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Seagrass, benthic habitats and targeted introduced species survey of the Port of Thursday Island: March 2002

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EXECUTIVE SUMMARY

This is the first fine scale assessment of seagrass distribution and benthic habitat in the Port of Thursday Island. Seagrass was the dominant benthic habitat and meadows covered the majority of the survey area (1503 ± 240 ha). The port contained a high diversity of species (11) and some of the best examples of intertidal and subtidal seagrass habitat that have been found in Queensland ports. Other benthic habitats such as soft coral, hard coral and sponge communities were also found within the port limits but they were dominant in only small areas or formed a minor component of communities dominated by seagrass. In addition to examining the benthic habitat in the Port of Thursday Island this survey determined whether targeted introduced marine taxa were present within the Port. No introduced marine bivalves (IMB), or other macro-taxa on the Australian Introduced Marine Pest Advisory Council (AIMPAC) marine pest target list were detected.

The extensive seagrass distribution in the intertidal areas of Thursday and Horn Islands has implications for port and coastal development. Seagrass meadows completely surrounded Thursday Island so any future port infrastructure developments such as wharves, breakwaters, reclamations and channel dredging will be likely to have impacts on seagrass. A proposed reclamation area adjacent to the barge offloading facility at Thursday Island had a consistent cover of seagrass. It is unlikely that an alternate location would not have impact on seagrass.

Results of this survey indicate seagrass communities within the Thursday Island port limits appear healthy. Future 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. 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 a monitoring program could be established. Future monitoring may require sourcing additional funding because of the limited funds available in this community port.

Although no introduced taxa that would detrimentally influence native assemblages were detected during this survey, the survey was a targeted one. It is recommended that a more detail introduced marine species survey be carried out to determine the status of other introduced taxa within the area. In addition, monitoring for introduced taxa should be undertaken on a periodic basis and settlement devices should be used to screen for species that may be introduced through shipping vectors (e.g. hull fouling). The use of settlement-monitoring devices in conjunction with ongoing surveys would provide an optimal chance of detecting any invasive species early, allowing appropriate management of such a situation to be implemented ensuring minimal impact on the native biodiversity in the area. A re-examination of the design and sampling regime for settlement devices that PCQ currently has in place may be necessary to optimise their effectiveness.

INTRODUCTION

Background

The Port of Thursday Island, (Port Kennedy), is a community port located in a natural harbour and covers an area that includes wharf facilities on Thursday and Horn Islands (Figure 1). The Port services the needs of both of these islands and also operates as a central transition point for the supply of essential freight to the other islands of Torres Strait (Ports Corporation of Queensland 2002). The Ports Corporation of Queensland (PCQ) is the port authority for the Port of Thursday Island.

Seagrass meadows are known to occur in close proximity to port facilities on Thursday Island (Coles personal observation) but they have been poorly mapped or quantified in the past. These important fisheries habitats are potentially vulnerable to port activities and expansion. PCQ is investigating expansion of some of the port facilities on Thursday Island which would involve reclaiming an area adjacent to the current barge landing facility. PCQ recognises that seagrass communities are an important habitat feature of the Port and have contributed toward funding this survey to aid in the assessment of proposed expansions. The survey was a joint project between PCQ, Queensland Fisheries Service, and the CRC Reef Research Centre's ports & shipping program.

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, percent cover, and sediment characteristics for the major seagrass meadows. In conjunction with the seagrass surveys, other important fisheries habitat including algae and benthic macro-invertebrate (BMI) communities were surveyed. Results of this baseline survey can be used to establish a monitoring program.

Recently, a number of introduced marine pest species, including the Asian green mussel (AGM), *Perna viridis*, have been detected on foreign fishing vessels and seized vessels in Cairns and Darwin.

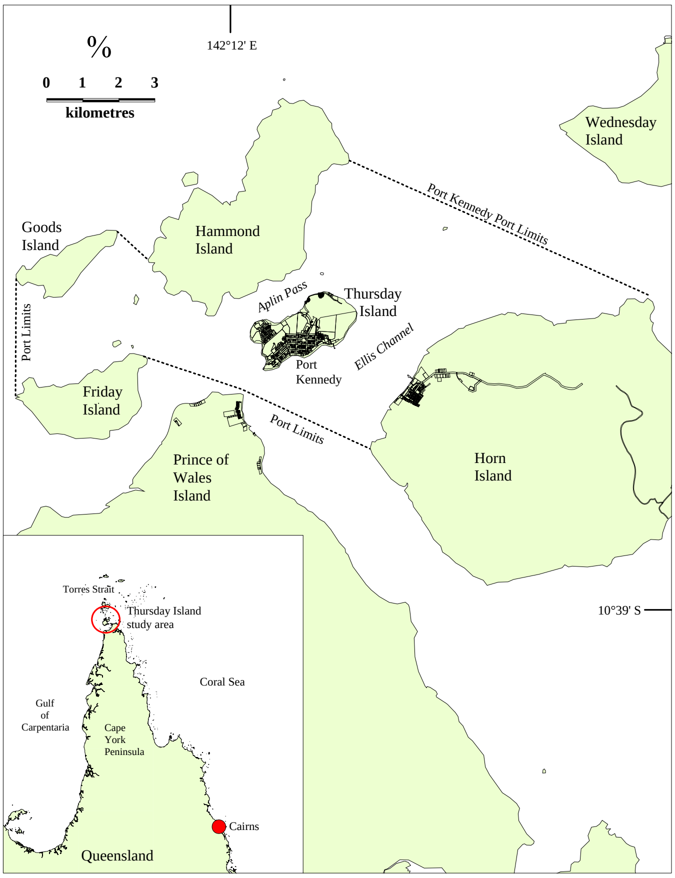

Figure 1 Thursday Island survey locality.

Poorly maintained vessels that frequent international ports pose a high risk of introducing a number of marine pests, such as the black striped mussel (BSM), *Mytilopsis sallei*, the AGM and the Caribbean tube worm (*Hydroides sanctaecrucis*) into tropical and sub-tropical Queensland ports. A number of vessels that could be harbouring marine pests are known to be located within the Port of Thursday Island at present, or have been in the past. In addition to the seagrass surveys, this survey also aimed to detect the presence of AGM and other introduced marine bivalves (IMB) in the port.

The objectives of this survey were to:

1. Conduct a baseline survey of seagrass distribution and abundance within the Thursday Island port limits;
2. Provide quantitative data on the Port of Thursday Island seagrass communities from which a monitoring program can be developed to estimate and assess changes;
3. Provide information on seagrass distribution and other sensitive habitats in the vicinity of proposed port reclamation areas to assist in the assessment of development options, and;
4. Conduct preliminary investigations into the presence of IMB, with a particular focus on the AGM or any other macro-taxa listed on the Australian Introduced Marine Pests Advisory Council (AIMPAC) target list (formerly ABWMAC).

Site Description

Torres Strait is situated between Papua New Guinea and Australia's most northern point, the Cape York Peninsula. Thursday Island is one of over 100 islands located in the Torres Strait, 18 of which are inhabited. Thursday Island is located approximately 35 kilometres northwest of the tip of Cape York Peninsula (Figure 1). The island is approximately 300 ha in area with a population of around 3500. The traditional name for Thursday Island, which is still being used, is Waibene and is thought to mean "dry place", owing to the lack of a consistent supply of fresh water on the island. The traditional owners of this island and the surrounding islands are called the Kaurareg Tribe (Australian Museums Online 2002). The Torres Strait was named in 1606 by Spanish navigator Lues Vaes de Torres. Thursday Island was given its English name by Captain William Bligh after he was set adrift from his ship the Bounty following a mutiny in 1787 (Australian Museums Online 2002).

Thursday Island is tropical and experiences a summer wet season and winter dry season. The wet season is usually between December and April with the average rainfall being 1717 mm per annum, the majority of which falls during the months of the wet. Mean daily temperatures range from a minimum of 22.7°C in July to a maximum of 32.1°C in October. During the dry season, the prevailing winds are southeasterly and water shortages occur some of the time. Thursday Island maintains an adequate year round water supply since the dam on Horn Island was built and water is pumped over via an underwater pipeline.

Fisheries resources of the Torres Strait are an important part of the economy and traditional way of life. The Torres Strait's population of around 8000 people are engaged mostly in fishing (i.e. crayfish and mackerel) and a declining pearling industry. Some of the other employment opportunities on Thursday Island include: tourism; light engineering; construction; non-government organizations; local council; Island Board of Industry Services and the State Public Service. Due to the high reliance on fishing in the area, habitats that support commercial and traditional fisheries such as seagrass, mangroves and algae are of critical importance to the region.

METHODOLOGY

Survey Approach

Seagrass, algae, and benthic macro-invertebrate (BMI) surveys of the Port of Thursday Island were conducted on 8 March and from 20-24 March 2002. The survey area included intertidal areas surrounding the islands and reefs as well as deeper sub-tidal areas. A variety of sampling methods were used based on the physical characteristics of the area such as depth, size of area to be surveyed and safety constraints. Four sampling techniques were used:

1. Helicopter intertidal mapping;
2. Intertidal habitat characterisation;
3. Subtidal diver habitat characterisation;
4. Subtidal camera habitat characterisation.

Helicopter intertidal mapping

Boundaries of intertidal seagrass meadows and reefs 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).

Intertidal habitat characterisation

Sites to determine habitat characteristics were scattered randomly throughout intertidal areas that were mapped using the helicopter. Sampling sites were examined either from the helicopter hovering within a metre of the seagrass meadow or by observers on foot. 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).

Subtidal diver habitat characterisation

In subtidal areas sites to determine habitat characteristics were located on transects and random sites between transects. 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).

Subtidal camera habitat characterisation

Where there was a deemed risk from crocodiles a camera system with a real-time video feed to a small vessel was used instead of divers. The camera attached to a 50 x 50 cm quadrat was lowered to the bottom at three random locations at each site. An observer viewing an LCD screen on the boat made habitat characterisations. A van Veen sediment grab was used at each site to confirm species viewed on the screen and sediment characteristics (Plate 4).

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

Plate 2 Intertidal habitat characterisation of exposed seagrass meadows on foot.

Plate 3 Subtidal habitat characterisation sites observed by free divers.

Plate 4 Subtidal habitat characterisation sites observed by real-time video camera.

Habitat Characterisation Sites

All habitat characterisation sites encompassed a circular area of the substratum of approximately $10m^2$. 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, information collected at each site was consistent. At each site percent cover estimates for seagrass, algae and BMI were made as an overall visual assessment of the site. Further observations were made specifically for each of these groups:

Seagrass

Seagrass habitat observations included species composition, above ground biomass, depth below mean sea level (MSL) (for subtidal sites), sediment type and 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 $0.25m^2$ 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. Three separate biomass ranges were used: low-biomass; high-biomass; and an *Enhalus* range. 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 (by diving to the seabed or on video) that represented the range of seagrass biomass in the survey. After ranking, seagrass in these quadrats was harvested and the actual biomass determined in the laboratory. A separate regression of ranks and biomass from these calibration quadrats was generated for each observer and applied to the field survey data to determine above ground biomass estimates.

Algae

Total percent cover of algae was recorded for each site, with the presence or absence of nine broad taxonomic groups recorded. These nine groups were representative of the major algae community types found in the survey area and were: red; brown; green; *Sargassum*; *Halimeda*; benthic micro-algae (BMA); encrusting; mixed; and unknown. *Sargassum* and *Halimeda* were distinguished from brown and green respectively due to the abundance of these genera in the survey area.

Benthic macro-invertebrates

Percent cover estimates at each site were made for four broad taxonomic groups of BMI that were representative of the major BMI habitat in the survey area: soft coral; hard coral; sponges; and other BMI.

Introduced marine bivalves

Additional sites were examined for the presence of IMB including the AGM, the BSM and other introduced macro-taxa on the AIMPAC target list. The survey that was undertaken was a targeted one and was developed taking into consideration the CRIMP (Centre for Research on Introduced Marine Pests) protocols on baseline surveys for introduced pest taxa in ports (Hewitt and Martin 1996; 2001) and a report on sampling tropical harbours for introduced marine taxa (Hoedt *et al.* 2001). Sites that were targeted were primarily human-made hard substrates known to be a habitat for IMB and other

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pest taxa. These included jetty pylons, mooring/navigation buoys and anchored vessels within the port limits considered likely to harbour bivalves. Soft substrates adjacent to these areas were also examined for infauna that may have been introduced. Sites were examined either by free divers, with a van Veen sediment grab (samples sieved to 0.5 mm) or by using the real-time video camera.

Habitat Mapping and Geographic Information System

All data were entered into a Geographic Information System (GIS). Rectified colour aerial photographs of the Thursday Island area (courtesy Beach Protection Authority: 1:50000, 19/06/1992), 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 ranged from $\pm \leq 5$m for isolated intertidal seagrass meadows to ± 75m for larger subtidal meadows (Table 1). The mapping precision estimate was used to calculate a range of meadow area for each meadow and was expressed as a meadow error (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 error 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 the Port of Thursday Island seagrass:

- **Survey sites** - dGPS sites containing all data collected at seagrass survey sites;
- **Seagrass percent cover** - seagrass meadows throughout the survey area showing percent cover in three ranges: < 10% cover; 10% - 50% cover; and > 50% cover;
- **Seagrass community types and density** - area data for seagrass meadows and information on community characteristics. Community types were determined according to overall species composition (Table 2); and density 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 the Port of Thursday Island.

Mapping precision	Mapping methodology
≤ 5m	Meadow boundaries mapped in detail by dGPS from helicopter or walking; 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 camera/grab and/or 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 camera/grab and/or diver surveys; All meadows subtidal; Relatively high density of survey sites; Recent aerial photography aided in mapping.
50m	Smaller subtidal inter-reef meadow boundaries determined from camera/grab surveys only; All meadows subtidal; Moderate density of survey sites; Recent aerial photography aided in mapping.
75m	Larger subtidal meadows with boundaries determined from camera/grab surveys only; All meadows subtidal; Relatively low density of survey sites; Recent aerial photography aided in mapping.

Table 2 Nomenclature for community types in the Port of Thursday Island, March 2002.

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

Table 3 Density categories and mean above ground biomass ranges for each species used in determining seagrass community density in the Port of Thursday Island, March 2002.

Density	Mean above ground biomass (g DW m^{-2})					
	H. uninervis **(narrow)**	***H. ovalis***	***H. uninervis*** **(wide)** ***C. serrulata*** ***S. isoetifolium***	***H. spinulosa***	***Z. capricorni***	***E. acoroides*** ***T. ciliatum***
Light	< 1	< 1	< 5	< 15	< 20	< 40
Moderate	1 - 4	1 - 5	5 - 25	15 - 35	20 - 60	40 - 100
Dense	> 4	> 5	> 25	> 35	> 60	> 100

Algae

Distribution of algae habitat in the Port was described using a thematic map layer of percent cover created in MapInfo®:

- **Algae percent cover** - algae habitat throughout the survey area showing total percent algae cover according to three ranges: < 10% cover; 10% - 50% cover; and > 50% cover. Presence or absence of each of the nine taxonomic groups was included in this layer.

Benthic macro-invertebrates

Distribution of BMI habitat in the Port was described using thematic map layers of percent cover created in MapInfo®. Each of the four taxonomic groups were included in a separate layer:

- **BMI percent cover** - BMI habitat throughout the survey area showing total percent cover for each of the four taxonomic groups (hard coral; soft coral; sponges; and other BMI) according to three ranges: < 10% cover; 10% - 50% cover; and > 50% cover.

Introduced marine bivalves

- **Survey sites** - Distribution of IMB survey sites in the Port was described in MapInfo®, with the site survey structure and presence or absence of IMB included.

RESULTS

Survey Area

A total of 511 sites (not including meadow boundary mapping sites) were surveyed within the Thursday Island port limits. An additional 30 sites were surveyed specifically for introduced marine bivalves (IMB) (Table 4).

Table 4 Survey sites for the Port of Thursday Island, March 2002.

Survey area and method		Number of survey sites
Intertidal	- Helicopter	115
	- Walking	46
Subtidal	- Divers	236
	- Camera and Grab	114
Introduced marine bivalves (IMB)		*30*
Total		**511 + *30***

Seagrass

Eleven seagrass species (from three families) were identified in the port limits survey area:

Family CYMODOCEACEAE Taylor:
Cymodocea rotundata Ehrenb. et Hempr. ex Aschers.
Cymodocea serrulata (R. Br.) Aschers. and Magnus
Halodule uninervis (wide and narrow leaf morphology) (Forsk.) Aschers. in Boissier
Syringodium isoetifolium (Aschers.) Dandy
Thalassodendron ciliatum (Forsk.) den Hartog

Family HYDROCHARITACEAE Jussieu:
Enhalus acoroides (L.F.) Royle
Halophila decipiens Ostenfeld
Halophila ovalis (R. Br.) Hook. F.
Halophila spinulosa (R. Br.) Aschers. in Neumayer
Thalassia hemprichii (Ehrenb.) Aschers. in Petermann

Family ZOSTERACEAE Drummortier:
Zostera capricorni Aschers.

Seagrass was present at 382 (74.8%) of the 511 sites surveyed and the total area of seagrass habitat mapped was 1503 ± 240 ha (Map 1). Intertidal seagrass habitat in the survey area covered 901 ± 51 ha and subtidal seagrass habitat covered an area of 602 ± 189 ha. The majority of the total seagrass area mapped (1057 ± 203 ha; 70.3%) had between 10% - 50% cover of seagrass (Map 1). A further 386 ± 18 ha (25.7%) of seagrass area had > 50% cover, and the remaining 60 ± 18 ha (4.0%) of seagrass habitat had < 10% cover (Map 1).

A total of 33 individual meadows in 16 community types were identified (Table 5, Map 2). The most widely distributed seagrass community type was intertidal moderate biomass *E. acoroides* with mixed species (703.3 ± 33.9 ha; 78.1% of the intertidal seagrass habitat). This community type occurred throughout the survey area, from extensive intertidal banks along the foreshores of Thursday Island

(Map 3), to Horn and Hammond Islands and to the reef platforms around Madge and Holmes reefs in the southern port limits (Map 4). Intertidal light biomass *E. acoroides* with mixed species communities also comprised a large proportion of the survey area (168.5 ± 11.8 ha; 18.7% of the intertidal seagrass habitat) and together these two community types comprised 871.9 ± 45.7 ha (96.8%) of the total intertidal seagrass habitat identified (Table 5; Map 2). Some meadows continued to the edge of the survey limits, and probably continued outside of the mapped boundaries (Maps 1 and 2).

Three community types formed the majority of subtidal seagrass habitat in the survey area. Two of these community types were comprised of moderate biomass *C. serrulata* or *C. serrulata*/*S. isoetifolium* with mixed species and occurred in Ellie Channel between Thursday and Horn Islands covering an area of 319.2 ± 108.6 ha (53.0% of the subtidal seagrass habitat). Aplin Pass between Thursday and Hammond Islands was almost entirely occupied by a subtidal moderate biomass *T. ciliatum* with mixed species community that covered 121.3 ± 28.0 ha (20.1%) of the total subtidal seagrass habitat (Table 5; Map 2).

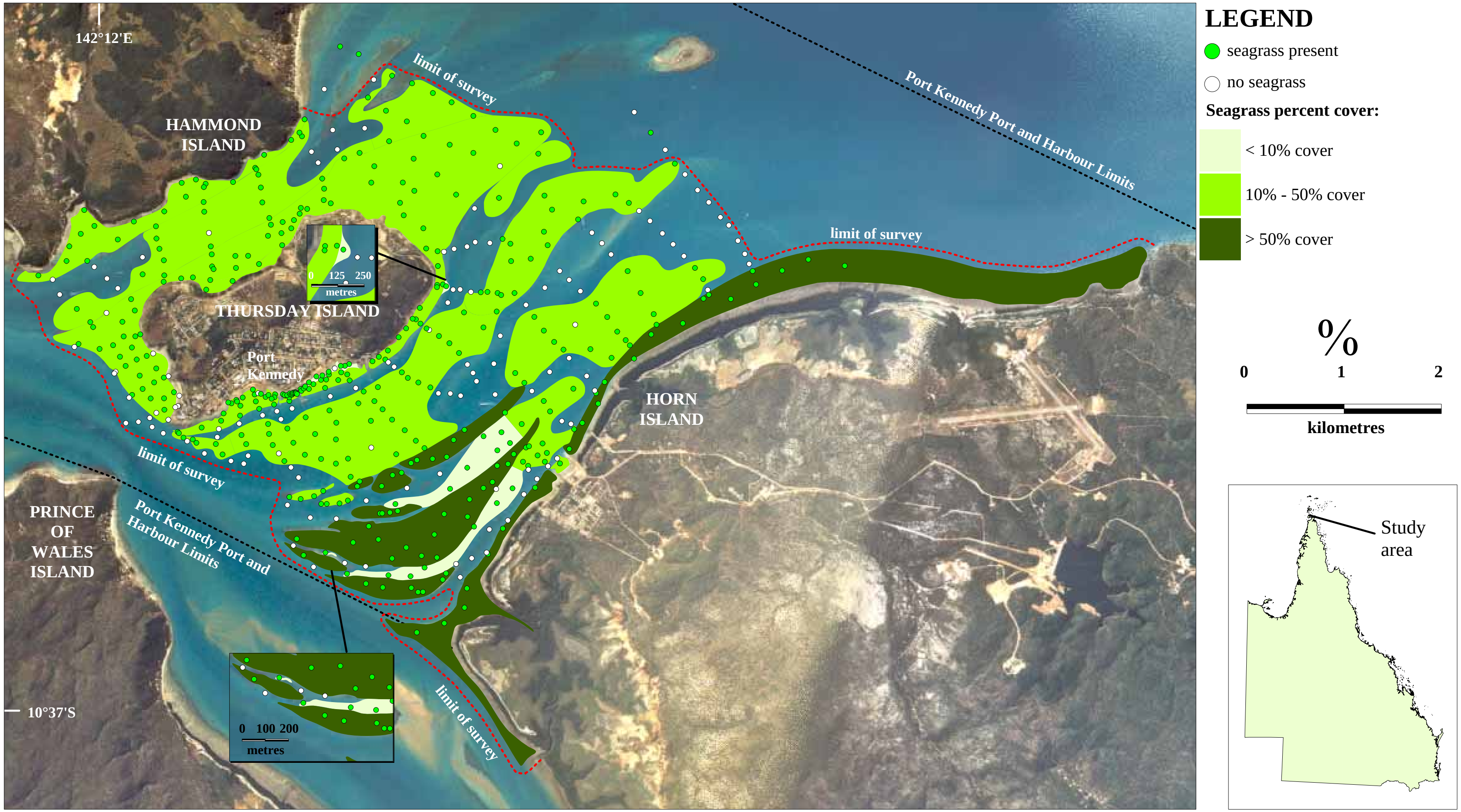
Four community types were identified with dense biomass, with three of these communities occurring subtidally (Table 5; Map 2). The only intertidal seagrass community type with dense biomass was a small (6.1 ± 0.7 ha) *T. ciliatum* with *E. acoroides* community located on a reef platform at Madge Reef near the southern boundary of the port limits (Table 5; Maps 2 and 3). Six community types with moderate biomass and a further six communities with light biomass were identified throughout the survey area and occurred both intertidally and subtidally (Table 5; Map 2).

Four distinct community types occurred on the intertidal sand/mud/shell banks immediately adjacent to port and township facilities on the southern shoreline of Thursday Island: light and moderate biomass *H. ovalis* with *H. uninervis* (thin) communities occurred nearest to shore; while light and moderate biomass *E. acoroides* with mixed species communities extended from the edge of the nearshore communities to the subtidal interface (Table 5; Map 5). Mean biomass of the nearshore light *H. ovalis* with *H. uninervis* (thin) communities was among the lightest recorded of all seagrass communities in the survey area. The Engineers, Main and Caltex Jetties adjacent to the port interrupted continuity of these communities alongshore (Map 4). A subtidal ‘channel’ devoid of seagrass and dominated by sand/shell sediments extended offshore along the edge of these intertidal seagrass communities for approximately 120 m before meeting an extensive subtidal moderate biomass *C. serrulata* with mixed species community which continued south to Madge Reef (Maps 4 and 5).

Two intertidal seagrass communities were located immediately adjacent to the site of the proposed port reclamation area near the Main Jetty: a light biomass *H. ovalis* with *H. uninervis* (thin) community (< 10% cover); and a light biomass *E. acoroides* with mixed species community (10% - 50% cover) (Map 6). The *H. ovalis* with *H. uninervis* (thin) community occurred along the inshore fringe of the *E. acoroides* with mixed species community which extended to the edge of the barge ramp and offshore to the subtidal boundary (Map 6).

The majority of seagrass habitat was found on sand/mud/shell sediments, with sediments in the proposed reclamation area dominated by mud/sand/shell. The maximum depth at which seagrass was found was 10.4 m below MSL (*Halophila spinulosa*) in the moderate *C. serrulata*/*S. isoetifolium* with mixed species community in Ellis Channel between Thursday and Horn Islands (Map 2).

Map 1. Seagrass percent cover and survey sites in the Port of Thursday Island, March 2002.



Source: Rasheed, M.A., Thomas, R., Roelofs, A. and Neil, K. (2003). Seagrass, benthic habitats and targeted introduced species survey of the Port of Thursday Island: March 2002. DPI Information Series QI03019 (DPI, Carins).

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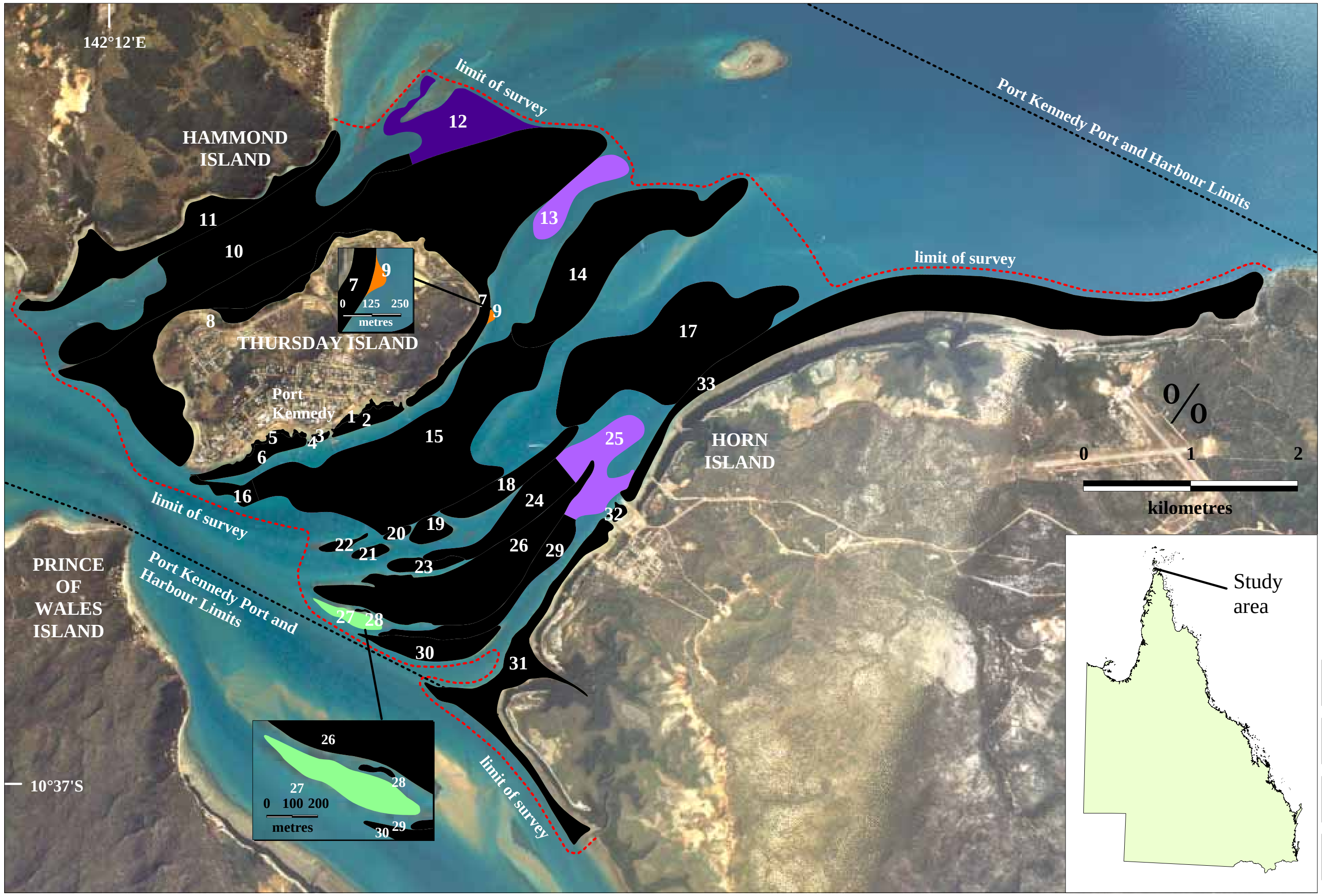
Project funded by the PCQ, CRC and QFS.
Survey dates: 8 March & 20-24 March 2002.
Aerial photographs: 19/06/1992, 1:50000, courtesy Beach Protection Authority.

Map 2. Seagrass community types and density in the Port of Thursday Island, March 2002.



LEGEND

Seagrass community type:

- *C. serrulata* with *H. ovalis*
- *C. serrulata* with mixed spp.
- *C. serrulata* with *S. isoetifolium/ H. spinulosa* and mixed spp.
- *C. serrulata/S. isoetifolium* with mixed spp.
- *E. acoroides*
- *E. acoroides* with mixed spp.
- *H. ovalis* with *H. spinulosa*
- *H. ovalis* with *H. uninervis* (thin)
- *H. uninervis* (thin) with *H. ovalis* and *T. hemprichii*
- *T. ciliatum* with *E. acoroides*
- *T. ciliatum* with mixed spp.

Community density (biomass):

- light
- moderate
- dense
- 21 Meadow ID

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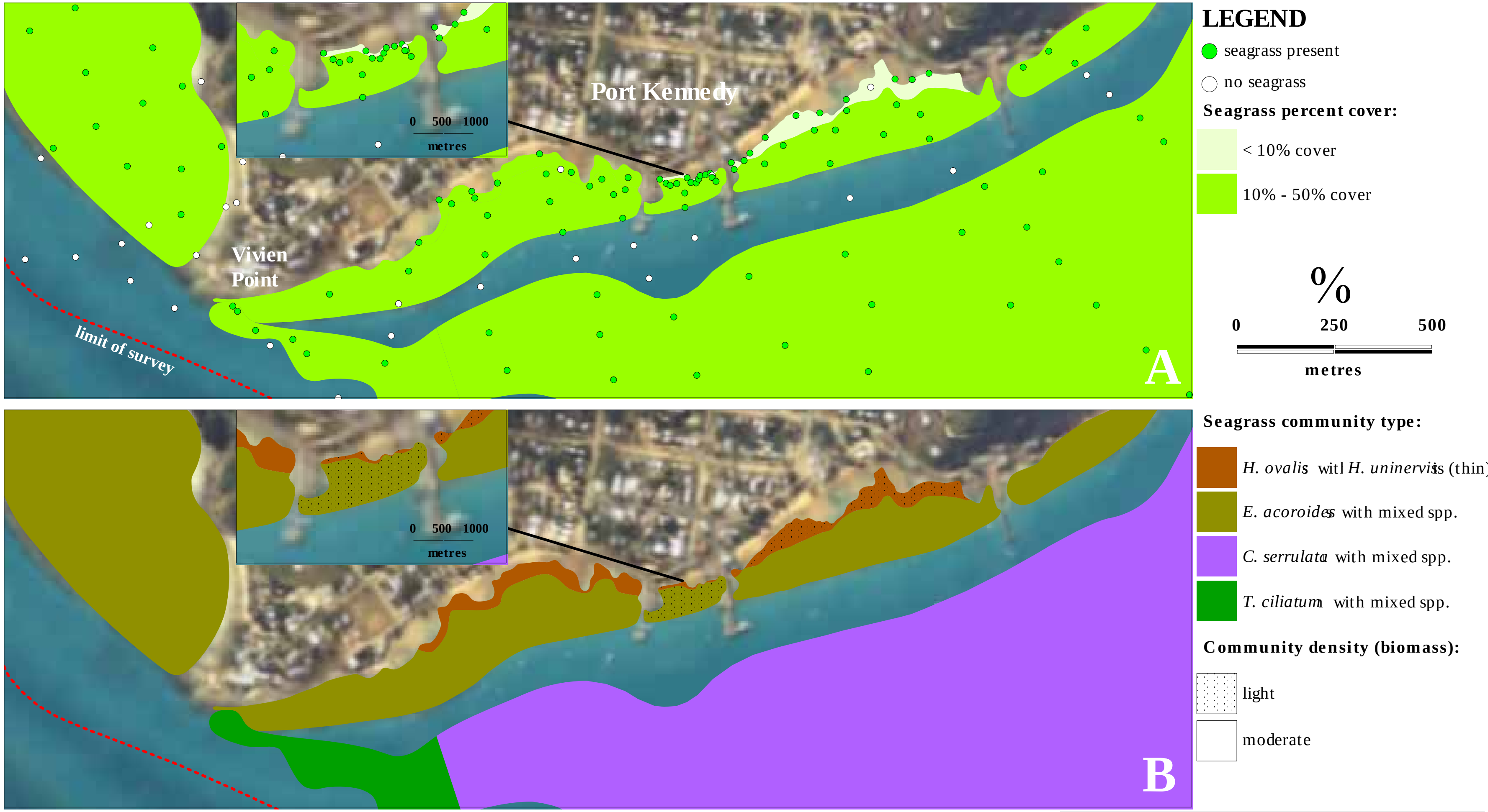
Table 5 Seagrass meadows and community types in the Port of Thursday Island, March 2002.

Meadow ID	Community type	Mean meadow biomass (g DW m^{-2}) ± SE	Intertidal/ Subtidal	Number of sites	Area ± R (ha)	Mean percent seagrass cover
28	Moderate *C. serrulata* with *H. ovalis*	10.0 ± 0	Subtidal	1	0.3 ± 0.2	5.0
24 29	Light *C. serrulata* with mixed species	1.9 ± 1.0 1.4 ± 0.5	Subtidal	7 7	30.8 ± 7.3 25.8 ± 9.6	5.7 4.9
15	Moderate *C. serrulata* with mixed species	19.8 ± 2.7	Subtidal	42	183.1 ± 62.4	17.6
13 25	Dense *C. serrulata* with mixed species	31.7 ± 8.8 30.0 ± 4.4	Subtidal	2 13	21.3 ± 5.2 37.2 ± 19.5	25.0 24.4
12*	Dense *C. serrulata* with *S. isoetifolium*/*H. spinulosa* and mixed species	28.5 ± 4.8	Subtidal	9	45.9 ± 9.8	33.2
17	Moderate *C. serrulata*/*S. isoetifolium* with mixed species	11.0 ± 2.7	Subtidal	20	136.1 ± 46.2	12.9
22	Light *E. acoroides*	29.6 ± 22.4	Intertidal	4	3.0 ± 0.5	14.3
4 14* 31 32	Light *E. acoroides* with mixed species	32.8 ± 8.5 20.9 ± 4.3 19.8 ± 6.9 17.5 ± 0	Intertidal	14 19 7 1	1.3 ± 0.6 108.4 ± 6.1 57.0 ± 4.8 1.9 ± 0.3	25.7 18.8 66.4 30.0
2 6 7 11* 18 19 20 23 26 30 33	Moderate *E. acoroides* with mixed species	43.3 ± 6.3 55.7 ± 8.9 49.8 ± 3.8 46.0 ± 7.9 96.1 ± 8.3 79.3 ± 24.9 69.1 ± 60.4 45.8 ± 13.6 68.8 ± 9.8 76.9 ± 14.0 47.6 ± 7.0	Intertidal	12 15 83 21 7 3 2 4 18 7 16	7.7 ± 2.3 13.2 ± 2.6 300.5 ± 8.4 56.4 ± 7.5 22.3 ± 1.6 7.2 ± 0.5 2.0 ± 0.3 7.0 ± 0.8 94.5 ± 1.5 19.8 ± 1.5 172.5 ± 7.0	43.9 43.7 46.1 37.1 92.3 67.0 50.0 51.3 87.4 93.0 70.1
9	Dense *H. ovalis* with *H. spinulosa*	8.9 ± 0	Subtidal	1	0.6 ± 0.5	5.0
1 3	Light *H. ovalis* with *H. uninervis* (thin)	0.3 ± 0.1 0.8 ± 0.1	Intertidal	10 3	2.3 ± 0.8 0.1 ± 0.1	8.5 5.7
5	Moderate *H. ovalis* with *H. uninervis* (thin)	3.4 ± 1.3	Intertidal	8	2.1 ± 0.8	38.8
8	Light *H. uninervis* (thin) with *H. ovalis* and *T. hemprichii*	0.4 ± 0.2	Intertidal	5	12.3 ± 2.0	24.8
21	Light *T. ciliatum* with *E. acoroides*	39.4 ± 27.4	Intertidal	4	3.1 ± 0.4	10.3
27	Dense *T. ciliatum* with *E. acoroides*	175.9 ± 0	Intertidal	1	6.1 ± 0.7	70.0
10 16	Moderate *T. ciliatum* with mixed species	74.0 ± 11.9 42.6 ± 9.2	Subtidal	20 7	114.0 ± 23.7 7.3 ± 4.3	18.4 10.1
Total				**393**	**1503.1 ± 239.6**	

* Full extent of meadow not surveyed because meadow boundaries continued beyond limit of survey.

Map 3. Seagrass resources, community types and density adjacent to Port Kennedy (Thursday Island), March 2002.



Source: Rasheed, M.A., Thomas, R and Roelofs, A.R. (2002). Seagrass, algae and benthic macro-invertebrate habitat of Port Kennedy (Thursday Island): March 2002. DPI Information Series QI----- (DPI, Carins).

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

Funded by the Ports Corporation of Queensland.
Survey dates: 8 March & 20-24 March 2002.
Aerial photographs: 19/06/1992, 1:50000, courtesy Beach Protection Authority.

Map 4. Intertidal *E. acoroides* with mixed species communities near Madge and Holmes Reefs, March 2002.

LEGEND

Seagrass community type:

- *C. serrulata* with *H. ovalis*
- *C. serrulata* with mixed spp.
- *C. serrulata/S. isoetifolium* with mixed spp.
- *E. acoroides*
- *E. acoroides* with mixed spp.
- *H. ovalis* with *H. uninervis* (thin)
- *T. ciliatum* with *E. acoroides*
- *T. ciliatum* with mixed spp.

Community density (biomass):

- light
- moderate
- dense
- 21 Meadow ID

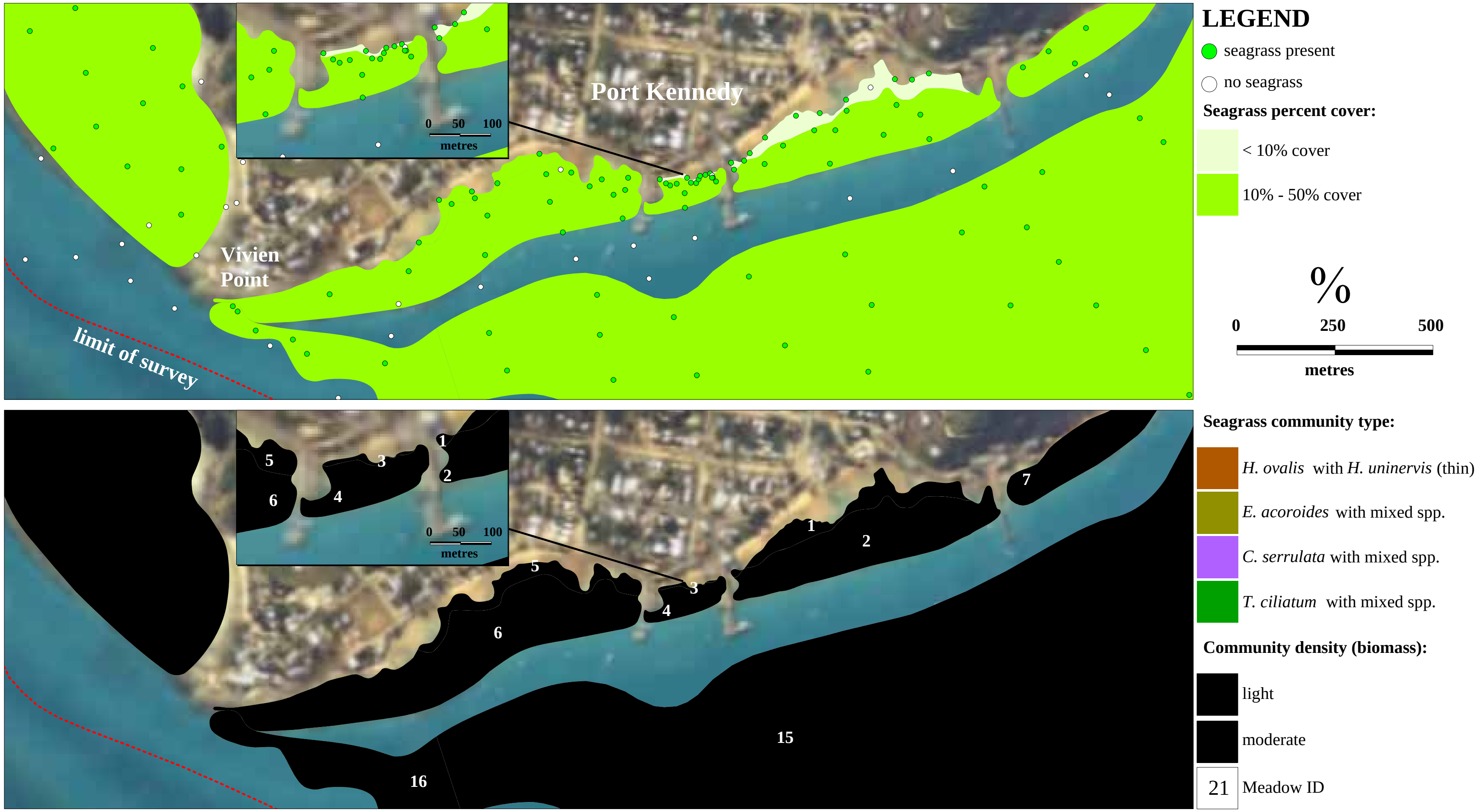
0 250 500
metres

Source: Rasheed, M.A., Thomas, R., Roelofs, A. and Neil, K. (2003). Seagrass, benthic habitats and targeted introduced species survey of the Port of Thursday Island: March 2002. DPI Information Series QI03019 (DPI, Carins).

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

Project funded by the PCQ, CRC and QFS.
Survey dates: 8 March & 20-24 March 2002.
Aerial photographs: 19/06/1992, 1:50000, courtesy Beach Protection Authority.

Map 5. Seagrass cover and community types adjacent to the Port facilities of Thursday Island, March 2002.

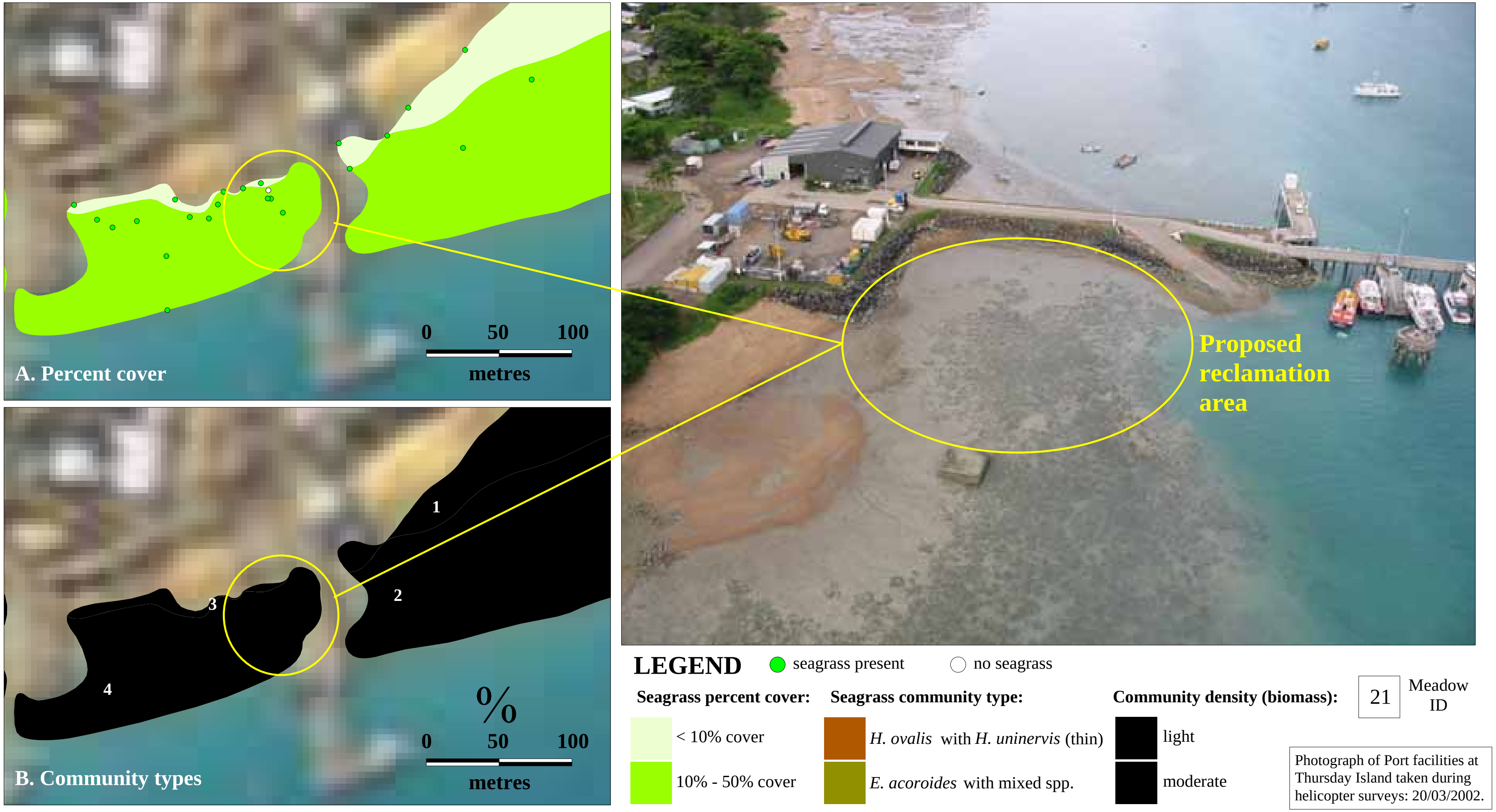


Source: Rasheed, M.A., Thomas, R., Roelofs, A. and Neil, K. (2003). Seagrass, benthic habitats and targeted introduced species survey of the Port of Thursday Island: March 2002. DPI Information Series QI03019 (DPI, Carins).

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

Project funded by the PCQ, CRC and QFS.
Survey dates: 8 March & 20-24 March 2002.
Aerial photographs: 19/06/1992, 1:50000, courtesy Beach Protection Authority.

Map 6. Seagrass percent cover and community types adjacent to the proposed reclamation area, March 2002.



Source: Rasheed, M.A., Thomas, R., Roelofs, A. and Neil, K. (2003). Seagrass, benthic habitats and targeted introduced species survey of the Port of Thursday Island: March 2002. DPI Information Series QI03019 (DPI, Carins).

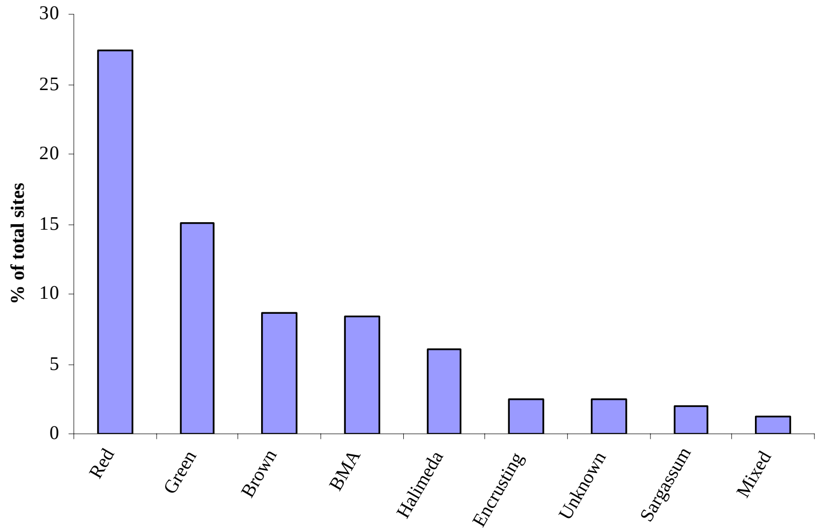
Produced by the Marine Ecology Group, Queensland Fisheries Service, DPI, Northern Fisheries Centre, Cairns.

Project funded by the PCQ, CRC and QFS.
Survey dates: 8 March & 20-24 March 2002.
Aerial photographs: 19/06/1992, 1:50000, courtesy Beach Protection Authority.

Algae

Algae were present at 265 (51.9%) of the 511 sites surveyed. Algae were distributed throughout the survey area although percent cover was higher in the southwestern region and Aplin Pass (Map 7). Most algal habitat occurred at subtidal sites (189 sites; 37.0% of total). Red algae were the most abundant and widespread taxonomic group identified and were present at 140 (27.4%) of the survey sites (Figure 2).

Figure 2 Algae abundance in the Port of Thursday Island, March 2002.



Most sites where algae were present had < 10% or from 10% - 50% total cover of algae. 15 sites (5.6% of sites where algae occurred) had > 50% cover (Table 6).

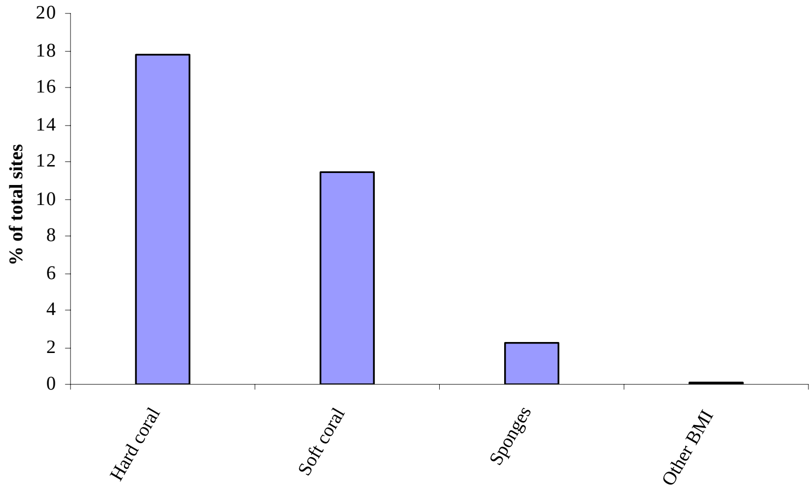
Table 6 Percent cover distribution of algae at sites where they occurred in the Port of Thursday Island, March 2002.

Percent cover category	Percent of algae sites
< 10%	49.1
10% - 50%	45.3
> 50%	5.6
% of total survey sites	**51.9**

Benthic macro-invertebrates

Surface BMI were present at 107 (20.9%) of the 511 sites surveyed. Hard and soft corals were the most abundant BMI identified, with hard coral present at 91 (17.8%) and soft coral present at 58 (11.4%) of the survey sites (Map 8; Figure 3). Hard and soft coral were found together at 50 (9.8%) of all sites and were mostly associated with either reef habitat at Madge and Holmes Reefs in the southern port limits, on hard rock substrate off Vivien Point or in Aplin Pass between Thursday and Hammond Islands (Map 8). Sponges were uncommon and occurred at 11 (2.2%) of the survey sites and were only found at depths > 7.0m below MSL (Map 8). Other BMI identified in the survey area were found in low numbers at 3 (< 1%) of the survey sites. The majority of BMI occurred at subtidal sites (89 sites; 17.4% of total).

Figure 3 Benthic macro-invertebrate abundance in the Port of Thursday Island, March 2002.



Where hard and soft corals occurred, their cover was predominantly from 10% - 50% (Table 7). At the majority of sites where sponges were present and all sites where other BMI were present, the percent cover of these taxa was < 10% (Table 7).

Table 7 Percent cover distribution of BMI at sites where they occurred in the Port of Thursday Island, March 2002.

Percent cover category	**Percent of sites for each taxa**			
	Hard coral	**Soft coral**	**Sponges**	**Other BMI**
< 10%	25.3	43.1	81.8	100
10% - 50%	62.6	56.9	18.2	0
> 50%	12.1	0	0	0
Percent of total survey sites	**17.8**	**11.4**	**2.2**	**< 1**

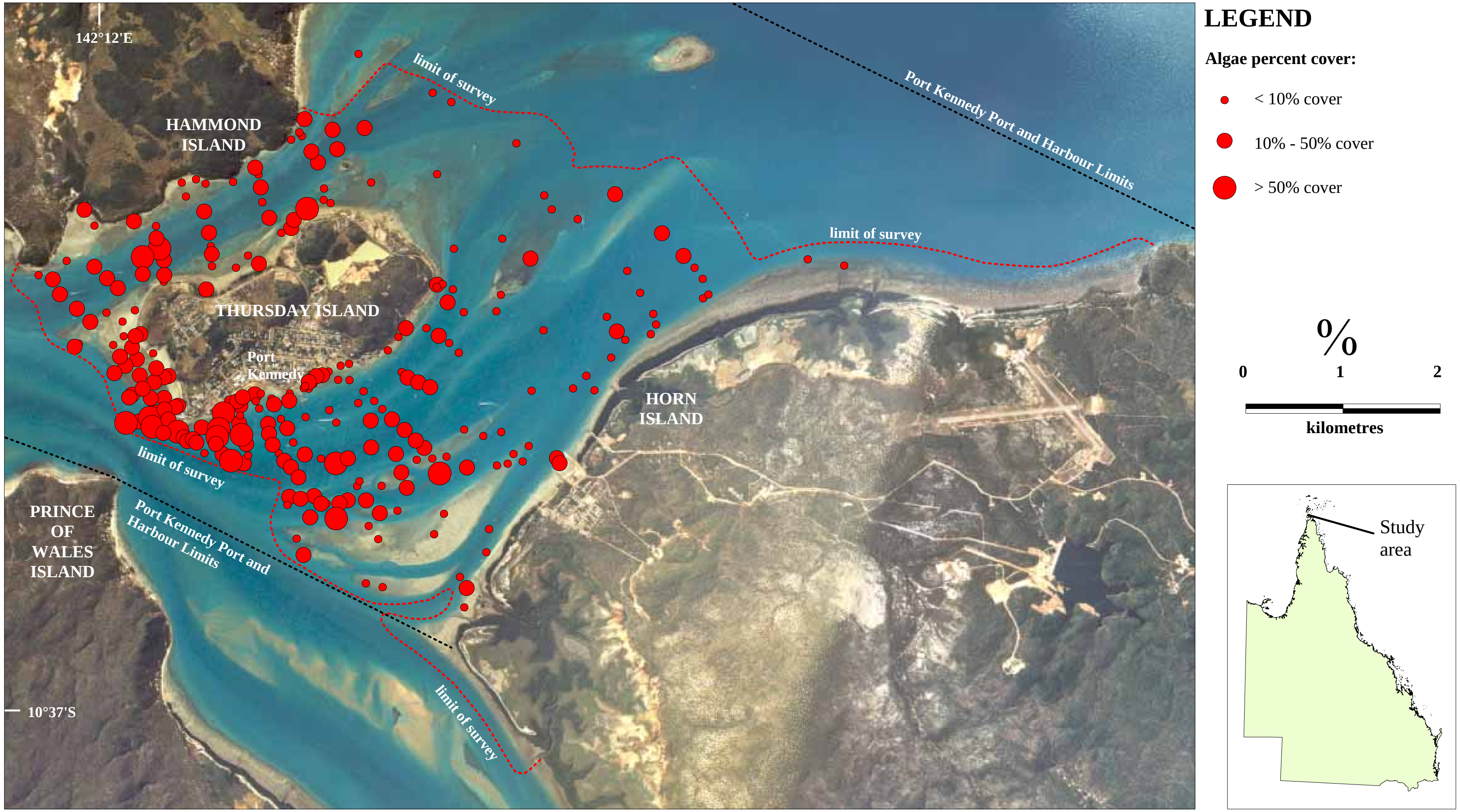
Introduced marine bivalves

An additional 30 sites were surveyed for IMB and any other macro-pest taxa. Sites included all wharf/jetty infrastructure on Thursday and Horn Islands (17 sites), mooring/navigation buoys and chains (11 sites) and two vessels that had been moored/anchored in the port long-term or had poor anti-fouling condition (Table 8; Map 9). A diverse range of native bivalves was observed at these sites, but there was no evidence of IMB such as the AGM or BSM. Of the native bivalve fauna taxa belonging to the families Ostreidae, Malleidae, Pteridae and Mytilidae were dominant. No other macro-pest taxa on the AIMPAC target list were found at the survey sites.

Table 8 Introduced marine bivalve survey sites in the Port of Thursday Island, March 2002.

Site ID	Description	Survey method	Comments	Black striped mussel	Asian green mussel
1	Ferro-cement ketch	Divers	Heavy fouling	No	No
2	Yellow buoy	Divers	Heavy fouling	No	No
3	Red buoy	Divers	Heavy fouling	No	No
4	Green buoy	Divers	Heavy fouling	No	No
5	Blue buoy	Divers	Moderate fouling	No	No
6	Timber vessel	Divers	Heavy fouling	No	No
7	Mooring buoy	Divers	Moderate fouling	No	No
8	Caltex Jetty	Divers	Moderate fouling	No	No
9	Caltex Jetty	Divers	Light fouling	No	No
10	Mooring buoy	Divers	Light fouling	No	No
11	Yellow buoy	Divers	Light fouling	No	No
12	Main (Navy) jetty	Divers	Light fouling	No	No
13	Main jetty (mooring dolphin)	Divers	Light fouling	No	No
14	Yellow buoy	Divers	Light fouling	No	No
15	Yellow buoy	Divers	Light fouling	No	No
16	Red buoy	Divers	Light fouling	No	No
17	Yellow buoy	Divers	Light fouling	No	No
18	Engineers jetty	Divers	Light fouling	No	No
19	Jardine jetty	Grab/Camera	Fine silt/sand	No	No
20	Jardine jetty	Grab/Camera	Fine silt/sand	No	No
21	Jardine jetty	Grab/Camera	Fine silt/sand	No	No
22	Jardine jetty	Grab/Camera	Fine silt/sand	No	No
23	Jardine jetty	Grab/Camera	Mud/sand/gravel	No	No
24	Caltex jetty	Grab	Sand/shell	No	No
25	Caltex jetty	Grab	Sand/shell	No	No
26	Caltex jetty	Grab	Sand/shell	No	No
27	Caltex jetty	Grab	Fine sand	No	No
28	Main jetty	Grab	Sand	No	No
29	Main jetty	Grab	Sand	No	No
30	Engineers jetty	Grab	Sand	No	No

Map 7. Distribution of algae habitat and percent cover in the Port of Thursday Island, March 2002.



Source: Rasheed, M.A., Thomas, R., Roelofs, A. and Neil, K. (2003). Seagrass, benthic habitats and targeted introduced species survey of the Port of Thursday Island: March 2002. DPI Information Series QI03019 (DPI, Carins).

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

Project funded by PCQ, CRC and QFS.
Survey dates: 8 March & 20-24 March 2002.
Aerial photographs: 19/06/1992, 1:50000, courtesy Beach Protection Authority.

Map 8. Benthic macro-invertebrate habitat and percent cover in the Port of Thursday Island, March 2002.

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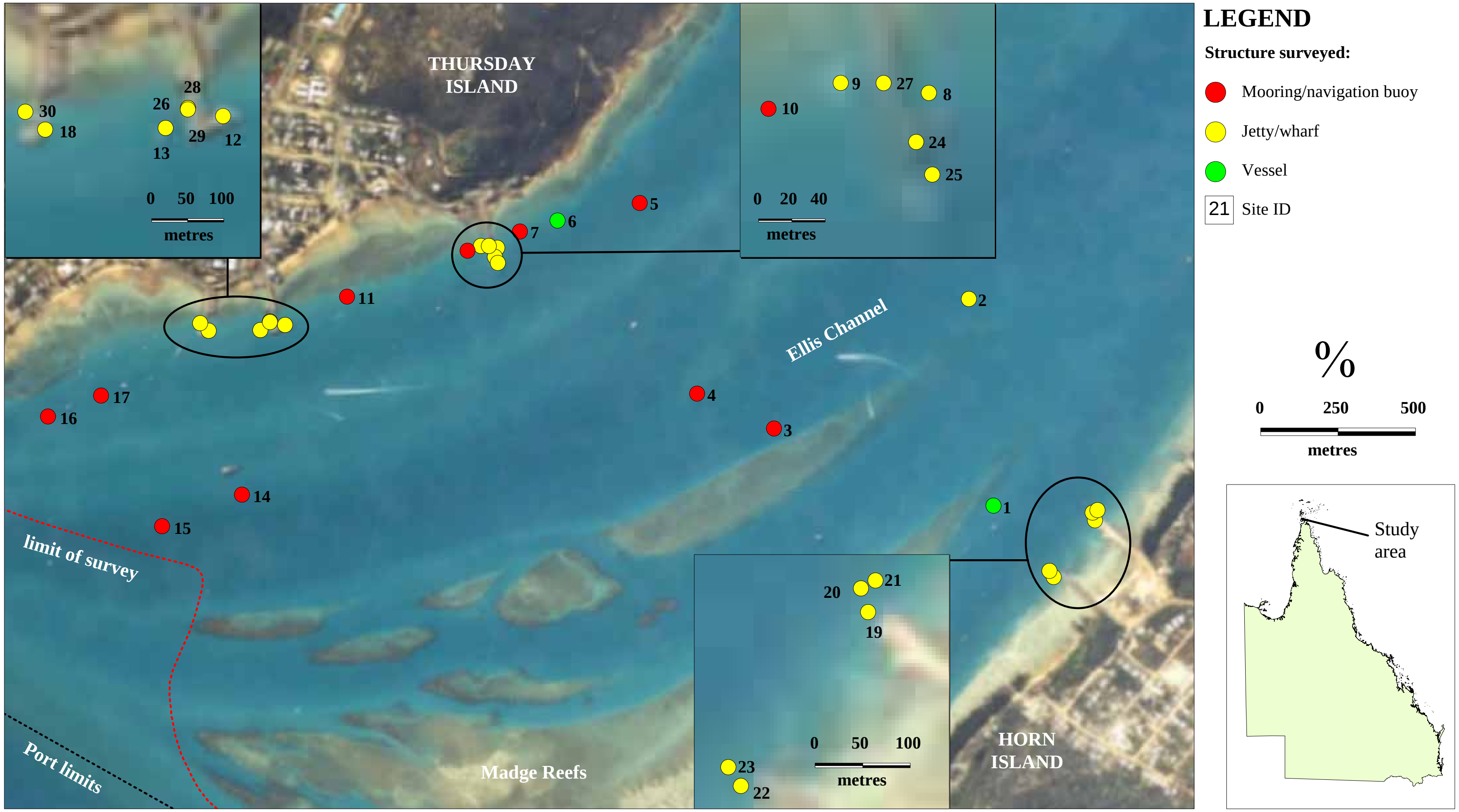
Map 9. Introduced marine bivalve survey sites in the Port of Thursday Island, March 2002.



Source: Rasheed, M.A., Thomas, R., Roelofs, A. and Neil, K. (2003). Seagrass, benthic habitats and targeted introduced species survey of the Port of Thursday Island: March 2002. DPI Information Series QI03019 (DPI, Carins).

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Survey dates: 8 March & 20-24 March 2002.
Aerial photographs: 19/06/1992, 1:50000, courtesy Beach Protection Authority.

DISCUSSION

This is the first fine scale assessment of seagrass distribution and benthic habitat in the Port of Thursday Island. Seagrass was the dominant benthic habitat and meadows covered the majority of the survey area. The port contained a high diversity of species and some of the best examples of intertidal and subtidal seagrass habitat that have been found in Queensland ports. Other benthic habitats such as soft coral, hard coral and sponge communities were also found within the port limits but they were dominant in only small areas or formed a minor component of communities dominated by seagrass. No introduced marine bivalves or other target introduced marine pest species on the AIMPAC list were detected in the port.

The Port of Thursday Island had the highest diversity of seagrass species found in a Queensland port containing 11 of the 15 currently recognised seagrass species in Queensland. This compares with seven species identified in the Port of Weipa (Roelofs *et al.* 2001) and eight at the Port of Cape Flattery (Ayling *et al.* 1997), the two nearest ports on mainland Cape York. Species diversity for the Port of Thursday Island is also higher than other nearby areas (non-port) on the mainland that have been studied such as Margaret/Shelburne Bay (eight species) (Sheppard *et al.* 2002). This study confirmed the presence of *Zostera capricorni* at Thursday Island, which was first recorded there by den Hartog (1970). The presence of *Zostera capricorni* at Thursday Island had been questioned, as other than Thursday Island there are no records of it further north than Cairns (i.e. 700km south of Thursday Island). Thursday Island is also the only Queensland port that contained *Thallasodendron ciliatum*, an unusual species with a unique ability among seagrasses to anchor itself to hard calcium carbonate substrates such as coral reefs.

The 1503 ± 240 ha of seagrass mapped in this survey did not fully describe the area of seagrasses in the port, as the survey did not extend completely to the port limits. Additionally, several of the seagrass meadows continued to the limit of the survey area and were likely to extend beyond this limit and as such the seagrass area for these meadows was underestimated.

The large and highly diverse seagrass area in the port is likely to be of high ecological and economic importance to the Thursday Island region. The fisheries value of seagrass habitat as nursery grounds for juvenile commercial fish and prawn species in Queensland is well documented (e.g. Rasheed *et al.* 1996; Watson *et al.* 1993). *Enhalus acoroides* 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. The relative value of *Enhalus acoroides* communities compared with other seagrass species has not been investigated.

Seagrass meadows also provide a direct food source for dugong and some turtle, which are highly important to Torres Strait Islanders both culturally and as food. Dugong are known to prefer *Halophila* and *Halodule* species as a food source (Lanyon 1991; Preen 1995). *Halophila* and *Halodule* species typically occurred as an understorey among larger growing species such as *Enhalus* and *Cymodocea* in Thursday Island. Much of the seagrass in the port therefore may not be suitable for dugong as meadows were dominated by less palatable species.

Areas containing macro-algae, soft coral and hard coral communities that were identified in this survey were also likely to play important ecological roles in the port. This survey had a particular focus on seagrass and was not intended to produce an exhaustive list of the other benthic taxa in the port. Therefore it was likely that the port contained other benthic taxa although seagrass remained the dominant benthic feature in the port.

Seagrass meadow area and biomass are likely to vary seasonally and between years in the Port of Thursday Island. 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.* 2002), Karumba (Rasheed *et al.* 2001), Mourilyan (McKenzie *et al.* 1998) and Cairns (McKenzie 1994; Rasheed 1998). Recent evidence suggests that the timing of high and low seasons for seagrass abundance may be substantially different between the east and west coasts of Cape York Peninsula (Rasheed *et al.* 2001). The timing and magnitude of seasonality in seagrass growth for Thursday Island and the Torres Strait region is not known.

The extensive seagrass distribution in the intertidal areas of Thursday and Horn Islands has implications for port and coastal development. Seagrass meadows completely surrounded Thursday Island so any future port infrastructure developments such as wharves, breakwaters, reclamations and channel dredging will be likely to have impacts on seagrass. A proposed reclamation adjacent to the barge offloading facility at Thursday Island had a consistent cover of seagrass. It is unlikely that an alternate location that would not impact on seagrass could be found on the island due to the ring of intertidal seagrass around the island.

Although the survey found no evidence of introduced marine taxa it was not an exhaustive introduced pest species baseline survey conducted to the CRIMP protocols so doesn't preclude the possibility of other introduced species being present. The survey was targeted at detecting the presence of any introduced bivalves and found, instead, that the native bivalve assemblages inhabiting hard substrates in the Port of Thursday Island were abundant and diverse. Thursday Island, however, remains a high-risk port for introductions of hull fouling organisms such as Asian green and black striped mussels and Caribbean tubeworm due to the high number of seized foreign fishing vessels that are periodically held in the port by the Commonwealth or State. These types of vessels are purported to be responsible for the recent outbreaks of these pest taxa in Cairns and Darwin. The development of inspection and treatment protocols for high-risk vessels entering the port should be a priority together with a regular monitoring program for introductions.

To provide a baseline of information for ongoing monitoring a comprehensive baseline assessment of the presence and prevalence of introduced taxa within the Port of Thursday Island would need to be undertaken. This information would allow areas at high risk of an introduction within the port to be identified for periodic monitoring. In conjunction with ongoing monitoring settlement devices should be used to screen for species that may be introduced through shipping vectors (e.g. hull fouling). PCQ has for several years been monitoring settlement devices in the port on a 3 monthly basis. The design of the monitoring devices currently in use and the sampling/ inspection regime may need to be modified to ensure that they are effective in light of recent advances in settlement device design and knowledge. These would provide an optimal chance of detecting any invasive species early, allowing appropriate management of such a situation to be implemented ensuring minimal impact on the native biodiversity in an area.

While results of this survey indicate seagrass communities within the Thursday Island port limits appear healthy no historical comparisons were possible as this was the first fine scale survey of the area. Future 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. 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 a monitoring program could be established.

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