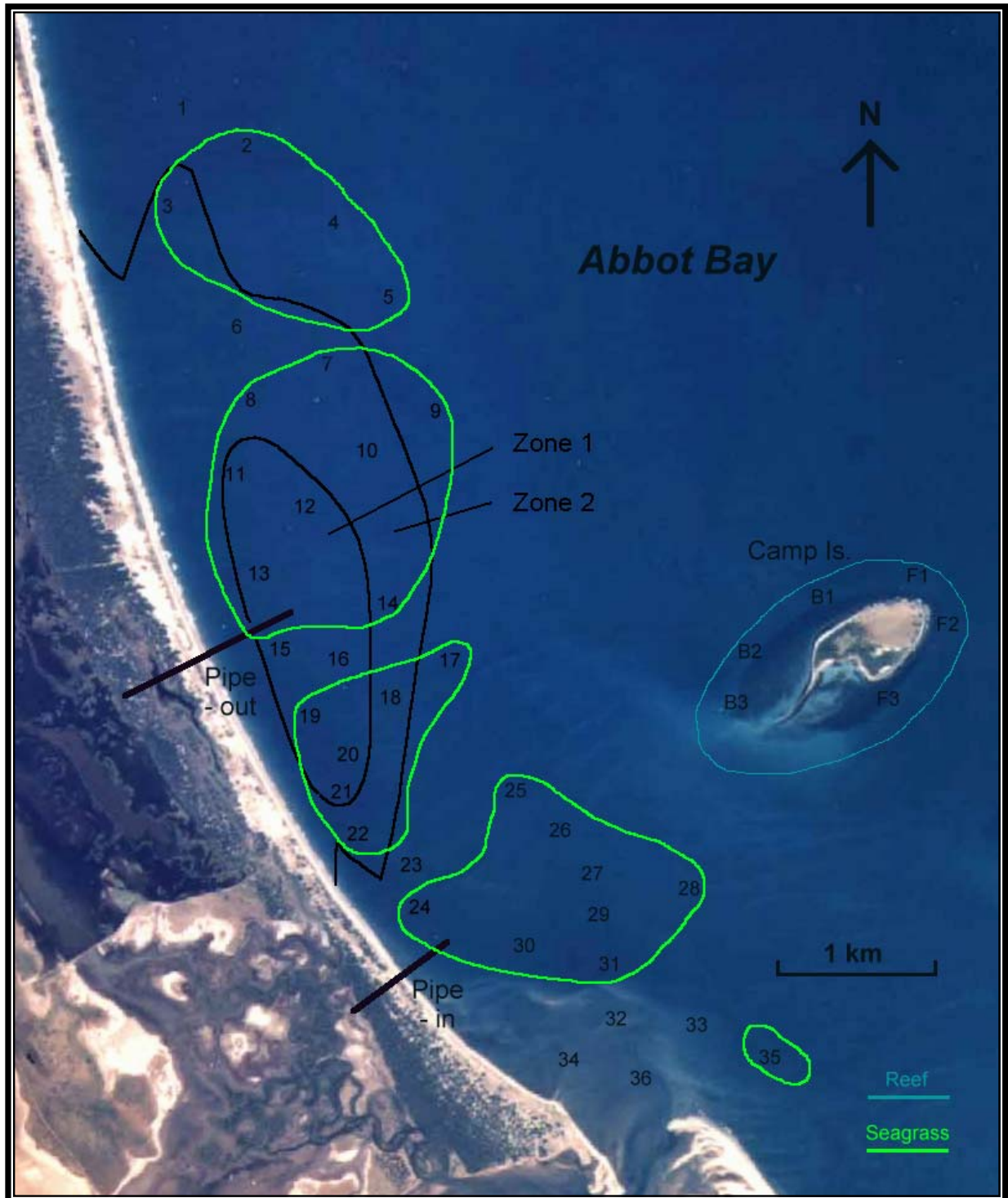


Figure 2: Detail of study area, showing sampling sites, plume modelling, fringing reefs and seagrass meadows detected

Results

Fringing Reefs

Divers identified fringing reefs around Camp Island with an extensive area of back reef (Figure 2). Coral Bleaching events in 1998 and 2001, and Crown-of-thorn starfish outbreaks in 2001 were reported by caretaker of Camp Island (Dennis Turner, *pers. com.*). The effects of these events were evident to the divers, by the

areas of recently dead coral, covered in algae. Sites F3 and B3 (see Figure 2) were particularly affected, as evidenced by the large areas of dead staghorn thickets.

Table 1 presents the mean % live cover for hard coral, soft coral, algae and sponges for all fringing reef sites at Camp Island. Graphs displaying this data for each site can be found in Appendix 4.

The mean % live hard coral cover for all Sites (see Figure 2) was 11.5% (+/- 2.6 SE). Cover ranged from 6.6% (+/- 2.7 SE) at site B2 on the southern side, through to 24.2% (+/- 6.2 SE) at the north-eastern point of the island. Acroporid corals were the most common hard corals found, making up more than 50 % of hard coral cover at all sites except B3.

Soft corals and sponges accounted for less than 5% cover. The total mean % algae cover was 43.4% (+/- 4.1 SE), with *Sargassum sp.* and *Padina sp.* being most common.

Table 1: Mean % live cover (+/- SE), Camp Island fringing reefs

Site	Hard coral		Soft coral		Algae		Sponges	
	μ	+/- se	μ	+/- se	μ	+/- se	μ	+/- se
Front 1 (F1)	24.2	6.2	1.6	0.9	36.1	1.3	0.8	0.7
Front 2 (F1)	8.2	3.2	1.4	0.5	60.5	10.4	1.5	1.0
Front 3 (F1)	8.0	2.2	0.0	0.0	31.4	3.3	5.4	1.3
All Fronts	13.4	3.2	1.0	0.4	42.7	5.1	2.6	0.8
Back 1 (B1)	8.5	2.7	0.6	0.4	44.0	3.9	3.7	1.9
Back 2 (B1)	6.6	2.7	0.7	0.7	44.4	5.3	3.0	2.2
Back 3 (B1)	13.3	3.9	0.3	0.3	43.9	7.7	1.7	1.0
All Backs	9.5	1.9	0.6	0.3	44.1	3.1	2.8	1.0
All Sites	11.5	2.6	0.8	0.3	43.4	4.1	2.7	0.9

No significant differences in mean % live cover of hard coral, soft coral, algae or sponges was noted between the three sites along the south-east front (F1, F2, F3) and the three sites on the lee side (B1, B2, B3) of the island (Figure 3).

Site F1, on the north-eastern point of Camp Island recorded the highest hard coral cover (Table1, Appendix 4), with a low score for number of species (Table 2). Acroporid corals were the dominant species at this site.

Site B3 on the south western side of the island recorded the greatest diversity of hard corals, with 21 species groups detected from 11 families. Site F2, on the eastern most point of the island, was the next most diverse site with 15 species groups from 7 families (Table 2).

Figure 3: Mean % live cover of hard coral, soft coral, algae and sponges on fringing reefs – Camp Island.

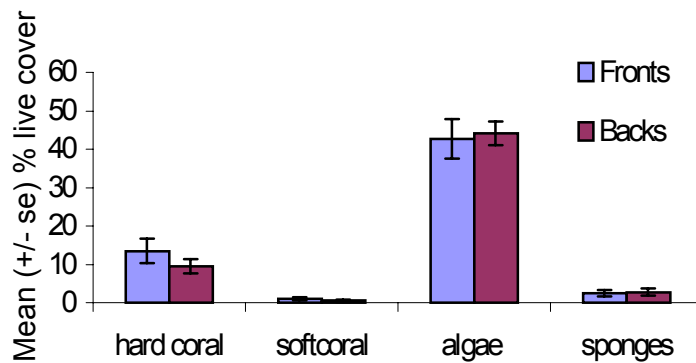


Table 2: Scleractinian corals at Camp Island

	Front 1	Front 2	Front 3	Back 1	Back 2	Back 3
Pocilloporidae						
<i>Pocillopora damicornis</i>					+	+
<i>Stylophora sp.</i>						+
<i>Palauastrea sp.</i>	+					
Acroporidae						
<i>Montipora spp.</i>	+			+	+	+
<i>Acropora spp.</i> (plate)	+					
<i>Acropora spp.</i> (staghorn)	+	+	+	+	+	+
<i>Acropora spp.</i> (corymbose)	+	+	+	+	+	+
<i>Astreopora sp.</i>		+	+			
Poritidae						
<i>Porites spp.</i> (massive)	+	+	+	+	+	+
<i>Goniopora spp.</i>						+
Siderasteridae						
<i>Psamnocora sp.</i>						+
Agaricidae						
<i>Leptoseris sp.</i>						+
Fungiidae						
<i>Fungia sp.</i>	+	+	+		+	+
Oculinidae						
<i>Galaxea spp.</i>		+			+	+
Pectiniidae						
<i>Echinophyllia sp.</i>						+
<i>Oxypora sp.</i>						+
<i>Pectinia sp.</i>					+	+
Mussidae						
<i>Lobophyllia sp.</i>						+
<i>Symphyllia sp.</i>					+	
Merulinidae						
<i>Hydnophora sp.</i>		+		+		+
<i>Merulina sp.</i>						+
Faviidae						
<i>Favia spp.</i>		+				
<i>Favites spp.</i>		+		+	+	+
<i>Barrabatoia sp.</i>		+				
<i>Leptoria sp.</i>		+				+
<i>Goniastrea spp.</i>		+				+
<i>Platygyra spp.</i>	+	+			+	
<i>Cyphastrea sp.</i>		+				+
<i>Moselya sp.</i>				+		
<i>Echinopora spp.</i>				+		
Dendrophylliidae						
<i>Turbinaria spp.</i>		+		+		
Species groups present	8	15	5	9	11	21

+ denotes presence

Seagrass Meadows

Seagrass meadows were detected throughout the sampling area (see Figure 2). Three species of seagrass (*Halophila ovalis*, *Halophila spinulosa* and *Halodule uninervis*) were recorded. *Halodule uninervis* could further be described as either thin or wide leaved. *Halophila ovalis* and *Halophila spinulosa* were the most common species, being found in 59% and 54% of samples, respectively. Dugong feeding trails were noted at Site 22 and on one of the Inlet Pipe sites.

Table 3 presents the mean (+/- SE) number of shoots m⁻² for these four species. Overall, the density of the seagrass meadows were low (see Appendix 5 and Appendix 7 for comparison) with moderate to high densities recorded in the area approximately 1km due north of the mouth of the Elliot River (see Figure 2). Appendix 6 shows mean densities for each site along with information on bottom type, epiphyte cover, other species present.

Zone 1 had significantly lower mean densities of *Halophila spinulosa* and *Halodule uninervis* (wide) than all other sites and significantly higher density of *Halodule uninervis* (thin). Zone 2 had a significantly higher density of *Halophila ovalis* and significantly lower density of *Halodule uninervis* (thin) than all other sites (see Figure 4).

The highest densities recorded were for sites 25 – 31 in the area due north of the mouth of the Elliot River and east of the intake pipe (see Figure 5). The mean density for *Halodule uninervis* (wide) at these sites was 622.6 (+/- 121.8 SE) shoots m⁻² and 252.0 6 (+/- 79.8 SE) shoots m⁻² for *Halophila spinulosa*. Individual quadrats recorded between 0 and 3620 shoots m⁻².

No seagrasses were recorded in the area adjacent to the river mouth (Sites 32, 33, 34, 36).

Table 3: Mean (+/- SE) no shoots m⁻² for seagrass meadows in Abbot Bay survey area.

	<i>Halophila ovalis</i>		<i>Halophila spinulosa</i>		<i>Halodule uninervis-thin</i>		<i>Halodule uninervis-wide</i>	
	μ	+/- se	μ	+/- se	μ	+/- se	μ	+/- se
All Sites	146.9	20.5	102.5	18.9	37.6	9.4	139.0	35.5
Zone 1 Sites	163.6	43.3	39.4	19.2	79.5	24.7	0.4	0.4
Zone 2 sites	234.4	51.2	123.0	34.3	38.3	18.0	56.6	18.3
Outfall sites	99.4	41.5	80.0	43.1	0.0	0.0	60.6	33.0
Inlet Sites	142.5	58.5	0.0	0.0	46.3	22.5	0.0	0.0
Sites 25-31	137.9	50.1	252.0	79.8	44.3	31.4	622.6	121.8

Figure 4: Seagrass density by zone.

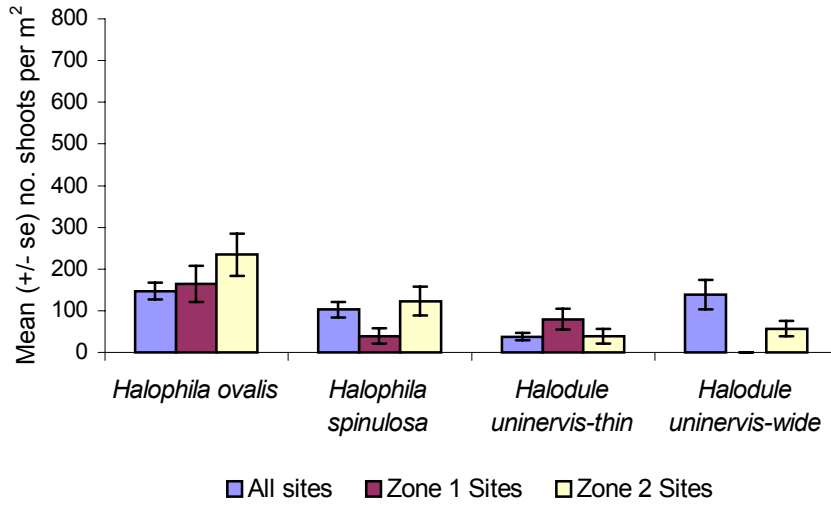
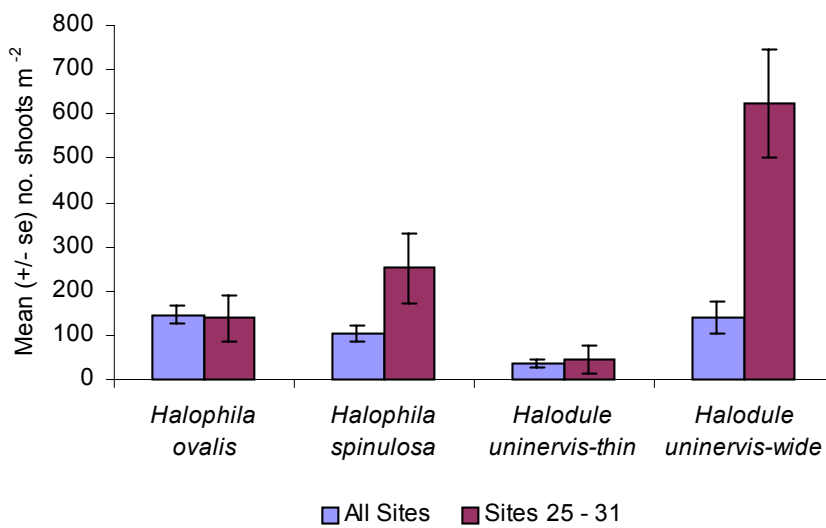
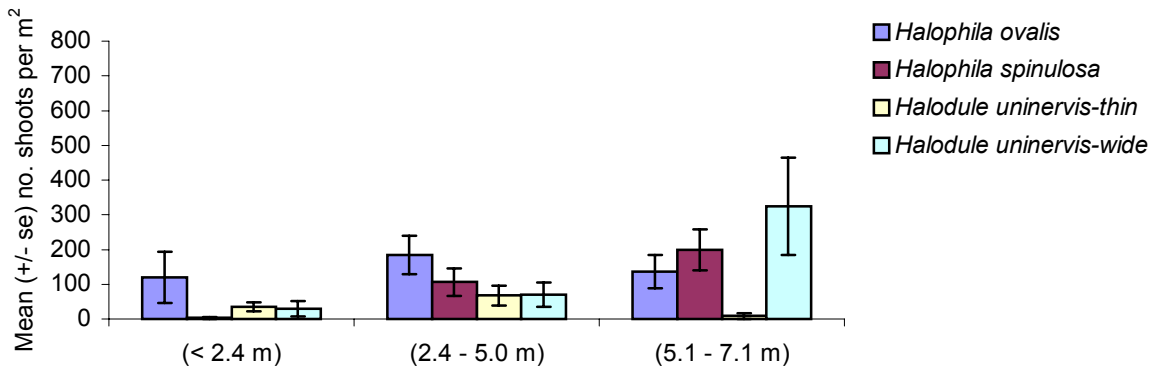


Figure 5: Sites 25 – 31.



Halophila ovalis was uniformly distributed throughout the depth range surveyed (see Figure 6). Significant increases in shoot densities for *Halophila spinulosa* and *Halodule uninervis* (wide) were noted with increasing depth. *Halodule uninervis* (thin) was present at only one of the deeper sites.

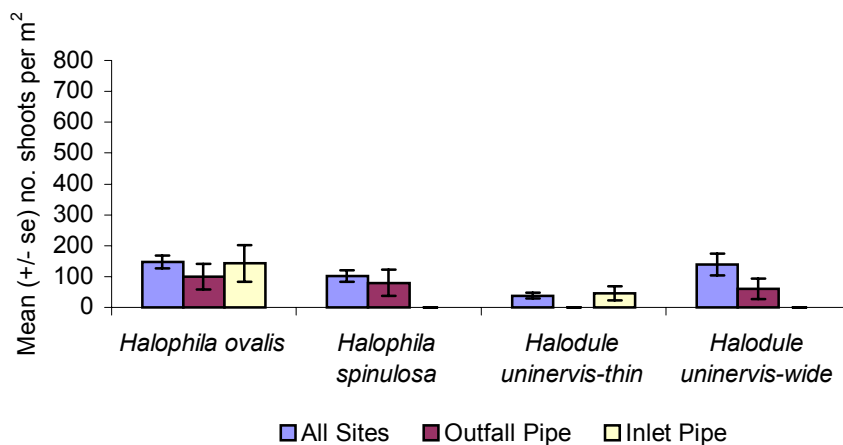
Figure 6: Seagrass density by Depth, Abbot Bay.



Pipe footprint

No *Halophila spinulosa* or *Halodule uninervis* (wide) was detected at the inlet pipe sites, and no *Halodule uninervis* (thin) was recorded at the outfall pipe sites (Figure 7). The density of *Halodule uninervis* (wide) was significantly lower at the outfall pipe sites compared to all sites surveyed.

Figure 7: Seagrass densities at pipe sites



References

- Lanyon, J. (1986) *Guide to the identification of seagrasses in the Great Barrier Reef region*. GBRMPA Special Publication Series No. 3, Townsville.
- Lee Long, W.J., Mellors, J.E. & R.G. Coles (1993) Seagrasses between Cape York and Hervey Bay, Queensland, Australia. *Aust. J. Mar. Freshwater Res.*, **44**, 19-31.
- Mather, P. and I. Bennet (1993) *A Coral Reef Handbook*. (Eds.) Surrey Beatty and Sons Pty. Ltd., Sydney.
- Veron, J.E.N. (1993) *Corals of Australia and the Indo-Pacific*. University of Hawaii Press, Honolulu.
- Turner, Dennis Caretaker of Camp Island (0419 680 616)

Further Reading

- Fonesca, M.S. (1987). The management of seagrass ecosystems. *Trop. Coastal Area Mgmt.* 2: 5-7.
- Lanyon, J., Limpus, C.J. and Marsh, H. (1989). Dugongs and turtles: grazers in the seagrass system. Pp 610-634 in *Biology of seagrasses: a treatise on the biology of seagrasses with special reference to the Australian region*. (Eds. A.W.D. Larkum, A.J. McComb and S.A. Shepherd). Elsevier, New York.
- Shepherd, S.A., McComb, A.J., Bultuis, D.A., Neveravskas, V., Steffensen, D.A. and R. West (1989). Decline of seagrasses. Pp 364-393 in *Biology of Australian Seagrasses – an Australian perspective*. (Eds. A.W.D. Larkum, A.J. McComb and S.A. Shepherd) Elsevier, Amsterdam.

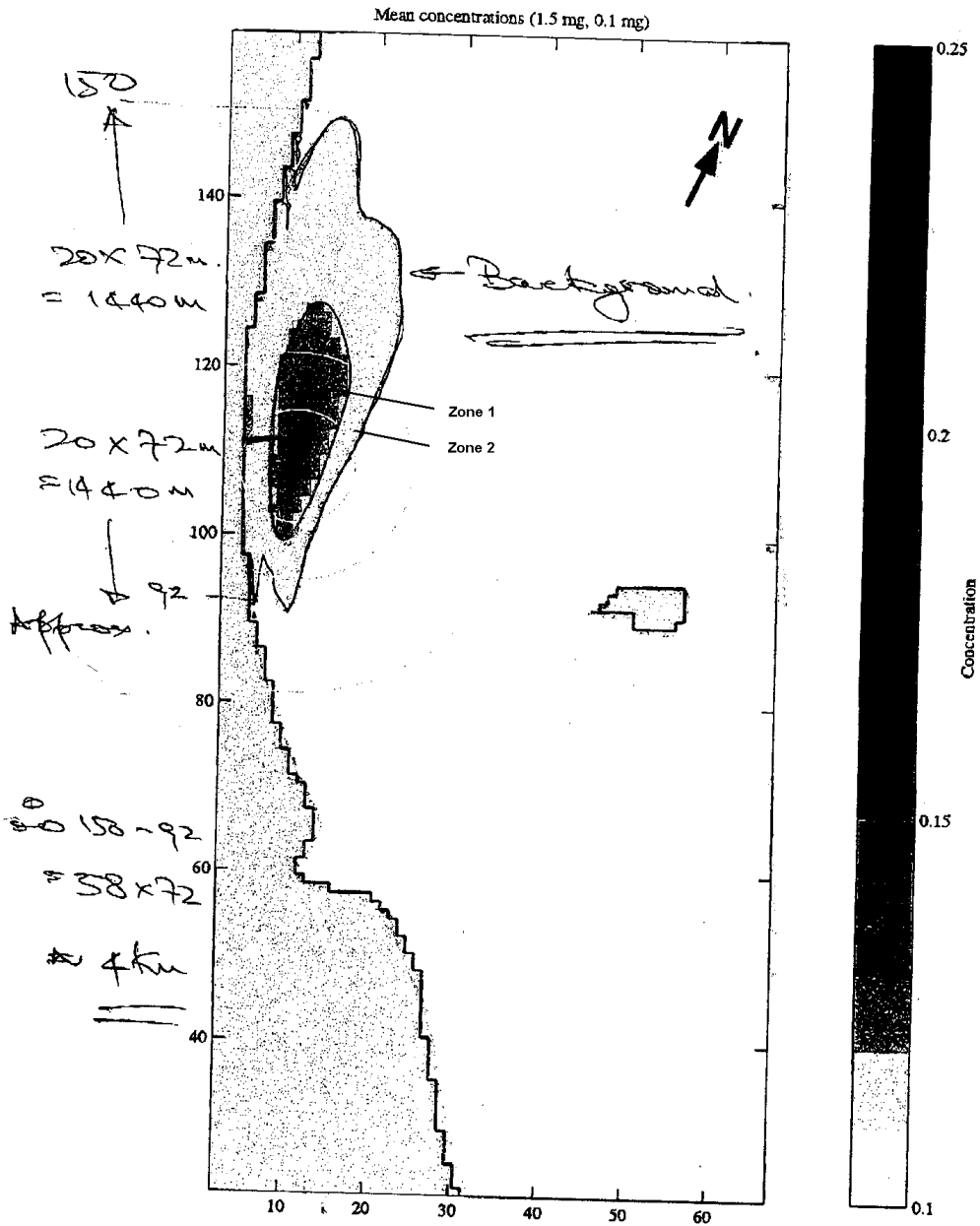
Appendix 1: Modelling supplied by Lambert and Rehbein.

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LAMBERT & REHBEIN

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Appendix 2: Metadata for Seagrass Meadows 1984-1988

Data Set

DSIN	10421
Title	Seagrass Meadows 1984-1988
Custodian	Queensland Fisheries Service - Northern Fisheries Centre
Jurisdiction	QLD

Description

Abstract	<p>Coastal seagrass meadows along the Queensland coast. Survey Dates: Tarrant Point to Cape York - October/November 1986 Cape York to Cairns - November 1984 Cairns to Bowen - October/November 1987 Bowen to Water Park Point - March/April 1987 Water Park Point to Hervey Bay - October/November 1988 Noosa to Coolangatta - August/December 1987</p> <p>Please note that more recent data maybe available and that users should ensure that they are using the most recent data available. Please contact the custodian for further information.</p>
Search Word(s)	Seagrasses
Geographic Extent Name(s)	Queensland Coast
Coordinates	N: -9 S: -29.5 E: 154 W: 138

Data Currency

Beginning date	1/11/1984
Ending date	30/11/1988

Dataset Status

Progress	Complete
Maintenance and update frequency	Not Required

Access

Stored Data Format	DIGITAL - ArcView Shapefile (.shp)
Available Format Type	DIGITAL - ArcView Shapefile (.shp)
Access Constraint	QFS data - release outside QFS on completion of a data agreement

Data Quality

Lineage	Derived from visual assessment of the seabed by diving along transects out from the coastline at intervals of about 4km. Extra dive checks were made between transects for continuity.
Positional Accuracy	Boundaries of meadows were determined based on the positions of survey sites and the presence of seagrass, coupled with depth contours and other available information. Accuracy varies from 10-100 metres, as it relies partly on locational accuracy of RADAR.
Attribute Accuracy	Information finalized.
Logical Consistency	Attributes are standardised.
Completeness	All meadows examined at the time of survey are represented. Seagrass distribution can change seasonally and between years, and users should ensure that they make appropriate enquires to determine whether new information is available on the particular subject matter.

Contact Information

Contact Organisation	Queensland Fisheries Service - Northern Fisheries Centre
Contact Position	Research Scientist
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State	Qld
Country	Australia
Postcode	4870
Telephone	(07) 4035 0113
Facsimile	(07) 4035 4664
Electronic Mail	campbes@dpi.qld.gov.au

Metadata Date

Creation Date	7/03/2002
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Appendix 3: Metadata for Reefs - GBRMP

Data Set

DSIN 10031
Title Reefs - GBRMP
Custodian Great Barrier Reef Marine Park Authority
Jurisdiction Great Barrier Reef

Description

Abstract Major CORAL REEF structures within the Great Barrier Reef World Heritage Area Attributes are [sub_id], [reef_name], [gaz_loc_code],[x_coord], [y_coord] (centroid label positions)]. A polygon coverage with 3403 records in Geographic Projection at a scale of 1:250 000. Derived from an AUSLIG source coverage. GBRMPA.Coverage Type = polygon.

Search Word(s) Coral, Reef

Geographic Extent Name(s) Great Barrier Reef

Coordinates N: -9
S: -24.5
E: 153
W: 141

Data Currency

Beginning date 13/01/1994
Ending date 1/10/2001

Dataset Status

Progress Complete
Maintenance and update frequency As required

Access

Stored Data Format DIGITAL - ARC/INFO, DIGITAL - ARC/INFO Export
Available Format Type DIGITAL - ARC/INFO, DIGITAL - ARC/INFO Export
Access Constraint QFS Use Only - Dataset available on CHRIS, not for release outside QFS

Data Quality

Lineage Produced under specific contract for GBRMPA by AUSLIG.

	Derived from datasets produced by the Division of National Mapping, RAN Hydrographic Service and James Cook University of North Queensland. Hydrographic survey techniques used in conjunction with analysis of Landsat Panchromatic Imagery and Aerial Photographic interpretation.
Positional Accuracy	REEFS coverage has not been statistically tested with precision survey techniques. Positional accuracy varies considerably and dataset should NOT be used for navigation purposes, however, for general use the coverage can be regarded as having a nominal scale of 1:250,000.
Attribute Accuracy	Reefs have reef names and latitudinal gazetted location codes attached. Item 'Qld_Name' contains information in line with gazetteer official names. Item 'GBR_Name' allows differentiation of specific reefs within groups by GBRMPA. Names were last updated in August, 2000 to reflect the correct names as per Queensland Place Names. Names and codes updated as required. Most of these attributes are <80% complete as new additions appear not to have their attributes updated.
Logical Consistency	REEF_ID attribute is numbered according to latitude and general cross-shelf location, eg., 18055: first 2 digits refer to latitude, last 3 digits refer to cross-shelf location.
Completeness	Major reef systems are present. Minor reefs and shoals may not be present.

Contact Information

Contact Organisation	Great Barrier Reef Marine Park Authority
Contact Position	Geographical Information Systems Manager
Mail Address	2 - 68 Flinders Street, PO Box 1379
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Country	Australia
Postcode	
Telephone	4750 0700
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Electronic Mail	gis@gbmpa.gov.au

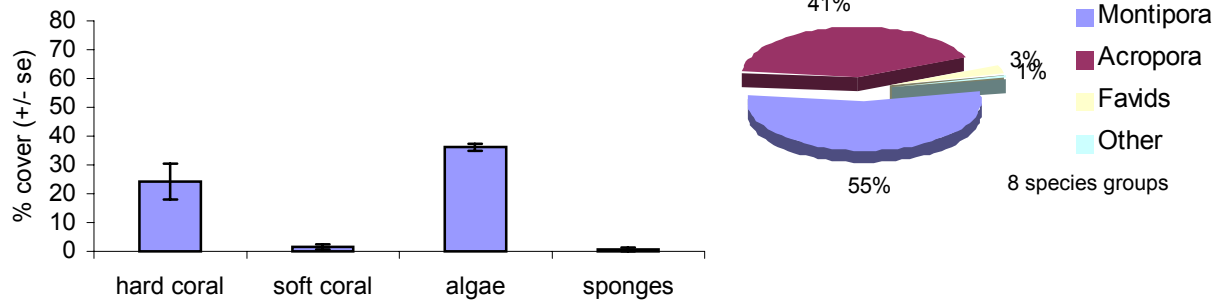
Metadata Date

Creation Date	21/06/2000
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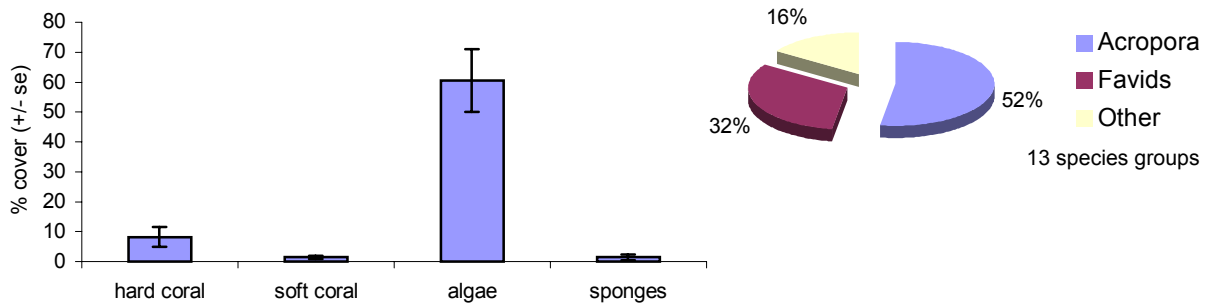
Appendix 4: Fringing Reefs data

Showing mean % live cover (+/- SE) for hard and soft coral, algae and sponges. Hard coral diversity shown to right.

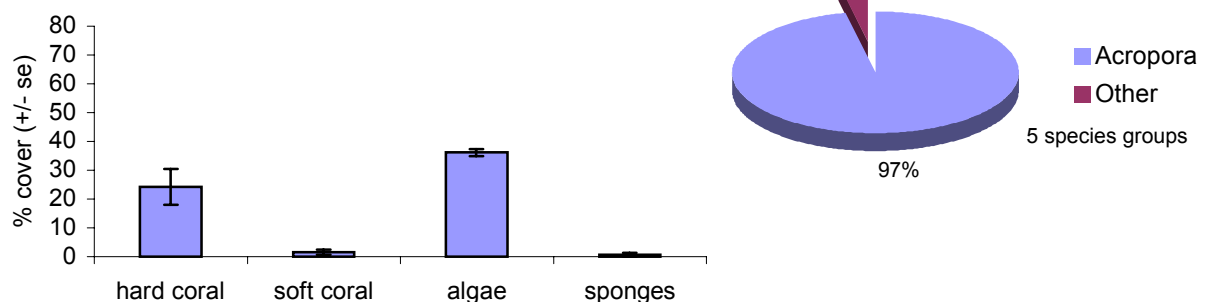
Front 1



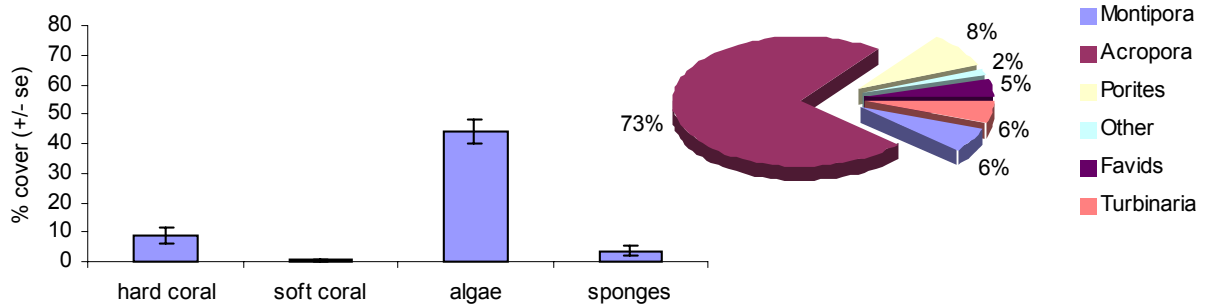
Front 2



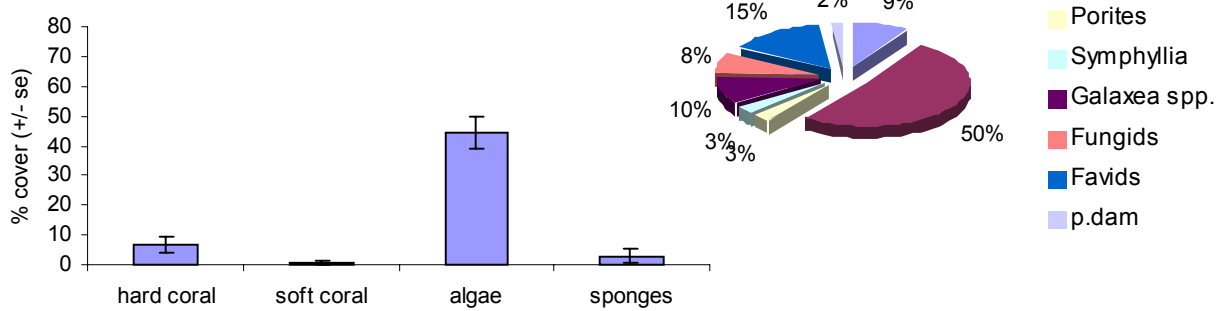
Front 1



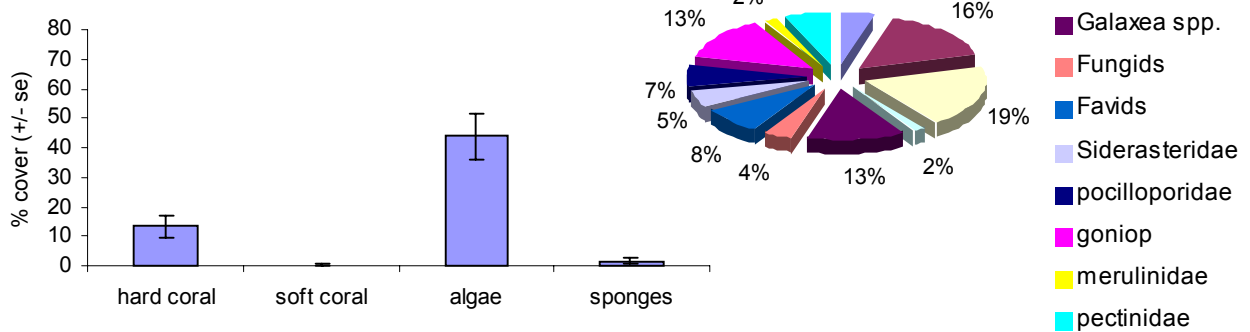
Back 1



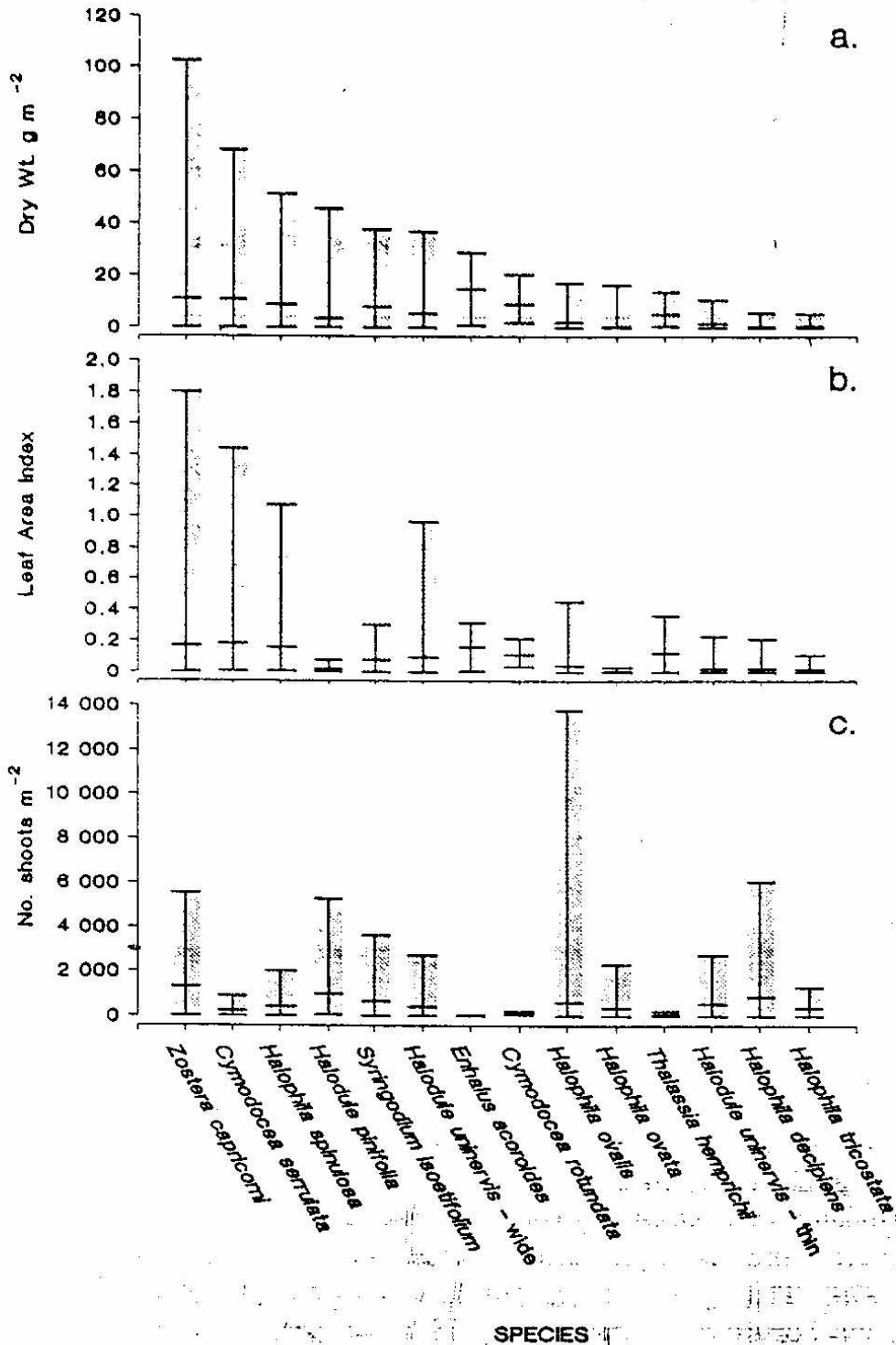
Back 2



Back 3



Appendix 5: from Lee Long *et. al.* (1993)



4. Means and ranges of (a) above-ground (leaves and shoots) biomass, (b) leaf area and (c) shoot densities of seagrasses sampled between Cape York and Hervey Bay.

Appendix 6: Seagrass Table

Summary of Seagrass Data

Site	Mean no. shoots (\pm se) per quadrat ¹				Epiphyte cover (%) ²			Bottom type ³	Other species ⁴	Depth ⁵	Notes
	H. ova	H. spair	H. uni ⁶ (thin)	H. uni ⁶ (wide)	< 10	10 - 50	> 50				
1	-	-	1.1 (1.0)	-	-	-	-	CS/S/G	2	4.7	
2	-	-	1.1 (1.0)	-	-	-	-	CS/S/G	4	6.9	
3	2.8 (2.2)	5.1 (3.4)	-	-	-	1	3	CS/S/G	2.9	4.1	
4	16.6 (3.3)	4.1 (2.8)	-	1.1 (0.7)	-	3	8	FS/ST	2.5	6.6	
5	4.3 (2.3)	5.5 (2.3)	-	-	-	3	4	CS/ST	2.38	7.1	
6	-	-	-	-	-	-	-	CS/S/G	-	4.2	
7	21.4 (4.6)	17.3 (6.3)	-	0.9 (0.6)	-	7	5	CS/FS/S/G	-	6.6	
8	-	0.1 (0.1)	-	-	-	1	1	CS/S/G/ST	3.10	5.4	
9	12.8 (4.4)	13.9 (4.0)	-	0.8 (0.8)	-	4	6	FS	2	6.4	
10	0.9 (0.9)	2.5 (2.0)	-	-	-	2	1	CS	-	6.0	
11	8.0 (3.6)	4.5 (4.5)	-	-	-	1	2	CS/FS	1	4.2	
12	13.1 (8.5)	6.3 (3.9)	-	2.0 (1.1)	-	4	-	CS/S/G	-	3.9	
13	0.4 (0.3)	-	-	2.5 (2.2)	-	1	1	CS/S/G	1	2.7	
14	-	0.3 (0.3)	-	-	-	2	2	CS/ST	10	5.6	
15	-	-	-	-	-	-	-	CS/S/G	8	2.4	
16	-	-	-	-	-	-	-	CS/ST	5.7	3.6	
17	2.8 (1.1)	25.3 (4.8)	-	-	-	7	7	FS	1.1	5.9	
18	13.5 (4.3)	14.1 (5.7)	-	4.9 (1.5)	-	13	5	FS/S/G	1	4.1	
19	2.1 (2.1)	1.9 (1.9)	-	5.1 (3.5)	-	1	1	CS/FS/ST	1	1.9	
20	0.1 (0.1)	0.4 (0.4)	-	0.1 (0.1)	-	1	2	CS/ST	2	3.2	
21	30.3 (2.6)	-	-	16.1 (5.0)	-	8	-	FS/ST	1	2.9	
22	36.5 (8.6)	-	-	3.6 (2.2)	-	8	-	FS/ST	1	2.3	
23	-	-	-	-	-	-	-	FS/ST	-	1.3	Dugong feeding trail
24	5.0 (2.5)	-	-	3.1 (3.1)	-	5	1	FS/ST	1	1.9	
25	25.9 (7.8)	31.5 (5.6)	-	20.9 (7.1)	-	8	8	FS/ST	2.7	6.7	
26	1.9 (1.9)	4.8 (3.2)	-	67.0 (62.6)	-	2	1	CS	2.57	5.7	
27	0.8 (0.8)	10.6 (6.3)	-	98.8 (42.8)	-	1	4	FS/ST	2.411	5.5	
28	1.1 (1.1)	2.6 (1.9)	-	5.3 (5.3)	-	7	2	CS	2.7	5.1	
29	7.4 (6.3)	0.5 (0.5)	-	1.81 (67.9)	-	2	2	CS/FS/ST	2.47	5.7	
30	-	15.6 (5.6)	-	32.3 (20.9)	-	4	1	CS/FS/ST	1.2	5.2	
31	34.4 (21.6)	24.9 (5.3)	-	18.1 (10.9)	-	1	5	CS/FS/ST	12.3, 5.7, 1.1	5.0	
32	-	-	-	27.5 (27.5)	-	3	-	FS/ST	-	1.0	
33	-	-	-	-	-	-	-	FS/ST	5	2.0	
34	-	-	-	-	-	-	-	CS	-	1.4	
35	19.3 (14.2)	3.8 (3.8)	-	15.3 (8.7)	-	4	2	CS/FS/ST	2.3, 4.12	4.9	
36	-	-	-	-	-	-	-	CS/S/G/D/G	2.8, 1.1	1.7	

Summary of Seagrass Data

Site	Mean no. shoots (\pm se) per quadrat ¹				Epiphyte cover (% ²)			Bottom type ³	Other species ⁴	Depth ⁵	Notes
	H. ova	H. spin	H. uni ⁶ (thin)	H. uni ⁶ (wide)	< 10	10 - 50	> 50				

Discharge pipe											
1	3.9 (2.0)	11.8 (7.8)	-	2.5 (2.5)	-	4	1	CS/SG/DG	6	4.5	
2	15.5 (6.9)	4.3 (2.8)	-	9.6 (5.7)	-	4	4	CS/ST/DG	1.2,6	4.0	
3	-	-	-	-	-	-	-	CS/ST/DG	1.2	3.7	
4	0.5 (0.5)	-	-	-	-	1	-	FS/ST/SG	-	3.1	
5	-	-	-	-	-	-	-	FS/ST	9	1.2	

Intake pipe											
1	28.5 (7.8)	-	5.0 (3.2)	-	-	5	2	FS/ST	-	0.9	Dugong feeding trail
2	-	-	4.3 (3.0)	-	-	2	-	FS/ST	-	0.6	
3	-	-	-	-	-	-	-	FS/ST	-	0.5	
4	-	-	-	-	-	-	-	FS/ST	-	0.5	
5	-	-	-	-	-	-	-	FS/ST	-	0.5	

Notes:

1. Quadrat size is 20x20 cm. 8 quadrats per site. Multiply by 25 to get approximate shoots/m².
2. Eg. For Site 3. No quadrats recorded epiphyte cover of less than 10%. 1 quadrat recorded 10 – 50% epiphyte cover, and 3 quadrats recorded over 50% epiphyte cover.
3.
 - FS Fine Sand
 - CS Coarse Sand
 - SG Shell Grit
 - ST Silt
 - DG Decomposed Granite
4.
 - 1 = *Caulerpa* sp., 2=filamentous algae, 3=*Halimeda* sp., 4=brittle star, 5=sand dollar, 6=sea cucumber, 7=polychaete worm, 8=Terrebrid gastropod, 9=solitary fungal coral, 10=sand anemone, 11=crab, 12=mangrove shoot.
5. Depth below Chart Datum.

Appendix 7: Seagrass sample

