Information Series QI02059

Seagrass habitat of Cairns Harbour and Trinity Inlet:

December 2001

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First Published 2002
QI02059

The correct citation of this document is:
Campbell, S. J., Rasheed, M.A. and Thomas, R. (2002). Seagrass habitat of Cairns Harbour and Trinity Inlet: December 2001. DPI Information Series QI02059 (DPI, Cairns), 25 pp.

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Acknowledgments:
This project was funded by the Trinity Inlet Management Program. The Marine Plant Ecology Group (MPEG) is funded by the Queensland Department of Primary Industries and CRC Reef Research Centre. MPEG staff including Anthony Roelofs, Len McKenzie, Rob Coles and Rudi Yoshida contributed to the technical design, field co-ordination, data analysis and report editing.

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EXECUTIVE SUMMARY

This report provides results of a seagrass survey of Cairns Harbour and Trinity Inlet conducted in December 2001. This is the first seagrass survey of the entire Cairns Harbour and Trinity Inlet area since December 1993. Although overall seagrass area was similar to that recorded in 1993 (815.4 ± 217.1 ha 2001; 984.9 ± 220.9 ha 1993) significant changes in seagrass abundance and biomass did occur within specific regions of the survey area. Substantial loss of seagrass area and biomass occurred in the Ellie Point area from 1993 & 1996 (seagrass survey of Ellie Point area only) to 2001. From 1996 to 2001 the total seagrass area for Ellie Point declined from 179.7 ± 52.8 ha to 91.9 ± 39.5 ha. In other regions of the survey area changes were within reliability estimates although seagrass area in all regions tended to be lower. While these changes in area were not significant at this stage (apart from Ellie Point) a continued reduction in area of seagrass habitat would be a concern.

An examination of change and causes of change to seagrass in the Cairns Harbour and Trinity Inlet area is limited due to the absence of a regular seagrass-monitoring program. We have developed some suggestions for the observed declines in seagrass distribution based on an examination of local climate, water quality and other information and our knowledge of seagrasses in other areas of north Queensland where regular monitoring is conducted. It is likely that high rainfall and flooding in the Barron River catchment during early 2000 may have contributed to the decrease in seagrass distribution and abundance in the Ellie Point region.

Although a number of possible causes of seagrass decline are discussed, establishing the actual cause of change would require more frequent regular seagrass monitoring. We recommend that Trinity Inlet Monitoring Program consider supporting annual monitoring of seagrass meadows in Cairns Harbour and Trinity Inlet. Conducting annual monitoring would allow us to better establish and interpret the causes of seagrass change and distinguish between impacts associated with port activities, anthropogenic inputs and climatic changes. An annual seagrass monitoring program would provide a tool for assessing the “environmental health” of marine environments in Cairns Harbour and Trinity Inlet and an understanding of the relationships between climate and seagrass abundance.

INTRODUCTION

Background

Cairns Harbour and Trinity Inlet seagrass habitat is regionally important and forms a key habitat in the Trinity Inlet Management Plan Marine Wetlands Management System (Trinity Inlet Management Plan 1999). The seagrass meadows are mostly within the Trinity Inlet Fish Habitat Area encompassing 1200 ha of tidal waters with seagrass, mangrove and salt marsh habitats. The State of Trinity Inlet Report and Ecological Overview (1997) recognised seagrass as crucial to maintaining biodiversity and fisheries productivity in the inlet and identified seagrass as a key habitat type for monitoring.

The first surveys of seagrass distribution, species diversity and abundance throughout Cairns Harbour were undertaken as part of broad scale surveys in February 1988 (Coles *et al.* 1993). In December 1993 the Cairns Harbour and Trinity Inlet regions were surveyed (Lee Long *et al.* 1996) and subsequent detailed mapping of Ellie Point seagrasses occurred in December 1996 (Rasheed and Roelofs 1996). In recognition of the need for up to date assessments of the status of seagrass habitat in the region, the Trinity Inlet Management Program commissioned the Queensland Department of Primary Industries (QDPI), Northern Fisheries Centre to survey seagrass habitat in November-December 2001. The objectives of the survey were to:

1. Survey seagrass distribution and abundance in Cairns Harbour and Trinity Inlet (within the Ports Limits);

2. Assess changes in distribution and abundance of seagrass in Cairns Harbour and Trinity Inlet since seagrass surveys in February 1988 and December 1993; and

3. Provide recommendations to Trinity Inlet Management Program and Cairns Port Authority on the maintenance of Cairns Harbour and Trinity Inlet seagrasses.

Site Description

Cairns Harbour and Trinity Inlet are situated on the north-eastern wet tropical coast of Queensland (Figure 1). For the purposes of this study, Trinity Inlet is defined as the area south of the Marlin Marina (northern) breakwater including all creeks flowing into the inlet (Figure 1). Cairns Harbour extends north of this to a line between the Barron River mouth and False Cape (Figure 1) and is separated into "western" and "eastern" regions by the dredged shipping channel (Figure 1). The Barron and Trinity catchments encompass the waterways that flow into Cairns Harbour and Trinity Inlet. Barron River catchment size is 218 km^2, and Trinity Inlet catchment encompasses 338 km^2 (Trinity Inlet Management Plan 1999). Rainfall in both catchments is monsoonal with the wet season extending from December to March (mean rainfall 240 mm per month, air temperature 30-34^{o}C). The dry season extends from April to November (mean rainfall 70 mm per month, air temperature 24-28^{o}C). The Barron River flows through the Barron Mouth sub-catchment into the marine waters north of Ellie Point. Trinity Inlet flows from the Trinity Catchment into Cairns Harbour. Agricultural and urban developments are the primary land uses in both catchments. The ongoing process of sand and mud deposition from the Barron River and Trinity Inlet is the main factor influencing changes in sediment composition and topography of Cairns Harbour.

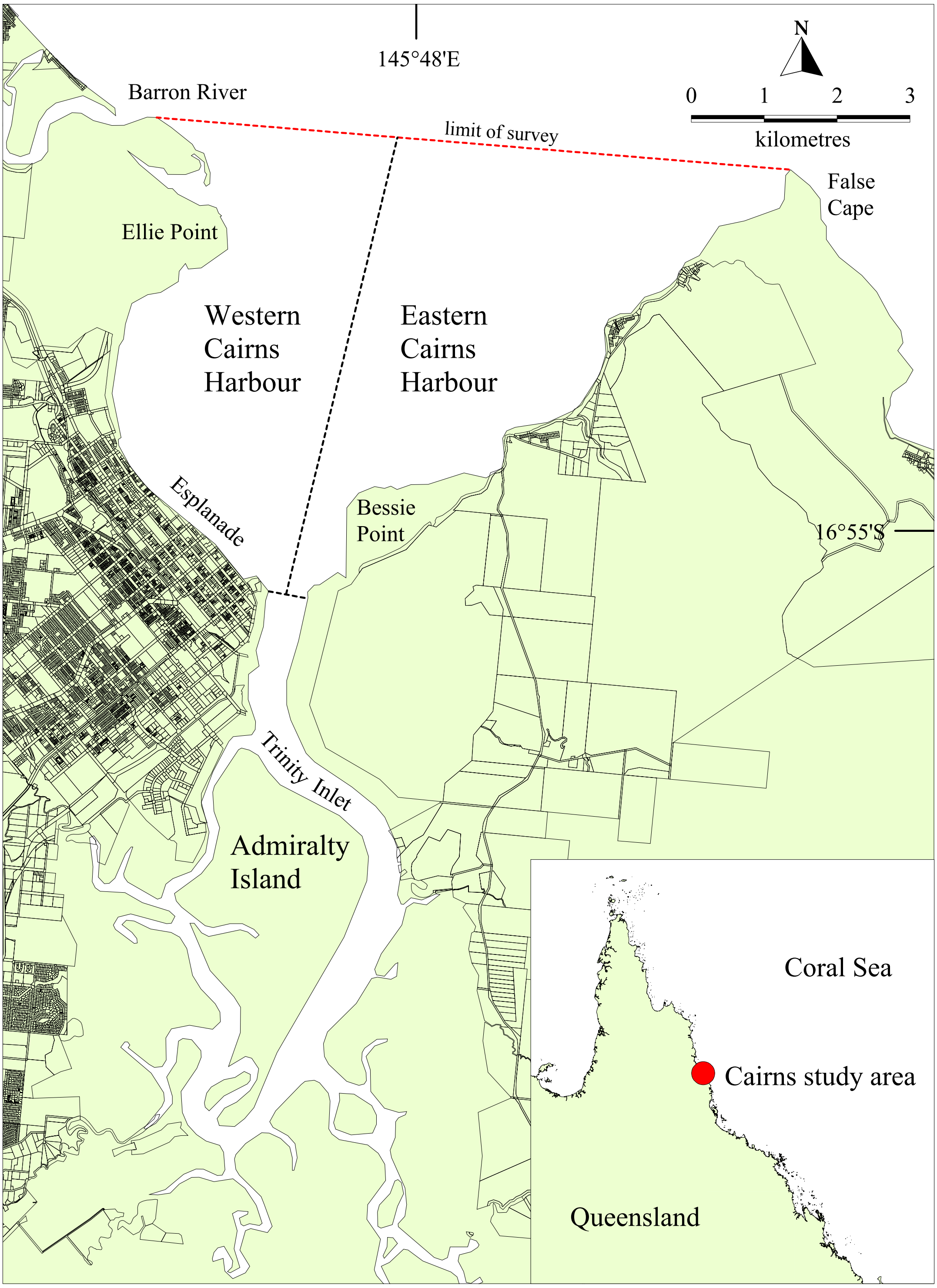


Figure 1. Cairns Harbour and Trinity Inlet survey locality.

The area supports significant seagrass habitat and represents the largest area of seagrass between Hinchinbrook and Cooktown (Lee Long *et al*. 1993, 1996). These seagrass meadows provide critical nursery habitat for regional prawn and finfish fisheries (Coles *et al.* 1993; Watson *et al.* 1993) and are feeding habitats for dugong (*Dugong dugon*), green sea turtle (*Chelonia mydas*) and wading bird populations.

Commercial fishing activities in the area are limited to net and crab fisheries. Commercial fishers market 38 species from 24 families from the mixed net and crab fishery of the greater Trinity Inlet region (Helmke *et al*. 2000). Commercial gill netting is prohibited in Trinity Inlet but bait fishing, gill netting and other forms of commercial fishing are allowed in Cairns Harbour. Recreational fishing in the area targets species such as barramundi, mangrove jack, fingermark, estuary cod, grunter, bream, trevally, queenfish, threadfin, barracuda and sickle fish (Mondora 1994). Trinity Inlet is also a significant cultural and economic resource for the Gunggandji, Yidinji and Yirranydji people. At least 11 fishing sites and four crabbing sites have been identified as being significant to indigenous peoples of the region. Significant sites include freshwater, estuarine creeks, foreshores, seagrass beds, wetlands and offshore areas from Ellie Point to False Cape (Helmke *et al*. 2000).

Cairns Harbour and Trinity Inlet Seagrasses

Cairns Harbour seagrasses were first mapped in February 1988 as part of a broad scale survey of the region (Coles *et al.* 1993). 806.9 ha of seagrasses were found within the Cairns Harbour and Trinity Inlet. In 1993 a fine scale survey of the distribution of seagrasses in Cairns Harbour, mapped 984.9 ± 220.9 ha of seagrass habitat (Lee Long *et al.* 1996) and provided information on changes in seagrass distribution since previous surveys. The increase of 178 ha of seagrass habitat from 1988 to 1993 was likely to be due to differences in methodology between the two surveys, with the broad scale survey potentially underestimating seagrass area. As part of the 1993 survey, a Geographic Information System (GIS) of Trinity Inlet was established for use in the assessment of changes to seagrass habitat in the region.

In 1996 seagrass meadows were mapped at Ellie Point as part of an assessment of its suitability as a sand extraction site for airport expansion (Rasheed and Roelofs 1996). A total of 179.7 ± 52.8 ha of seagrass was described within the survey area (Rasheed and Roelofs 1996).

In 1988 and 1993 seagrass habitat was mostly located on the shallow mud banks lining the perimeter of Cairns Harbour. On the western shore seagrass meadows consisted of those dominated by *Zostera capricorni* (515.4 ± 73.3 ha in 1993) and on the eastern shore meadows were dominated by *Halodule* species (460.3 ± 142.4 ha in 1993). Narrow banks of predominantly *Halophila* species were located on the subtidal slopes of Trinity Inlet, mostly along the eastern banks. The highest diversity of seagrasses occurred on the western shore of Cairns Harbour. In Cairns Harbour, *Zostera capricorni* meadows were mostly restricted to mud or mud/sand sediments along the eastern shores, whereas *Halodule uninervis* meadows in the north-eastern region and mixed species meadows in the north-western region were found where the sediment was composed of sand (Coles *et al.* 1993; Lee Long *et al.* 1996).

Seagrasses in Cairns are vulnerable to a number of impacts due to the high use of the Port, waterways and surrounding catchment. Potential impacts include scouring from outboard motors, downstream effects of urban, industrial and agricultural land-use, and changes in hydrology and water quality associated with port developments and maintenance. The continued growth and development of the Cairns region and Trinity and Barron catchments is likely to cause increasing pressure on the seagrasses of the region.

METHODOLOGY

Seagrass surveys of Cairns Harbour were conducted in November and December 2001. Intertidal areas were surveyed from a helicopter on 13-14 November 2001, and subtidal areas were surveyed from a boat on 6-7 December 2001. The survey area included intertidal and subtidal banks from Ellie Point in the north to False Cape in the East, and intertidal and subtidal areas within Trinity Inlet (Figure 1).

At each survey site, seagrass meadow characteristics, including seagrass species composition, above-ground biomass, percent algal cover, depth below mean sea level (MSL) (for subtidal meadows), sediment type, time and position (differential Global Positioning System (dGPS)) fixes (± 1.5 m) were recorded.

Seagrass biomass (above-ground) was determined using a modified "visual estimates of biomass" technique described by Mellors (1991). This technique involves an observer ranking seagrass biomass in the field in 3 random placements of a $0.25 m^2$ quadrat at each site. The data was collected at 400 sites either by diving to the seabed (189 sites), from the helicopter (96 sites) or by deployment of underwater video (115 sites). Ranks were made in reference to a series of quadrat photographs of similar seagrass habitats for which the above-ground biomass has previously been measured. This method was utilised for both the subtidal and intertidal survey areas. Two separate biomass ranges were used: low-biomass and high-biomass. The relative proportion of the above-ground biomass (percentage) of each seagrass species within each survey quadrat was also recorded. Field biomass ranks were then converted into above-ground biomass estimates in grams dry weight per square metre (g DW m^{-2}). At the end of sampling each observer ranked a series of calibration quadrats (by diving to seabed or on video) that represented the range of seagrass biomass in the survey. After ranking, seagrass in these quadrats was harvested and the actual biomass determined in the laboratory. A separate regression of ranks and biomass from these calibration quadrats was generated for each observer and applied to the field survey data to determine above-ground biomass estimates.

The presence or absence of seagrass was defined by the above-ground biomass. Where above-ground biomass was absent, the presence of rhizome/root and seed bank material was not reported. Survey sites with no seagrass can be found within meadows because seagrass cover within meadows is not always uniform and may be patchy and contain bare gaps or scars.

Intertidal survey methods

Seagrass surveys in intertidal areas were conducted by helicopter. Exposed areas were surveyed at low spring tide to determine seagrass meadow presence, seagrass abundance and meadow boundaries. DGPS was used to fix and record the position of meadow boundaries.

Seagrass meadow characteristics were collected at sites scattered within the seagrass meadow as the helicopter hovered within two metres above the seagrass. Above ground biomass ranks, seagrass species composition, algal cover, and sediment types were determined from three random placements of a $0.25 \ m^2$ quadrat out the side of the helicopter. Positions of all sites were recorded using dGPS. Helicopter was also used to determine subtidal areas likely to contain seagrass.

Subtidal survey methods

In subtidal areas seagrass mapping and surveys were conducted from a boat. Two methods were used to record above-ground biomass ranks, seagrass species composition, algal cover, and sediment type from three random placements of $0.25 \ m^2$ quadrats. The first method involved diving to the seabed and placing the quadrat at three random placements within a radius of 10 m. The second method was employed in areas where diver safety was an issue. A real-time underwater video camera mounted to a 0.25 m^2 quadrat provided live images that were viewed and ranked from a colour 22 cm CRT monitor aboard the research vessel.

Sites were scattered throughout subtidal meadows in order to cover the spatial extent of the meadow. A higher number of sites were used in areas where habitat complexity/variability was high. The presence and type of seagrass species at each site determined habitat complexity and meadow boundaries. A van Veen sediment grab was used at each camera site to determine sediment type and to confirm species viewed on the video screen.

Geographic Information System

All survey data were entered into a Geographic Information System (GIS) for presentation of seagrass species distribution and abundance. A GIS base map was generated in the GIS program MapInfo® using aerial photography (courtesy Beach Protection Authority: 1:25000, 9/08/1998; 1:12000, 18/08/2001) which was rectified and projected using Latitude/Longitude Australian Geodetic Datum 1966 (AGD 66, Zone 55).

Three GIS layers were created in MapInfo® for this survey to describe Cairns Harbour seagrasses:

- **Site information -** point data containing all information collected at seagrass survey sites;

- **Seagrass meadow biomass and types -** polygon layer displaying area data for seagrass meadows and summary information on meadow characteristics. Seagrass meadow types were determined according to their species composition and above ground biomass, and follow a nomenclature developed for seagrass meadows of the Queensland region (Table 1).

Table 1. Range of biomass (g DW m^{-2}) for each species and abundance category (light, moderate and dense).

Abundance category	*Zostera capricorni*	*Halophila ovalis*	*Halophila decipiens*	*Halodule uninervis*
Light	≤ 20	≤ 1	≤ 1	≤ 1
Moderate	20.1- 39.9	1.1 - 4.9	1.1 - 4.9	1.1 - 3.9
Dense	≥ 40	≥ 5	≥ 5	≥ 4

- **Seagrass meadow cover** - polygon layer displaying the seagrass meadow cover categories. Seagrass meadow cover was assigned to one of three categories according to methodology described by Roelofs *et al.* (2001). Seagrass meadow cover categories were not assigned to subtidal meadows in this survey. These cover categories were:

1. *Isolated seagrass patches* - The majority of area within the meadow consists of unvegetated sediment interspersed with isolated patches of seagrass (see Plate 1).
2. *Aggregated seagrass patches* - Meadows comprised of numerous seagrass patches but still feature substantial gaps of unvegetated sediment within the meadow boundaries (see Plate 2).
3. *Continuous seagrass cover* - The majority of area within the meadows is comprised of continuous seagrass cover interspersed with a few gaps of unvegetated sediment (see Plate 3).

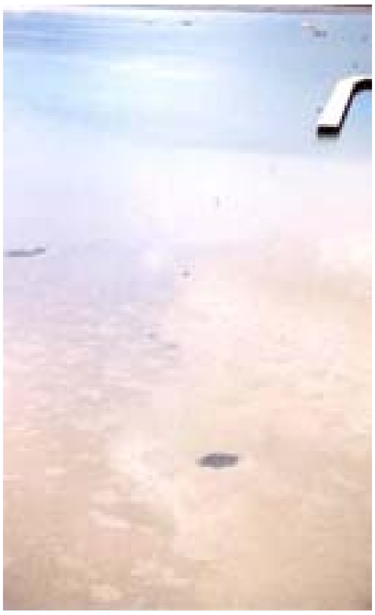


Plate 1. Isolated patches of *Zostera capricorni*.

Plate 2. Aggregated patches of *Zostera capricorni.*

Plate 3. Continuous cover of *Zostera capricorni.*

Accurate mapping of most seagrass meadow boundaries was determined in the field using dGPS for both intertidal and subtidal meadows. Rectified colour aerial photographs of Cairns Harbour and Trinity Inlet (Courtesy Beach Protection Authority: 1:25000, 1/07/1996; 1:25000, 9/08/1998; 1:12000, 18/08/2001), combined with aerial photography and videotape footage taken from the helicopter during surveys also assisted with mapping. Other information including depth below MSL, substrate type, the shape of existing geographical features such as banks and channels, and evidence of strong wave energy or tidal currents was also interpreted and used in determining meadow boundaries.

The precision of determining meadow boundaries depended on the range of mapping information and methods available for each meadow. Intertidal meadow boundaries followed with a dGPS had the highest precision. Sub-tidal areas where boundaries of meadows could not be seen from the surface had the lowest mapping precision. For these meadows, boundaries were based on the mid-point between the last site where seagrass was present and the first non-seagrass site on a transect.

Each meadow was assigned a "mapping error" estimate in metres based on mapping precision for that meadow (Table 2). Mapping error estimates ranged from ± 1 m for isolated intertidal seagrass patches to ± 100 m for larger subtidal meadows (Table 2). The mapping error estimate was used to calculate a range of meadow area for each meadow. A buffer equal to the error estimate was created around each meadow using the buffer function in MapInfo. The area of this buffer was calculated and expressed as a meadow error in hectares. Other sources of mapping error associated with digitising and rectifying aerial photographs onto base maps and with dGPS fixes for survey sites were assumed to be embedded within the mapping error estimates.

Table 2. Mapping precision for seagrass meadow boundaries in Cairns Harbour and Trinity Inlet.

Mapping Error Estimate (R)	Mapping Information & Methods Used
1m	Meadow boundaries determined by dGPS from helicopter Small isolated patch meadows (< 5 m diameter) completely exposed or visible at low tide Area of patches estimated by observer Recent aerial photography used to validate patch locations
5m	Meadow boundaries mapped in detail by 'tracing' meadow boundaries from helicopter Larger intertidal meadows completely exposed or visible at low tide High density of mapping sites Error largely based on dGPS accuracy Recent aerial photography
10m	Meadow boundaries determined from camera/grab and/or diver surveys Small meadows located on mud/sand banks Bank features aided in mapping
30m	Large proportion of boundary traced from helicopter Some areas of boundary mapped from camera/grab and/or diver surveys Recent aerial photography Bank features aided in mapping
50m	Majority of meadow boundaries determined from camera/grab and/or diver surveys Some of the boundary (inshore) traced from helicopter Meadows largely subtidal
80-100m	Meadow boundaries determined from camera/grab and/or diver surveys Meadows completely subtidal Low density of survey sites Error based on number and distances between survey sites

RESULTS

Seagrass species

Six seagrass species (from three families) were identified in the survey of Cairns Harbour and Trinity Inlet during December 2001:

Family CYMODOCEACEAE TAYLOR:
Halodule uninervis (wide and narrow leaf morphology) (Forsk.) Aschers.
Cymodocea serrulata (R. Br.) Aschers. and Magnus
Cymodocea rotundata Ehrenb. & Hempr. Ex Aschers

Family HYDROCHARITACEAE JUSSIEU:
Halophila decipiens Ostenfeld
Halophila ovalis (R. Br.) Hook.*f.*

Family ZOSTERACEAE Drummortier:
Zostera capricorni Aschers.

Seagrass distribution and abundance

A total of 400 ground truth sites (not including meadow boundary mapping sites) were surveyed in Cairns Harbour and Trinity Inlet during November and December 2001. Of these, 304 subtidal sites were surveyed from boat and 96 intertidal sites were surveyed from helicopter. The total area mapped was 815.4 ± 220.7 ha in 32 meadows (Maps 1, 2 and 3). Large areas of seagrass were found on intertidal banks and at subtidal sites. The maximum depth at which seagrass was found was 3.7 m below MSL (*Halodule uninervis* (narrow)) at Bessie Point. Most seagrass was found on mud/sand sediments. The mean above ground biomass of the 32 meadows ranged from 0.02-57.59 g DW m^{-2}, and was dependent on the mix of species present with *Zostera capricorni* dominated meadows generally higher in biomass than *H. uninervis* and *Halophila* spp. dominated meadows (Table 3).

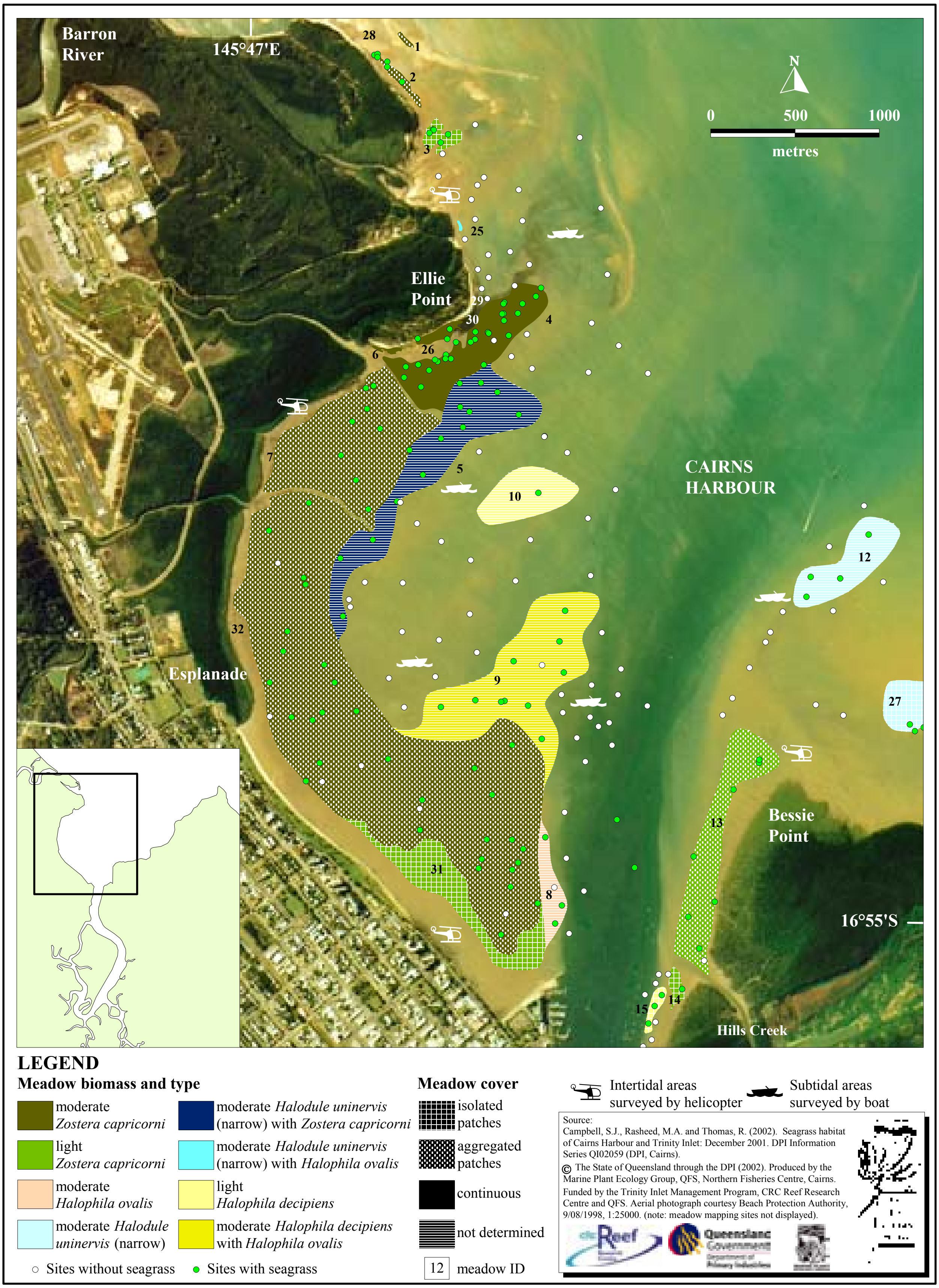
Meadow areas ranged from 0.12 to 311.8 ha. Small meadows (< 5 ha) generally consisted of seagrass communities with light or moderate biomass. Large meadows (20-312 ha) were comprised of either light or moderate biomass meadows with isolated patches, aggregated patches and continuous cover (Plates 1, 2, 3).

Meadows were dominated by species in the following order: *Z. capricorni* (50%), *H. ovalis* (25%), *H. uninervis* (15.6%), and *H. decipiens* (12.5%). The majority of meadows were classified as light and moderate, with only one meadow classified as dense (meadow no. 19 = dense *H. ovalis*) (Table 3, Map 3).

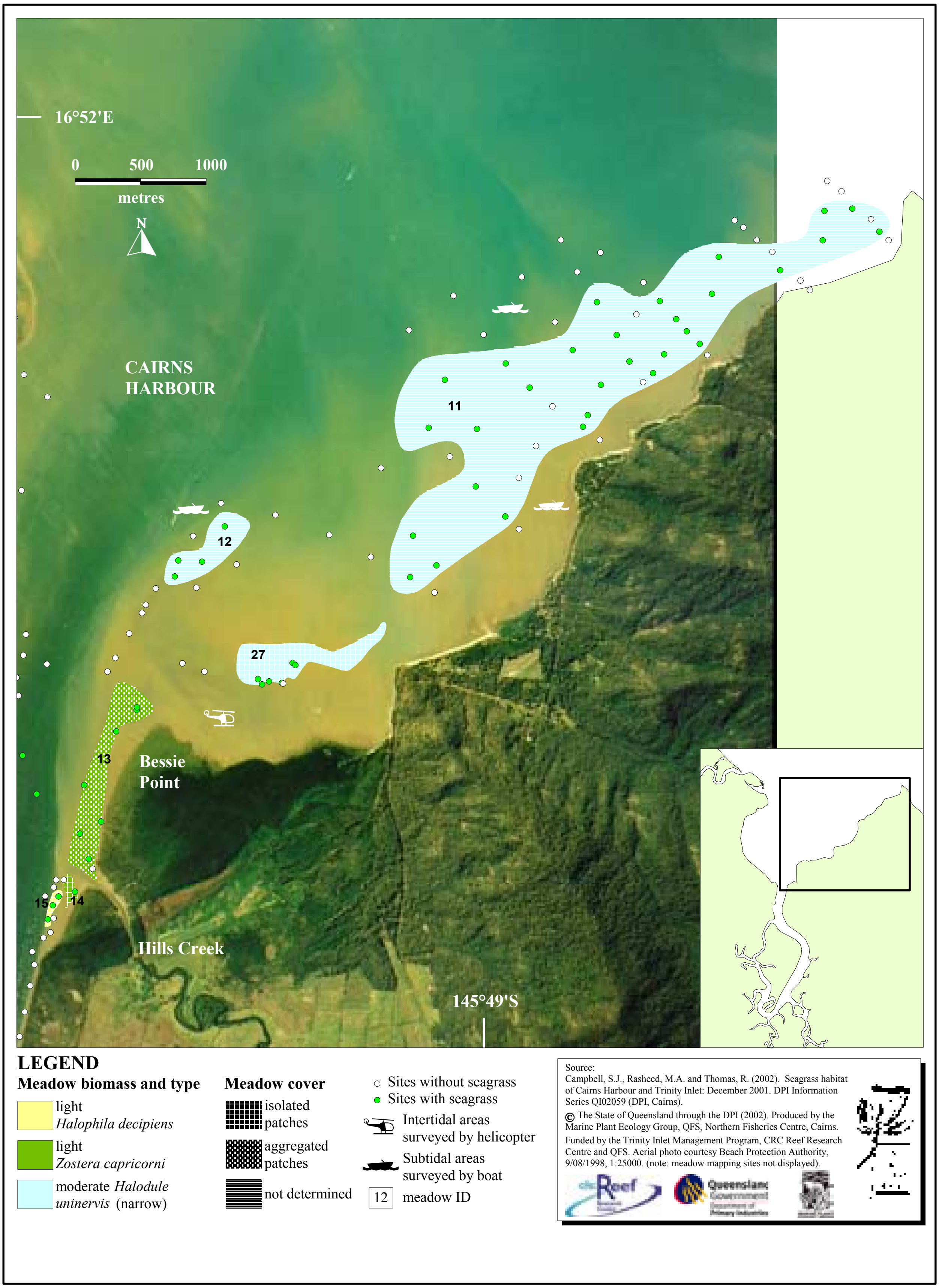
Table 3. Seagrass meadow types, mean biomass and area in Cairns Harbour and Trinity Inlet, December 2001.

(Regions: E = Eastern Cairns Harbour; W = Western Cairns Harbour; T = Trinity Inlet. NA = biomass not sampled).

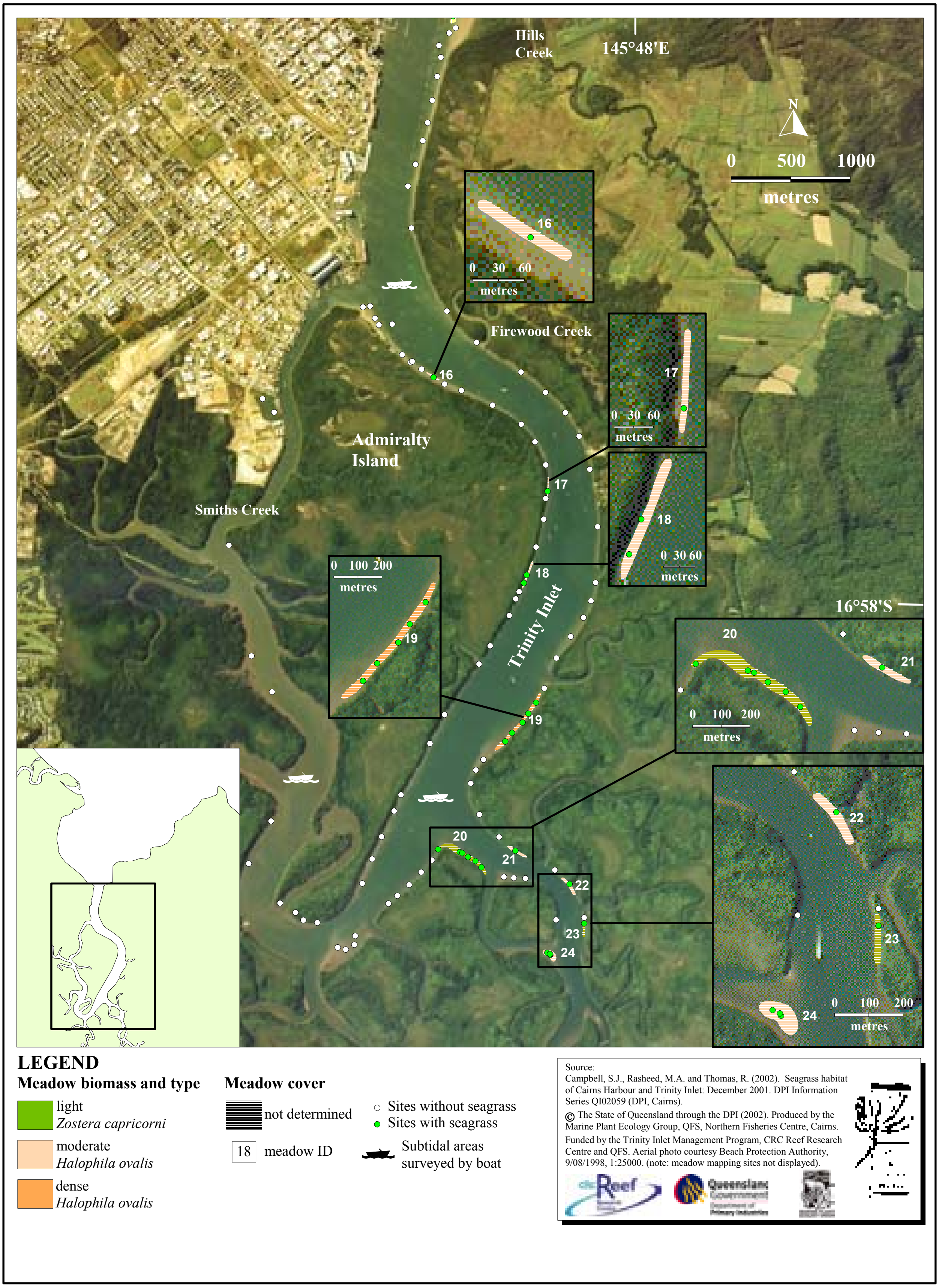
Meadow ID	Region	Meadow biomass and type	Mean biomass (g DW m^{-2})	Area ± R (ha)
1	W	moderate *Zostera capricorni*	NA	0.36 ± 0.15
2	W	moderate *Zostera capricorni*	57.59 ± 7.97	1.61 ± 0.48
3	W	light *Zostera capricorni*	8.34 ± 5.77	2.67 ± 0.47
4	W	moderate *Zostera capricorni*	35.93 ± 4.51	26.18 ± 1.48
5	W	moderate *Halodule uninervis* (narrow) with *Zostera capricorni*/*Halophila ovalis*	1.22 ± 0.48	40.89 ± 24.74
6	W	moderate *Zostera capricorni*	NA	0.42 ± 0.24
7	W	moderate *Zostera capricorni*	47.40 ± 8.19	52.33 ± 1.65
8	W	moderate *Halophila ovalis*	4.44 ± 2.56	7.00 ± 5.48
9	W	moderate *Halophila decipiens* with *Halophila ovalis*/*Halodule uninervis* (narrow)	1.29 ± 0.62	52.97 ± 23.01
10	W	light *Halophila decipiens*	0.01 ± 0	14.39 ± 14.23
11	E	moderate *Halodule uninervis* (narrow)	2.00 ± 0.45	311.80 ± 120.80
12	E	moderate *Halodule uninervis* (narrow)	2.45 ± 1.10	16.73 ± 10.22
13	E	light *Zostera capricorni*	15.46 ± 9.19	27.21 ± 3.60
14	E	light *Zostera capricorni*	2.95 ± 2.12	1.53 ± 0.65
15	E	light *Halophila decipiens* with *Halophila ovalis*	0.04 ± 0.02	1.66 ± 0.72
16	T	light *Halophila ovalis*	0.04 ± 0.02	0.17 ± 0.14
17	T	light *Halophila ovalis*	0.04 ± 0.02	0.16 ± 0.17
18	T	light *Halophila ovalis*	0.02 ± 0	0.43 ± 0.26
19	T	dense *Halophila ovalis*	6.59 ± 2.08	1.66 ± 0.64
20	T	light *Zostera capricorni*	4.46 ± 4.11	1.73 ± 1.11
21	T	moderate *Halophila decipiens*	3.88 ± 2.44	0.42 ± 0.21
22	T	moderate *Halophila ovalis*	NA	0.49 ± 0.21
23	T	light *Zostera capricorni*	0.02 ± 0.01	0.25 ± 0.17
24	T	moderate *Halophila ovalis*	1.57 ± 1.07	0.67 ± 0.18
25	W	moderate *Halodule uninervis* (narrow) with *Halophila ovalis*	NA	0.12 ± 0.09
26	W	moderate *Zostera capricorni*	37.36 ± 13.82	1.74 ± 0.39
27	E	moderate *Halodule uninervis* (narrow)	1.95 ± 1.26	23.22 ± 2.92
28	W	moderate *Zostera capricorni*	NA	<0.01
29	W	moderate *Zostera capricorni*	NA	<0.01
30	W	moderate *Zostera capricorni*	NA	<0.01
31	W	light *Zostera capricorni*	NA	20.90 ± 2.06
32	W	moderate *Zostera capricorni*	34.48 ± 5.25	205.70 ± 4.25
Total				**815.4 ± 217.1**



Map 1. Seagrass meadows and survey sites in Western Cairns Harbour, December 2001.



Map 2. Seagrass meadows and survey sites in Eastern Cairns Harbour, December 2001.



Map 3. Seagrass meadows and survey sites in Trinity Inlet, December 2001.

Comparison with previous surveys

There have been two previous seagrass surveys that included all of Cairns Harbour and Trinity Inlet; a broad scale survey in February 1988 and a fine scale survey in December 1993. In addition to surveys of the entire harbour, the Ellie Point area has been the subject of intense fine-scale seagrass survey in December 1996.

Cairns Harbour and Trinity Inlet

The 1988 survey was part of a broad scale survey of the east coast of Queensland. Accordingly fewer sites in the Cairns region were examined in 1988 than in 1993, which may explain the lower total area of seagrasses recorded in 1988 compared with 1993 (Table 4). Both 1993 and 2001 surveys were fine-scale and direct comparisons are more appropriate (Table 4). Overall changes in seagrass area from 1993 to 2001 were within the mapping reliability estimates calculated for these meadows. Similarly changes in seagrass area for all 3 regions of the survey area (western and eastern Cairns Harbour and Trinity Inlet) were within the mapping reliability estimates (Table 3). Although no change in seagrass area can be determined from seagrass area estimates and their reliability values, a close examination of maps suggests that in the western region of Cairns Harbour *Zostera capricorni* and *Halodule*/*Halophila* meadows may have contracted and fragmented (Map 4). *Halodule/Halophila* meadows in eastern Cairns Harbour also appear to have contracted since 1993 (Map 5). In Trinity Inlet some seagrass loss was evident on the eastern banks of Trinity Inlet with some loss of seagrass on the eastern and northern banks of Admiralty Island. Meadow fragmentation recorded in 2001 resulted in an increase in the number of isolated seagrass meadows in both western and eastern regions of Cairns Harbour from 1993 to 2001 (Maps 4 and 5; Table 4). In Trinity Inlet the number of meadows decreased from 1993 to 2001 (Table 4).

Table 4. Region, number of seagrass meadows and total area in Cairns Harbour and Trinity Inlet for 1988, 1993 and December 2001.

(R = mapping reliability estimate)

Region	No. of meadows			Area ± R (ha)		
	1988	1993	2001	1988	1993	2001
Western Cairns Harbour	3	16	17	374.2	515.4 ± 73.3	427.3 ± 78.7
Eastern Cairns Harbour	3	3	6	424.4	460.3 ± 142.4	382.1 ± 135.3
Trinity Inlet	4	13	9	8.3	9.3 ± 5.2	6.0 ± 3.1
Total	**10**	**32**	**32**	**806.9**	**984.9 ± 220.9**	**815.4 ± 217.1**

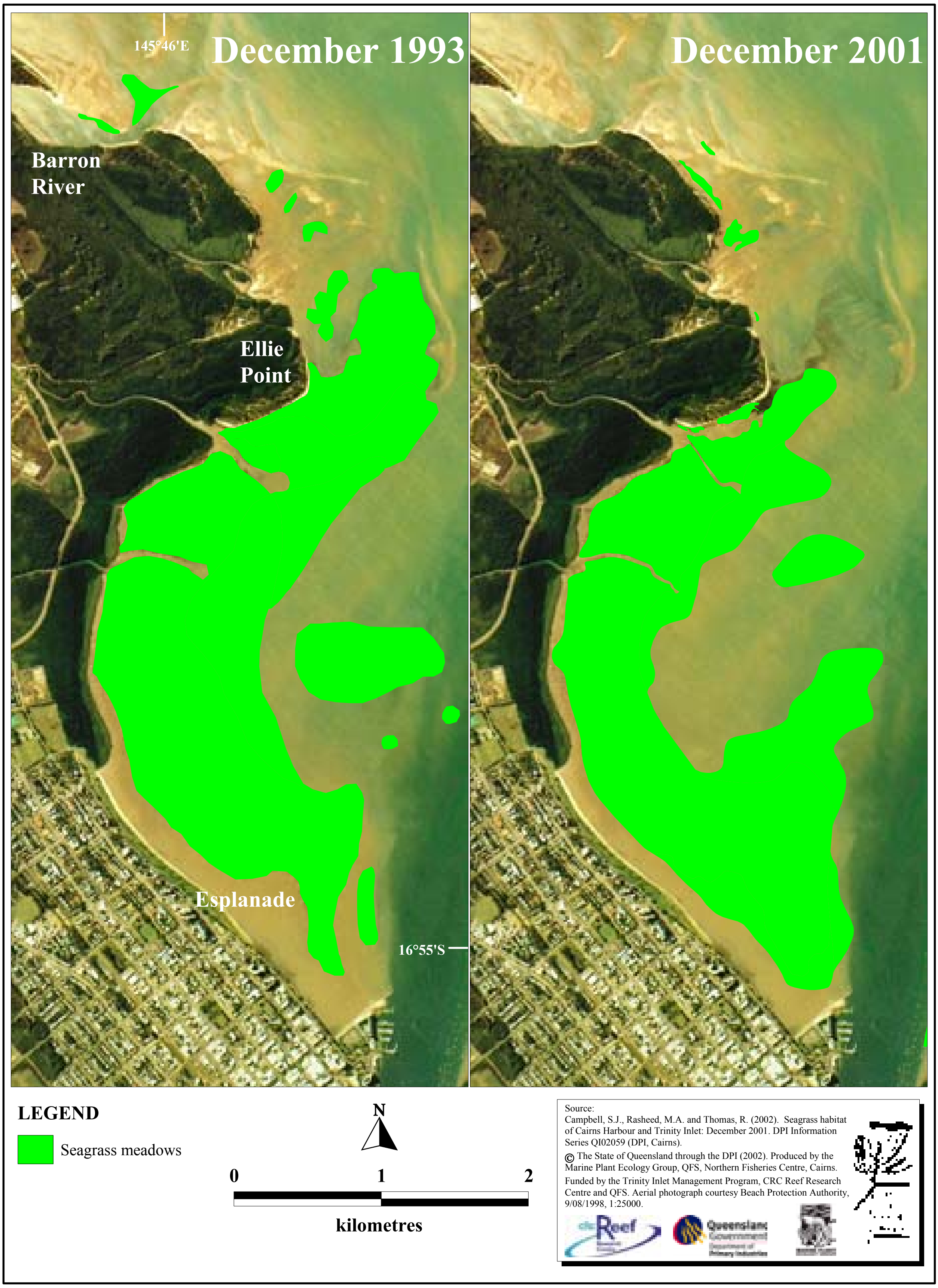
Ellie Point

Seagrass mapping in the Ellie Point area has been more precise than for other areas in Cairns Harbour resulting in relatively small mapping reliability error estimates. A fine scale survey of seagrasses in the Ellie Point area of western Cairns Harbour was conducted in December 1996. There was a substantial reduction in total area and biomass of seagrass meadows in this region between 1996 and 2001 (Table 5; Map 6). *Zostera capricorni* and *Halophila ovalis /Halodule uninervis* meadows declined in area by 41% and 53% respectively, although estimates for *Halophila*/*Halodule* were within reliability estimates suggesting no real change. Above-ground biomass of *Zostera capricorni* and *Halophila/Halodule* meadows declined by 43% and 90% respectively (Table 5). In 2001 *Zostera* meadows had become fragmented resulting in an increased number of small isolated meadows compared with 1996.

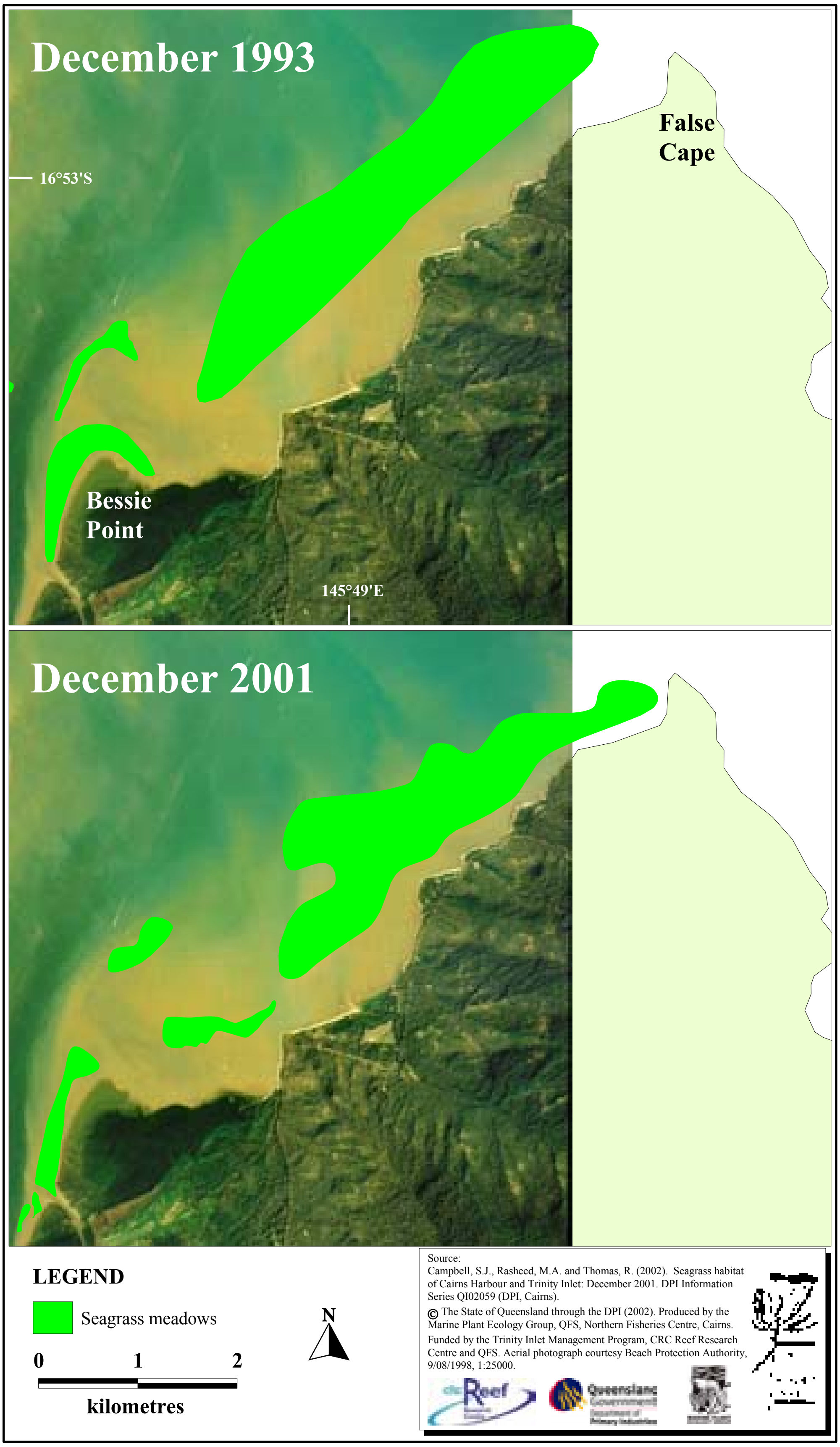
Table 5. Meadow type, number, area and mean biomass at Ellie Point in December 1996 and December 2001.

(number in brackets indicates the number of meadows where biomass was estimated).

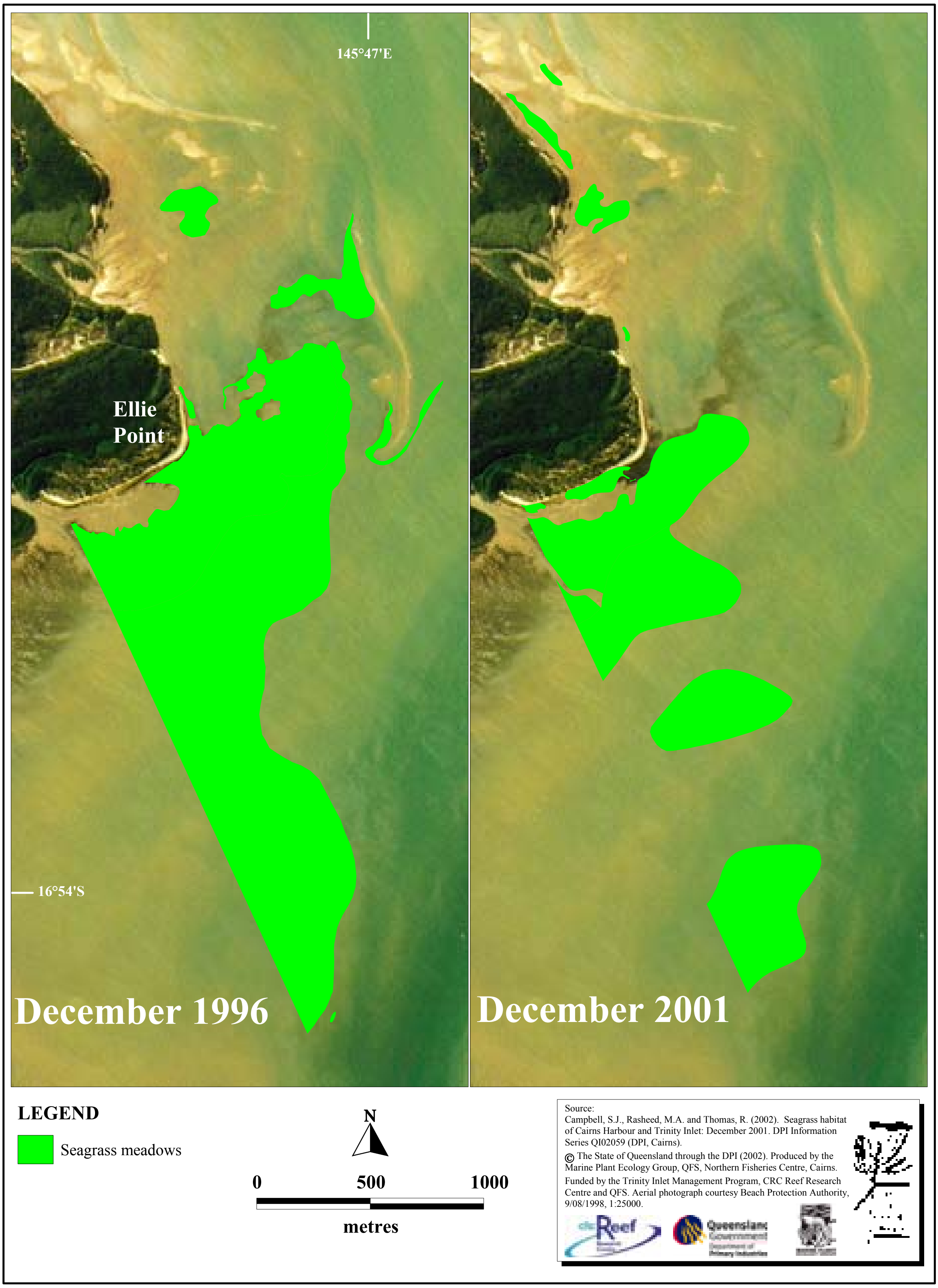
Meadow type	**No. of meadows**		**Area ± R (ha)**		**Mean biomass ± SE (g DW m^{-2})**	
	1996	**2001**	**1996**	**2001**	**1996**	**2001**
Zostera capricorni	2	10	57.3 ± 9.7	33.9 ± 3.4	77.7 ± 5.0	35.5 ± 3.9
Halophila/Halodule	5	4	122.4 ± 43.1	58.0 ± 36.1	8.4 ± 2.3	0.4 ± 0.3
Total	**7**	**14**	**179.7 ± 52.8**	**91.9 ± 39.5**	**n/a**	**n/a**



Map 4. Seagrass meadows in Western Cairns Harbour in December 1993 and 2001.



Map 5. Seagrass meadows in Eastern Cairns Harbour in December 1993 and 2001.



Map 6. Seagrass meadows at Ellie Point in December 1996 and 2001.

DISCUSSION

Seagrass area declines from 1993 to 2001 recorded in this survey were likely to be within the range of natural change for tropical Queensland seagrass meadows. With the exception of the Ellie Point region all reductions in seagrass area were within mapping reliability estimates. At Ellie Point the loss of seagrass area was greater than mapping error estimates and greater than previous changes in seagrass distribution that have been recorded when relatively minor loss (2 ha) of *Zostera capricorni* meadows occurred from 1987 to 1991 (McKenzie 1994). The majority of meadows at Ellie Point were intertidal allowing more precise mapping than other areas within Cairns Harbour. This has led to a better ability to detect changes in meadow area at Ellie Point.

A likely cause of the decrease in seagrass meadows at Ellie Point is from sediment disturbance associated with the Barron River sediment delta and cyclone related disturbance in 1999 and 2000. Aerial photography from the region shows an erosion of sand banks on the eastern side of the meadow between 1996 and 2001 (Plate 4; Figure 3). In addition, the extraction of 350,000 m^3 of sand in 1983 (Beach Protection Authority 1984) modified the sand banks and may have exacerbated sediment movement. Sediment instability resulting from seagrass loss could lead to burial of nearby healthy seagrass causing further declines.

A reduction in total area of *Zostera capricorni* meadows and the water depth to which *Zostera capricorni* meadows occur at Ellie Point (1.6m in 1996 to 1.2m depth below MSL in 2001) suggests seagrass loss has occurred here from 1996 to 2001. A decline in the above-ground biomass of this meadow is further evidence of disturbance to these meadows. Present day above-ground biomass estimates for these meadows (35.5 g DW m^{-2}) were considerably lower then previous estimates in December 1989 (74.85 g DW m^{-2}), 1990 (80.3 g DW m^{-2}) (McKenzie 1994) and 1996 (Lee Long *et al.* 1996). Additionally the 95% reduction in the above-ground biomass of *Halodule*/*Halophila* meadows in 2001 compared to 1996 at Ellie Point suggests reduced growth rates that may be due to impacts driven by climatic factors. The sampling design used by McKenzie (1994) differed from the present study as it focussed on sampling in the northern section of the Ellie Point meadow and was based on assessments of above-ground biomass from harvested plots. The present study involved visual assessments of above-ground biomass from randomly selected plots over the whole of the Ellie Point meadow. These differences in sampling design, however, are unlikely to explain the reduction in biomass over the past 10 years.

Changes in seagrass distribution and biomass have previously been associated with poor water quality, chronic low light availability (Abal and Dennison 1996, Longstaff *et al*. 1999) and physical disturbance associated with high rainfall and flooding events (Preen *et al*. 1995, McKenzie *et al*. 2000, Thomas and Rasheed 2001). An examination of historical rainfall data in the Cairns region suggests a cyclical trend, with high rainfall events occurring every four to five years (shaded areas in Figure 2). Total seagrass area tended to be low in the years immediately following higher rainfall and higher following low rainfall periods (Figure 2). Total seagrass area was ~800 ha in both early 1988 and in late 2001, following high rainfall years in 1985 and 1999-2000 respectively. In 1993, following low rainfall in 1992-1993, the area of seagrass was higher (~1000 ha) (Figure 2). It is possible that high rainfall and flooding in 1999-2000 may have contributed to the observed lower seagrass distribution in 2001 compared with 1993 and 1996 in proximity to areas of catchment inputs. This effect has been observed for other seagrass areas in north Queensland. A seagrass-monitoring program in nearby Mourilyan Harbour also indicated high rainfall as a possible cause of seagrass loss (Thomas and Rasheed 2001).

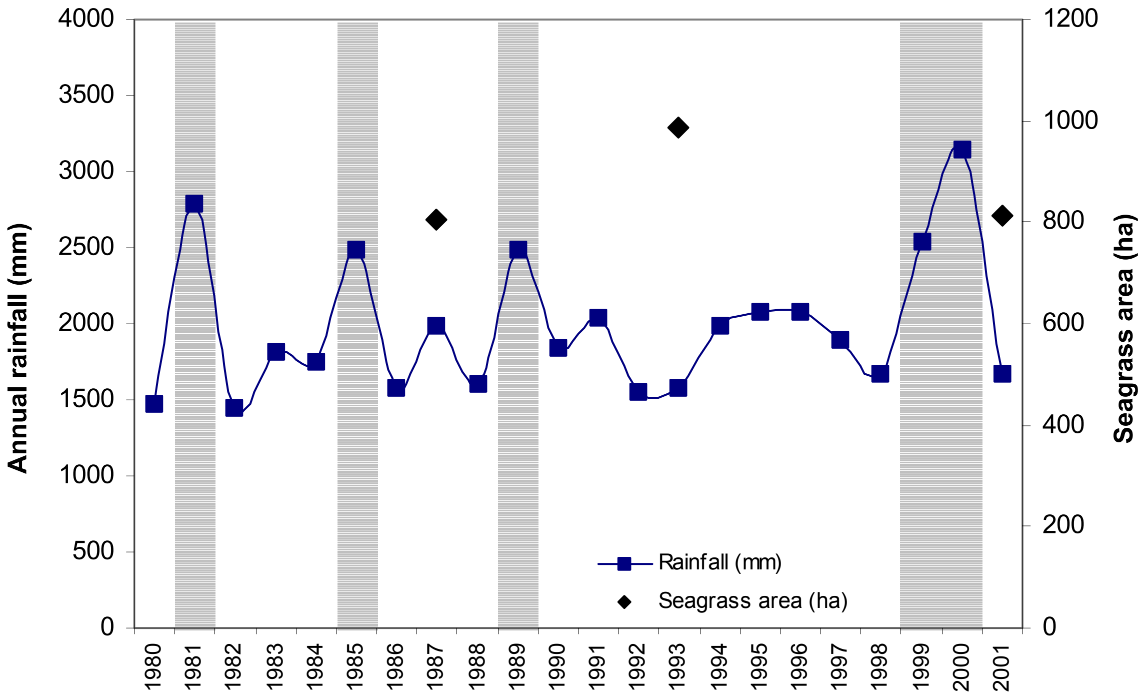


Figure 2. Mean annual rainfall for Cairns from 1980-2001 and total seagrass meadow area in Cairns Harbour for 1988, 1993 and 2001.

Although seagrass abundance is likely to be associated with climatic conditions, the health of seagrass meadows in Trinity Inlet and Cairns Harbour may also be linked to impacts associated with agricultural land use in the Barron and Trinity catchments. Land use practices such as land clearing, crop fertilisation and destruction of stream bank vegetation can exacerbate the effects of high rainfall on seagrasses by providing high concentrations of sediments and nutrients to marine waters. Sediments can reduce light available for seagrass photosynthesis and also physically smother seagrass (Longstaff *et al.* 1999). Nutrients may promote seagrass growth but may also indirectly inhibit seagrass growth by promoting the growth of algae that can smother seagrass and reduce light availability. Herbicides used in sugar farming are known to be toxic to seagrass germination and photosynthesis (Haynes *et al*. 2000).

In the Barron Mouth sub-catchment 1484 hectares (37%) are used for cane farming contributing high nutrient loads (12% of the nitrogen loads, 20% of the phosphorus loads of the Barron River catchment) to local waterways (Cogle *et al*. 2000). Water quality monitoring at the Barron River mouth during low flow periods has detected elevated concentrations of nitrogen, phosphorus and suspended sediments relative to other sub-catchments in the Barron catchment (Cogle *et al*. 2000). At the Barron River mouth, the median total nitrogen concentrations during 1999 (~0.28 mg L^{-1}) (Cogle *et al*. 2000) were above the ANZECC[1] trigger level of 0.250 mg L^{-1} for estuarine waters (ANZECC 2001). Similarly the median total phosphorus concentrations at Barron river mouth (0.047 mg L^{-1}) were above the ANZECC trigger level of 0.002 mg L^{-1} for estuarine waters (ANZECC 2001). The breaching of ANZECC water quality trigger levels is cause for concern and indicates a possible threat to ecosystem health. However nutrient inputs from Trinity Inlet catchment may also affect seagrasses in Trinity Inlet and the eastern and south-western region of Cairns Harbour. Land use in the Trinity

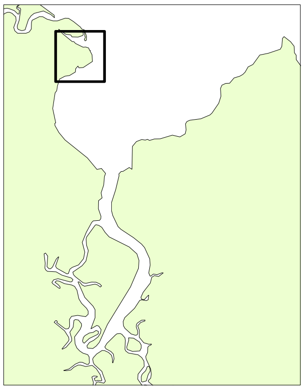
[1] Australian and New Zealand's Environment Conservation Councils guidelines (2001) for maintenance of health of marine, estuarine and fresh waters. ANZECC trigger levels are water quality standards that if breached indicate a threat to ecosystem health.

Inlet catchment includes sugar cane, bananas and horticultural crops that apply nutrient fertilisers and herbicides.

In Trinity Inlet, available water quality data during low flow periods has indicated elevated mean chlorophyll-*a* and total phosphorus concentrations that were above Trinity Inlet Water quality guidelines and ANZECC trigger levels (2 ug L^{-1} and 20 ug L^{-1} respectively) for tropical waters (Trinity Inlet Management Plan 2001). Elevated total nitrogen concentrations have also been observed from 1993 to 2000 at several sites in Trinity Inlet (Trinity Inlet Management Plan 2001). On a broader scale a recent review of water quality in Trinity Inlet concluded that the elevation of nutrients and chlorophyll productivity coupled with depression of dissolved oxygen point to excessive nutrient inputs and declining water quality in the Inlet (Trinity Inlet Management Plan 2001). During low flow periods the main cause of poor water quality was attributed to the sewage nutrient inputs into Trinity Inlet from the Smiths Creek Sewage Treatment Plant (Trinity Inlet Management Plan 2001). The change in the estimate of total area of seagrass habitat in the inlet from 1993 to 2001 is within mapping reliability estimates, suggesting no measurable change has occurred over the past 8 years. However, the downward trend in seagrass distribution and poor water quality suggests that future monitoring should be conducted to detect change in seagrass meadows that may be linked with water quality.

The findings of this survey suggest that over the whole region the total area of seagrass habitat has remained relatively stable over the past 8 years. Some areas (i.e. Ellie Point, Trinity Inlet) when examined more closely appear to have declined. High loads of nutrients entering Cairns Harbour and poor water quality reported for Trinity Inlet is cause for concern. Expansions in population, land-use, port development and vessel traffic could threaten seagrass meadows and justify the development of a routine monitoring program that aims to assess natural and anthropogenic changes to seagrass meadows. Information on the dynamics of seagrass meadows in the region is crucial to managing factors that may threaten seagrass meadows and understanding the implications for fisheries and the broader marine environment. We suggest a regular annual seagrass mapping/monitoring program be integrated with sediment and water quality monitoring and assessed in relation to available climatic and water quality data. Only then can we provide conclusive evidence of the causes of seagrass change and distinguish between impacts associated with port activities, anthropogenic inputs and climatic changes. An annual seagrass monitoring program would provide a tool for assessing the "environmental health" of marine environments in Cairns Harbour and Trinity Inlet and an understanding of the relationships between climate and seagrass abundance.

Plate 4. Sand bank movement encroaching on near-shore *Zostera capricorni* meadows at Ellie Point.



Source:
Campbell, S.J., Rasheed, M.A. and Thomas, R. (2002). Seagrass habitat of Cairns Harbour and Trinity Inlet: December 2001. DPI Information Series QI02059 (DPI, Cairns).

 Produced by the Marine Plant Ecology Group, QFS, Northern Fisheries Centre, Cairns. Funded by the Trinity Inlet Management Program, CRC Reef Research Centre and QFS.

Aerial photographs courtesy Beach Protection Authority: 1/07/1996, 1:25000; 9/08/1998, 1:25000; 18/08/2001, 1:12000.

Figure 3. Aerial photographs of Ellie Point from 1996, 1998 and 2001 showing changes to sandbanks and seagrass meadows.

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