GREAT BARRIER REEF
MARINE PARK AUTHORITY

RESEARCH PUBLICATION No. 51

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DPI QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

CRC Reef Research Centre

SEAGRASS ECOLOGY GROUP

QUEENSLAND GOVERNMENT

GREAT BARRIER REEF MARINE PARK AUTHORITY

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Table of Contents

List of Figures, Tables & Maps

EXECUTIVE SUMMARY

KEY RESULTS

1. 25,900 ±3,000 ha of seagrass habitat was mapped between Dunk Island and Cleveland Bay in Spring (October) 1996. Approximately 12,700 ha of seagrass habitat was mapped in the Hinchinbrook Region (Dunk Island to Lucinda Point).
2. Twelve species (including one possible new species) of seagrass (in 3 Families) were found in the survey area.
3. Eight seagrass **community** types were identified, based on species present. Communities dominated by *Halophila spinulosa* were more numerous, more extensive and generally much higher in above-ground biomass than most other community types.
4. Eight seagrass **habitat** types were identified, ranging from coastal intertidal to fringing reef and deep sub-tidal habitats around continental islands. Coastal habitats dominated by *Halophila* and *Halodule* species were most common.
5. Average above-ground biomass for meadow types ranged from 1.1 g DW. m^{-2} (*Halophila ovalis* dominant) to 34.5 g DW. m^{-2} (*Cymodocea serrulata* dominant).
6. Average above-ground biomass per seagrass species varied from 1.7 g DW. m^{-2} (*Halophila decipiens*) to 28.2 g DW. m^{-2} (*Cymodocea serrulata*) in October 1996.
7. *Halophila ovalis* had the greatest depth range of all seagrass species, being found at depths from 0.93 m above MSL to 15.1 m below MSL.
8. Parts of Halifax Bay and Magnetic Island exposed to high wave energy were not surveyed in 1996 due to extreme weather conditions. These need to be surveyed, but the potential extent of seagrass habitat area in these exposed locations is expected to be small.

KEY ISSUES

1. The general location of seagrass meadows in these surveys was similar to that found in the original broad-scale survey, 1987. In this survey however, many new areas of seagrass were found, both in areas previously surveyed and previously un-surveyed.
2. We conclude that an overall increase has occurred in areal extent of seagrass habitat in the Dunk Island to Cleveland Bay region, mostly in the areal extent of sub-tidal seagrass habitat, since 1987.
3. The large sub-tidal seagrass habitat areas (eg., Missionary Bay, Shepherd Bay, Townsville foreshore and Cleveland Bay) are probably very important alternative food sources for grazers (eg., dugong, sea turtles) when the narrow intertidal habitat areas are inaccessible at low tides.
4. There is a large diversity of seagrass community and habitat types in the Hinchinbrook region, but their individual contribution to fisheries production and turtle/dugong feeding needs investigation so that priority areas can be identified for protection.
5. Large areas in this region are sheltered from waves and currents, providing large potential area for seagrass growth. The distribution patterns of seagrasses overall in this region appear to be influenced mostly by shelter, turbidity (light penetration) and tidal exposure.
6. This baseline survey was designed to establish a data set on which monitoring programs can be based to investigate changes in seagrass biomass and distribution. Corresponding data on possible influencing factors will also be needed to help elucidate the causes of seasonal and long-term variations in seagrass distribution and abundance.

↳ INTRODUCTION

Current coastal zone management issues in the Hinchinbrook region include protection of fisheries habitats, dugong habitat areas and increases in aquaculture, agriculture and tourist operations. A regional coastal management plan which is being developed, also requires detailed information on seagrass resources for the coastal zone from Dunk Island in the north, to Cleveland Bay in the south. Decreases in estimates of dugong abundance in the southern half of the Great Barrier Reef region since the 1980's have also prompted the need for detailed baseline and monitoring surveys of seagrasses in this and other regions.

Seagrasses are important nursery habitat for commercial species of penaeid prawns and fish (Coles and Lee Long 1985; Coles *et al.* 1993; Watson *et al.* 1993). Seagrass meadows in Queensland are also essential food for dugong, *Dugong dugon* (Miller), and green sea turtles, *Chelonia mydas* (Linnaeus) (Lanyon *et al.* 1989). Seagrasses in coastal regions act as "nutrient and sediment sinks" (Short 1987) and help maintain sediment stability and water clarity. Coastal seagrass meadows are therefore an important resource economically and ecologically.

Tropical seagrass meadows are subject to temporal changes, varying seasonally and between years (Mellors *et al.* 1993; McKenzie 1994), with likely consequences for faunal populations of fisheries and conservation value. Widespread loss of *Halophila* and *Halodule* in Hervey Bay had large impacts on local dugong populations (Preen and Marsh 1995). Positive correlation between ENSO cycles and reproduction and growth in green sea turtles in the southern Great Barrier Reef (Limpus and Nicholls 1988) implied changes in quantity or quality of the turtles' staple seagrasses as a possible explanation. The potential for widespread seagrass loss has been well documented and the causes of loss can be natural, such as cyclones and floods (Poiner *et al.* 1989), due to human influences such as agricultural runoff (Preen *et al.* 1995), industrial runoff (Shepherd *et al.* 1989), oil spills (Jackson *et al.* 1989), harbour dredging (Onuf 1994), or any combination of these (Pringle 1989). Any of these impacts are possible in the Dunk Island to Cape Cleveland region.

Seagrass meadows in this region (Dunk Island to Cape Cleveland) were first mapped during a broad-scale survey in October/November 1987 (Coles *et al.* 1992) and large areas of dense seagrass were found in sheltered sections of the coast.

The only measure of temporal change in seagrasses of the Hinchinbrook Island Region comes from detailed Spring and Autumn baseline surveys at Oyster Point, Cardwell (Coles *et al.* 1997). Seasonal variations in seagrass abundance included a spring/summer maximum and autumn/winter minimum, as found in monthly sampling of specific northern Queensland locations (Mellors *et al.* 1993). Long-term variation in seagrass distribution and abundance in northern Australia has received very little investigation (McKenzie 1994). It is unclear whether year-to-year changes in seagrass abundance in the Hinchinbrook Region would reflect those at other north-eastern Queensland locations.

This survey was designed with the following objectives:

❶ *To map the fine-scale distribution of coastal and island seagrass meadows in the Hinchinbrook to Townsville Region (Dunk Island to Lucinda, Lucinda to Cape Cleveland).*

❷ *To estimate seagrass biomass for the major seagrass meadows.*

❸ *To present in a GIS, quantitative data on the major coastal seagrass communities in the Hinchinbrook to Townsville Region for use in future monitoring.*

❹ *To provide comment on differences in seagrass distribution and abundance data since the original QDPI broad-scale seagrass surveys of 1987, and recommendations on seagrass conservation management for this region.*

This survey provides a spring-time baseline survey of seagrass distribution and abundance in the Hinchinbrook Region. Seagrass habitats between Dunk Island and Lucinda are required in detail on a Geographic Information System (GIS), suitable for developing a long-term monitoring program. Sampling between Lucinda and Cape Cleveland at a lower spatial intensity will enable identification and mapping of major seagrass areas.

METHODS

Description of study locality

The coastal and island waters from Dunk Island (17°55'S) to Cleveland Bay (19°15'S), are at the southern end of the wet tropics region of northern Queensland (Figure 1). Monsoonal summer rains provide the bulk of precipitation for the region and intermittent showers can occur through the remainder of the year. South-easterly trade winds however dominate the drier winter and spring period, June to November. These trade winds create a general northerly, longshore current inshore, while a light southerly flow exists on the mid and outer shelf under the influence of the East Australian Current (Wolanski 1994). The semi-diurnal tides reach a maximum range of 3.5 m during Summer spring tides (Queensland Department of Transport 1996).

Numerous creeks and rivers drain the Great Dividing Range and narrow coastal plain, and the largest catchment in the region is the Herbert River system which drains into the southern end of Hinchinbrook Channel. There are two large and relatively exposed bays (Rockingham and Halifax) and two very large bays (Missionary and Cleveland).

Patch reefs on the mid and outer shelf of the Great Barrier Reef provide shelter from Pacific Ocean swells. Continental islands dominate the inner shelf features and are all within the 20 m bathymetry contour. These islands also provide further shelter from waves. The Hinchinbrook Channel is a dominant feature in the region and has a very low net water exchange over a tidal cycle (Wolanski 1994).

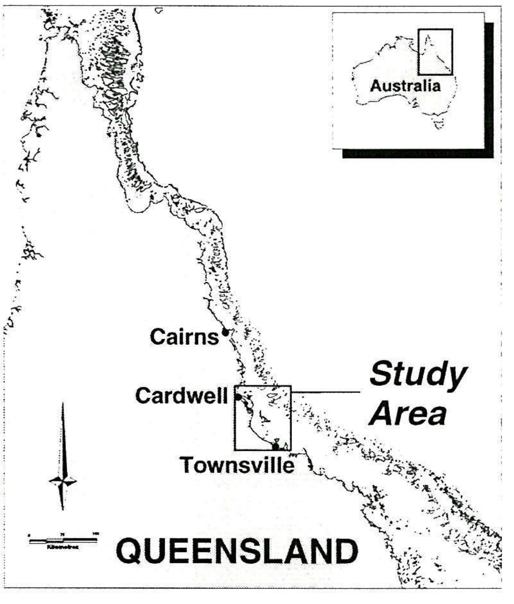


Figure 1. Location of Hinchinbrook Region study area.

Inshore sediments are dominated by terrigenous sands and muds, but carbonate composition of sediments begins close to the coast at about the 20 m contour (Maxwell 1968). Shelf sediments originating from rivers, inshore reefs and the Great Barrier Reef are transported northward and shoreward, with rapid accretion of fine sediments in the lee of headlands (Larcombe *et al.* 1996).

Survey methods

Seagrass communities of the coastal and island waters from Dunk Island to Cleveland Bay were surveyed by divers in spring 1996, between 7th - 16th October. Areas of survey were selected from previous knowledge of seagrass resources (Coles *et al.* 1992), aerial photography, and ground reconnaissance. Results from a detailed fine-scale survey of seagrasses adjacent to Oyster Point, Hinchinbrook Channel, conducted between the 4th - 7th

August 1996 (Coles *et al.* 1997) were included in the present survey with permission from the Queensland Department of Economic Development and Trade.

The field sampling design was implemented to estimate seagrass meadow area and above-ground seagrass biomass. From Dunk Island to Lucinda seagrasses were surveyed at fine scale, with sites and transects approximately 100-500 m apart, using divers and aerial photography (Map 1). Seagrasses from Lucinda to Cape Cleveland were surveyed at a lower intensity, with sites and transects approximately 100-1000 m apart, but sufficient to map and describe the major seagrass habitats. Intertidal and sub-tidal areas were surveyed using boats and divers. Recent (1995) low-tide aerial photography (not digitised due to inadequate control points and poor rectification) was interpreted to help map seagrass distribution patterns where high density habitat was visible but inaccessible during the dive survey.

Halifax Bay coastal and island waters, and windward parts of Magnetic Island were not surveyed because of prohibitive weather conditions. Seagrass habitat in these areas do not appear in aerial photos as clearly distinct from reef or algae habitat. Seagrass maps from initial broad-scale surveys of those areas (Coles *et al.* 1992) will be presented here.

Data Collection

Seagrass habitat characteristics including visual estimates of above-ground biomass (3 replicates of a 0.25 m^2 quadrat), species composition, % algae cover, sediment type, water depth and geographic location were recorded. Aerial photographs (not digitised) were interpreted to aid in mapping some intertidal seagrass meadow boundaries. Survey transects extended from the upper intertidal to depths beyond the outer edge of seagrass meadows. Sites between transects were also dived to check for continuity of habitat types. A differential Global Positioning System (dGPS) was used to accurately determine geographic location of sampling sites (±5 m).

Above-ground biomass was determined by a "visual estimates of biomass" technique modified from Mellors (1991). At each site, divers recorded an estimated rank of seagrass biomass and species composition in three replicate quadrats. On completion of the survey, each diver ranked ten quadrats which were harvested and the above-ground dry biomass (g DW. m^{-2}) measured. The regression curve representing the calibration of each divers' ranks was used to calculate above-ground biomass from all their estimated ranks during the survey.

Seagrass community types were determined by dominant seagrass species found within each meadow. Each community type was assigned a numerical code for further biomass and areal analysis. Seagrass habitat types were determined by species composition and physical attributes (ie intertidal or subtidal, coastal or fringing reef) influencing each seagrass community. Numerical codes were also assigned to each of the distinct habitat types for analysis of biomass and distribution.

Seagrass species were identified where possible according to Kuo and McComb (1989). Voucher specimens were collected if taxonomic verification was required.

Depths of survey sites were recorded with an echo-sounder and converted to depths (m) below mean sea level (MSL), correct to tidal plane datum's (Queensland Department of Transport 1996) for the localities surveyed. Lucinda tidal plane data was used for correcting depth measures at Hinchinbrook sites south of Haycock Island. Cardwell tidal plane data was used for correcting depth measures for sites in the Channel north of Haycock Island.

Field descriptions of sediment type from hand or grab samples were recorded for each site: shell grit, rock gravel, coarse sand, sand, fine sand and mud.

Geographic Information Systems (GIS)

A GIS basemap of the study region including coastline (low and high), reefs and islands was obtained from GBRMPA and AusLig© (digitised at 1:250,000 scale).

A GIS of seagrass community distribution was created in MapInfo® and ArcView® using the above survey information. A CD Rom copy of the GIS with metadata will be archived at the GBRMPA and the original archived with the custodians (QDPI) at Northern Fisheries Centre.

Boundaries of seagrass habitat were interpreted using one or more of the following: seagrass data at each dive site, extent of habitat visible from the vessel, aerial photography (not digitised) and bathymetry. Errors in GIS maps include those associated with digitising and rectifying basemaps and with Global Positioning System (GPS) fixes for survey sites. The point at which divers estimated bottom vegetation may be up to 5 m from the point at which a GPS fix was obtained. Differentially corrected GPS fixes were also only precise to within 5 m. These errors are considered to be within the errors associated with distance between survey sites.

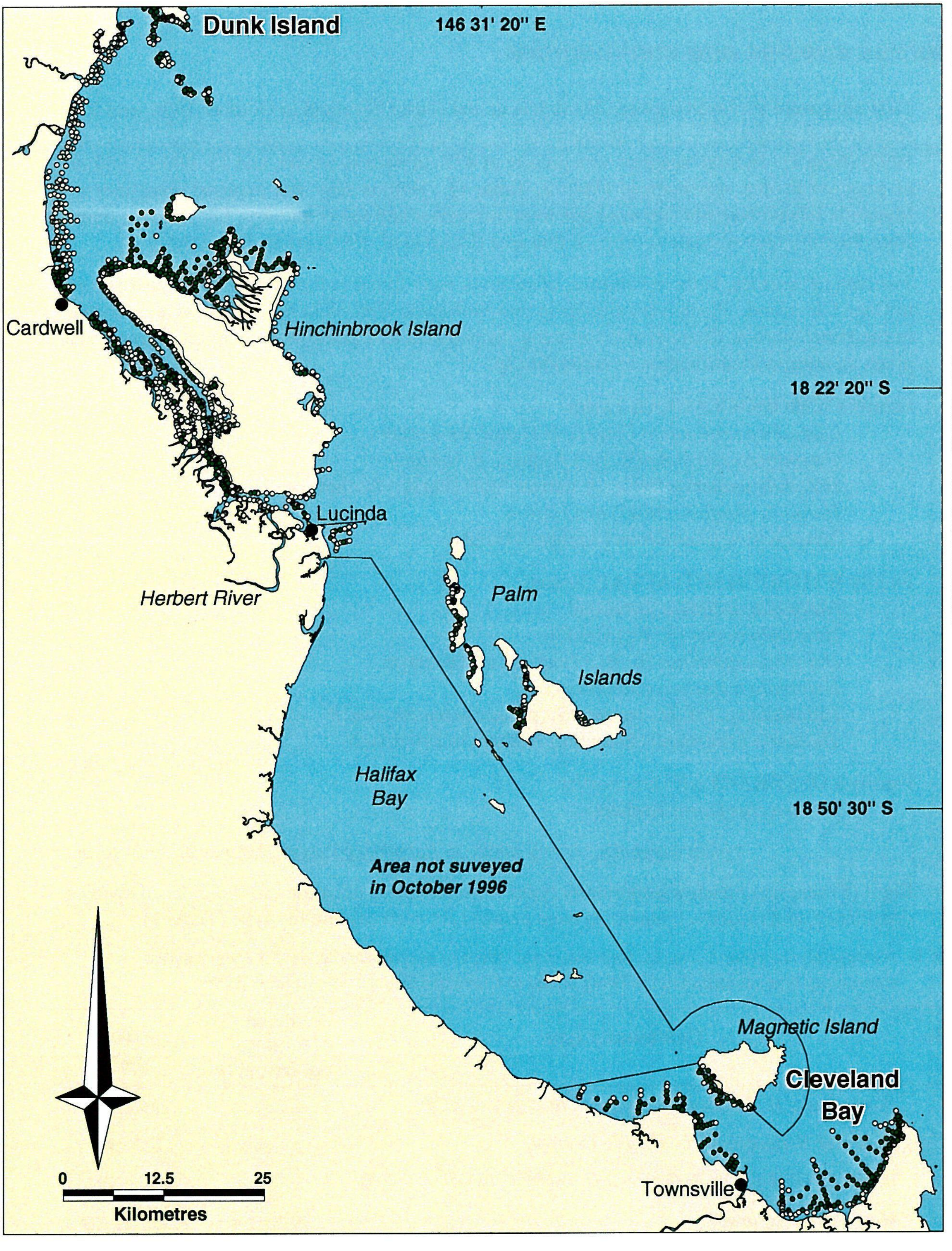
Estimates of mapping reliability were assigned to each meadow, based on the range of mapping techniques used and associated spatial errors. Boundaries of meadows in intertidal depths were usually mapped with greatest reliability (identified from surface observations, from dive sites usually less than 100 m apart, and sometimes interpreted from aerial photos). Boundaries in sub-tidal depths (eg., the outer boundaries of large meadows) were mapped with less reliability because of *a)* very gradual changes in habitat and *b)* poor underwater visibility. Where the depth of outer boundaries were established, bathymetry was used to help outline the meadow boundary between survey sites. Estimates of mapping reliability ranged from 10 m to 500 m and were recorded in the GIS.

Analysis

Standard parametric tests were used for analysis of data (Sokal and Rohlf 1987). All divers had significant linear regressions ($r^2 > 0.85$) when calibrating above-ground biomass estimates against a set of harvested quadrats.

Meadows were classified into seagrass community types according to the dominant species present. Some seagrass community types occurred in a range of habitats, so the dominant seagrass habitat types were also identified. Depth and biomass of seagrasses were also examined by selected localities.

MAP 1. Location of survey sites between Dunk Island and Cleveland Bay - October 1996.



LEGEND

- ● Seagrass
- ○ No seagrass

Source: Lee Long, W.J., McKenzie, L.J., Roelofs, A.J., Makey, L.E., Coles, R.G. & Roder, C.A. (1998). Baseline Survey of Hinchinbrook Region Seagrasses - October (Spring) 1996. Great Barrier Reef Marine Park Authority, Research Publication No. 51, 26pp. Sampling dates 7-16 October 1996. (1987 seagrass areas from Coles et al. 1992)

Funded by the Great Barrier Reef Marine Park Authority, the Australian Cooperative Research Centre Program through the CRC for Ecologically Sustainable Development of the Great Barrier Reef, and the Department of Primary Industries.

↳RESULTS

Seagrass species and communities

1804 sites were surveyed between Dunk Island and Cape Cleveland in October 1996, and 521 sites were surveyed in a more detailed survey of Oyster Point in August 1996 (Coles *et al.* 1997) (Map 1). In total, seagrass was present at 47% of sites surveyed, and 25, 900 ±3,000 ha of seagrass habitat was mapped (Map 2, Table 1). Halifax Bay and exposed coastlines of Magnetic Island were not surveyed due to poor weather and sea conditions, but seagrass maps from the initial broad-scale surveys of this area (Coles *et al.* 1992) are included (Map 2).

Twelve (12) species, in three Families, of seagrass were found in the survey from Dunk Island to Cape Cleveland. Plants very similar in morphology to *Halophila tricostata*, were collected in the Hinchinbrook Channel and are being investigated as a possible new taxon. These were given an interim identification as *Halophila* sp.

Family **CYMODOCEACEAE** Taylor
- *Cymodocea rotundata* Ehrenb. & Hemp. Ex Aschers
- *Cymodocea serrulata* (R. Br.) Aschers. & Magnus
- *Halodule uninervis* (wide- & narrow-leaf) (Forsk.) Aschers.
- *Halodule pinifolia* (Miki) den Hartog
- *Syringodium isoetifolium* (Aschers.) Dandy

Family **HYDROCHARITACEAE** Jussieu
- *Halophila decipiens* Ostenfeld
- *Halophila ovalis* (R. Br.) Hook f.
- *Halophila spinulosa* (R. Br.) Aschers. in Neumayer
- *Halophila tricostata* (Greenway)
- *Halophila* sp. (cf. *H. tricostata*) (presently undescribed)*
- *Thalassia hemprichii* (Ehrennb.) Aschers in Petermann

Family **ZOSTERACEAE** Dummortier
- *Zostera capricorni* Aschers.

** plant morphology is very similar to Halophila tricostata, but may be a new taxon.*

Eight (8) seagrass meadow/community types were identified according to the order of species dominance, and meadow boundaries were mapped for each community type (Table 1).

Table 1. Average above-ground seagrass biomass, areal extent of seagrass and code, for each seagrass community type identified in the Dunk Island to Cleveland Bay survey, October 1996.

Code	Community type	mean biomass (g DW. m^{-2})	area (ha)
1	*H. tricostata/ H. decipiens/ H. uninervis (*narrow*)/ H. ovalis*	*6.5 ±1.0*	*449 ±178*
2	*H. ovalis/ H. decipiens/ H. uninervis (*narrow*)*	*1.1 ±0.2*	*1762 ±322*
3	*H. pinifolia/ H. uninervis (*narrow*)/ H. uninervis (*wide*)/ H. ovalis*	*3.4 ±0.4*	*4341 ±587*
4	*H. spinulosa/ H. ovalis*	*21.7 ±1.4*	*13913 ±1373*
5	*H. uninervis/H. ovalis*	*16.2 ±1.6*	*1210 ±307*
6	*T. hemprichii/ H. uninervis/ H. ovalis/ S. isoetifolium*	*24.9 ±2.6*	*131 ±14*
7	*C. serrulata/ H. uninervis/ H. ovalis/ S. isoetifolium*	*34.5 ±2.4*	*4058 ±198*
8	*Z. capricorni/ H. uninervis/ H. ovalis*	*7.3 ±2.6*	*14 ±5*

Seagrass meadows occurred in various habitats from intertidal to a maximum 15 m deep. They occurred at sheltered coastal and island locations, including on shallow, fringing reefs and in the mouths of some estuaries and creeks (Map 2). Large meadows were mapped at Dunk Island, Missionary Bay and Shepherd Bay at Hinchinbrook Island, Magnetic Island, along the Townsville foreshore and in Cleveland Bay. In Hinchinbrook Channel, seagrasses along the eastern banks were confined to narrow bands, depending on the bank profile. The wider, western banks of Hinchinbrook Channel supported larger meadows (Map 3).

Eight major seagrass habitat types were found:

1. Intertidal and shallow sub-tidal habitat dominated by *Halophila ovalis*, sometimes with *Halodule uninervis* (eg., perimeters of Hinchinbrook Channel, Missionary Bay, Cleveland Bay);

2. Intertidal coastal habitat dominated by *Halodule uninervis* or *H. pinifolia* (eg., perimeters of Hinchinbrook Channel, Missionary Bay, Cleveland Bay);

3. Shallow sub-tidal habitat dominated by *Halophila spinulosa* or *Halodule uninervis* (narrow), (eg., at Dunk Island, Missionary Bay, Shepherd Bay, Cleveland Bay and Townsville-Pallarenda foreshore);

4. Shallow sub-tidal habitat dominated by the ephemeral (seasonal) *Halophila* sp. (cf. *H. tricostata*) or *H. decipiens* (mostly along sheltered banks of creeks or channels in the Hinchinbrook Channel; some areas of deep water in the lee of islands also supported habitat dominated by *H. tricostata*.);

5 Intertidal habitats dominated by *Zostera capricorni*, with small amounts of *Halophila ovalis* or *Halodule uninervis* (eg., in southern Hinchinbrook Channel and the perimeter of Cleveland Bay);

6 Fringing reef seagrass communities dominated by *Halophila ovalis* or *Halodule uninervis* (eg., on sheltered fringing reefs at Dunk, Palm and Magnetic Islands);

7 Fringing reef or shallow (<5m) subtidal meadows dominated by *Cymodocea serrulata* or *Thalassia hemprichii*, with varying amounts of *Halophila* or *Halodule* species (eg., at Palm Islands, Magnetic Island and Cleveland Bay);

8 Deep subtidal (>5 m), mixed species habitat dominated by *Cymodocea serrulata* (eg., at Great Palm Island).

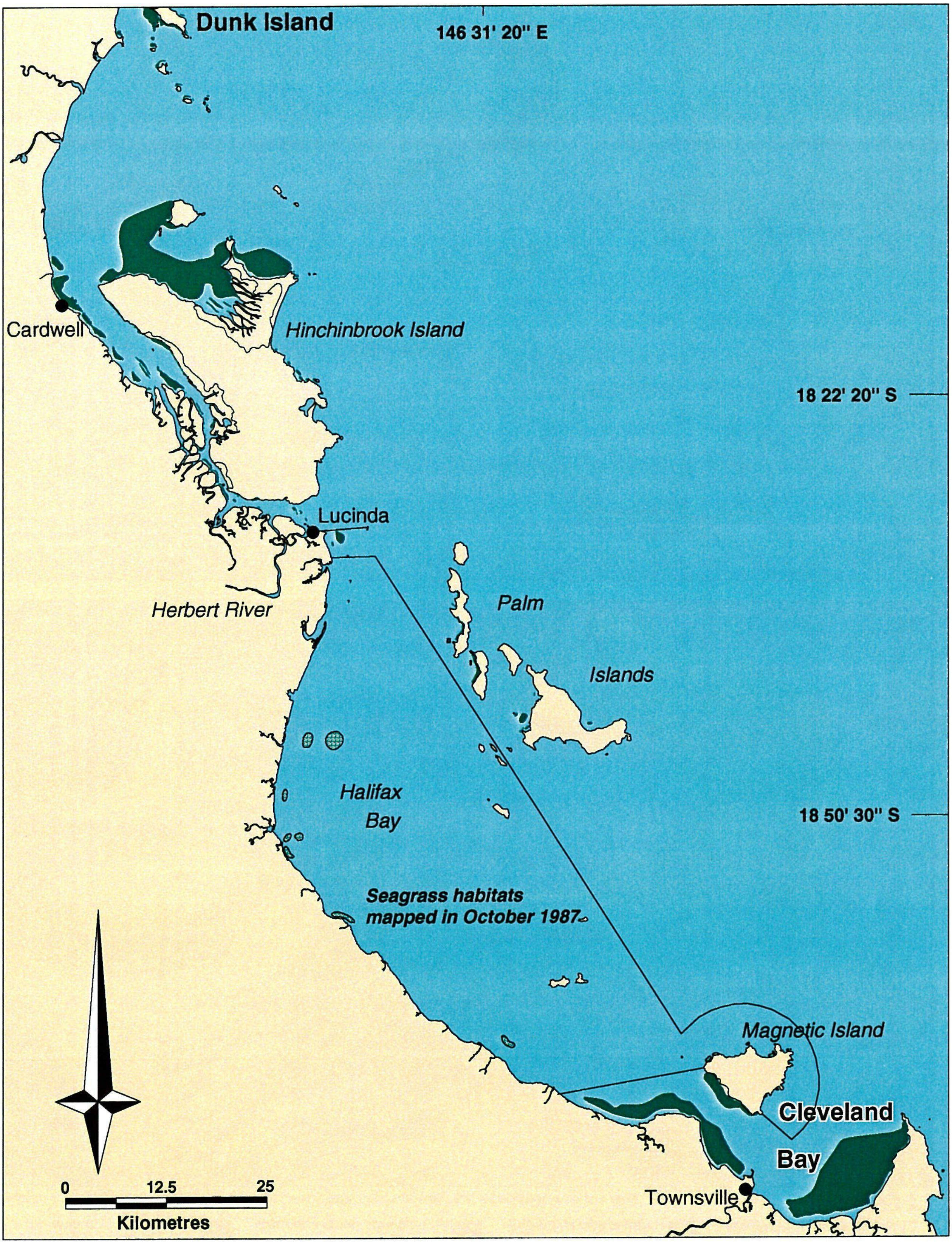
Seagrass spatial distribution

A total 25,900 ±3,000 ha of seagrass habitat was mapped in this detailed survey between Dunk Island and Cape Cleveland (Map 2, Table 2). This does not include all seagrass habitat in the region, because exposed sections of Halifax Bay, eastern Magnetic Island, and fringing reefs on some small islands were inaccessible during the present survey. A total of 2400 ha of habitat was mapped in 1987 during a broad-scale survey in Halifax Bay and eastern Magnetic Island (Coles *et al.* 1992). The Department of Primary Industries, Queensland and Great Barrier Reef Marine Park Authority hold MapInfo® and ArcInfo® versions of the detailed GIS of seagrass habitats mapped from this survey. Seagrass areas mapped previously in Halifax Bay and on exposed parts of Magnetic Island are also included, in lieu of fine-scale surveys being completed for these areas.

Maps 3-8 in this report are magnified for identification of small meadows. Estimates of mapping error are not to be inferred from the scale of these presentation maps. These can be obtained from the original GIS and be used when measuring changes in distribution.

Shallow sub-tidal communities dominated by *Halophila* species made up most (65.7%) of the seagrass area mapped in this survey, and these occurred predominantly in the large, sheltered bays (Missionary, Shepherd and Cleveland Bays) and the Townsville foreshore (Table 2, Maps 3A, 7A and 7B). Seagrass meadows along the banks of Hinchinbrook Channel were discontinuous, but included some dense habitat mostly on the western side of the channel (Maps 4A, 4B and 6A, 6B). Very few creek banks supported seagrass - the most substantial area was 4.5 ±3.6 ha in Deluge Inlet (Map 6A).

MAP 2. Location of seagrass meadows between Dunk Island and Cleveland Bay - October 1996 (and areas surveyed in 1987).



LEGEND

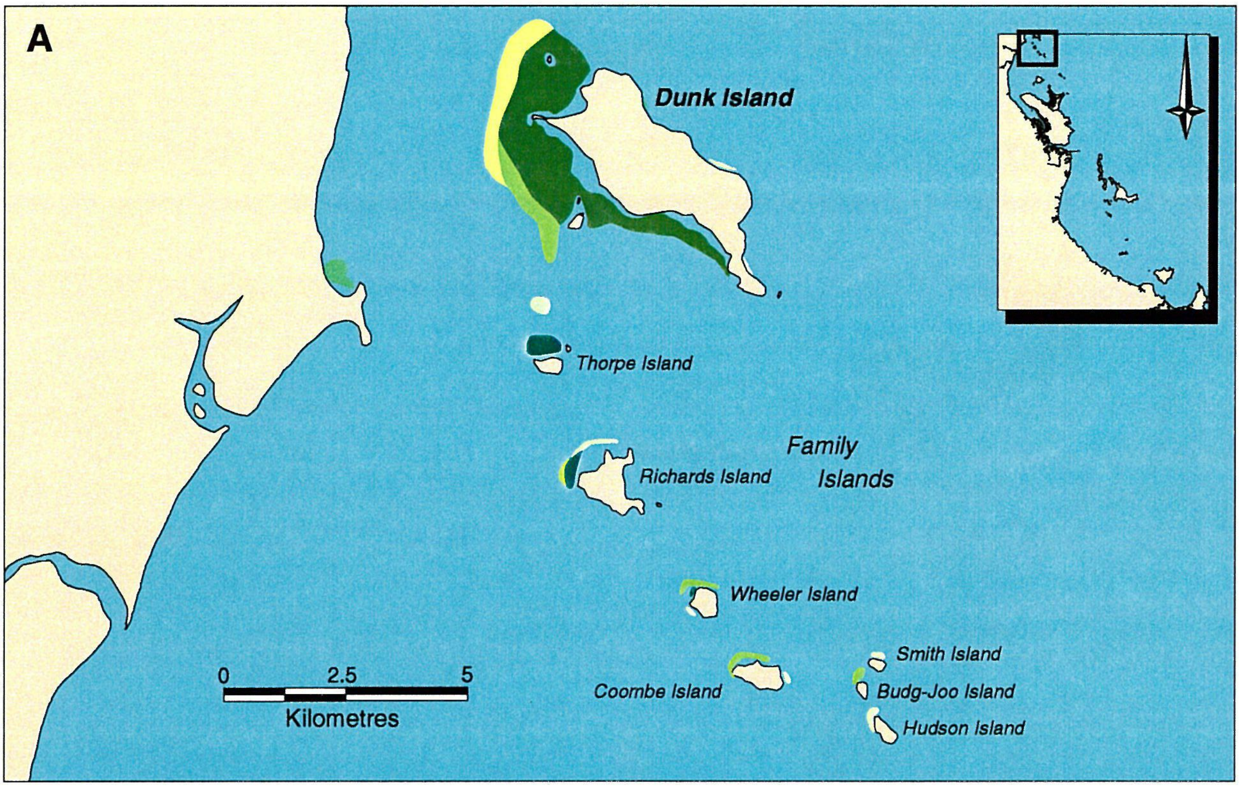
Seagrass

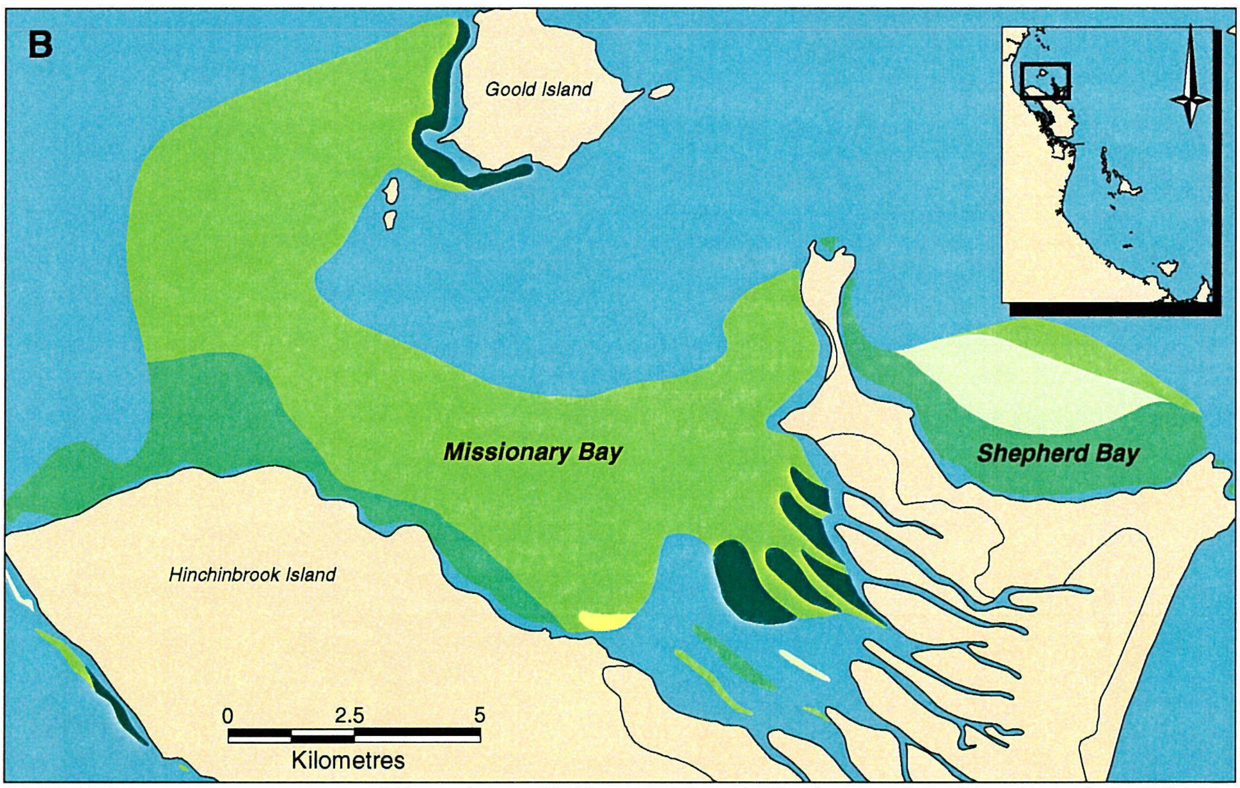
Seagrass 1987

Source: Lee Long, W.J., McKenzie, L.J., Roelofs, A.J., Makey, L.E., Coles, R.G. & Roder, C.A. (1998). Baseline Survey of Hinchinbrook Region Seagrasses - October (Spring) 1996, Great Barrier Reef Marine Park Authority, Research Publication No. 51, 26pp. Sampling dates 7-16 October 1996. (1987 seagrass areas from Coles et al. 1992)

Funded by the Great Barrier Reef Marine Park Authority, the Australian Cooperative Research Centre Program through the CRC for Ecologically Sustainable Development of the Great Barrier Reef, and the Department of Primary Industries.

MAP 3. Distribution of seagrass meadows around Dunk and Family Islands group (A) and within Missionary and Shepherd Bays (B) - October 1996.





LEGEND

* Map scales magnified for presentation only. Mapping errors for each meadow are in the GIS database.

- ***H. tricostata/H. decipiens/ H. ovalis***
- ***H. uninervis/ H. pinifolia H. decipiens/ H. ovalis***
- ***H. uninervis (wide and thin)/ H. ovalis***
- ***C. serrulata/H. uninervis/ H. ovalis/ S. isoetifolium***
- ***H. ovalis/ H. decipiens/ H. uninervis (thin)***
- ***H. spinulosa/ H. ovalis***
- ***T. hemprichii/ H. uninervis/ H. ovalis/ S. isoetifolium***
- ***Z. capricorni/ H. uninervis H. ovalis***

Source: Lee Long, W.J., McKenzie, L.J., Roelofs, A.J., Makey, L.E., Coles, R.G. & Roder, C.A. (1998). Baseline Survey of Hinchinbrook Region Seagrasses - October (Spring) 1996. Great Barrier Reef Marine Park Authority, Research Publication No. 51, 26pp.
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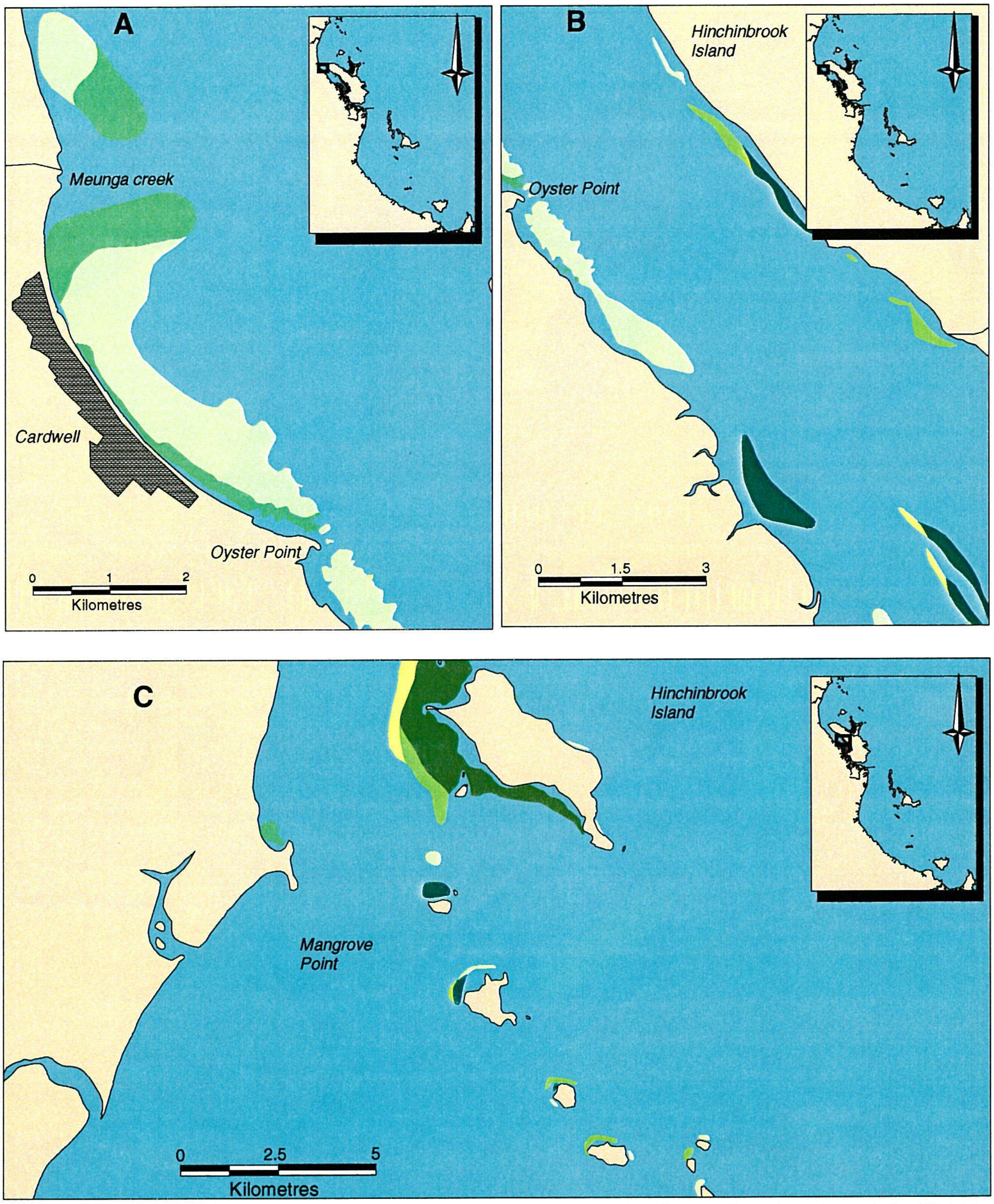
Funded by the Great Barier Reef Marine Park Authority, the Australian Cooperative Research Centre Program through the CRC for Ecologically Sustainable Development of the Great Barrier Reef, and the Department of Primary Industries.

MAP 4. Distribution of seagrass meadows within northern Hinchinbrook Channel - October 1996.



* Map scales magnified for presentation only. Mapping errors for each meadow are in the GIS database.

LEGEND

- *H. tricostata/H. decipiens/ H. ovalis*
- *H. ovalis/ H. decipiens/ H. uninervis (thin)*
- *H. uninervis/ H. pinifolia H. decipiens/ H. ovalis*
- *H. spinulosa/ H. ovalis*
- *H. uninervis (wide and thin)/ H. ovalis*
- *T. hemprichii/ H. uninervis/ H. ovalis/ S. isoetifolium*
- *C. serrulata/H. uninervis/ H. ovalis/ S. isoetifolium*
- *Z. capricorni/ H. uninervis H. ovalis*

Source: Lee Long, W.J., McKenzie, L.J., Roelofs, A.J., Makey, L.E., Coles, R.G. & Roder, C.A. (1998). Baseline Survey of Hinchinbrook Region Seagrasses - October (Spring) 1996. Great Barrier Reef Marine Park Authority, Research Publication No. 51, 26pp.
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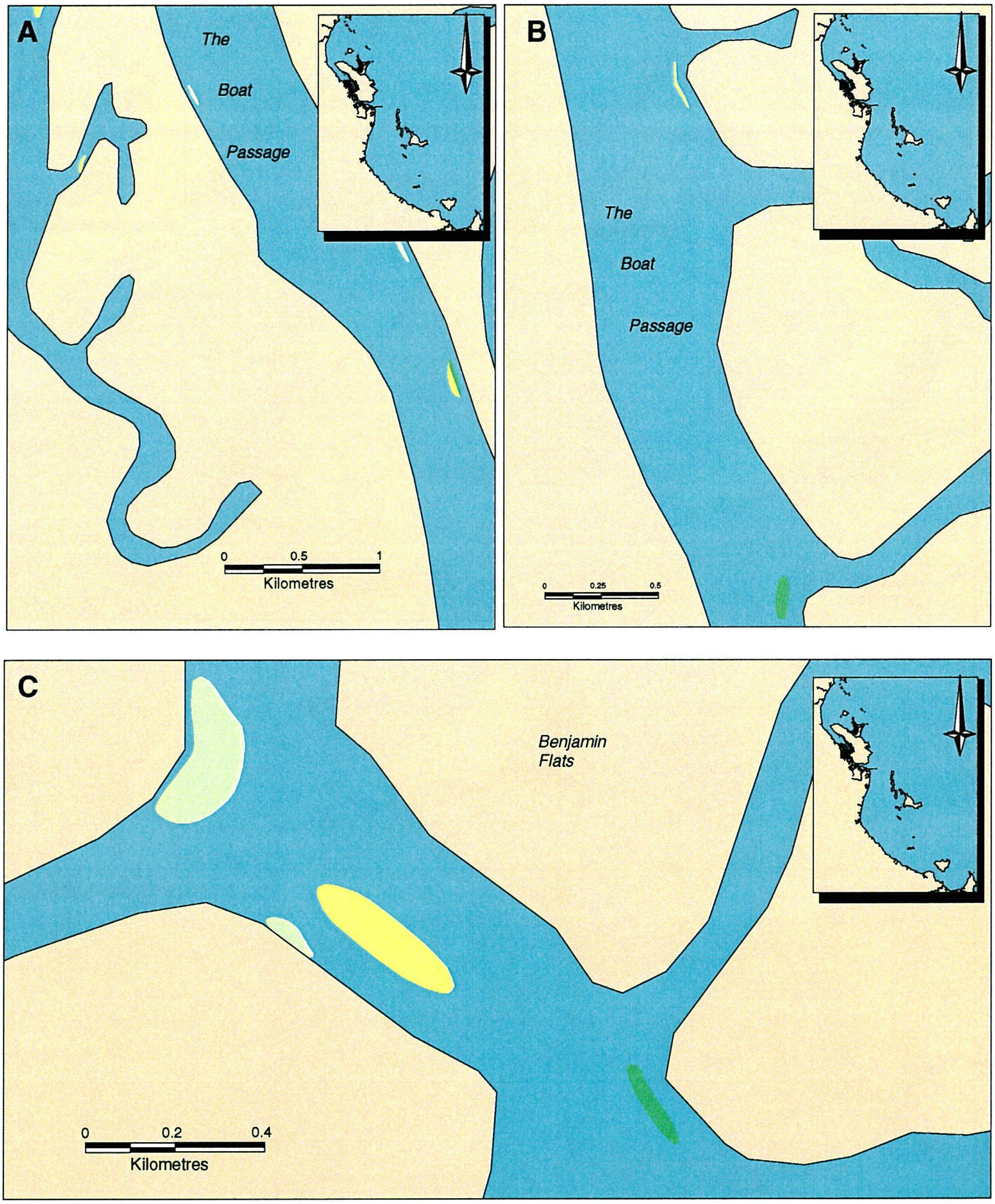
MAP 5. Distribution of seagrass meadows within central Hinchinbrook mangrove system - October 1996.



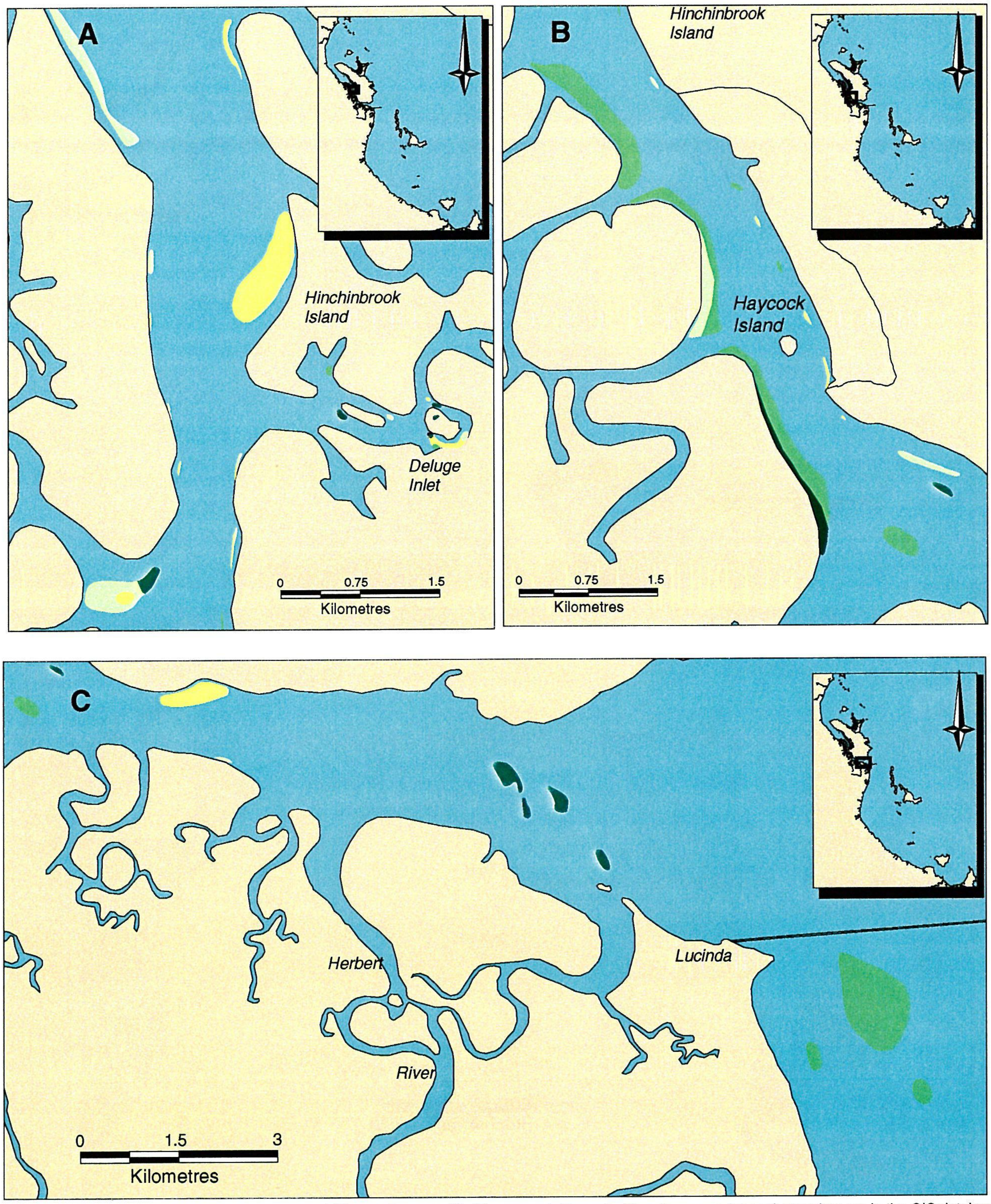
* Map scales magnified for presentation only. Mapping errors for each meadow are in the GIS database.

LEGEND

- ***H. tricostata/H. decipiens/ H. ovalis***
- ***H. ovalis/ H. decipiens/ H. uninervis (thin)***
- ***H. uninervis/ H. pinifolia H. decipiens/ H. ovalis***
- ***H. spinulosa/ H. ovalis***
- ***H. uninervis (wide and thin)/ H. ovalis***
- ***T. hemprichii/ H. uninervis/ H. ovalis/ S. isoetifolium***
- ***C. serrulata/H. uninervis/ H. ovalis/ S. isoetifolium***
- ***Z. capricorni/ H. uninervis H. ovalis***

Source: Lee Long, W.J., McKenzie, L.J., Roelofs, A.J., Makey, L.E., Coles, R.G. & Roder, C.A. (1998). Baseline Survey of Hinchinbrook Region Seagrasses - October (Spring) 1996. Great Barrier Reef Marine Park Authority, Research Publication No. 51, 26pp.
Sampling dates 7-16 October 1996.
Funded by the Great Barier Reef Marine Park Authority, the Australian Cooperative Research Centre Program through the CRC for Ecologically Sustainable Development of the Great Barrier Reef, and the Department of Primary Industries.

MAP 6. Distribution of seagrass meadows within southern Hinchinbrook Channel - October 1996.



* Map scales magnified for presentation only. Mapping errors for each meadow are in the GIS database.

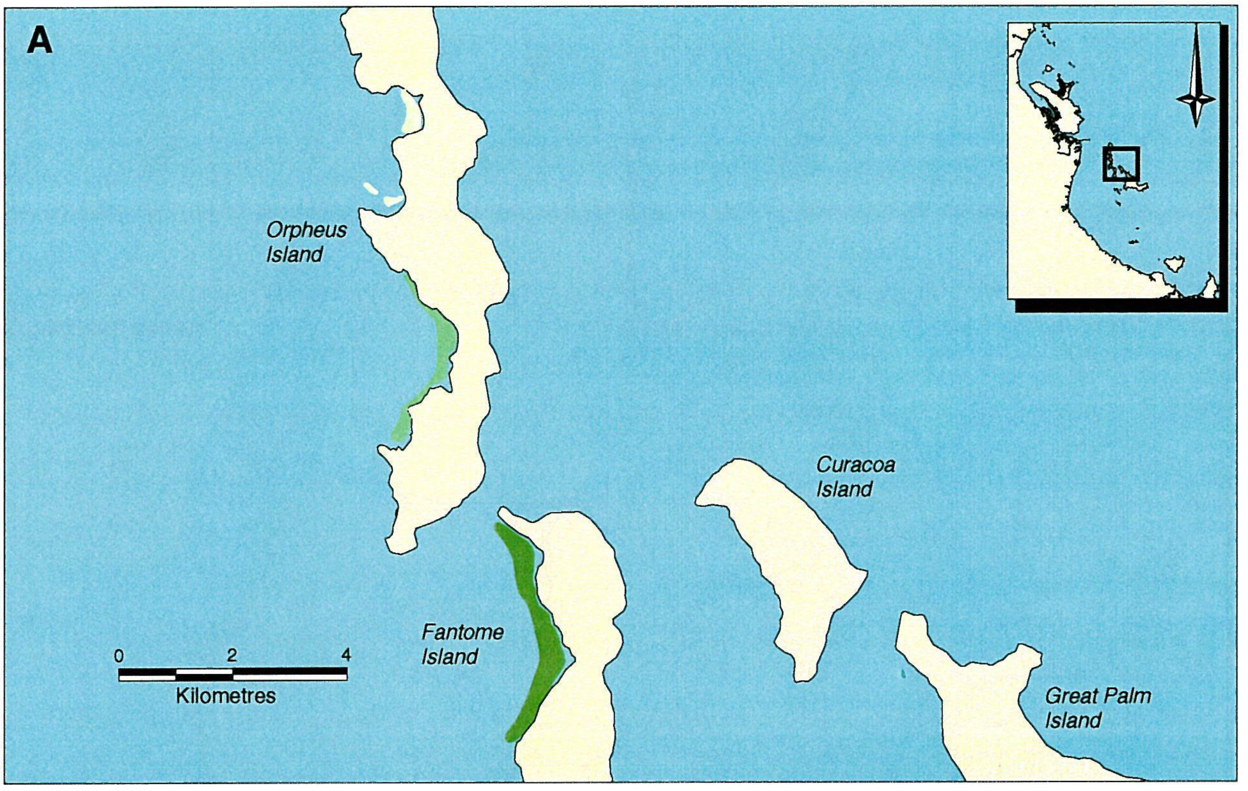
LEGEND

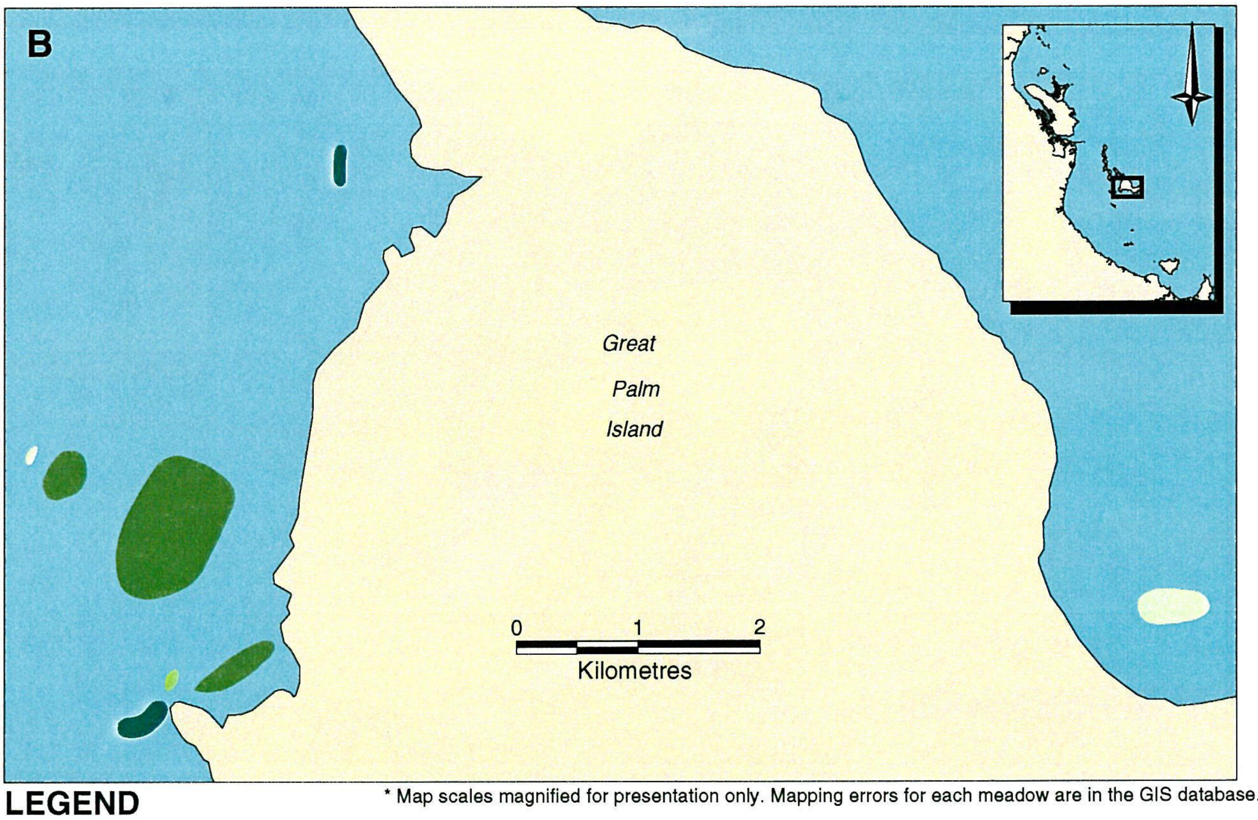
- ***H. tricostata/H. decipiens/ H. ovalis***
- ***H. uninervis/ H. pinifolia H. decipiens/ H. ovalis***
- ***H. uninervis (wide and thin)/ H. ovalis***
- ***C. serrulata/H. uninervis/ H. ovalis/ S. isoetifolium***
- ***H. ovalis/ H. decipiens/ H. uninervis (thin)***
- ***H. spinulosa/ H. ovalis***
- ***T. hemprichii/ H. uninervis/ H. ovalis/ S. isoetifolium***
- ***Z. capricorni/ H. uninervis H. ovalis***

Source: Lee Long, W.J., McKenzie, L.J., Roelofs, A.J., Makey, L.E., Coles, R.G. & Roder, C.A. (1998). Baseline Survey of Hinchinbrook Region Seagrasses - October (Spring) 1996. Great Barrier Reef Marine Park Authority, Research Publication No. 51, 26pp.
Sampling dates 7-16 October 1996.

Funded by the Great Barrier Reef Marine Park Authority, the Australian Cooperative Research Centre Program through the CRC for Ecologically Sustainable Development of the Great Barrier Reef, and the Department of Primary Industries.

MAP 7. Distribution of seagrass meadows around the Palm Islands - October 1996.





LEGEND

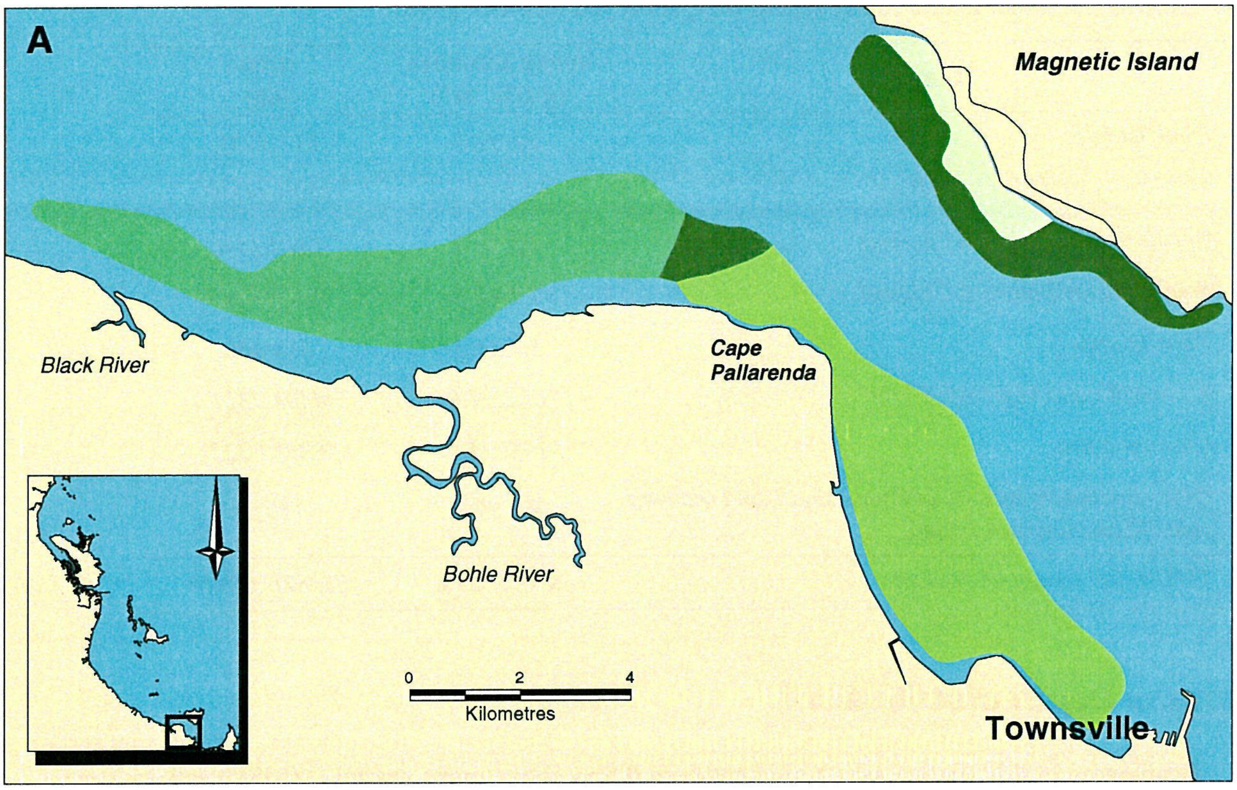
* Map scales magnified for presentation only. Mapping errors for each meadow are in the GIS database.

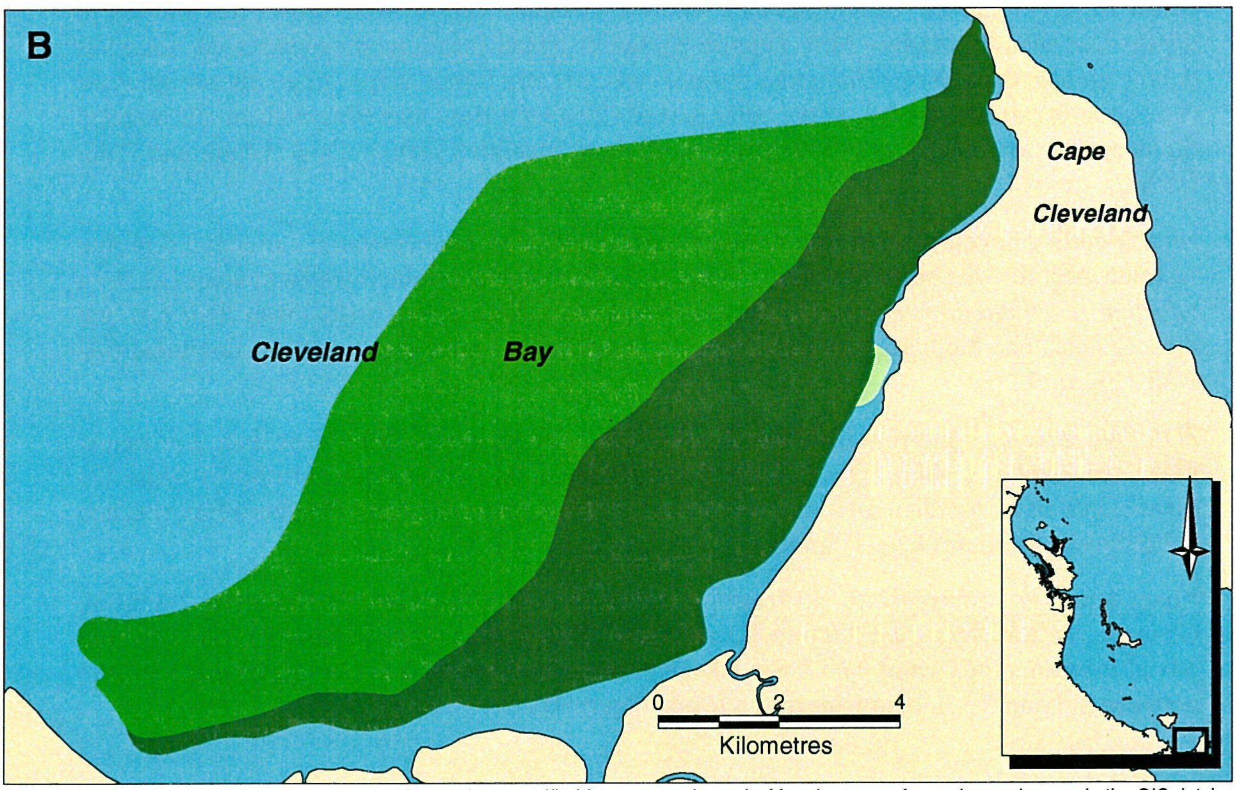
- ***H. tricostata/H. decipiens/ H. ovalis***
- ***H. uninervis/ H. pinifolia H. decipiens/ H. ovalis***
- ***H. uninervis (wide and thin)/ H. ovalis***
- ***C. serrulata/H. uninervis/ H. ovalis/ S. isoetifolium***
- ***H. ovalis/ H. decipiens/ H. uninervis (thin)***
- ***H. spinulosa/ H. ovalis***
- ***T. hemprichii/ H. uninervis/ H. ovalis/ S. isoetifolium***
- ***Z. capricorni/ H. uninervis H. ovalis***

Source: Lee Long, W.J., McKenzie, L.J., Roelofs, A.J., Makey, L.E., Coles, R.G. & Roder, C.A. (1998). Baseline Survey of Hinchinbrook Region Seagrasses - October (Spring) 1996. Great Barrier Reef Marine Park Authority, Research Publication No. 51, 26pp.
Sampling dates 7-16 October 1996.

Funded by the Great Barier Reef Marine Park Authority, the Australian Cooperative Research Centre Program through the CRC for Ecologically Sustainable Development of the Great Barrier Reef, and the Department of Primary Industries.

MAP 8. Distribution of seagrass meadows at Townsville and Magnetic Island (A) and Cleveland Bay (B) - October 1996.





LEGEND

* Map scales magnified for presentation only. Mapping errors for each meadow are in the GIS database.

- *H. tricostata/H. decipiens/ H. ovalis*
- *H. uninervis/ H. pinifolia H. decipiens/ H. ovalis*
- *H. uninervis (wide and thin)/ H. ovalis*
- *C. serrulata/H. uninervis/ H. ovalis/ S. isoetifolium*
- *H. ovalis/ H. decipiens/ H. uninervis (thin)*
- *H. spinulosa/ H. ovalis*
- *T. hemprichii/ H. uninervis/ H. ovalis/ S. isoetifolium*
- *Z. capricorni/ H. uninervis H. ovalis*

Source: Lee Long, W.J., McKenzie, L.J., Roelofs, A.J., Makey, L.E., Coles, R.G. & Roder, C.A. (1998). Baseline Survey of Hinchinbrook Region Seagrasses - October (Spring) 1996. Great Barrier Reef Marine Park Authority, Research Publication 51, 26pp.
Sampling dates 7-16 October 1996.

Funded by the Great Barier Reef Marine Park Authority, the Australian Cooperative Research Centre Program through the CRC for Ecologically Sustainable Development of the Great Barrier Reef, and the Department of Primary Industries.

Table 2. Average above-ground seagrass biomass and seagrass areal extent of seagrass for selected localities, Dunk Island to Cleveland Bay, surveyed October 1996.

Locality	mean biomass (g DW. m^{-2})	area (ha)
Dunk Islands	*6.8 ±1.0*	*817 ±238*
Missionary and Shepherd Bays	*11.9 ±1.1*	*9925 ±1392*
Northern Hinchinbrook Channel	*1.9 ±0.2*	*1470 ±440*
Southern Hinchinbrook Channel	*1.7 ±0.3*	*382 ±148*
Palm Islands	*5.7 ±1.2*	*336 ±60*
Townsville and Magnetic Island	*17.2 ±1.9*	*4404 ±331*
Cleveland Bay	*19.7 ±1.9*	*8394± 323*
Other (including inshore of Dunk Island, and seaward side of Hinchinbrook Island)	*0.2 ±0.1*	*150 ±1*
TOTAL (all localities pooled)	$\bar{x}$ *=8.1 ±1.0*	*25, 878 ±2984*

Seagrass depth distributions

Seagrasses in this survey were found between 0.9 m above mean sea level (MSL) and 15.1 m below MSL (Figure 2). Seagrasses as a whole at coastal locations were most often limited to depths less than 4 m below MSL (Figure 3), but at island locations meadows were found at depths greater than 10 m. *Halophila* species were usually found deeper than other seagrasses (eg., up to 6.7 m below MSL at the outer part of Cleveland Bay) and *Halophila ovalis* reached the deepest overall (15.1 m below MSL) at offshore localities such as Dunk Island and Palm Island.

Mean depths of occurrence for individual seagrass species were between 0.7 m and 3.6 m, but were deepest for *Halophila* species (Figure 2). Mean depths of blade-leafed species (*Zostera capricorni, Thalassia hemprichii* and *Cymodocea rotundata*) were all shallower than 1 m and these species had the narrowest depth ranges, restricted to above the lowest astronomical tide LAT (Figure 2).

Halodule uninervis (narrow-leaf) and *H. pinifolia* were generally found less than 2 m below mean sea level at inshore sites (Hinchinbrook Channel and Townsville foreshore) while the mean depth of *Halodule uninervis* (narrow leaf) at Missionary Bay and Shepherd Bay reached 3.2 m below mean sea level (Figure 3).

Mean depths of occurrence for all seagrass species in the southern and northern Hinchinbrook Channel were all less than 2.9 and 2.3 m below MSL respectively (Figure 3). At offshore island locations (eg., Dunk and Palm Islands) mean depths for the same species increased to between 3.8 and 9.3 m below mean sea level (Figure 3).

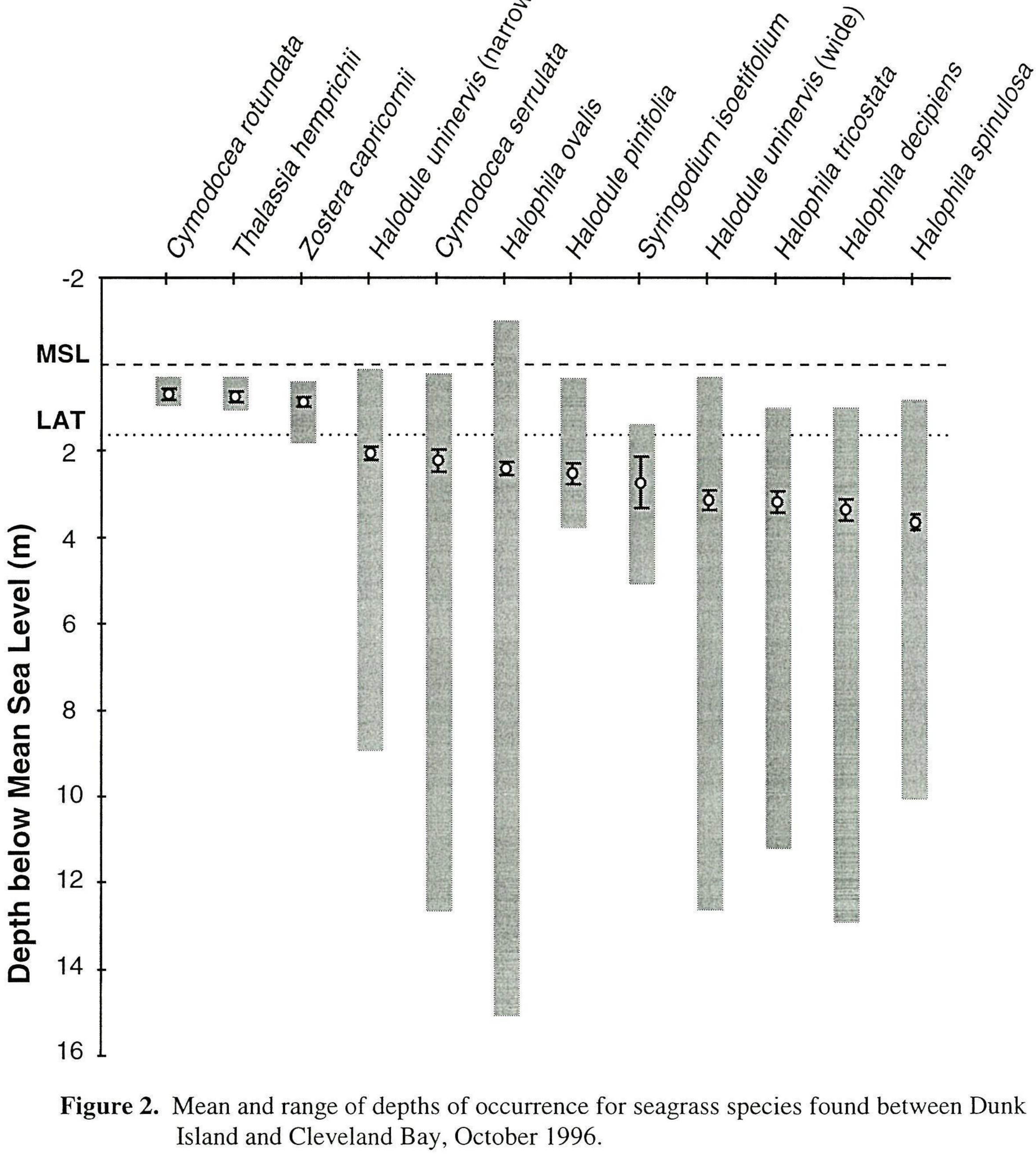


Figure 2. Mean and range of depths of occurrence for seagrass species found between Dunk Island and Cleveland Bay, October 1996.

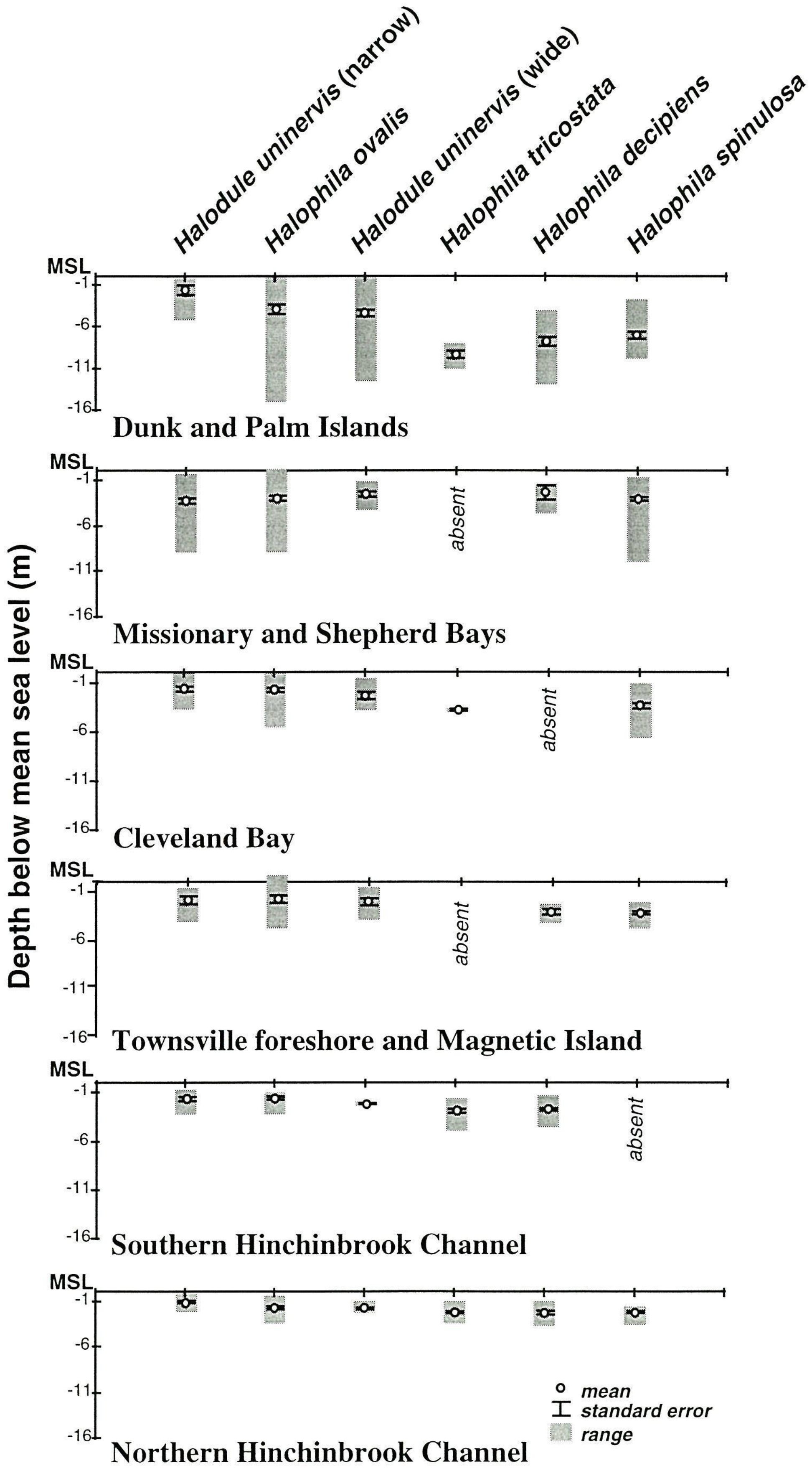


Figure 3. Mean and range of depth of occurrence for selected seagrass species at localities between Dunk Island and Cleveland Bay, October 1996.

Seagrass biomass

Maximum above-ground seagrass biomass for any species was 83.7 g DW. m^{-2} on an intertidal site dominated by *Cymodocea serrulata* in Cleveland Bay (Figure 4). Mean biomass for meadows identified in the survey ranged from 0.016 g DW. m^{-2} along the western edge of northern Hinchinbrook channel to 67.0 g DW. m^{-2} at the northern tip of Palm Island.

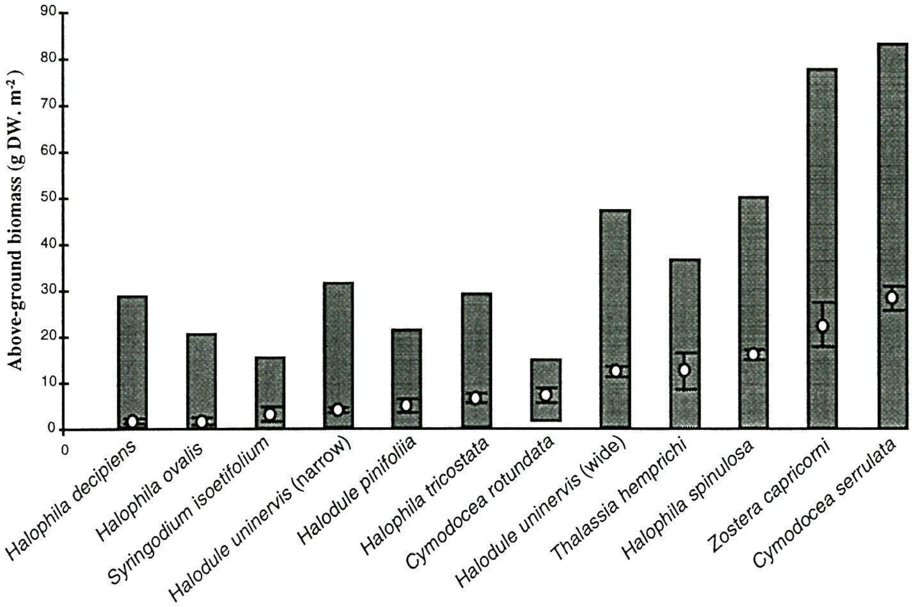


Figure 4. Means, range and SE for estimated above-ground biomass for seagrass species (all sites pooled) between Dunk Island and Cleveland Bay, October 1996.

Above-ground biomass was lowest for community types dominated by *Halophila* and *Halodule* species and greatest in communities dominated by the broad-leaf species *Thalassia* and *Cymodocea* species (Table1, Figure 5).

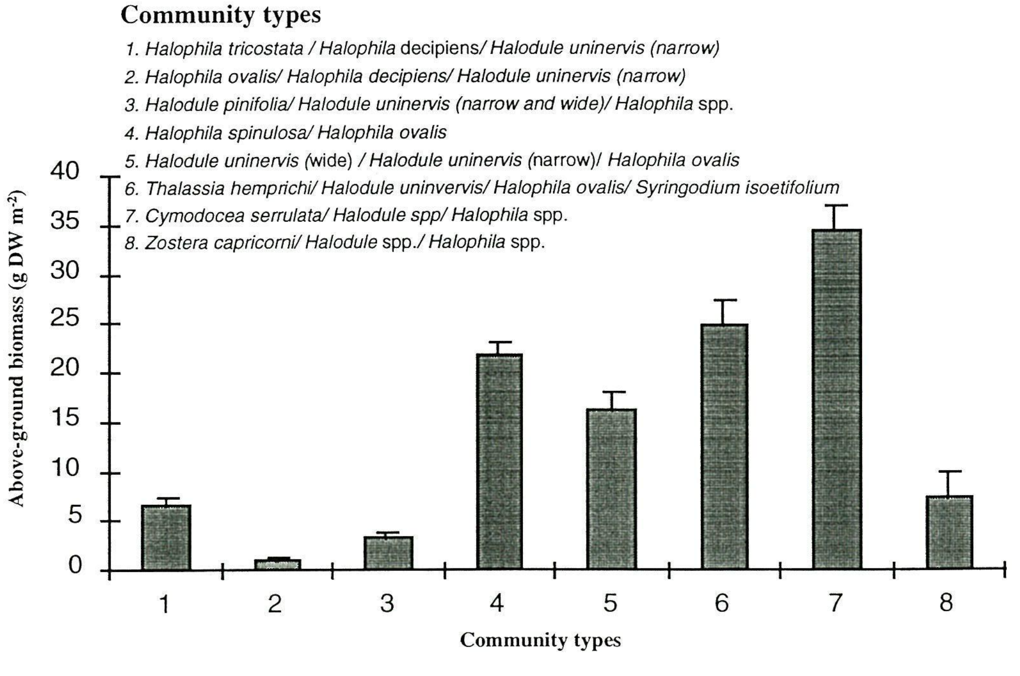


Figure 5 . Means (± SE) for estimated above-ground biomass for identified community types between Dunk Island and Cleveland Bay, October 1996.

For seagrass regions identified in this survey, mean above-ground seagrass biomass ranged from 1.7 ±0.3 g DW. m^{-2} in southern Hinchinbrook channel to 19.7 ±1.9 g DW. m^{-2} in Cleveland Bay (Figure 6). Seagrass meadows surveyed at Dunk and Palm Islands averaged 6.8 ±1.0 and 5.7 ±1.2g DW. m^{-2} respectively.

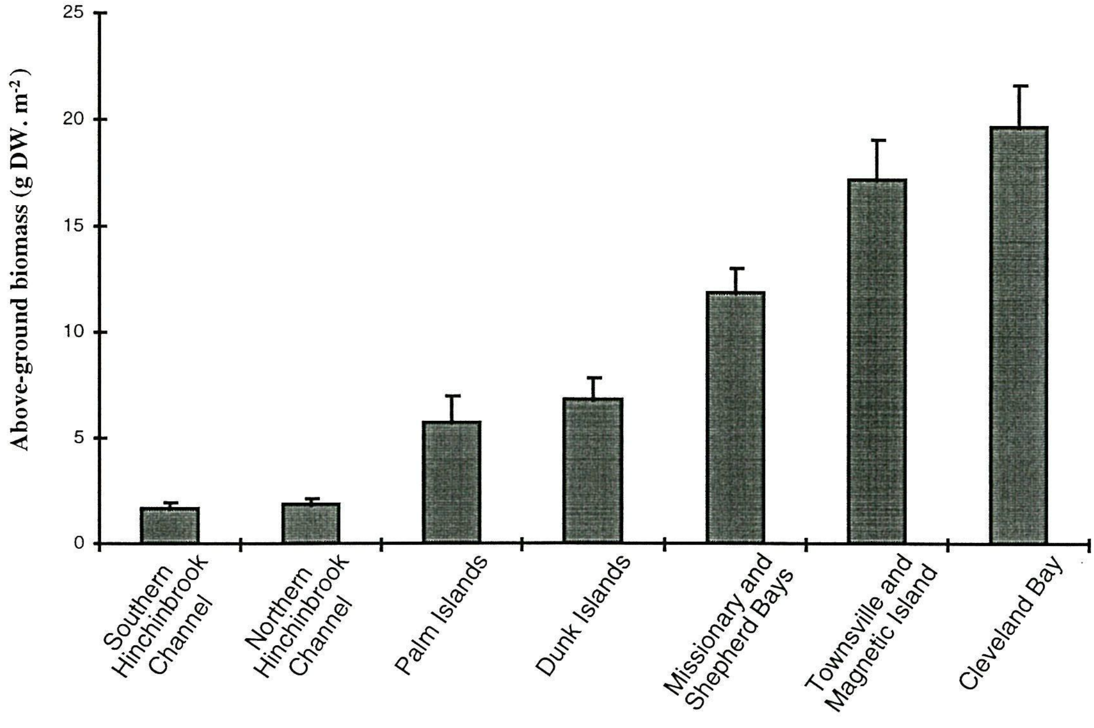


Figure 6. Means (± SE) for estimated above-ground biomass for selected localities between Dunk Island and Cleveland Bay, October 1996.

Seagrass habitat of fringing reef/shallow subtidal meadows dominated by *Cymodocea serrulata* (eg., Cleveland Bay, Magnetic Island, Palm Isles) yielded the greatest biomass (average 33.7 ±2.3 g DW. m^{-2}), while intertidal and shallow sub-tidal habitat (eg., perimeters of Hinchinbrook channel) dominated by *Halophila ovalis* contained the lowest above-ground seagrass biomass (average 2.6 ±0.6. g DW. m^{-2}).

↳ DISCUSSION

Seagrass abundance and distribution

Large seagrass meadows in the sheltered bays (Missionary, Shepherd, and Cleveland Bays) formed the most prominent seagrass features in the Dunk Island to Cleveland Bay region. Other important features were dense meadows of mostly *Halophila* and *Halodule* species along the Cardwell and Townsville foreshores and in the lee of the large continental islands: Dunk, Palm and Magnetic. It is unclear why large, sheltered, sub-tidal meadows were dominated by low-biomass *Halophila* species in the northern Hinchinbrook region but by the high-biomass *Cymodocea serrulata* in Cleveland Bay. Major differences in seagrass community type between localities are likely to influence secondary productivity and other species of fisheries importance, but this remains little understood.

The species found in this survey represent almost 80 percent of the known species listed from Queensland (Lee Long *et al.* 1993) and most are typical of the Indo-West Pacific region (den Hartog 1970; Fortes 1989; Coles and Kuo 1995). A wide range of coastal, island and fringing reef features in this region contribute to a high diversity of seagrass species, communities and habitat types, including coastal intertidal to subtidal, fringing reef and deepwater habitats. These types of seagrass communities and habitat types are common to many localities on the Queensland east coast (Lee Long *et al.* 1993). The total area which receives shelter from south-easterly trade winds and swells is large in this region and probably very important in determining the maximum potential area of seagrass habitat compared to neighbouring regions. The overall seagrass distribution in the region is probably mostly influenced by shelter, water turbidity and tidal exposure.

High turbidity nearshore, a result of high concentrations of phytoplankton and suspended solids (Furnas and Mitchell 1997), appears to limit the maximum depth of coastal seagrasses to approximately 4 m (below MSL), eg., in the Hinchinbrook Channel and Townsville foreshore. An increase in the depth range of seagrass growth from inshore to offshore localities is most likely related to general decrease in turbidity offshore (thus increased availability of photosynthetically active radiation at depth). *Halophila ovalis* was found to 15m deep at Dunk and Palm Islands. Large meadows of *Halophila ovalis* and other *Halophila* species have been found in clearer offshore waters at least 25 m deep near Lizard Island in the far northern Great Barrier Reef (Lee Long *et al.* 1996) and Hervey Bay, southern Queensland (Lee Long *et al.* 1992; Preen *et al.* 1995).

Seagrass depth ranges in the survey region otherwise appear typical of most coastal localities on the Queensland coast north to Cape York (Coles *et al.* 1987) and south to Bowen (Coles *et al.* 1992). Further south in the Shoalwater Bay region, seagrass survival is mostly restricted to the intertidal zone (Lee Long *et al.* 1997a). In Shoalwater Bay large tidal ranges and tidal currents create greater resuspension of fine, coastal sediments and high water turbidity, so that seagrasses appear only to receive sufficient light for photosynthesis on the shallow banks during low tide.

In Shoalwater Bay the seagrass distribution restricted to intertidal banks probably limits opportunities for dugong to feed (ie., high tide access only) and may limit dugong numbers there. In the Hinchinbrook and Townsville regions, large areas of sub-tidal seagrass habitat should be a significant alternative food source for dugong and turtle populations when access to intertidal seagrass habitat is restricted during low tide periods.

The seagrass habitats mapped between Dunk Island and Cleveland Bay are likely to be regionally important to fisheries and dugong/turtle populations because the next substantial areas of seagrass habitat occur large distances to the north (Cairns) and south (Upstart Bay)

(Coles *et al.* 1992; Lee Long *et al.* 1993). The ecological links between various seagrass habitat types and associated fisheries species needs clarification. Detailed fauna sampling in seagrasses is necessary to identify the priority areas of greatest prawn and fish productivity, and assist in managing conflicting uses of these coastal habitats.

Temporal change in seagrass distribution and abundance

Maps of seagrass habitat from this survey provide the first fine-scale baseline suitable for future monitoring of the Hinchinbrook region. The estimates of reliability of meadow boundaries vary according to the survey techniques used and associated errors in mapping for each area. These estimates of reliability for each meadow are recorded in the GIS and will be used when attempting to detect changes in the area of habitat during monitoring programs.

Large areas of seagrass habitat mapped in 1996 occurred in places which, during earlier (1987) broad-scale surveys, did not appear to support seagrass habitat. Increases in habitat area since 1987 were mostly in subtidal areas of Missionary Bay, Shepherd Bay, Townsville foreshore and Cleveland Bay.

These increases in subtidal habitats include mostly *Halophila* and *Halodule* species, the preferred food species of dugong. Marsh (In Press) notes that such long-term and moderate-scale changes in seagrass abundance could influence dugong populations by impacting fecundity, reproductive success and survival of infants. Sudden large-scale losses of seagrass in Hervey Bay in 1992 led to direct mortalities and emigration of dugongs from the Hervey Bay population (Preen *et al.* 1995). Limpus (pers comm. 1997) noted decreases in sea turtle vitellogenesis, spermatogenesis and adolescent growth rates following cyclone-related seagrass losses at Shoalwater Bay in 1991, then increases in these same parameters with observed recovery of local seagrass resources in 1995/96. The impact of long-term changes in habitat on associated fisheries stocks in north-eastern Queensland is not as well understood.

Little else is known about long-term changes in seagrass distribution and abundance for the Hinchinbrook region, but aerial observations and surface reconnaissance surveys in 1992 (Mellors pers comm. 1992) found very little intertidal seagrass habitat in this and neighbouring regions where there was seagrass in 1987 (cf., Coles *et al.* 1992). The observed changes in area of intertidal and subtidal habitat since 1987 and 1992 is evidence for large natural variability in these habitats. We suspect that long-term changes in seagrasses may be influenced by region-wide changes in climatic conditions, perhaps related to *El Nino* events. Seagrass growth is largely influenced by availability of photosynthetically active light (Dennison *et al.* 1993), so years of reduced light (eg., prolonged climatic conditions of strong wind and cloud cover) will likely inhibit seagrass growth and survival (McKenzie 1994). Conversely, years of clear, calm weather would contribute to greater seagrass growth and survival. Species at sub-tidal depths and at the deep extent of their distribution would be most vulnerable to changes in the amount of available light for photosynthesis.

Monitoring of seagrasses at a range of localities, with information on climatic factors and water quality conditions, may elucidate long-term patterns and causes of change. Anthropogenic influences such as runoff from agricultural catchments also need to be measured within monitoring programs, to help identify the influences of land run-off on coastal seagrass systems. Incremental increases in the impacts of coastal development and catchment run-off may result in incremental degradation of habitats going "un-noticed". Formal habitat monitoring programs have been recommended to ensure that both incremental and acute damage is detected and early action be taken to avoid further loss (Lee long *et al.* 1997b). Monitoring and management of seagrass resources at both local and regional scales will enable detection of incremental losses and help in managing animal populations which are dependent on regional-scale seagrass resources.

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