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Port Curtis and Rodds Bay seagrass
and benthic macro-invertebrate
community baseline survey
November/December 2002



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EXECUTIVE SUMMARY

A survey of seagrass and deepwater benthic-macro-invertebrate communities in Port Curtis and Rodds Bay was conducted between October and December 2002. The survey area contained extensive seagrass communities in coastal and deeper offshore areas as well as a diverse range of benthic macro-invertebrate communities. Seagrass was the dominant habitat feature of intertidal banks in the port and the Dugong Protection Area (DPA) covering a total of 7,246 ha. Seagrass meadows were also found in deeper areas within the port limits covering an additional 6,332 ha. Seagrass communities in the port included meadows of species preferred as food by dugong as well as denser, high biomass meadows that are known to be important as juvenile prawn nursery grounds in other Queensland locations. The extensive areas of seagrass in Port Curtis and Rodds Bay are likely to be of regional significance as they are the only major area of seagrass between Hervey Bay (170 km south) and Shoalwater Bay (170 km north) that have been described.

Benthic macro-invertebrate communities were found throughout the deepwater section of the survey area. There was a clear difference in communities between the inner (inside Facing Island) and outer (outside Facing Island) port areas with the outer port area dominated by low-density benthic macro-invertebrate communities and the inner port dominated by highly diverse and high-density communities. The difference in community density was likely to be a result of the relatively high tidal currents flowing in the channels of the inner port area compared with that in the open area outside Facing Island.

The extensive distribution of seagrass within the port has implications for port development and maintenance programs. Many of the seagrass and benthic macro-invertebrate communities described in this survey occurred in proximity to maintained channels, port facilities, reclamations and the dredge spoil disposal site. The presence of seagrass in these areas indicates that current port management practices are meeting environmental requirements for maintenance of healthy seagrass communities. As the port expands however, these habitats are likely to come under increased pressure and will require ongoing monitoring, maintenance of good water quality, and careful design and placement of new port facilities for their continued health.

While results of this survey indicate seagrass communities within the Port Curtis port limits appear healthy, detailed historical comparisons were not possible, as this was the first fine scale survey of the complete area. Further monitoring of seagrasses in the port would be valuable given the proximity of meadows to port infrastructure and possible impacts associated with port and coastal developments. The ability of seagrasses to show measurable growth responses to changes in water quality and their extensive distribution through the port makes them an ideal candidate for monitoring marine environmental health in Port Curtis and should be considered in the design of the Port Curtis integrated monitoring program. Regular seagrass monitoring would give a better picture of the health of seagrass meadows and an overall indication of environmental health in the port. This survey provided the baseline information from which such a monitoring program could be established.

INTRODUCTION

Port Curtis (Port of Gladstone) is Queensland's largest and Australia's fourth largest multi-commodity port handling over 50 million tonnes of cargo each year (53.8 million tonnes in 2001/2002). A diverse range of cargoes move through the port with a significant amount of the cargo concerned with import and export of raw materials such as coal, bauxite and Naphtha as well as export of products processed and refined in the port such as alumina products and cement. The last decade has seen significant expansion of the port and facilities with plans to continue expansion to accommodate the growing industrial base in Gladstone. The Gladstone Port Authority (GPA) is the port authority for Port Curtis and is responsible for managing and operating port facilities as well as managing the port environment.

The naturally protected waters of Port Curtis provide shelter for a diverse and productive marine environment. Large seagrass meadows were identified in coastal areas within Port Curtis and Rodds Bay during broad-scale surveys of the east coast of Queensland in 1988 (Figure 1) (Coles *et al.* 1990). The value of these seagrasses as nursery habitat for juvenile prawns and commercial fish is well recognized (see Watson *et al.* 1993). Seagrasses in Queensland are also an important food resource for dugong and sea turtles. Recently the value of seagrasses in the Port Curtis area to dugong has been recognized by the declaration of the Rodds Bay Dugong Protection Area (DPA). The Rodds Bay DPA encompasses the majority of the port limit area (Figure 1). Seagrasses can also be used as a tool to monitor the environmental health of ports and coastal areas as they show measurable responses to changes in water quality (Dennison *et al.* 1993). The Queensland Fisheries Service (QFS) Marine Ecology Group (MEG) have established seagrass monitoring programs in a number of Queensland ports through the CRC Reef Research Centres Ports & Shipping program. These mapping and monitoring programs have aided in the planning of dredging programs and port developments that have a minimal effect on the marine environment as well as assisting in the assessment of effects of port maintenance and development operations.

GPA is committed to maintaining the health of the marine environment within the port limits, and has recognised that seagrass meadows comprise an important and sensitive component of the marine habitats within the port. GPA have been monitoring seagrasses at two locations in the port, Fisherman's Landing and Wiggins Island, bi-annually since 1997, but there has been no comprehensive survey of seagrasses within the port since 1988 and detailed fine-scale surveys of seagrasses within the whole port limits have not previously been conducted. Seagrass distribution in the deeper offshore areas within the port limits, including the dredge spoil ground is unknown, although deepwater seagrasses are known to occur to the north and south (Queensland Fisheries Service in prep). Similarly seagrass in areas of the Rodds Bay DPA that lie outside the Gladstone Port Limits have not been investigated since the 1988 broadscale surveys and have not been mapped as part of a fine scale survey.

Considering the current expansion and future development plans for the port, GPA has commissioned the MEG to conducted fine scale surveys of seagrass resources in the Gladstone port area. The goals of the study were to provide information required to aid in planning of port development and maintenance programs that will have minimal effects on the marine environment as well as information for more effective management of dugong within the Rodds Bay DPA. The survey will also provide a baseline from which seagrass

monitoring programs can be developed for Port Curtis and Rodds Bay. The survey area included all areas within the port limits and Rodds Bay Dugong Protected Area (Figure 1).

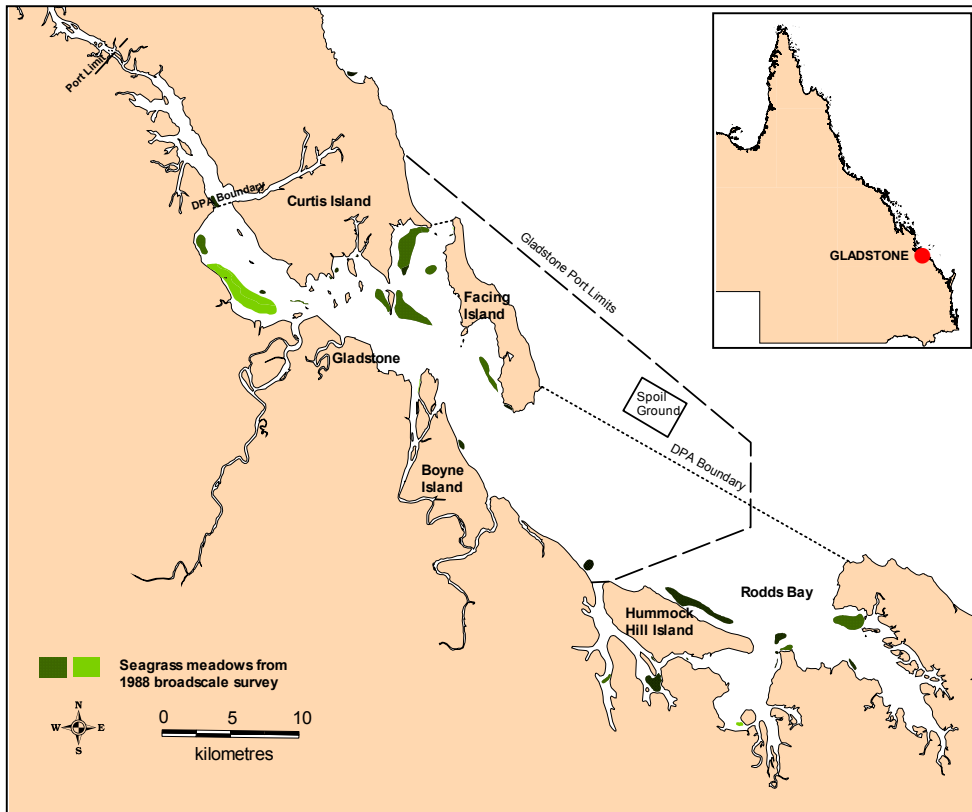


Figure 1 Location of Port Curtis & Rodds Bay survey area and seagrass meadows mapped in the 1988 broadscale survey

The sampling approach for the current survey was based on the need to establish baseline data on seagrass habitat within the study area, including seagrass characteristics such as above ground biomass, seagrass species composition and sediment characteristics for the major seagrass meadows in coastal and offshore areas. In conjunction with the offshore seagrass surveys, other important habitats including benthic macro-invertebrate (BMI) communities were surveyed. The objectives of this survey were to:

1. Survey and describe seagrass communities within the Gladstone port limits (Port Curtis) and the Rodds Bay Dugong Protection Area (DPA);
2. Establish a baseline from which monitoring programs can be developed;
3. Provide a GIS database and maps within and adjacent to dredged areas in the port and approach channels as well as the dredge spoil ground and areas planned for expansion of port facilities;
4. Discuss the implications of the survey results for protection of dugong in the Rodds Bay DPA and port development and maintenance programs.

METHODOLOGY

Survey Approach

Seagrass and benthic macro-invertebrate surveys of the Gladstone port limits (Port Curtis) and Rodds Bay were conducted between October and December 2002. The survey had two major components, a coastal intertidal to shallow subtidal seagrass survey, and an offshore (deepwater) seagrass and benthic macro-invertebrate survey.

Coastal Seagrass Survey

A variety of sampling methods were used to survey seagrass in coastal areas based on the physical characteristics such as depth, size of area to be surveyed and safety constraints. Three sampling techniques were used:

1. *Helicopter intertidal seagrass mapping and species validation*

Boundaries of intertidal seagrass meadows were determined around spring low tide when meadows were exposed. Observers in a helicopter hovered directly over the meadow edge (at a height of between 10-100m) and the position was fixed using a differential geographic positioning system (dGPS). Meadow boundary position fixes were taken approximately every 50m or when there was a change in boundary direction (Plate 1). Within meadows the helicopter was used to determine the range of seagrass species and meadow landscape category (Figure 2). The position of submerged areas likely to contain seagrass was noted to help focus effort during the boat-based surveys.



Plate 1 Helicopter intertidal mapping of exposed seagrass meadows at spring low tide.

2. *Intertidal seagrass habitat characterisation*

Sites to determine habitat characteristics were scattered randomly throughout the intertidal areas that were mapped using the helicopter. Sampling sites were examined from the helicopter hovering within a metre above the seagrass meadow. Sampling intensity was stratified with a greater number of sites located in areas where habitat complexity was high or where there was a higher likelihood of impacts (i.e. in proximity to port or town infrastructure or proposed developments) (Plate 2).



Plate 2 Intertidal habitat characterisation of exposed seagrass meadows from helicopter.

3. *Subtidal diver seagrass habitat characterisation*

In subtidal areas habitat characteristics were determined at sites located on transects. Additional sites were sampled between transects to check for habitat continuity. Sites were examined by free-diving observers swimming to the bottom. Seagrass meadow boundaries were determined by continuing transects until three successive sites indicated that seagrass was no longer present (Plate 3).



Plate 3 Subtidal habitat characterisation sites observed by free divers.

Coastal Seagrass Habitat Characterisation Sites

Coastal habitat characterisation was based on a site that encompassed a circular area of the substratum of approximately 10m². The position of each site was recorded using a differential Global Positioning System (dGPS) accurate to ± 5.0m. While methods of observing habitat characterisation sites varied (helicopter/diver), information collected at each site was consistent. This included seagrass species composition, seagrass above ground biomass, percent cover of algae, depth below mean sea level (MSL) (for subtidal sites), sediment type and the time. Seagrass above ground biomass 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 three random placements of a 0.25m² quadrat at each site. Ranks were made in reference to a series of quadrat photographs of similar seagrass habitat 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 completion of sampling each observer ranked a series of calibration quadrats 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.

Isolated seagrass patches - The majority of area within the meadows consisted of unvegetated sediment interspersed with isolated patches of seagrass



Aggregated seagrass patches - Meadows are comprised of numerous seagrass patches but still feature substantial gaps of unvegetated sediment within the meadow boundaries



Continuous seagrass cover - The majority of area within the meadows comprised of continuous seagrass cover interspersed with a few gaps of unvegetated sediment.



Figure 2 Seagrass meadow landscape categories used in the Port Curtis & Rodds Bay seagrass baseline survey, 2002.

Deepwater Seagrass & Benthic Macro-invertebrate Survey

A different approach was taken for offshore areas that were too deep for free divers to effectively sample (>5m below mean sea level). In these areas a deepwater camera system and sledge sampler was used. Offshore subtidal areas were sampled using a real time camera system towed behind the research vessel “Gwendoline May”. Offshore sites were randomly located throughout the survey area. A stratified random design was employed with a greater number of sites located in areas of particular interest such as the dredge spoil ground and in proximity to dredged channels.

Deepwater Habitat Characterisation Sites

At each offshore sampling site the real-time underwater camera system was towed for four minutes (time required to cover approximately 100 metres of benthos) at drift speed (less than one knot). Footage was observed on a TV monitor and recorded to digital tape. The camera was mounted on a sled that incorporated a sled net 600 mm width and 250 mm deep with a net of 10 mm-mesh aperture (Plate 4). Surface benthos was captured in the net (semi-quantitative bottom sample) and used to confirm benthic macro-invertebrates, algal and seagrass habitat characteristics observed on the monitor. Benthic macro-invertebrates collected in the sled net were identified into taxa groups and counts made of individuals (Plate 4). A Van Veen grab (grab area 0.0625 m²) was used to confirm sediment type and collect infaunal taxa.



Plate 4 Offshore video sampling sled and sorting benthic samples from the sled net.

For each site a benthic macro-invertebrate community density category was determined by analysis of the video record. Four community density categories were used:

- open substrate* - dominant feature was bare substrate with occasional isolated benthic macro-invertebrate individuals;
- low density* - benthic macro-invertebrates present on the screen for < 10% of the site video record;
- medium density* - benthic macro-invertebrates present in 10 - 80% of the site video record;
- high density* - benthic macro-invertebrates present on the screen for > 80% of the site video record.

Seagrass biomass was assessed for sites where seagrass presence was noted in the field. Seagrass biomass estimates were based on ten random time frames allocated within the four minutes of video footage for each site. Above ground seagrass biomass was determined by a visual estimates of biomass technique modified from Mellors (1991) for use with video recording. Seagrass species composition was also recorded. The video was paused at each of the ten random time frames selected then advanced to the nearest point on the tape where the bottom was visible and sled was stable on the bottom. From this frame an observer recorded an estimated rank of seagrass biomass and species composition. To standardise biomass estimates a 0.25 m² quadrat, scaled to the video camera lens used in the field, was superimposed on the screen. On completion of the videotape analysis, the video observer ranked five additional quadrats that had been previously videoed for calibration. These quadrats were videoed in front of a stationary camera, and then harvested, dried and weighed. A linear regression was calculated for the relationship between the observer ranks and the actual harvested value. This regression was used to calculate above ground biomass for all estimated ranks made from the survey sites.

Habitat Mapping and Geographic Information System

All data were entered into a Geographic Information System (GIS). Rectified colour aerial photographs of the Gladstone area (courtesy of Gladstone Port Authority & Beach Protection Authority/Department Natural Resources & Mines), combined with aerial photography and videotape footage taken from the helicopter during surveys 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 habitat boundaries.

Seagrass

The precision of determining seagrass meadow boundaries depended on the range of mapping information and methods available for each meadow. Intertidal meadow boundaries followed with dGPS had the highest precision. Large subtidal areas where meadow boundaries 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 next non-seagrass site.

Each meadow was assigned a mapping precision estimate (in metres) based on mapping methodology utilised for that meadow (Table 1). Mapping precision for coastal seagrass meadows ranged from $\pm \leq 5\text{m}$ for isolated intertidal seagrass meadows to $\pm 20\text{m}$ for subtidal meadows (Table 1). For offshore meadows where boundaries were determined by distance between video sampling sites mapping was less precise and ranged from $\pm 200\text{m}$ to $\pm 500\text{m}$ dependant on the distance between sites. The mapping precision estimate was used to calculate a range of meadow area for each meadow and was expressed as a meadow reliability estimate (R) in hectares. Additional 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 meadow reliability estimates.

The presence or absence of seagrass at each site 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.

Three GIS layers were created in MapInfo® to describe Port Curtis and Rodds Bay seagrasses:

- **Survey sites** - dGPS sites containing all data collected at seagrass survey sites;
- **Seagrass Landscape Category (coastal meadows only)** - area data (polygons) showing the seagrass landscape category determined for each meadow (see Figure 2 for category definitions);
- **Seagrass community types and density** - area data for seagrass meadows and information on community characteristics. Community types were determined according to overall species composition. A standard nomenclature system was used to name each of the meadows in the survey area. This system was based on the percent composition of biomass contributed by each species within the meadow (Table 2). This layer also included a measure of meadow density that was determined by the mean above ground biomass of the dominant species within the community (Table 3).

Table 1 Mapping precision and methodology for seagrass meadows in Port Curtis & Rodds Bay, October-December 2002.

Mapping precision	Mapping methodology
≤ 5m	Meadow boundaries mapped in detail by dGPS from helicopter; Intertidal meadows completely exposed or visible at low tide; Relatively high density of mapping and survey sites; Recent aerial photography aided in mapping.
10m	Meadow boundaries determined from helicopter and diver surveys; Inshore boundaries mapped from helicopter; Offshore boundaries interpreted from survey sites and aerial photography; Relatively high density of mapping and survey sites;
20m	Meadow boundary interpreted from diver surveys; All meadows subtidal; Relatively high density of survey sites; Recent aerial photography aided in mapping.
200m	Meadow boundary determined by offshore video sites; Offshore (deepwater) meadows only; Some depth information available for boundary determination.
300-500m	Meadow boundary determined by offshore video sites; Offshore (deepwater) meadows only; Relatively low density of survey sites.

Table 2 Nomenclature for community types in Port Curtis & Rodds Bay, October-December 2002.

Community type	Species composition
Species A	Species A is 90-100% of composition
Species A with Species B	Species A is 60-90% of composition
Species A with Species B/Species C	Species A is 50% of composition
Species A/Species B	Species A is 40% - 60% of composition

Table 3 Density categories and mean above ground biomass ranges for each species used in determining seagrass community density in Port Curtis & Rodds Bay, October-December 2002.

Density	Mean above ground biomass (g DW m ⁻²)				
	<i>H. uninervis</i> (narrow)	<i>H. ovalis</i> <i>H. decipiens</i>	<i>H. uninervis</i> (wide)	<i>H. spinulosa</i>	<i>Z. capricorni</i>
Light	< 1	< 1	< 5	< 15	< 20
Moderate	1 - 4	1 - 5	5 - 25	15 - 35	20 - 60
Dense	> 4	> 5	> 25	> 35	> 60

Benthic Macro-invertebrates

Benthic macro-invertebrate community boundaries were determined by information collected at the deepwater habitat characterisation sites. Unlike the coastal survey area there was limited additional information available to assist with mapping. As a consequence the precision in determining boundaries was much lower than for the coastal area and largely dependant on the distance between offshore video sampling sites. Mapping precision ranged from ± 200m to ± 500m dependant on the distance between sites. The mapping precision estimate was used to calculate a range of area for each benthic community region and was expressed as a reliability estimate (R) in hectares.

Two GIS layers were created in MapInfo[®] to describe Port Curtis and Rodds Bay benthic macro-invertebrate communities:

- **Survey sites** - dGPS sites containing all data collected at offshore benthic community survey sites;
- **Benthic Community density and category** - area data for benthic macro-invertebrate community regions. Community types (categories) within this layer were determined according to overall taxa composition observed on the video and collected in the sled net at sites within each region; and density was determined by the mean % time benthic macro-invertebrates were present on the video record for sites within regions.

RESULTS

A total of 1344 habitat characterisation sites were surveyed within Port Curtis and Rodds Bay (total does not including meadow boundary mapping sites). These sites included 1201 coastal sites examined from helicopter and by free divers and 143 deepwater sites examined using real-time video equipment (Table 4; Map 1).

Table 4 Survey sites and techniques in Port Curtis, November/December 2002.

Survey area	Survey technique	No. of sites
Coastal	Helicopter	618
	Free-divers	583
Deepwater	Real-time video	143
Total		1344

Seagrass

Six seagrass species (from three families) were found in the survey area:

Family CYMODOCEACEAE Taylor:

Halodule uninervis (wide and narrow leaf morphology) (Forsk.) Aschers. in Boissier

Family HYDROCHARITACEAE Jussieu:

Halophila decipiens Ostenfeld

Halophila minor (Zoll.) den Hartog

Halophila ovalis (R. Br.) Hook. F.

Halophila spinulosa (R. Br.) Aschers. in Neumayer

Family ZOSTERACEAE Drummortier:

Zostera capricorni Aschers.

Coastal Seagrass Habitat

Extensive areas of seagrass were found in the coastal component of the survey conducted in intertidal to shallow subtidal areas (< 5m below mean sea level). Coastal seagrass communities were found throughout the survey area from the Narrows in the north to Rodds Bay in the south. Seagrass communities were found on the majority of the shallow coastal mud and sand banks within the survey area but rarely penetrated far into subtidal areas off the edge of the banks.

Seagrass was present at 749 (62%) of the 1201 coastal survey sites. 7246 ± 421 ha of coastal seagrass habitat was mapped in 129 individual seagrass meadows (Maps 2-8; Tables 5-11). Seagrass meadows most commonly occurred on intertidal mud and sand substrates. There were only 12 coastal seagrass meadows that were completely subtidal and these were generally small *Halophila* dominated meadows immediately adjacent to the mud and sand banks (Maps 2-8; Tables 5-11). The maximum depth that coastal seagrasses

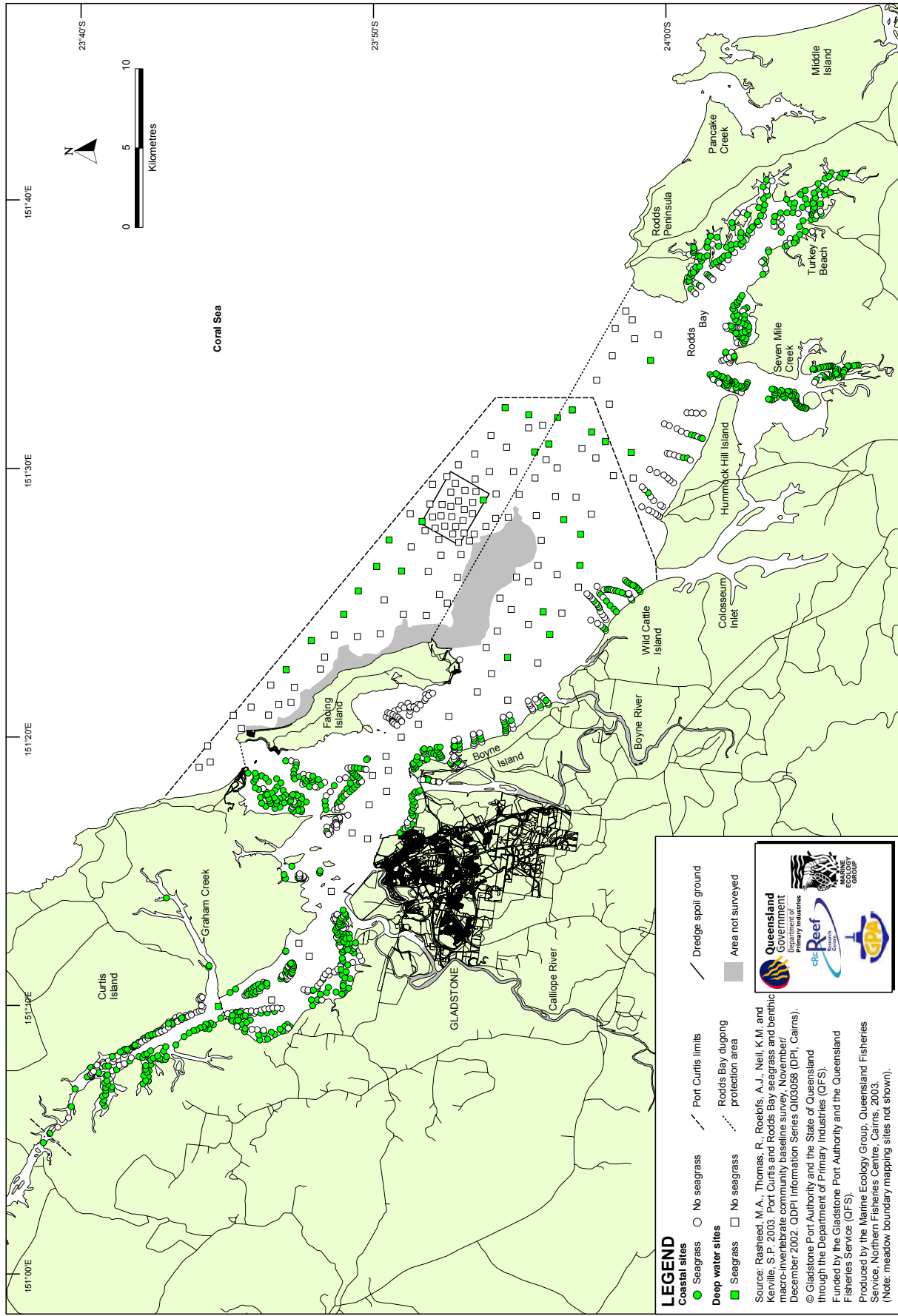
were recorded in the survey was 4.1 m below mean sea level for *Halophila spinulosa* in meadow 111 at the mouth of Seven Mile Creek, Rodds Bay (Map 7).

The coastal seagrass habitat in Port Curtis and Rodds Bay was divided into 32 community types, depending on species presence and dominance (Tables 5-11). Communities that were dominated by *Zostera capricorni* were the most widely distributed throughout the survey area and comprised 68% (90 individual meadows; 4955.5 ± 298.6 ha) of the coastal seagrass habitat. *Z. capricorni* often occurred in conjunction with *Halophila ovalis* to form both light and moderate biomass mixed species communities. *Z. capricorni* communities most commonly occurred as aggregated patches on the extensive intertidal mud and sand banks located throughout the survey area (Maps 2-8; Table 5-11).

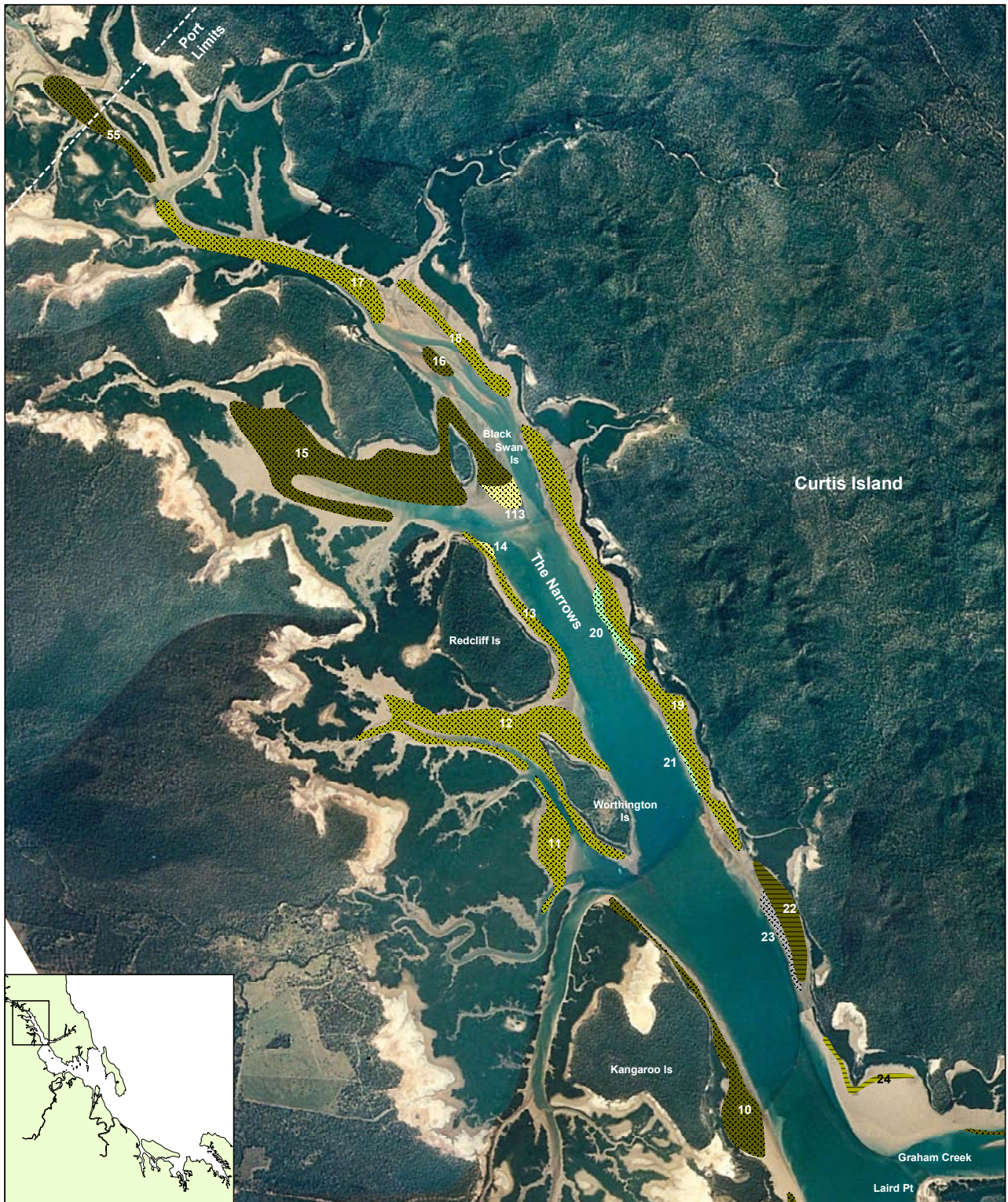
Communities dominated by *Halodule uninervis* (wide and thin leaf morphology) were the second most widely distributed and occurred in two main areas. In the north of the survey area, *H. uninervis* communities dominated the intertidal sand and mud banks between Quoin and Facing Islands. Further south, *H. uninervis* communities occurred in the shallow subtidal regions along the exposed coasts of Boyne, Wild Cattle and Hummock Hill Islands.

Minor coastal seagrass habitats included subtidal *Halophila ovalis* and *H. decipiens* communities located adjacent to Fisherman's Landing Wharves in the north and intertidal *H. ovalis* dominated communities further south in Rodds Bay. *H. spinulosa* dominated two communities at the mouth of Seven Mile Creek in Rodds Bay and also formed a minor component of other subtidal meadows throughout the survey area. *H. minor* was found at only a few sites on intertidal banks in Rodds Bay.

MAP 1. Coastal and deep water survey sites in Port Curtis and Rodds Bay, November/December 2002



MAP 2. Coastal seagrass distribution and community types in The Narrows region, 2002



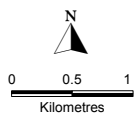
LEGEND

Community type

- Zostera capricorni* with *Halophila ovalis*
- Zostera capricorni*
- Halophila decipiens*
- Halophila decipiens* with *Halophila spinulosa*
- Halophila decipiens* with *Halophila spinulosa*/
Halophila ovalis

Meadow cover

- Isolated patches
- Aggregated patches
- Meadow ID



Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series QI03058 (DPI, Cairns).

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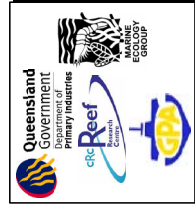


Table 5 Seagrass community types, cover, mean above ground biomass and area in The Narrows region (Map 2), November/December 2002.

Meadow ID	Community type	Cover	Species present	Biomass (g dw m ⁻²)	Area ± R (ha)	No. of sites
10	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. spinulosa</i>	3.6 ± 0.5	39.7 ± 6.6	13
11	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	11.3 ± 5.1	23.5 ± 3.2	5
12	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. decipiens</i> , <i>H. spinulosa</i>	7.2 ± 1.6	92.2 ± 12.3	21
13	Moderate <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	36.6 ± 7.4	17.2 ± 4.3	2
14	Moderate <i>Halophila decipiens</i>	Aggregated patches	<i>H. decipiens</i>	2.1 ± 0	1.0 ± 0.6	1
15	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	5.70 ± 0.8	149.1 ± 11.6	17
16	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	6.8 ± 0	5.2 ± 1.0	1
17	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	3.9 ± 2.8	50.2 ± 5.8	3
18	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	5.4 ± 0	19.8 ± 3.5	1
19	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. spinulosa</i>	12.1 ± 3.1	75.3 ± 10.1	13
20*	Moderate <i>Halophila decipiens</i> with <i>Halophila spinulosa</i>	Aggregated patches	<i>H. decipiens</i> , <i>H. spinulosa</i>	3.3 ± 1.1	6.8 ± 4.3	7
21*	Moderate <i>Halophila decipiens</i> with <i>Halophila spinulosa</i>	Aggregated patches	<i>H. decipiens</i> , <i>H. spinulosa</i>	1.2 ± 0.4	2.3 ± 1.8	4
22	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Isolated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	3.6 ± 2.1	22.3 ± 2.8	5
23*	Moderate <i>Halophila decipiens</i> with <i>Halophila spinulosa</i> / <i>Halophila ovalis</i>	Aggregated patches	<i>H. decipiens</i> , <i>H. spinulosa</i> , <i>H. ovalis</i>	2.4 ± 0.7	7.5 ± 2.3	5
24	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	6.5 ± 2.7	0
55	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	3.1 ± 2.9	26.1 ± 3.3	3
113	Moderate <i>Halophila decipiens</i>	Aggregated patches	<i>H. decipiens</i>	1.9 ± 0	7.5 ± 1.4	1

*denotes subtidal meadow

MAP 3. Coastal seagrass distribution and community types in the Graham Creek region, 2002



Source: Rasheed, M.A., Thomas, R., Roelids, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey. November/December 2002. QDP Information Series Q03058 (DPI, Cairns).
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LEGEND

Community type

- Zostera capricorni* with *Halophila ovalis*
- Zostera capricorni*

Meadow cover

- Isolated patches
- Aggregated patches

Meadow ID

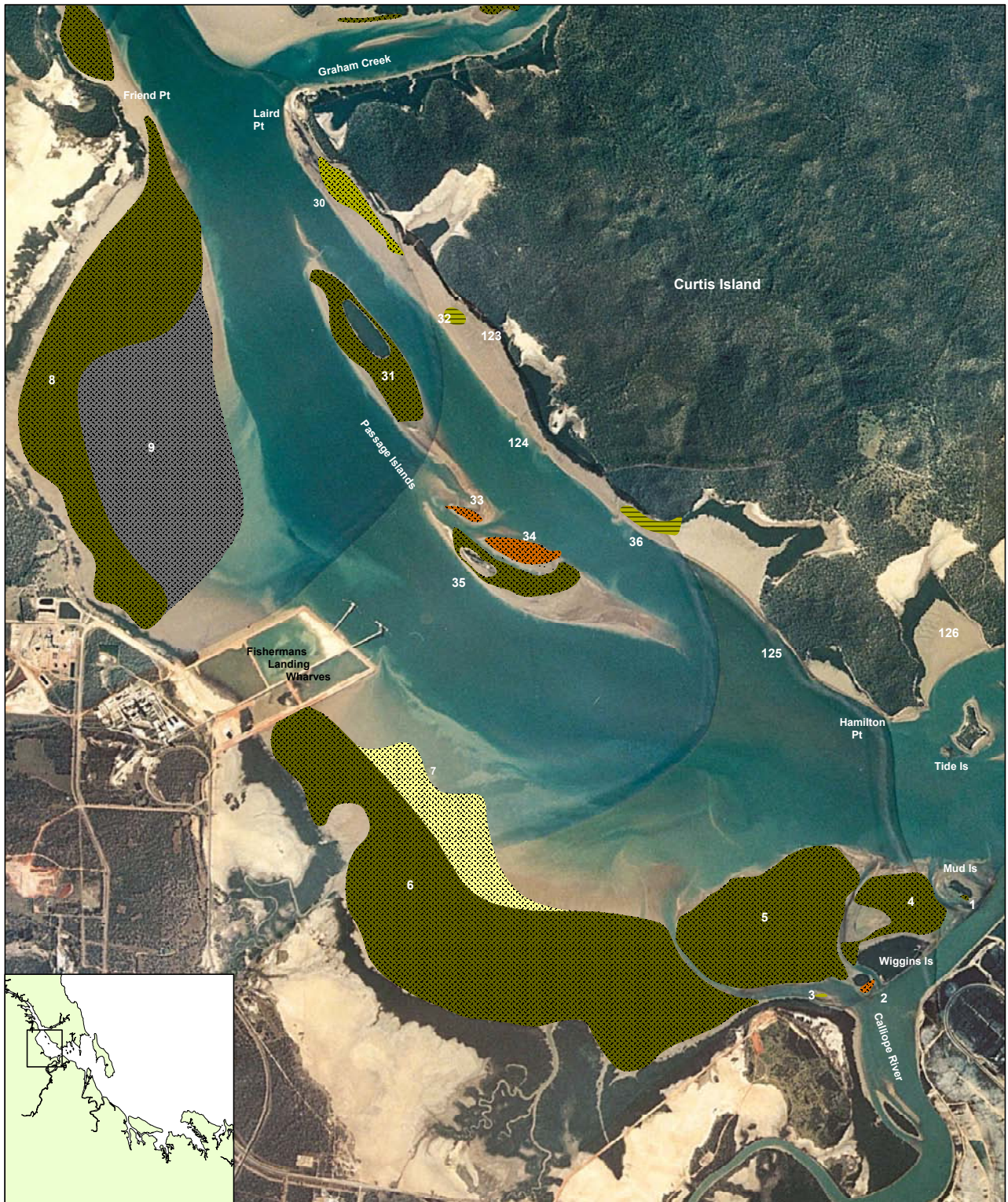
0 0.5 1
kilometres

N

Table 6 Seagrass community types, cover, mean above ground biomass and area in the Graham Creek region (Map 3), November/December 2002.

Meadow ID	Community type	Cover	Species present	Biomass (g dw m ⁻²)	Area ± R (ha)	No. of sites
25	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	2.3 ± 0.6	0
26	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	4.1 ± 0.5	2.8 ± 0.4	2
27	<i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	na	0.5 ± 0.3	0
28	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	0.9 ± 0.3	0
29	<i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	na	0.1 ± 0.1	0
114	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	0.7 ± 0.3	0
115	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	2.5 ± 0.3	0
116	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	11.3 ± 1.0	0
117	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	3.5 ± 1.7	0
118	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	3.1 ± 0	2.3 ± 0.4	1
119	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	1.8 ± 0.6	0

MAP 4. Coastal seagrass distribution and community types in Fishermans Landing region, 2002



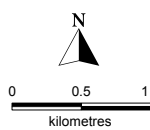
LEGEND

Community type

- Zostera capricorni* with *Halophila ovalis*
- Zostera capricorni*
- Halophila decipiens*
- Halophila ovalis* with *Zostera capricorni*
- Halophila decipiens* with *Halophila ovalis*

Meadow cover

- Isolated patches
- Aggregated patches
- Continuous cover
- Meadow ID



Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series QI03058 (DPI, Cairns).

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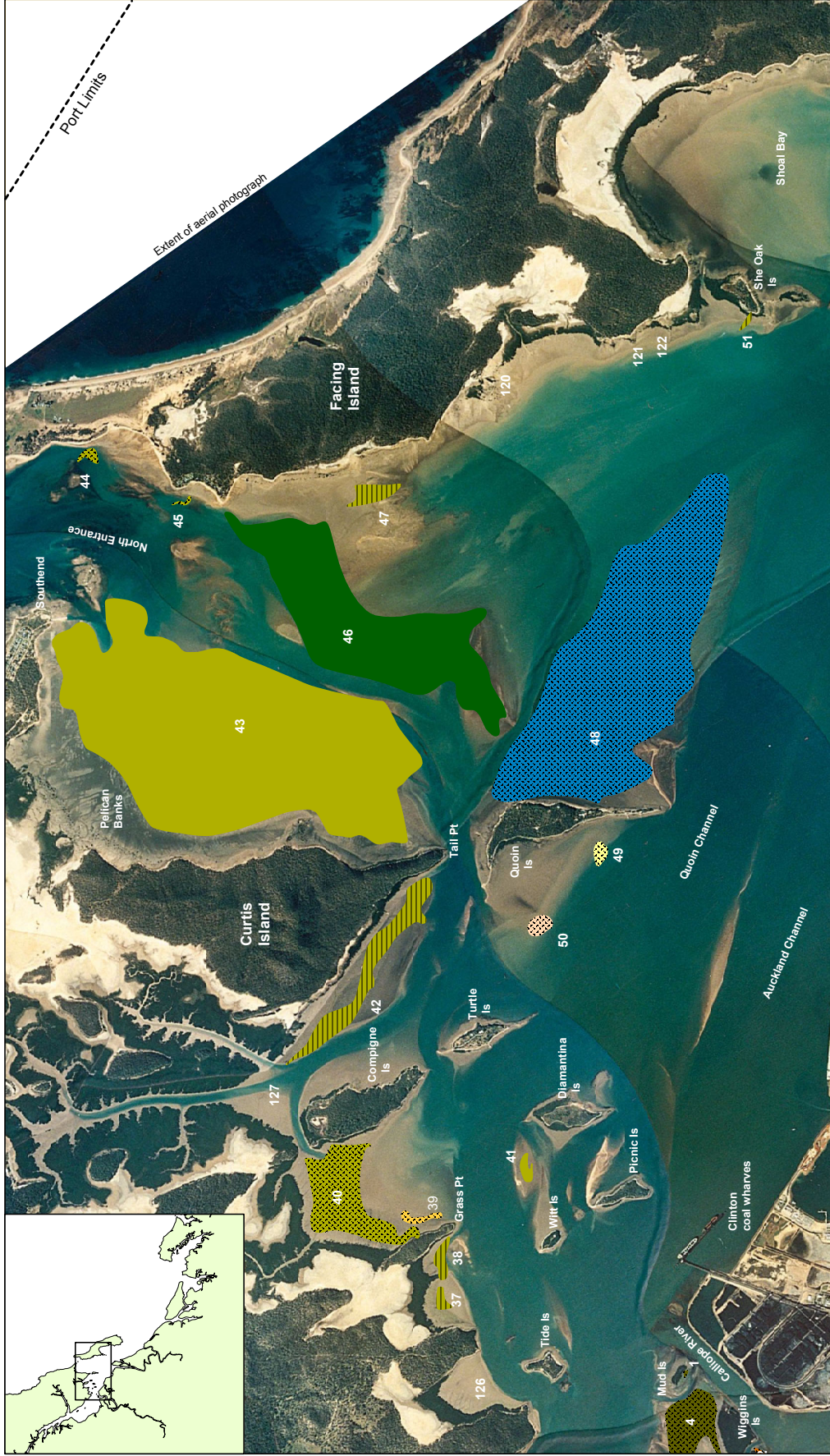


Table 7 Seagrass community types, cover, mean above ground biomass and area in Fisherman's Landing region (Map 4), November/December 2002.

Meadow ID	Community type	Cover	Species present	Biomass (g dw m ⁻²)	Area ± R (ha)	No. of sites
1	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	0.5 ± 0	0.3 ± 0.1	1
2	<i>Halophila ovalis</i> with <i>Zostera capricorni</i>	Aggregated patches	<i>H. ovalis</i> , <i>Z. capricorni</i>	na	0.9 ± 0.2	0
3	<i>Halophila ovalis</i> with <i>Zostera capricorni</i>	Isolated patches	<i>H. ovalis</i> , <i>Z. capricorni</i>	na	0.3 ± 0.1	0
4	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	0.8 ± 0.4	35.8 ± 1.7	11
5	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (thin)	1.4 ± 0.3	149.8 ± 2.5	31
6	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. decipiens</i> , <i>H. spinulosa</i>	1.1 ± 0.1	464.0 ± 12.9	32
7	Light <i>Halophila decipiens</i>	Aggregated patches	<i>H. decipiens</i>	0.9 ± 0.2	72.6 ± 11.4	3
8	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. decipiens</i> , <i>H. spinulosa</i>	2.1 ± 0.3	269.1 ± 11.3	34
9	Light <i>Halophila decipiens</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>H. decipiens</i> , <i>H. ovalis</i>	0.9 ± 0.3	268.3 ± 14.9	7
30	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	2.9 ± 1.5	14.9 ± 1.3	2
31	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	0.9 ± 0.2	40.0 ± 2.6	19
32	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	2.4 ± 0.3	0
33	Moderate <i>Halophila ovalis</i> with <i>Zostera capricorni</i>	Aggregated patches	<i>H. ovalis</i> , <i>Z. capricorni</i>	2.0 ± 1.2	2.1 ± 0.4	3
34	Moderate <i>Halophila ovalis</i> with <i>Zostera capricorni</i>	Aggregated patches	<i>H. ovalis</i> , <i>Z. capricorni</i>	1.0 ± 0.5	10.1 ± 0.8	6
35	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	0.7 ± 0.2	22.1 ± 2.0	18
36	Light <i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	0.3 ± 0.3	6.5 ± 0.7	2
123	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	na	0
124	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	na	0
125	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	na	0
126	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	na	0

* denotes subtidal meadow

MAP 5. Coastal seagrass distribution and community types in the Quoin Island region, 2002

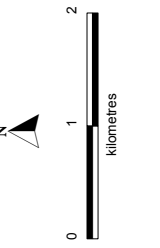


LEGEND

- Community type**
- Zostera capricorni* with *Halophila ovalis*
 - Zostera capricorni*
 - Halophila decipiens*
 - Halophila ovalis* with *Halophila decipiens*
 - Halophila ovalis*

- Meadow cover**
- Halodule uninervis* (thin) with *Halodule uninervis* (wide)
 - Halodule uninervis* (wide) with *Zostera capricorni* / *Halodule uninervis* (thin)
 - Continuous cover
 - Meadow ID

- Isolated patches
- Aggregated patches



Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodd's Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series QI030368 (DPI, Cairns).

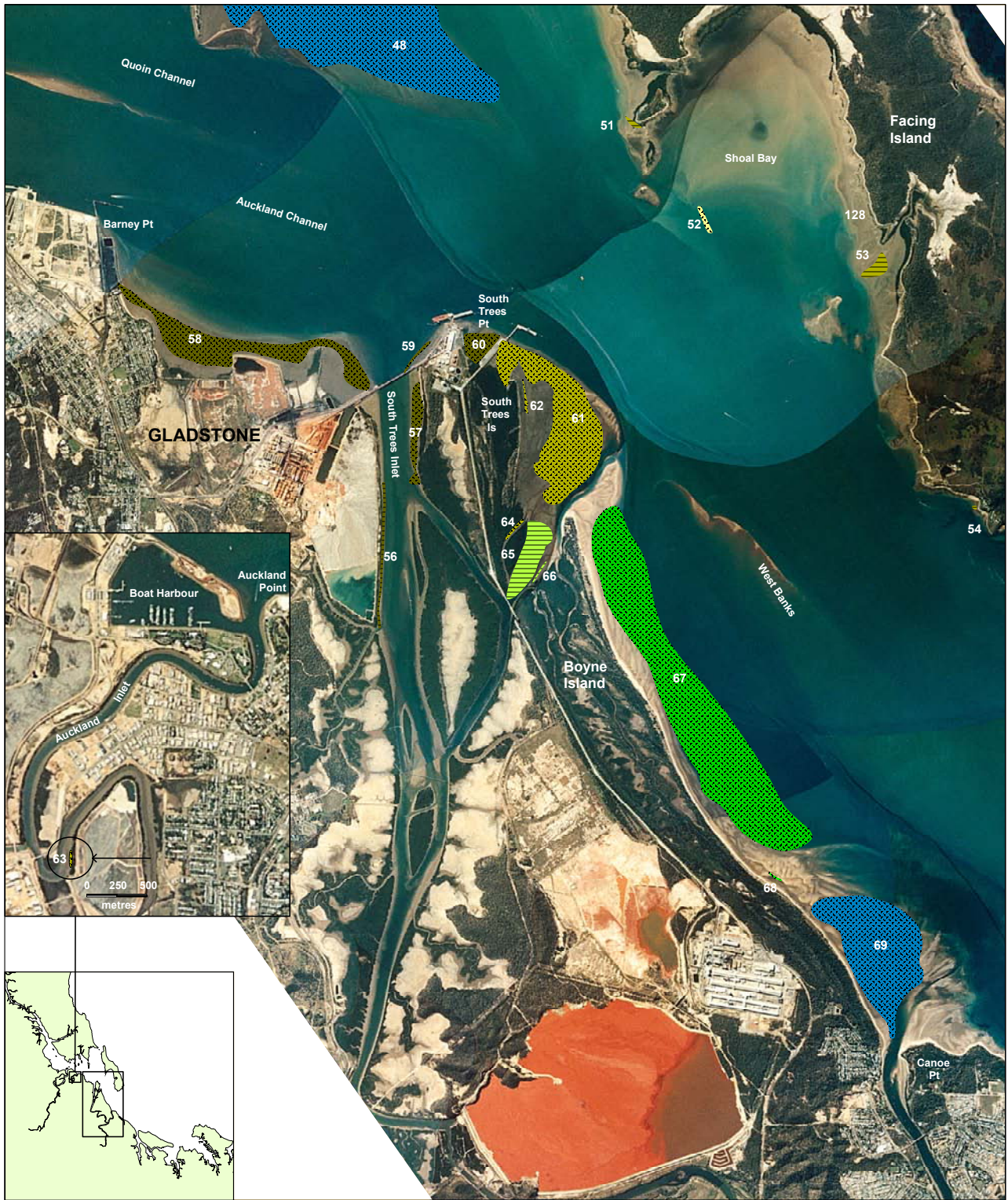
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 Produced by the Marine Ecology Group, Queensland Fisheries Service, Northern Fisheries Centre, Cairns, 2003.

Table 8 Seagrass community types, cover, mean above ground biomass and area in the Quoin Island region (Map 5), November/December 2002.

Meadow ID	Community type	Cover	Species present	Biomass (g dw m ⁻²)	Area ± R (ha)	No. of sites
37	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	2.6 ± 0.4	0
38	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	4.8 ± 0.6	0
39	Moderate <i>Halophila ovalis</i> with <i>Halophila decipiens</i>	Aggregated patches	<i>H. ovalis</i> , <i>H. decipiens</i>	1.3 ± 0.4	3.1 ± 2.3	3
40	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	0.8 ± 0.2	62.4 ± 4.5	3
41	Light <i>Zostera capricorni</i>	Continuous cover	<i>Z. capricorni</i> , <i>H. ovalis</i>	3.6 ± 0.6	3.0 ± 0.5	3
42	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	42.4 ± 5.6	0
43	Moderate <i>Zostera capricorni</i>	Continuous cover	<i>Z. capricorni</i> , <i>H. uninervis</i> (wide), <i>H. ovalis</i> , <i>H. spinulosa</i>	20.8 ± 3.1	624.8 ± 12.3	58
44	<i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	2.3 ± 0.4	0
45	<i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	0.8 ± 0.3	0
46	Moderate <i>Halodule uninervis</i> (wide) with <i>Zostera capricorni</i> / <i>Halodule uninervis</i> (thin)	Continuous cover	<i>H. uninervis</i> (wide), <i>Z. capricorni</i> , <i>H. uninervis</i> (thin), <i>H. ovalis</i> , <i>H. spinulosa</i>	9.8 ± 2.9	245.5 ± 9.7	27
47	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	8.6 ± 0.7	0
48	Moderate <i>Halodule uninervis</i> (thin) with <i>Halodule uninervis</i> (wide)	Aggregated patches	<i>H. uninervis</i> (thin), <i>H. uninervis</i> (wide), <i>H. spinulosa</i> , <i>H. ovalis</i> , <i>Z. capricorni</i>	1.8 ± 0.2	421.4 ± 10.2	39
49*	Moderate <i>Halophila decipiens</i>	Aggregated patches	<i>H. decipiens</i>	1.4 ± 0.6	3.0 ± 1.5	4
50*	Moderate <i>Halophila ovalis</i>	Aggregated patches	<i>H. ovalis</i>	1.4 ± 0	4.6 ± 1.7	1
51	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	1.0 ± 0.3	0
120	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	na	0
121	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	na	0
122	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	na	0
127	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	na	0

* denotes subtidal meadow

MAP 6. Coastal seagrass distribution and community types in the South Trees region, 2002



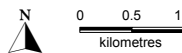
LEGEND

Community type

- Zostera capricorni* with *Halophila ovalis*
- Halophila decipiens*
- Zostera capricorni*
- Halodule uninervis* (thin) with *Halodule uninervis* (wide)
- Halodule uninervis* (wide) with *Halophila ovalis*
- Halodule uninervis* (wide) with *Halodule uninervis* (thin) / *Zostera capricorni*

Meadow cover

- Isolated patches
- Aggregated patches
- Meadow ID



Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/ December 2002. QDPI Information Series QI03058 (DPI, Cairns).

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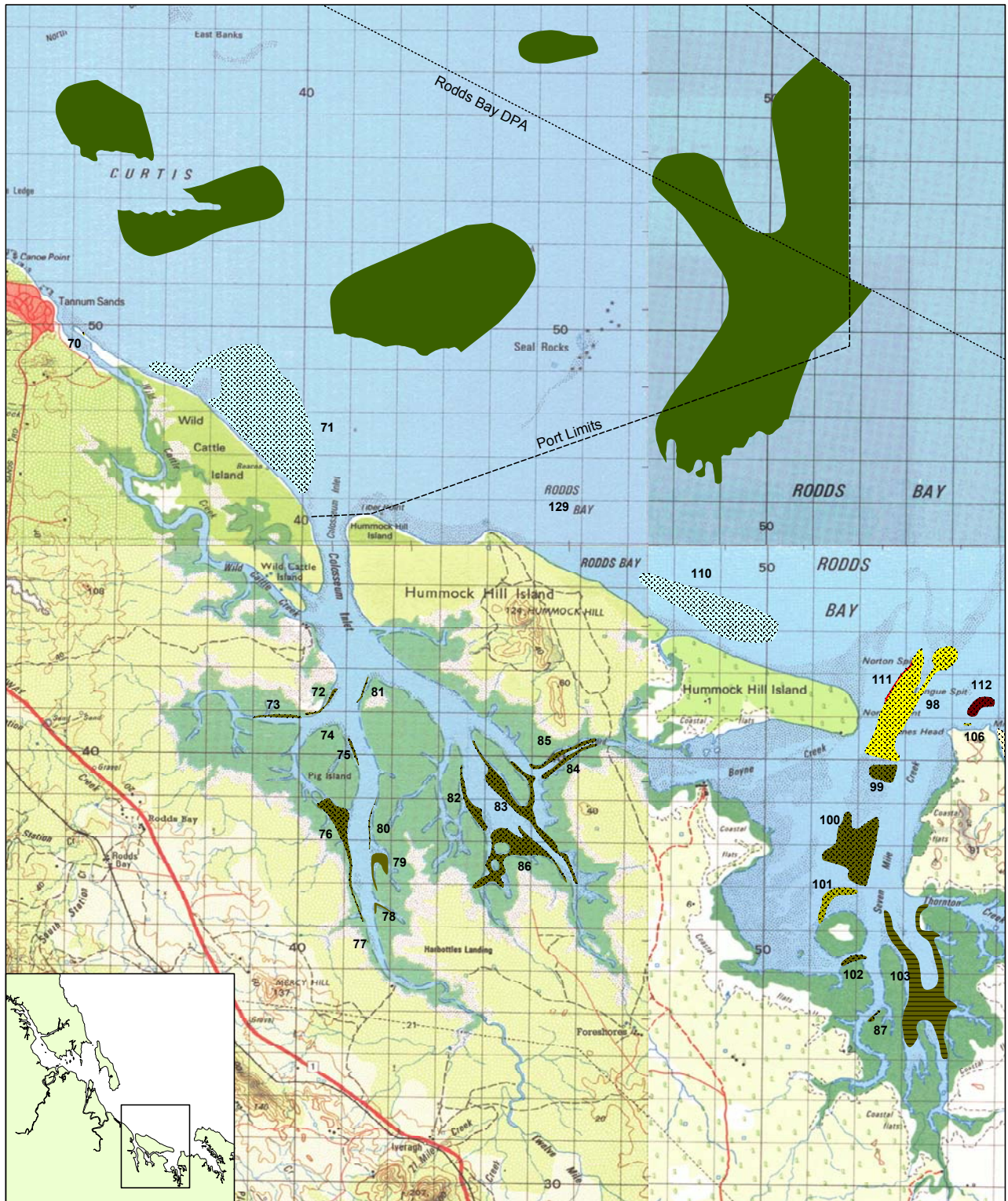
Produced by the Marine Ecology Group, Queensland Fisheries Service, Northern Fisheries Centre, Cairns, 2003.

Table 9 Seagrass community types, cover, mean above ground biomass and area in the South Trees region (Map 6), November/December 2002.

Meadow ID	Community type	Cover	Species present	Biomass (g dw m ⁻²)	Area ± R (ha)	No. of sites
52*	Light <i>Halophila decipiens</i>	Aggregated patches	<i>H. decipiens</i>	0.5 ± 0	2.0 ± 1.7	1
53	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	5.3 ± 0.5	0
54	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	0.2 ± 0.1	0
56	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Isolated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	5.3 ± 1.9	0
57	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	7.0 ± 6.3	12.0 ± 1.4	5
58	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	1.8 ± 0.5	71.9 ± 3.9	23
59	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	1.6 ± 0.6	0
60	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	9.4 ± 3.3	11.1 ± 0.7	6
61	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	4.7 ± 1.7	108.5 ± 3.2	20
62	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	19.2 ± 0	1.0 ± 0.4	1
63	<i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	na	0.3 ± 0.2	0
64	Moderate <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	56.6 ± 19.7	1.1 ± 0.7	4
65	Moderate <i>Halodule uninervis</i> (wide) with <i>Halophila ovalis</i>	Isolated patches	<i>H. uninervis</i> (wide), <i>H. ovalis</i>	15.8 ± 8.0	24.3 ± 2.5	7
66	<i>Halodule uninervis</i> (wide) with <i>Halophila ovalis</i>	Isolated patches	<i>H. uninervis</i> (wide), <i>H. ovalis</i>	na	0.6 ± 0.3	0
67	Light <i>Halodule uninervis</i> (wide) with <i>Halodule uninervis</i> (thin)/ <i>Zostera capricorni</i>	Aggregated patches	<i>H. uninervis</i> (wide), <i>H. uninervis</i> (thin), <i>Z. capricorni</i> , <i>H. ovalis</i>	2.9 ± 0.6	272.7 ± 10.5	21
68	<i>Halodule uninervis</i> (thin) with <i>Halodule uninervis</i> (wide)	Aggregated patches	<i>H. uninervis</i> (thin), <i>H. uninervis</i> (wide)	na	0.4 ± 0.2	0
69	Light <i>Halodule uninervis</i> (thin) with <i>Halodule uninervis</i> (wide)	Aggregated patches	<i>H. uninervis</i> (thin), <i>H. uninervis</i> (wide)	0.9 ± 0.7	123.1 ± 5.1	15
128	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	na	0

*denotes subtidal meadow

MAP 7. Coastal seagrass distribution and community types in Hummock Hill Island region, 2002



LEGEND

Community type

- Zostera capricorni* with *Halophila ovalis*
- Zostera capricorni*
- Halophila spinulosa* with *Halodule uninervis* (thin) *Zostera capricorni*
- Zostera capricorni* with *Halodule uninervis* (thin)
- Halophila spinulosa* with *Halodule uninervis* (wide)

- Halodule uninervis* (thin)
- Deep water meadow
- Meadow ID

Meadow cover

- Isolated patches
- Aggregated patches
- Continuous cover

0 1 2
Kilometres



Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series QI03058 (DPI, Cairns).
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 Basemap courtesy AUSLIG, Australia's national mapping agency 2003.

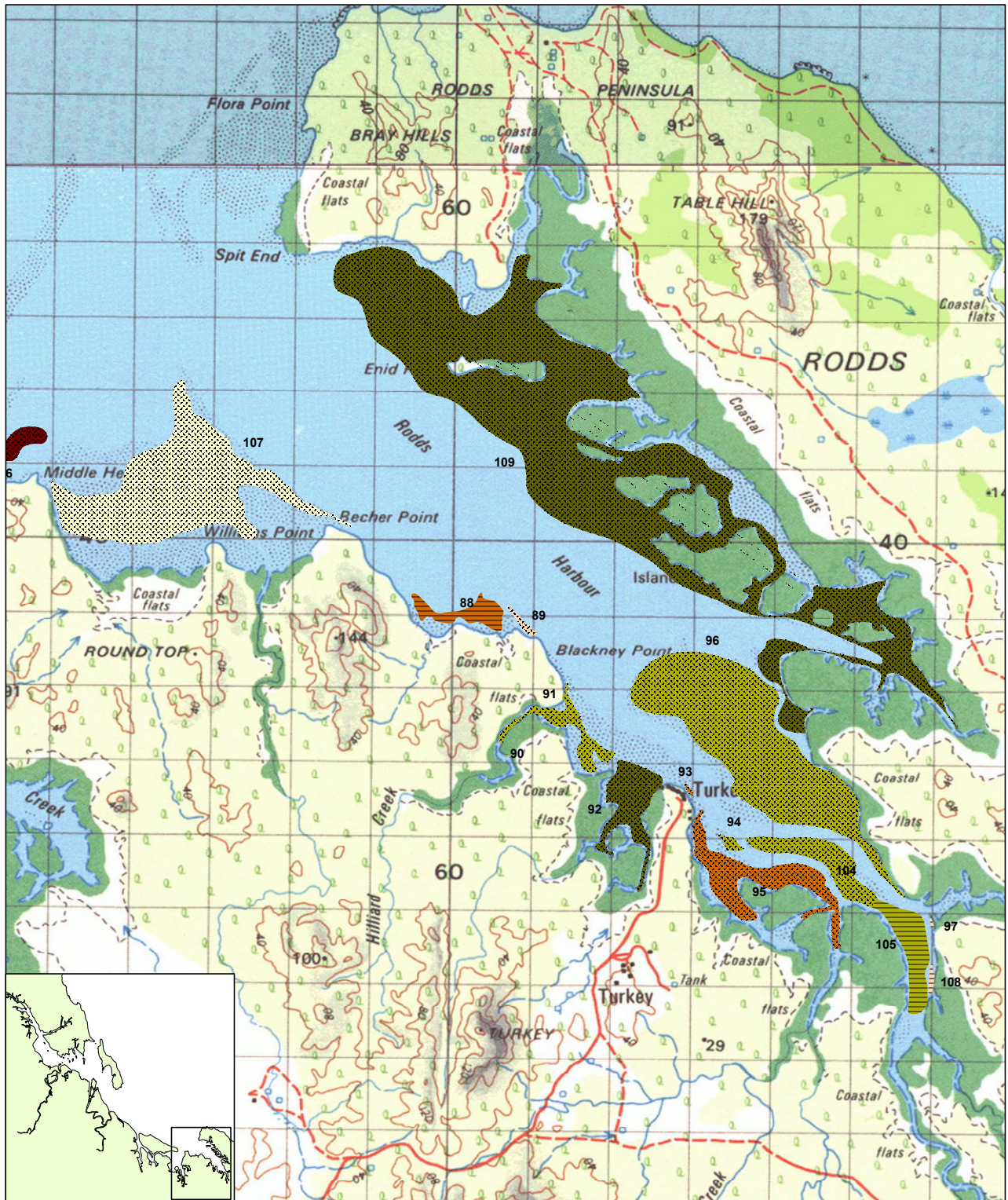


Table 10 Seagrass community types, cover, mean above ground biomass and area in the Hummock Hill Island region (Map 7), November/December 2002.

Meadow ID	Community type	Cover	Species present	Biomass (g dw m ⁻²)	Area ± R (ha)	No. of sites
70	<i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	na	0.2 ± 0.1	0
71	Moderate <i>Halodule uninervis</i> (thin)	Aggregated patches	<i>H. uninervis</i> (thin), <i>H. ovalis</i> , <i>Z. capricorni</i>	2.1 ± 0.4	484.8 ± 12.4	34
72	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	4.9 ± 1.0	0
73	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	5.9 ± 1.1	0
74	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	na	0
75	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	3.1 ± 0.7	0
76	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (wide)	na	40.6 ± 3.3	0
77	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Continuous cover	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (wide)	na	0.1 ± 0.1	0
78	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Continuous cover	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (wide)	na	2.8 ± 0.7	0
79	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Continuous cover	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (wide)	na	13.4 ± 1.4	0
80	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (wide)	na	2.5 ± 1.3	0
81	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	2.2 ± 0.7	0
82	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (wide)	na	18.5 ± 3.5	0
83	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (wide)	na	69.7 ± 11.0	0
84	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (wide)	na	12.6 ± 3.0	0
85	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (wide)	na	13.7 ± 3.4	0
86	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (wide)	na	75.2 ± 9.3	0
87	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	2.0 ± 0.4	0
98	Light <i>Zostera capricorni</i> with <i>Halodule uninervis</i> (thin)	Aggregated patches	<i>Z. capricorni</i> , <i>H. uninervis</i> (thin), <i>H. uninervis</i> (wide), <i>H. ovalis</i> , <i>H. minor</i>	8.5 ± 2.4	160.7 ± 9.5	25
99	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	20.2 ± 1.8	0
100	Moderate <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	23.5 ± 3.9	115.3 ± 2.6	27
101	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	3.2 ± 0.8	20.5 ± 1.4	13
102	<i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	na	6.7 ± 0.7	0
103	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Isolated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	3.5 ± 1.0	171.8 ± 7.2	44
106*	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	2.4 ± 1.4	0.8 ± 0.2	2
110*	Dense <i>Halodule uninervis</i> (thin)	Aggregated patches	<i>H. uninervis</i> (thin), <i>H. ovalis</i> , <i>Z. capricorni</i>	4.2 ± 0.6	202.3 ± 14.4	7
111*	Light <i>Halophila spinulosa</i> with <i>Halodule uninervis</i> (thin)/ <i>Zostera capricorni</i>	Aggregated patches	<i>H. spinulosa</i> , <i>H. uninervis</i> (thin), <i>Z. capricorni</i> , <i>H. ovalis</i>	7.2 ± 2.9	4.1 ± 2.5	7
112*	Light <i>Halophila spinulosa</i> with <i>Halodule uninervis</i> (wide)	Aggregated patches	<i>H. spinulosa</i> , <i>H. uninervis</i> (wide)	10.7 ± 5.9	15.3 ± 1.7	6
129	Dense <i>Halophila decipiens</i>	Isolated patches	<i>H. decipiens</i>	6.5 ± 1.0	0.1 ± 0	1

* denotes subtidal meadow

MAP 8. Coastal seagrass distribution and community types in the Rodds Bay region, 2002



LEGEND

Community type

- Zostera capricorni* with *Halophila ovalis*
- Halophila ovalis*
- Zostera capricorni*
- Halophila ovalis* with *Zostera capricorni*
- Zostera capricorni* with *Halodule uninervis* (wide)/
Halodule uninervis (thin)
- Halophila spinulosa* with *Halodule uninervis* (wide)

Meadow cover

- Isolated patches
- Aggregated patches
- Meadow ID

0 0.5 1
kilometres



Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series QI03058 (DPI, Cairns).

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Produced by the Marine Ecology Group, Queensland Fisheries Service, Northern Fisheries Centre, Cairns, 2003.

Basemap courtesy AUSLIG, Australia's national mapping agency 2003.



Table 11 Seagrass community types, cover, mean above ground biomass and area in the Rodds Bay region (Map 8), November/December 2002.

Meadow ID	Community type	Cover	Species present	Biomass (g dw m ⁻²)	Area ± R (ha)	No. of sites
88	Light <i>Halophila ovalis</i> with <i>Zostera capricorni</i>	Isolated patches	<i>H. ovalis</i> , <i>Z. capricorni</i>	0.9 ± 0.4	24.9 ± 1.7	5
89	Light <i>Halophila ovalis</i>	Aggregated patches	<i>H. ovalis</i>	0.5 ± 0	3.3 ± 0.6	1
90	<i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i>	na	0.1 ± 0.1	0
91	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	16.9 ± 7.5	29.2 ± 2.8	7
92	Light <i>Zostera capricorni</i> with <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	2.2 ± 1.6	52.6 ± 2.9	4
93	Moderate <i>Halophila ovalis</i> with <i>Zostera capricorni</i>	Aggregated patches	<i>H. ovalis</i> , <i>Z. capricorni</i>	1.7 ± 0	0.6 ± 0.2	1
94	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i>	15.1 ± 11.8	3.4 ± 0.4	3
95	Light <i>Halophila ovalis</i> with <i>Zostera capricorni</i>	Aggregated patches	<i>H. ovalis</i> , <i>Z. capricorni</i>	0.8 ± 0.4	76.8 ± 4.3	8
96	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	6.4 ± 3.1	321.9 ± 10.6	21
97	Moderate <i>Halophila ovalis</i>	Isolated patches	<i>H. ovalis</i>	1.1 ± 0	0.4 ± 0.2	1
104	Light <i>Zostera capricorni</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. ovalis</i> , <i>H. uninervis</i> (thin)	8.4 ± 3.7	47.7 ± 4.3	17
105	Light <i>Zostera capricorni</i>	Isolated patches	<i>Z. capricorni</i> , <i>H. ovalis</i>	1.9 ± 1.9	44.2 ± 3.9	3
107	Light <i>Zostera capricorni</i> with <i>Halodule uninervis</i> (wide)/ <i>Halodule uninervis</i> (thin)	Aggregated patches	<i>Z. capricorni</i> , <i>H. uninervis</i> (wide), <i>H. uninervis</i> (thin), <i>H. ovalis</i> , <i>H. minor</i>	5.7 ± 1.4	278.0 ± 11.5	50
108	Light <i>Halophila ovalis</i>	Isolated patches	<i>H. ovalis</i>	0.3 ± 0.3	2.1 ± 0.4	2
109	Light <i>Zostera capricorni</i> with <i>Halodule uninervis</i> (thin)/ <i>Halophila ovalis</i>	Aggregated patches	<i>Z. capricorni</i> , <i>H. uninervis</i> (thin), <i>H. ovalis</i> , <i>H. uninervis</i> (wide), <i>H. spinulosa</i> , <i>H. decipiens</i> , <i>H. minor</i>	7.9 ± 1.7	879.3 ± 50.1	83

Deepwater Seagrass Habitat

Large areas of deepwater seagrass (>5m below MSL) were found within the Port Curtis port limits. Seagrass occurred at 17% of the offshore survey sites and formed six individual meadows with a total area of 6,332 ha (Table 12; Map 9). Deepwater meadows occurred offshore from Facing Island and around Seal Rocks, West Banks and East Banks (Map 9). No deepwater meadows occurred in the inner port area (inside Facing Island).

Deepwater seagrass meadows were dominated by low biomass *Halophila* species (Plate 5) with *Halodule uninervis* (narrow) occurring in only one meadow (Table 12). Cover of seagrass in the deepwater meadows was low ranging from 0.01% to 1.9% of the total bottom area (Table 12). The maximum depth recorded for offshore seagrass was 19.1m below mean sea level for *Halodule spinulosa* in meadow 130 (Map 9).

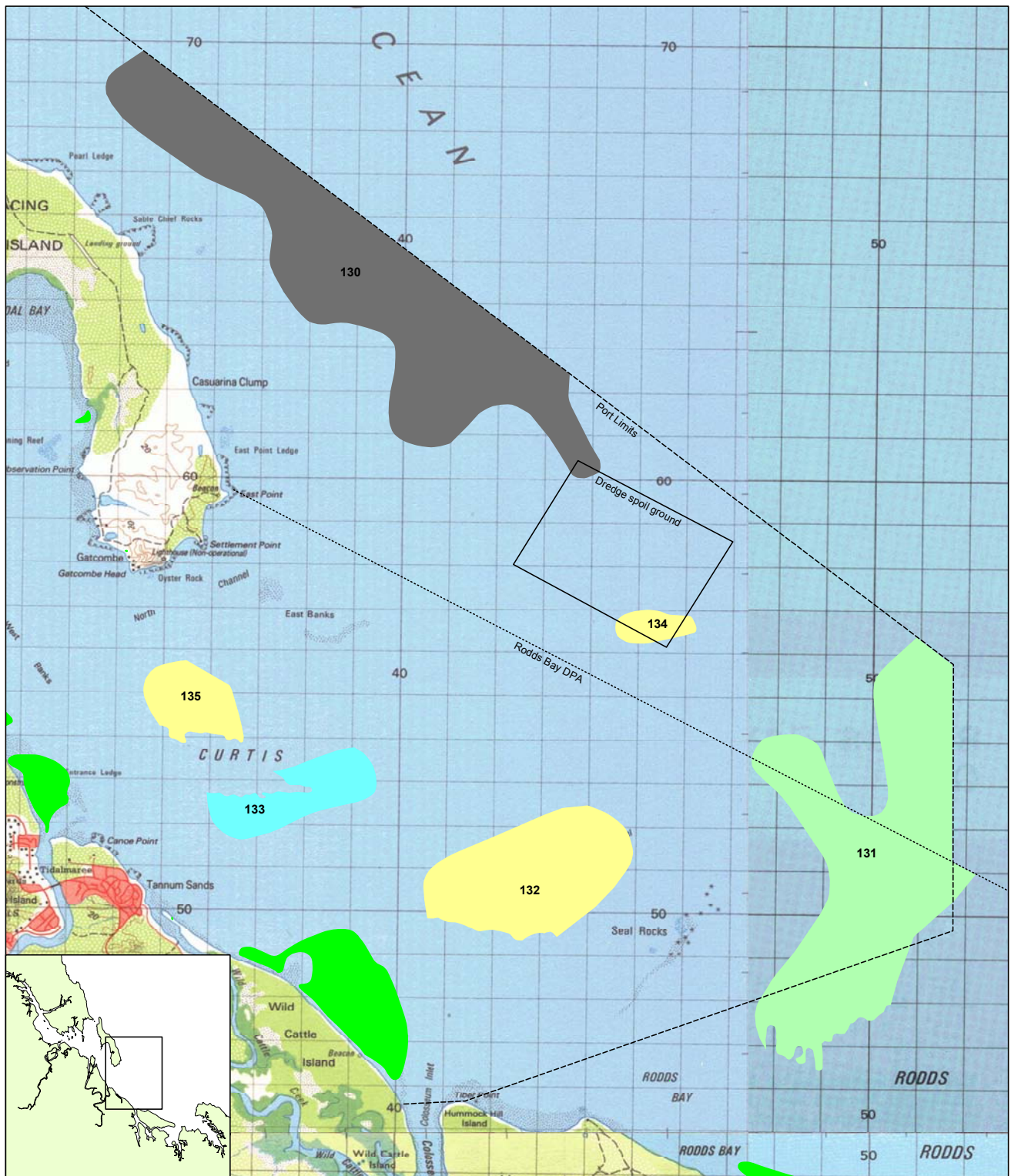
Table 12 Deepwater seagrass community types, cover, mean above ground biomass and area in Port Curtis and Rodds Bay November/December 2002.

Meadow ID	Community type	Mean meadow biomass g DW m ⁻² ± SE	Number of sites	Area ± R (ha)	Mean % seagrass cover
130	Light <i>Halophila spinulosa</i> / <i>Halophila decipiens</i> / <i>Halophila ovalis</i>	0.17 ± 0.14	8	2449 ± 1700	1.9
131	Light <i>Halophila decipiens</i> with <i>Halophila spinulosa</i>	0.17 ± 0.17	9	2214 ± 1589	0.3
132	Light <i>Halophila decipiens</i>	0.06 ± 0.06	3	920 ± 675	0.9
133	Light <i>Halodule uninervis</i> (narrow)/ <i>Halophila ovalis</i>	0.01	2	369 ± 331	0.04
134	Light <i>Halophila decipiens</i>	0.17	1	102 ± 96	0.5
135	Light <i>Halophila decipiens</i>	0.01	1	278 ± 233	0.01
Total			24	6332 ± 4624	



Plate 5 Deepwater seagrass habitats in Port Curtis (a) *Halophila spinulosa*/ *Halophila decipiens*/ *Halophila ovalis*; (b) *Halophila decipiens*.

MAP 9. Deep water seagrass distribution and community types in Port Curtis and Rodds Bay, 2002



LEGEND

Community type

- Halophila decipiens* with *Halophila spinulosa*
- Halophila decipiens*
- Halophila spinulosa*/*Halophila decipiens*/*Halophila ovalis*
- Halodule uninervis* (narrow) / *Halophila ovalis*
- Coastal seagrass meadow

131 Meadow ID



Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series QI03058 (DPI, Cairns).

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Produced by the Marine Ecology Group, Queensland Fisheries Service, Northern Fisheries Centre, Cairns, 2003.
Basemap courtesy AUSLIG, Australia's national mapping agency 2003.



Benthic Macro-invertebrates

Benthic macro-invertebrates occurred throughout the survey area (Map 10). The dominant community types in the area outside of Facing Island were those that had a low density of macro-invertebrates with open substrate comprising the majority of the area (Map 10; Table 13). There were two small areas of higher density macro-invertebrates associated with coral bommies outside Facing Island and medium density communities within the dredge spoil disposal site and surrounding seal rocks (Map 10). Inside Facing Island benthic communities were dominated by medium and high-density community types with only small areas of low-density communities (Map 10; Table 13). Benthic macro-invertebrate communities were divided into regions based on density of individuals and community composition. There were four density categories and a range of different community types within the categories combining to give eleven different benthic macro-invertebrate region types (Table 13; Map 10).

Open substrate with occasional individual

This was the lowest density category used to describe macro-invertebrate regions and formed 37% of the survey area. There was one community type in this category - *community dominated by open substrate with isolated benthic individuals*. These regions were nearly all bare substrate with small holes created by burrowing worms, crustacea or fish and only an occasional isolated macro-invertebrate (Plate 6). Macro-invertebrate isolates within these regions were from a range of taxa groups (Table 14). There were three regions of this category; region 7, outside Facing Island from Curtis Island to East Bank (8193 ha); region 11, north west of Seal Rocks (206 ha); and region 15, at the entrance to Rodds Bay (1477 ha) (Map 10; Table 13).

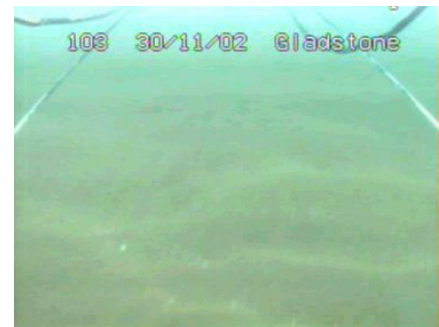


Plate 6 Open substrate with occasional individual (frame taken from video footage).

Low density benthic community

Community types in this category covered 32% of the survey area (Table 13). There was one community type in this density category - *community dominated by open substrate with a low density of varied benthic taxa*. There were eight regions of this community type spread throughout the survey area (Map 10). The dominant feature of this region type was large areas of open substrate, which were interspersed with occasional groups of benthic macro-invertebrates (Plate 7). Although density of individuals was low, there was a wide representation of taxa found within these regions (Table 14).



Plate 7 Low density benthic community (frame taken from video footage).

Medium density benthic community

There were five different benthic macro-invertebrate community types for this density category covering 15% of the survey area (Plate 8; Table 14):

1. *Mostly open substrate interspersed with small rubble dominated by echinoids and gastropods - low numbers of other taxa* (Table 14). There was one of these regions in the study area; region 1 (532 ha) outside Facing Island adjacent to the port limits boundary (Map 10; Table 13).
2. *Rubble substrate dominated by bryozoans and hydroids - low numbers of other taxa*. This region covered a significant proportion of the dredge spoil ground (region 2; 715 ha) (Map 10; Table 14).
3. *Rubble substrate dominated by bryozoans, hard coral, hydroids, echinoids - low numbers of other taxa*. This community type occurred in one region (region 14; 1984ha) to the north of Seal Rocks (Map 10; Table 14).
4. *Rubble reef and coral bommies interspersed with open substrate dominated by bryozoans, hydroids, sponges, soft coral, hard coral, gastropods and bivalves*. This medium density community occurred in a single region (17; 424ha) on the southern side of Seal Rocks.
5. *Rubble reef dominated by bivalves, ascidians, bryozoans and hard corals- low numbers of other taxa*. This region (9; 444ha) occurred in the deep channel area from the mouth of the narrows at Graham Creek to Fisherman's Landing (Map 10; Table 14).

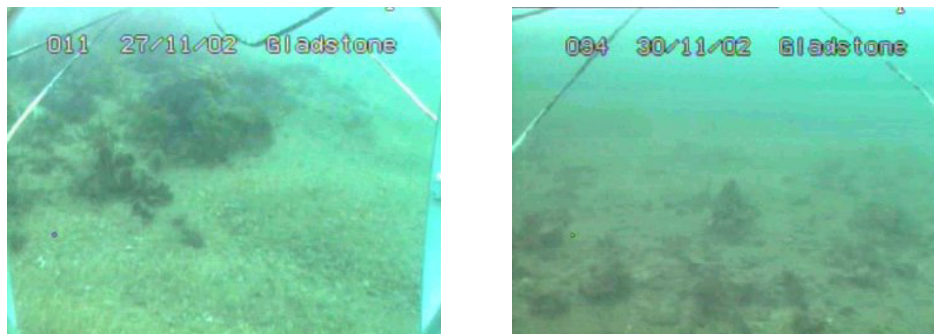


Plate 8 Examples of medium density benthic communities (frames taken from video footage).

High density benthic community

High density benthic communities were mostly located in a narrow strip running in the channel from Fisherman's Landing to inside Facing Island and East Bank. There were four different benthic macro-invertebrate community types for this density category forming 16% of the survey area (Plate 9; Table 14):

1. *Rubble reef dominated by sponges, soft coral, hard coral, hydroids, bryozoans, gorgonians with a mix of other benthic taxa* (Table 14). There were 2 of these regions in the study area; region 16 (915 ha) inside Facing Island; and region 23 (944 ha) inside East Bank (Map 10; Table 14).

2. *Scallop / rubble reef community dominated by bivalves with mix of reef taxa* (Table 14). There were two of these regions in the study area; region 18 (1456ha); and region 22 (461 ha) (Map 10; Table 13). Both areas were located inside Facing Island. The regions were dominated by large numbers of scallops but were otherwise similar to regions in the previous category (Table 14).
3. *Rubble substrate dominated by bryozoans, sponges, ascidians, bivalves and hard coral - low number of other benthic taxa* (Table 14). There was one small area (region 5; 157ha) of this region type inside West Banks (Map 10).
4. *Rubble reef and coral bommies interspersed with open substrate – mixed coral reef community*. There were two small regions (region 3, 98ha & region 4, 158ha) of low coral reef bommies located outside Facing Island (Map 10).

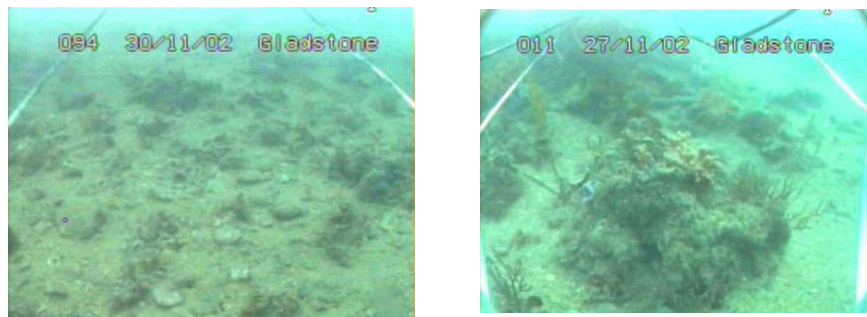


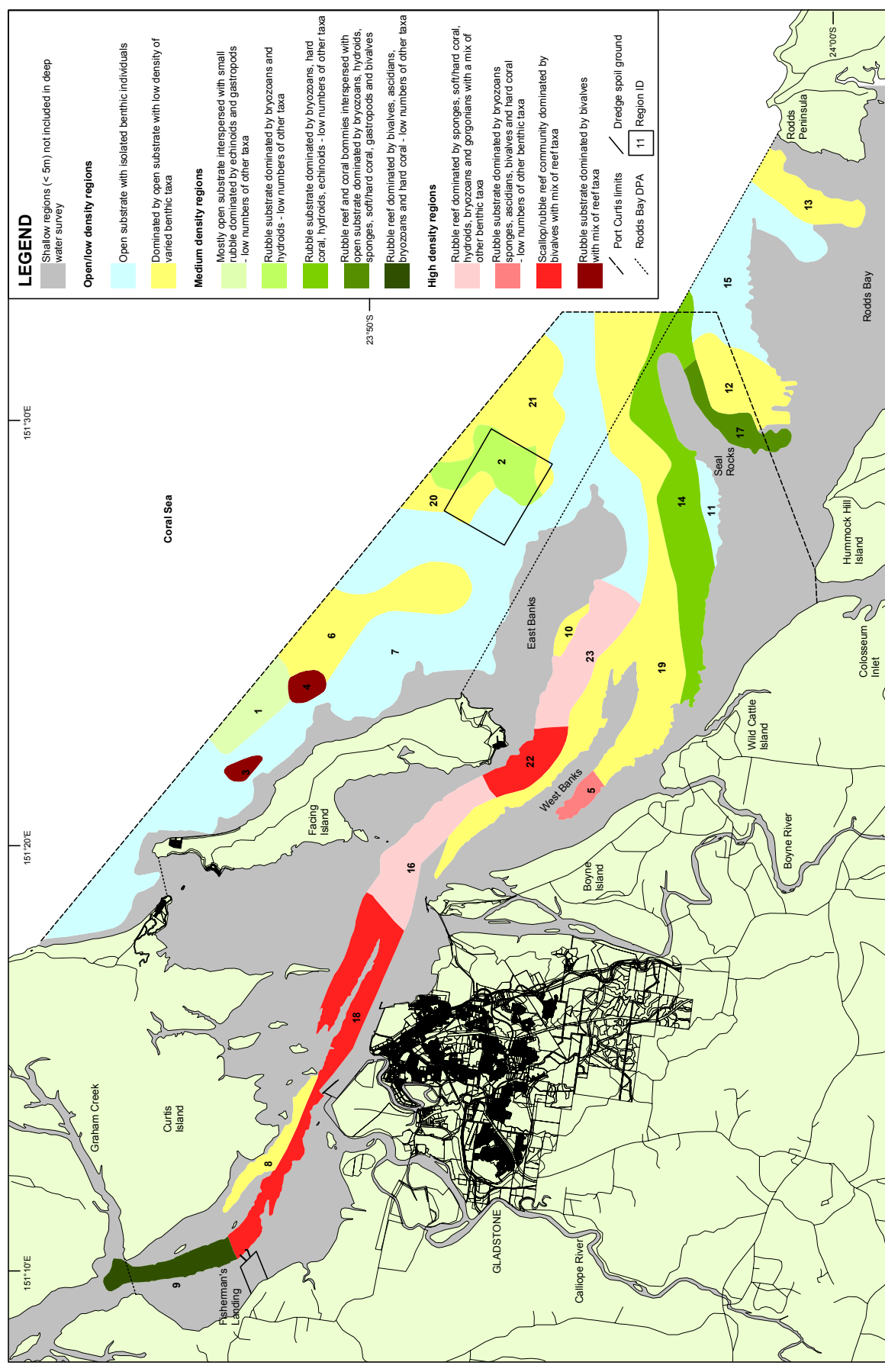
Plate 9 Examples of high density benthic communities (frames taken from video footage).

Table 13 Benthic macro-invertebrate regions in Port Curtis & Rodds Bay - density, number of sites, area and description for regions mapped in November 2002.

(R = estimate of mapping reliability).

Density category	Benthic macro-invertebrate region description	Region No.	No. of sites	Area \pm R (ha)
Open substrate, occasional individual	Open substrate with isolated benthic individuals	7	47	8,193 \pm 5,499
		11	1	206 \pm 101
		15	6	1,477 \pm 1,101
Low density benthic community	Dominated by open substrate with low density of varied benthic taxa	6	4	1,383 \pm 1,111
		8	2	308 \pm 147
		10	1	116 \pm 58
		12	4	882 \pm 605
		13	3	583 \pm 404
		19	14	3,766 \pm 3,487
		20	7	401 \pm 337
Medium density benthic community	Mostly open substrate interspersed with small rubble dominated by echinoids and gastropods - low numbers of other taxa	1	2	532 \pm 347
	Rubble substrate dominated by bryozoans and Hydroids - low numbers of other taxa	2	10	715 \pm 442
	Rubble substrate dominated by bryozoans, hard coral, hydroids, echinoids - low numbers of other taxa	14	10	1,984 \pm 1,612
	Rubble reef and coral bommies interspersed with open substrate dominated by bryozoans, hydroids, sponges, soft coral, hard coral, gastropods and bivalves	17	3	424 \pm 281
	Rubble reef dominated by bivalves, ascidians, bryozoans and hard corals- low numbers of other taxa	9	2	444 \pm 270
High density benthic community	Rubble reef dominated by sponges, soft coral, hard coral, hydroids, bryozoans, gorgonians with a mix of other benthic taxa	16	4	915 \pm 352
		23	5	944 \pm 337
	Rubble substrate dominated by bryozoans, sponges, ascidian, bivalves and hard coral - low number of other benthic taxa	5	1	157 \pm 64
	Scallop / rubble reef community dominated by bivalves with mix of reef taxa	18	6	1,456 \pm 832
		22	2	461 \pm 217
	Rubble reef and coral bommies interspersed with open substrate – mixed coral reef community	3	1	98 \pm 93
		4	1	158 \pm 105
TOTAL ALL AREAS		23	143	26,770 \pm 11,560

MAP 10. Deep water benthic macro-invertebrate regions in Port Curtis and Rodds Bay, November/December 2002



Source: Rastheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kenville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series Q103056 (DPI, Cairns).

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Table 14 Benthic macro-invertebrate communities in Port Curtis & Rodds Bay – density and types of taxa present for each benthic community region containing offshore survey sites.

L = low, average of <6 individuals per site; M = medium, 6-20 individuals per site; H = high, average of >20 individuals per site

Taxa		Benthic Community Region																						
		1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Annelida	Polychaeta	M	M	H	M	L	L	L	L	L		L	L	M		M	M	M	L	L	L	M	M	
Sipuncula	Unsegmented worms															L		L						
Ectoprocta	Encrusting bryozoan		M	L	M	L	L	L	M	M		L	L	H		M	H	L	M	M	L	M	M	
	Erect bryozoan		L	M	L	L	L		L	L		L		L		L	M	L	L	L	L	L	L	
	Motile bryozoan						L								L				L		L			
Cnidaria	Zoantharia																							
	Zoanthids	L	L			L	L				L		L	L					L	L	L		L	
	Anemones					L	L							L					L	L	L			
	Anthozoa	Colonial hard corals		L	L	L		L	L	L					L		M	M	L	L	L		L	M
		Solitary hard corals		L	L			L	L				L	L	M		L	L	L	M				L
	Gorgonians		L	L	L	L	L	L	L				L			M		L	L	L		L	L	
	Sea pens																	L		L	L		L	
	Soft coral		L	L	L		L			L		L	L	L		M	M	L	L	L		M	M	
Hydrozoa	Hydroids	M	M	L	L	L	L	L			L	L	M		M	H	L	M	L	L	M	M		
Echinodermata	Asteroid	L	L			L	L	L	L				L		L		L	L	L	L		L		
	Crinoid		L	L		L	L					L	M	L		L	L	L	L		L	L	L	
	Echinoid	H	L			H	L		L			M	L	M	L		L		M	L	L	L	L	
	Holothuroid		L			L							L	L					L				L	
	Ophiuroid		L			L	L					L	L	L		M	L	L	L	L	L		M	
Ctenophore	Comb jelly		L				L	L							L				L	L				
Urochordata	Ascidians	L	L	L	M		L		M		L	L	L		L	L	L	L				L	M	
Porifera	Sponges		L	M	M		L		L	L		L	L	L		M	M	L	L	L		M	M	
Arthropoda	Crustacea	Brachyuran	L	M	L	M	L	L		M	L		L	L	M	L	M	L	M	L	L	L	M	H
		Penaeid prawns	L	L			L	L	L					L	L	L					L			
		Carid shrimps	L	L	L		L	L	L	L						L		L	L	L	L			L
		Other decapods					L	L						L		L					L			
		Isopod																		L				
		Stomatopod		L		L								L				L		L		L		L
		Amphipod				M		L					L		L			M		L				
		Barnacle						L	M								L		L	L				L
Pycnogonida	Sea spiders		L			L	L							L					L					
Mollusca	Bivalves	L	L		M	L	L	L	M	L		L	L	L		L	M	H	L	L	L	H	M	
	Gastropods	M	L	M	L	M	L	L	L			L	L	L		L	M	M	L	L	L	M	L	
	Cephalopods					L	L					L	L	L		L			L	L				
	Mollusc egg mass		L			L	L	L				L		L					L	L	L	L		
	Nudibranch		L			L	L									L			L					
Chiton																			L					
Vertebrata	Fish	L	L			L	L				M	L	L	L	L		L		L	L			L	

Algae

Macro-algae were only a minor component of the benthic communities in the survey area. Macro-algae cover was generally low and did not form distinct macro-algae community regions. In the offshore section of the survey area macro-algae cover was typically less than 1%. Only two offshore sites, adjacent to seal rocks, had significant macro-algae cover (5% and 10%). These two sites incorporated sections of reef associated with Seal Rocks and contained a mix of algae species commonly associated with reef communities. It was likely that other rocky or reef areas within the port limits would contain similar algae communities but these areas were generally not examined as part of the survey.

While there were no significant areas of macro-algae in the coastal section of the survey area some of the coastal seagrass meadows had a relatively high percentage cover of filamentous green algae. The highest cover of filamentous algae occurred on the two seagrass meadows adjacent to Wiggins Island meadows 4 and 5 with 35% and 28% cover respectively (Map 4).

DISCUSSION

Port Curtis and Rodds Bay contained extensive seagrass communities in coastal and deeper offshore areas as well as a diverse range of benthic macro-invertebrate communities. Many of these communities occurred in proximity to port infrastructure, developments and dredged channels. Seagrass communities in the port included meadows of species preferred as food by dugong as well as dense high biomass meadows that are known to be important as juvenile prawn nursery grounds in other Queensland locations (eg. Watson *et al.* 1993). The deepwater section of the survey area was dominated by large areas of low-density benthic communities outside of Facing Island and by highly diverse and high-density benthic macro-invertebrate communities in the inner port area (inside Facing Island).

Much of the survey area was relatively well protected from southeasterly winds by Rodds Peninsula and from northerly winds by Curtis and Facing Islands. This protection from wind and wave action probably explains the extensive seagrass distribution within the survey area. Other large areas of coastal seagrass in Queensland also occur in areas sheltered from the prevailing southeasterly winds such as northward opening bays and estuaries (eg. Coles *et al.* 2002; 1990; Lee Long *et al.* 1997). The extensive areas of coastal seagrass in Port Curtis and Rodds Bay are likely to be of regional significance as they are the only described major area of seagrass between Hervey Bay 170 km to the south and Shoalwater Bay 170 km to north (Coles *et al.* 1990).

Coastal seagrass was generally confined to shallow intertidal banks with only small areas of subtidal seagrass found. This was especially the case in the inner port area from The Narrows to Boyne Island. A restriction of seagrasses to intertidal banks is common in other locations such as Karumba and Weipa in the Gulf of Carpentaria and is generally an indicator of high turbidity with a resulting low light penetration (Rasheed *et al.* 2001b; Roelofs *et al.* 2003). It is unlikely however that low light was the major factor in determining seagrass distribution in Port Curtis. Areas in Queensland with similar or greater turbidity to Port Curtis, such as Mourilyan Harbour (Thomas & Rasheed 2003), Cairns Harbour (Campbell *et al.* 2003) and Upstart Bay (Rasheed & Thomas 2002) have extensive sub-tidal seagrass communities and subtidal communities did occur south of Boyne Island in Port Curtis. It is more likely that strong currents in the relatively narrow channels and rapid drop off from the banks in the inner port were responsible for the observed distribution. In other areas of Port Curtis and in the other Queensland locations the gradient from the banks to subtidal areas was less severe and currents smaller allowing for the establishment of large subtidal seagrass communities. All of the subtidal areas that contained seagrass in the inner Port Curtis area were on intermediate depth banks outside of the deep channels (eg. north of Fisherman's Landing).

The large seagrass area in the port is likely to be of high ecological and economic importance to the Gladstone region. The fisheries value of seagrass habitat as nursery grounds for juvenile commercial fish and prawn species in Queensland is well documented (eg. Rasheed *et al.* 1996; Watson *et al.* 1993). *Zostera capricorni* communities that dominated the intertidal regions of the survey area provide a high level of habitat complexity due to the large size of this species. These areas are likely to provide an important refuge for fish and crustacean species. Similar *Zostera capricorni* meadows in Cairns Harbour have been demonstrated to be important habitat for juvenile tiger prawns and were estimated to be worth over AUD \$3,687 per hectare per year in total landed value (1992 value) (Watson

et al. 1993). While this value may be different for Gladstone's *Zostera* meadows they are still likely to be an important fisheries habitat.

The current DPA boundary (that includes most of the port) appears to be appropriate in terms of seagrass distribution. Dugong are known to target *Halophila* and *Halodule* species as they are more palatable and easily digested than other seagrass species (Lanyon 1991; Preen 1995). Meadows containing these species occurred within the inner port area as well as in Rodds Bay outside the port limits. During the survey, dugong were observed feeding on seagrass meadows between Fisherman's Landing and Wiggins Island as well as in Rodds Bay. Coastal seagrass meadows suitable for dugong feeding occurred throughout the survey area and dugong feeding trails were observed in many of these meadows during the aerial surveys. Large numbers of green sea turtles were also observed congregating over seagrass meadows, especially on meadows at the mouth of Seven Mile and Boyne Creeks in Rodds Bay.

This survey was the first time deepwater seagrass communities within the Port Curtis port limits have been mapped. The 6,332 ha of deepwater meadows found therefore have not previously been described. Deepwater seagrasses within the port occurred outside of Facing Island and towards Rodds Bay including some areas of the dredge spoil ground and in proximity to dredged channels. All seagrass meadows in areas deeper than 5m below mean sea level consisted of low biomass *Halophila* and *Halodule* species. The *Halophila* species that dominated these meadows are commonly found in deeper waters inside the Great Barrier Reef (Coles *et al.* 1996; Rasheed *et al.* 2001a) and similar meadows have been found to the north and south of the survey area (QFS in prep). The low percent cover of seagrass (<2%) is typical for many of the deepwater meadows that have been mapped off the Queensland coast (Rasheed *et al.* 2001a; Coles *et al.* 1996). These seagrass meadows were all comprised of species targeted by dugong and occurred at depths that were well within their effective diving range (Lanyon 1991; Preen 1995).

This survey is the first fine-scale survey of seagrass habitats to cover the complete port limits and Rodds Bay DPA. The only previous survey that covered this area was part of broadscale seagrass mapping of Queensland's east coast in 1988 (Coles *et al.* 1990). The area of coastal seagrass mapped in the 2002 fine-scale survey (7,246 ha) was substantially higher than the broadscale survey conducted in 1988 (2,211 ha). A direct comparison of the two surveys is probably not appropriate, however, as the methods used and goals of the surveys were substantially different. The 1988 survey was based on a much smaller number of survey sites and didn't extend into the narrows past Graham Creek. The 1988 survey was also conducted without the aid of helicopter mapping, which enabled large areas of intertidal seagrass to be mapped in the 2002 baseline survey. While not describing the full extent of coastal seagrass, the sites examined in 1988 that contained seagrass generally had seagrass in 2002. Most of the additional area of seagrass was found in locations that had no survey sites in 1988, particularly in the Rodds Bay area.

Seagrass meadow area and biomass are likely to vary seasonally and between years in Port Curtis and Rodds Bay. Other seagrass meadows in tropical Queensland that have been studied show marked seasonal and inter-annual changes such as Weipa (Roelofs *et al.* 2001; Roelofs *et al.* 2003), Karumba (Rasheed *et al.* 2001b), Mourilyan (McKenzie *et al.* 1998) and Cairns (McKenzie 1994; Rasheed 1999; Campbell *et al.* 2003). Generally seagrass meadows on the east coast of Queensland peak in biomass and area in late spring/summer and are lowest over winter (eg. Rasheed 1999; McKenzie *et al.* 1998; McKenzie 1994). It is likely therefore that the distribution and abundance (biomass) recorded in this baseline represented the peak for 2002. For other ports where seagrass has been monitored over several years such as Mourilyan, Cairns, Karumba and Weipa, 2002 was a

year of below average seagrass biomass and area for many of the meadows that had been monitored. It is possible therefore that seagrass biomass and area for Port Curtis and Rodds Bay may be or have been higher in other years than that measured in the 2002 baseline.

The deepwater survey area supported a range of other benthic communities apart from seagrass with benthic macro-invertebrates being found throughout the survey area. There was an obvious distinction in the density and diversity of benthic macro-invertebrate communities between the inner port area (inside Facing Island) and the outer port. The most complex and diverse benthic macro-invertebrate communities occurred in the inner port area with the outer port dominated by open substrate and a low density of benthic macro-invertebrates. It is likely that the diversity of benthic life in the channels of the inner port were related to the high currents flowing through these channels compared with the open areas outside of Facing Island. The benthic communities in these inner port areas were dominated by filter feeding species such as sponges, gorgonians and bivalves that tend to thrive in high current environments. The large areas of high density communities found in Port Curtis were unusual for Queensland tropical and sub-tropical ports that have been surveyed. The low density benthic macro-invertebrate communities found outside of Facing Island were more typical and similar to open deepwater sections of other Queensland ports that have been surveyed, such as Mackay (Rasheed *et al.* 2001a) and Cairns (Neil *et al.* in prep).

Seagrass / Benthic Communities and Port Facilities

The extensive seagrass distribution in Port Curtis has implications for port and coastal development. Many of the seagrass and benthic macro-invertebrate communities described in this survey occurred in proximity to maintained channels, port facilities and the dredge spoil disposal site (Maps 11, 12, 13 and 14).

Two deepwater seagrass meadows had sections within the dredge spoil ground and the other four deepwater meadows were in proximity to Wild Cattle, Boyne Island and Golding Cuttings in the South Channel (Map 11). The seagrass that occurred within the spoil ground was restricted to the northwest and southeast corners, with the majority of the spoil ground free of seagrass (Map 11). The *Halophila* species that made up these meadows are considered ephemeral and highly variable (eg. Birch & Birch 1984; Williams 1988) and species in this genus are annual in some locations completely disappearing during winter (Kuo *et al.* 1993). These species are capable of rapid colonisation and produce large numbers of seeds that enable them to colonise highly disturbed environments (Birch & Birch 1984; Rasheed 2000).

Coastal seagrass meadows occurred immediately adjacent to the reclamation at Fisherman's Landing and around the infrastructure and facilities at South Trees Point (Map 12). Seagrass meadows covered most of the intertidal areas surrounding current port facilities and the majority of the intertidal areas within the port limits so any future port infrastructure developments such as wharves, breakwaters and reclamations would potentially have direct impacts on seagrass.

The fact that apparently healthy seagrass meadows occurred in such close proximity to port facilities indicates that the port marine environment seems relatively healthy. Although without previous information or ongoing monitoring it is not possible to ascertain if the present seagrass distribution reflects the historical extent of seagrass abundance and distribution in the region. The 2002 survey provides a baseline from which future changes can be assessed.

High density benthic macro-invertebrate communities were also found around the maintained channels within the port from South Channel (Map 13) to Targinie Channel near Fisherman's Landing (Map 14). These communities were some of the most diverse and densest mapped in the deepwater survey area. As discussed earlier they were dominated by filter feeders and their location is probably associated with the high tidal current flow in the channel regions of the inner port.

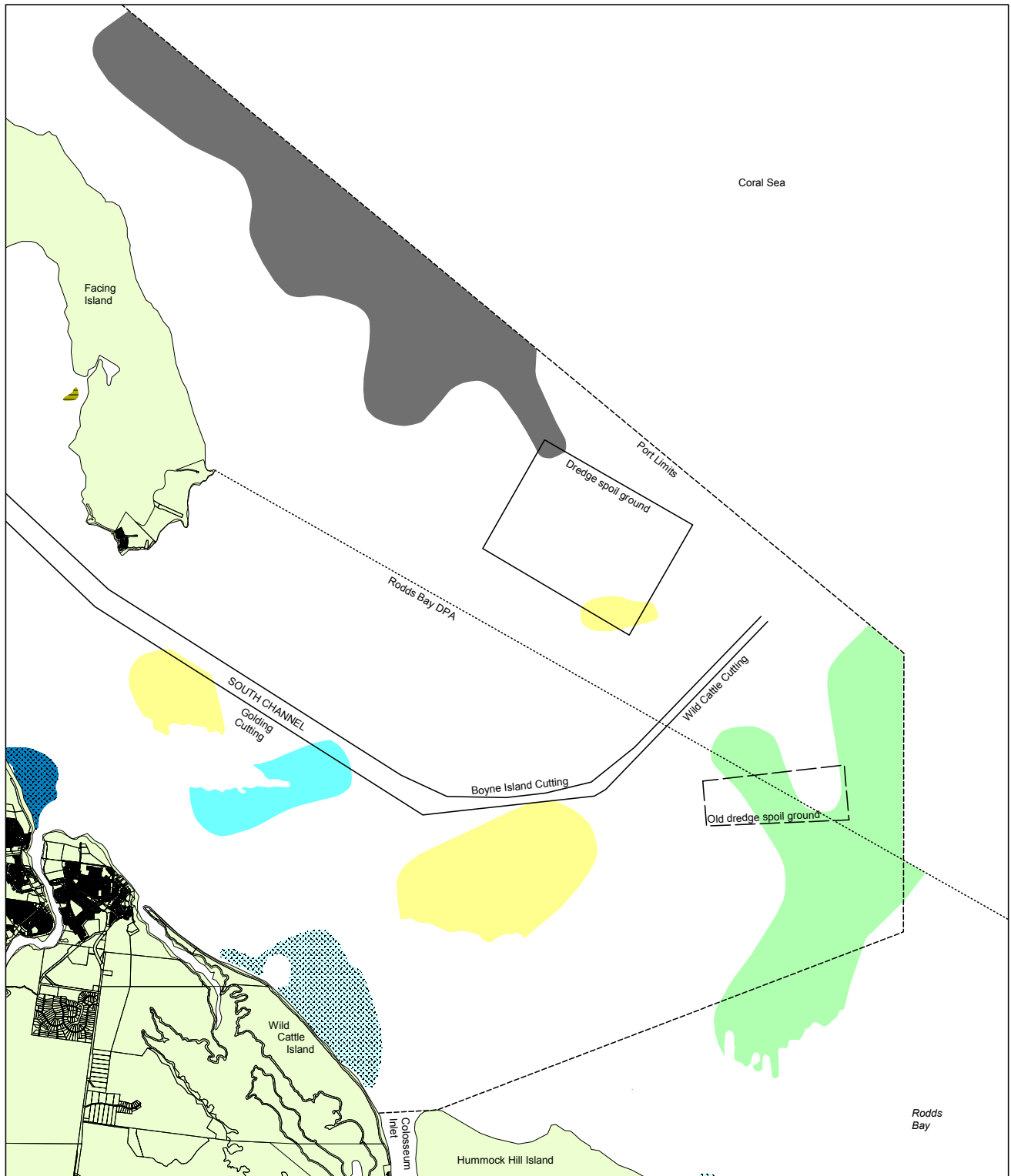
A medium density benthic macro-invertebrate community covered a large section of the dredge spoil disposal site (Map 13). This community was surrounded by low density and open communities and was not typical of the other communities outside of Facing Island (Map 13). The high amount of rubble and associated benthic-macro invertebrates in this area may be due to translocation of material from the channels in the inner port area that contain higher density communities. The coarser sediment material from dredge spoil disposal may also be providing a more suitable substrate for the settlement and recruitment of some benthic macro-invertebrates.

Proposed Monitoring

While results of this survey indicate seagrass communities within the Port Curtis port limits appear healthy detailed historical comparisons were not possible as this was the first fine scale survey of the complete area. Further monitoring of seagrasses in the port would be valuable given the proximity of meadows to port infrastructure and possible impacts associated with port and coastal developments. The ability of seagrasses to show measurable growth responses to changes in water quality and their extensive distribution through the port makes them an ideal candidate for monitoring marine environmental health in Port Curtis. Regular seagrass monitoring would give a better picture of the health of seagrass meadows and an overall indication of environmental health in the port. This survey provided the baseline information from which such a monitoring program could be established.

We suggest a monitoring program measuring biomass, area and species composition of selected meadows, as well as measurements of seed banks and physiological stress of seagrasses should be considered. Selecting examples from the range of meadow types within the port as well as targeting meadows that are most "at risk" due to their location would ensure that changes in seagrasses within the port were detected and enable an evaluation of the port related activities on the marine environment. From the results of this baseline survey we have selected eight meadows that represent the seagrasses within the port and a good coverage of meadows that are most likely to be impacted by port facilities (Map 15). These meadows include both intertidal and subtidal seagrasses as well as meadows preferred as food by dugong and those likely to support high fisheries productivity. Long-term seagrass monitoring programs using these methods have been established in several Queensland ports (eg. Rasheed *et al.* 2001b; Roelofs *et al.* 2003; Campbell *et al.* 2003). These programs have been successful in monitoring seagrass health, detecting local and regional scale changes in seagrasses, discerning natural changes from human induced or port related change and have led to successful conduct of port maintenance and development programs that have a minimal impact on the marine environment. A similar seagrass program for Port Curtis could be useful as part of the port's integrated monitoring program.

MAP 11. Southern Port Curtis seagrass communities and approximate channel location



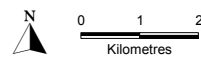
LEGEND

Community type

- Halophila decipiens*
- Halophila decipiens* with *Halophila spinulosa*
- Halophila spinulosa*/*Halophila decipiens*/*Halophila ovalis*
- Halodule uninervis* (narrow) *Halophila ovalis*
- Halodule uninervis* (thin) with *Halodule uninervis* (wide)

Meadow cover

- Aggregated patches



Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/ December 2002. QDPI Information Series QI03058 (DPI, Cairns).

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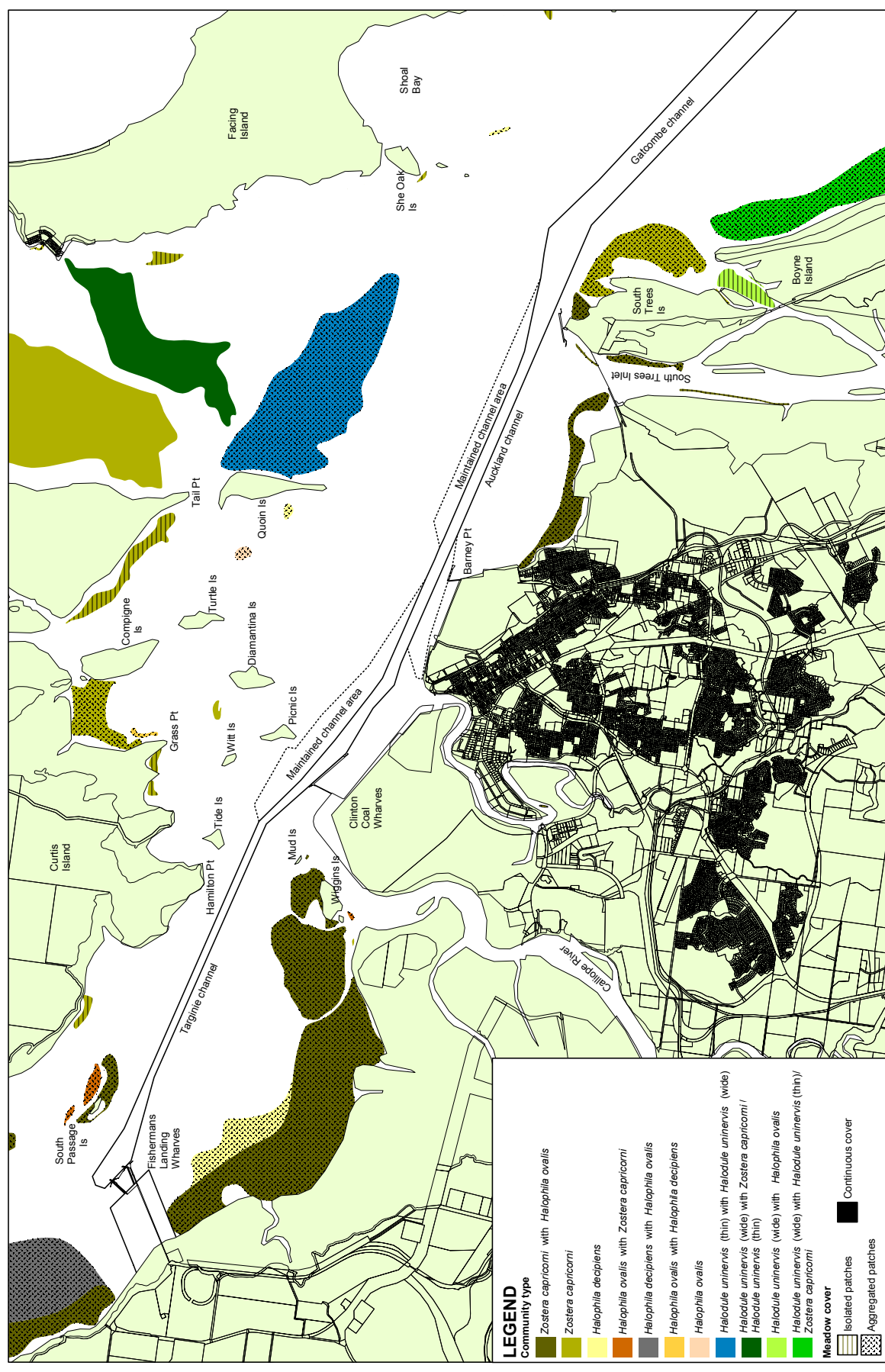
Funded by the Gladstone Port Authority and the Queensland Fisheries Service (QFS).

Produced by the Marine Ecology Group, Queensland Fisheries Service, Northern Fisheries Centre, Cairns, 2003.

Basemap courtesy AUSLIG, Australia's national mapping agency 2003.



MAP 12. Northern Port Curtis coastal seagrass communities, port infrastructure and approximate channel location



LEGEND

Community type

- Zostera capricorni with Halophila ovalis
- Zostera capricorni
- Halophila decipiens
- Halophila ovalis with Zostera capricorni
- Halophila decipiens with Halophila ovalis
- Halophila ovalis with Halophila decipiens
- Halophila ovalis
- Halodule uninervis (thin) with Halodule uninervis (wide)
- Halodule uninervis (wide) with Zostera capricorni
- Halodule uninervis (thin)
- Halodule uninervis (wide) with Halophila ovalis
- Halodule uninervis (wide) with Halodule uninervis (thin)
- Zostera capricorni

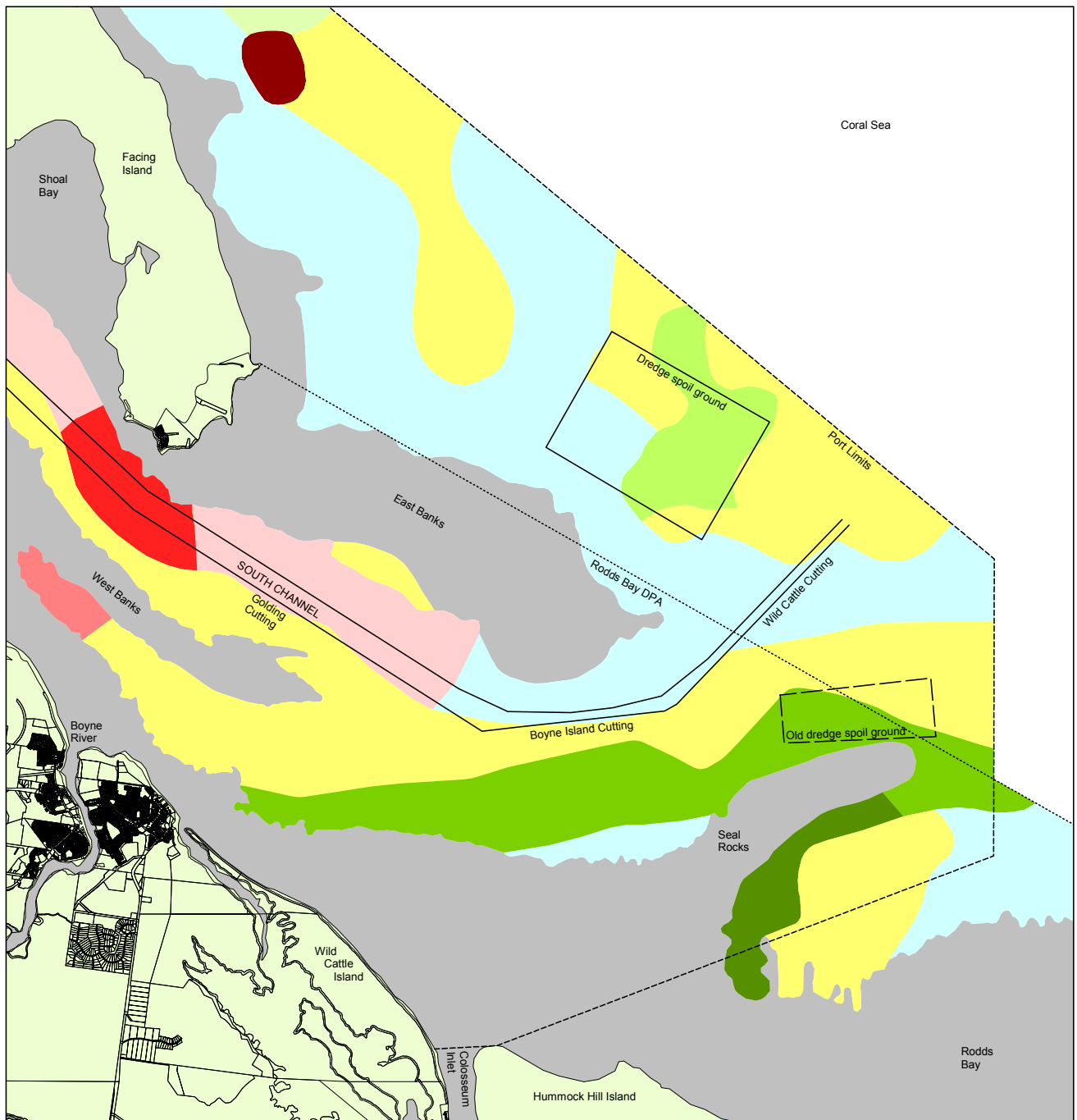
Meadow cover

- Isolated patches
- Aggregated patches
- Continuous cover

Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M., and Kenville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series Q1030568 (DPI, Cairns).

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 Produced by the Marine Ecology Group, Queensland Fisheries Service, Northern Fisheries Centre, Cairns, 2003.

MAP 13. Southern Port Curtis benthic macro-invertebrate regions and approximate channel location



LEGEND

Open/low density regions

- Open substrate with isolated benthic individuals
- Dominated by open substrate with low density of varied benthic taxa

Medium density regions

- Mostly open substrate interspersed with small rubble dominated by echinoids and gastropods - low numbers of other taxa
- Rubble substrate dominated by bryozoans and hydroids - low numbers of other taxa
- Rubble substrate dominated by bryozoans, hard coral, hydroids, echinoids - low numbers of other taxa
- Rubble reef and coral bommies interspersed with open substrate dominated by bryozoans, hydroids, sponges, soft/hard coral, gastropods and bivalves

High density regions

- Rubble reef dominated by sponges, soft/hard coral, hydroids, bryozoans and gorgonians with a mix of other benthic taxa
- Rubble substrate dominated by bryozoans, sponges, ascidians, bivalves and hard coral - low numbers of other benthic taxa
- Scallop/rubble reef community dominated by bivalves with mix of reef taxa
- Rubble substrate dominated by bivalves with mix of reef taxa

Shallow regions (< 5m) not included in deep water survey



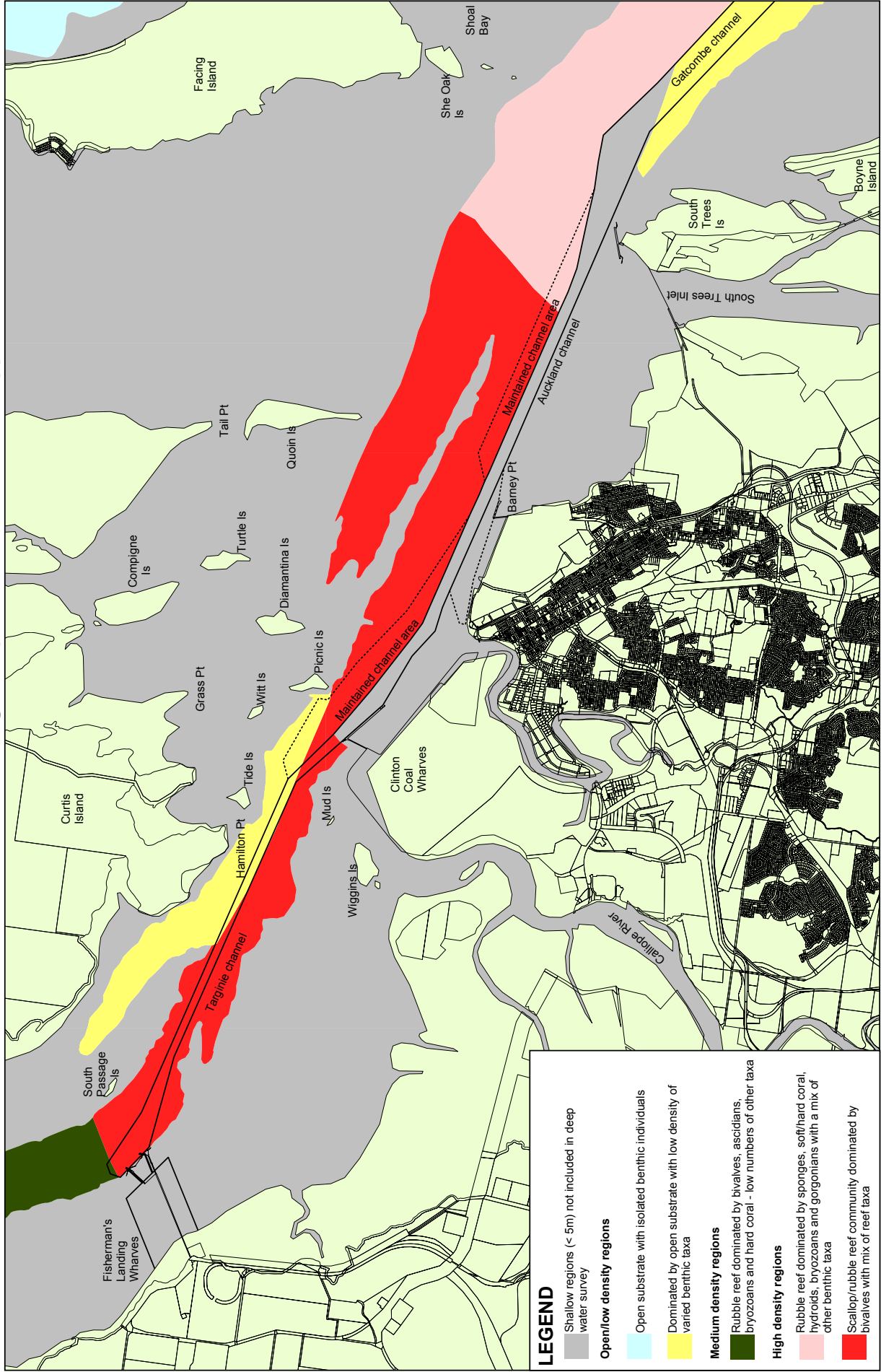
Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series QI03058 (DPI, Cairns).

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Produced by the Marine Ecology Group, Queensland Fisheries Service, Northern Fisheries Centre, Cairns, 2003.



MAP 14. Northern Port Curtis benthic macro-invertebrate regions, port infrastructure and approximate channel location



Produced by the Marine Ecology Group, Queensland Fisheries Service, Northern Fisheries Centre, Cairns, 2003.

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 Funded by the Gladstone Port Authority and the Queensland Fisheries Service (QFS).

Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P. 2003. Port Curtis and Roodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series QI03058 (DPI, Cairns).

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Queensland Fisheries Service

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MAP 15. Proposed coastal seagrass monitoring meadows for Port Curtis



Source: Rasheed, M.A., Thomas, R., Roelofs, A.J., Neil, K.M. and Kerville, S.P., 2003. Port Curtis and Rodds Bay seagrass and benthic macro-invertebrate community baseline survey, November/December 2002. QDPI Information Series QI03058 (DPI, Cairns).
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 Funded by the Gladstone Port Authority and the Queensland Fisheries Service (QFS).
 Produced by the Marine Ecology Group, Queensland Fisheries Service, Northern Fisheries Centre, Cairns, 2003.



Meadow cover

- Aggregated patches
- Continuous cover
- Meadow ID

LEGEND

Monitoring meadow community type

- Zostera capricorni* with *Halophila ovalis*
- Zostera capricorni*
- Halophila decipiens*
- Halodule uninervis* (thin) with *Halodule uninervis* (wide)
- Non-monitoring meadow

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macro-invertebrate community baseline survey
November/December 2002

