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MARINE PARK AUTHORITY

RESEARCH PUBLICATION NO. 72

Seagrass and Marine Resources in the Dugong Protection Areas of

Upstart Bay, Newry Region, Sand Bay, Llewellyn Bay, Ince Bay and the Clairview Region

April/May 1999 and October 1999

Edited by
Rob G Coles, Warren J Lee Long,
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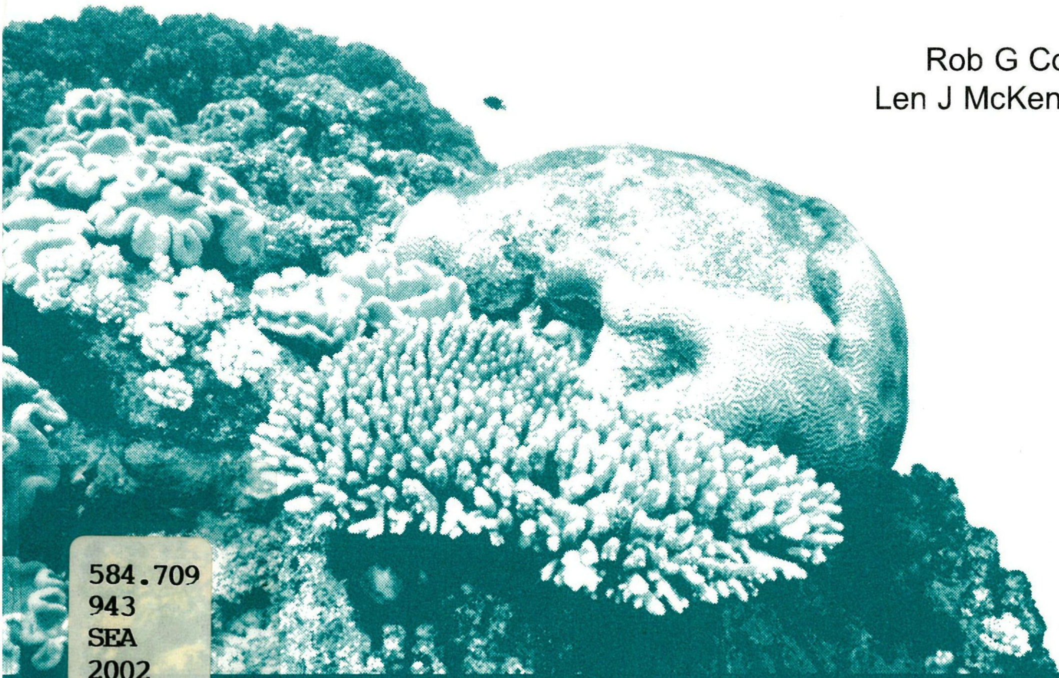

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Information contained in this publication is provided as general advice only. For application to specific circumstances, professional advice should be sought. Seagrass maps in this report are magnified so that small meadows can be illustrated. Estimates of mapping error (necessary for measuring changes in distribution) are not to be inferred from the scale of these hard-copy presentation maps. These can be obtained from the original GIS database maintained at the Northern Fisheries Centre, Cairns.

The Department of Primary Industries, Queensland has taken all reasonable steps to ensure the information contained in this publication is accurate at the time of the survey. Seagrass distribution and abundance can change seasonally and between years, and readers should ensure that they make appropriate enquires to determine whether new information is available on the particular subject matter.

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EXECUTIVE SUMMARY

Project Brief

The Marine Plant Ecology Group (Queensland Fisheries Service, Queensland Department of Primary Industires) was commissioned by the Great Barrier Reef Marine Park Authority to undertake two (one autumn and one spring) detailed seagrass surveys of the Dugong Protection Areas in Upstart Bay, Newry region, Sand Bay, Llewellyn Bay, Ince Bay, and a reconnaissance survey in the Clairview region. The information gathered from these surveys enhances the understanding and subsequent management of seagrass resources for fisheries and as dugong feeding habitats.

Methods

Three sampling techniques were used to survey the DPAs. These were tailored according to the physical characteristics of each of the DPAs and according to knowledge of seagrass distribution from previous surveys (Coles *et al.* 1987). The techniques were: ***helicopter reconnaissance surveys*** (27-28th April 1999) of the extensive intertidal flats of Newry region, Sand Bay, Llewellyn Bay, Ince Bay and the Clairview region; ***dive-based surveys*** (16-25 May 1999 and 12-20 October 1999) of Upstart Bay, Newry region, Sand Bay, Llewellyn Bay and Ince Bay to sample shallow subtidal areas and intertidal areas and ***deepwater surveys*** (16-25 May 1999 and 12-20 October 1999) of Upstart Bay, Newry region, Sand Bay, and Llewellyn Bay using remote, real-time video sampling in >10m waters.

The seagrass distribution was mapped. Seagrass characteristics measured at each site included above-ground seagrass biomass and seagrass species composition. Environmental parameters measured included sediment characteristics and water depth. Beam trawling was conducted in representative seagrass communities within each DPA to provide an indication of seagrass associated fauna and implication for fisheries. A Geographic Information System (MapInfo$_{®}$) was used to produce detailed maps.

Key Results

- The ***total area*** of seagrass habitat mapped in the 5 DPAs surveyed (excluding Clairview region) was 6015±982ha in May 1999 and 7128±1232ha in October.
- Mean ***biomass*** for the above-ground plant material for the seagrass species found in the 5 DPAs ranged from less than 5 g DW m^2 in Llewellyn Bay to just over 20 grams dry weight (g DW m^2) in Upstart Bay.
- *Halodule uninervis* was the most common of the ***10 seagrass species*** found in the study area (all sites pooled) and was present at approximately 55% of the seagrass sites. This is one of the species of seagrass preferred by dugong.
- With the exception of Nobbies Inlet in Upstart Bay, almost no seagrass was found in creeks and rivers entering into the DPAs.
- ***Depth ranges*** for seagrasses were very narrow with almost all records between 0 and 6 m below MSL. Most of the seagrass habitats found in the DPAs were at intertidal depths and would not be accessible to dugong during low-tide periods.

The scarcity of seagrass habitat in sub-tidal areas is likely a result of the large tidal ranges and tidal currents and the corresponding high coastal water turbidity.

- Commercial prawns and fish species were found in trawls on the dense *Zostera capricorni* meadows in Upstart Bay and the Newry region.

Summary Table Summary of seagrass resources in the Dugong Protection Areas of *Upstart Bay, Newry region, Sand Bay, Llewellyn Bay, Ince Bay and Clairview region* in April/May 1999 and October 1999.

DPA	Area of seagrass (ha – ha)		No. of seagrass species		Average above-ground seagrass biomass (gDWm^{-2})		Dugong preferred seagrass species present		Dugong or feeding trails sighted	
	May 1999	Oct 1999	May 1999	Oct 1999	May 1999	Oct 1999	May 1999	Oct 1999	May 1999	Oct 1999
Upstart Bay	2247 ±345	2987 ±532	6	7	22.1 ±5.4	21.0 ±5.3	✓	✓	✓	-
Newry region	2450 ±360	2451 ±345	9	7	8.3 ±0.8	15.8 ±2.5	✓	✓	✓	✓
Sand Bay	0	0	0	0	0	0	-	-	-	-
Llewellyn Bay	115 ± 50	117 ±55	3	4	7.0 ± 0.5	2.4 ±0.6	✓	✓	-	-
Ince Bay	1204 ±134	1573 ±187	4	5	7.2 ±1.2	4.1 ±1.3	✓	✓	✓	✓
Clairview region	na	na	>2	na	na	na	✓	*na*	✓	*na*

Key Issues

- DPAs with the greatest seagrass abundance were all "DPA As", offering the higher level of protection (Upstart Bay, Newry region and Ince Bay). The two bays assigned "Dugong DPA B" status had little or no seagrass (Llewellyn Bay & Sand Bay respectively). Anecdotal evidence indicates that dugong move through these areas, and they may act as a buffer to the "A" areas. The Clairview region "DPA B" appears to have extensive seagrass resources.

- From the quantitative long-term information that is available on seagrasses for the DPAs there is no evidence of seagrass area being less in 1999 than in 1987.

- It is difficult to interpret comparisons between the present results and those collected 12 years ago. In 1987 only one day was allocated to each region and no seasonal comparison was undertaken. Due to tidal conditions and time constraints on the day, little or no sampling occurred in the upper intertidal regions of Llewellyn Bay and Seaforth. Position fixing was by RADAR and position errors could be up to 100 times the error in the present study. Seagrass biomass was estimated by percent area cover and is not easily comparable with present visual estimates of seagrass biomass.

- Most of the seagrass resources are confined to intertidal and very shallow sub-tidal depths due to large tidal ranges and tidal currents generating high coastal turbidity in these DPAs. This allows only a very limited area of seagrass feeding habitat available to dugong during low tide periods.

- Regular seasonal and annual surveys would be necessary to build a more detailed picture of the range of changes in availability that dugong face in finding food throughout the year and between years.

- There is little information on below ground biomass although roots and rhizomes make up a significant proportion of dugong food. Other information not available for dugong management include:
    - rates of seagrass productivity through a year;
    - long term trends in species mix and seasonality; and
    - the area of seagrass (and availability through a tidal cycle) that is required to support a dugong.

1.INTRODUCTION AND OVERVIEW

INTRODUCTION

Study Brief

The waters of northern Australia, including the Great Barrier Reef World Heritage Area, have a significant proportion of the world's dugong (*Dugong dugon*) population and are likely to support the only remaining large populations. Aerial surveys of dugong populations have been commissioned by the Great Barrier Reef Marine Park Authority and carried out by James Cook University since 1984. An estimated 15% of the Australian population of around 85,000 animals is in the World Heritage Area (Marsh *et al.* 1999).

Declines in dugong numbers in the Great Barrier Reef Marine Park south of Cooktown are known to have occurred since 1987 (Marsh *et al.* 1996). Dugong are listed as vulnerable to extinction both internationally and under Queensland legislation (Queensland Nature Conservation Regulations 1994, IUCN 2000). Dugong are also a listed species under the Environmental Protection and Biodiversity Conservation Act 1999, and afforded protection under this Act.

In November 1996 the Great Barrier Reef Ministerial Council agreed that emergency action was required to conserve dugong numbers in the Great Barrier Reef World Heritage Area. As a consequence, 16 areas have been declared Dugong Protected Areas (DPAs). These areas were chosen because they were known to include large areas of seagrass and significant dugong populations. The Ministerial Council also acknowledged that one of the reasons for the decline in dugong numbers may be seagrass habitat loss.

Seagrasses are essential food for dugong. There is however, insufficient long-term information on the abundance, productivity and seasonal change of the preferred seagrass (food) species of dugong within the Great Barrier Reef World Heritage Area to make any firm connection between habitat status and dugong numbers. Seagrass information that is available for many of the DPAs, and on which the boundaries of the DPAs were determined, is broad-scale and over 10 years old.

For better management and to better understand the seagrass resources within DPAs the Great Barrier Reef Marine Park Authority commissioned detailed seagrass surveys of the DPAs in Upstart Bay, Newry region, Sand Bay, Ince Bay and Llewellyn Bay (Map 1.1). The Authority also commissioned a helicopter flyover and some limited ground truthing of the Clairview region DPA .

The objectives were:

1. To map the distribution of coastal inshore and island seagrass meadows within the DPAs of Upstart Bay, Newry region/Sand Bay and Ince/Llewellyn Bays in Autumn and Spring and to provide some management and planning advice for the Clairview region DPA;

2. To produce a detailed Geographic Information Systems on seagrass habitats within each of the DPAs for use by managers;

3. To identify areas of seagrass with a distribution, species composition, and density particularly suitable for dugong feeding within each of the DPAs;

4. To compare the survey results with previous seagrass survey results available for the DPAs;

5. To provide information needed to further improve understanding of the relationship between dugong feeding behaviour and the location and species characteristics of seagrasses and;

5. To identify juvenile prawns, other invertebrates and fish species present in representative seagrass meadows within each of the DPAs of Upstart Bay, Newry/Sand Bays and Ince/Llewellyn Bays in autumn and spring.

Dugong

Dugong are marine mammals of the order Sirenia. They look similar to a rotund dolphin or seal, although they are less streamlined. Despite their appearance, dugong and their relative (manatees) are more closely related to elephants than to other marine mammals. Dugong have a life span of about 70 years and an adult can grow to lengths greater than 3 m and weigh in excess of 400 kg (Marsh *et al.* 1999). Females have their first calf between 10 and 17 years. Calves are born singly between September and November, with an interval of 3 to 7 years between each calf being born. Calving is thought to occur in specialised areas, often shallow waters removed from seagrass meadows. The gestation period is 13 months, and calves suckle for 18 months. During this time there is a strong bond between the cow and calf (Marsh *et al.* 1999).

Dugong are the only marine mammal that is strictly a herbivore, feeding almost exclusively on seagrasses. Dugong prefer seagrasses that are lower seral or "pioneer" species (Preen 1995a, 1995b), especially species of the genera *Halophila* and *Halodule*. These species are lower in fibre and higher in available nitrogen (*Halodule*) and digestibility (*Halophila*) (Lanyon 1991).

Dugong have a wide geographical distribution in shallow tropical and subtropical waters of the Indo-Pacific region. Their range includes waters of 43 different countries, extending from eastern Africa to Vanuatu and between 27 degrees north and south of the equator (Marsh *et al.* 1999). Many dugong populations however, are relict or extinct. In Australia, their range is from Shark Bay in Western Australia, across the north to Moreton Bay, south eastern Queensland (Marsh *et al.* 1999).

To address declines in the dugong population south of Cooktown a two-tiered system of 16 DPAs came into effect in January 1998 in the GBR region. In these areas fishing practices which used gill- and mesh- netting were restricted, banned or modified, because incidental catch in commercial nets was considered to be a major threat to dugong populations. A reduction or cessation of indigenous fishing, a review of shark meshing activity and restrictions on boat speeds were also part of the DPA approach.

Present day dugong populations face numerous impacts that contribute to a decline in numbers either through direct impacts on dugong or indirect impacts via the seagrass food resource. Factors identified as presently posing a real or potential risk to populations include boat traffic, dredging, coastal development, traditional hunting, commercial gill netting, illegal fishing, defence activities, land clearing, agricultural activities and sediment run-off (Great Barrier Reef Marine Park Authority, Dugong Information Kit, February 1998). Natural impacts including tropical cyclones, floods, storms and predators may also effect dugong numbers. For dugong populations to exist in a healthy state, these impacts must be effectively managed or the effects understood and where possible, prevented altogether. Underpinning all these factors is the requirement for dugong to have available a healthy and abundant food source in the form of seagrass meadows.

Dugong strandings and mortality in the present study DPAs have been minimal in 1999 and 2000, compared with all other DPAs (Table 1.1).

Table 1.1 Dugong strandings and mortality in Dugong Protection and adjacent areas 1999 and 2000 (Source: Queensland Parks and Wildlife Service)

Dugong Protected Area	No. of dugong strandings and mortality 1999	Adjacent sites in 1999	No. of dugong strandings and mortality 2000	Adjacent sites in 2000
Upstart Bay DPA "A"	0	0	2	0
Newry region DPA "A"	0	1	0	0
Sand Bay DPA "B"	0	0	2	0
Llewellyn Bay DPA "B"	0	0	0	0
Ince Bay DPA "A"	0	0	0	0
Clairview region DPA "B"	0	1	0	0
All other DPAs*	37	5	36	1
TOTAL	37	7	40	1

- All other DPAs include Hinchinbrook region, Taylors Beach, Cleveland Bay, Bowling Green Bay, Edgcumbe Bay, Repulse Bay, Shoalwater Bay, Rodds Bay and Hervey Bay/ Great Sandy region.

Seagrasses of Queensland

Seagrasses are flowering plants that can live entirely immersed in seawater. Tropical species are usually found in less than 10 metres below mean sea-level but may be found at depths to 50 metres or more (den Hartog 1977, Coles *et al.* 2000). They are found on substrates ranging from the nutrient rich soft muds adjacent to mangrove fringes to carbonate sands around cays on the outer Great Barrier Reef. Several species have also colonised the coral reef platforms, exposed reef slopes and to depths of 60m in the Great Barrier Reef lagoon.

Although totally submerged, seagrasses have all the general structures of their terrestrial plant relatives - a root system, a vascular system, and vegetative and sexual reproduction with flowers fertilised by water borne pollen. Adaptation to the marine environment has imposed major constraints on morphology, and structure and the restriction to seawater has influenced their geographic distribution and speciation.

Seagrasses are one of the globes most common coastal ecosystem types forming vast meadows that are highly dynamic and important contributors to primary production (Costanza *et al.* 1997). Entire commercial fisheries may depend on seagrass nursery areas in Queenslands tropical coastal areas (Watson *et al.* 1993).

Instances of widespread seagrass losses have been reported from most parts of the world. Some from natural causes such as the wasting disease (Rasmussen 1977) of *Zostera marina* and from storms (Patriquin 1975). More commonly losses have resulted from the consequences of human activities such as land reclamation and changes in land use (Kemp *et al.* 1983) or eutrophication and light reduction (Shepherd *et al.* 1989).

It is important to document seagrass diversity and distribution before further changes occur. A scan of the scientific literature quickly identifies the paucity of published seagrass research, apart from taxonomic studies, available for tropical regions.

There are 15 or 16 species (there is presently some taxonomic uncertainty for species of the genus *Halophila*; J. Kuo, University of Western Australia, Pers. Comm.) of seagrass in Queensland east coast waters occupying a variety of habitats. Most species are widely distributed along the coast (Lee Long *et al.* 1993). The most commonly found species are in the genera *Halodule* and *Halophila*. Almost all can be found in shallow coastal waters. Only species of the genus *Halophila* are commonly found 15m or more below MSL (Coles *et al.* 2000).

In the mid 1980's, Coles *et al.* (1987) described from broad scale coastal surveys, three general depth zones of seagrass species composition for tropical waters: a shallow zone less than six metres deep with a high species diversity and likely to include all species found in the region; a zone between 6 and 11 metres where the most commonly found species were the pioneering *Halodule* and *Halophila* species, and a zone deeper than 11 metres where only species of the genus *Halophila* were common. The ability of *Halophila* species to grow in low light intensities may give this genus advantage over others in deep or turbid water (Coles *et al.* 1987).

The range of depth of seagrass is most likely to be controlled at its deepest edge by the availability of light of suitable spectral qualities for photosynthesis. Exposure at low tide, wave action and associated turbidity and low salinity from fresh water influences determine seagrass species survival at the nearshore edge. Seagrasses will survive in the intertidal zone especially in sites sheltered from wave action or where there is entrapment of water at low tide, (such as on a reef platform) protecting the seagrasses from exposure to drying at low tide.

Natural seasonal variation in seagrass biomass has been documented (McKenzie 1994) and more recent detailed surveys have indicated some large long-term changes in seagrass area at regional scales (Lee Long *et al.* 1998). The causes and scale of long-term changes, and the ecological consequences for faunal populations of fisheries and conservation value are not well understood for tropical species.

The Importance of Seagrasses in the Coastal Ecosystem

Seagrasses form complex ecosystems in coastal waters providing physical and biological functions such as:

(1) Larger seagrass species buffer wave action, stabilise and hold bottom sediments, and reduce sediment resuspension and erosion during storms;

(2) Meadows serve as a shelter for resident and transient adult and juvenile animals many of which are of commercial and recreational importance or important to traditional fishing communities;

(3) Seagrasses and their epiphytes are a major marine source of carbon and provide a food source to complex food webs through direct grazing or through detrital pathways; and

(4) Seagrass plants trap detritus, sediment and nutrients (derived from land runoff) within the seagrass ecosystem.

Seagrasses are also important in interactions with the other major coastal communities of mangroves and coral reefs. Each of these communities may exert a stabilising effect on the environment, which results in important physical and biological effects on the other communities (Amesbury and Francis 1988). Barrier reefs protect coastlines and in the Great Barrier Reef, the lagoon is protected from ocean swells allowing mangroves and seagrass communities to develop. The sediment trapping function of seagrasses benefits nearby corals by reducing sediment loads in the water. Mangroves also trap sediment from the land, reducing the chance of seagrasses and corals being inundated. Sediment banks accumulated by seagrasses may eventually form substrate that can be colonised by mangroves. All three communities trap and hold nutrients from being dispersed into the surrounding nutrient-poor oceanic waters.

Seagrass primary productivity ranks amongst the highest for submerged aquatic communities reaching rates of 550g C $m^{-2}yr^{-1}$ for above-ground productivity (Hillman *et al.* 1989). The major factors affecting seagrass productivity are irradiance, temperature, nutrient availability, and water movement. Light and temperature are probably the main factors governing seasonal and depth changes in productivity at any site (Hillman *et al.* 1989). Moriarty *et al.* (1985) suggested nutrient limitation, in particular nitrogen, may also limit growth in tropical seagrasses. However, in tropical coral reef waters where carbonate sediments predominate, N:P ratios in plant tissues suggest availability of phosphorous is also a limiting factor (Short 1987).

Standing crop biomass measurements for the tropics generally have relatively low values. Brouns (1987) recorded *Cymodocea serrulata* at 148 g DW m^{-2} above-ground biomass. Herbert (1986) recorded 104 g DW m^{-2} for *Halophila hawaiiana*. Similar or lower values were recorded for northern Australia (Lee Long *et al.* 1993) and in the present study. There is little information on how this biomass value changes seasonally. In Papua New Guinea variation in standing crop for five species was slight (Brouns 1987). Mellors *et al.* (1993) reported only a two-fold seasonal change in all species at Green Island, northern Australia, associated primarily with temperature and light availability. However some tropical *Halophila* species are annuals and almost completely absent (Kuo *et al.* 1993) at times of the year, leading to very large seasonal changes in biomass.

Seagrasses in tropical reef regions represent an accumulation of nutrients in what is otherwise a nutrient-poor environment. They are capable of absorbing nutrients from run-off and interstitial waters. They influence nutrient cycling and nitrogen fixation and may increase nutrient flux to local waters. Their influence may also extend to nearby regions through the export of live and dead seagrass material.

The abundant fauna in seagrass meadows is due to the richness of these systems as a source of food and shelter and their use as nursery areas by many fish and crustacean species (Coles *et al.* 1993; Bell and Pollard 1989). Recent fisheries research has shown that it is the shallow, high-diversity zone that is most productive, at least for commercially important penaeid shrimp fisheries (Derbyshire *et al* 1995).

Dugong and some turtle are direct grazers of seagrasses and the importance of these animals has helped to raise conservation concerns for seagrasses in northeastern Australia. However many other species are also direct grazers. McRoy and Helfferich (1980) recorded 154 species, including invertebrates and fish which consume living seagrass.

Previous samples from tropical seagrasses in northern Australia identified 134 fish taxa at a density of nearly 9000 fish per hectare of seagrass (Coles *et al.* 1993). Twenty species of penaeid shrimp were also identified, of which nine species were of commercial importance to the fishing industry. Simulation modelling using just the three penaeid species that form the largest component of the fishery rate this tropical seagrass bed of 876 ha worth an estimated mean value of 1.2 million dollars Australian per year for 1987 to 1989, a figure that was verified from commercial fishing log book records (Watson *et al.* 1993).

Most information on seagrass fauna has come from studies of taxa of direct fisheries importance. Where there are not major commercial fisheries to fund research, or where fauna has no direct fisheries values, knowledge remains patchy. Howard *et al.* (1989) describe four types of fauna in seagrasses: *infauna* (animals living in the sediment amongst the seagrass rhizomes); *motile epifauna* (smaller, mobile animals on the sediment surface or on seagrass stems or leaves); *sessile epifauna* (permanently attached animals living on seagrass stems or leaves); and *epibenthic fauna* (the larger mobile animals which are loosely associated with seagrass meadows). All these groups should be considered when estimating the contribution of seagrass meadows to local productivity.

While carnivorous fish are the most important trophic group of fish communities, seagrass-associated crustaceans dominate the diet of fish communities (Klumpp *et al.* 1989). Crustaceans are the main source of food for fishes in seagrass beds and are thought to be a major link between primary producers and higher consumers (Klumpp *et al.* 1989).

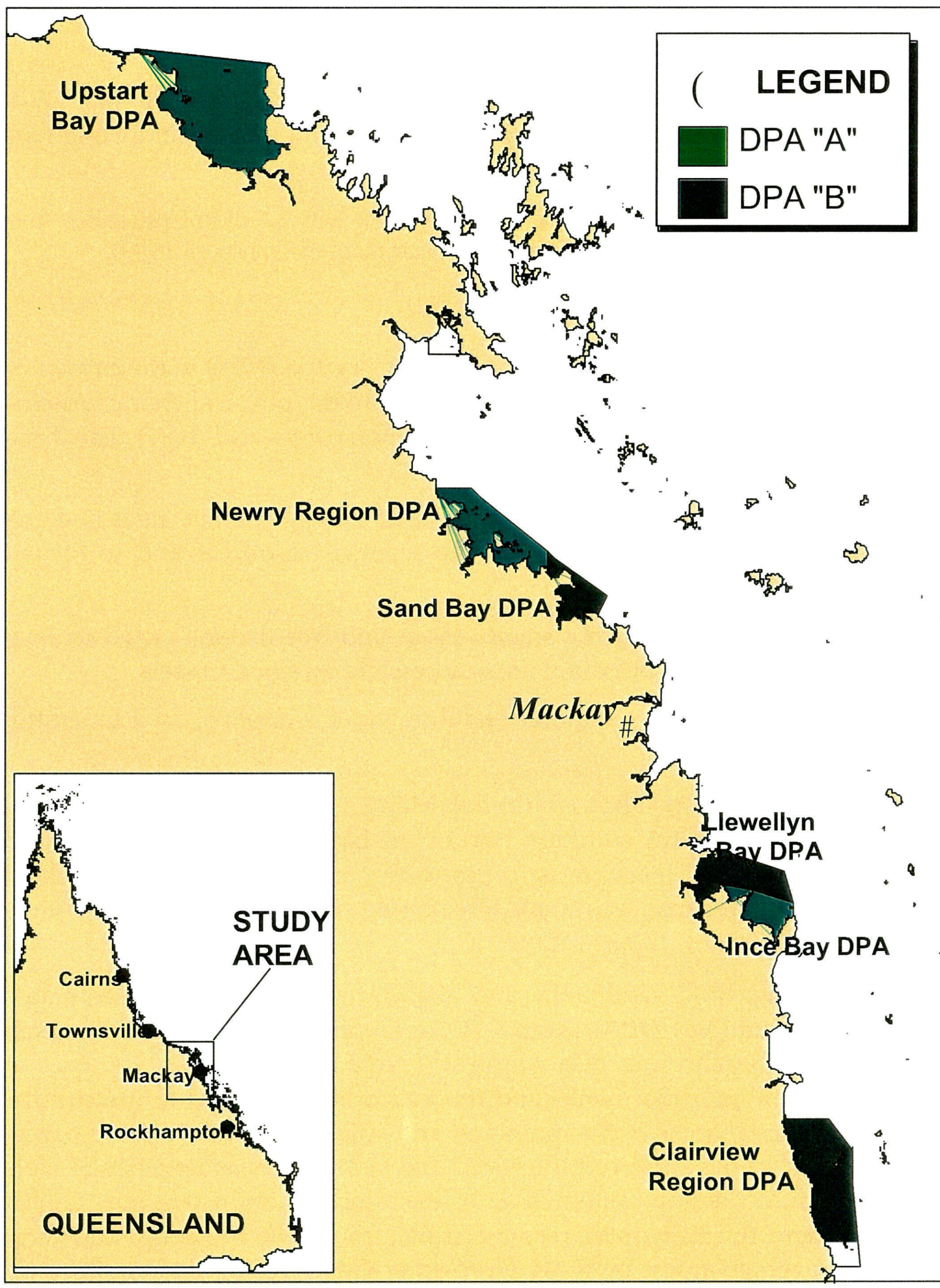
Although seagrass meadows by definition are dominated by the biomass of the seagrasses themselves, a diverse assemblage of other benthic flora are found within a seagrass meadow. Seagrass leaf surfaces typically carry a complex layer of diatoms, micro and macroalgae, bacteria, encrusting algae, fungi and other accumulated debris. Little information exists on algae production rates in the tropics as leaf turnover can be very rapid, but in temperate seagrasses epiphyte production can be 10% - 40% of seagrass leaf production (Klumpp, *et al.* 1989).

Seagrasses play a vital role in supporting coastal marine communities and in maintaining diverse flora and fauna. They support coastal fisheries productivity and play a role in maintaining coastal water quality and clarity. It is important that coastal zone and catchment management decisions take into account these values and that seagrass areas are protected from loss.

METHODS

Description of Study Region

The study region includes the Upstart Bay, Newry region, Sand Bay, Llewellyn Bay, Ince Bay and Clairview region DPAs and is within the northern and central belts of Queensland (19°42′S to 21°36′S) (Map 1.1).



Map 1.1 The study region encompassing the Upstart Bay, Newry region, Sand Bay, Ince, Llewellyn Bay and Clairview region Dugong Protection Areas.

Agriculture (sugar and dry land grazing) is the main industry and urban development is low throughout the regions catchments. Mackay is the largest city situated on the coast between the Sand Bay and Llewellyn Bay Dugong Protection Areas, with a population of just over 124,000.

Monsoonal summer rains provide the bulk of precipitation for the region; intermittent showers occur through the remainder of the year. South-easterly trade winds dominate the drier winter and spring period (June to November). These trade winds create a general northerly, longshore current inshore, while a light southerly flow exists on the mid and outer shelf under the influence of the East Australian Current (Wolanski, 1994).

Numerous creeks and rivers drain the Great Dividing Range and narrow coastal plain. The largest catchment in the region is the Burdekin River system, which drains into the northern part of Upstart Bay.

Tidal ranges in the study region vary from approximately 3.6 m in Upstart Bay to approximately 8.5m in the Clairview region (Queensland Department of Transport, 1999).

Seagrass Survey Approach

Three sampling techniques were used to survey the DPAs in the present study. These were tailored to each of the DPAs according to the physical characteristics of the bays and to prior knowledge of seagrass distribution (Coles *et al.* 1987). The three techniques were:

1. Helicopter reconnaissance surveys - used to map shallow tidal flats inaccessible to small boats, scope the extent of the seagrass resources and to focus diver-based survey effort
2. Dive-based surveys (using small vessels and free divers) - used to sample shallow subtidal areas and intertidal areas accessible by small vessels
3. Deepwater surveys - remote, real-time video sampling used in subtidal areas too deep for free diving.

The majority of Upstart Bay is subtidal (Map 2.1). Shallow intertidal banks are confined to Nobbies Inlet in the southern part of the bay and a narrow fringe adjacent to the western shoreline. Helicopter surveys were not necessary to survey this DPA as the area of intertidal banks was small. Dive-based surveys and deepwater video were used to survey the bay.

Extensive intertidal sandbanks and shallow subtidal waters dominate the Newry region and Sand Bay DPAs (Map 3.1). Aerial photographs (1:25,000) taken at low tide (courtesy of Beach Protection Authority) were interpreted for presence or absence of seagrasses on intertidal banks and the helicopter was used to ground truth exposed upper intertidal areas of the mainland and adjacent islands. A dive-based survey was undertaken in the sheltered intertidal and subtidal areas between St Helens Bay and Seaforth in the Newry region DPA. A less intensive effort was spent on the Sand Bay DPA, where the helicopter reconnaissance found no seagrass, and large intertidal banks prevented access by boats. Deepwater video was used along the offshore margin of these DPAs.

Extensive intertidal sandbanks dominate Ince Bay, with the entire bay <5 m in depth (the majority <2m below MSL) (Map 4.1). Shallow subtidal and intertidal areas (<5m in depth) dominate Llewellyn Bay. A helicopter was used to survey the large exposed banks of Ince Bay, and along the western and southern shorelines of Llewellyn Bay. Divers were used to survey the accessible intertidal areas and subtidal areas of both DPAs. Deepwater video was used in the deeper waters of the DPAs.

Seagrasses were surveyed during autumn (April/May) and spring (October) to estimate the range of areal extent and biomass abundance of the meadows. Seagrass has been recorded at greatest/least areal distribution (McKenzie *et al.* 1998) and greatest/least abundance (McKenzie 1994; Mellors *et al.* 1993) during these seasons. The Clairview region DPA was only surveyed from a helicopter and only in April (autumn) with few ground truth sites.

Helicopter Surveys

Helicopter aerial surveys of intertidal seagrasses were conducted during the low spring tides on 27th and 28th April 1999. During flights, observers interpreted the distribution of seagrass onto survey charts and a Hi8 video camera was used to store a visual record for future reference and to aid interpretation when mapping on a GIS. Sites in seagrass meadows were also selected for ground truthing. At each site, a standard quadrat (0.25m^2) was haphazardly placed within a 5 m radius (3 quadrats per site), to visually estimate seagrass abundance (Mellors, 1991) and seagrass species composition.

Dive Surveys

Shallow sub-tidal (2-10m below MSL) areas were surveyed by diver observations (free-diving) 16th-25th May (autumn) and 12th-20th October (spring) 1999. Dive sites were distributed haphazardly along transects according to changes in depth and habitat type (50m to 500 m apart). Survey transects extended from the upper intertidal reaches to approximately the 10 m (below MSL) depth contour (up to 7km offshore).

Seagrass habitat characteristics including above-ground seagrass biomass, species composition, % algae cover, sediment type, water depth and GPS coordinates were recorded at each site.

Above-ground seagrass biomass was determined by a visual estimates of biomass technique modified from Mellors (1991). This method avoids extensive destructive sampling. At each intertidal and shallow sub-tidal site, observers recorded an estimated rank of seagrass biomass and species composition in three replicates of a 0.25 m^2 quadrat per site. On completion of the survey, each observer ranked five quadrats that were harvested from a "low biomass" site and another five quadrats from a "high biomass" site and the above-ground biomass (g DW m^{-2}) measured. The regression curves representing the "high" and "low" biomass calibration of each observer's ranks was used to calculate above-ground biomass from their estimated ranks during the survey. All observers had significant linear regressions (r^2 >0.80) when calibrating above-ground biomass estimates against the sets of harvested quadrats (Appendix 1). Photographic examples of above-ground biomass (g DW m^{-2}) were used as a guide and to achieve consistency between divers and through time (Appendix 2).

Deepwater Surveys

Deep-water sites (>10m) were surveyed using a real-time towed underwater video camera and a sled-net. Five minutes of towed (at drift speed) video footage was recorded for each site and images were archived on VHS and DVCAM videotapes.

Deepwater sites were checked for seagrass presence by replaying and examining the videotapes. Seagrass biomass estimates were based on 10 random time frames, at a one-second accuracy, allocated within the 5 minutes of footage for each site (within-site variance was reduced by at least 50% with 10 replicates). Above-ground seagrass biomass was again determined by a visual estimates of biomass technique in this case modified from Mellors (1991) for use with video recording. Seagrass species composition was also recorded where this was possible. The video was paused at each of the 10 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 m^2 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 to ten 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 regression curve was calculated for the relationship between the observer ranks and the actual harvested value. This curve was used to calculate above-ground biomass for all estimated ranks made from the survey sites. All observers had significant linear regressions (r^2 =0.98) when calibrating above-ground biomass estimates against the harvested quadrats.

A second set of video images of quadrats that had been harvested, dried and weighed were used by the observer as a quick reference to minimise any drift in estimation over time during a series of video estimations. Sites that were used for biomass estimation were selected at random from the entire data set to limit the potential for bias through time.

Taxonomic specimens were collected from the towed dredge samples and by divers where ground truthing was undertaken. Seagrass species were identified according to taxonomic keys of Kuo and McCombe (1989) and Lanyon (1986). Seagrass voucher specimens for taxonomic use were lodged with the QDPI Northern Fisheries Centre Herbarium. Seagrass identifications were made from video tape alone only where species were clearly identifiable. Where identification was difficult on screen and no confirmation of the species was obtained from dredge or diver samples the genus was recorded.

Algae species were identified according to Cribb (1996) and percent cover of algae was estimated for each site.

A Van Veen grab was used to sample sediment type and a Secchi disc was used to measure water clarity at each site. Field descriptions of sediment type from hand samples were also recorded for each site as shell grit, rock, gravel, coarse sand, sand, fine sand and mud. Sediment and secchi information is presented in the site layer associated with the Geographic Information System.

Water depths of survey sites were recorded with an echo sounder (to the nearest decimetre) and converted to depths in metres below mean sea level (correct to tidal plane datums) (Queensland Department of Transport 1999).

Geographic location of sampling sites (±5 m) was determined by a differential Global Positioning System (dGPS).

Dugong observations

Dugong feeding trails were recorded as present at sites when observed by divers and observed from the helicopter flights. Dugongs were recorded when observed opportunistically from the vessels. This fauna information was coupled with position fixes and exported to MapInfo® and displayed on maps.

Invertebrate and Fish Communities

Qualitative sampling using beam trawls was conducted in representative seagrass communities within the DPAs. Two trawling sites were chosen in the Upstart Bay and Newry Bay DPAs. One site was chosen in the Ince Bay DPA. Sites were trawled in May and October 1999. Sampling was conducted at the time of high water at night. A beam trawl (1.5 m wide, 0.5 m high with a 2.0 mm mesh) was towed along each 100 m transect at approximately 0.5 m s^{-1} (Coles *et al.* 1993). Four replicate trawls were conducted at each site as previous studies in north Queensland have shown that that is sufficient to adequately sample the representative fauna (Coles *et al.* 1993).

All Penaeidae (prawns) were identified to species according to Dall (1957) and Grey *et al.* (1983). Carapace length (posterio-dorsal margin of the carapace to the orbit of the eye) was measured to the nearest 0.1mm. All fish were identified as far as possible and standard length (tip of snout to last vertebra) measured to the nearest 0.1mm for the largest and smallest individuals from each taxa in May 1999 and October 1999.

Numbers of Brachyura (crabs), squid, sepiolids (cuttlefish) and miscellaneous crustaceans (shrimps, isopods, amphipods, and stomatopods) were pooled respectively and recorded for each trawl. Biomass (g dry weight) of fish, penaeids (all species pooled), crustaceans and miscellaneous from each trawl was determined by drying (60°C, 48 hrs) and weighing samples. Biomass of fish in May was for all taxa pooled and in October was separated by Family. Molluscs, polychaetes and other phyla were not measured for biomass.

Geographic Information System

All survey data was entered into Microsoft Access® then exported to MapInfo® to construct a Geographic Information System (GIS) for mapping and presentation.

Recent colour aerial photographs (Beach Protection Authority, June 1998, 1:25,000) were rectified for use in the GIS to assist in mapping boundaries of intertidal seagrass meadows in Upstart Bay, Newry region, Sand Bays, Llewellyn Bay and Ince Bay.

Seagrass meadows with an average above-ground seagrass biomass over 20 g DW m^{-2} were considered "high biomass" and those with an average of less than 20 g DW m^{-2} were considered "low biomass" for analysis and presentation purposes

Boundaries of seagrass meadows were determined based on the GPS fix at each survey site and ground-truthed aerial photographs. Meadow boundaries drawn on GIS maps are estimates based on above-ground seagrass presence/absence information and location of sample sites. Each seagrass meadow in the DPAs was assigned a Mapping Quality rank (decreasing Mapping Quality from rank 1 to 6) (Table 1.2) based on the data sources and accuracy of each technique used for mapping the meadow. Other errors associated with mapping, include those associated with digitising and rectifying aerial photographs onto a base map. Differences between the GPS, and the diver's sampling position, were assumed to be embedded within this range. Estimates of error (in hectares) were calculated using the polygon buffer function in MapInfo®. Seagrass information for the 1999 helicopter survey in the Clairview region DPA was from field observations and qualitative information from landing sites.

Information specific to each site surveyed and each meadow drawn in each of the DPAs is found within the GIS.

Table 1.2. Map quality for seagrass meadows in Upstart Bay, Newry region, Sand Bay, Llewellyn Bay and Ince Bay. *No seagrass was mapped from deepwater video sampling, it is not included in this table. Seagrass area was mapped for seagrass meadows in the Clairview region DPA, but coarse reliability than shown in this table.

Mappin g Quality	Data sets	Comments
1	*Helicopter reconnaissance, aerial photos and dive survey*	*Detailed checking of meadow boundary during dive survey. Aerial photos taken June 1998, 1:25,000 scale, colour, high definition. Error = 15-20m*
2	*Helicopter reconnaissance, aerial photos and dive survey*	*Some meadow boundaries checked with several transects during dive survey. Aerial photos taken June 1998, 1:25,000 scale, colour, very high definition. Error = 20-30m*
3	*Helicopter reconnaissance aerial photos and dive survey*	*Occasional meadow boundaries checked during dive survey. Aerial photos June 1998, 1:25,000 scale, high definition. Error = 15-40 m*
4	*Helicopter and aerial photos*	*Photos of suitable resolution. Meadow boundaries checked during ground truth survey. No dive survey. Error = 25-50m*
5	*Aerial photos and dive survey*	*Meadow boundaries checked during dive survey. Aerial photos taken June 1998 or May 1991, 1:25,000 scale, colour and black & white images, low to high definition. Error = 30-50m*
6	*Dive survey only*	*Subtidal meadows not visible in aerial photos, Data densities generally low and reliant solely on dive survey. Error = 30- 70 m*

Analysis

Seagrass abundance data is presented graphically with standard errors calculated. A visual representation is best where signals are large and seasonal comparisons fit poorly with the assumptions of ANOVA.

Direct statistical comparisons between 1987 and 1999 seagrass data were not performed as methodology and site location accuracy has changed and improved. Comparisons rely on maps and graphical representation.

OVERVIEW AND SUMMARY OF RESULTS

Seagrass Species

In the five DPAs surveyed in May and October 1999, ten species of seagrasses (from three families) were identified (Table 1.3). Two species were also found in the Clairview region DPA but this list is likely to be incomplete as Clairview was not surveyed subtidally or at a fine scale.

Table 1.3. Seagrass species present in the Upstart Bay, Newry region, Sand Bay, Llewellyn Bay and Ince Bay Dugong Protection Areas

Seagrass Family	Seagrass species	UPSTART BAY		NEWRY REGION		SAND BAY		LLEWELLYN BAY		INCE BAY		CLAIRVIEW REGION	
		May 1999	Oct 1999	May 1999	Oct 1999	May 1999	Oct 1999	May 1999	Oct 1999	May 1999	Oct 1999	Mch 1987	April 1999
ZOSTERACEAE Drummortier	*Zostera capricorni*	✓	✓	✓	✓	-	-	✓	✓	✓	✓	✓	-
CYMODOCEACEAE Taylor	*Cymodocea rotundata*	-	-	✓	-	-	-	-	-	-	-	-	-
	Cymodocea serrulata	✓	✓	✓	✓	-	-	-	-	-	-	-	-
	Halodule uninervis	✓	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓
	Syringodium isoetifolium	-	-	✓	✓	-	-	-	-	-	-	-	-
HYDROCHARITACEAE Jussieu	*Halophila decipiens*	✓	✓	✓	✓	-	-	-	✓	-	✓	-	-
	Halophila minor	-	-	✓	-	-	-	-	-	-	-	-	-
	Halophila ovalis	✓	✓	✓	✓	-	-	✓	-	✓	✓	✓	✓
	Halophila spinulosa	✓	✓	✓	✓	-	-	-	✓	✓	✓	-	-

General Seagrass Distribution

787 sites were sampled in May 1999 and 892 in October 1999 in the Upstart Bay, Newry region, Sand Bay, Ince Bay and Llewellyn Bay DPAs. 48 sites were surveyed from helicopter in the Newry/Sand, Llewellyn/Ince and Clairview DPAs, 27-28th April 1999. 12 sites were ground truthed in the Clairview region DPA to confirm seagrass presence, abundance and species.

The total area of seagrass habitat mapped in the 5 DPAs surveyed in May 1999 was 6015 ± 982ha and 7128 ±1232ha in October. Of the 10 species, *Halodule uninervis* was the most common species in the study area in May 1999 (all sites pooled) and was present at approximately 55% of sites that had seagrass. Depth ranges are very narrow with almost all records between 0 and 6 m below MSL.

Species number decreased with increasing latitude in agreement with previous observations (Lee Long *et al.* 1993). Some species may be limited in the present case by the high tidal range and exposure at low tide in the regions south of Mackay.

It is difficult to interpret the present results when compared with those collected 12 years ago by Coles *et al.* (1987). In 1987 only one day was allocated to each region and there was no seasonal comparison undertaken. Particularly at Llewellyn Bay and

Seaforth this led to little or no sampling in the upper intertidal regions due to tide height and time constraints on the day. Position fixing at the time was by RADAR fix and position errors could be up to 100 times the error in the present study. Biomass was estimated by percent area cover and so is not easily comparable with present techniques.

Despite this, some patterns in distribution have remained remarkably similar. Upstart Bay seagrasses in both surveys were predominantly on the extensive intertidal and shallow subtidal banks that fringe the bay. Seagrasses remain absent from the deeper waters in the middle of the bay. Almost 1000ha more seagrass area was mapped in 1999 compared with 1987 but a large part of this may be due to improved survey techniques. There is no evidence of long-term decline in seagrass area in this or any of the DPAs surveyed. The suite of seagrasses species is similar with only *Syringodium isoetifolium* and *Cymodocea rotundata* missing in the present survey. *Syringodium isoetifolium* population size can change rapidly (Rasheed 2000) and *Cymodocea rotundata* is uncommon on the east coast and may have been an isolated patch in 1987 or simply missed in the latest survey. Upstart Bay seagrasses remain important to penaeid prawn and fish production and diversity.

In the Newry region and Sand Bay DPAs, Port Newry was rich in seagrass species (up to six at a site) in 1987 and again in 1999, and seagrass was found in the same general locations. Sand Bay remains consistently without seagrass despite records of dugong in the area. Sand Bay is exposed to wave action and is unlikely to support large meadows of seagrass although it is possible that seagrass survives there on occasions.

The area of seagrass mapped in Ince Bay in October 1999 is unchanged from the area mapped in 1987. Llewellyn Bay has now seagrass meadows that were not recorded at all in 1987 but this is likely due to improved techniques (including use of helicopter) allowing access to intertidal sandbanks in an area with tide ranges of 5 metres or more.

The flyover of the Clairview region DPA indicates intertidal seagrass in similar locations to that in 1987.

In the present surveys and in 1987 the suite of seagrass species is predominantly species that are preferred dugong food. Those species can occur at depths ranges from around 20 cm above MSL to 13 metres below MSL and be potentially available to dugong as food in all but the most extreme tidal or weather conditions. However, because large tidal ranges and tidal currents generate high coastal turbidity in these DPAs, most of the seagrass resources are confined to intertidal and very shallow sub-tidal depths, leaving a very limited area of seagrass (feeding habitat) available to dugong during low tide periods.

Mean biomass for the above-ground plant material of any seagrass species in the DPAs ranged from a high of just over 20 grams dry weight (g DW m^2) in each square metre of sea bed in Upstart Bay; to less than 20 in the Newry region; less than 15 in Ince Bay; and only a mean of 5 g DW m^2 in Llewellyn Bay.

The maximum above-ground biomass for a single species was 100 g DW m^2 in a square metre of *Zostera capricorni* in Upstart Bay. This upper range represents dense seagrass beds by tropical standards with plants standing 20 to 30cm tall. Most seagrass area was relatively low biomass, particularly early in the year (Figure 1.1). Dugong feeding trails were usually common only in areas with an above-ground biomass of less than 15 g DW m^{-2}.

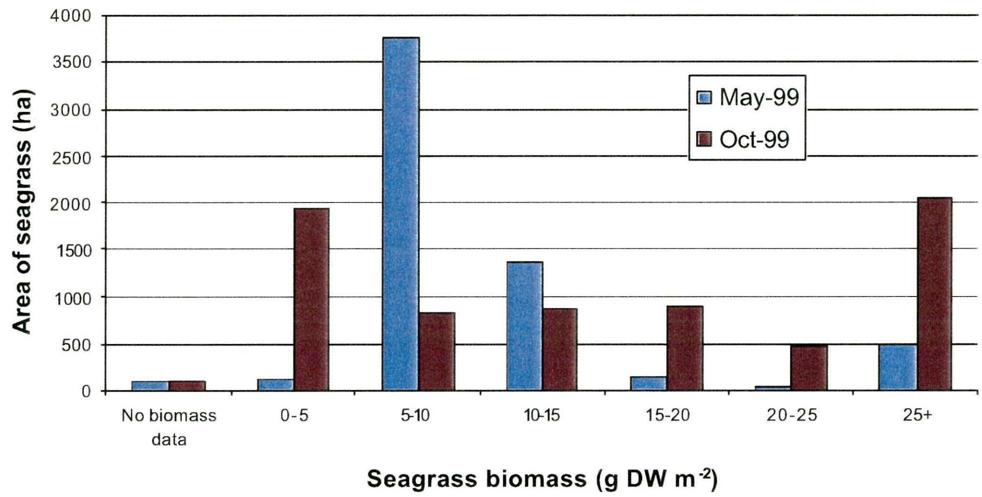


Figure 1.1. Total meadow area of above-ground seagrass biomass (all species and DPAs pooled), May and October 1999.

DISCUSSION

Habitat Area and Distribution

The area of seagrass within the DPAs is substantial and represents an important food resource for dugong. The majority of the meadows are low biomass and are dominated by *Halophila* and *Halodule*, species that are the preferred food species for dugong (Preen 1995b). All seagrass meadows surveyed were contained wholly within the DPA boundaries. Most of these habitats were at intertidal depths and not accessible to dugong during low-tide periods. The scarcity of seagrass habitat in sub-tidal areas is likely a result of large tidal ranges and tidal currents and corresponding high coastal water turbidity. Influence of tide-generated currents on coastal turbidity, on the sub-tidal extension of seagrass habitat and on availability of food to dugong, increases from regions of small tidal range (eg., Hinchinbrook region - Lee Long *et al* 1998) to medium tidal range (eg., Upstart Bay), large tidal range (Newry region and Llewellyn/Ince Bays) and very large tidal range (eg., Shoalwater Bay region - Lee Long *et al* 1997).

Bays with the greatest seagrass abundance were all "DPA A", offering the higher level of protection (Upstart Bay, Newry region and Ince Bay). Two bays assigned "DPA B" had little (Llewellyn Bay) or no (Sand Bay) seagrass. Anecdotal evidence is that dugong may move through these areas which would then act as a buffer to the "A" areas. Clairview region although assigned as a B area appeared to support similar dugong populations to the nearby A area in Ince Bay.

Except for Nobbies Inlet in Upstart Bay, almost no seagrass was found in creeks and rivers entering into the DPAs. Under present management arrangements for net fishing in DPAs only, limited netting (limited to 3 nets in "A" and "B" zones and fishers must be within 800m of nets) is allowed in the creeks and rivers. Because there is no seagrass in these creeks and rivers, the net fishery is unlikely to lead to conflict with feeding dugong (R. Garret QDPI, pers. comm. 2001). In the Upstart and Newry DPAs, some important dugong feeding habitats are also areas of high recreational vessel traffic, where threats to dugong through boat strike and disturbance to feeding, are increasing.

Temporal Changes

Recent research and monitoring programs are showing that many of the seagrass species in tropical waters may vary greatly in abundance seasonally and inter-annually. The range of change may extend to entire species being absent at times of the year (eg. *Halophila tricostata* Kuo *et al.* 1993) and meadows changing and moving significantly (Lee Long *et al.*, 1997, McKenzie *et al.* 1998). Little quantitative long-term information is available for the DPAs and the best interpretation from the present study is that there is no evidence of seagrass being less now than in 1987. However, regular seasonal and annual surveys are necessary to build a more detailed picture of the range of changes that dugong face in finding food throughout the year and between years.

Little seagrass was found in the deepwater (10m to 20m) video camera surveys although some areas appeared to be suitable habitat for seagrass colonisation. Typical deepwater seagrass species such as *Halophila decipiens* and *Halophila tricostata* are known to be highly seasonal in abundance and tend to germinate in early spring and disappear by late summer (Kuo *et al.* 1993), times in between the sampling times in the present study. Little is known about the importance of *Halophila tricostata* and *Halophila decipiens* to dugong diets.

Implications for Dugong Management and Fisheries

Coles *et al.* (1997) described seven classes of information on seagrasses needed to assess the value of a seagrass habitat for dugong. These were:

1. Estimates of seagrass area and biomass available;
2. Above-ground and below-ground biomass measures;
3. Mix of seagrass species present;
4. Range of depths and availability to dugong;
5. The area, biomass, availability, productivity of seagrass required to support a dugong in breeding condition;
6. Long term trends in area, biomass, species composition, and productivity; and
7. Seasonal changes in seagrass parameters.

For the DPAs in this study there is now a set of information to answer points 1, 3, and 4. We have little information on below ground biomass although roots and rhizomes make up a significant proportion of the food dugong eat. Key pieces of information missing are rates of seagrass productivity through a year and long term trends in seasonality and what area of seagrass is required to support a dugong.

It is essential that research is undertaken to answer these questions, however empirical estimates can be made based on numbers in Hervey Bay to the south. These suggest that a maximum population of around 2000 animals was supported by nearly 2000 square kilometres of seagrass. Historically, numbers of dugong per area of seagrass may have been much higher. Unlike the DPAs in the present study some of the Hervey Bay seagrass resources include large areas of subtidal habitat that is always available although some is in a 20 to 30 metre depth range and may not be ideal for feeding. A best estimate with this in mind would be that on average an area of available seagrass of between 50 and 100 hectares is required to provide long-term food support for a dugong. A sustainable dugong population for the Upstart Bay to Ince Bay DPAs based on these estimates would be 55 to 110 animals.

The dense *Zostera capricorni* meadows in Upstart Bay and the Newry region support commercial prawn and fish species. Similar meadows in other north Queensland locations are also important nursery habitats for juvenile prawns (McKenzie *et al.* 1996; Coles *et al.* 1993). The survey results in the present study support the protection of seagrasses under the *Queensland Fisheries Act 1994* as these habitats are confirmed as components of the ecosystem supporting sustainability of the east coast prawn and fin fish fisheries.

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2. SEAGRASS AND MARINE RESOURCES OF THE UPSTART BAY DUGONG PROTECTION AREA

Michael Rasheed & Ross Thomas

BACKGROUND

Description of Study Locality

Upstart Bay is between Cape Upstart and the southern shore of the Burdekin River delta approximately 120 km south of the city of Townsville. This part of the Burdekin Shire coastline is relatively undeveloped. The catchments and coastal land adjacent to Upstart Bay comprises leasehold, freehold, vacant crown land, reserve and National Park. Land use includes cattle grazing, salt evaporators and tourism. Plans for the area include subdivision, development of tourist resorts and of aquaculture facilities (Environment Australia 2001).

The area has a tropical climate and a tropical monsoon rainfall pattern, with a mean annual rainfall of 1071mm, the majority of which falls between December and March (Ayr). Mean daily minimum temperatures in the area range from 12.1°C in July to 22.5°C in January and maximums from 25.2°C in July to 32.1°C in December (Ayr) (Australian Bureau of Meteorology 2000).

The bay has wide intertidal flats in the south and east, but the remainder is mostly shallow (<10m) subtidal to deep subtidal in depth. The maximum tidal range is 3.6m. Catchments feeding into Upstart Bay include Nobbies Inlet in the south, and Molongle and Rocky Ponds creeks that drain off the Bobawaba Range in the west (Map 2.1). The mountainous region of Cape Upstart National Park dominates the eastern catchment boundary with several small intermittent creeks draining into the bay (Map 2.1). The mouth of the extensive Burdekin River system is located at the north western entrance to the bay (Map 2.1), and most of this run-off is taken north by the prevailing currents.

Wetland habitat types in southern Upstart Bay include open water and lower-intertidal seagrass meadows, largely unvegetated higher-intertidal and supra-tidal flats, beaches and beach ridges supporting areas of low vine forest, mangroves, freshwater impoundments and associated swamps (Environment Australia 2001). The Upstart Bay area supports significant representative areas of rare and threatened notophyll vine forest. Large populations of waterbirds use the area for breeding and as a drought refuge (Environment Australia 2001).

Dugong have been observed in most of the bay with largest concentrations associated with seagrass meadows in the southern parts (GBRMPA 1997). Marsh *et al.* (1996) estimated dugong populations in the bay had declined 89% from 171 ±87 (representing 4% of the southern GBR population) in 1987 to 19 ±19 (2% of the southern GBR population) in 1994. To protect dugong and their habitat in Upstart Bay the area was declared a level 'A' Dugong Protection Area (DPA) in January 1998. Commercial fish netting which may impact on dugong is restricted in DPA level 'A' areas.

Other types of reserve or habitat protected areas are also in place in the Upstart Bay area. Great Barrier Reef Marine Park zoning within Upstart Bay includes both Marine Park General Use 'A' and 'B' areas (Map 2.1). The Great Barrier Reef World Heritage Area coastal boundary in the Upstart Bay region generally runs along the coast at mean low water mark. Most of Upstart Bay also lies within the Burdekin Fish Habitat Area (FHA) (Map 2.1) This management 'B' type FHA was declared in 1999 and extends from Upstart Bay in the south to Cape Bowling Green in the north covering an area of 102 000 ha. FHAs protect important fisheries habitats such as mudflats, seagrasses, and mangroves by restricting activities that may damage them (such as dredging and infrastructure development), while allowing all legal forms of fishing to occur.

Upstart Bay is recognised as having a high fisheries value, supporting a large range of fish and penaeid prawns (Environment Australia 2001). Waters between latitudes 19° 30'S and 20° 00'S, and longitudes 147° 30'E and 148° 00'E which include Upstart Bay and adjacent areas of Abbot Bay and the adjacent reef lagoon, support commercial trawl, net and line fisheries. In 1999, 540 boats recorded 5882 fishing days for these waters, representing less effort but larger catches than the previous five years (Queensland Fisheries Service log book data). The main target commercial fishery species for these waters in 1999 included shark (72 tons), spanish mackerel (19 tons), barramundi (6.9 tons), mullet (3.2 tons) and blue-salmon (2.7 tons). Additional fish species included flathead, trevally, whiting, queenfish, cod, grunter, bream, king-salmon, mackerel and mixed fish species (Table 2.1, QFS log book data). The main target commercial species for prawn fisheries in these waters were tiger prawns (*Penaeus* spp.) (33 tons), banana prawns (*Penaeus* spp.) (20 tons), king prawns (*Penaeus* spp.) (15 tons), endeavour prawns (*Metapenaeus* spp.) (4.1 tons) and coral prawns (*Metapenaeopsis* spp.) (1.4 tons). Scallops (mud: 313 tons; saucer: 11 tons), mud crabs (55 tons), Moreton Bay bugs (14 tons), squid (0.24 tons) and blue swimmer crabs (0.12 tons) were also important fishery components of these waters (QFS log book data). (Table 2.1).

Table 2.1. Number of boats, fishing days and total catches recorded for waters between latitudes 19° 30'S and 20° 00'S, and longitudes 147° 30'E and 148° 00'E, from 1994 to1999 (*source: Queensland Fisheries Service*).

Year	Boats	Fishing days	Total catch (tons)			
			Fish	Prawns	Others*	Total
1994	745	7616	43.28	186.64	146.70	376.62
1995	655	7210	17.92	182.98	194.12	395.02
1996	748	7589	21.75	276.31	262.54	560.61
1997	711	6873	54.12	206.40	93.03	353.54
1998	578	5913	97.24	183.97	139.23	420.44
1999	540	5882	111.34	74.40	393.69	579.44

*Others = scallops, crab, bugs, squid, octopus, cuttlefish and lobster.

Seagrasses of Upstart Bay

Seagrass meadows of Upstart Bay were first mapped during a broad-scale dive-based survey of seagrasses between Cairns and Bowen in October/November 1987 (Coles *et al.* 1992; Lee Long *et al.* 1993). In the 1987 survey, 20.5km^2 of seagrass meadows were mapped over intertidal sand/mud banks in the south eastern area of Upstart Bay, including 11.0km^2 with >50% vegetation cover, 7.3km^2 with 10-50% cover and 2.2km^2 with <10% cover (area recalculated from original 1987 maps). Very little seagrass was found along the western shore and in the sub-tidal areas of the Bay. Nine species of seagrass from 3 families were identified within Upstart Bay in the 1987 survey.

Seagrasses in Upstart Bay were also mapped in May 1989 and November 1989 by QDPI Northern Fisheries Centre using the same methodology as the earlier 1987 broad-scale survey. These surveys, conducted after Cyclone Aivu passed through the bay in April 1989, were to assess the impact of the cyclone on seagrass meadows and of any recovery 6 months later. The May 1989 survey indicated a decrease (11.5 km2) in total area of seagrass beds from 1987 (Table 2.2). By November 1989 the seagrass area had increased by 6.6 km2 from the May survey, which was still 4.9 km2 less than in the November 1987 survey (Table 2.2). Biomass and species composition measured at 4 sites in the bay in all 3 surveys indicated that there were fewer species and biomass was lower in both May and November 1989 than in November 1987 (QDPI unpublished data). There was an increase in biomass from May to November 1989 indicating that some recovery from the effects of the cyclone had occurred.

Table 2.2. Area of seagrass habitats mapped in Upstart Bay in November 1987, May 1989 and November 1989 (calculated from QDPI 1987 maps & unpublished data).

% Seagrass Cover	Seagrass area (km^2)		
	November 1987	May 1989	November 1989
<10	2.2	4.4	5.8
10-50	7.3	2.2	3.1
>50	11.0	2.4	6.7
TOTAL	20.5	9.0	15.6

Seagrass information in these surveys was broad-scale and recorded only limited information on species composition and meadow characteristics. A more recent and detailed survey of the area that measured biomass, species composition and seasonality and utilised more accurate mapping techniques was considered necessary for assessment of seagrass resources within the DPA. As a result the present survey which is of greater accuracy and detail is not directly comparable with the previous surveys. The present survey provides a baseline of seagrass distribution and abundance from which future comparisons can be made as well as providing information on the fish and crustaceans that utilise the seagrass resources of Upstart Bay.

RESULTS

Seagrass species, distribution and abundance

Seven seagrass species (from 3 families) were found during the 1999 surveys of the Upstart Bay Dugong Protection Area (Table 2.3).

Table 2.3. Seagrass species present in the Upstart Bay Dugong Protection Area May 1999 and October 1999.

Seagrass Family	Seagrass species	Upstart Bay	
		May 1999	Oct 1999
ZOSTERACEAE Drummortier	*Zostera capricorni* Aschers.	✓	✓
CYMODOCEACEAE Taylor	*Halodule uninervis* (narrow and wide leaf morphs) (Forsk.) Aschers.	✓	✓
	Cymodocea serrulata (R. Br.) Aschers. & Magnus	✓	✓
HYDROCHARITACEAE Jussieu	*Halophila decipiens* Ostenfeld	✓	✓
	Halophila ovalis (R. Br.) Hook. *F*	✓	✓
	Halophila spinulosa (R. Br.) Aschers. in Neumayer	✓	✓
	Halophila tricostata Greenway	-	✓

Halophila tricostata was only found in October 1999, all other species were found in both May and October.

190 coastal sites and 14 deep-water video sites were ground truthed in May 1999 (Map 2.3), and 334 coastal sites and 12 deep-water video sites in October 1999 (Map 2.4). *Zostera capricorni* was the most common species found at sites in both surveys followed by *Halodule uninervis* and *Halophila ovalis.*

A total of 2247 ± 345 ha of seagrass in 8 meadows were identified in May (Map 2.4, Map 2.6 and Table 2.4) and 2987 ± 532 ha in 14 meadows in October (Map 2.5 & Map 2.7, Table 2.4). Seagrasses were only found on the shallow banks (< 4m below MSL) in Nobbies Inlet and the southern part of the bay in May (Map 2.4). Seagrass distribution was more extensive in October 1999. A subtidal *Halophila tricostata* meadow was found in the eastern part of the bay and several small *Halophila* and *Halodule* meadows had developed in shallow embayments adjacent to the north western and north eastern shores of the bay (Map 2.6).

There were three meadow types identified in May (Map 2.6,Table 2.4):

1. High biomass *Zostera capricorni* meadows which were located along the inshore fringe, adjacent to mangroves;
2. Low biomass mixed species *Halophila* and *Halodule* dominated meadows, located further off the shore, adjacent to the *Zostera* meadows;
3. A small *Halodule uninervis* (wide) dominated meadow;

There were an additional 3 meadow types identified in October 1999 (Map 2.7, Table 2.4):

4. A small, low biomass, subtidal *Halophila decipiens* meadow in an embayment on the north eastern section of the bay;
5. *Halophila tricostata* meadows in deeper subtidal areas in the eastern section of the bay;
6. A small low biomass intertidal *Halophila ovalis* and *Zostera capricorni* meadow adjacent to the north eastern shore.

The majority of seagrass area in May 1999 was low biomass *Halophila* and *Halodule* meadows (75% of the total) and high biomass *Zostera capricorni* meadows (24% of the total) (Map 2.6, Table 2.4). Three meadow types formed the majority of seagrass area in October 1999, low biomass *Halophila* and *Halodule* meadows (42% of the total), high biomass *Zostera capricorni* meadows (41% of the total) and *Halophila tricostata* meadows (16% of the total) (Map 2.7, Table 2.4).

Table 2.4. Mean above-ground biomass, number of meadows identified and area for each seagrass meadow type in May 1999 and October 1999 in the Upstart Bay Dugong Protection Area.

Meadow type* (seagrass community)	May 1999			October 1999		
	mean ±SE (range) (g DW m^{-2})	**# meadows**	**Area (ha)**	**mean ±SE (range) (g DW m^{-2})**	**# meadows**	**Area (ha)**
High biomass *Zostera capricorni* dominated	32.4 ± 6.0 (20.4-39.4)	5	538.9	47.9 ±2.4 (43.0-53.9)	4	1227.0
Low biomass *Halophila & Halodule*	9.6 ± 0.5 (9.6-10.7)	2	1694.3	6.9 ± 3.4 (2.5-17.0)	4	1266.5
Halodule uninervis (wide) dominated	15.3	1	13.7	4.5	1	0.6
Halophila decipiens dominated	*Not present*	-	-	1.2	1	4.5
Low biomass *Zostera capricorni & Halophila ovalis*	*Not present*	-	-	0.2	1	17.3
Halophila tricostata dominated	*Not present*	-	-	22.9 ± 5.8 (13.3-33.3)	3	471.2
Total meadows	**22.1 – 5.4**	**8**	**2246.9**	**21.0 – 5.3**	**14**	**2987.1**

* No seagrass was found at the deepwater sites (> 10m) surveyed in May or October 1999.

Mean above-ground biomass for *Zostera capricorni* and *Halophila tricostata* meadows was significantly higher in October 1999 compared to May 1999 (Figure 2.1). Biomass for the mixed species *Halophila* and *Halodule* meadows did not differ significantly between surveys (Figure 2.1).

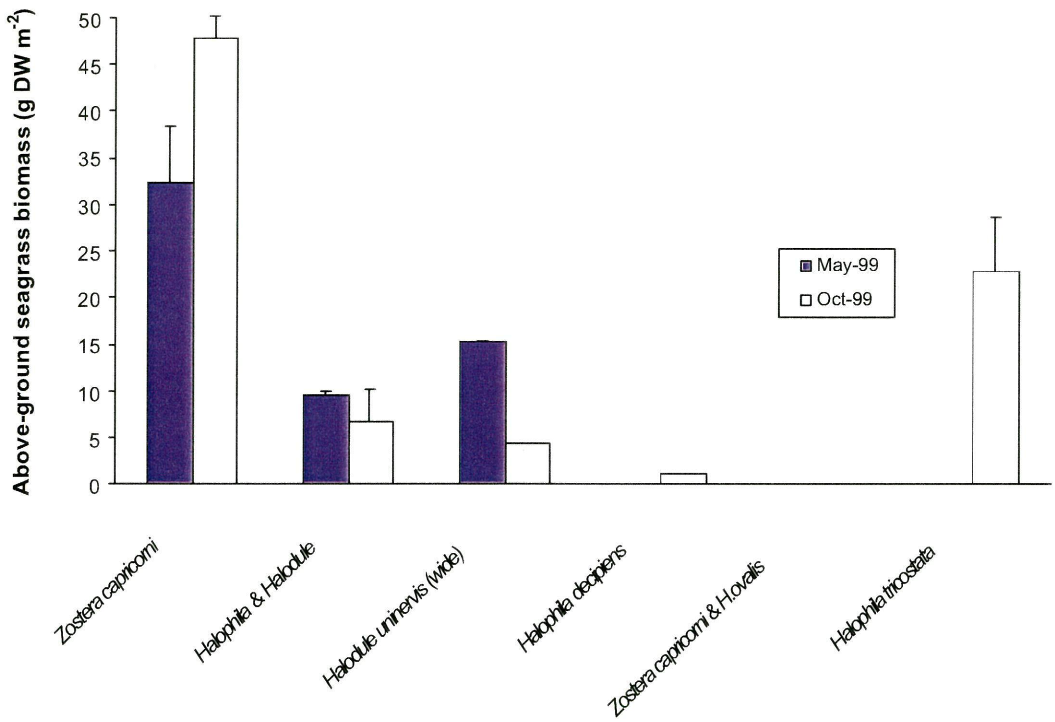


Figure 2.1. Above-ground biomass for each meadow type in May and October 1999 (*mean and standard error*).

Above-ground biomass for *Zostera capricorni, Halophila spinulosa* and *Halophila tricostata* (all sites pooled) was significantly higher in October than May (Figure 2.2). Biomass did not differ significantly between May and October for the other species (Figure 2.2). Mean biomass was highest for *Zostera capricorni* (May, 26.5 g and October, 43.2 g DW m^{-2}) and lowest for *Halophila ovalis* (May, 2.0 g and October, 2.4 g DW m^{-2}) (Figure 2.2).

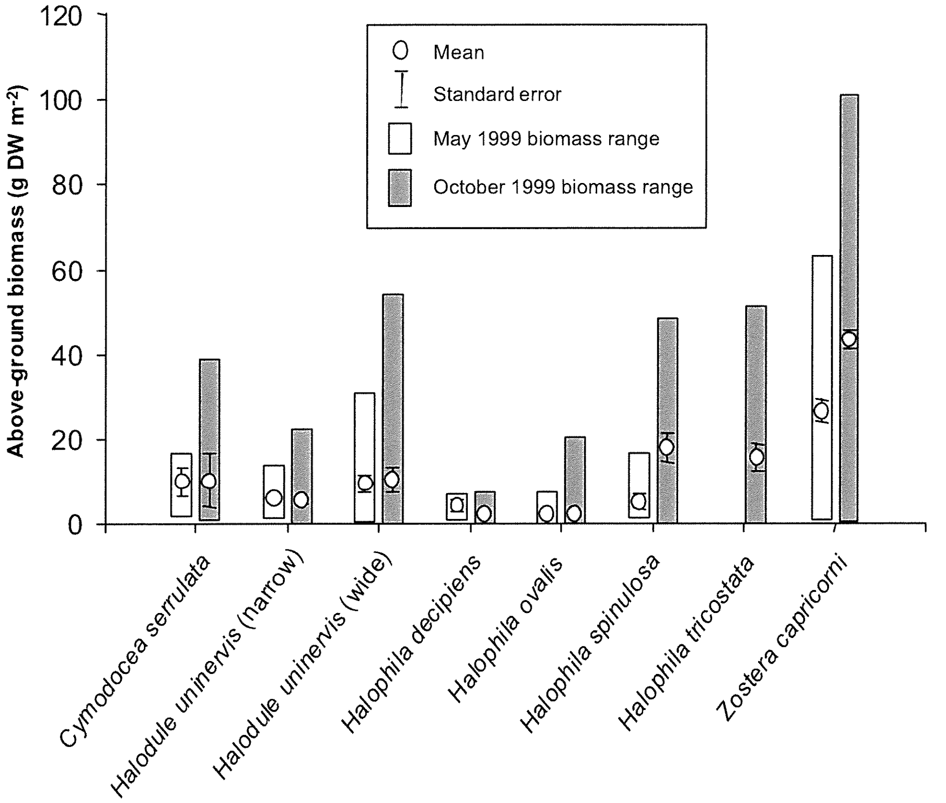


Figure 2.2. Mean (±SE) and range of above-ground biomass for seagrass species (from sites where the species occurred) in May and October 1999.

Seagrass Depth Distribution

Seagrasses in Upstart Bay were found at depths from 0.09 m to 3.80 m below Mean Sea Level (MSL) in May 1999 (Figure 2.3). Depth distribution for seagrass species was wider in October 1999 with seagrasses found between MSL and 5.83 m below MSL (Figure 2.3).

Zostera capricorni had the shallowest mean depth (0.84 m in May and 0.64 m in October) but was found in both intertidal and subtidal areas (predominantly intertidal) (Figure 2.3). *Halophila tricostata* had the deepest mean depth (4.2 m below MSL) and occurred exclusively in subtidal areas (Figure 2.3). Mean depths for *Halophila spinulosa* and *Halophila decipiens* were also below the lowest astronomical tide, although depth ranges for these species extended to intertidal areas in October 1999.

Most species had wide depth distributions, with the exception of *Cymodocea serrulata, Halophila spinulosa* and *Halophila decipiens* in May 1999, when they occurred at only a few sites (Figure 2.3). Depth distribution was widest for *Halodule uninervis* (wide leaf morphology) in October 1999 (4.5 m) and *Zostera capricorni* in May 1999 (3.6 m)

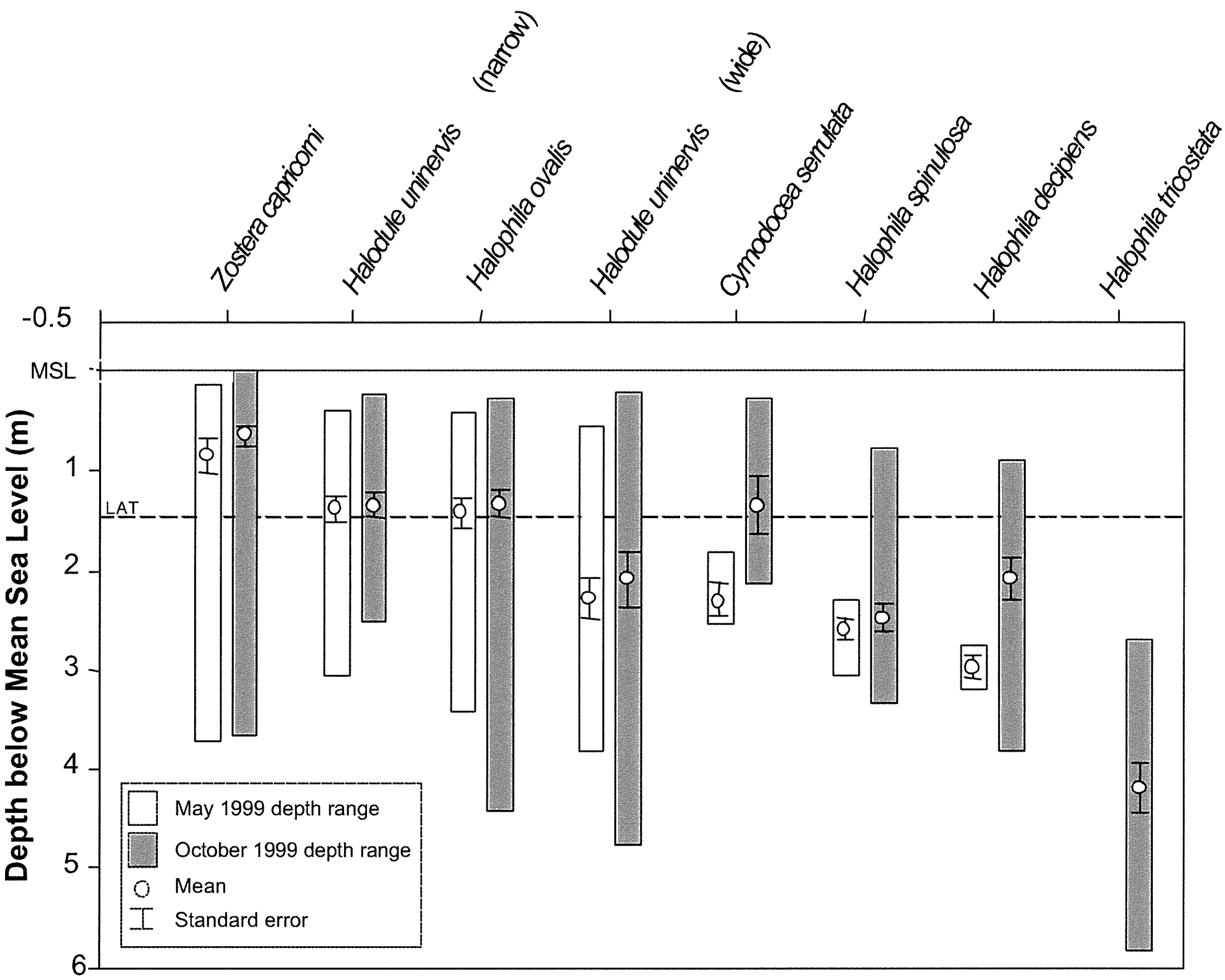
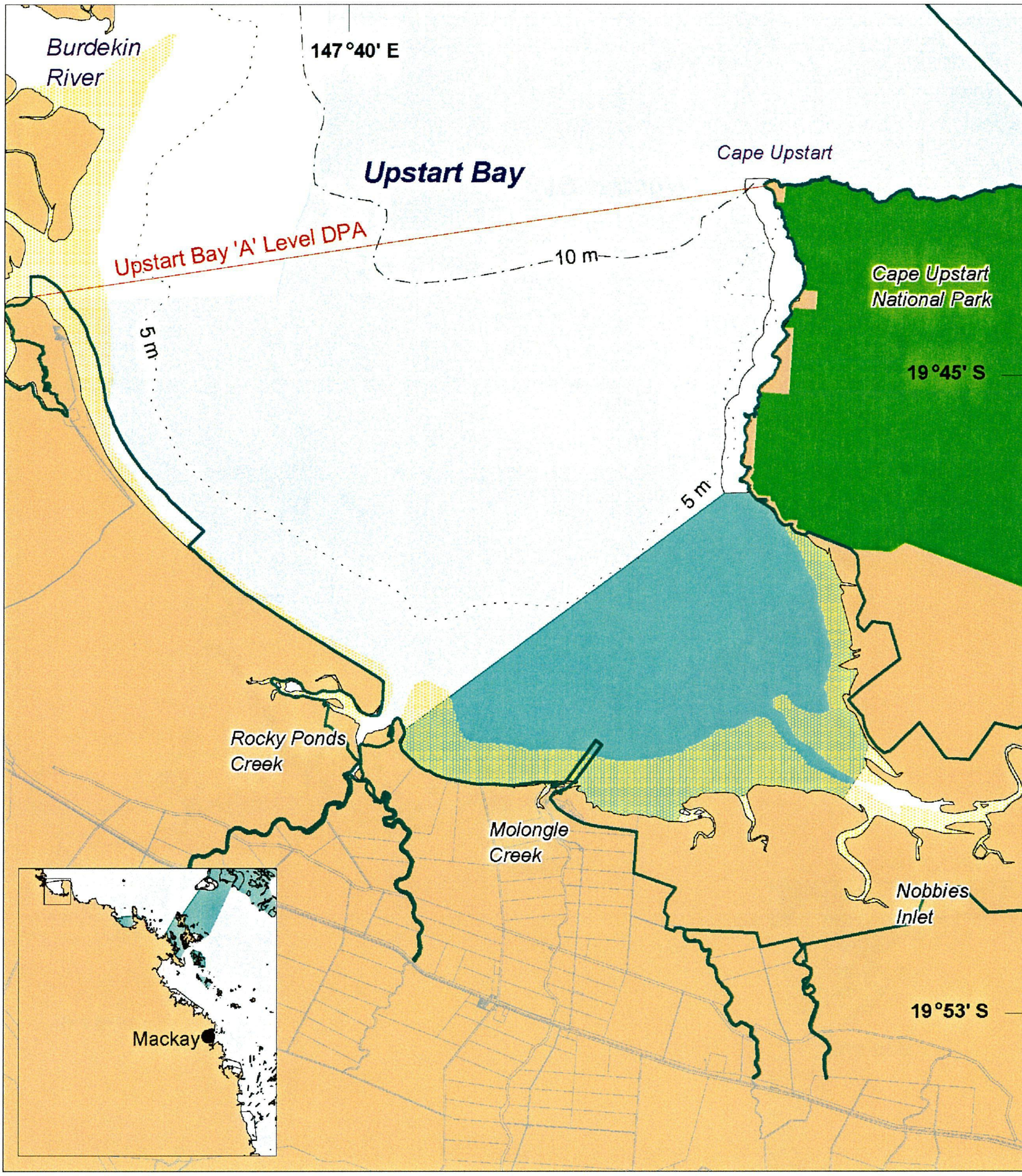


Figure 2.3. Means, standard errors and depth of occurrence ranges for each seagrass species of Upstart Bay (MSL= Mean Sea Level; LAT= Lowest Astronomical Tide). *(Statistics calculated using only survey sites from transects which ran perpendicular from shore to the seaward edge of meadows).*

Map 2.1 The Upstart Bay Dugong Protection Area



LEGEND

- Sandbanks
- Dugong Protection Area Boundary
- Fish Habitat Area Boundary
- National Park
- Marine Park - General Use A
- Marine Park - General Use B

Source: Rasheed, M.A. and Thomas, R. (2001). Seagrass and Marine Resources of the Upstart Bay Dugong Protection Area. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 2, pp 21-50. (DPI, Cairns).

Report to the Great Barrier Reef Marine Park Authority. (Queensland Department of Primary Industries: Northern Fisheries Centre, Cairns).

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

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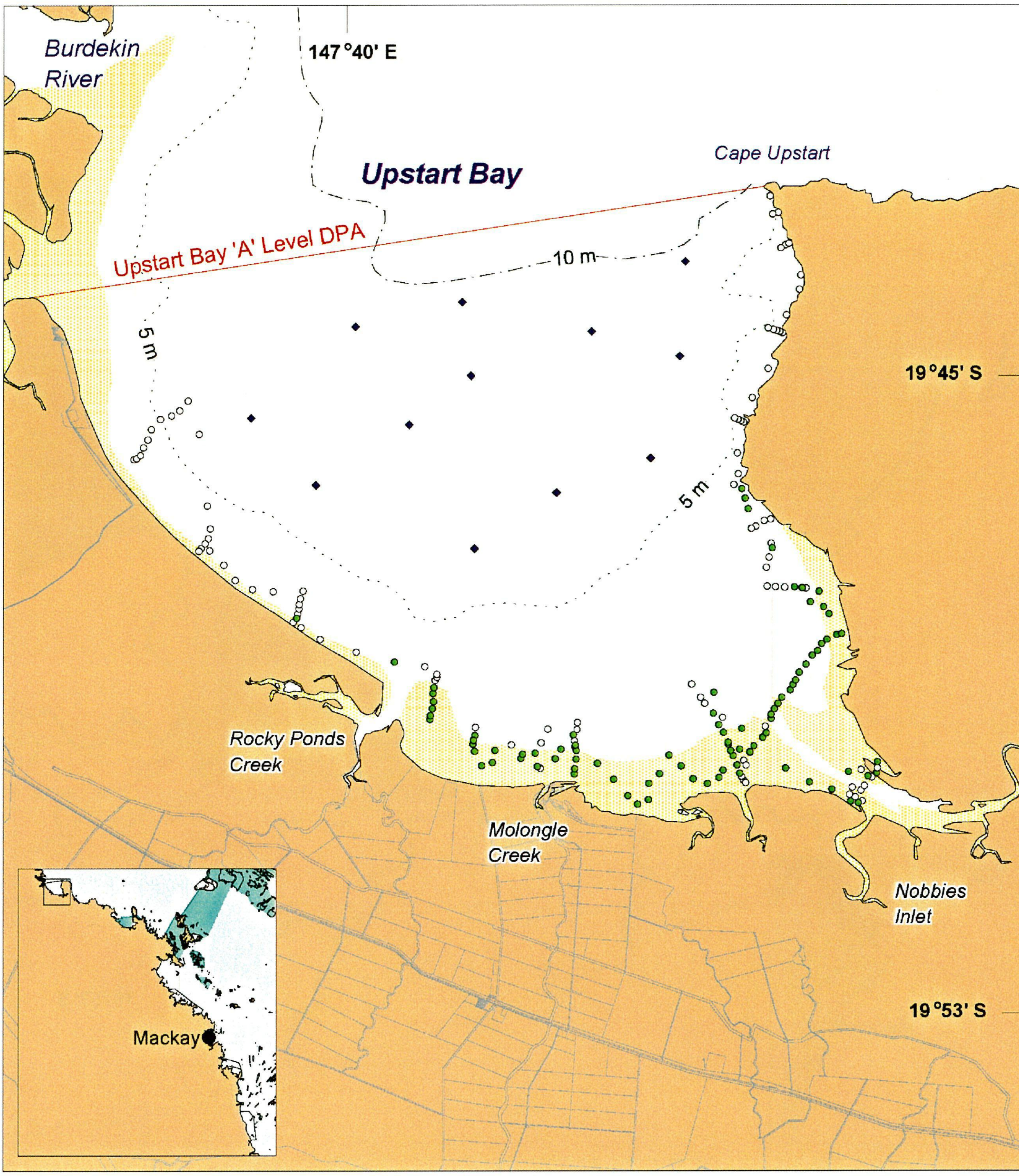
Map 2.2 Survey sites within the Upstart Bay Dugong Protection Area - May 1999



N

0 2 4

Kilometres

LEGEND

- Sandbanks
- ◆ Deepwater video site
- ● Seagrass
- ○ No seagrass

Source: Rasheed, M.A. and Thomas, R. (2001). Seagrass and Marine Resources of the Upstart Bay Dugong Protection Area. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 2, pp 21-50. (DPI, Cairns).

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Sampling dates: Diver and deepwater video survey 16-25 May 1999

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

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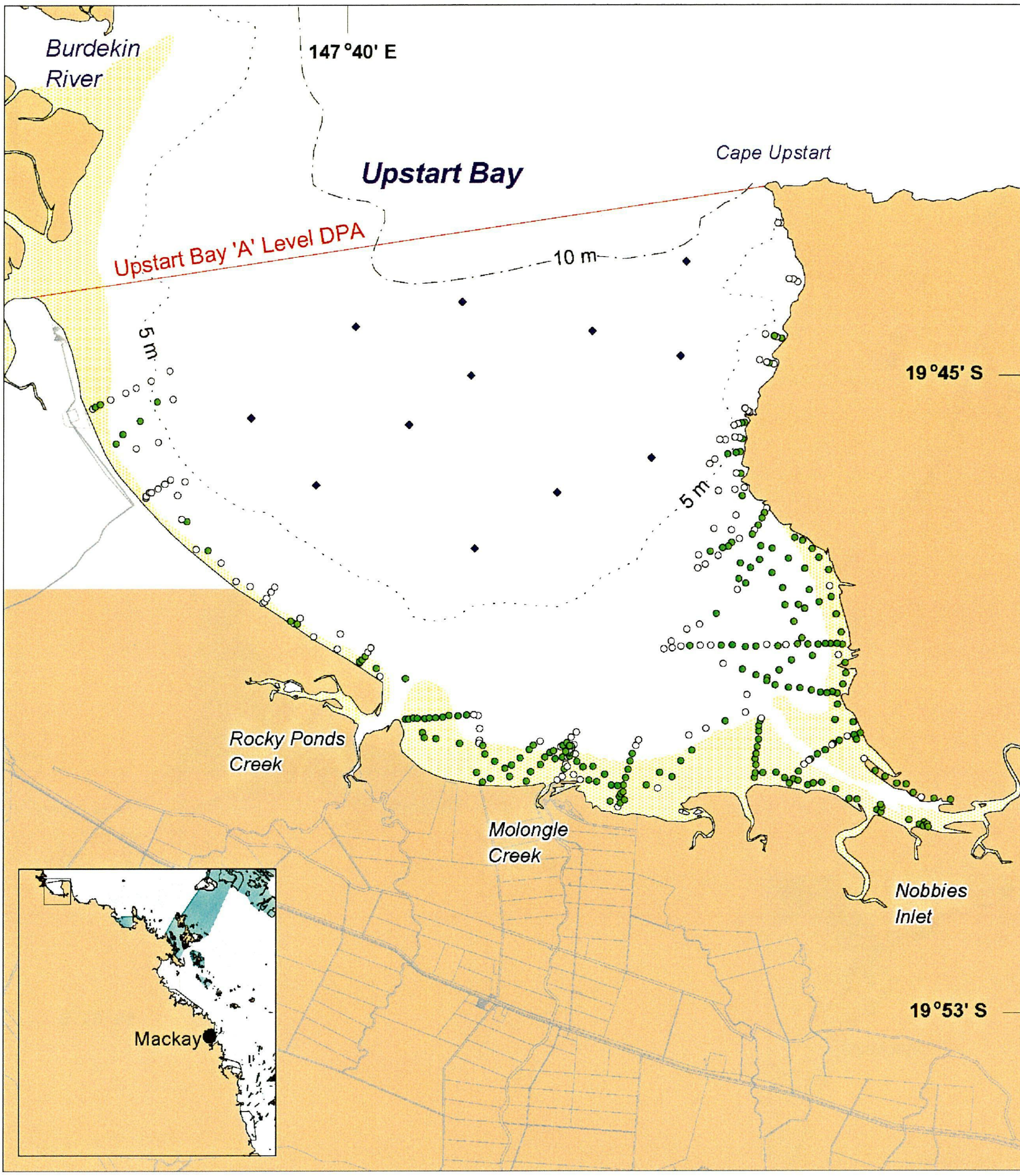
Map 2.3 Survey sites within the Upstart Bay Dugong Protection Area - October 1999



LEGEND

- Sandbanks
- Deepwater video site
- Seagrass
- No seagrass

Source: Rasheed, M.A. and Thomas, R. (2001). Seagrass and Marine Resources of the Upstart Bay Dugong Protection Area. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 2, pp 21-50. (DPI, Cairns).

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Sampling dates: Diver and deepwater video survey 12-20 October 1999.

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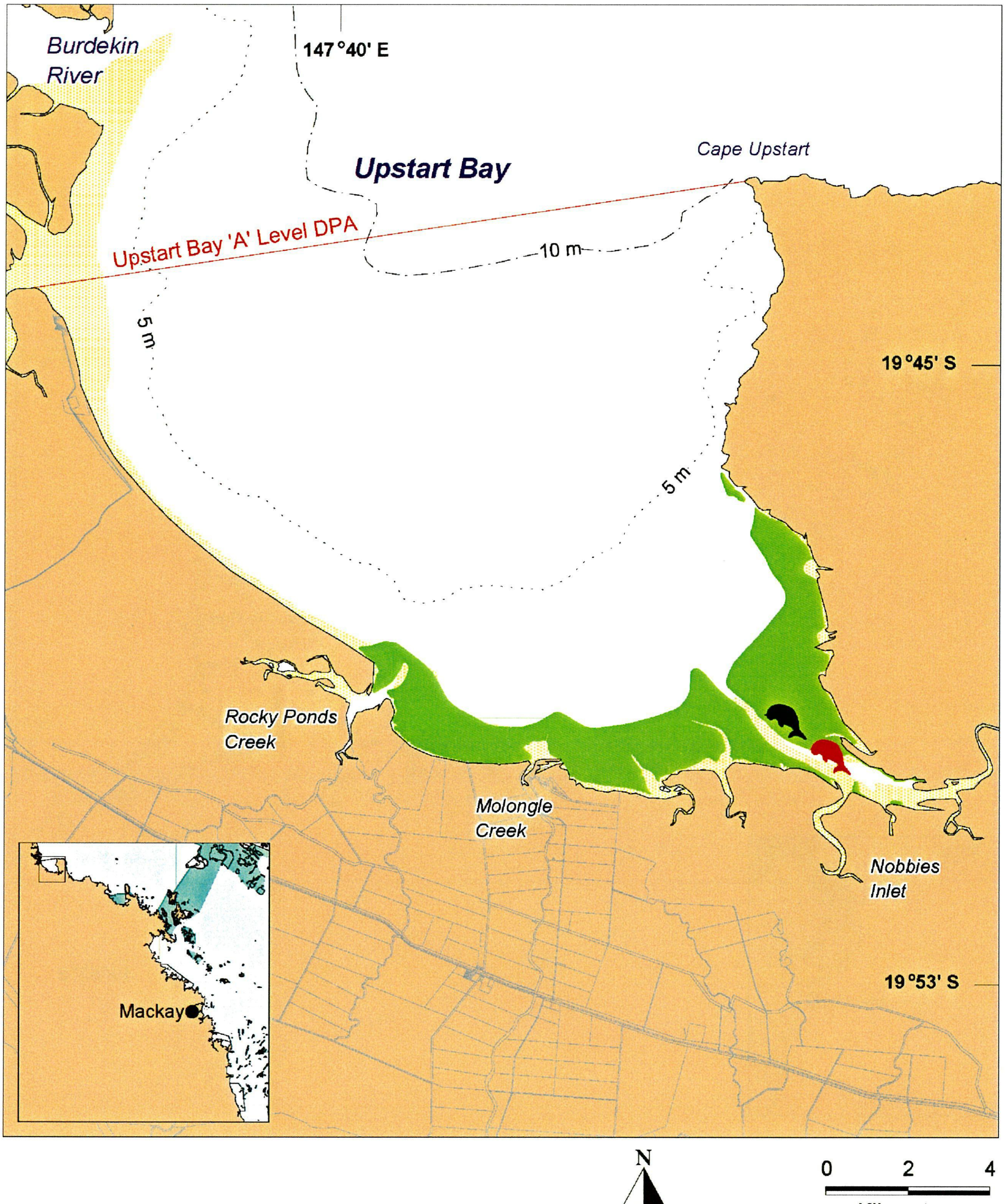
Map 2.4 Location of seagrass meadows in the Upstart Bay Dugong Protection Area - May 1999



LEGEND

- Sandbanks
- Seagrass meadow
- Dugong sighted
- Dugong feeding trails

Source: Rasheed, M.A. and Thomas, R. (2001). Seagrass and Marine Resources of the Upstart Bay Dugong Protection Area. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 2, pp 21-50. (DPI, Cairns).

Sampling dates: Diver and deepwater video survey 16-25 May 1999.

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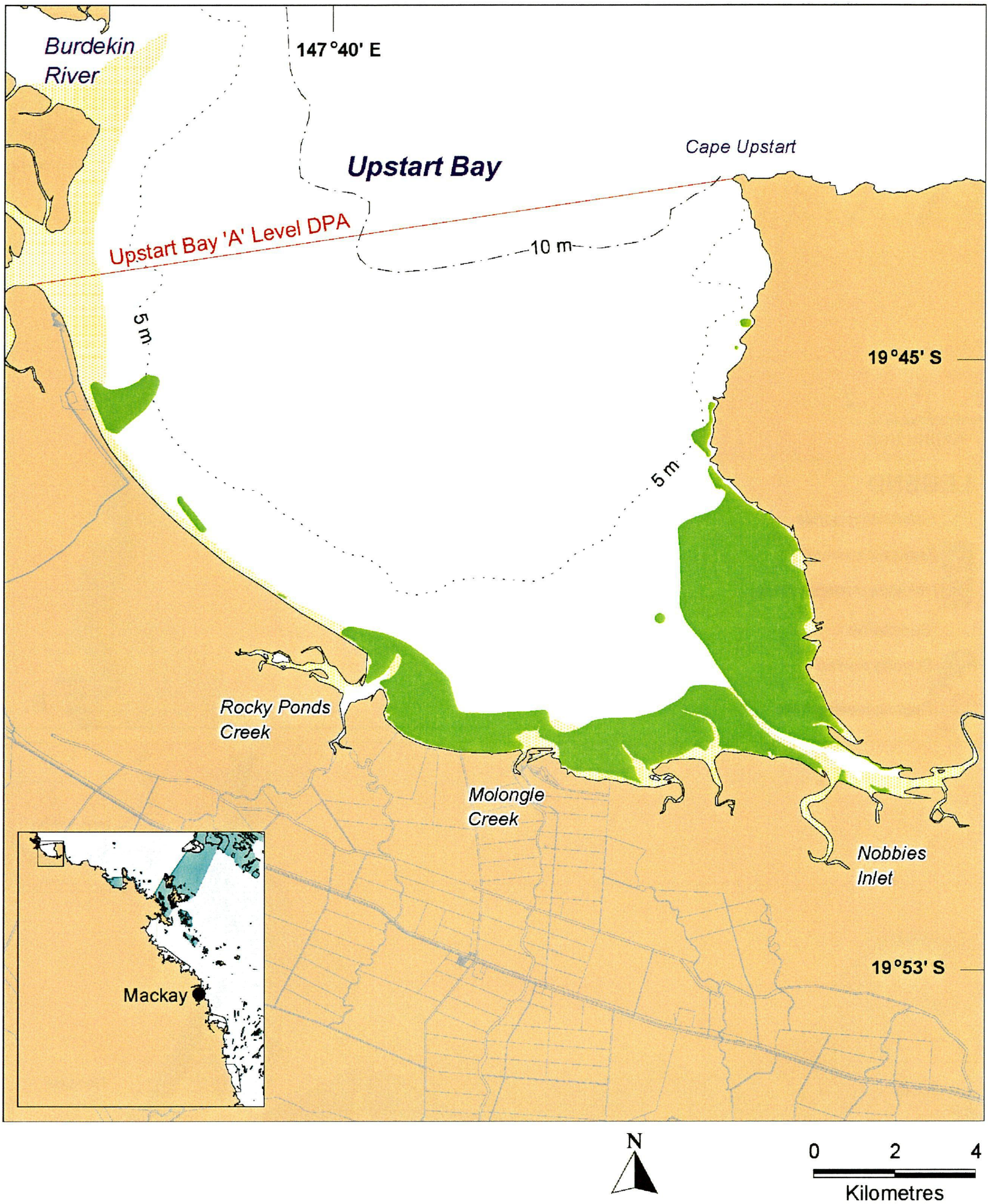
Map 2.5 Location of seagrass meadows in the Upstart Bay Dugong Protection Area - October 1999



LEGEND

- Sandbanks
- Seagrass meadow
- Dugong sighted
- Dugong feeding trails

Source: Rasheed, M.A. and Thomas, R. (2001). Seagrass and Marine Resources of the Upstart Bay Dugong Protection Area. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 2, pp 21-50. (DPI, Cairns). Report to the Great Barrier Reef Marine Park Authority. (Queensland Department of Primary Industries: Northern Fisheries Centre, Cairns).

Sampling dates: Diver and deepwater video survey 12-20 October 1999.

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

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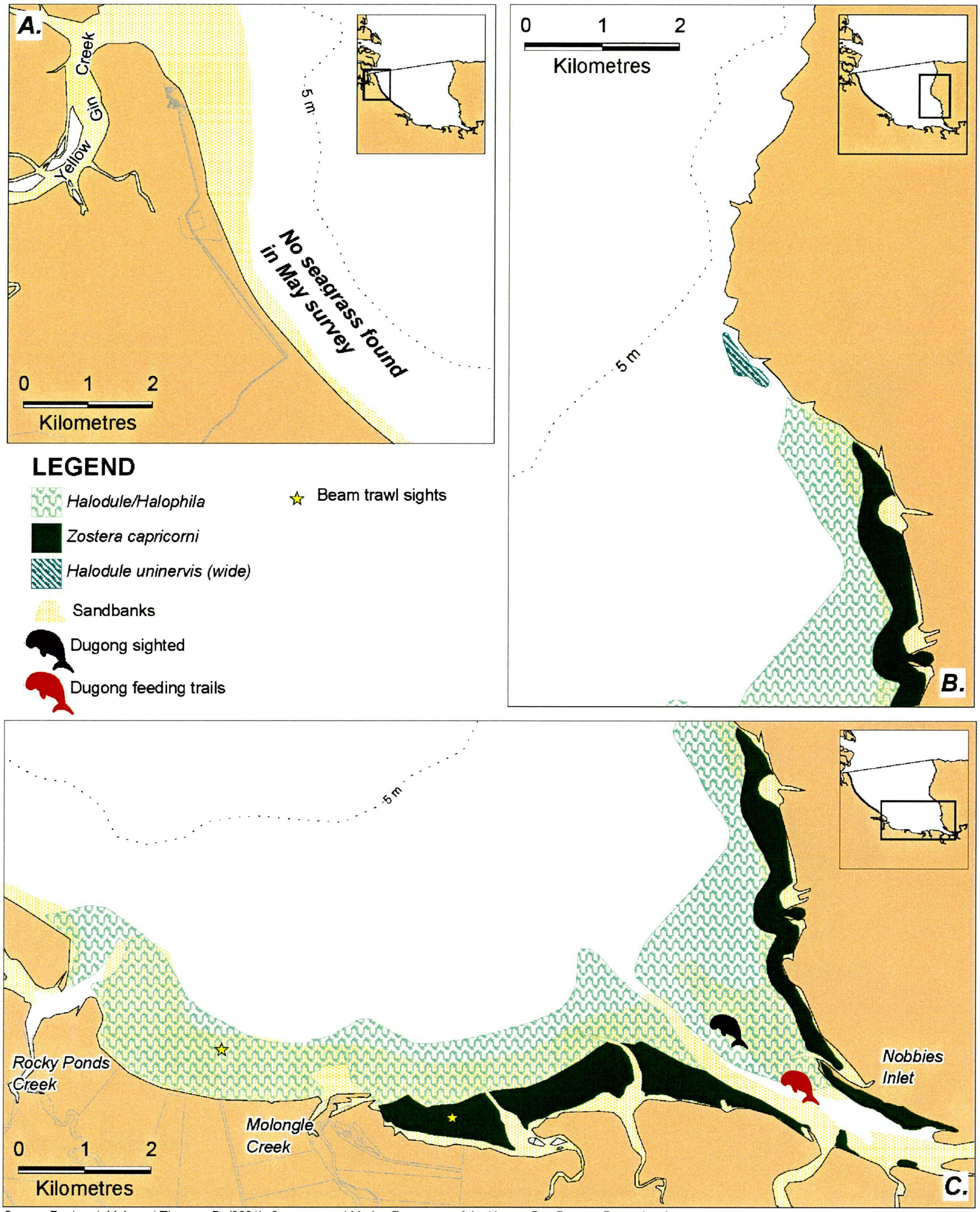
Map 2.6 Seagrass communities mapped in the Upstart Bay Dugong Protection Area - May 1999 (enlargements)



Source: Rasheed, M.A. and Thomas, R. (2001). Seagrass and Marine Resources of the Upstart Bay Dugong Protection Area. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 2, pp 21-50. (DPI, Cairns). Report to the Great Barrier Reef Marine Park Authority. (Queensland Department of Primary Industries: Northern Fisheries Centre, Cairns).

Sampling dates: Diver and deepwater video survey 16-25 May 1999.

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

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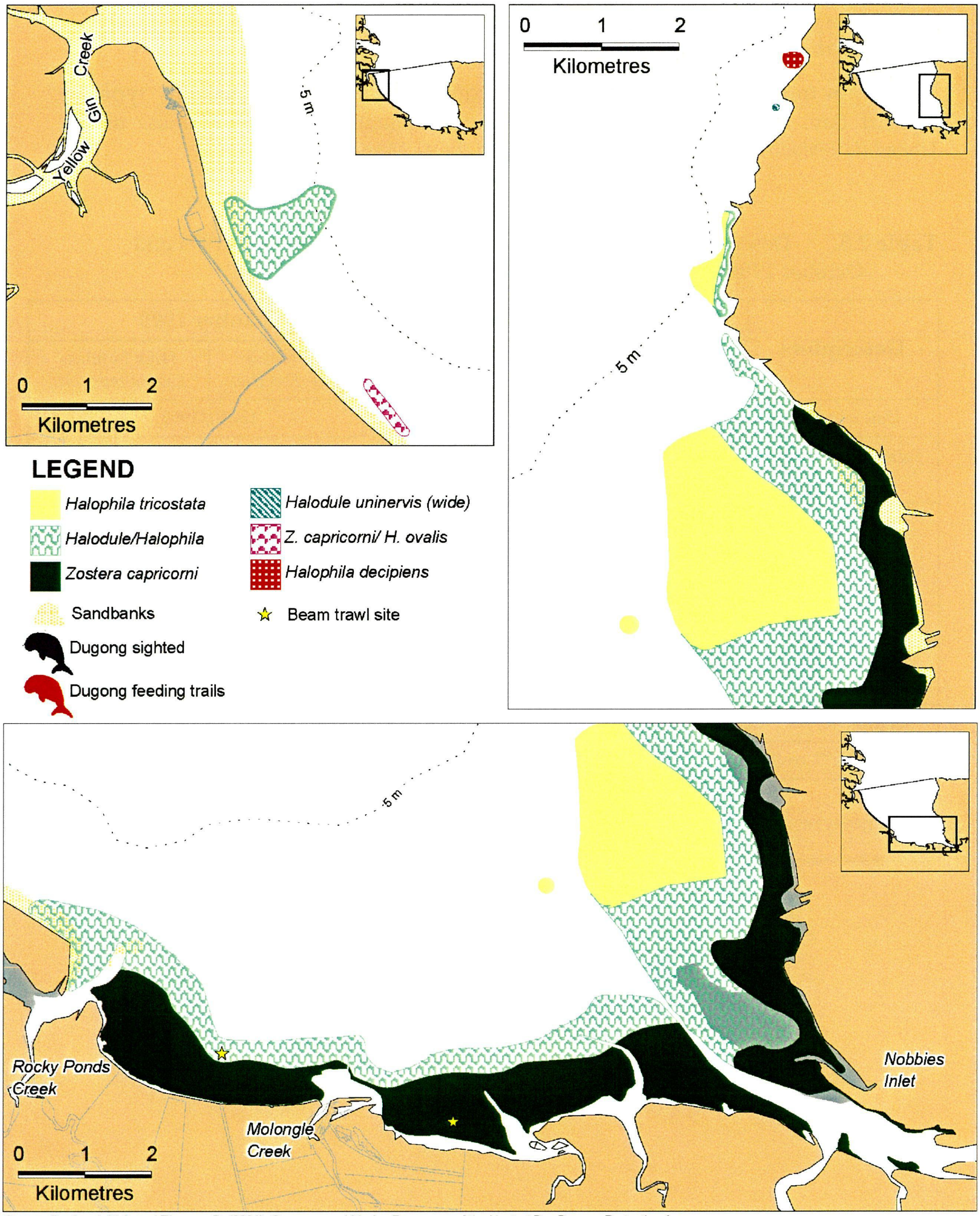
Map 2.7 Seagrass communities mapped in the Upstart Bay Dugong Protection Area - October 1999 (enlargements)



Source: Rasheed, M.A. and Thomas, R. (2001). Seagrass and Marine Resources of the Upstart Bay Dugong Protection Area. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 2, pp 21-50. (DPI, Cairns). Report to the Great Barrier Reef Marine Park Authority. (Queensland Department of Primary Industries: Northern Fisheries Centre, Cairns).

Sampling dates: Diver and deepwater video survey 12-20 October 1999.

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Invertebrates and Fish

Description of Beam Trawl Sites

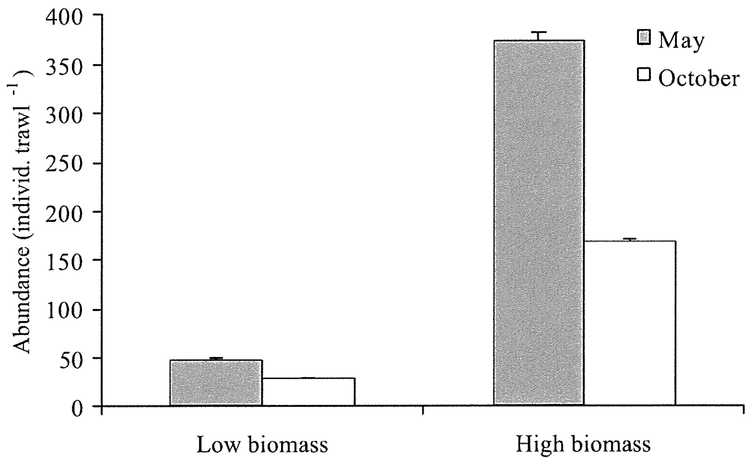
Two beam trawl sites were selected in the dominant seagrass community types in Upstart Bay: high biomass *Zostera capricorni* dominated and low biomass mixed *Halophila/Halodule* meadows (Table 2.5, Map 2.6 & Map 2.7).

Table 2.5. Description of beam trawl sites in Upstart Bay in May 1999 and October 1999

Descriptors	May 1999		October 1999	
	Low biomass *Halodule/Halophila*	High biomass *Zostera capricorni*	Low biomass *Halodule/Halophila*	High biomass *Zostera capricorni*
Date sampled	17/05/1999		13/10/1999	
Mean biomass ± SE (g DW m^{-2})	9.59 ±1.24	37.34 ±3.65	5.02 ±0.93	43.01 ±2.33
Seagrass species present	*Halodule uninervis* (narrow morphology) *Halophila ovalis, Halophila decipiens, Zostera capricorni*	*Zostera capricorni, Halodule uninervis* (wide morphology) *Halophila ovalis,*	*Halodule uninervis* (narrow and wide morphology) *Halophila ovalis, Halophila decipiens, Zostera capricorni*	*Zostera capricorni, Halodule uninervis* (wide morphology) *Halophila ovalis,*
Depth below MSL (m)	1.13	0.3	1.19	0.1
Sediment type	Sand	Mud	Sand	Mud
Mean algae % cover	7.5	0	1.8	0.7
Algae types	Brown filamentous, Red algae, turf mat	-	Brown and Green filamentous	Green filamentous

Invertebrates
Penaeid prawns

1695 individual juvenile or sub-adult penaeid prawns from 8 trawls (all sites and trawls pooled) were collected in May and 788 from 8 trawls in October 1999 (Figure 2.4, Table 2.6). Significantly more penaeid prawns were caught in the high biomass *Zostera* trawl site than in the low biomass *Halophila/Halodule* site in both May and October (Figure 2.4, Table 2.6).



Low biomass
Halodule/alophila

High biomass
Zostera capricorni

Figure 2.4. Abundance of penaeid prawns at each trawl site in Upstart Bay in May and October 1999 (*mean and standard error displayed*).

Abundance of penaeid prawns was higher in May 1999 than October 1999 for the high biomass seagrass site (Figure 2.4). There were no significant differences in penaeid abundance for the low biomass seagrass site between May and October (Figure 2.4). 10 species of penaeid prawn were identified from beam trawls in May and 7 in October (Table 2.6). More penaeid species were found at the high biomass seagrass site than at the low biomass site in May and October 1999 (Figure 2.4).

The dominant penaeid species collected was different for each trawl site and survey date (Figure 2.5). The most abundant penaeid species collected in the low seagrass biomass site was *Penaeus latisulcatus* in May 1999 and *Penaeus longistylus* in October 1999 (Figure 2.5). For the high seagrass biomass site the dominant species was *Metapenaeus* sp. in May and *Penaeus esculentus* in October (Figure 2.5).

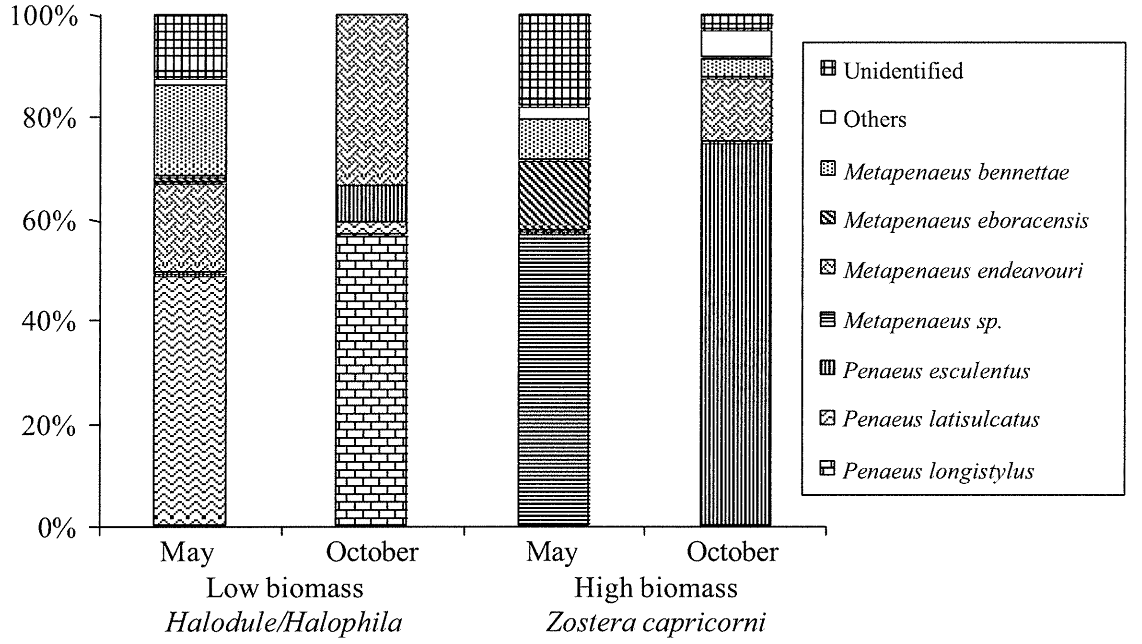
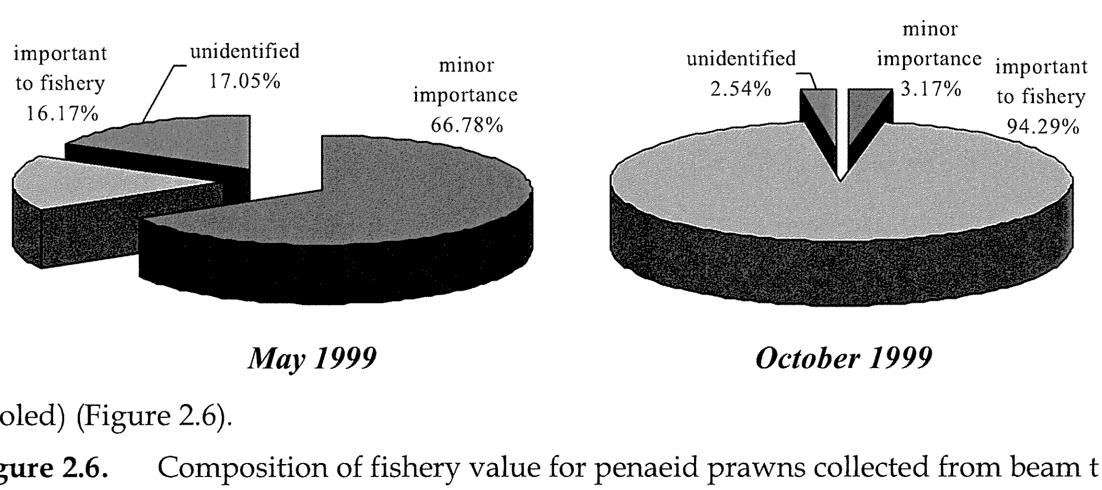


Figure 2.5. Percent species composition of penaeid prawns at each beam trawl site in May and October 1999.

In May, penaeid species of commercial importance made up only 16.2% of the total penaeid catch (both sites pooled). In October, penaeid species of commercial importance comprised the majority (94.3%) of the total penaeid catch (both sites



pooled) (Figure 2.6).

Figure 2.6. Composition of fishery value for penaeid prawns collected from beam t rawls in May and October 1999 (all sites pooled).

At the low seagrass biomass trawl site, commercially important species comprised the majority of the penaeid catch in both May and October. At the high seagrass biomass site, commercially important species made up a much smaller component of the total catch in May. The majority of the penaeids caught at the high seagrass biomass site in October were important to the commercial fishery.

Table 2.6. Species, fishery code, carapace length, abundance and biomass* (g DW) of penaeid prawn species collected by beam trawl at sites within the Upstart Bay Dugong Protection Area - May and October 1999.

Value codes: IV. important to northeastern Queensland prawn fishery; III. Component of fishery ; II. minor to insignificant importance; I. no importance (from Coles et al. *1993)*

** Biomass = all species pooled*

Meadow	Species	Common name	Fishery code	May 1999			October 1999		
				mean CL (mm) ±SE (range)	*n* (%)	biomass	mean CL (mm) ±SE (range)	*n* (%)	biomass
Low biomass *Halodule/ Halophila*	*Metapenaeus bennettae*	Greentail	II	6.07 ±0.38 (3.20 - 12.20)	35 (17.86)		*absent*	-	
	Metapenaeus eboracensis	York prawn	II	9.30 ±0.30 (9.00 - 9.60)	2 (1.02)		*absent*	-	
	Metapenaeus endeavouri	True Endeavour	IV	4.26 ±0.20 (2.90 - 9.80)	35 (17.86)		8.47 ±0.17 (5.60 - 10.20)	38 (33.33)	
	Metapenaeus ensis	False/Red Endeavour	IV	4.55 ±0.65 (3.90 - 5.20)	2 (1.02)		*absent*	-	
	Metapenaeus sp.	-	-	*absent*	-		*absent*	-	
	Penaeus esculentus	Brown Tiger	IV	9.80	1 (0.51)		6.75 ±1.00 (2.80 - 11.20)	8 (7.02)	
	Penaeus latisulcatus	Western/Blue-leg King	IV	5.49 ±0.21 (3.20 - 14.20)	96 (48.98)		7.40 ±0.67 (6.50 - 8.70)	3 (2.63)	
	Penaeus longistylus	Red Spot King	IV	*absent*	-		7.02 ±0.13 (4.80 - 10.20)	65 (57.02)	
	Penaeus merguiensis	Common Banana	IV	10.00	1 (0.51)		*absent*	-	
	Penaeus semisulcatus	Grooved Tiger	IV	*absent*	-		*absent*	-	
	Penaeus semisulcatus/esculentus	Grooved/Brown Tiger	IV	*absent*	-		*absent*	-	
	Penaeus sp.	-	-	*absent*	-		*absent*	-	
	Trachypenaeus fulvus	Brown Rough	II	*absent*	-		*absent*	-	
	Unidentified	-	-	-	24 (12.24)		*absent*	-	
TOTAL				**5.44 ±0.16 (2.90 - 14.20)**	**196 (100)**	**4.70**	**7.49 ±0.13 (2.80 - 11.20)**	**114 (100)**	**6.95**
High biomass *Zostera capricorn i*	*Metapenaeus bennettae*	Greentail	II	7.76 ±0.19 (3.60 - 13.40)	122 (8.14)		11.29 ±0.29 (8.30 - 14.00)	25 (3.71)	
	Metapenaeus eboracensis	York prawn	II	5.66 ±0.09 (3.50 - 11.00)	207 (13.81)		*absent*	-	
	Metapenaeus endeavouri	True Endeavour	IV	8.60	1 (0.07)		8.77 ±0.21 (4.80 - 14.00)	87 (12.91)	
	Metapenaeus ensis	False/Red Endeavour	IV	6.75 ±0.25 (4.00 - 11.80)	40 (2.67)		10.30 ±0.31 (7.80 - 12.90)	25 (3.71)	
	Metapenaeus sp.	-	-	4.49 ±0.00 (4.30 - 4.80)	859 (57.30)		*absent*	-	
	Penaeus esculentus	Brown Tiger	IV	11.30	1 (0.07)		9.13 ±0.13 (2.40 - 19.80)	504 (74.78)	
	Penaeus latisulcatus	Western/Blue-leg King	IV	*absent*	-		8.40	1 (0.15)	
	Penaeus longistylus	Red Spot King	IV	*absent*	-		*absent*	-	
	Penaeus merguiensis	Common Banana	IV	*absent*	-		*absent*	-	
	Penaeus semisulcatus	Grooved Tiger	IV	13.20	1 (0.07)		*absent*	-	
	Penaeus semisulcatus/esculentus	Grooved/Brown Tiger	IV	*absent*	-		9.02 ±1.07 (3.90 - 13.90)	12 (1.78)	
	Penaeus sp.	-	-	4.50	1 (0.07)		*absent*	-	
	Trachypenaeus fulvus	Brown Rough	II	5.95 ±0.35 (5.60 - 6.30)	2 (0.13)		*absent*	-	
	Unidentified	-	-	-	265 (17.68)		-	20 (2.97)	
TOTAL				**5.10 ±0.04 (3.50 - 13.40)**	**1499 (100)**	**19.71**	**9.21 ±0.11 (2.40 - 19.80)**	**674 (100)**	**97.00**

Other invertebrates

Crabs were more abundant in October 1999 for both beam trawl sites than in May 1999 (Figure 2.7). Miscellaneous crustaceans (primarily caridean shrimps) made up the majority of the invertebrate biomass at the high seagrass biomass site in May 1999. Penaeids comprised the majority of the invertebrate biomass for the low seagrass biomass trawl site in May 1999. Miscellaneous others made up a minor component of the catch for each trawl location and included gastropod and bivalve molluscs, pygmy squid (*Idiosepius pygmaeus*), polychaete worms, sepiolids, and opisthobranchs.

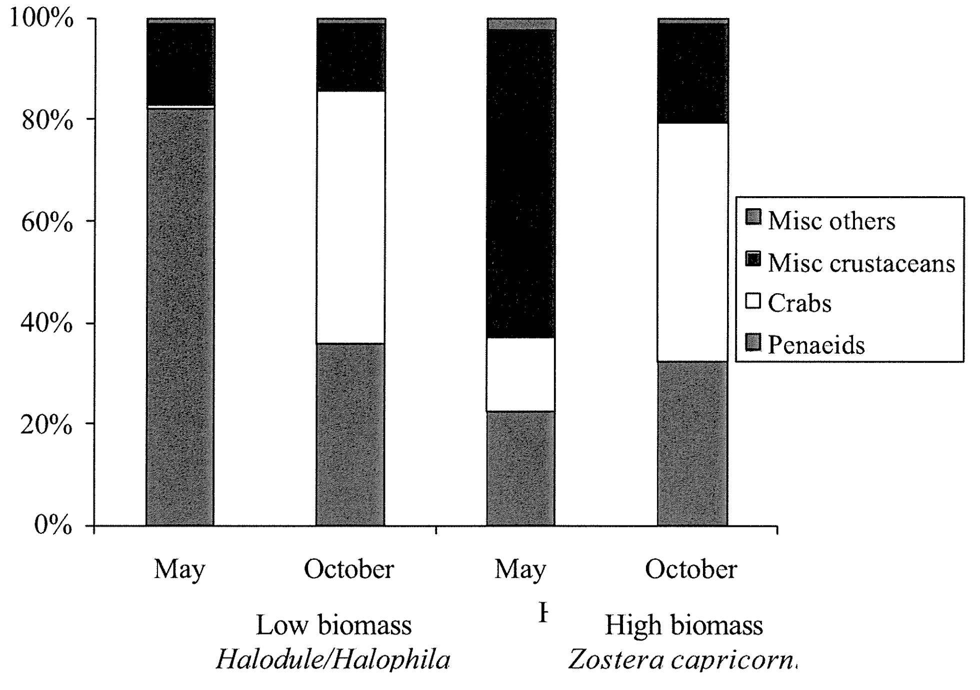


Figure 2.7. Percent composition of invertebrate groups to the total sample biomass (g DW) at each beam trawl site in May and October 1999.

Fish

1834 individual fish from 8 beam trawls (all sites and trawls pooled) were collected in May 1999 and 1062 from 8 trawls in October 1999. Significantly more fish were caught in the high biomass *Zostera* trawl site than in the low biomass *Halophila/Halodule* site in both May and October (Figure 2.8, Table 2.7).

Fish abundances at the high biomass trawl site were significantly higher in May than October 1999 (Figure 2.8).

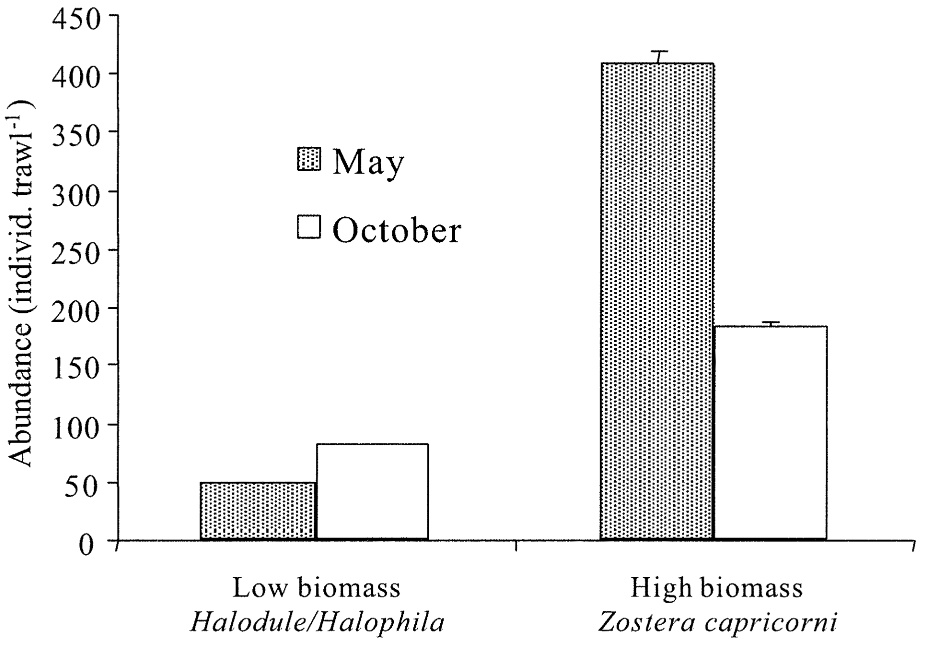


Figure 2.8. Abundance of fish at each trawl site in May and October 1999 (mean and standard error displayed).

Fish collected were generally small and ranged in length from 1.2 to 177.6 mm standard length (Table 2.7). In May 1999 the most abundant fish taxa were the Gobiidae, comprising 78% and 98% of the total catch for the low biomass and high biomass meadows respectively (Figure 2.9, Table 2.7). The dominant fish families were different in October 1999, with Sillaginidae comprising 62% of the catch in the low biomass meadow and Teraponidae 84% of the high biomass meadow (Table 2.7).

Table 2.7 Taxa , value codes, size data, abundance and biomass* (g DW) for fish species collected by beam trawl at sites within the Upstart Bay Dugong Protection Area - May and October 1999.

Value codes (from Coles et al. *1993): A, targeted aquarium species; a, incidental aquarium species; b, incidental baitfish species; C, targeted commercial species; c, incidental commercial species; R, targeted recreational species; r, incidental recreational species.*

** Biomass in May 1999 is for all taxa pooled*

Meadow	Family	Species	Common name	Fishery code	May 1999			October 1999		
					mean SL (mm) ±SE (range)	n (%)	biomass*	mean SL (mm) ±SE	n (%)	biomass
	Anguillidae	*Anguilla reinhardti*	Long-finned eel	C	absent	-		absent	-	-
	Bothidae	*Bothidae* sp. B	Flounder	-	9.1	1 (0.51)		10	1 (0.30)	0.001
	Callionymidae	*Callionymidae* sp. A	Dragonet	A	9.4	1 (0.51)		17	1 (0.30)	0.001
	Chandidae	*Ambassis vachelli*	Vachelli's glass perchlet	a	40.10 ±1.37 (37.40 - 41.90)	3 (1.52)		absent	-	-
	Engraulidae	*Stolephorus indicus*	Anchovy	-	11.23 ±0.34 (10.60 - 11.90)	4 (2.03)		absent	-	-
	Engraulidae	*Stolephorus* sp. A	Anchovy	-	13.00 ±0.00 (13.00 - 13.00)	13 (6.60)		19.41 ±1.96 (11.70 - 24.90)	7 (2.13)	0.12
	Gerreidae	*Gerreidae* sp. A	Mojarra	b	absent	-		absent	-	-
	Gobiidae	*Exyrias puntang*	Goby	A	absent	-		absent	-	-
	Gobiidae	*Glossogobius biocellatus*	Mangrove goby	-	15.61 ±0.68 (7.90 - 27.70)	48 (24.37)		16.04 ±1.41 (12.40 - 19.40)	5 (1.52)	0.08
	Gobiidae	*Glossogobius circumspectus*	Goby	-	16.66 ±0.47 (5.90 - 29.40)	106 (53.81)		18.83 ±1.03 (13.40 - 21.60)	7 (2.13)	0.29
Low biomass *Halodule/ Halophila*	Haemulidae	*Pomadasys kaakan*	Golden grunter	cR	absent	-		18.32 ±0.36 (17.20 - 20.70)	12 (3.65)	0.31
	Leiognathidae	*Leiognathidae* sp. A	Ponyfish	-	absent	-		11.31 ±0.20 (1.90 - 13.40)	66 (20.06)	0.44
	Mullidae	*Mullidae* sp. A	Goatfish	a	absent	-		25.4	1 (0.30)	0.1
	Platycephalidae	*Cymbacephalus nematophthalmus*	Fringe-eyed flathead	cR	absent	-		absent	-	-
	Platycephalidae	*Platycephalidae* sp. A	Flathead	?	14.10 ±2.76 (10.40 - 19.50)	3 (1.52)		absent	-	-
	Scorpaenidae	*Paracentropogon* sp. A	Scorpionfish	A	absent	-		absent	-	-
	Siganidae	*Siganus guttatus*	Golden spinefoot	ac	absent	-		absent	-	-
	Sillaginidae	*Sillago* sp. A	Whiting	cr	20.79 ±1.95 (12.40 - 37.40)	15 (7.61)		13.14 ±0.14 (7.00 - 26.30)	201 (61.09)	0.76
	Syngnathidae	*Hippichthys heptagonus*	Pipefish	A	absent	-		34.8	1 (0.30)	0.02
	Teraponidae	*Pelates quadrilineatus*	Trumpeter	-	13.4	1 (0.51)		18.40 ±0.56 (14.00 - 25.30)	25 (7.60)	0.61
	Tetraodontidae	*Tetraodontidae* sp. A	Toadfish	a	5.4	1 (0.51)		30.4	1 (0.30)	0.27
	Tetraodontidae	*Tetraodontidae* sp. B	Toadfish	a	8.5	1 (0.51)		absent	-	-
	Tetraodontidae	*Tetraodontidae* sp. C	Toadfish	a	absent	-		23.2	1 (0.30)	0.14
	Unidentified	Unidentified larvae	-	-	absent	-		absent	-	-
TOTAL					16.50 ±0.42 (5.40 - 41.90)	197	4.61	13.85 ±0.19 (1.90 - 34.80)	329	3.142

[T]able 2.7 continued

[M]eadow	Family	Species	Common name	Fishery code	May 1999			October 1999		
					mean SL (mm) ±SE (range)	n (%)	biomass*	mean SL (mm) ±SE (range)	n (%)	biomass
High [b]iomass *Zostera [ca]pricorni*	Anguillidae	*Anguilla reinhardti*	Long-finned eel	C	absent	-		absent	-	-
	Bothidae	*Bothidae* sp. B	Flounder	-	absent	-		absent	-	-
	Callionymidae	*Callionymidae* sp. A	Dragonet	A	10.73 ±0.39 (10.20 - 11.50)	3 (0.18)		absent	-	-
	Chandidae	*Ambassis vachelli*	Vachelli's glass perchlet	a	33.01 ±1.82 (22.50 - 43.80)	15 (0.92)		139.17 ±20.38 (108.20 - 177.60)	3 (0.41)	2.09
	Engraulidae	*Stolephorus indicus*	Anchovy	-	absent	-		absent	-	-
	Engraulidae	*Stolephorus* sp. A	Anchovy	-	12.6	1 (0.06)		absent	-	-
	Gerreidae	*Gerreidae* sp. A	Mojarra	b	9.8	1 (0.06)		10.1	1 (0.14)	0.01
	Gobiidae	*Exyrias puntang*	Goby	A	absent	-		34.07 ±2.03 (31.20 - 38.00)	3 (0.41)	0.52
	Gobiidae	*Glossogobius biocellatus*	Mangrove goby	-	23.38 ± (10.90 - 48.40)	65 (3.97)		40.30 ±2.10 (38.20 - 42.40)	2 (0.27)	0.52
	Gobiidae	*Glossogobius circumspectus*	Goby	-	13.48 ±0.08 (1.20 - 25.20)	1523 (93.04)		19.68 ±1.21 (12.20 - 26.10)	12 (1.64)	0.31
	Haemulidae	*Pomadasys kaakan*	Golden grunter	cR	absent	-		absent	-	-
	Leiognathidae	*Leiognathidae* sp. A	Ponyfish	-	absent	-		12.4	1 (0.14)	0.01
	Mullidae	*Mullidae* sp. A	Goatfish	a	absent	-		absent	-	-
	Platycephalidae	*Cymbacephalus nematophthalmus*	Fringe-eyed flathead	cR	absent	-		95.3	1 (0.14)	2.48
	Platycephalidae	*Platycephalidae* sp. A	Flathead	?	16.67 ±2.21 (7.60 - 28.50)	10 (0.61)		absent	-	-
	Scorpaenidae	*Paracentropogon* sp. A	Scorpionfish	A	absent	-		45.7	1 (0.14)	0.9
	Siganidae	*Siganus guttatus*	Golden spinefoot	ac	33.21 ±1.41 (22.80 - 36.60)	9 (0.55)		absent	-	-
	Sillaginidae	*Sillago* sp. A	Whiting	cr	10.70 ±1.45 (7.80 - 12.30)	3 (0.18)		absent	-	-
	Syngnathidae	*Hippichthys heptagonus*	Pipefish	A	76.58 ±4.31 (65.00 - 85.20)	5 (0.31)		66.15 ±2.09 (37.00 - 100.50)	87 (11.87)	4.82
	Teraponidae	*Pelates quadrilineatus*	Trumpeter	-	8.5	1 (0.06)		29.42 ±0.50 (8.90 - 63.60)	618 (84.31)	120.82
	Tetraodontidae	*Tetraodontidae* sp. A	Toadfish	a	absent	-		absent	-	-
	Tetraodontidae	*Tetraodontidae* sp. B	Toadfish	a	absent	-		40.30 ±0.32 (39.70 - 40.90)	4 (0.55)	2.35
	Tetraodontidae	*Tetraodontidae* sp. C	Toadfish	a	absent	-		absent	-	-
	Unidentified	Unidentified larvae	-	-	6.9	1 (0.06)		absent	-	-
[T]OTAL					14.35 ±0.14 (1.20 - 85.20)	1637	19.15	34.24 ±0.71 (8.90 - 177.60)	733	134.83

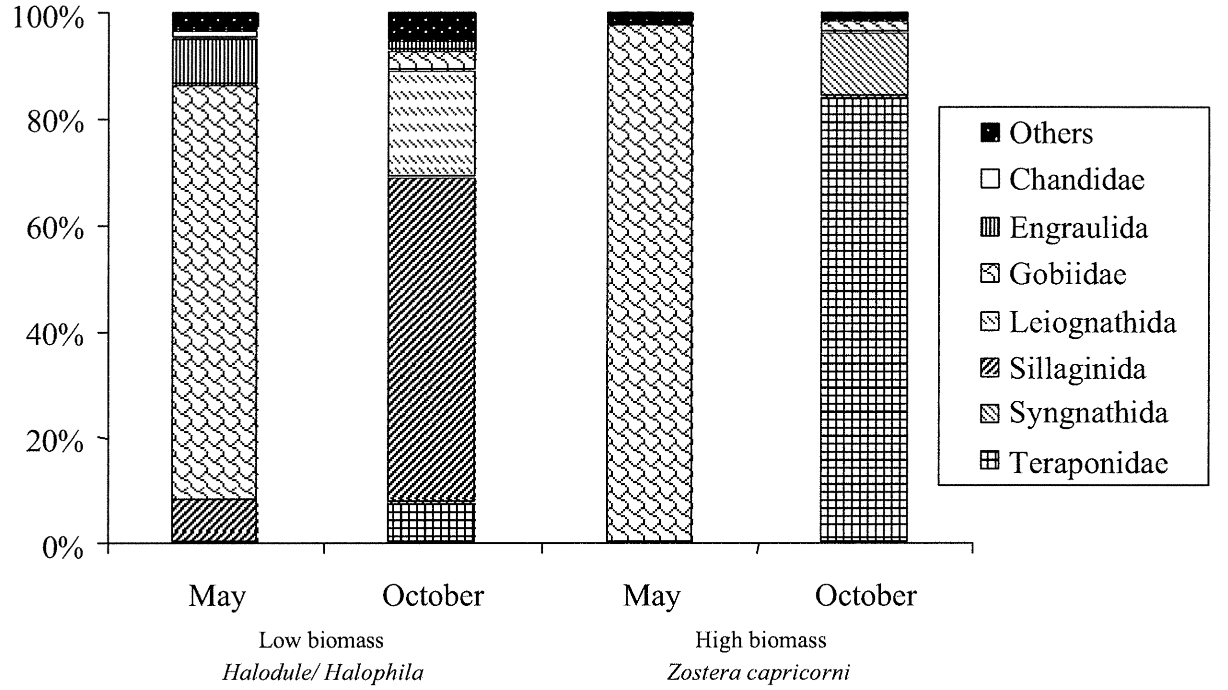
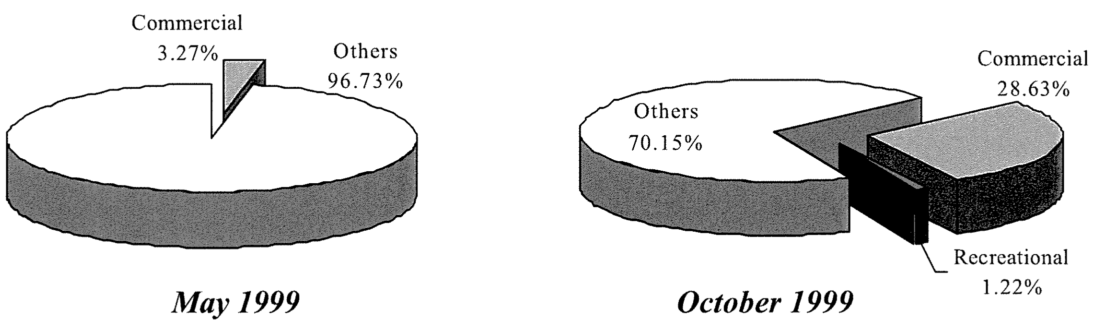


Figure 2.9. Percent composition of each family of fish collected at each trawl site in May and October 1999.

Fish species with some commercial importance made up over 28% of the catch in October but less than 4% in May (Figure 2.10). This was mostly due to large numbers of whiting being caught in October 1999 (Table 2.7). Recreationally important species comprised a minor component of the total catch in both May and October (Figure 2.10).



Recreational anglers however, also target some of the commercially important species.

Figure 2.10. Composition of fishery value for fish collected from beam trawls in May 1999 and October 1999 (*all meadows pooled*).

Sea Turtle, Dugong and Dolphins

Several dugong and dugong feeding trails were sighted on the shallow banks near the mouth of Nobbies Inlet during the May 1999 seagrass survey (Map 2.5). No dugong or dugong feeding trails were recorded in October 1999. Numerous green sea turtles and dolphins were observed over the seagrass meadows throughout Upstart Bay in both surveys.

DISCUSSION

Seagrass

Large areas of intertidal and shallow subtidal seagrass meadows were found within the Upstart Bay Dugong Protected Area in both the May and October 1999 surveys. Seagrass abundance, distribution, depth range and species richness was greater in October than in May, indicating that these meadows may vary seasonally. Similar patterns in seagrass seasonality have been reported for other north Queensland meadows (McKenzie 1994, McKenzie *et al.* 1996, Rasheed 2000 and 1999, Rasheed *et al.* 1996) and in other tropical locations throughout the world (eg. Alcoverro *et al.* 1995, Duarte 1989, Zieman 1975).

Seagrass species richness in Upstart Bay was high, similar to other large bays in tropical north Queensland such as Trinity Inlet (Lee Long *et al.* 1996) and Shoalwater Bay (Lee Long *et al.* 1997). Except for *Halophila tricostata* (October only) all seagrass species in Upstart Bay were present in both May and October. *Halophila tricostata* in north Queensland is typically annual in habit, over-wintering in a seed bank, germinating in spring and disappearing in summer after completion of fruit maturation (Kuo *et al.* 1993).

Seagrass species and meadows were mostly in intertidal and shallow subtidal areas of the bay. No seagrass was found in the deeper waters in the middle of the bay. Conditions in these deeper areas were unlikely to be conducive to seagrass growth. In this area sediments tended to consist of fine mud and may have been more susceptible to re-suspension than the coarser sediments in shallow coastal parts of the bay. A higher degree of sediment re-suspension combined with increased light attenuation with depth probably creates unsuitable light conditions for seagrass growth. The middle of the bay would also offer little shelter in which seagrass could successfully establish as it is not protected from wind and wave action.

The total area of seagrass recorded for Upstart Bay in May and October 1999 was higher than that of any previous survey (Table 2.8). This difference may be due to the more accurate methods used in this survey that were not available in previous surveys (eg. dGPS, GIS and recent aerial photography). Previous surveys, however, indicate that seagrass area in Upstart Bay can vary widely between years (Table 2.8). Large inter-annual variations in seagrass meadow area and abundance have been found in other north Queensland tropical seagrass meadows where long-term monitoring has been conducted such as Mourilyan Harbour (McKenzie *et al.* 1996, 1998) and Karumba (Rasheed *et al.* 1996, Rasheed *et al.* 2001). Inter-annual variability tends to be higher in meadows dominated by *Halophila* and *Halodule* species (McKenzie *et al.* 1998, Rasheed *et al.* 2001) but also occurs in tropical *Zostera capricorni* meadows similar to those found in Upstart Bay (McKenzie 1994).

Large-scale loss of seagrasses occurred in Upstart Bay in 1989 when Cyclone Aivu passed directly over the Bay. Over half the area of seagrass meadows mapped in 1987 had been lost by the May 1989 survey conducted a few weeks after the cyclone (Table 2.8). There was some recovery of these meadows 6 months after the cyclone although the increase in area may have been more a reflection of seasonality rather than significant recovery from cyclone damage. How long it took for the Upstart Bay seagrass meadows to fully recover from the cyclone impact is unclear as further sampling was not undertaken.

Table 2.8. Comparison of total seagrass area for Upstart Bay from November 1987, May 1989 November 1989 (calculated from QDPI 1987 maps & unpublished data) and May 1999 and October 1999 (this report).

Survey Date	Area (Ha.)	Survey scope	Source
November 1987	**2005**	Broad-scale	Coles *et al.* 1992
May 1989 (post cyclone)	**900**	Broad-scale	*QDPI unpublished*
November 1989	**1560**	Broad-scale	*QDPI unpublished*
May 1999	**2247**	Fine-scale	*This report*
October 1999	**2987**	Fine-scale	*This report*

The capacity for Upstart Bay seagrass meadows to recover from loss is likely to depend on the meadow type and the reproductive strategies employed by the seagrass species in the area. This aspect of tropical seagrass ecology is poorly understood (Rasheed 1999, 2000). Some species such as *Halodule uninervis* have the capacity to develop large stores of long-lived seeds in the sediments (seed banks) which may enable them to recover well from large scale losses (Inglis 2000). The ability of a species to produce seed banks is not consistent however, and has been shown to vary between locations in north Queensland (Inglis 2000, Rasheed 2000). *Halodule uninervis* meadows near Townsville produced large numbers of seeds from which recovery can occur (Inglis 2000) but a meadow of the same species near Cairns relied almost exclusively on clonal reproduction for recovery, with no seed bank produced (Rasheed 2000). These examples illustrate the importance of understanding the reproductive strategies employed by species at a particular location for the assessment of their capacity to recover from loss. Currently there is no information on the seed-banks or reproductive status of Upstart Bay seagrasses.

At present, anthropogenic threats to Upstart Bay seagrass meadows appear to be low although several planned and developing activities have the potential to impact on seagrass meadows if not well managed. There is a proposal to dredge a boating channel at the mouth of Molongle Creek adjacent to seagrass meadows and issues concerning the disposal of the dredge material are yet to be resolved. There are also proposals for aquaculture development in the area including Rocky Ponds Creek. Large-scale development in the Burdekin catchment also has the potential to increase water turbidity in Upstart Bay and affect seagrass survival.

Invertebrates and fish

The importance of seagrass meadows in north Queensland as nursery areas for juvenile penaeid species has been well established (eg. Coles *et al.* 1987a, 1987b, 1992, 1993). Upstart Bay seagrass meadows support significant numbers and a large diversity of juvenile penaeid prawns. The dominant penaeid species differed for each meadow type and time of survey but all were of commercial importance (*Penaeus latisulcatus, Penaeus longistylus, Metapenaeus sp.* and *Penaeus esculentus*). Prawn surveys in 1987 indicated that Upstart Bay seagrass meadows supported the highest densities of juvenile commercial penaeid prawns in areas sampled between Cairns and Bowen (Coles *et al.* 1992). Results from May and October 1999 show high biomass *Zostera* meadows supported a greater diversity and overall abundance of penaeids than the lower biomass *Halodule/Halophila* meadows in Upstart Bay. Similar patterns of penaeid diversity and abundance for low and high biomass meadows have been found in other areas in Queensland, including Mourilyan Harbour (McKenzie *et al.* 1996) and Cairns Harbour/Trinity inlet (Coles *et al.* 1993). The lower biomass meadows in Upstart Bay also supported populations of juvenile penaeid prawns and should be considered as important habitat for penaeid prawn fisheries production.

Upstart Bay seagrass meadows also support a large variety of juvenile fish species. At least 24 species were captured in beam trawls, a similar diversity of species to surveys conducted in the area in 1987 (21 species) (Coles *et al.* 1992). Most of the species collected were not of direct commercial or recreational importance, but the diversity and number of fish was likely to provide the basis for a productive ecosystem and food for larger, fast-swimming and commercially important fish that are not usually caught in beam-trawls.

Dugong

The Upstart Bay Dugong Protected Area supports large meadows of seagrass species known to be preferred as dugong food, such as *Halodule uninervis* (narrow) and *Halophila* species (Preen 1995). Dugong were observed in the seagrass meadows during the survey and dugong feeding trails were also found indicating that dugong actively use the seagrass meadows in Upstart Bay for feeding. These meadows occurred in both shallow subtidal and intertidal areas of the Bay, providing a potential food source for dugong throughout the tidal cycle, yet most of the preferred habitat was confined to intertidal depths - particularly in May. Seagrass occurs mainly intertidally in some other areas of northern Queensland that dugong frequent, such as Shoalwater Bay, and is only available for grazing around high tide (Lee Long *et al.* 1997). Dugong populations in Queensland were highest in regions where very extensive food resources were available in deepwater (>15m at Hervey Bay and Lookout Point to Barrow Point).

Seagrass meadows of dugong preferred species within Upstart Bay were made up of species known to be highly seasonal and susceptible to storm damage in other locations. The susceptibility of these meadows to seasonal change and storm damage is likely to have implications for dugong relying on them as a food source. Large-scale loss of seagrass due to storm-related damage has been associated with high dugong mortality in Hervey Bay (Preen & Marsh 1995) and seagrasses in Upstart Bay have been similarly affected by storm damage in the past. Unlike Hervey Bay, there were no deepwater (>6 m) seagrass meadows available for dugong to feed on in Upstart Bay as an alternative should the shallow meadows be lost. The implications of seagrass loss in the area to dugong will depend, in part, on the ability of the meadows to recover. The capacity of Upstart Bay meadows for recovery is unknown, as seed-bank status and reproductive strategies of these meadows have not been measured.

Due to the capacity for seagrass meadows to vary in time and space, a continuing monitoring program of seagrass status within DPAs may be required to ensure that DPAs remain relevant in terms of seagrass distribution and to develop strategies for ensuring continued survival of dugong. If monitoring indicated large areas of seagrass within a particular DPA were lost, extra protective measures may need to be implemented in neighbouring DPAs or nearby seagrass areas outside the DPAs to ensure that food is available locally for dugong.

Other threats to dugong in Upstart Bay include boat strike and traditional hunting. The traditional owners of the area, the Giru Dala people, have agreed not to hunt dugong in the Bay, but there still remains a threat of boat-strike from recreational boating. The southeastern corner of the Bay is heavily used by recreational boating and for transit to houses and holiday shacks on the eastern side of the Bay. The location of boat ramps in the area directs boat traffic over seagrass meadows and areas frequented by dugong.

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3. SEAGRASS AND MARINE RESOURCES OF THE NEWRY REGION AND SAND BAY DUGONG PROTECTION AREAS

Anthony Roelofs & Chantal Roder

BACKGROUND

Description of Study Locality

The Newry region and Sand Bay DPAs extend from just north of Dewars Point (near Hervey Creek) to the southern edge of Sand Bay (Williamson's Beach) and cover approximately 239 km^2 (Map 3.1). The study area is between 20°45′ S and 21° S and is comprised of coastal islands, coral reefs, and extensive shallow water, subtidal and intertidal mud and sand flats. The region's catchment consists of Saunders, Station, Oyster, Reedy and Zamia creeks draining the Tonga Range in the north; Alligator, Somerset, Black Rock, St. Helens, One Mile and Murray creeks draining the Clarke and Whiptail ranges to the west; and Conow, Cluny and Victor creeks drain the low hills in the south (Spain 1992).

Maximum rainfall in the area is between 1397 and 2007 mm which falls mostly from December to April (Mackay). Wet season rainfall can dilute estuarine waters to brackish levels in some areas. Mean annual rainfall is 1608 mm and minimum and maximum daily temperatures range from 12.7°C in July to 30.0°C in January (Mackay, 36.9 year average, Australian Bureau of Meteorology 2000). The tidal range for the area is approximately 5 m. Winds are predominantly south-easterly in the dry cooler months of the year and light northerly winds during the summer wet season months.

Extensive mangrove wetlands, intertidal and shallow water habitats, and coastal islands with coral reef occur within the DPA boundaries. The region is recognised as a nationally important area for shorebirds. Flatback turtles *Chelonia depressa* and green turtles *Chelonia mydas* use the area for foraging and occasionally nesting (Spain 1992).

The area is a popular destination for holiday-makers and retirees with accommodation and facilities available at St. Helens Beach, Seaforth and Port Newry. There is also a small resort on Newry Island (Brodie *et al.* 1997).

Potential disturbances or threats to seagrasses within the Newry region/Sand Bay DPA range from small physical (eg. propeller scars) and chemical (eg. outboard pollution and minor fuel spills) impacts to more widespread, such as increased sediment loads from land clearing within the catchment area (Spain 1992).

Newry, Rabbit, Acacia, Mausoleum and Rocky islands are all national parks and much of the area including the mangroves is a fauna sanctuary. St. Helens Bay and Sand Bay are Fish Habitat Areas (FHA) (Repulse, 015-041 and Sand Bay, 015-042) while most other land is leasehold or freehold (Map 3.1). Fish Habitat Areas have been declared throughout coastal Queensland to enhance existing and future fishing activities and to protect the habitat upon which fish and other aquatic fauna depend. The sea waters and land areas adjacent to Seaforth are not within these FHAs. The coastal waters of St. Helens Bay are zoned Marine Park General Use A or B. The conservation areas within the region are managed either by Queensland Parks and Wildlife, Environment Protection Agency or Queensland Department of Primary Industries.

The Newry region and Sand Bay Dugong Protected Areas (DPAs), were declared in January 1998 to protect key dugong (*Dugong dugon*) populations and habitat. Newry region and Sand Bay DPAs (including Repulse Bay DPA) are estimated to protect 2% of the 1994 southern Great Barrier Reef dugong population (GBRMPA 1997). The region supported a "cottage based" dugong fishery based at Newry Island during at least the first half of the 20th century (Marsh, JCU, Pers. Comm.). Dugong populations in the Newry and Sand Bay regions are estimated to have declined from 240 ±104 in 1986 to 38 ±37 in 1994 and eight dugong carcasses have been reported from the area in recent years (GBRMPA 1997).

Two levels of DPA are in place in the Newry region and Sand Bay. The Newry region DPA has an 'A' level of protection which offers more restrictions to netting practices than the 'B' level of the Sand Bay DPA. By restricting commercial netting activities in certain areas, DPAs serve to protect dugong from entanglement in some fishing nets, as they forage and move. Specific restrictions on commercial netting in the Newry region 'A' DPA include prohibiting offshore set and drift nets and foreshore set nets. Set net use is permissible within the Newry region creeks and rivers, but there are restrictions on net length and drop as well as fisher attendance. Specific control measures in the Sand Bay 'B' DPA include restrictions on the length, placement and attendance of offshore, foreshore and river set nets as well as the allowance of a new rocky foreshore (headlands) set net. River set net use is less restrictive in 'B' areas than in 'A' areas.

Port Newry, St. Helens Bay, Seaforth and Sand Bay are popular areas for recreational boating, camping, and fishing. The area offers sheltered estuarine and reef fishing, easily and safely accessed by small vessel via an all-tide, all-weather public boat ramp. Recreationally targeted fish species include king salmon (*Polydactylus sheridani*), blue salmon (*Eleutheronema tetradactylum*), grunter (*Pomadasys kakaan*), whiting (*Sillago* sp), mangrove jack (*Lutjanus argentimaculatus*), spanish mackeral (*Scomberomorus commersoni*) and mixed reef species. Significant catches of banana prawns (*Penaeus merguiensis*) are made by cast netters and drag netters. There were over 6600 recreational vessels registered in the Newry and greater Mackay area in 1995 and this figure was increasing at a rate of ~18% per year (Gilbert and Benzaken 1997). An average weekend at Port Newry can see up to 50 recreational vessels under 5m use the region and on long weekends or public holidays this can increase to around 100 vessels (B. Depper, Queensland Boating & Fisheries Patrol. Pers. Comm.). The region also has one recreational fishing charter operator.

Commercial fishing and crabbing is carried out within the region by up to 4 crabbing and 6 gill netting operators (Table 3.1). The main target species are barramundi (*Lates calcarifer*), king and blue salmon and various shark species. Significant catches of banana prawns are made by beam trawl operators in Murray Creek and by otter trawlers offshore of Cape Hillsborough (B. Depper, QBFP. Pers. Comm. 2000).

Table 3.1. Number of boats, fishing days and total catches recorded for waters between latitudes 20°30'S and 21° 00'S, and longitudes 148° 30'E and 149° 00'E, from 1995 to1999 (source: Queensland Fisheries Service).

Year	Boats	Fishing days	Total catch (tons)			
			Fish	Prawns	Others*	Total
1994	284	2516	27.91	50.79	8.67	87.36
1995	293	3189	43.36	70.87	5.90	120.12
1996	257	1715	46.53	25.47	3.88	75.88
1997	310	3045	92.18	51.21	8.85	152.24
1998	324	3343	36.14	81.75	8.17	126.06
1999	238	2559	86.88	28.84	5.69	121.41

* Others = scallops, crab, bugs, squid, octopus and cuttlefish.

Seagrasses of the Newry Region/Sand Bay

Seagrass meadows in and around the Newry region/Sand Bay Dugong Protected Areas were first mapped during a broad scale survey of seagrasses from Bowen to Water Park Point in March and April 1987 (Coles *et al.* 1987a, Lee Long *et al.* 1993). 7.4 km^2 of seagrass meadows were mapped including 4.9km^2 of low (<10% cover) and 2.5km^2 of medium (10–50%) density seagrass meadows, and up to seven seagrass species (from three families), were found in the Port Newry, Seaforth and St. Helens Bay region. No areas of seagrass more than 50% cover were recorded at this locality during the survey. Port Newry was recognised as being species rich with up to six species present at a single site. The total cover of seagrass meadows in these areas was estimated at approximately 490 ha. This may have been an underestimate of total seagrass area as surveying the large exposed mud and sand banks was not possible due to tidal conditions at the time (R. Coles, QDPI. Pers. Comm.).

RESULTS

Seagrass Species, Distribution and Abundance

Seagrass was common in the Newry region DPA, however no seagrass was found in the Sand Bay DPA. Nine species of seagrasses (from three families) were identified in the Newry region DPA in 1999 (Table 3.2).

Table 3.2. Seagrass species present in the Port Newry and Sand Bay Dugong Protection Areas May 1999 and October 1999.

Seagrass Family	Seagrass species	Port Newry		Sand Bay	
		May 1999	Oct 1999	May 1999	Oct 1999
ZOSTERACEAE Drummortier	*Zostera capricorni* Aschers.	✓	✓	-	-
CYMODOCEACEAE Taylor	*Cymodocea rotundata* Ehrenb. & Hempr. Ex Aschers	✓	-	-	-
	Cymodocea serrulata (R. Br.) Aschers. & Magnus	✓	✓	-	-
	Halodule uninervis (narrow and wide leaf morph) (Forsk.) Aschers.	✓	✓	-	-
	Syringodium isoetifolium (Aschers.) Dandy	✓	✓	-	-
HYDROCHARITACEAE Jussieu	*Halophila decipiens* Ostenfeld	✓	✓	-	-
	Halophila minor (Zollinger) den Hartog	✓	-	-	-
	Halophila ovalis (R. Br.) Hook. *f*	✓	✓	-	-
	Halophila spinulosa (R. Br.) Aschers. in Neumayer	✓	✓	-	-

312 coastal sites (293 dive, 19 helicopter) and 14 deep-water video sites were ground truthed in the Newry region and Sand Bay DPAs in May 1999 (Map 3.2) and 292 coastal (all dive) and 14 deep-water video sites were sampled in October 1999 (Map 3.3). The total area of seagrass habitat mapped in May was 2,450 ±360 ha and 2,451 ?345 ha in October 1999 (Maps 3.4 & 3.5). Seagrass habitats were located on mud through to sand substrates and extended from intertidal depths to 5.5 m below MSL in St Helens Bay. No seagrass was found south of Finlayson Point or at any of the deepwater video survey sites.

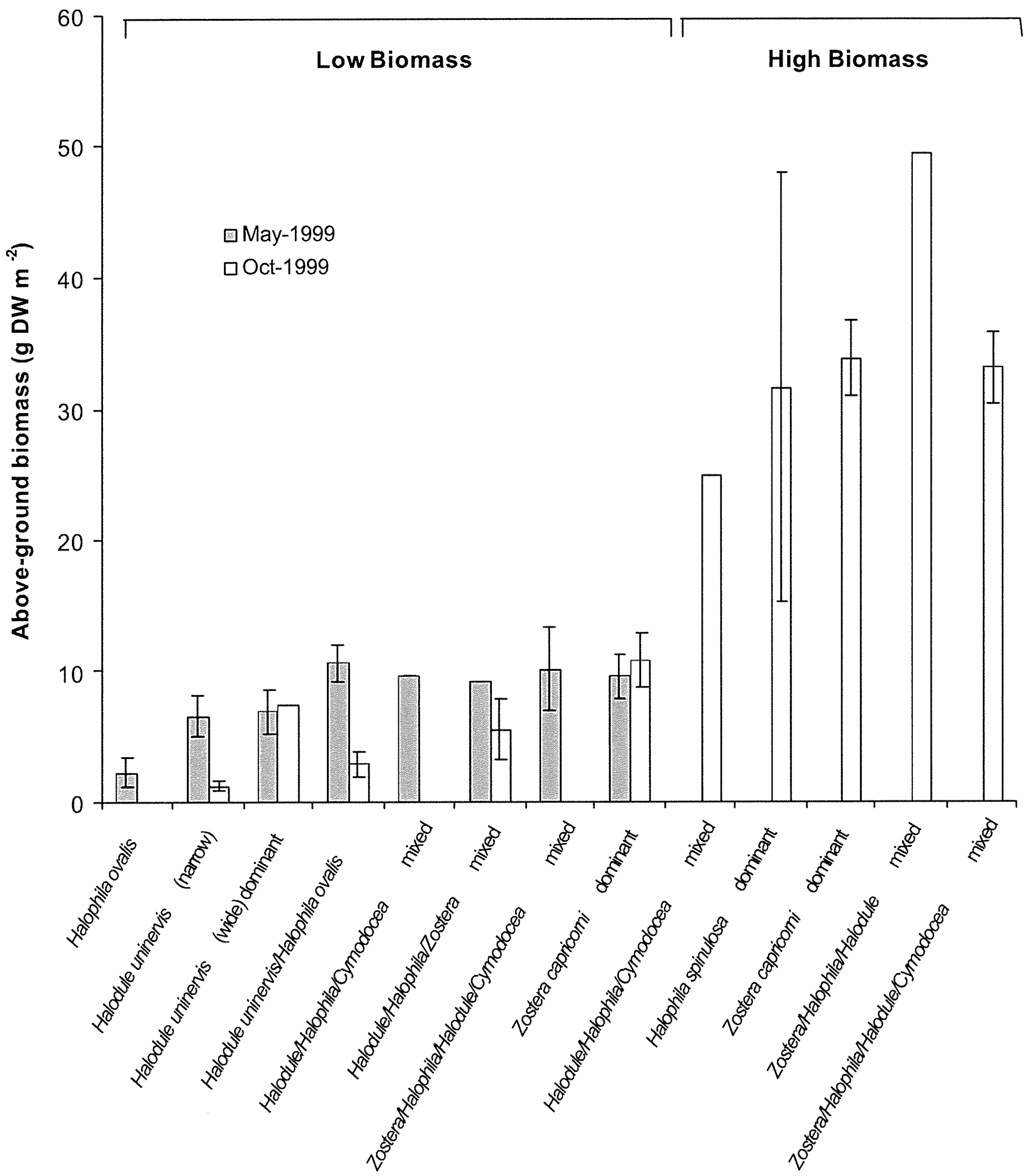
Three main seagrass habitat types were identified:

1. large continuous meadows on intertidal banks (dominated by either *Halodule uninervis* (narrow) or *Zostera capricorni*);
2. patchy meadows on intertidal sand banks in St. Helen's Bay (*Halodule uninervis* (narrow) or *Zostera capricorni*);
3. shallow sub-tidal meadows found in Port Newry region and eastern parts of St. Helen's Bay (mixed species).

Minor seagrass habitats included *Halodule uninervis* (wide), *Syringodium isoetifolium* and *Halophila spinulosa* meadows in small isolated areas around Rabbit Is, Newry Is and

Outer Newry Is (Maps 3.8a, 3.9a, 3.10a & 3.11a), and a small *Halodule uninervis/Halophila ovalis* meadow north of Dewars Point (Maps 3.6a & 3.7a).

There were 13 meadow types in the Newry region DPA classified on seagrass species presence and dominance (Figure 3.1, Table 3.3). Meadow types were also divided into broad categories of Low (<20 g DW m^2) and High (>20 g DW m^2) above-ground biomass. The majority of meadows found in May 1999 were low biomass (Maps 3.6, 3.8 & 3.10). Extensive low biomass meadows of *Halodule uninervis* (narrow) and *Halodule uninervis/Halophila ovalis* in St. Helens Bay were found in both May and October (Maps 3.6 & 3.7). Mixed species meadows (*Zostera capricorni, Halodule uninervis* (wide), *Cymodocea serrulata* and *Halophila spinulosa*) dominated in Port Newry and were on



average higher in biomass than all other meadows in October 1999 (Map 3.11).

Figure 3.1. Above-ground seagrass biomass for each meadow type in May and October 1999 (*mean and standard error displayed*).

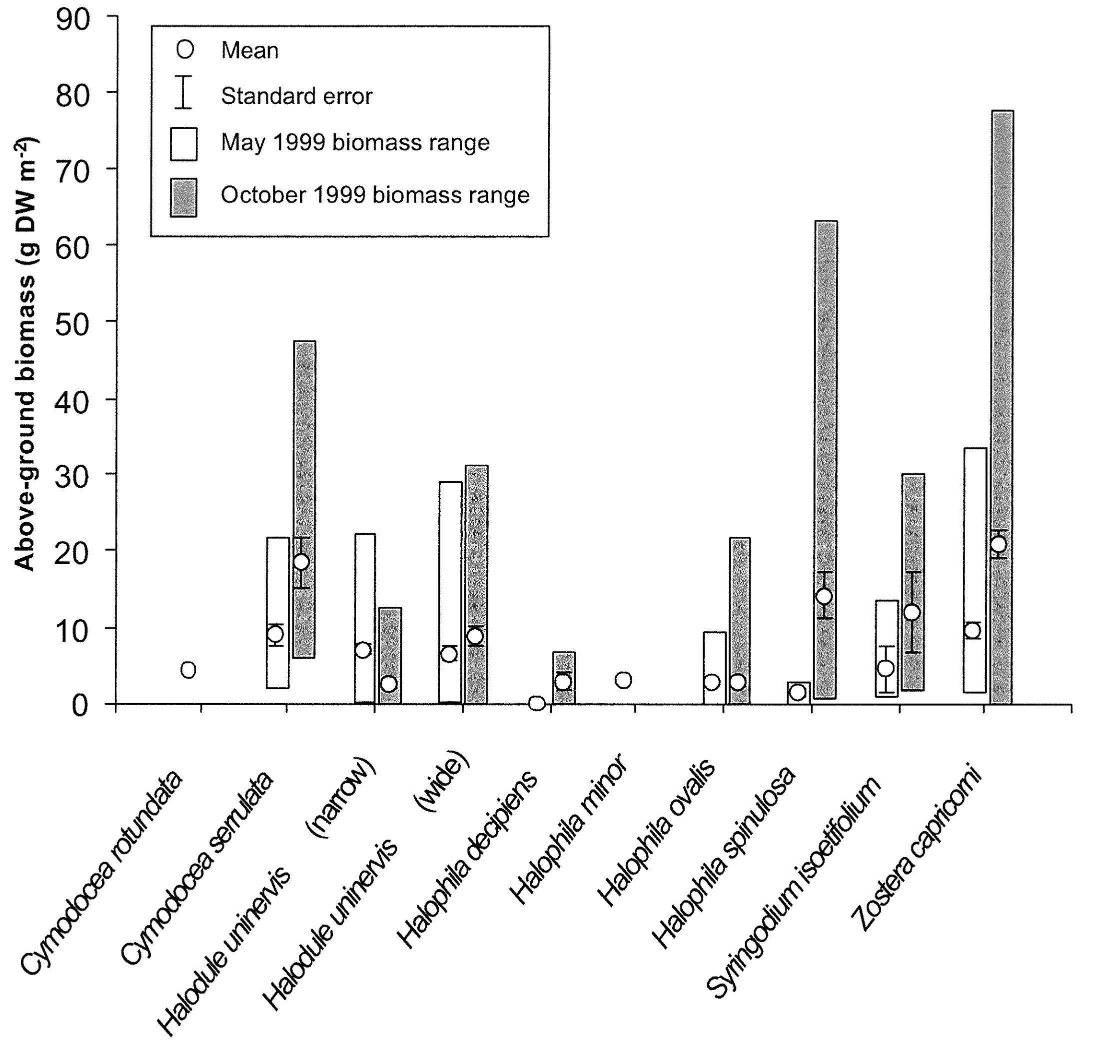


Figure 3.2. Mean (±SE) and range of above-ground biomass for each seagrass species in the survey area (from sites where the species occurred) in May and October 1999.

Halophila ovalis had similar mean above-ground biomass (g DW m^{-2}) between May and October 1999 (Figure 3.2). *Zostera capricorni, Halophila spinulosa* and *Cymodocea serrulata* mean biomass increased significantly over this period. Biomass ranges for these species also increased. *Halodule uninervis* (narrow) was the only species to decrease in biomass and range significantly between sampling times (Figure 3.2). Biomass for most species was more variable in October.

Overall, mean seagrass biomass (all species pooled) in the Newry region DPA increased between May and October 1999 (4.5 ?0.4 and 11.9 ?1.1 g DW m^{-2} respectively). The increase was mostly in Port Newry where low biomass meadows in May became high biomass in October (Maps 3.10 & 3.11). An increase in *Zostera capricorni* biomass (7.8 ?1.3 to 24.0 ?2.8 g DW m^{-2}) and distribution (570 ?67 ha to 787 ?107 ha) was the major cause of the overall biomass increase from May to October (Table 3.3, Maps 3.10b & 3.11b). *Halophila spinulosa* and *Cymodocea serrulata* also contributed to the overall increase in abundance and distribution in this region over the same period but to a lesser extent (Figure 3.2, Table 3.3, Maps 3.10 & 3.11).

Table 3.3 Mean above-ground biomass, number of meadows identified, and area for each seagrass meadow type identified in the Newry Region DPA, May1999 and October 1999.

** Range of meadow area calculated using estimate of mapping reliability -refer Methods (Section 1)*

Meadow type		May 1999			October 1999		
		Mean biomass ±SE (range) (g DW m^{-2})	**Number of meadows**	**Area (range*) (ha)**	**Mean biomass ±SE (range) (g DW m^{-2})**	**Number of meadows**	**Area (range*) (ha)**
Low biomass	*Halophila ovalis*	2.3 ±1.2 (1.1 - 3.5)	7	8.8 (3.4 - 14.2)	-	3	0.3 (0 - 1.2)
	Halodule uninervis (narrow)	6.6 ±1.6 (1.1 - 12.9)	1	434.6 (362.5 - 506.7)	1.3 ±0.4 (0.4 - 1.9)	9	324.7 (277.6 - 371.8)
	Halodule uninervis (wide) dominant	6.9 ±1.7 (4.3 - 13.6)	4	8.5 (0 - 22.1)	7.4	1	1.4 (0 - 3.8)
	Halodule uninervis/Halophila ovalis	10.6 ±1.4 (7.1 - 15.4)	5	405 (323.1 - 486.9)	2.9 ±0.96 (0.3 - 7.0)	4	448.7 (357 - 540.4)
	Halodule/Halophila/Cymodocea mixed	9.6	2	650 (602.7 - 697.3)	-	0	-
	Halodule/Halophila/Zostera mixed	9.3	9	48.5 (10.8 - 86.2)	5.5 ±2.3 (4.3 - 11.0)	2	106.6 (47.8 - 165.4)
	Zostera capricorni dominant	9.6 ±1.7 (3.1 - 15.6)	1	408.2 (305 - 511.4)	10.8 ±2.0 (0.4 - 20.5)	14	314.5 (223.7 - 405.3)
	Zostera/Halophila/Halodule/Cymodocea mixed	10.2 ±3.2 (3.8 - 13.9)	14	466.4 (415.6 - 517.2)	-	0	-
High biomass	*Halodule/Halophila/Cymodocea* mixed	-	0	-	24.9	2	445.9 (397.1 - 494.7)
	Zostera capricorni dominant	-	3	0.9 (0 - 2)	33.8 ±2.9 (26.4 - 40.2)	1	204.6 (159.6 - 249.6)
	Zostera/Halophila/Halodule mixed	-	0	-	49.5	7	1.7 (0 - 3.8)
	Zostera/Halophila/Halodule/Cymodocea mixed	-	6	16.1 (9.1 - 23.1)	33.1 ±2.8 (27.8 - 40.6)	6	598.6 (527.7 - 669.5)
	Halophila spinulosa dominant	-	1	2.9 (0 - 6.6)	31.6 ±16.3 (7.4 - 62.6)	1	4.4 (0 - 9.8)
Total meadows		8.3 ±0.8 (0 - 15.6)	53	2449.8 (2089.8 - 2809.8)	15.8 ±2.5 (0.3 - 62.6)	50	2451.2 (2106.2 - 2796.2)

Seagrass Depth Distribution

Seagrasses in the Newry region DPA were found at depths between Mean Sea Level (MSL) and 5.5 m below MSL in May and between 0.3 m above MSL and 5.2 m below MSL in October 1999 (Figure 3.3). *Halodule uninervis* (narrow) occurred at the deepest depth of all species in May while *Halophila spinulosa* and *Halophila decipiens* both occurred at the deepest depth in October.

Mean depths of occurrence for almost all species were in the intertidal zone (ie. above Lowest Astronomical Tide (LAT)) in May and October. *Halophila decipiens* had the deepest mean depth of all species in October 1999 with *Halophila spinulosa* and *Syringodium isoetifolium* the next deepest on average during both surveys (Figure 3.3). No seagrass species depth range was exclusively sub-tidal during the study period.

Mean depths below MSL for the major species (*Zostera capricorni, Halodule uninervis, Halophila ovalis* and *Halophila spinulosa*) were slightly deeper in October when compared to May. Most of the increase in mean depth for *Zostera capricorni* occurred in Port Newry in October (Map 3.11b).

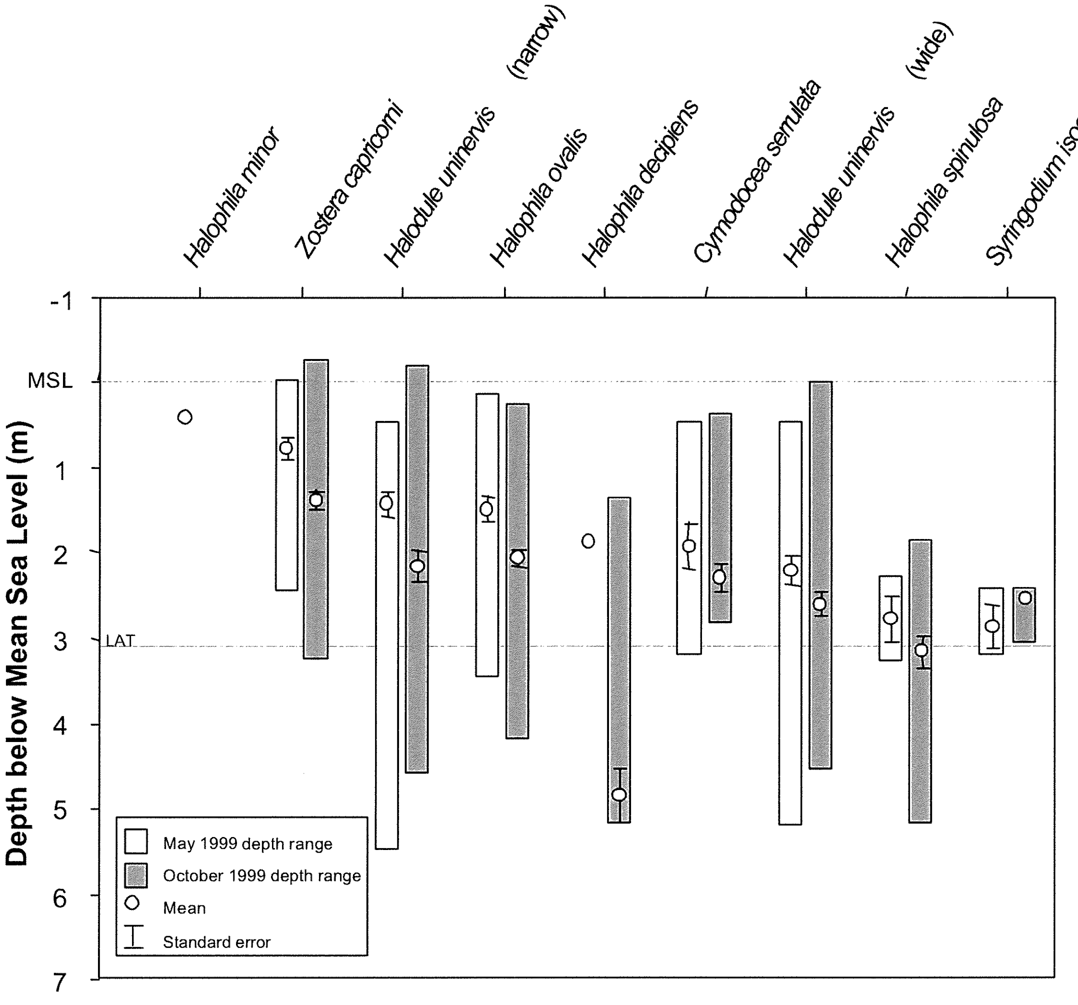
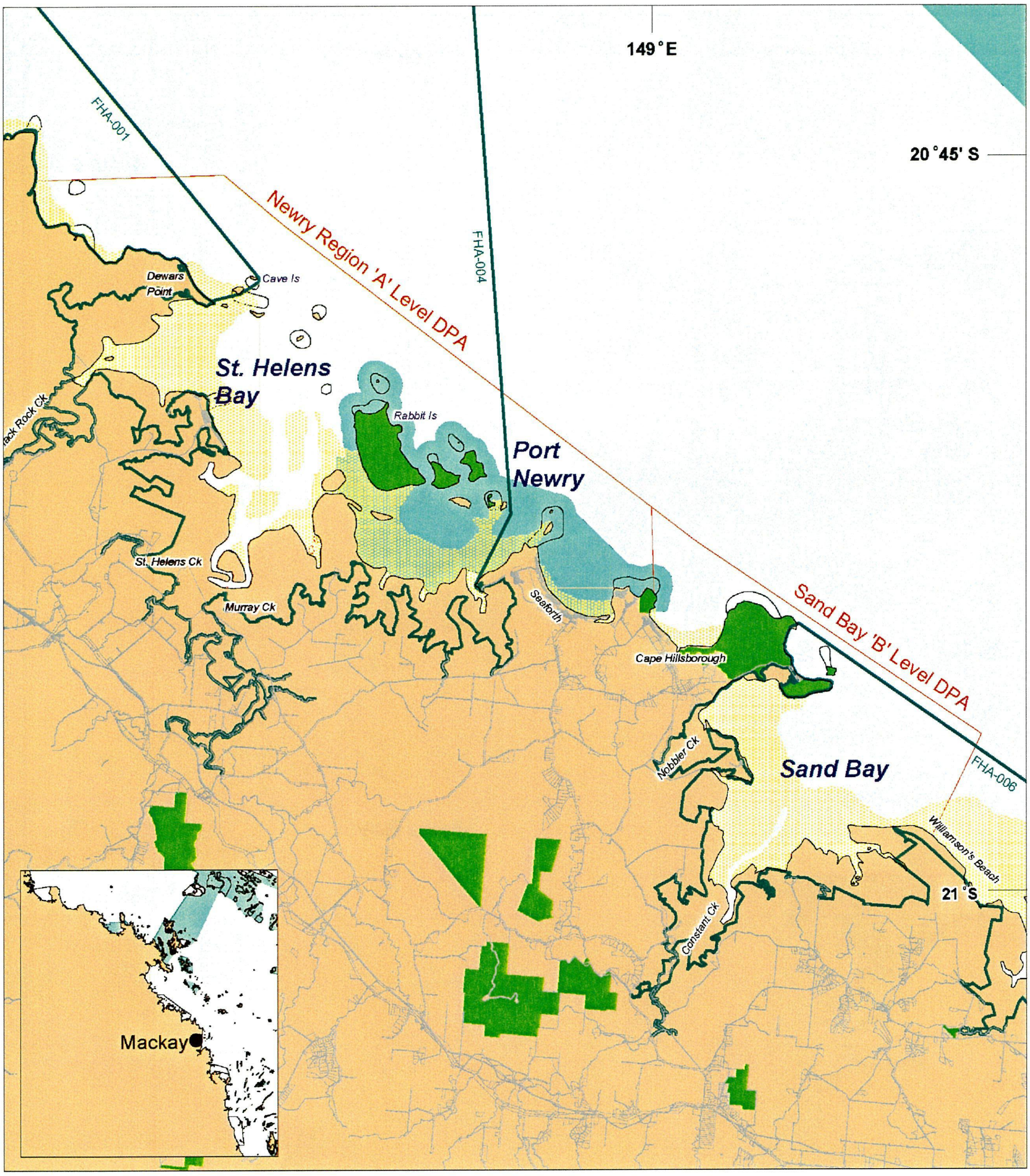


Figure 3.3. Means, standard errors and ranges of depth of occurrence for each seagrass species found in the Newry region DPA (MSL = Mean Sea Level, LAT = Lowest Astronomical Tide) (*Statistics calculated using only survey sites from transects which ran perpendicular from shore to the seaward edge of meadows*).

Map 3.1 Newry Region and Sand Bay Dugong Protection Areas



LEGEND

- Sandbanks
- Dugong Protection Area Boundary
- Fish Habitat Area Boundary
- National Park
- Marine Park - General Use A
- Marine Park - General Use B

Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resources of the Newry Region and Sand Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 3, pp 51-84. (DPI, Cairns).

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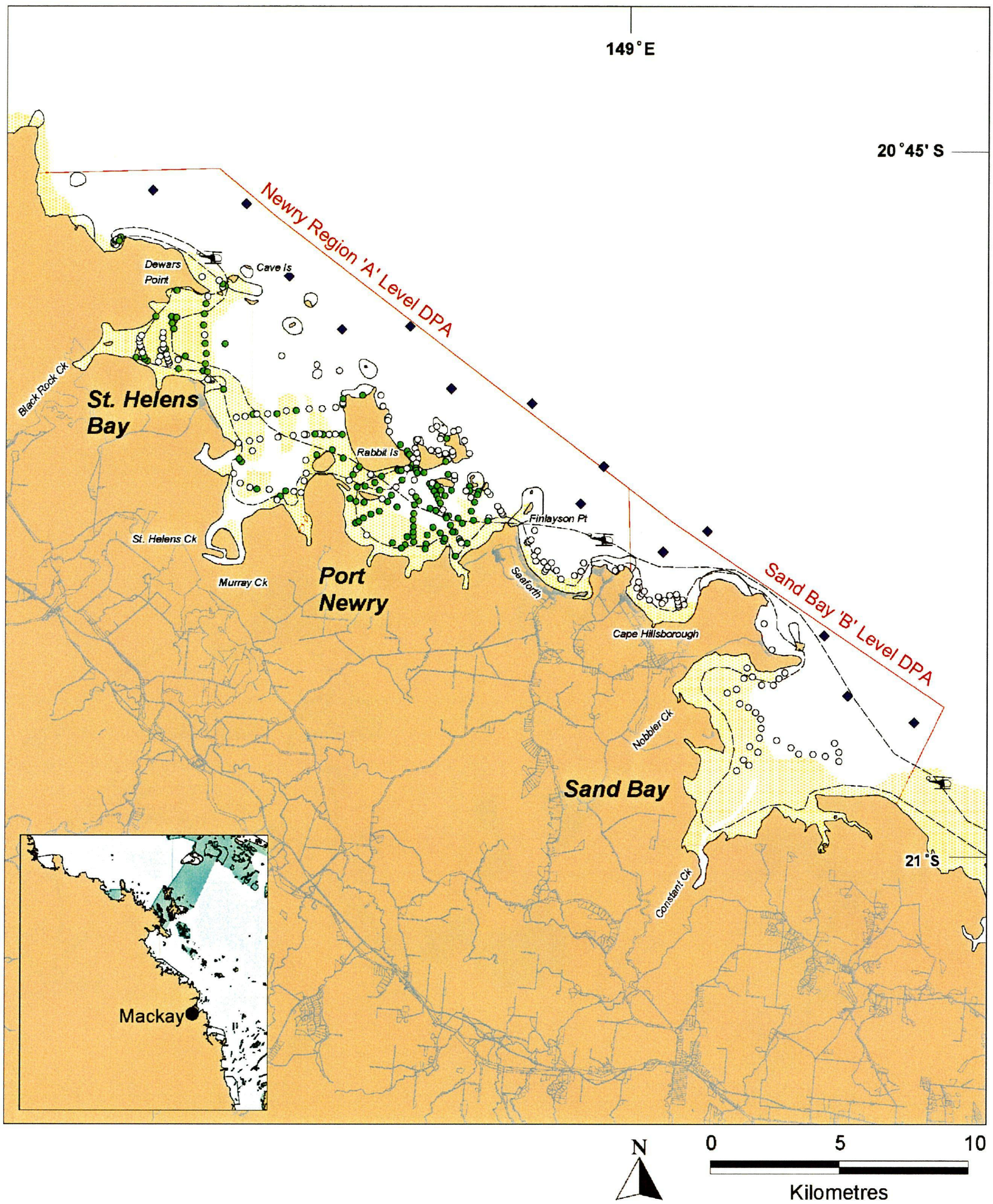
CRC Reef Research Centre

Map 3.2 Survey sites within the Newry Region/Sand Bay Dugong Protection Areas - May 1999



LEGEND

- Sandbanks
- Deepwater video site
- Seagrass
- No seagrass
- Helicopter flight path

Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resources of the Newry Region and Sand Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 3, pp 51-84. (DPI, Cairns).

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Sampling dates: Helicopter survey 27-28 April 1999
Diver and deepwater video survey 16-25 May 1999.

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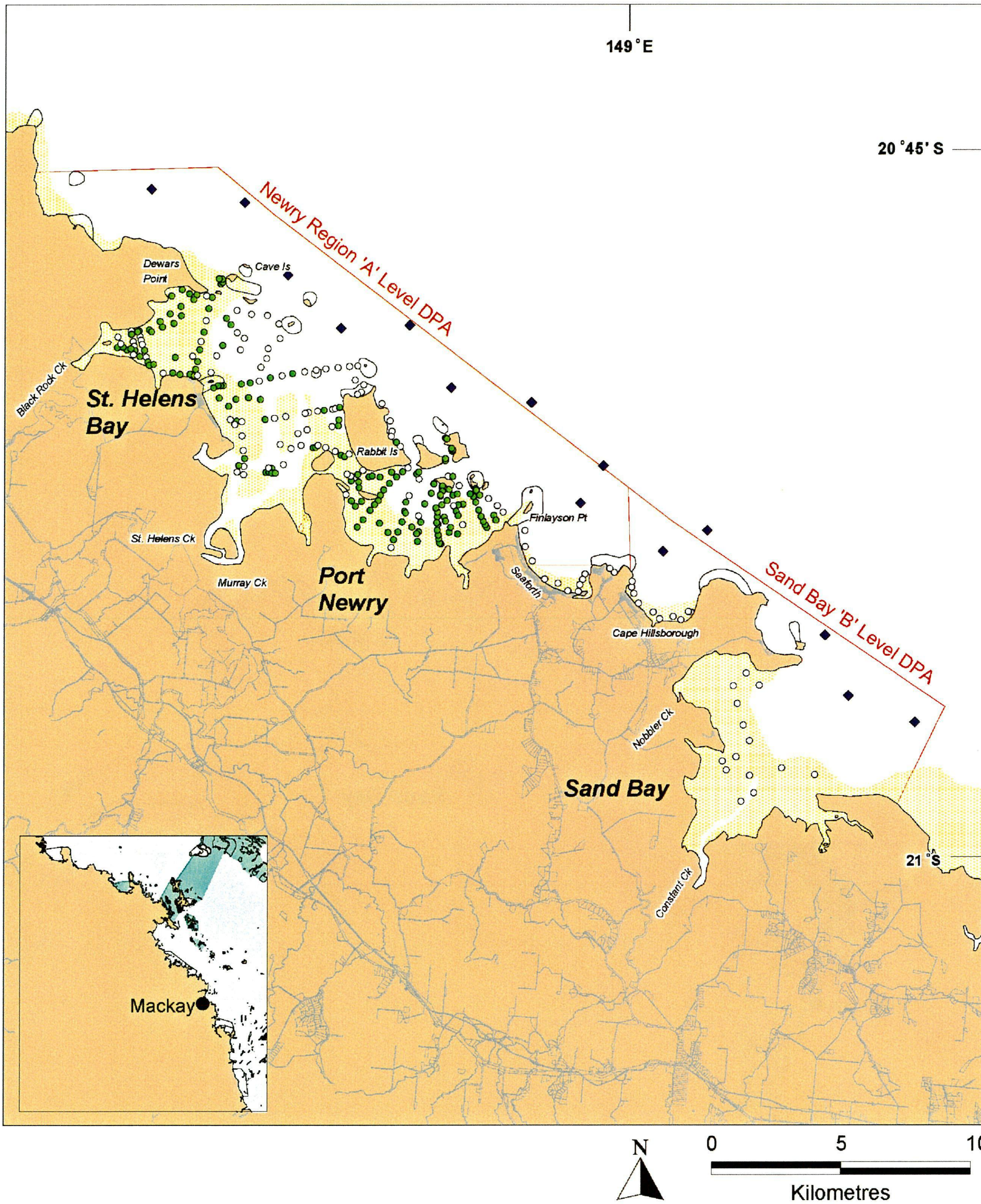
Map 3.3

Survey sites within the Newry Region/Sand Bay Dugong Protection Areas - October 1999



LEGEND

- Sandbanks
- ◆ Deepwater video site
- ● Seagrass
- ○ No seagrass

Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resources of the Newry Region and Sand Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October) 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 3, pp 51-84. (DPI, Cairns)

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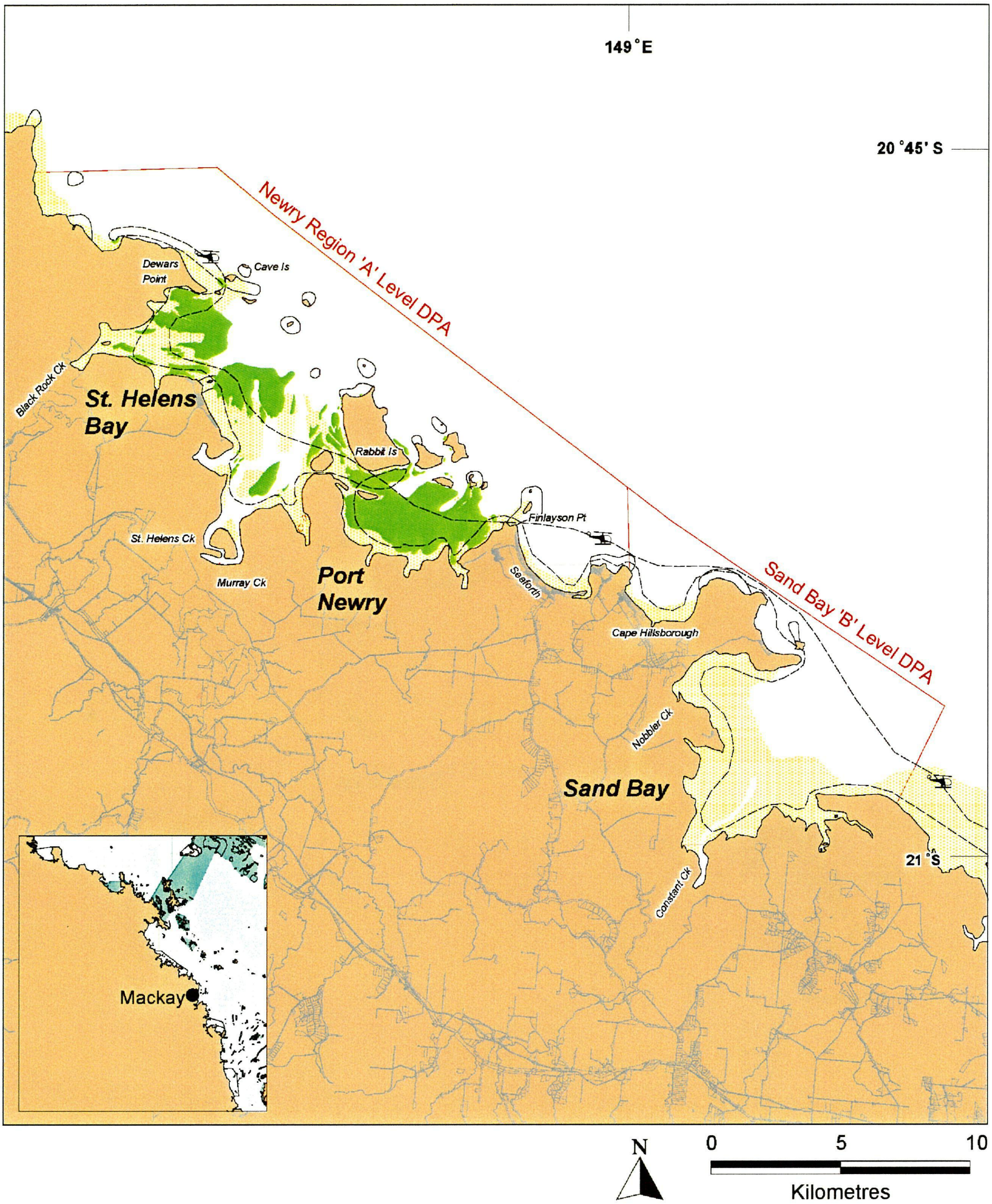
Map 3.4 Location of seagrass meadows in the Newry Region/ Sand Bay Dugong Protection Areas - May 1999



LEGEND

- Sandbanks
- Seagrass meadow
- Helicopter flight path

Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resources of the Newry Region and Sand Bay Dugong Protection Areas. In: 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region. April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 3, pp 51-84. (DPI, Cairns).

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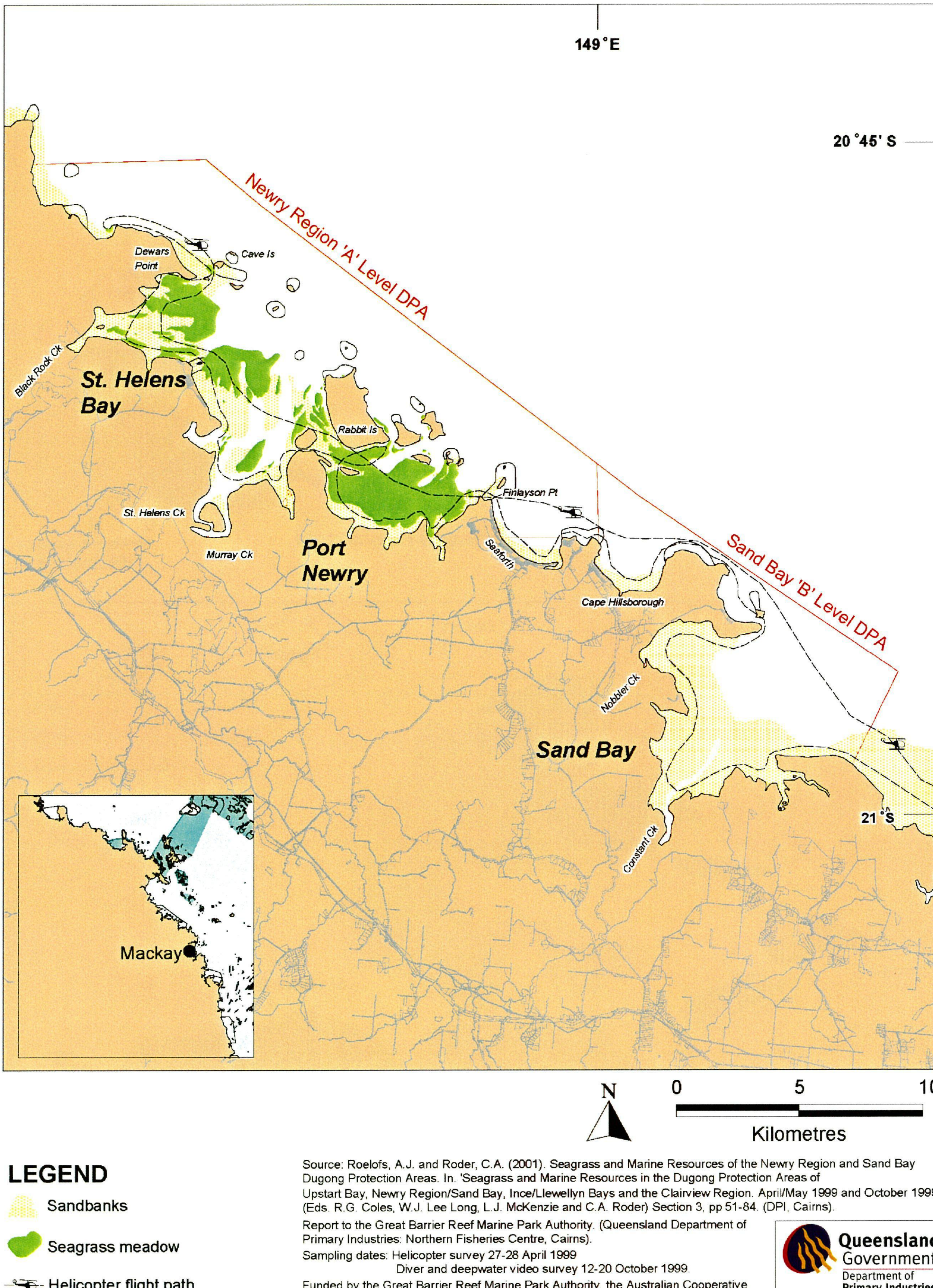
Map 3.5

Location of seagrass meadows in the Newry Region/ Sand Bay Dugong Protection Areas - October 1999



Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resources of the Newry Region and Sand Bay Dugong Protection Areas. In 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region. April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 3, pp 51-84. (DPI, Cairns).

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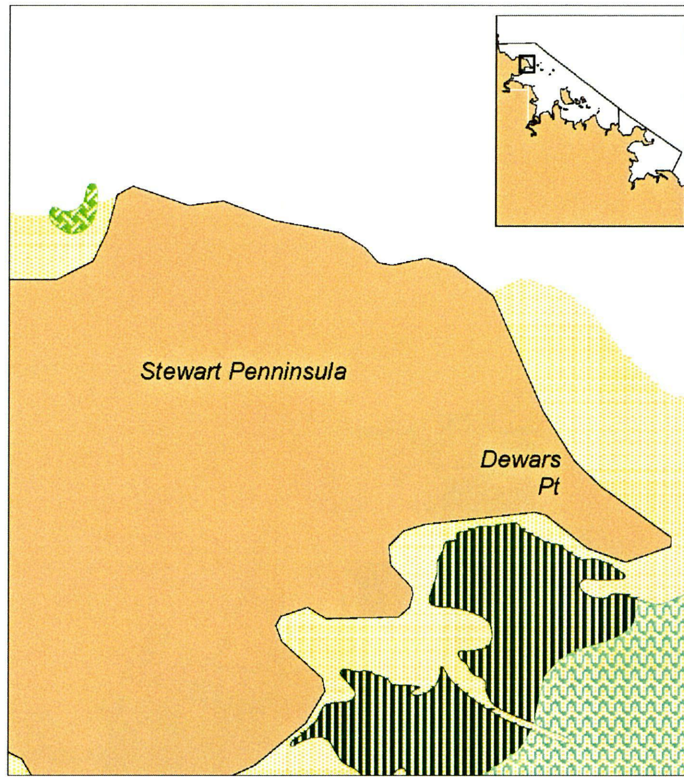
Map 3.6

Seagrass communities mapped in the Newry Region Dugong Protection Area - May 1999 (enlargements)

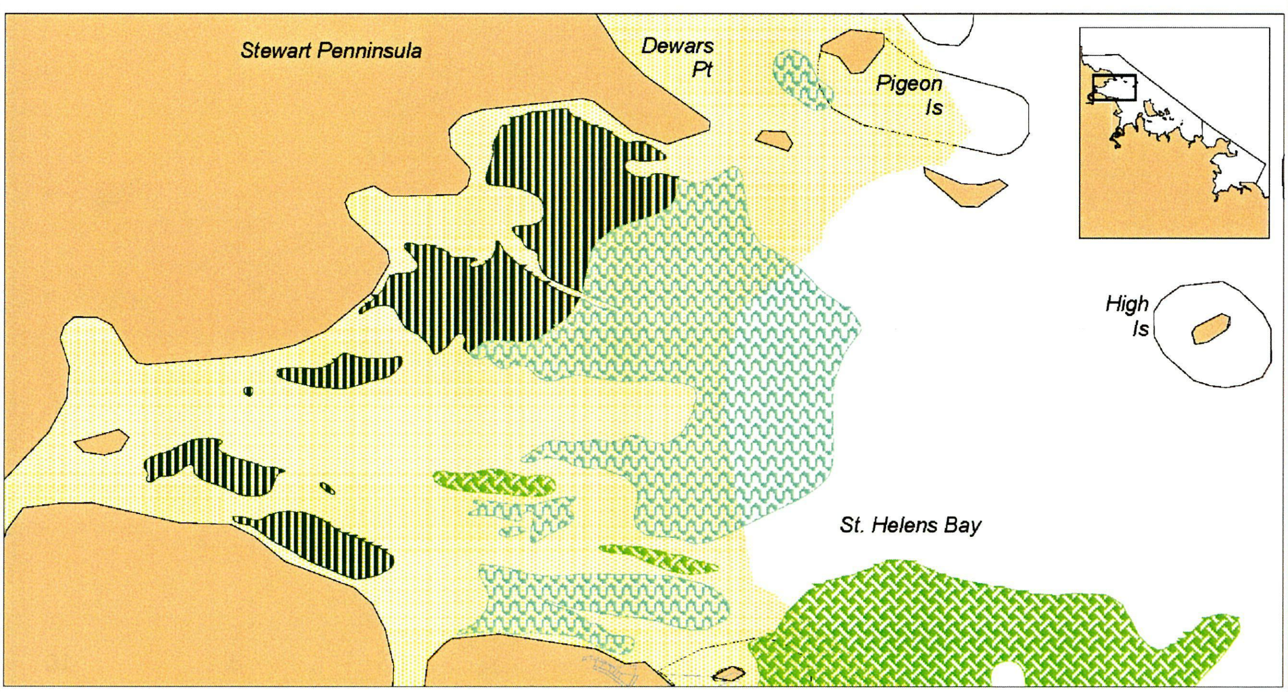


a. Stewart Penninsula

0 0.5
Kilometres

LEGEND

- Low biomass Halodule uninervis (narrow)
- Low biomass Halodule uninervis/Halophila ovalis
- Low biomass Zostera capricorni dominant
- Sandbanks



b. St. Helens Bay - North

0 1 2
Kilometres
N

Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resources of the Newry Region and Sand Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder). Section 3, pp 51-84. (DPI, Cairns).
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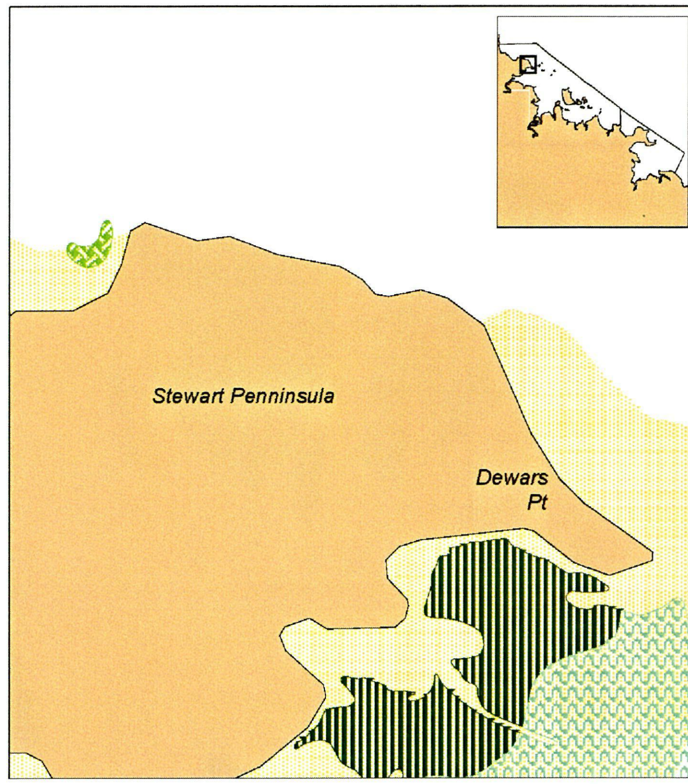
Map 3.7

Seagrass communities mapped in the Newry Region Dugong Protection Area - October 1999 (enlargements)

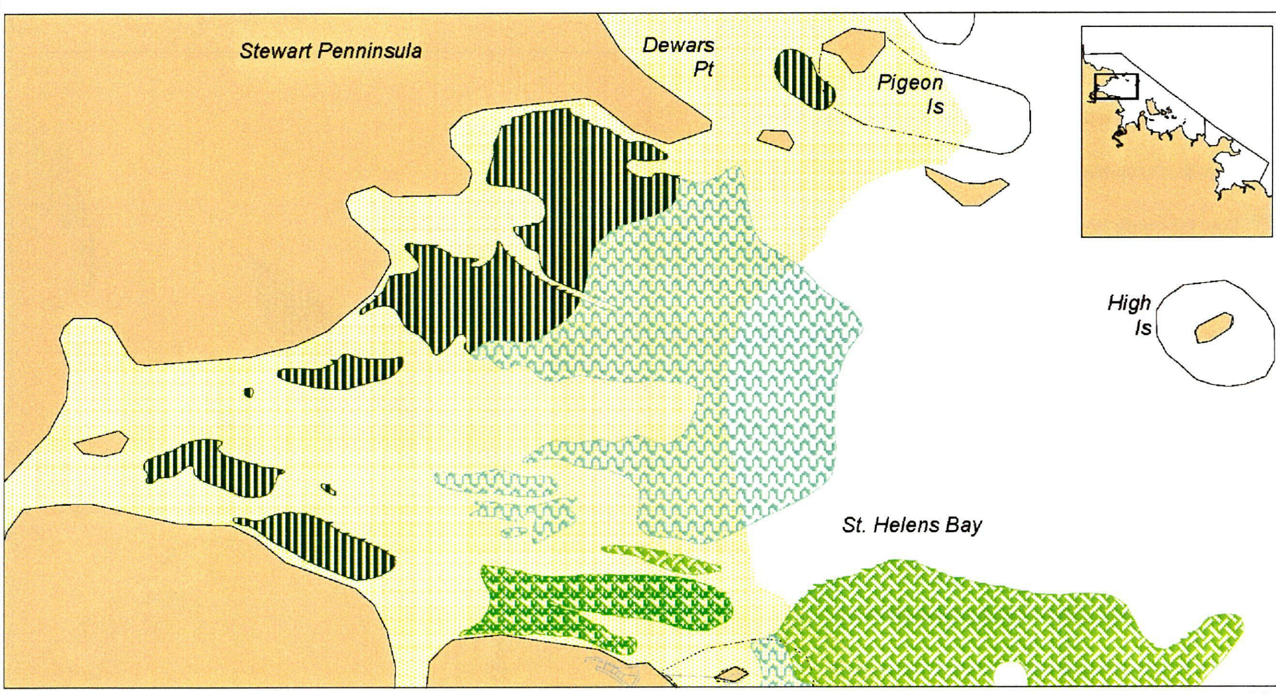
LEGEND

- Low biomass Halodule/Halophila/Zostera mixed
- Low biomass Halodule uninervis (narrow)
- Low biomass Halodule uninervis/Halophila ovalis
- Low biomass Zostera capricorni dominant
- Sandbanks



a. Stewart Penninsula

0 0.5 1
Kilometres



b. St. Helens Bay - North

0 1 2 N
Kilometres

Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resources of the Newry Region and Sand Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie, and C.A. Roder). Section 3, pp 51-84. (DPI, Cairns).
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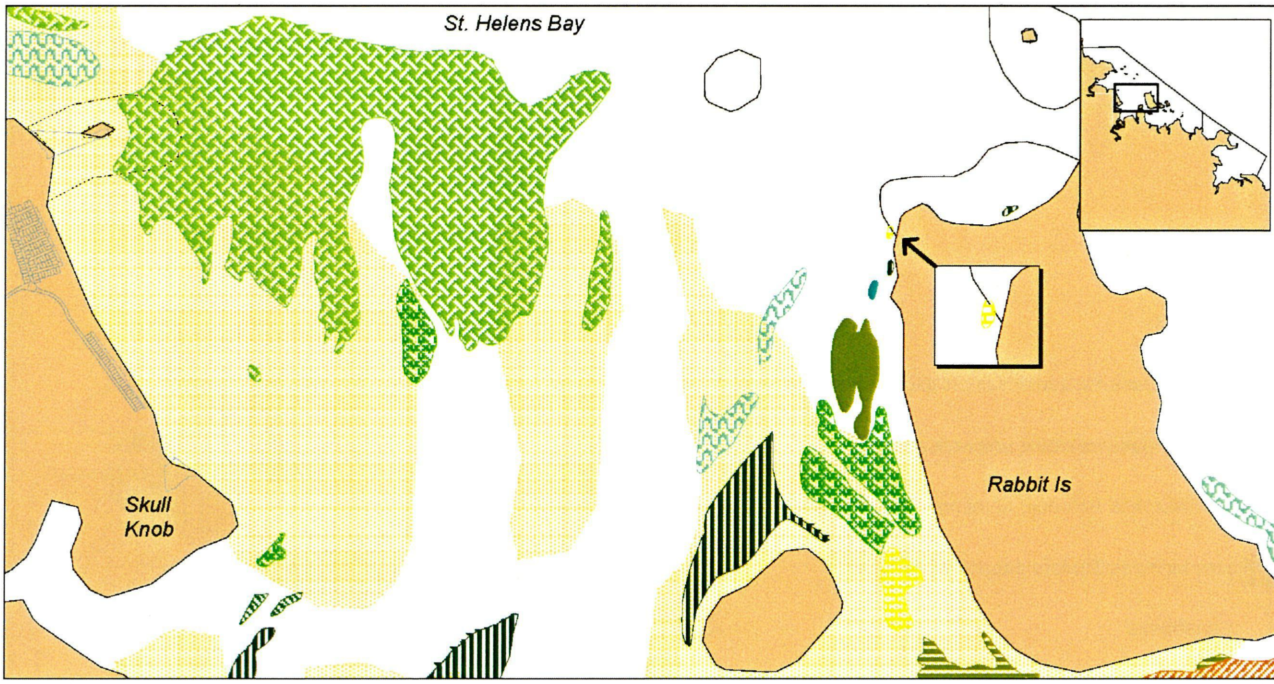
Produced by the Marine Plant Ecology Group, DPI, Northern Fisheries Centre, Cairns, 2001.

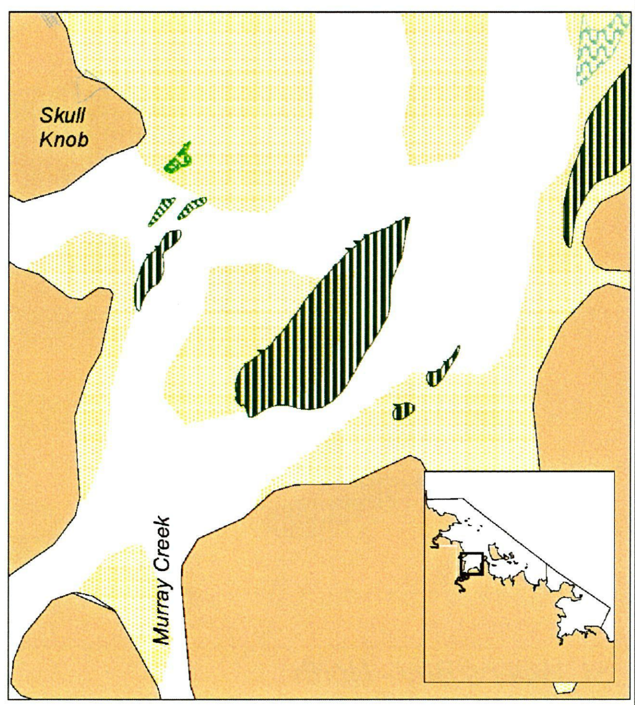
Map 3.8 Seagrass communities mapped in the Newry Region Dugong Protection Area - May 1999 (enlargements)



a. St. Helens Bay - South

LEGEND

- Low biomass Halodule/Halophila/Cymodocea mixed
- Low biomass Halophila ovalis
- Low biomass Halodule/Halophila/Zostera mixed
- Low biomass Zostera/Halophila/Halodule/Cymodocea mixed
- High biomass Zostera/Halophila/Halodule/Cymodocea mixed
- Low biomass Halodule uninervis (narrow)
- Low biomass Halodule uninervis (wide) dominant
- Low biomass Halodule uninervis/Halophila ovalis
- Low biomass Zostera capricorni dominant
- High biomass Zostera capricorni dominant
- High biomass Halophila spinulosa dominant
- Sandbanks



b. Murray Creek

Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resources of the Newry Region and Sand Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay Ince/Llewellyn Bays and the Clairview Region. April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder). Section 3, pp 51-84. (DPI, Cairns).
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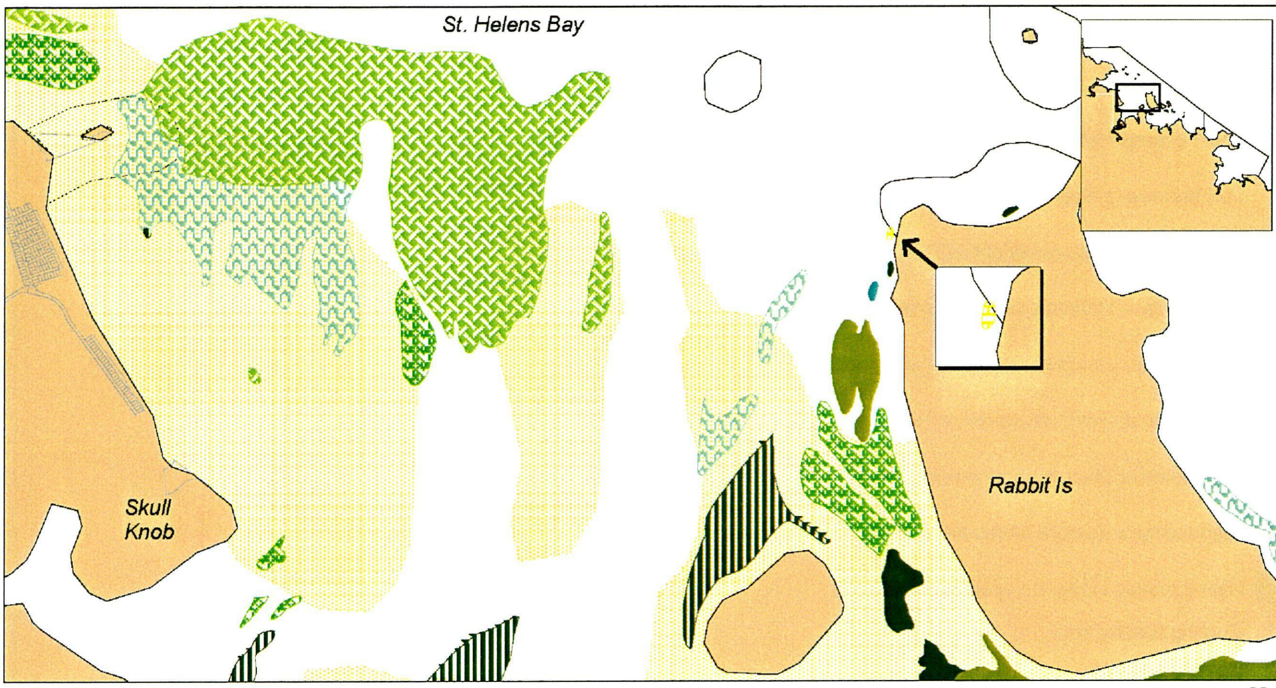
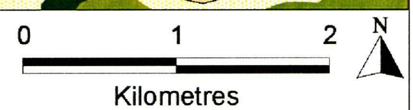
Map 3.9

Seagrass communities mapped in the Newry Region Dugong Protection Area - October 1999 (enlargements)

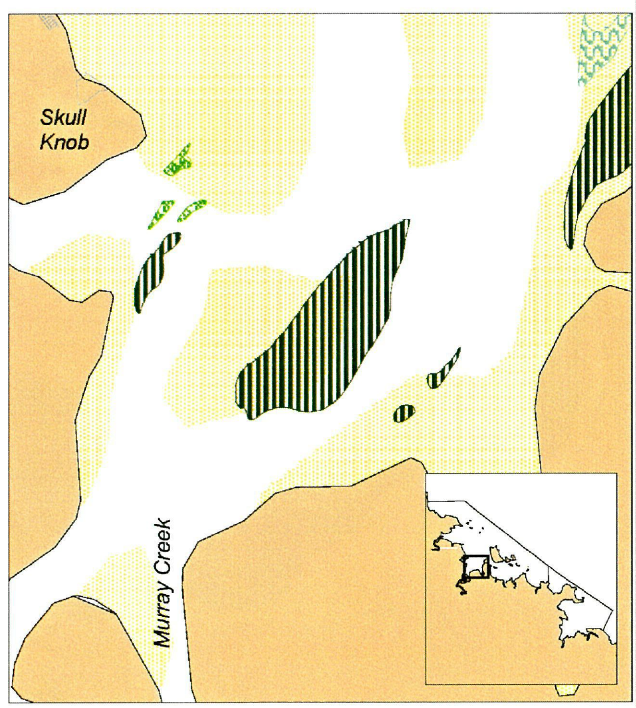


a. St. Helens Bay - South



LEGEND

- Low biomass Halophila ovalis
- Low biomass Halodule/Halophila/Zostera mixed
- High biomass Zostera/Halophila/Halodule/Cymodocea mixed
- Low biomass Halodule uninervis (narrow)
- Low biomass Halodule uninervis/Halophila ovalis
- Low biomass Zostera capricorni dominant
- High biomass Zostera capricorni dominant
- High biomass Halophila spinulosa dominant
- Sandbanks



b. Murray Creek

Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resources of the Newry Region and Sand Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay Ince/Llewellyn Bays and the Clairview Region. April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder). Section 3, pp 51-84. (DPI, Cairns).
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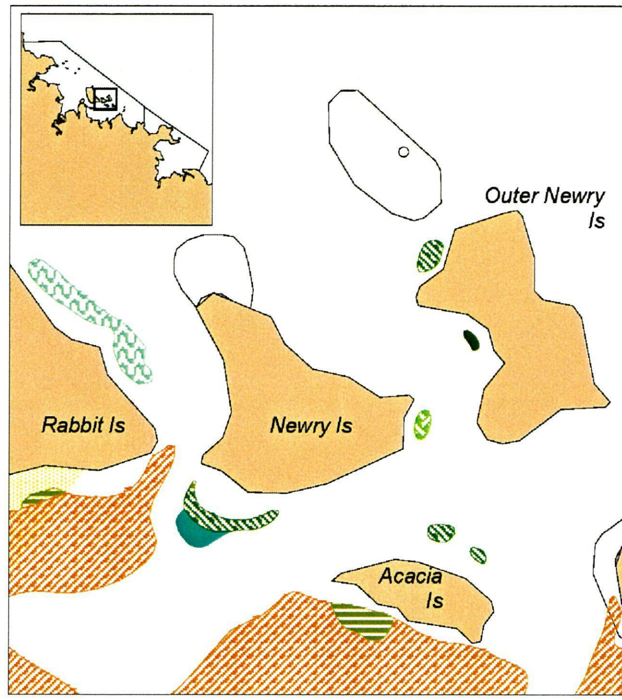
Map 3.10

Seagrass communities mapped in the Newry Region Dugong Protection Area - May 1999 (enlargements)

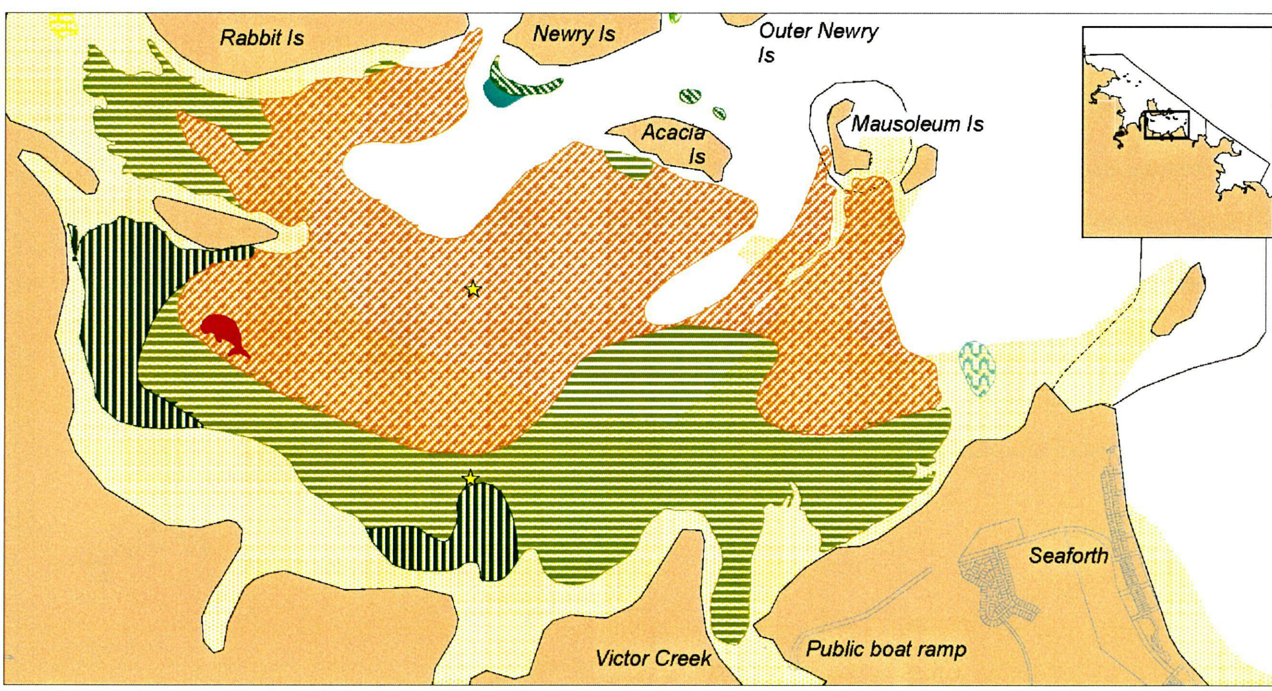
LEGEND

- Low biomass Halodule/Halophila/Cymodocea mixed
- Low biomass Halophila ovalis
- Low biomass Zostera/Halophila/Halodule/Cymodocea mixed
- Low biomass Halodule uninervis (narrow)
- Low biomass Halodule uninervis (wide) dominant
- Low biomass Halodule uninervis/Halophila ovalis
- Low biomass Zostera capricorni dominant
- High biomass Zostera capricorni dominant
- High biomass Halophila spinulosa dominant
- Dugong feeding trail
- Dugong sighted
- Sandbanks
- Beam trawl site



a. Newry Island Group

0 0.5 1
Kilometres



b. Port Newry

0 1 2
Kilometres

Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resource of the Newry Region and Sand Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay Ince/Llewellyn Bays and the Clairview Region. April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder). Section 3, pp 51-84. (DPI, Cairns).
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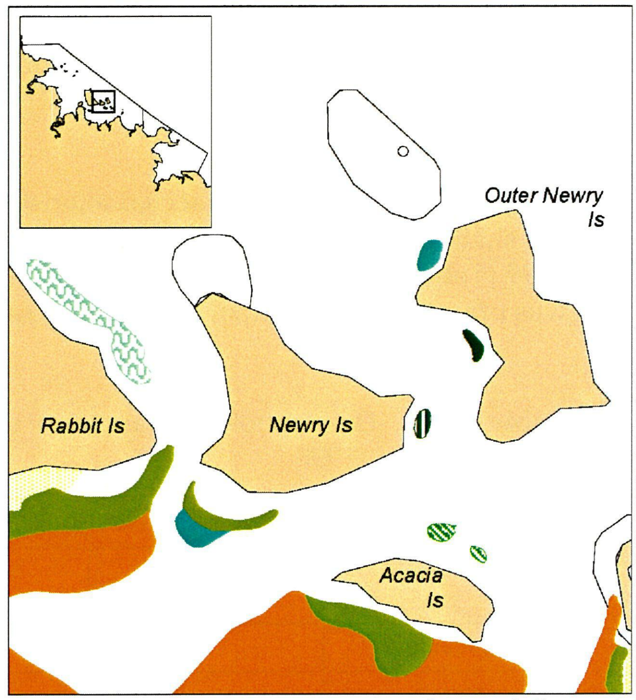
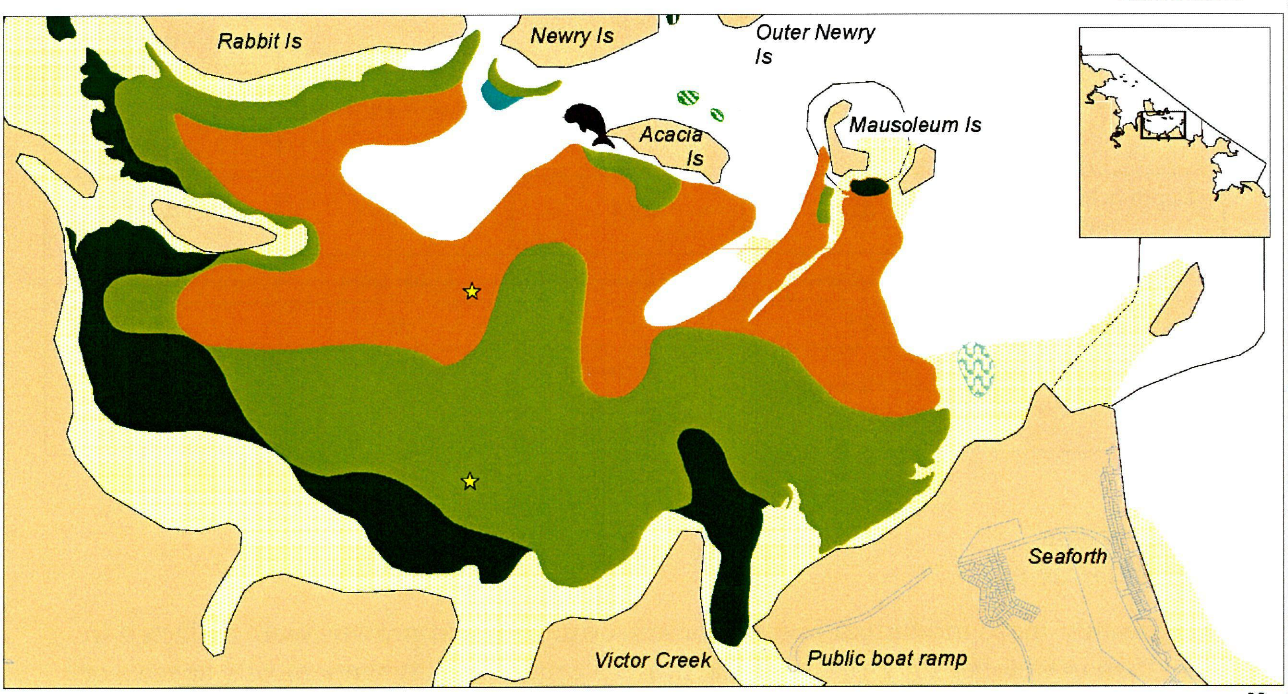
Map 3.11 Seagrass communities mapped in the Newry Region Dugong Protection Area - October 1999 (enlargements)

LEGEND

- High biomass Halodule/Halophila/Cymodocea mixed
- High biomass Zostera/Halophila/Halodule/Cymodocea mixed
- Low biomass Halodule uninervis (wide) dominant
- Low biomass Halodule uninervis/Halophila ovalis
- Low biomass Zostera capricorni dominant
- High biomass Zostera capricorni dominant
- High biomass Halophila spinulosa dominant
- Dugong feeding trail
- Dugong sighted
- Sandbanks
- Beam trawl site



a. Newry Island Group



b. Port Newry

Source: Roelofs, A.J. and Roder, C.A. (2001). Seagrass and Marine Resources of the Newry Region and Sand Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay Ince/Llewellyn Bays and the Clairview Region. April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder). Section 3, pp 51-84. (DPI, Cairns).
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Invertebrates and Fish
Description of Beam Trawl Sites

Beam trawl sites were chosen in two of the three main seagrass habitat types found in the region. One site was in a large continuous intertidal meadow (dominated by *Zostera capricorni*) and one in a shallow subtidal mixed-species meadow (Maps 3.10 & 3.11).

Seagrass biomass and habitat characteristics for the intertidal *Zostera/Halophila* site and the shallow subtidal *Halodule/Halophila* site were similar between May and October 1999 (Table 3.4). The same sites (within 50 m) were used in each survey. Algae cover was present at the subtidal *Halodule/Halophila* beam trawl site in May only.

Table 3.3. Description of beam trawl sites at Port Newry in May 1999 and October 1998.

Descriptors	May 1999		October 1999	
	Intertidal *Zostera/Halophila*	Subtidal *Halodule/Halophila*	Intertidal *Zostera/Halophila*	Subtidal *Halodule/Halophila*
Date sampled	19/05/1999		16/10/1999	
Mean biomass ± SE (g DW m^{-2})	12.87 ±4.27	16.61 ±6.26	19.41 ±7.38	13.45 ±8.61
Seagrass species present	*Zostera capricorni, Halophila ovalis*	*Halodule uninervis, Cymodocea serrulata, Halophila ovalis, Halophila spinulosa*	*Zostera capricorni, Halophila ovalis, Halodule uninervis*	*Halodule uninervis, Cymodocea serrulata, Halophila ovalis, Halophila spinulosa, Zostera capricorni*
Depth below MSL (m)	0.6	2.8	1.1	3.2
Sediment type	Mud/Sand	Mud/Sand/Shell	Mud/Sand	Mud/Sand/Shell
Mean algae % cover	2.5	15	0	2.5
Algae types	Miscellaneous Green	*Caulerpa* sp./Green filamentous		*Caulerpa* sp./Green filamentous

Invertebrates
Penaeid Prawns

Significantly more individual juvenile or sub-adult penaeid prawns were collected in May than in October 1999, however the prawns caught in May were mostly species of minor importance to fisheries (Table 3.5, Figure 3.4). Abundances of prawns were similar between intertidal Zostera/Halophila and sub-tidal Halodule/Halophila beam trawl sites between each sampling event, but the abundances of the commercially valuable species increased at both sites from May to October (Table 3.5, Figure 3.4).

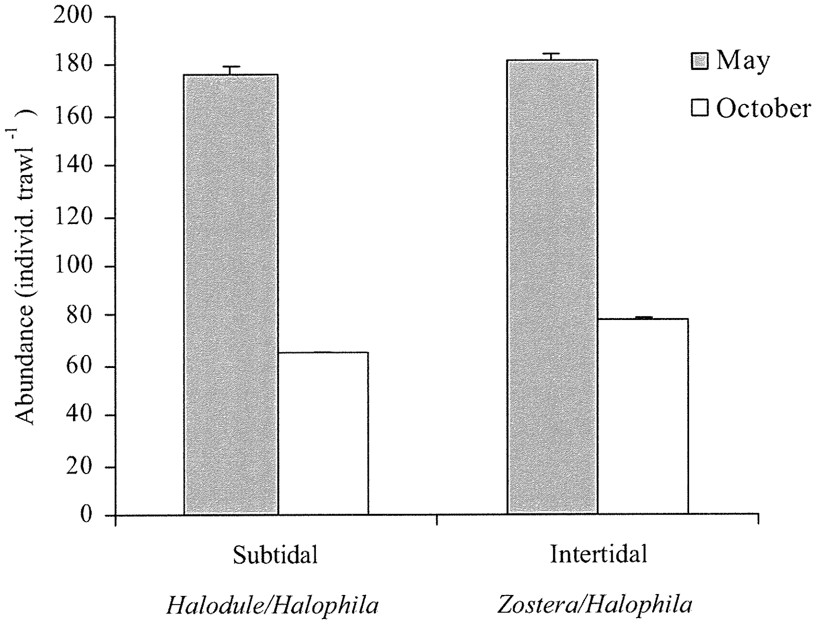


Figure 3.4. Abundance of penaeid prawns at each trawl site at Port Newry in May and October 1999 (*mean and standard error displayed*).

Prawns were generally larger in October than in May and commercially important species comprised a greater proportion of the catch in October. In October, larger juvenile and sub-adult endeavour (*Metapenaeus endeavouri*) and tiger prawns (*Penaeus esculentus* and *Penaeus semisulcatus*) dominated both the intertidal and subtidal sites (Table 3.5). In May, the subtidal site had mostly coral prawns (*Trachypenaeus* spp) (non-commercial) and the inter-tidal site had mostly commercially important prawn species (predominantly small *Metapenaeids*) (Table 3.5, Figure 3.5).

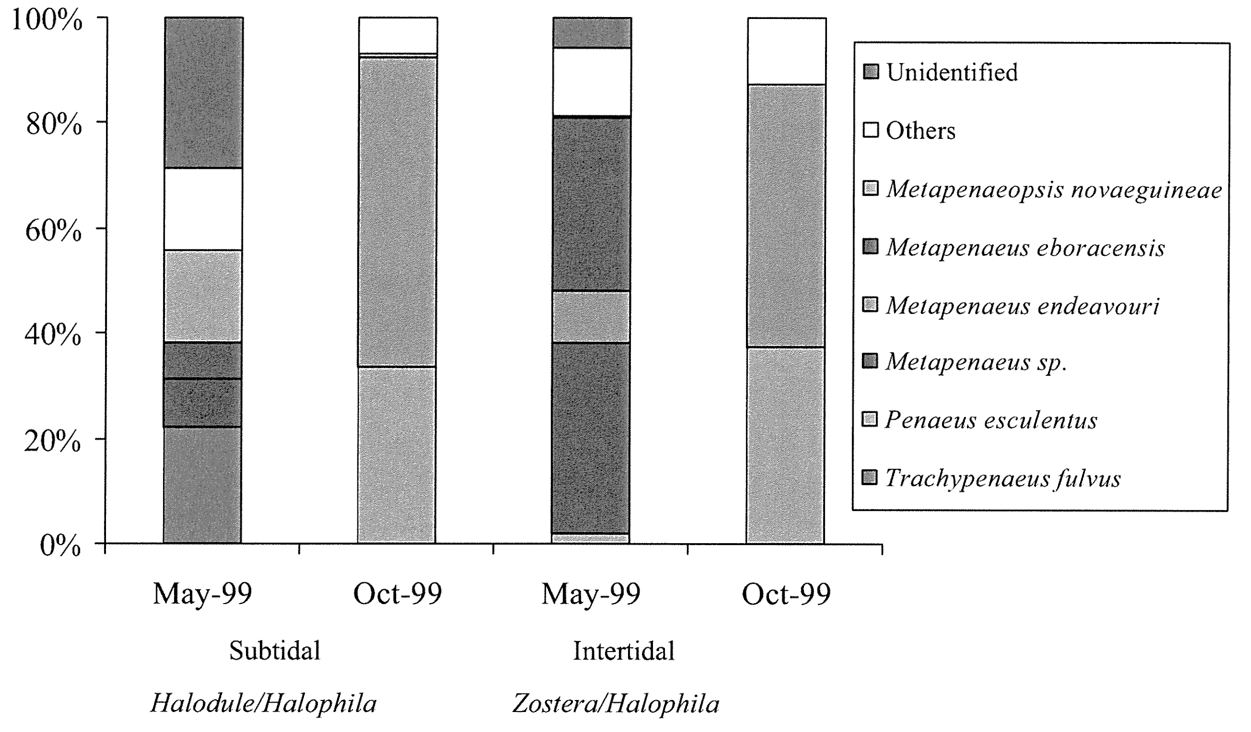
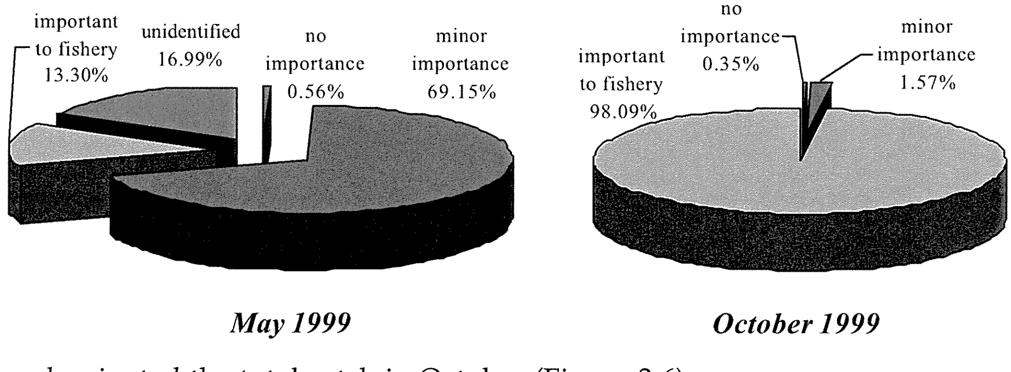


Figure 3.5. Percent species composition of penaeid prawns collected at each meadow in May and October 1999.

Prawn species richness was higher at the bean trawl sites in May than October. Species not caught in October included mainly velvet prawns (*Metapenaeopsis* spp.) and rough prawns (*Trachypenaeus* spp.) (Table 3.5). Three major commercial penaeid prawn species (brown tiger prawns, grooved tiger prawns and true endeavour prawns) were more abundant (both sites pooled) in October (96% of total catch) than in May (6% of total catch) (Table 3.5, Figure 3.6). Overall, commercially important penaeid prawn



species dominated the total catch in October (Figure 3.6).

Figure 3.6. Composition of fishery value for penaeid prawns collected from beam trawls in May and October 1999 (all meadows pooled).

Table 3.5 Species, fishery code, carapace length, abundance and biomass (g DW)* of penaeid prawn species collected by beam trawl from the Newry Region Dugong Protection Area - May and October 1999.

Value codes (from Coles et al. *1993): IV, important to north-eastern prawn fishery; III, component of fishery; II, minor to insignificant importance; I, no importance to fishery.*

** Biomass = all species pooled.*

Meadow	Species	Common name	Fishery code	May 1999			October 1999		
				mean CL (mm) ±SE (range)	*n* (%)	biomass*	mean CL (mm) ±SE (range)	*n* (%)	biomass*
Subtidal *Halodule/Halophila*	*Metapenaeopsis mogiensis*	-	I	3.43 ±0.13 (2.80 - 3.90)	8 (1.13)		3.00	1 (0.38)	
	Metapenaeopsis novaeguineae	Northern Velvet	II	5.18 ±0.12 (3.00 - 10.10)	123		8.95 ±2.05 (6.90 - 11.00)	2 (0.77)	
	Metapenaeopsis palmensis	Southern Velvet	II	6.85 ±0.15 (3.60 - 8.70)	37 (5.23)		*absent*	-	
	Metapenaeopsis sp.	-	-	5.03 ±0.59 (4.10 - 6.90)	6 (0.85)		*absent*	-	
	Metapenaeus bennettae	Greentail	II	8.20 ±0.89 (3.50 - 13.20)	11 (1.56)		12.30	1 (0.38)	
	Metapenaeus eboracensis	York prawn	II	5.06 ±0.11 (4.00 - 7.20)	50 (7.07)		*absent*	-	
	Metapenaeus endeavouri	True Endeavour	IV	*absent*	-		8.79 ±0.14 (5.60 - 13.20)	153	
	Metapenaeus sp.	-	II-IV	4.64 ±0.03 (3.50 - 4.70)	65 (9.19)		*absent*	-	
	Parapenaeopsis tenella	Smoothshell	II	5.40 ±0.25 (4.50 - 6.20)	6 (0.85)		*absent*	-	
	Penaeus esculentus	Brown Tiger	IV	*absent*	-		8.39 ±0.37 (2.40 - 18.50)	87 (33.46)	
	Penaeus latisulcatus	Western/Blue-leg	IV	*absent*	-		11.91 ±0.41 (10.20 - 15.10)	13 (5.00)	
	Penaeus semisulcatus/esculentus	Grooved/Brown Tiger	IV	*absent*	-		7.77 ±2.28 (3.50 - 11.30)	3 (1.15)	
	Penaeus sp.	-	II-IV	*absent*	-		*absent*	-	
	Trachypenaeus curvirostrus	Southern Rough	II	4.95 ±0.12 (3.80 - 7.00)	35 (4.95)		*absent*	-	
	Trachypenaeus fulvus	Brown Rough	II	5.53 ±0.09 (3.30 - 10.10)	156		*absent*	-	
	Trachypenaeus sp.	-	-	5.40 ±0.34 (4.50 - 6.30)	8 (1.13)		*absent*	-	
	Unidentified	-	-	-	202		*absent*	-	
TOTAL				**5.36 ±0.06 (2.80 - 13.20)**	**707 (100)**	**9.32**	**8.80 ±0.16 (2.40 - 18.50)**	**260 (100)**	**34.42**
Intertidal *Zostera/Halophila*	*Metapenaeopsis mogiensis*	-	I	*absent*	-		4.00	1 (0.32)	
	Metapenaeopsis novaeguineae	Northern Velvet	II	5.70	1 (0.14)		*absent*	-	
	Metapenaeopsis palmensis	Southern Velvet	II	*absent*	-		*absent*	-	
	Metapenaeopsis sp.	-	-	*absent*	-		*absent*	-	
	Metapenaeus bennettae	Greentail	II	6.44 ± 0.19 (4.20 - 9.70)	43 (5.90)		10.93 ±0.36 (10.00 - 12.20)	6 (1.90)	
	Metapenaeus eboracensis	York prawn	II	5.91 ±0.07 (4.10 - 10.20)	241		*absent*	-	
	Metapenaeus endeavouri	True Endeavour	IV	5.92 ±0.16 (3.30 - 9.30)	72 (9.88)		8.13 ±0.13 (2.30 - 13.40)	157	
	Metapenaeus sp.	-	II-IV	4.61 ±0.03 (3.80 - 5.00)	265		*absent*	-	
	Parapenaeopsis tenella	Smoothshell	II	*absent*	-		*absent*	-	
	Penaeus esculentus	Brown Tiger	IV	4.08 ±0.17 (3.20 - 5.00)	13 (1.78)		7.63 ±0.30 (2.00 - 18.00)	118	
	Penaeus latisulcatus	Western/Blue-leg	IV	6.78 ±0.19 (4.60 - 9.90)	38 (5.21)		12.00	1 (0.32)	
	Penaeus semisulcatus/esculentus	Grooved/Brown Tiger	IV	*absent*	-		6.72 ±0.65 (1.80 - 12.90)	32 (10.16)	
	Penaeus sp.	-	II-IV	7.03 ±0.27 (3.50 - 7.30)	14 (1.92)		*absent*	-	
	Trachypenaeus curvirostrus	Southern Rough	II	*absent*	-		*absent*	-	
	Trachypenaeus fulvus	Brown Rough	II	*absent*	-		*absent*	-	
	Trachypenaeus sp.	-	-	*absent*	-		*absent*	-	
	Unidentified	-	-	-	42 (5.76)		*absent*	-	
TOTAL				**5.48 ±0.05 (3.20 - 10.20)**	**729 (100)**	**13.69**	**7.85 ±0.15 (1.80 - 18.00)**	**315 (100)**	**29.81**

Other invertebrates

Other invertebrates collected by beam trawling included crabs (e.g., blue swimmer/sand crabs), miscellaneous crustaceans (caridean shrimps, stomatopods, isopods, other crabs (spider and hermit crabs)), and miscellaneous other faunal groups (molluscs, octopus, asteroids (starfish), ophiuroids (brittle stars), holothurians (sea cucumbers), sepiolids (cuttlefish), opisthobranchs (bubble shells and sea hares), and polychaete worms). Crabs were more prominent in the beam trawl biomass (g DW) in October at both the intertidal (*Zostera/Halophila)* and the subtidal (*Halodule/Halophila)* sites (Figure 3.7). The percent composition of biomass of miscellaneous other invertebrates were also greatest in October due to a small number of large individual holothurians and sea hares in the catch.

The total biomass of invertebrate at intertidal and subtidal sites was lower in May than in October 1999 (May, 38.3 and 15.3 g DW; October, 272.1 and 157.8 g DW respectively). Penaeid prawns contributed more to the invertebrate beam trawl biomass in May compared to October. Miscellaneous crustaceans were more abundant in October than in May and caridean shrimps dominated this category at both sites in both surveys.

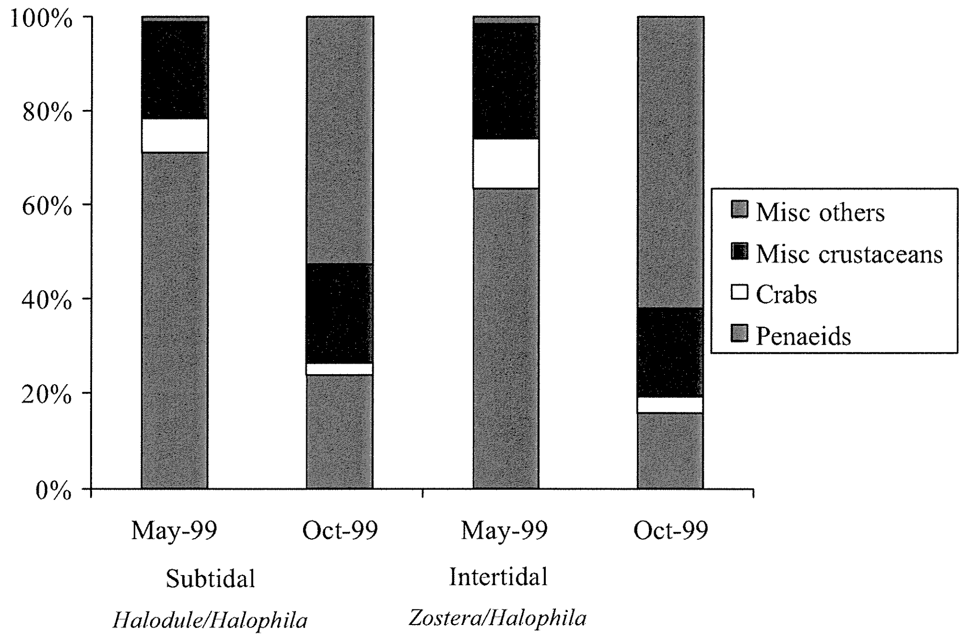


Figure 3.7. Percent composition of invertebrate groups to the total biomass (g DW) at each beam trawl site in May and October 1999.

Fish

The majority of fish species caught by beam trawl at Port Newry in May and October are known resident species within seagrass meadows. Intertidal *Zostera/Halophila* beam trawl catches contributed the most to fish abundance in both surveys (Table 3.6). The most abundant fish species at both sites in May and October were the goby, *Glossogobius circumspectus*, and the striped trumpeter, *Pelates quadrilineatus* respectively (Table 3.6). The subtidal *Halodule/Halophila* site had very low abundances of fish in May 1999 compared to the intertidal site (Figure 3.8).

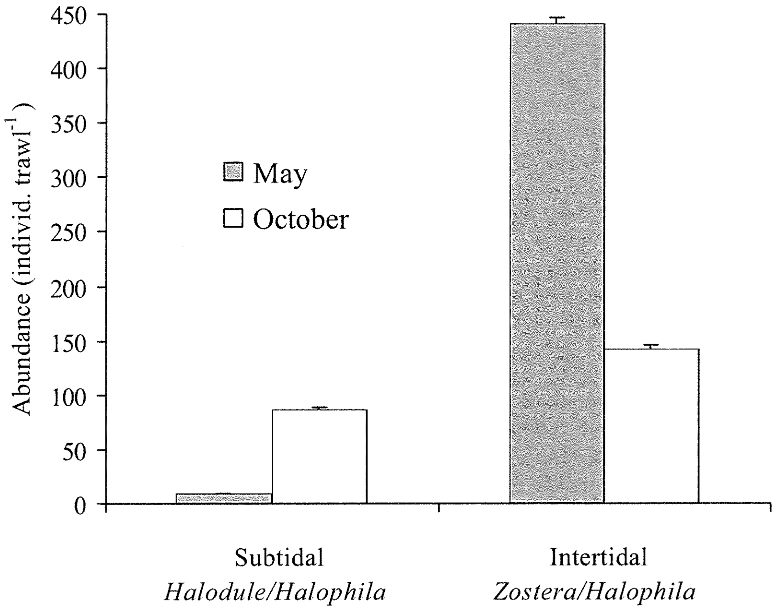


Figure 3.8. Abundance of fish at each trawl site at Port Newry in May 1999 and October 1999 (*mean and standard error displayed*).

Fish at both sites were generally smaller in May compared with October (Table 3.6). Gobies (Family Gobiidae) were the most abundant fish family in May, comprising 96% of the total catches (all sites pooled). It was only a minor component in October (3%) (Figure 3.9).

Fish species richness was greatest in October with 17 species from 16 families found at the subtidal *Halodule/Halophila* site and 20 species from 19 families at the intertidal *Zostera/Halophila* site (Table 3.6). The greater number of species in October was mostly from small juveniles of predatory fish species (cardinal fish, wrasse, scorpion fish, trumpeter, and flathead) and benthic feeders (pipefish and leatherjackets). In May, the number of fish species was similar between the intertidal and shallow subtidal sites.

Table 3.6 Taxa, value codes, size data, abundance and biomass (g DW)* for fish collected by beam trawl from an intertidal *Zostera/Halophila* site and a subtidal *Halodule/Halophila* site within the Newry Region Dugong Protection Area - May and October 1999.

Value codes (from Coles et al.1993): A, targeted aquarium species; a, incidental aquarium species; b, incidental baitfish species; C, targeted commercial species; c , incidental commercial species; R, targeted recreational species; r, incidental recreational species.

** Biomass = all taxa pooled in May 1999.*

Meadow	Family	Species	Common name	Fishery code	May 1999			October 1999		
					mean SL (mm) ±SE (range)	n (%)	biomass*	mean SL (mm) ±SE (range)	n (%)	biomass*
Subtidal *Halodule/ Halophila*	Anguillidae	*Anguilla reinhardti*	Long-finned eel	C	absent	-		absent	-	-
	Apogonidae	*Gronovichthys atripes*	Cardinalfish	a	absent	-		18.07 ±0.55 (14.00 - 26.20)	33 (9.48)	1.43
	Blenniidae	*Blenniidae* sp. A	Blenny	br	absent	-		47.83 ±9.82 (28.40 - 60.00)	3 (0.86)	1.48
	Bothidae	*Bothidae* sp. A	Flounder	-	46.8	1 (2.86)		31.20 ±10.30 (20.90 - 41.50)	2 (0.58)	0.25
	Callionymidae	*Callionymidae* sp. A	Dragonet	A	9.65 ±0.25 (9.40 - 9.90)	2 (5.71)		absent	-	-
	Cynoglossidae	*Cynoglossidae* sp. A	Tongue-sole	a	40.8	1 (2.86)		absent	-	-
	Engraulidae	*Stolephorus indicus*	Anchovy	-	50.2	1 (2.86)		absent	-	-
	Engraulidae	*Stolephorus* sp. A	Anchovy	-	19.18 ±10.48 (8.70 - 50.60)	4 (11.43)		22.94 ±0.31 (22.30 - 24.00)	5 (1.44)	0.09
	Gerreidae	*Gerreidae* sp. A	Mojarra	b	absent	-		absent	-	-
	Gobiidae	*Exyrias puntang*	Goby	A	31	1 (2.86)		absent	-	-
	Gobiidae	*Glossogobius biocellatus*	Mangrove goby	-	absent	-		29.94 ±1.63 (18.90 - 35.00)	11 (3.16)	1.79
	Gobiidae	*Glossogobius circumspectus*	Goby	-	12.11 ±0.59 (7.20 - 17.10)	17 (48.57)		11.4	1 (0.29)	0.001
	Gobiidae	*Gobiidae* sp. A	Goby	-	absent	-		absent	-	-
	Haemulidae	*Pomadasys kaakan*	Golden grunter	cR	absent	-		15.1	1 (0.29)	0.001
	Hemiramphidae	*Hyporhamphus ardelio*	Garfish	-	absent	-		absent	-	-
	Labridae	*Labridae* sp. A	Wrasse	a	absent	-		23.21 ±1.73 (10.00 - 49.90)	28 (8.05)	2.94
	Leiognathidae	*Leiognathus* sp. A	Ponyfish	-	40	1 (2.86)		absent	-	-
	Lethrinidae	*Lethrinus* sp. A	Sweetlip	c?	absent	-		absent	-	-
	Monacanthidae	*Monacanthidae* sp. A	Leatherjacket	a	absent	-		18.29 ±1.11 (9.60 - 35.70)	31 (8.91)	1.75
	Mullidae	*Mullidae* sp. A	Goatfish	a	absent	-		30.40 ±0.40 (30.00 - 30.80)	2 (0.58)	0.09
	Platycephalidae	*Platycephalidae* sp. A	Flathead	?	27.97 ±8.67 (11.00 - 52.20)	4 (11.43)		38.00 ±6.38 (9.50 - 51.70)	7 (2.01)	1.281
	Scorpaenidae	*Paracentropogon* sp. A	Scorpionfish	A	6.8	1 (2.86)		20.63 ±0.92 (15.20 - 32.30)	19 (5.46)	1.14
	Siganidae	*Siganidae* sp. A	Spinefoot	ac	absent	-		20.75 ±0.45 (20.30 - 21.20)	2 (0.58)	0.04
	Siganidae	*Siganus guttatus*	Golden spinefoot	ac	absent	-		20.73 ±0.38 (19.70 - 22.10)	7 (2.01)	0.16
	Sillaginidae	*Sillago* sp. A	Whiting	cr	absent	-		15.1	1 (0.29)	0.001
	Syngnathidae	*Hippichthys heptagonus*	Pipefish	A	absent	-		54.25 ±4.32 (34.50 - 98.80)	16 (4.60)	0.5
	Teraponidae	*Pelates quadrilineatus*	Trumpeter	-	absent	-		28.16 ±0.62 (11.80 - 45.00)	179 (51.44)	20.42
	Tetraodontidae	*Tetraodontidae* sp. A	Toadfish	a	7.4	1 (2.86)		absent	-	-
	Triacanthidae	*Tripodichthys angustifrons*	Triplespine	-	21.8	1 (2.86)		absent	-	-
	Triglidae	*Parapegasus natans*	Gurnard	-	absent	-		absent	-	-
TOTAL					**18.82 ±2.38 (6.80 - 52.20)**	**35 (100)**	**2.2**	**26.78 ±0.61 (9.50 - 98.80)**	**348 (100)**	**33.364**

Table 3.6 continued

Meadow	Family	Species	Common name	Fishery code	May 1999 mean SL (mm) ±SE (range)	May 1999 n (%)	May 1999 biomass*	October 1999 mean SL (mm) ±SE (range)	October 1999 n (%)	October 1999 biomass*
Intertidal *Zostera/ Halophila*	Anguillidae	*Anguilla reinhardti*	Long-finned eel	C	absent	-		129.9	1 (0.20)	0.25
	Apogonidae	*Gronovichthys atripes*	Cardinalfish	a	absent	-		17.89 ±0.45 (11.10 - 33.30)	63 (12.63)	3.04
	Blenniidae	*Blenniidae* sp. A	Blenny	br	absent	-		absent	-	-
	Bothidae	*Bothidae* sp. A	Flounder	-	absent	-		44.47 ±3.31 (38.00 - 48.90)	3 (0.60)	1
	Callionymidae	*Callionymidae* sp. A	Dragonet	A	10.4	1 (0.06)		absent	-	-
	Cynoglossidae	*Cynoglossidae* sp. A	Tongue-sole	a	absent	-		absent	-	-
	Engraulidae	*Stolephorus indicus*	Anchovy	-	51.8	1 (0.06)		absent	-	-
	Engraulidae	*Stolephorus* sp. A	Anchovy	-	absent	-		20.36 ±0.43 (9.80 - 27.20)	82 (16.43)	0.66
	Gerreidae	*Gerreidae* sp. A	Mojarra	b	13.41 ±0.21 (11.00 - 17.60)	32 (1.81)		12	1 (0.20)	0.01
	Gobiidae	*Exyrias puntang*	Goby	A	26.29 ±1.63 (12.40 - 37.30)	16 (0.91)		absent	-	-
	Gobiidae	*Glossogobius biocellatus*	Mangrove goby	-	21.86 ±0.49 (13.10 - 25.30)	32 (1.81)		32.14 ±1.06 (25.50 - 36.10)	10 (2.00)	1.41
	Gobiidae	*Glossogobius circumspectus*	Goby	-	13.61 ±0.07 (7.10 - 25.00)	1667 (94.39)		23.2	1 (0.20)	0.03
	Gobiidae	*Gobiidae* sp. A	Goby	-	10.45 ±0.15 (10.30 - 10.60)	2 (0.11)		absent	-	-
	Haemulidae	*Pomadasys kaakan*	Golden grunter	cR	absent	-		absent	-	-
	Hemiramphidae	*Hyporhamphus ardelio*	Garfish	-	absent	-		56.9	1 (0.20)	0.13
	Labridae	*Labridae* sp. A	Wrasse	a	absent	-		25.03 ±1.68 (9.70 - 37.70)	23 (4.61)	2.81
	Leiognathidae	*Leiognathus* sp. A	Ponyfish	-	absent	-		absent	-	-
	Lethrinidae	*Lethrinus* sp. A	Sweetlip	c?	absent	-		39.8	1 (0.20)	0.29
	Monacanthidae	*Monacanthidae* sp. A	Leatherjacket	a	absent	-		19.52 ±1.43 (9.50 - 59.40)	49 (9.82)	6.67
	Mullidae	*Mullidae* sp. A	Goatfish	a	absent	-		29	1 (0.20)	0.07
	Platycephalidae	*Platycephalidae* sp. A	Flathead	?	absent	-		48.98 ±3.82 (25.60 - 60.00)	8 (1.60)	2.57
	Scorpaenidae	*Paracentropogon* sp. A	Scorpionfish	A	absent	-		20.76 ±1.48 (11.50 - 29.10)	12 (2.40)	0.82
	Siganidae	*Siganidae* sp. A	Spinefoot	ac	absent	-		20.7	1 (0.20)	0.02
	Siganidae	*Siganus guttatus*	Golden spinefoot	ac	absent	-		27.15 ±4.79 (21.80 - 41.50)	4 (0.80)	0.46
	Sillaginidae	*Sillago* sp. A	Whiting	cr	15.47 ±1.14 (12.00 - 22.10)	11 (0.62)		absent	-	-
	Syngnathidae	*Hippichthys heptagonus*	Pipefish	A	59.70 ±10.90 (48.80 - 70.60)	2 (0.11)		52.19 ±3.54 (35.00 - 99.00)	21 (4.21)	0.47
	Teraponidae	*Pelates quadrilineatus*	Trumpeter	-	14.35 ±0.55 (13.80 - 14.90)	2 (0.11)		36.80 ±0.71 (11.00 - 63.10)	208 (41.68)	60.46
	Tetraodontidae	*Tetraodontidae* sp. A	Toadfish	a	absent	-		9.03 ±0.71 (7.00 - 11.50)	7 (1.40)	0.08
	Triacanthidae	*Tripodichthys angustifrons*	Triplespine	-	absent	-		absent	-	-
	Triglidae	*Parapegasus natans*	Gurnard	-	absent	-		53.00 ±4.50 (48.50 - 57.50)	2 (0.40)	0.28
TOTAL					**13.95 ±0.09 (7.10 - 70.60)**	**1766 (100)**	**16.77**	**29.59 ±0.63 (7.00 - 129.90)**	**499 (100)**	**81.53**

The majority of fish species collected were of no direct value to either the commercial or recreational fishery (Figure 3.10, Table 3.6). The only targeted commercial fish species collected in beam trawls from both sites and survey dates was the long-finned eel, *Anguilla reinhardti,* and only one individual was caught at the inshore site in October 1999 (Table 3.6). Commercial fish species overall comprised only a minor percentage of the catches overall, ranging from 2.0% in May to 37.9% in October 1999 (all sites pooled)(Figure 3.10). Most commercially important fish species were those that have some importance to the aquarium industry.

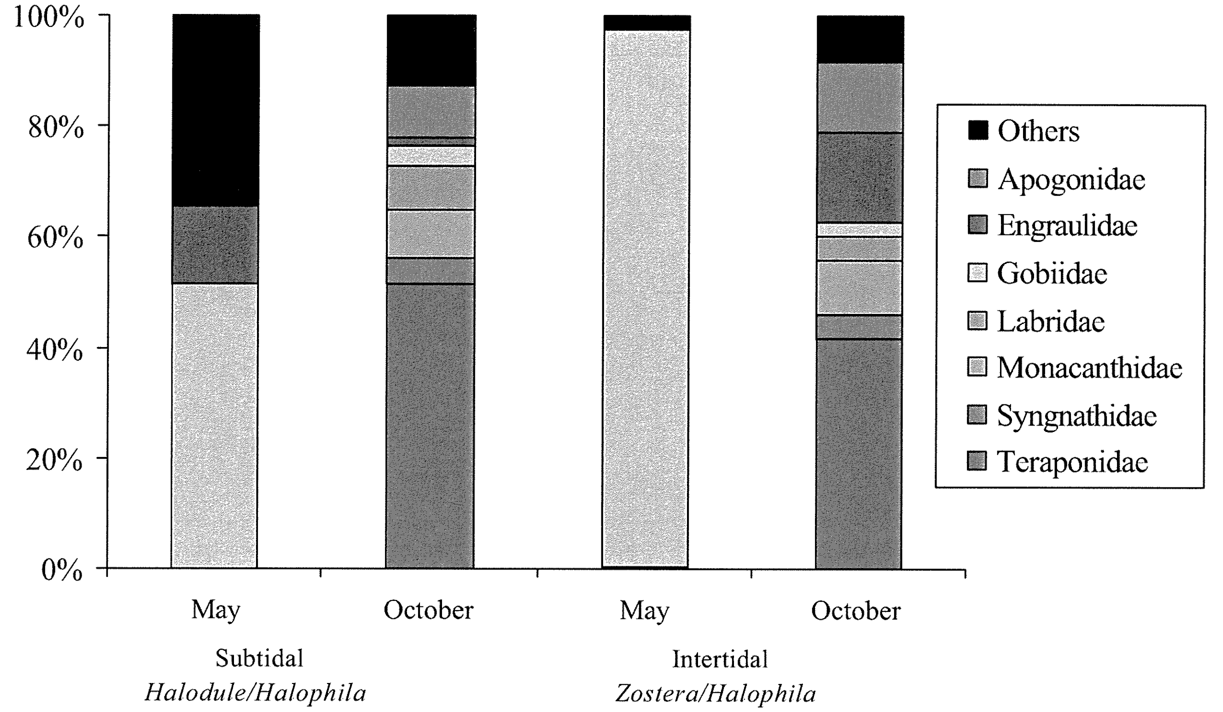


Figure 3.9. Percent composition of each family of fish collected at each beam trawl site in May 1999 and October 1999.

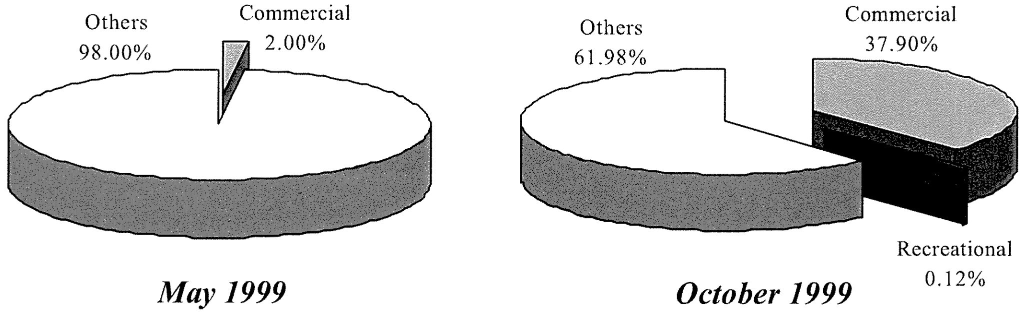


Figure 3.10. Composition of fishery value for fish collected from beam trawls in May 1999 and October 1999 (all sites pooled).

Dugong, Sea Turtles and Dolphins

No dugong were sighted during the May 1999 survey although feeding trails were found in a *Zostera capricorni* (narrow leaf morph) and *Halophila ovalis* meadow in the northern section of Port Newry (Map 3.10). Two dugong were sighted during the October 1999 survey travelling close to Newry and Acacia Islands (Maps 3.11), although no feeding trails were observed in the October dive survey.

Approximately 25 green turtles were seen throughout the study region on both surveys.

Dolphins were seen on several occasions during both surveys near the mother vessel anchorage at Mausoleum Island and Newry Island.

DISCUSSION

Seagrass

No seagrass was found in the Sand Bay DPA in either survey. Sand Bay is comprised of extensive shallow sand banks and is exposed to strong south easterly trade winds. The habitat has highly mobile sandy sediments, strong water currents and wave action, and long exposure times during low tides, and it may be difficult for seagrass to establish and maintain growth. No seagrass was found in Sand Bay during the 1987 broad scale survey either (Coles *et al.* 1987a), and anecdotal evidence suggest there has never been substantial quantities of seagrass in the region (S. Fisher, QPWS. Pers. Comm.). Despite this, pioneering seagrasses such as *Halophila ovalis* and *Halodule uninervis* could grow here in limited quantities. These species occurred in exposed areas of Llewellyn Bay during this survey (see Section 4.0).

Port Newry and St. Helens Bay support diverse and extensive seagrass meadows. The present study mapped nearly 2000 hectares more seagrass habitat than the broad scale surveys by QDPI in 1987 (Coles *et al.* 1987a). Tidal conditions limited the 1987 survey and the large exposed sand and mud banks probably supported more seagrass habitat than was mapped.

The area of seagrass habitat mapped in the Newry region was similar in May and October 1999, however mean above-ground seagrass biomass almost doubled between survey times. Increases in biomass of *Zostera capricorni* dominated meadows and *Halodule/Halophila/Cymodocea* meadows in Port Newry from May to October contributed to most of this overall biomass increase. Large seasonal fluctuations in seagrass biomass are not unusual for these species (Lee Long *et al.* 1997, McKenzie 1994, McKenzie *et al.* 1998) and the variations recorded in the present study fall within known biomass ranges. Small changes in meadow area are also not unusual for *Zostera capricorni* dominated meadows (McKenzie *et al.* 1998).

The total area of low biomass *Halodule uninervis/Halophila ovalis* meadows in St. Helens Bay changed little between the May and October 1999 surveys. These species are known to be seasonally highly variable in their distribution and biomass in Queensland tropical waters (Lee Long *et al.* 1999, McKenzie *et al.* 1998, QDPI 2000). The outer edges of meadows in the St. Helens Bay region could not be mapped accurately enough in each survey to discern small changes in meadow area.

Seagrass distribution in the Newry region DPA extended from around mean sea level to shallow subtidal depths for most of the region. *Cymodocea serrulata, Halophila spinulosa, Halophila ovalis* and *Halodule uninervis* also extended into subtidal parts of Port Newry and St. Helens Bay. Seagrasses were found in the same general locations as the 1987 broad scale survey (Coles *et al.* 1987a, Lee Long *et al.* 1993). Port Newry seagrass habitat was also particularly species rich with up to six seagrass species found at a site.

No seagrass was found in the deeper (>10m) offshore waters during this study. The deep water sites had highly mobile mud/sand sediments that is easily resuspended in the light to moderate winds (15–25 knots) experienced during the surveys. This caused increased turbidity, and reduced the light and visibility at the sea floor to nil. Deep water surveys (>15 m) by QDPI found seagrasses were sparse south of Mackay where tidal velocities were high (tidal range 4-6m) (Coles *et al.* 2000). The tidal range in the Newry region is approximately 5m and the area is relatively shallow at about 8 to 15 m. Moderate tidal velocities and wave action would quickly disturb the region's muddy-sand sediments making it sometimes difficult for seagrass survival. *Halophila* species such as *H. ovalis* and *H. decipiens*, however, could grow here at times. These plants are colonisers and have seasonal growth habits; quickly growing from seed stock to mature plants, flowering and fruiting, then dying back all within a 6 month period (Birch and Birch 1984, McKenzie *et al.* 1996, 1998).

Seagrass depth ranges in the survey region were small (maximum depth = 5.5 m below MSL). These are within known ranges of most Queensland coastal localities north of Hervey Bay (Coles *et al.* 1987a, Lee Long *et al.* 1997, 1998), although they are most similar to those of Shoalwater Bay. The maximum depth distribution of Newry region seagrasses species is not as deep when compared to other regions. The Newry region was found to be mostly shallow (<6m below MSL) and deeper areas were usually heavily scoured by tidal currents and contained coarse sediments.

Prawns and Fish

Newry region seagrass habitats are regionally important as nursery areas to commercial prawn fisheries. Small juvenile endeavour and tiger prawns were present at the intertidal site in May 1999 and juvenile and sub-adult prawns dominated intertidal and shallow subtidal samples in October. This pattern suggests endeavour and tiger prawns recruit into intertidal seagrass habitat areas in Port Newry early in the year and post larvae grow to juvenile and sub-adult prawns in the intertidal and the shallow subtidal seagrass habitat between May and October.

Prawn catch abundances at the intertidal *Zostera/Halophila* and the subtidal *Halodule/Halophila* sites were similar from May to October although the suite of species differed. Prawns from the genus *Metapenaeopsis* (coral and velvet prawns) were absent from the intertidal *Zostera/Halophila* site but were caught at the subtidal *Halodule/Halophila* site. This pattern was similar to the 1996 Shoalwater Bay study which found *Metapenaeopsis* spp. were absent from *Zostera capricorni* dominated beam trawl sites (Lee Long *et al.* 1997).

More prawns of low commercial value were caught at Port Newry in May compared to October 1999, but more juveniles of commercially valuable species were caught in October. Coles *et al.* (1993) and Watson *et al.* (1993) found for Queensland's tropical east coast that the life history of the major commercial prawns species included post-larvae settlement late in summer. The present study indicates that the period of post-larvae settlement of commercially important species in this region may extend outside the summer period documented for more northern regions.

There is a significant commercial beam trawl fishery for banana prawns in the Newry/St. Helen region. This species was not caught in our small mesh beam trawls. Banana prawns are commonly found on bare muddy sediments adjacent to mangrove areas and are typically absent from beam trawls over seagrass beds in tropical Australia (Coles *et. al.* 1987b).

The suite of prawn species collected at Port Newry is similar to beam trawl catches of juvenile prawns caught here by Coles et al. (1987b), and includes most of the species found in seagrasses at other locations along the Queensland East Coast (Cairns - Coles *et al.* 1993; Shoalwater Bay - Lee Long *et al.* 1997; Mourilyan Harbour - McKenzie *et al.* 1996; Oyster Point - Lee Long *et al.* 1999).

High abundances of juvenile fish indicate the importance of Port Newry seagrass meadows as nursery areas. The abundance of other invertebrates also indicates the high productivity of the habitat. Seagrass meadows are known to provide protection from predators and a food source to juvenile and adult fish species (Baron *et al.* 1993, Rooker *et al.* 1998), and are typically more species rich than adjacent bare sand and mud areas (Gray *et al.* 1996).

Fish species diversity at both beam trawl sites at Port Newry increased from May to October, however seagrass abundance remained similar over the same period. Most of the fish species caught are known resident species within seagrass meadows and, in the Cairns region, are known to recruit from late summer to Spring (QDPI, unpublished data). The increase in average size of fish caught from May to October suggests most of the recruitment at Port Newry occurred in the Autumn to Winter months. The increase in fish species number from May to October in Port Newry is possibly due to the natural variability of resident fish populations within the area, more than the seasonal variability in seagrass habitat.

Port Newry seagrass habitat does not appear to support substantial abundances of juveniles of commercial fish species apart from some incidental aquarium fish species. Beam trawling, however, only catches a sub set of the total fish community. Larger, fast swimming fish tend to escape capture (McKenzie *et al.* 1996) and are usually missed by beam trawls.

Dugong

Low biomass *Halophila ovalis, Halodule uninervis* (wide leaf morph) and *Zostera capricorni* (narrow with some wide leaf morph) dominated the upper tidal reaches of the Newry region DPA. These seagrass species are preferred food for dugong (Preen 1995, Lee Long *et al.* 1997). Feeding trails were observed in Port Newry in May 1999 predominantly in foreshore areas where the preferred seagrass species were found. Shallow subtidal meadows in Port Newry also contain seagrass species that are potential food for dugong (*Halophila ovalis* and *Halophila spinulosa*) and these may provide a food resource during low tides when access to the intertidal banks is limited. Although the threat to dugong from fishing nets in the Newry region has been removed by the management measures of the 'A' level DPA, the high level of boat traffic in Port Newry still poses a potential threat to dugong through boat strikes and disturbance to feeding. Areas adjacent to the main boat channel in Port Newry contain prime feeding habitat for dugong. The implementation of education and awareness programs for recreational boat users in the Newry region on dugong and ways to minimise impacts of boat traffic may be appropriate.

Lack of seagrass habitat in Sand Bay does not rule out dugong using the Sand Bay area. Official sightings and carcass records up to 1997 indicate three dugong had been sighted and one dugong carcass recovered in the Sand Bay DPA (GBRMPA 1997). A QPWS aerial survey in May 2000 found no dugong in Sand Bay and at least three dugong in Port Newry (S. Fisher, QPWS, Pers. Comm.).

No seagrass habitat suitable for dugong feeding was found inside the creeks and rivers within the study region and dugong are unlikely to use these areas frequently for foraging. A small high biomass *Zostera capricorni* meadow was found inside the mouth of Victor Creek in Port Newry although it is unlikely this habitat would be targeted by dugong. High biomass *Zostera capricorni* (wide leaf morph) is not a preferred food for dugong and there are major meadows containing their preferred seagrass species nearby.

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4. SEAGRASS AND MARINE RESOURCES OF THE LLEWELLYN BAY AND INCE BAY DUGONG PROTECTION AREAS

Chantal Roder & Anthony Roelofs

BACKGROUND

Description of Study Locality

Llewellyn and Ince Bays are approximately 40 km south of the city of Mackay. Agriculture (sugar and dry land grazing) is the main industry. Urban development is low throughout this region and its catchment.

Maximum rainfall in the area is between 1397 and 2007 mm which falls mostly from December to April (Mackay). Wet season rainfall can dilute estuarine waters to brackish levels in some areas. Mean annual rainfall is 1608 mm and minimum and maximum daily temperatures range from 12.7°C in July to 30.0°C in January (Mackay) (36.9 year average, Australian Bureau of Meteorology 2000). The tidal range for the area is approximately 5 m. Winds are predominantly south-easterly in the dry cooler months of the year and light northerly winds during the summer wet season months.

Water depths within Ince Bay are less than 6m below MSL. Water depths to the west in Llewellyn Bay reach 13.5 m near Irving Island. The tidal range for the area is up to 6.4 m. Vast intertidal banks are exposed during spring low tides. During wet season events, some areas of Llewellyn and Ince Bays are diluted to brackish levels by freshwater flooding and stream flow from the adjacent catchments.

The catchment for Llewellyn Bay includes Elizabeth Ck, Freddy Ck, Tommy Ck, Rubicon Ck, Cherry Tree Ck, Tedlands Ck, Rocky Dam Ck and a number of unnamed creeks, all draining out of Connors Range (Map 4.1). The catchment for Ince Bay is Cape Creek and a number of unnamed streams draining the mount Funnel Range (Map 4.1). Both catchments are relatively free of residential or urban areas. Extensive cane production occurs in the lower catchment area of Llewellyn Bay and dryland grazing occurs in both Llewellyn and Ince Bay catchments. Overgrazing on the upland and salt-water couch areas and inappropriate land-clearing practices have resulted in erosion problems in the catchments (Anon 1993). Land tenure includes large areas of freehold, with some leasehold. Potential disturbances include invasion of freshwater wetlands from pasture species and aquaculture farm discharge. An aquaculture farm has been constructed at Armstrong Beach.

Ince Bay is a relatively remote DPA with only low levels of recreational and commercial use (B Depper, QBFB, Pers. Comm.). Campsites are located in Cape Palmerston National Park and recreational fishers access the bay from Cape Palmerston by travelling along the beach from the township of Greenhill, or by boat from Armstrong Beach to the north. Beach launching of smaller vessels occurs from the National Park sites. The average range of recreational fishing trips in the area is 30km return (Gilbert and Benzaken 1997). Much of the area is tidal and the shallow bathymetry generally excludes use of the area by larger vessels. Sarina and Mackay are the nearest main population centres to Ince Bay. Recreational fishing and crabbing are the main activities undertaken in the area (Gilbert and Benzaken 1997). The large coal loading facility at Hay Point lies 25 km to the north. Bulk carriers often lie anchored up to 10 km offshore of this area.

Ince and Llewellyn Bay Dugong Protected Areas (DPAs) were declared on the 12th January 1998 to protect key dugong populations and habitat. The DPA boundaries were based on information on dugong population numbers and seagrasses suitable for dugong feeding. Aerial surveys in the mid 1990's revealed a dramatic decline in dugong numbers in the southern Great Barrier Reef Marine Park. In Ince and Llewellyn Bays, these aerial surveys found that the dugong population had declined from 542 ±293 to 82 ±60 between 1987 to 1994 (Marsh *et al.* 1996). The meadows in this area (mapped in 1987 by Coles *et al.* 1987a) were considered the most important meadows for dugong feeding to the north of Shoalwater Bay. Ince Bay was declared a DPA 'A' and Llewellyn Bay declared a 'B' DPA.

The Ince Bay DPA 'A' level of protection offers greater restrictions to netting practices than the 'B' level of protection in the Llewellyn Bay DPA. Specific restrictions on commercial netting in Ince Bay DPA include prohibiting offshore set and drift nets and foreshore set nets. Set net use is permissible within Ince Bay creeks and rivers, but restrictions apply on net length and drop and nets must have fisher attendance. Specific restrictions on commercial netting in the Llewellyn Bay 'B' DPA include restrictions on the length, placement and attendance of offshore, foreshore and river set nets as well as the allowance of a new rocky foreshore (headlands) set net. River set net use is less restrictive in 'B' areas than in 'A' areas.

Conservation management occurs on the Palmerston National Park, Marine Park areas, Fish Habitat Areas, and the Dugong Protection Areas. Palmerston National Park covers an area from Cape Palmerston to Cutlack Island (Map 4.1). Coastal waters in the north-east of the study area have Marine Park General Use A Zoning. Coastal waters in the south-east are zoned Marine Park General Use B. The Sarina Inlet-Ince Bay area has also been recognised as a good example of a diverse, marine, estuarine and freshwater wetlands area (Queensland, Brigalow Belt, Central Mackay Coast Bioregion No. CMC011QL) (Environment Australia, 2001).

Fish Habitat Areas (FHA) have been declared throughout coastal Queensland to enhance existing and future fishing activities and to protect the habitat upon which fish and other aquatic fauna depend. Southern Llewellyn Bay has been declared as the Rocky Dam FHA (033-023), with management status "B". This area is declared from Allom Point to the southern bank of the mouth of Elizabeth Creek and covers a total area of 3,300 ha (Map 4.1). Ince Bay has been declared the Cape Palmerston FHA (015-043A) with management status "A" (including greater restrictions on development and related disturbances). This area is declared from Allom Point, to Taffy Island to Cape Palmerston and covers an area of 12, 000 ha (Map 4.1).

During the 1994-1999 period, the most productive commercial fin fish fisheries within the region included shark, barramundi, mackerel, mullet, blue salmon and to a lesser extent queen fish, king salmon and whiting (QFMA, 2000 data). The most important prawn fisheries included king, banana and tiger prawns (QFMA, 2000 data) (Table 4.1).

Table 4.1. Number of boats, fishing days and total commercial fish catches recorded for waters between latitudes 21° 00'S and 21° 30'S, and longitudes 149° 00'E and 149° 30'E, from 1994 to1999 (source: Queensland Fisheries Service).

Year	Boats	Fishing days	Total catch (tons)			
			Fish	Prawns	Others*	Total
1994	325	5517	55.51	41.71	12.22	109.44
1995	330	3026	54.85	57.06	22.60	134.51
1996	310	2766	46.77	71.62	10.99	129.37
1997	321	2402	39.27	37.47	7.71	84.45
1998	261	2114	31.93	34.09	9.00	75.02
1999	248	2370	38.12	30.70	10.31	76.14

* Others = scallops, crab, bugs, squid, octopus, cuttlefish and lobster.

Seagrasses of Ince and Llewellyn Bay

Coles *et al.* (1987a) conducted a broad scale survey of seagrasses between Bowen and Water Park Point (including Ince and Llewellyn Bay) in March 1987. Sites were surveyed on hookah or by free diving and interpolation between these sites created maps of seagrass distribution. No seagrass was found in Llewellyn Bay, (much of the bay was inaccessible due to low tides on the day of the survey, R Coles, QDPI, Pers Comm.) but large areas of seagrass were identified on the intertidal flats of Ince Bay. A total of 1471 ha of seagrass was mapped between Allom Point and Glendower Point, Cutlack Island and Hogans Camp Island (Lee Long *et al.* 1993).

Lee Long *et al.* (1993) reported that the areas of seagrass habitat surveyed by Coles *et al.* (1987a) included 575ha <10% cover, and 549ha of 10-50% cover in Ince Bay. Seagrass species present in Ince Bay included *Halophila ovalis, Halodule pinifolia* and *Halophila spinulosa.*

A consulting firm, FRC (1997) surveyed Ince Bay between 27th June and 9th July 1997. They found seagrass meadows in similar locations as did Coles *et al.* (1987a) but reported much smaller size and lower density. Three main areas of seagrass were identified in Ince Bay: east of Allom Point; west of Glendower Point; and offshore of Hogans Camp Island (FRC, 1997). They reported around 50% of the meadow area shown on Coles *et al.* (1987a) maps. All seagrass cover FRC (1997) surveyed was sparse (<10%), with the exception of one small area off Hogans Camp Island. FRC (1997) also reported three species of seagrass present: *Halodule uninervis, Halodule pinifolia and Halophila ovalis.*

The present survey remaps the seagrasses of the area including both Ince and Llewellyn Bay. It is designed to provide a baseline set of maps and information including distributions in post and pre wet season times of the year. Estimates of the fisheries values of the seagrass meadows are provided as well as observational information on the populations of sea turtles and dugong.

RESULTS

Seagrass Species, Distribution and Abundance

Llewellyn Bay was surveyed for seagrass up to 1.5 km from the coast (Maps 4.2 & 4.3). This survey region included intertidal banks and shallow sub-tidal areas in bays, inlets and other sheltered localities where seagrass was observed on the reconnaissance flight (Map 4.2 & 4.3). 124 coastal sites were surveyed in May (Map 4.2), and 96 coastal sites were surveyed in October in Llewellyn Bay (Map 4.3). The coastal sites surveyed in May include 6 sites sampled by helicopter during the reconnaissance survey. The nine deepwater sites sampled in May were repeated in October in the Llewellyn Bay DPA. Seagrass was present at 25% of sites in May 1999, and 29% of sites sampled in October.

Ince Bay was surveyed with sites distributed haphazardly over intertidal banks up to 3.5 km from the coast. 155 sites were surveyed in May (Map 4.2) and 168 sites were surveyed in October (Map 4.3). The coastal survey sites recorded for May also included 11 helicopter sites surveyed late April 1999. Seagrass was present at 70 sites in May, and 127 sites in October.

Three species of seagrasses were found in Llewellyn Bay during the May 1999 survey and four species were found in October 1999 (Table 4.2). Four species of seagrasses were found in Ince Bay during the May 1999 survey, while five species were found during the October 1999 survey (Table 4.2).

Table 4.2. Seagrass species present in the Llewellyn Bay and Ince Bay Dugong Protection Areas May 1999 and October 1999.

Seagrass Family	Seagrass species	Llewellyn Bay		Ince Bay	
		May 1999	Oct 1999	May 1999	Oct 1999
ZOSTERACEAE Drummortier	*Zostera capricorni* Aschers.	✓	✓	✓	✓
CYMODOCEACEAE Taylor	*Halodule uninervis* (narrow leaf morph) (Forsk.) Aschers.	✓	✓	✓	✓
	Halodule uninervis (wide leaf morph) Aschers.	-	-	-	✓
HYDROCHARITACEAE Jussieu	*Halophila decipiens* Ostenfeld	-	✓	-	✓
	Halophila ovalis (R. Br.) Hook.*f*	✓	-	✓	✓
	Halophila spinulosa (R. Br.) Aschers. in Neumayer	-	✓	✓	✓

Distribution of Seagrass Meadows

Llewellyn Bay had small isolated seagrass meadows as opposed to the large meadows heavily used by dugong in Ince Bay. Seagrasses were mostly on inter-tidal banks in both DPAs (Maps 4.4 and 4.5).

Seagrass within the Llewellyn Bay DPA was confined to 11 small isolated patches within a 1.5km strip along the coast in May and October (Maps 4.6 & 4.7). These meadows were mostly in embayments (Deception Inlet, Armstrongs Beach and the mouth of Rocky Dam Creek) and along the edges of sand and mud banks in the southern part of Llewellyn Bay (Maps 4.6 & 4.7). Total area of seagrass did not change from May (115.1 ± 49.8 ha) to October (117.1 ± 55.0) (Map 4.6 and Map 4.7, Table 4.3). Small isolated patches of *Halophila decipiens* and *Halophila spinulosa* were found at 3 deepwater sites (>10m below MSL) and only in October.

Extensive seagrass meadows covering intertidal sandbanks were mapped in Ince Bay in May and October (Maps 4.8 & 4.9). These banks extended for 10km between Glendower Point and Cape Palmerston and up to 3.5 km from the shoreline. Nine seagrass meadows were mapped in both surveys. Total area of seagrass habitat increased from May (1203.6 ±133.8 ha) to October (1572.75 ±187.1 ha). Distribution and area of the large *Halodule uninervis* (narrow) meadows changed little between surveys, although *Zostera capricorni* meadows increased in area from May (4.8 ha) to October (281.2 ha). A single isolated patch of *Halophila spinulosa* in May (4.3ha) became a large meadow (58.1 ha) in October (Table 4.3). Smaller meadows of *Halophila ovalis*/ *Halodule uninervis* (narrow) mixed, and *Halodule uninervis* (wide) were found on banks, channels and shallow sub-tidal areas in the eastern part of Ince Bay, north of the mouth of Cape Creek.

Table 4. 3 Mean above-ground biomass, number of meadows identified and area of the major seagrass meadow types identified in May 1999 and October 1999 in the Llewellyn Bay and Ince Bay Dugong Protection Areas.

† Range of meadow areas is calculated from estimates of mapping error (refer to methods).

Community Meadow type	May 1999			October 1999		
	Biomass mean ±SE (range) (g DW m^{-2})	**# meadows**	**Area (ha) (RANGE)†**	**Biomass mean ±SE (range) (g DW m^{-2})**	**# meadows**	**Area (ha) (RANGE)†**
LLEWELLYN BAY						
Halodule uninervis (narrow) dominated	5.78 ±1.3 (0.01-10.39)	9	100.77 (57.4-144.2)	1.77 ±1.0 (0.01-4.58)	4	26.10 (4.9-47.3)
Halophila ovalis and *Halodule uninervis (narrow)*	6.41	1	2.74 (0.6-4.9)	No biomass recorded	1	2.69 (0.1-5.3)
Zostera capricorni and *Halodule uninervis (narrow)*	absent	-	-	2.22 (0.29-4.15)	2	12.21 (3.1-21.3)
Zostera capricorni dominated	18.9	1	11.63 (65.4-164.9)	3.82 ±1.09 (2.26-7.03)	4	76.07 (55.5-96.6)
Llewellyn Bay TOTAL MEADOWS	**7.03 –0.59**	**11**	**115.1 (65.4-164.9)**	**2.44 –0.63**	**11**	**117.1 (63.6-170.6)**
INCE BAY						
Halodule uninervis (narrow) dominated	7.39 ±1.34 (2.34-12.40)	6	1190.80 (1075.6-1306.0)	2.19 ±0.86 (0.67-5.39)	5	1089.80 (965.7-1213.9)
Halophila ovalis/ Halodule uninervis (narrow)	12.3	1	3.67 (0-9.7)	2.43	1	120.05 (106.1-134.0)
Halodule uninervis (wide) dominated	-	-	-	0.76	1	23.61 (12.8-34.4)
Halophila spinulosa dominated	1.80	1	4.29 (0-11.0)	11.16	1	58.14 (39.8-77.1)
Zostera capricorni dominated	6.89	1	4.81 (0-10.7)	11.18	1	281.15 (264.8-297.5)
Ince Bay TOTAL MEADOWS	**7.23 –1.23**	**9**	**1203.57 (1069.8-1337.4)**	**4.06 –1.3**	**9**	**1572.75 (1389.1-1756.9)**

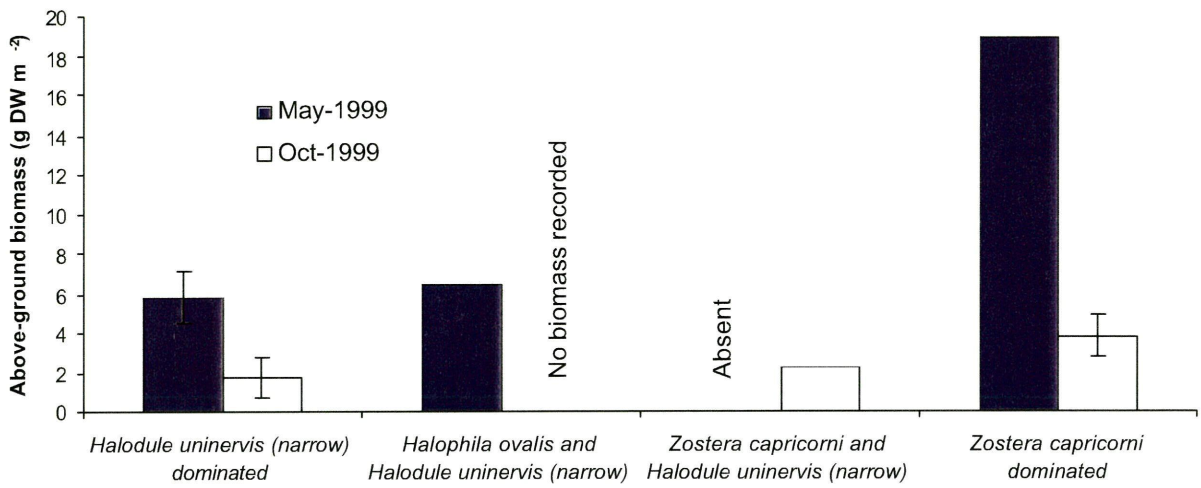


Figure 4.1. Above-ground seagrass biomass for each community type in Llewellyn Bay, May and October 1999 (*mean and standard error displayed*).

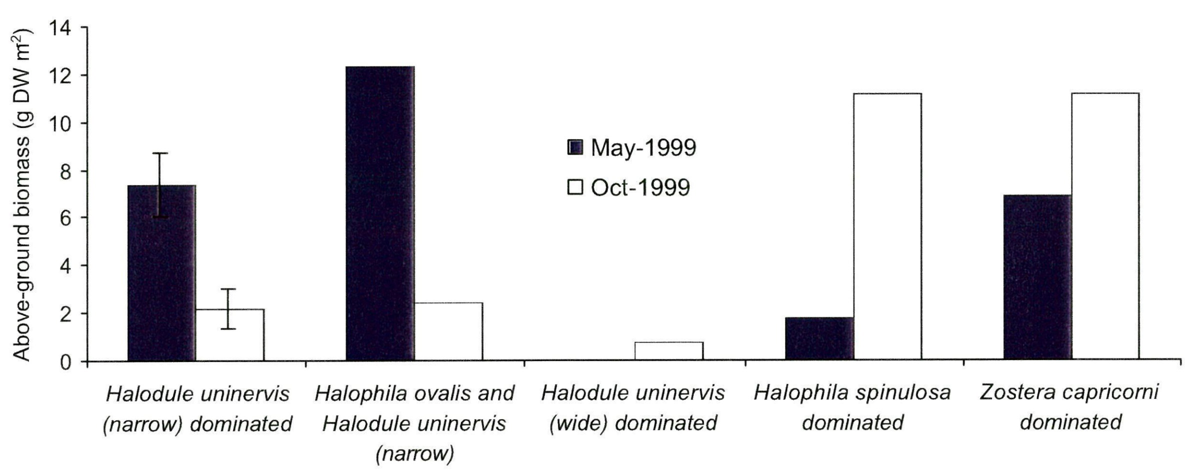


Figure 4.2. Above-ground seagrass biomass for each community type in Ince Bay, May and October 1999 (*mean and standard error displayed*).

Seagrass Biomass

Seagrass biomass ranged from 0.003 to 38.1 gDW m^{-2} (above-ground biomass) in Llewellyn and Ince Bays. Both DPAs contained mostly low biomass seagrass (mean above-ground biomass of less than 20 g DW m^{-2}) (Figures 4.1 and 4.2). Greatest seagrass biomass occurred where community types were *Zostera capricorni* dominant in Llewellyn Bay in May (Figure 4.1). Above-ground biomass of *Halophila ovalis* and *Halodule uninervis* (narrow) meadows were low in biomass and declined between surveys in both DPAs (Figures 4.1 and 4.2).

Above-ground seagrass biomass in Llewellyn Bay ranged from 3.5 to 18.9 g DW m^{-2} in May and from 0.003 to 23.8 g DW m^{-2} in October (Figure 4.3). Mean above-ground biomass for all seagrass species however, was less than 10 g DW m^{-2} in both surveys. *Halodule uninervis* (narrow) and *Zostera capricorni* decreased in mean biomass from May to October. *Halophila ovalis* was only found in the May survey, with mean biomass of 4.8 ±2.6 g DW m^{-2}.

Above-ground seagrass biomass in Ince Bay ranged from 0.03 to 15.6 g DW m^{-2} in May and from 0.007 to 38.1 g DW m^{-2} in October. *Halophila spinulosa* was the only seagrass with a mean above-ground biomass greater than 10 g DW m^{-2} and increased in biomass between surveys. *Halodule uninervis* (narrow) mean biomass decreased between surveys, whereas *Zostera capricorni* and *Halophila ovalis* did not change significantly. *Halodule uninervis* (wide) and *Halophila decipiens* were only present in the October 1999 survey and were less than 3 g DW m^{-2} mean above-ground biomass (Figure 4.3).

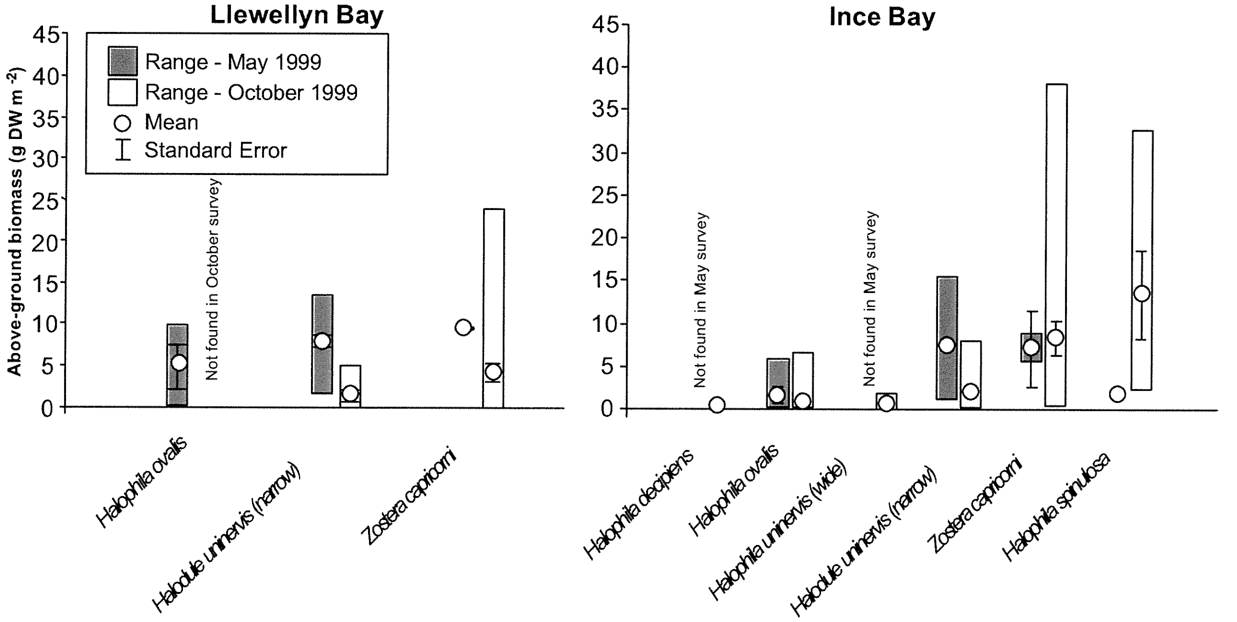
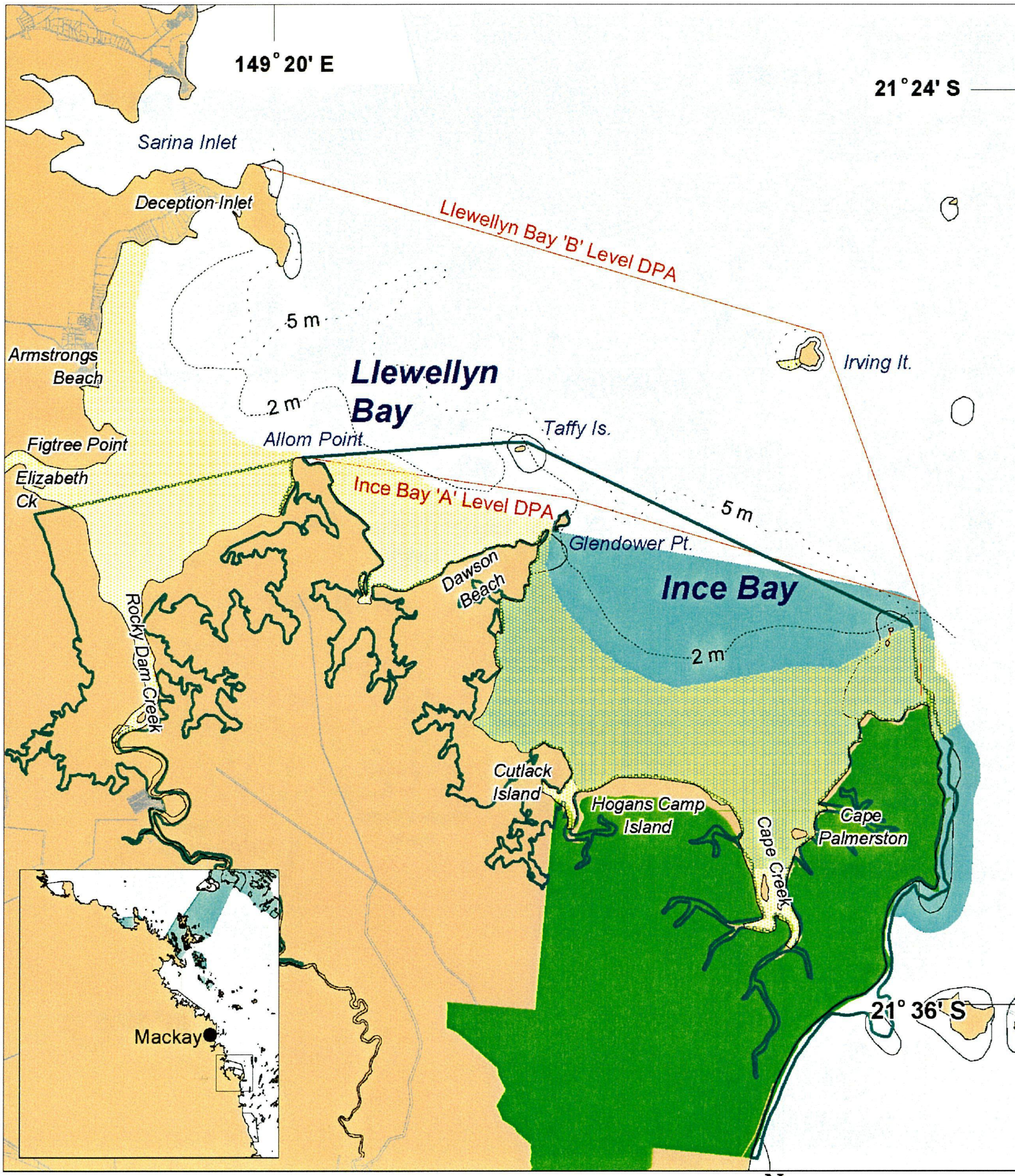


Figure 4.3. Mean, range and standard error of above-ground biomass for seagrass species (*all sites pooled*) for Llewellyn Bay and Ince Bay, May and October 1999.

Map 4.1 Llewellyn Bay and Ince Bay Dugong Protection Areas



N

0 2 4

Kilometres

LEGEND

- Sandbanks
- Dugong Protection Area Boundary
- Fish Habitat Area Boundary
- National Park
- Marine Park - General Use A
- Marine Park - General Use B

Source: Roder, C.A. and Roelofs, A.J. (2001). Seagrass and Marine Resources of the Llewellyn Bay and Ince Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 4, pp 85-116. (DPI, Cairns).

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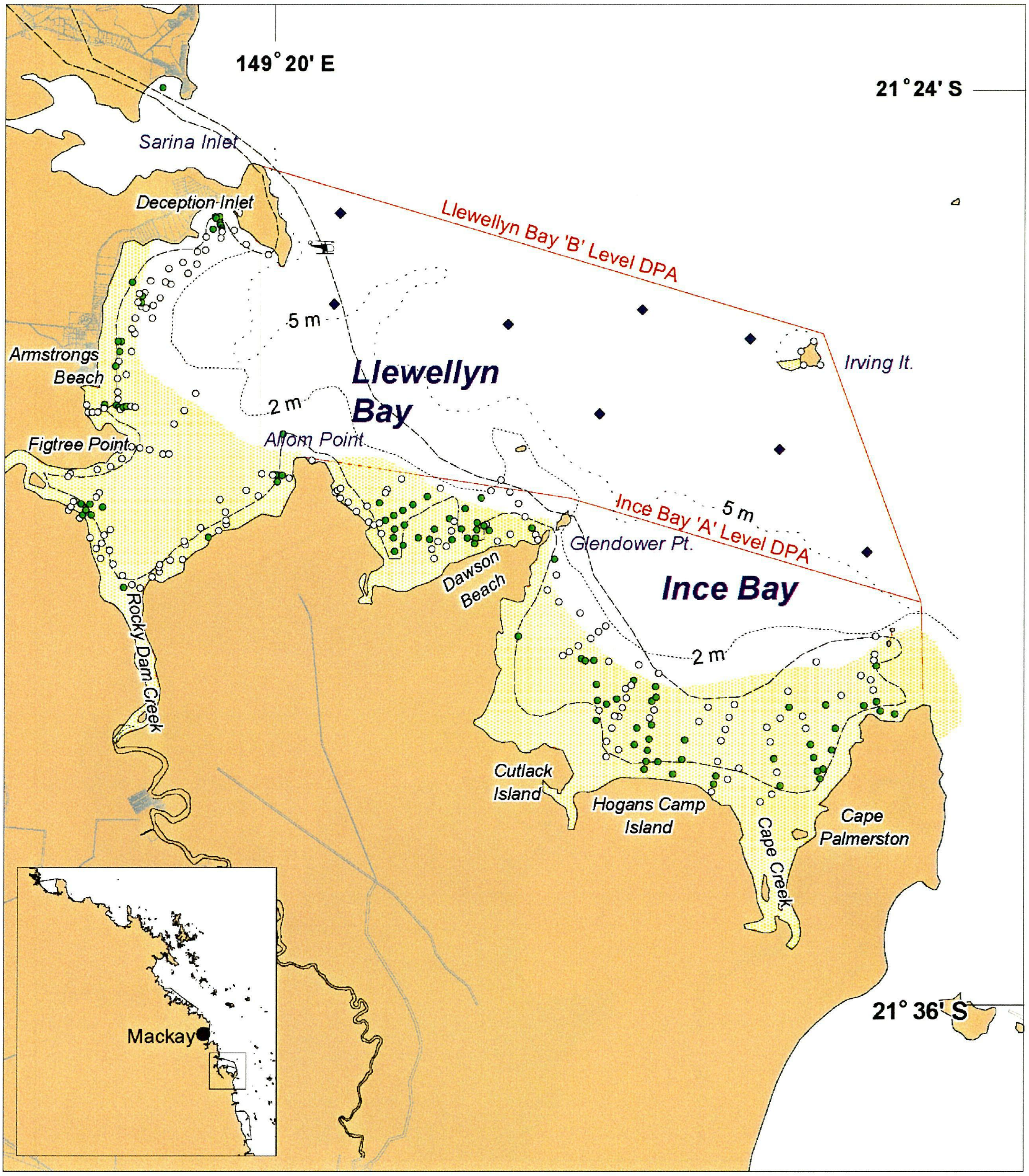
Map 4.2

Survey sites within Llewellyn Bay and Ince Bay Dugong Protection Areas - May 1999



LEGEND

- Sandbanks
- Deepwater video site
- Seagrass
- No seagrass
- Helicopter flight path

Source: Roder, C.A. and Roelofs, A.J. (2001). Seagrass and Marine Resources of the Llewellyn Bay and Ince Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region. April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 4, pp 85-116. (DPI, Cairns).

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Sampling dates: Helicopter survey 27-28 April
Diver and deepwater video survey 16-25 May 1999.

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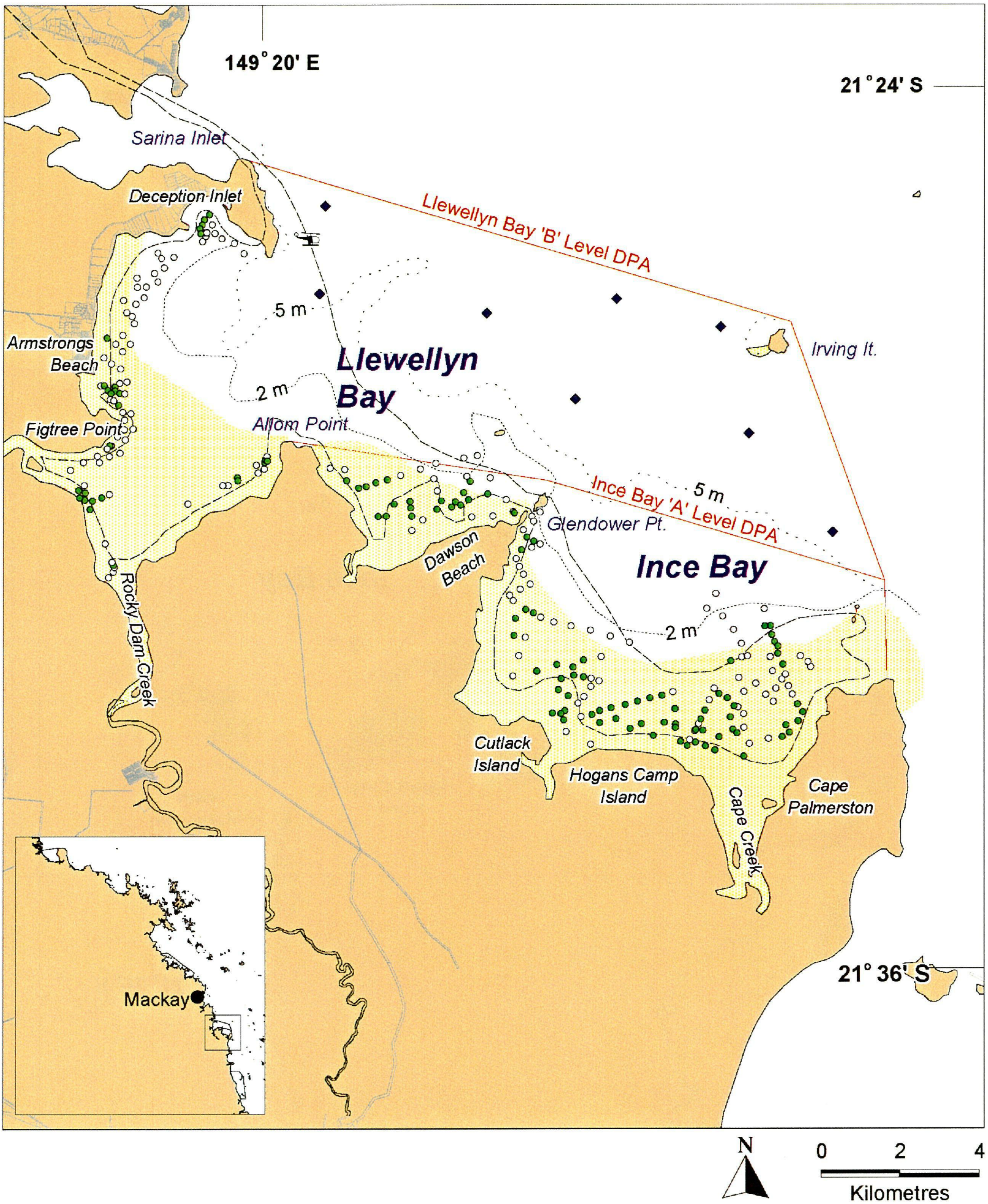
Map 4.3

Survey sites within Llewellyn Bay and Ince Bay Dugong Protection Areas - October 1999



LEGEND

- Sandbanks
- Deepwater video site
- Seagrass
- No seagrass
- Helicopter flight path

Source: Roder, C.A. and Roelofs, A.J. (2001). Seagrass and Marine Resources of the Llewellyn Bay and Ince Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 4, pp 85-116. (DPI, Cairns).

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Sampling dates: Helicopter survey 27-28 April
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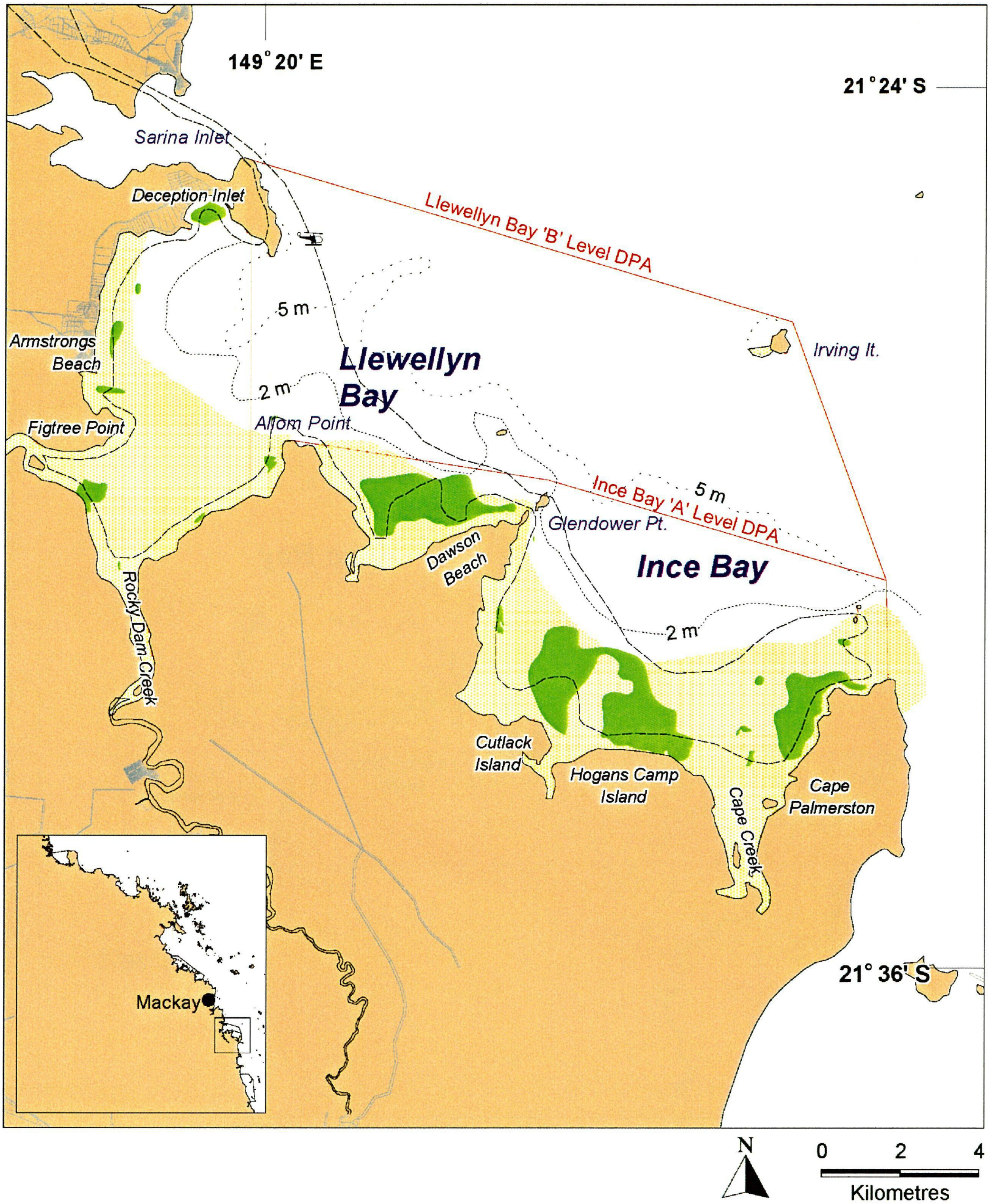
Map 4.4

Location of seagrass meadows in Llewellyn Bay and Ince Bay Dugong Protection Areas - May 1999



LEGEND

- Sandbanks
- Seagrass meadow
- Helicopter flight path

Source: Roder, C.A. and Roelofs, A.J. (2001) Seagrass and Marine Resources of the Llewellyn Bay and Ince Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 4, pp 85-116. (DPI, Cairns).

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Sampling dates: Helicopter survey 27-28 April
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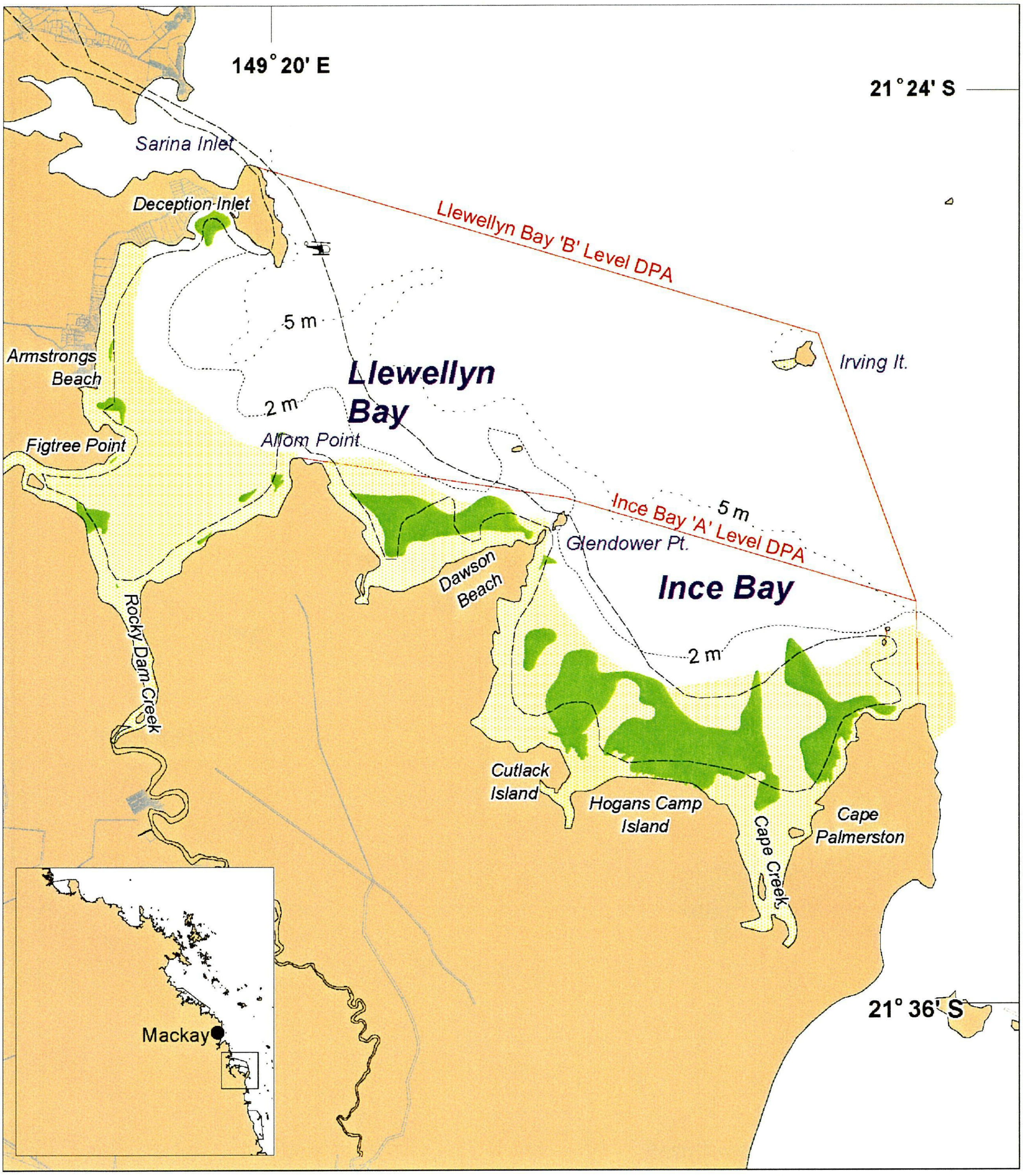
Map 4.5 Location of seagrass meadows in Llewellyn Bay and Ince Bay Dugong Protection Areas - October 1999



LEGEND

Sandbanks

Seagrass meadow

Helicopter flight path

Source: Roder, C.A. and Roelofs, A.J. (2001). Seagrass and Marine Resources of the Llewellyn Bay and Ince Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 4, pp 85-116. (DPI, Cairns)

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Sampling dates: Helicopter survey 27-28 April
Diver and deepwater video survey 12-20 October 1999.

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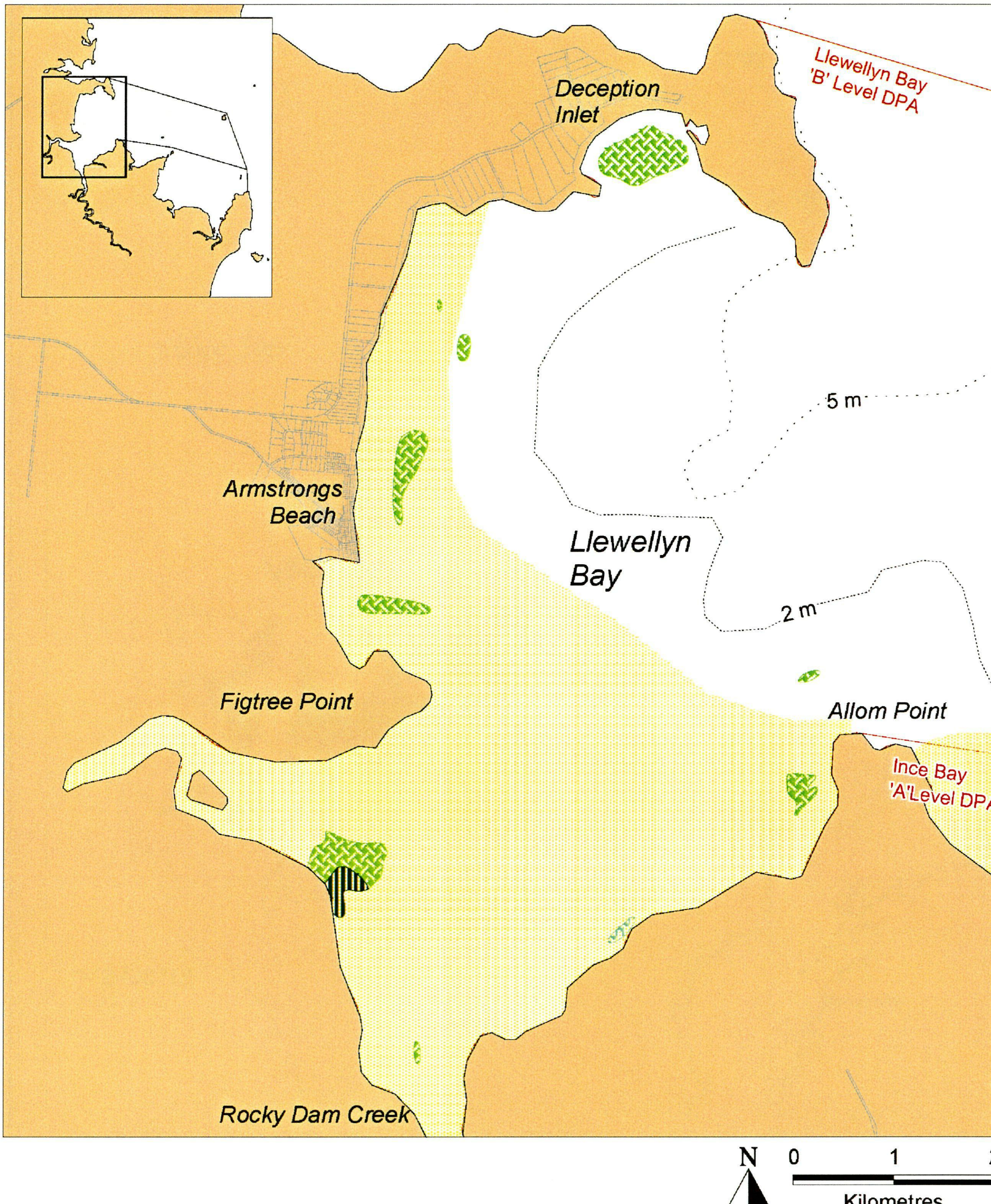
Map 4.6 Seagrass communities mapped in the Llewellyn Bay Dugong Protection Area - May 1999



LEGEND

- low biomass *Halophila ovalis/ Halodule uninervis (narrow)*
- low biomass *Halodule uninervis*
- low biomass *Zostera capricorni*
- Sandbanks

Source: Roder, C.A. and Roelofs, A.J. (2001) Seagrass and Marine Resources of the Llewellyn Bay and Ince Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 4, pp 85-116. (DPI, Cairns)

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Sampling dates: Helicopter survey 27-28 April
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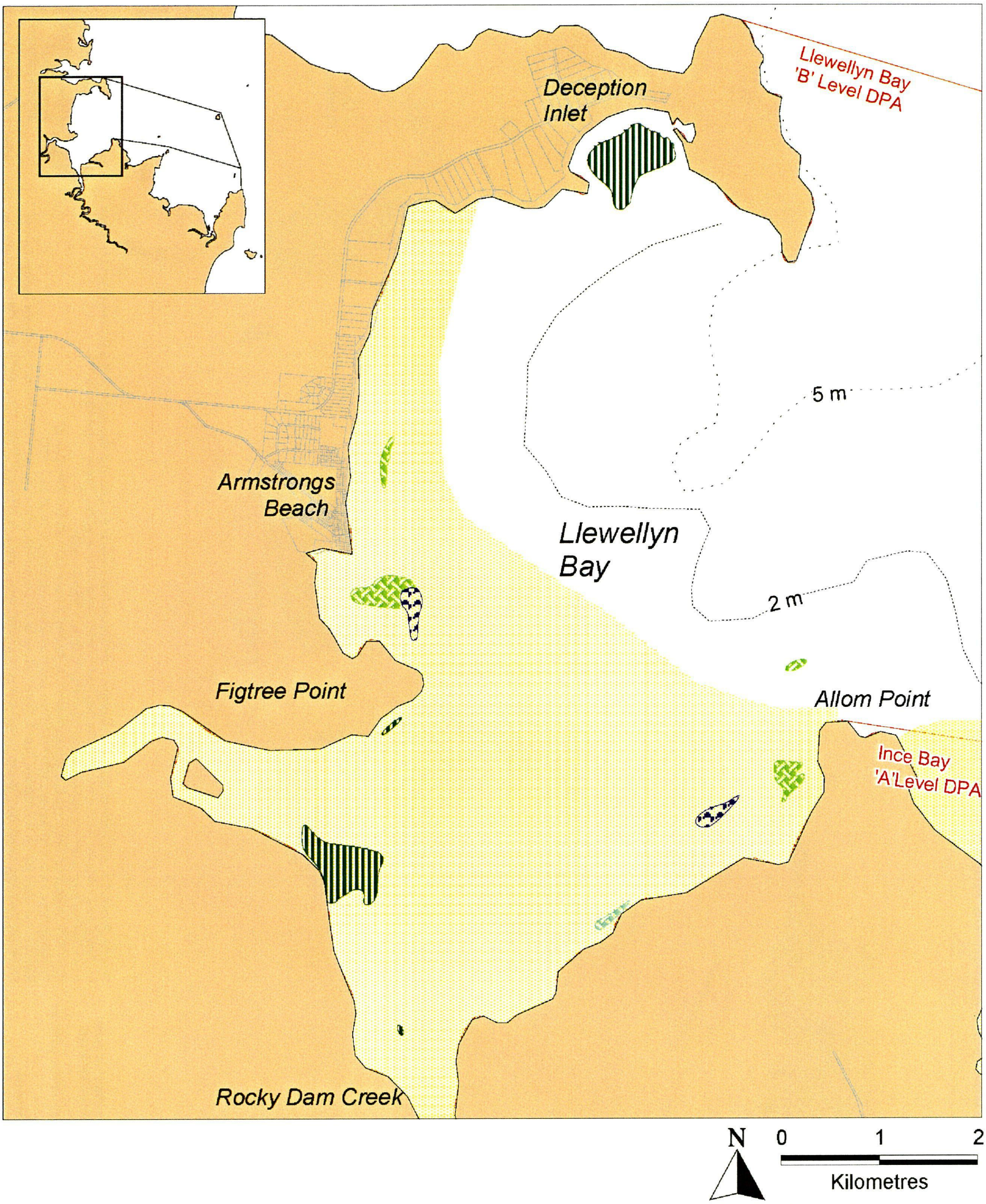
Map 4.7 Seagrass communities mapped in the Llewellyn Bay Dugong Protection Area - October 1999



LEGEND

- *low biomass Halophila ovalis/ Halodule uninervis (narrow)*
- *low biomass Halodule uninervis*
- *low biomass Zostera capricorni*
- *low biomass Zostera capricorni/ Halodule uninervis (narrow) mixed*
- Sandbanks

Source: Roder, C.A. and Roelofs, A.J. (2001) Seagrass and Marine Resources of the Llewellyn Bay and Ince Bay Dugong Protection Areas. In 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 4, pp 85-116. (DPI, Cairns).

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Sampling dates: Helicopter survey 27-28 April
Diver and deepwater video survey 12-20 October 1999.

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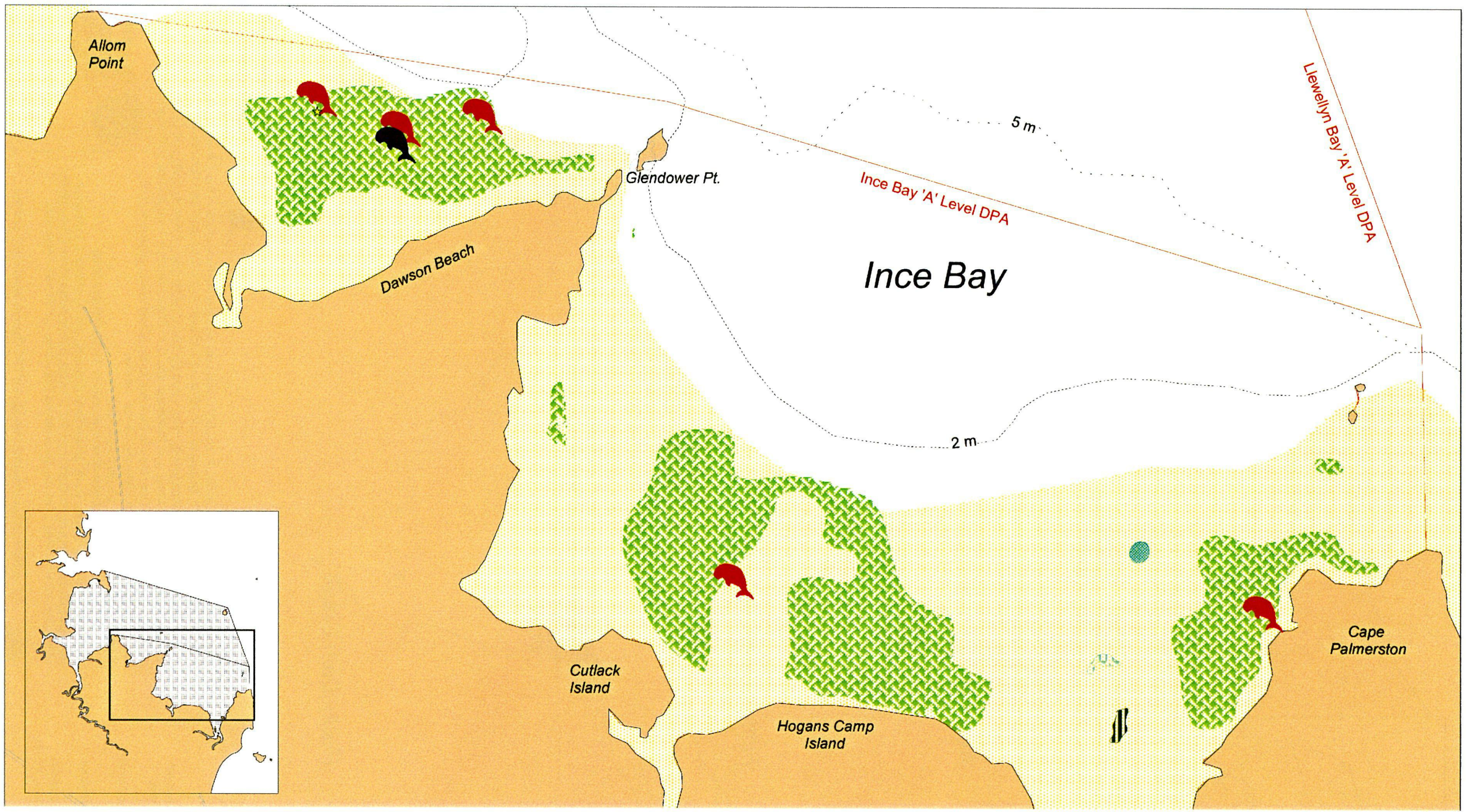
Map 4.8 Seagrass communities mapped in the Ince Bay Dugong Protection Area - May 1999



LEGEND

- Sandbanks
- Dugong sighted
- Dugong feeding trails
- Beam trawl site
- *low biomass Halophila ovalis/ Halodule uninervis (narrow)*
- *low biomass Halodule uninervis*
- *Halophila spinulosa*
- *low biomass Zostera capricorni*

Source: Roder, C.A. and Roelofs, A.J. (2001) Seagrass and Marine Resources of the Llewellyn Bay and Ince Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources within the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairveiw Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder). Section 4, pp 85-116 (DPI, Cairns).
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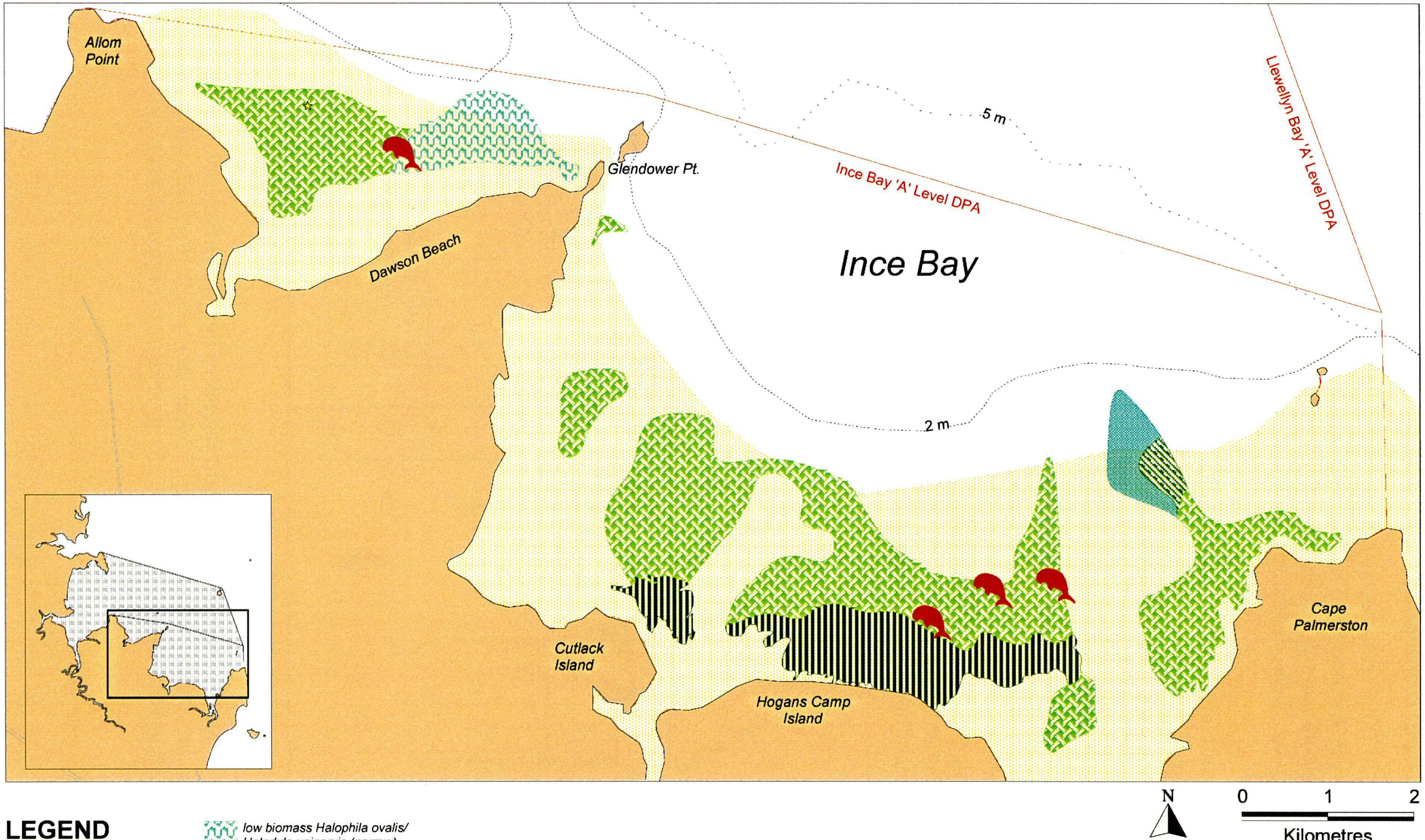
Map 4.9 Seagrass communities in the Ince Bay Dugong Protection Area - October 1999



LEGEND

- Sandbanks
- Dugong sighted
- Dugong feeding trails
- Beam trawl site
- *low biomass Halophila ovalis/ Halodule uninervis (narrow)*
- *low biomass Halodule uninervis*
- *Halophila spinulosa*
- *low biomass Zostera capricorni*
- *Halodule uninervis (wide)*

Source: Roder, C.A. and Roelofs, A.J. (2001) Seagrass and Marine Resources of the Llewellyn Bay and Ince Bay Dugong Protection Areas. In. 'Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Ince/Llewellyn Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder). Section 4, pp 85-116. (DPI, Cairns).
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Produced by the Marine Plant Ecology Group, DPI, Northern Fisheries Centre, Cairns, 2001.

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Seagrass Depth Distribution

Seagrasses in both DPAs occurred mostly on intertidal sandbanks and mudbanks above Lowest Astronomical Tide (LAT) in May and October. *Halophila decipiens, Halophila spinulosa* and *Halodule uninervis* (wide) were only found subtidally in the October survey. Mean depths for most species were greater in October in both DPAs (Figure 4.4).

Seagrasses in Llewellyn Bay were found between 0.14m above MSL and 2.8m below MSL in May 1999 and to 13m below MSL in October 1999 (Figure 4.4). *Halodule uninervis* (narrow), *Halophila ovalis* and *Zostera capricorni* occurred at depths less than 2.8m below MSL in May and October. (Figure 4.4). *Halophila spinulosa* and *Halophila decipiens* occurred in October only and between 10m and 13m below MSL (Figure 4.4).

Seagrasses in Ince Bay were found in shallow coastal waters to 3.9m below MSL in May and to 5.6m below MSL in October (Figure 4.4). *Halodule uninervis* (narrow), *Halophila ovalis* and *Zostera capricorni* occurred at depths less than 4m below MSL in both surveys. *Halophila decipiens, Halophila spinulosa* and *Halodule uninervis* (wide) were found mostly at shallow sub-tidal depths. They were predominantly leeward of Cape Palmerston and more abundant in October than May.

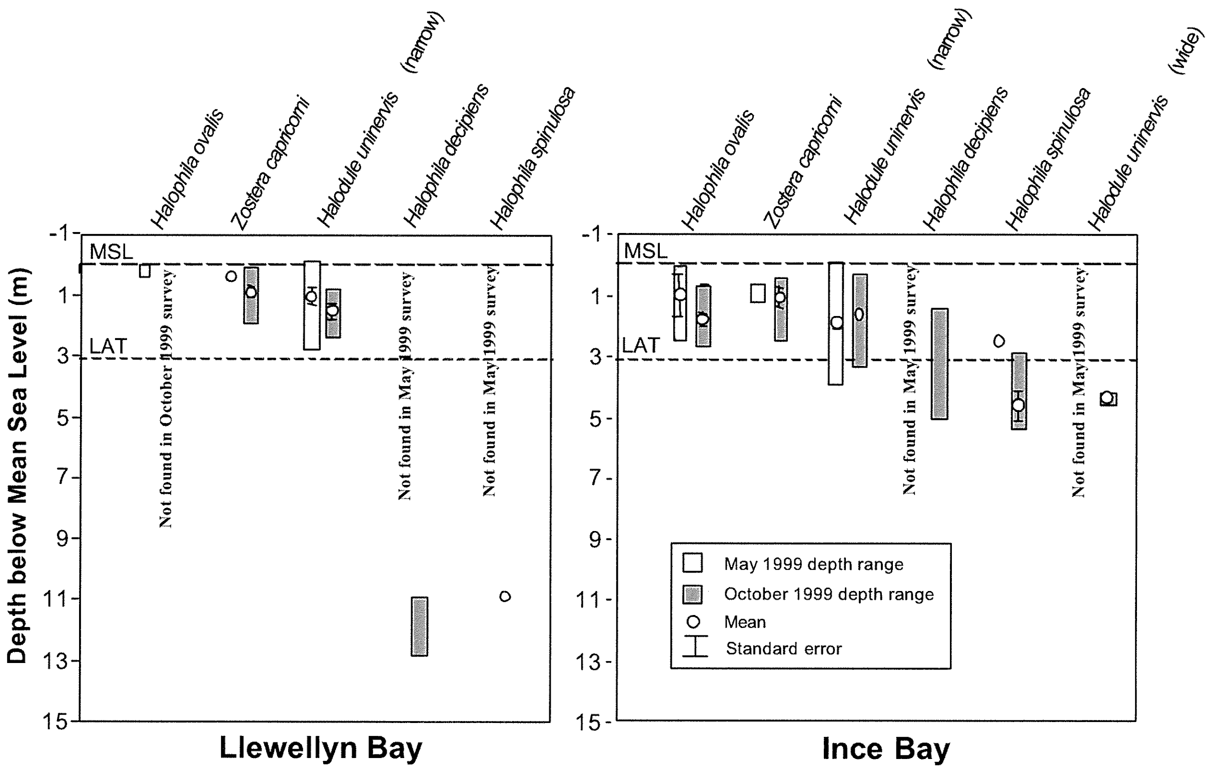

Figure 4.4. Means standard errors and ranges of depth of occurrence for each seagrass species of Ince Bay (MSL= Mean Sea Level). *(Calculated using only sites from transects which ran perpendicular from shore to the seaward edge of meadows).*

Invertebrates and Fish
Description of Beam Trawl Sites

One beam trawl site was chosen in an extensive *Halodule uninervis* (narrow leaf morph) meadow that was considered representative of Ince Bay seagrass habitat (Map 4.2 & 4.3, Table 4.4). This meadow was of relatively sparse seagrass growth with a biomass average of 6.3 ±0.7 g DW m^{-2} in May to 1.9 ±0.5 g DW m^{-2} in October (Table 4.4).

Beam trawling was not undertaken in Llewellyn Bay, as the small isolated patches of seagrass were not suitable for trawling.

Table 4.4. Description of beam trawl site in Ince Bay May 1999 and October 1999.

Descriptors	**May 1999**	**October 1999**
Date sampled	24/5/1999	18/10/1999
Mean biomass ± SE (g DW m^{-2})	6.33±0.77	1.90±0.47
Seagrass species present	*Halodule uninervis* (narrow morphology)	*Halodule uninervis* (narrow morphology)
Depth below MSL (m)	2.13	2.14
Sediment type	Sand	Sand/Shell
Mean algae % cover	0.33	0
Algae types	Blue-green filamentous	-

Invertebrates

Penaeid prawns

A total of 37 and 14 individual juvenile or sub-adult penaeid prawns were collected in beam trawls taken from Ince Bay in May and October respectively (Figure 4.5).

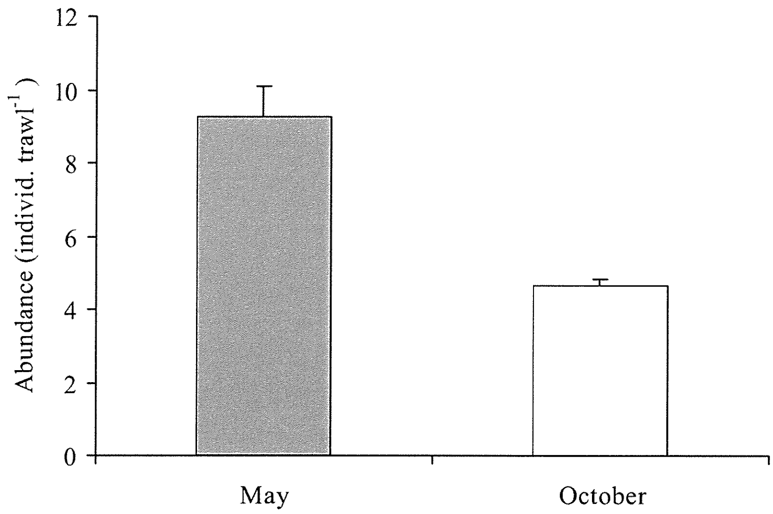

Figure 4.5. Abundance of penaeid prawns at each trawl site in Ince Bay in May and October 1999 (*mean and standard error displayed*).

Only two species of penaeid prawn (*Metapenaeus bennettae* and *Metapenaeus endeavouri)* were identified from the May catch. Most of the catch (83.8%) could not be identified (due to poor condition of the prawn head and body) (Figure 4.6, Table 4.5). In October, there were six species of penaeid prawns and these were mostly king prawns (*Penaeus latisulcatus*) (Figure 4.6, Table 4.5).

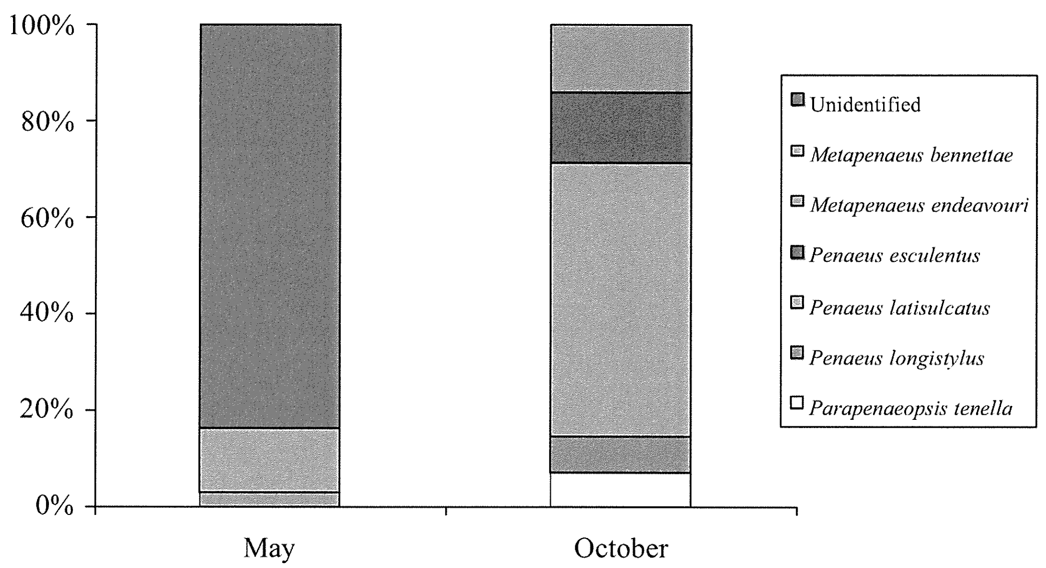

Figure 4.6. Percent species composition of penaeid prawns collected in May 1999 and October 1999.

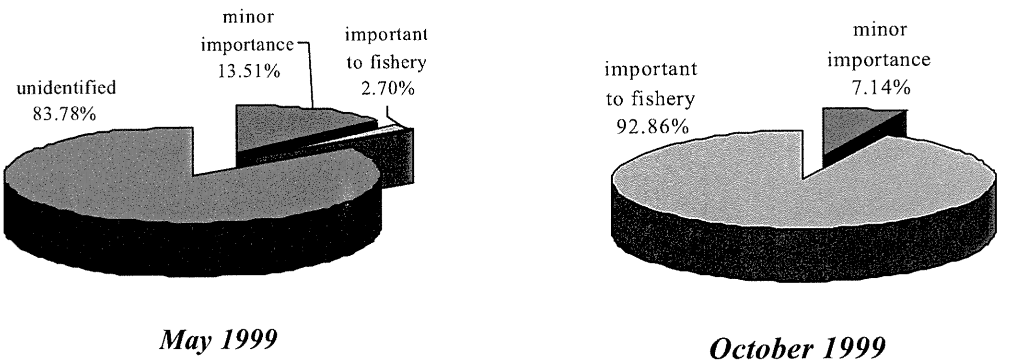

Figure 4.7. Composition of fishery value for penaeid prawns collected from beam trawls in May 1999 and October 1999.

All penaeid prawns identified in the surveys were of importance to the local commercial prawn fishery and the more valuable species occurred mostly in October (Figure 4.7).

Table 4.5 Species, fishery code, carapace length, abundance and biomass* of penaeid prawns collected by beam trawl from Ince Bay Dugong Protection Area - May and October 1999.

Value codes (from Coles et al. *1993) : IV, important to north eastern prawn fishery; III, component of fishery; II minor to insignificant importance.*

** Biomass = All species pooled*

Species	Common name	Fishery code	May 1999			October 1999		
			mean CL (mm) ±SE (range)	*n* (%)	biomass	mean CL (mm) ±SE (range)	*n* (%)	biomass
Metapenaeus bennettae	Greentail	II	6.48 ±0.75 (4.90 - 8.80)	5 (13.51)		*absent*	-	
Metapenaeus endeavouri	True Endeavour	IV	3.80	1 (2.70)		6.80 ±0.80 (6.00 - 7.60)	2 (14.29)	
Parapenaeopsis tenella	Smoothshell	II	*absent*	-		5.40	1 (7.14)	
Penaeus esculentus	Brown Tiger	IV	*absent*	-		3.20 ±0.80 (2.40 - 4.00)	2 (14.29)	
Penaeus latisulcatus	Western/Blue-leg King	IV	*absent*	-		6.90 ±0.98 (3.60 - 10.20)	8 (57.14)	
Penaeus longistylus	Red Spot King	IV	*absent*	-		5.00	1 (7.14)	
Unidentified	-	-	-	31 (83.78)		*absent*	-	
TOTAL			**6.03 ±0.76 (3.80 - 8.80)**	**37 (100)**	**0.90**	**6.11 ±0.67 (2.40 - 10.20)**	**14 (100)**	**0.66**

Other invertebrates

Total weight of other invertebrates was only 1.3 g DW in May and 27.7 gDW in October. Penaeids and miscellaneous crustaceans (including caridean shrimps and ostracods) accounted for more than 98% of dry weight biomass in the May sample (Figure 4.8). Most of the Brachyura crabs were caught in October and contributed to the majority of the invertebrate biomass. Penaeid prawns and miscellaneous crustaceans made up 32 % of the catch (including caridean shrimps, ostracods, isopods and stomatopods) in October (Figure 4.8).

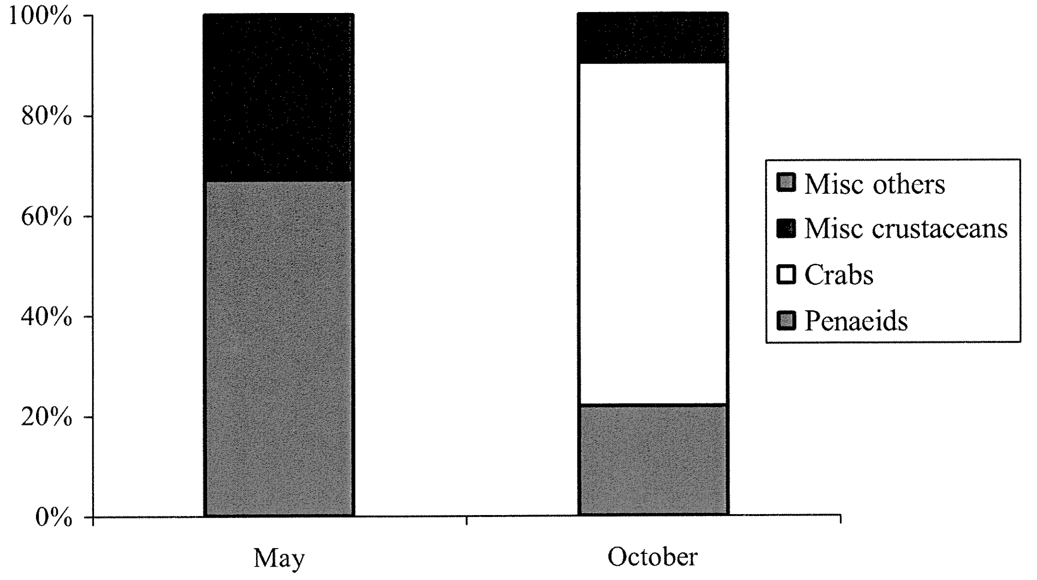

Figure 4.8. Percentage composition of invertebrate groups to the total biomass (g DW) in Ince Bay May 1999 and October 1999.

Fish

Greater diversity and abundance of fish were collected in October than in May (Table 4.6, Figures 4.9 & 4.10). A total 131 individual fish were collected from 4 beam trawls in May and 331 from 4 trawls in October. Five species of fish (4 species of Gobiidae) were caught in May and 17 species in October. Gobiidae dominated the catch in May, however Sillaginidae (whiting) were the most abundant family in October (Figure 4.10).

The mean and range of fish standard length (all taxa pooled) was similar between surveys (14.44 ±0.36 mm in May and 13.41 ±0.25 mm in October) (Table 4.6).

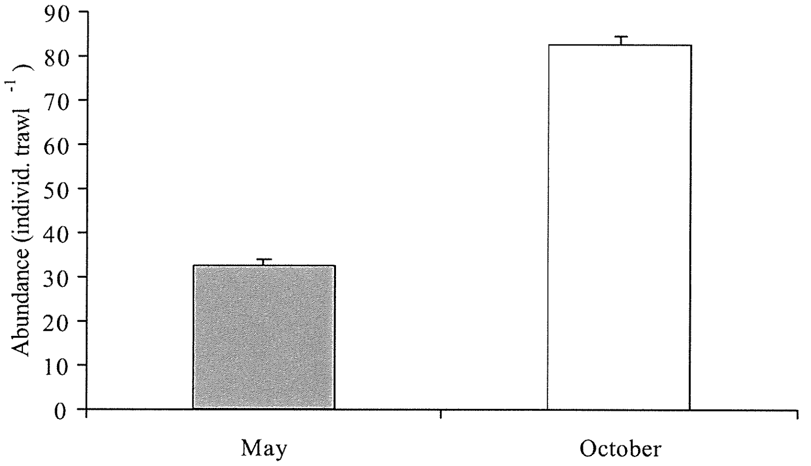

Figure 4.9. Abundance of fish per trawl in Ince Bay, May and October 1999 (*mean and standard error displayed*).

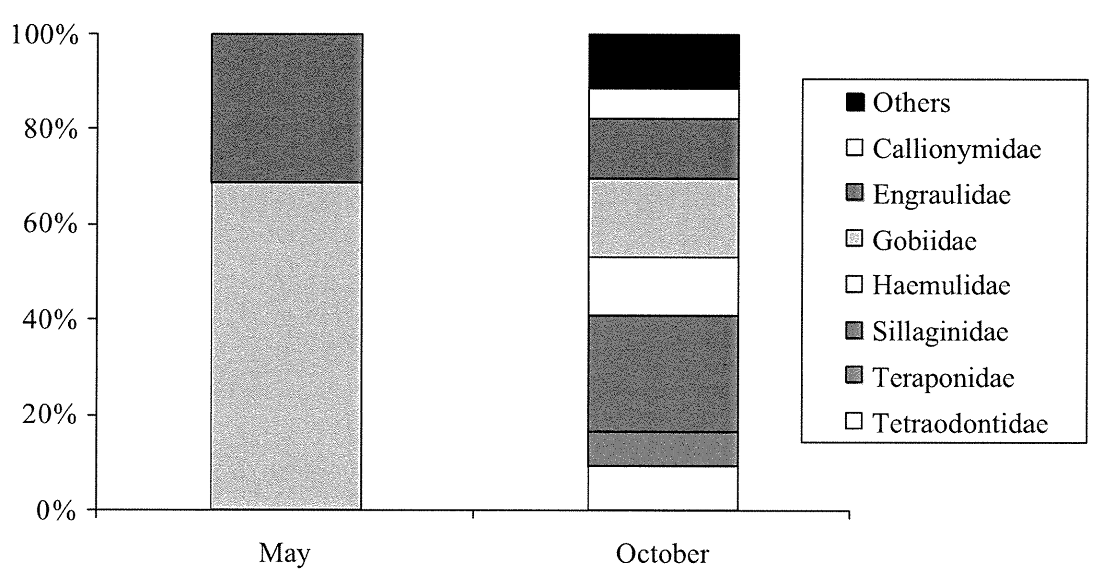

Figure 4.10. Percent composition of each family of fish collected in Ince Bay in May 1999 and October 1999.

No commercially important species of fish were caught in the beam trawls in May 1999. The Goby (*Exyrias puntang*) which is of some importance to the aquarium trade in northeastern Australia was caught, but only comprised 3% of the catch (Table 4.6). In October, over 40% of the fish were of some commercial importance (including whiting, golden grunter, mojarra, and spinefoot) and 12 % of the catch were of recreational importance (including golden grunter) (Figure 4.11).

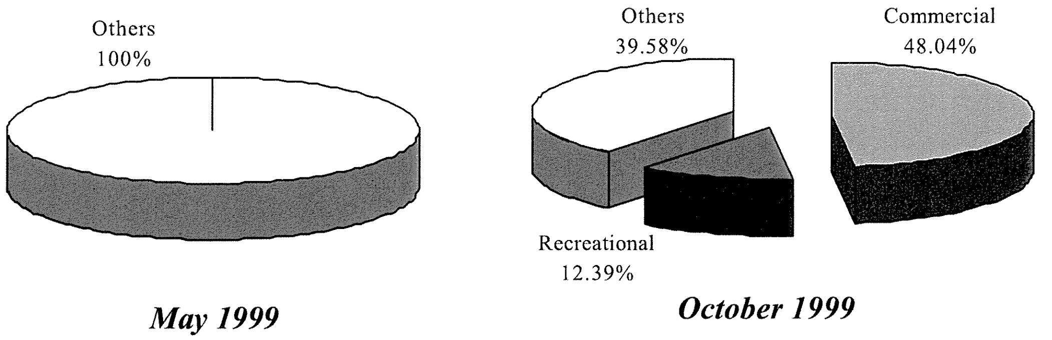

Figure 4.11. Composition of fishery value for fish collected from beam trawls in Ince Bay in May 1999 and October 1999.

Table 4.6 Taxa,value codes, size data abundance and biomass* for fish collected from Ince Bay May and October 1999.

Value codes (from Coles et al. *1993):**A**, targeted aquarium species;* ***a**, incidental aquarium species;* ***b**, incidental baitfish species;* ***C**, targeted commercial species;* ***c** incidental commercial species;* ***R** , targeted recreational species;* ***r**, incidental recreational species.*

* Biomass = all taxa pooled in May 1999.

Family	Species	Common name	Fishery code	May 1999			October 1999		
				mean SL (mm) ±SE (range)	*n* (%)	biomass g DW	mean SL (mm) ±SE (range)	*n* (%)	biomass g DW
Apogonidae	*Gronovichthys atripes*	Cardinalfish	a	*absent*	-		13.70 ±1.40 (12.30 - 15.10)	2 (0.60)	0.03
Callionymidae	*Callionymus limiceps*	Dragonet	A	*absent*	-		11.60 ±1.34 (6.00 - 25.30)	22 (6.65)	0.18
Engraulidae	*Stolephorus* sp. A	Anchovy	-	13.88 ±0.54 (7.50 - 27.60)	41 (31.30)		12.91 ±0.58 (6.40 - 23.90)	41 (12.39)	0.11
Gerreidae	Gerreidae sp. A	Mojarra	b	*absent*	-		10.90	1 (0.30)	0.01
Gobiidae	*Exyrias puntang*	Goby	A	29.37 ±2.27 (26.00 - 33.70)	3 (2.29)		*absent*	-	-
Gobiidae	*Glossogobius biocellatus*	Mangrove goby	-	24.27 ±0.77 (22.80 - 25.40)	3 (2.29)		*absent*	-	-
Gobiidae	*Glossogobius circumspectus*	Goby	-	13.87 ±0.33 (7.40 - 22.50)	81 (61.83)		12.75 ±0.47 (6.80 - 20.70)	55 (16.62)	0.26
Gobiidae	Gobiidae sp. A	Goby	-	13.00 ±1.21 (10.70 - 14.80)	3 (2.29)		*absent*	-	-
Haemulidae	*Pomadasys kaakan*	Golden grunter	cR	*absent*	-		18.28 ±0.25 (11.70 - 22.20)	41 (12.39)	0.86
Hemiramphidae	*Hyporhamphus ardelio*	Garfish	-	*absent*	-		33.50	1 (0.30)	0.01
Labridae	Labridae sp. A	Wrasse	a	*absent*	-		9.20	1 (0.30)	0.01
Leiognathidae	Leiognathidae sp. A	Ponyfish	-	*absent*	-		9.06 ±0.48 (7.80 - 10.10)	5 (1.51)	0.04
Monacanthidae	Monacanthidae sp. A	Leatherjacket	a	*absent*	-		10.82 ±1.06 (6.20 - 17.60)	13 (3.93)	0.12
Siganidae	Siganidae sp. A	Spinefoot	ac	*absent*	-		21.15 ±0.26 (20.20 - 21.80)	6 (1.81)	0.20
Siganidae	*Siganus guttatus*	Golden spinefoot	ac	*absent*	-		21.63 ±0.37 (20.90 - 22.10)	3 (0.91)	0.08
Sillaginidae	*Sillago* sp. A	Whiting	cr	*absent*	-		14.40 ±0.32 (7.50 - 20.10)	81 (24.47)	0.41
Teraponidae	*Pelates quadrilineatus*	Trumpeter	-	*absent*	-		11.96 ±0.45 (7.90 - 15.70)	23 (6.95)	0.06
Tetraodontidae	Tetraodontidae sp. A	Toadfish	a	*absent*	-		10.32 ±0.91 (7.60 - 13.40)	6 (1.81)	0.06
Tetraodontidae	Tetraodontidae sp. C	Toadfish	a	*absent*	-		7.82 ±0.57 (3.10 - 12.70)	25 (7.55)	0.16
Unidentified	Unidentified larvae	-	-	*absent*	-		9.78 ±2.32 (5.80 - 18.70)	5 (1.51)	0.02
TOTAL				**14.44 ±0.36 (7.40 - 33.70)**	**131 (100)**	**1.10**	**13.41 ±0.25 (3.10 - 33.50)**	**331 (100)**	**2.62**

Dugong and Sea Turtles

Dugong feeding trails were abundant throughout the extensive *Halodule uninervis* meadows between Allom Point, Glendower Point and Cape Palmerston (Map 4.8 & 4.9) during both dive surveys and the helicopter reconnaissance. Only one dugong was sighted in the eastern end of Ince Bay in May (Map 4.8) over an extensive *Halodule uninervis* (narrow) meadow.

Turtles were frequently sighted during the dive surveys in localities where seagrass was present in Ince Bay.

No sea turtles, dugong or dugong feeding trails were observed in Llewellyn Bay.

DISCUSSION

Seagrass

All seagrasses in Ince Bay occurred on large intertidal banks. Small isolated meadows of seagrass were present both intertidally and subtidally Llewellyn Bay. The distribution and abundance of seagrasses within the sheltered parts of both bays could be due to prevailing winds and currents. In Ince Bay, the north facing coastline protects extensive seagrass meadows on intertidal flats from the predominantly south-easterly winds, swells and currents, while the northern part of Llewellyn Bay is not sheltered from south-easterly weather and seagrasses were only found in small isolated patches in relatively sheltered areas.

The area of seagrass in Ince Bay in 1987 was similar to that found in the present survey. Seagrass area increased slightly (less than 10%) between the surveys conducted in May and October 1999. Coles *et al.* (1987a) mapped 1472 ha in 1987, while the present study mapped 1204 ±134 in May and 1573 ±187 ha in October 1999. The location of Ince Bay seagrass meadows in 1999 was also similar to the March 1987 broad scale survey (Coles *et al.* 1987a).

No seagrass was found in Llewellyn Bay during the 1987 survey, however, 115 ±50 ha of seagrass habitat was mapped in Llewellyn Bay May 1999 and 117 ±55 ha in October 1999. The difference between 1987 and the 1999 surveys is most likely a consequence of no sites being sampled in the intertidal region due to the tidal conditions restricting vessel access in the 1987 survey (Coles *et al.* 1987a).

FRC (1997) estimated a decline of around 50% in Ince Bay seagrass habitat area in July 1997 compared with the broadscale survey undertaken by Coles *et al.* (1987a). Large errors can be expected with broad-scale mapping. Variations in the area of seagrass reported by FRC (1997) could be due to short term (eg flood events) or long term (eg El Nino/La Nina related variations in the Southern Oscillation Index) changes in environmental conditions. Seasonal changes in the abundance of north Queensland seagrasses range up to six fold (McKenzie, 1994). The area of seagrass habitat has also been reported to change naturally within the tropical regions. QDPI (1999) found up to a 20% change in the area of a *Halodule pinifolia* dominated meadow (morphologically similar to the narrow leafed form of *Halodule uninervis*) over four years of monitoring in Karumba.

Deepwater seagrasses (>10 m below MSL) were only found in the October 1999 survey in Llewellyn Bay where *Halophila decipiens* and *Halophila spinulosa* were found in low abundance at three deepwater sites. Seagrass was not found at the same deepwater sites in May 1999, and this could be due to a typically low growing period through autumn (Lee Long *et al.* 1997). The paucity of deepwater seagrasses in this region is probably due to strong currents, large tides and limited light reaching the plants. Deepwater surveys by QDPI found seagrasses were sparse south of Mackay where tidal velocities were high (tidal range 4-6m) (Coles *et al.* 2000). Strong tidal currents appear to "scour" the substrate and limit establishment of seagrasses. Seagrass growth from seeds is probably very opportunistic in this area and limited by the tide and current conditions. Tidal currents and associated high water turbidity in Ince and Llewellyn Bay may limit light penetration at depth and confine seagrass survival to the intertidal banks where sufficient light reaches the plants during day-time low tides.

More seagrass species were found in October than in May, for both DPAs. In October 1999, *Halophila decipiens* and *Halophila spinulosa* were found in Llewellyn Bay and *Halophila decipiens* and *Halodule uninervis* (wide) were found in Ince Bay. The presence of various seagrass species and their ability to recover can vary substantially between years depending on the seed stock and viability (McKenzie *et al.* 1998). Presently, nothing is known of the available seed bank and genetic diversity within these Dugong Protection Areas.

All seagrasses found in Ince Bay and Llewellyn Bay were of low biomass (<30 g DW m^{-2}) and predominantly of narrow leaf morphology (*Halodule uninervis* and *Zostera capricorni*). While there was a significant difference between the biomass of *Halodule uninervis* (narrow) between the May and October 1999 survey in Llewellyn Bay, this may be an artefact of field observers mistaking *Zostera capricorni* (narrow leaf form) with *Halodule uninervis*. The growth forms of both these species in Llewellyn Bay were very similar and an inexperienced diver/observer could have recorded *Zostera capricorni* plants as *Halodule uninervis* (narrow form). The biomass of other species found in Ince and Llewellyn DPAs changed little between the two surveys.

Ince and Llewellyn Bay are relatively remote, with the nearest large township of Mackay approximately 40 km north. Urban/stormwater runoff problems are minimal in the Bays compared to more populated areas. Recreational fishing and boating originating from the Armstrong Beach boat ramp and Cape Palmerston beach launch represents a minor threat to the seagrasses growing in this region. There is no increasing development pressure upstream from Ince Bay which supports large areas of dugong preferred seagrass species. Conservation management in Ince Bay and its catchment such as Cape Palmerston National Park, the Cape Palmerston and Rocky Dam FHA and Marine Park - General Use B in Ince Bay, will help to conserve the existing seagrass resources of the area. Llewellyn Bay does not support extensive areas of seagrass resources and it is not protected with the same level of conservation management eg, a general Use'A' zone where trawling is permitted.

Prawns and Fish

King prawns, banana prawns and tiger prawns dominated commercial prawn catches between 1994-1999 within the study region, with catches of 34.1 tonnes up to 71.6 tonnes (QFMA, 2000 data). Beam trawls conducted in this survey over sparse *Halodule uninervis* habitat caught very few penaeid prawn species targeted by this fishery. Banana prawns were not caught in the Ince Bay beam trawls and very few brown tiger prawns (n=2), red spot king prawns (n=1), and western king prawns (n=8) were caught in October 1999. Juvenile banana prawns are usually found within mangrove habitats and bare muddy substrata adjacent to mangrove areas and have been absent from beam trawls over seagrass beds in the past (Coles *et al.* 1987b). Red spot king prawns have been found over shallow reef platform habitats and in large numbers in inshore coastal waters in the Escape River (Coles *et al.* 1987b). The low abundances of prawns caught in the surveys may be due the time of year. Brown tiger prawns and western king prawns post-larvae settle in summer rather than winter and spring (Coles *et al.* 1987b)

The major commercial fin fish fisheries within the study region include shark, barramundi, mackerel, mullet, blue salmon and to a lesser extent queen fish, king salmon and whiting (QFMA, 2000 data). Whiting, golden grunter, spinefoot and golden spinefoot juveniles were the only fish caught in Ince Bay beam October trawl with some commercial importance, while gobies and anchovies dominated the catch in the May beam trawls. Beam trawling only catches a sub set of the total fish community, and large faster swimming fish tend to escape capture (McKenzie *et al.* 1996) and could have been missed in the May and October beam trawls.

Beam trawl catches in the present study indicate that the seagrass habitat in Ince Bay is more important to commercial prawn and fin fish fisheries particularly in Spring when recruits are settling.

The Ince Bay beam trawl site did not support as many species or individual fish compared with other sites beam trawled by QDPI in North Eastern Australia (Coles *et al.* 1993, McKenzie *et al.* 1998, Lee Long *et al.* 1999). Larger, denser seagrass habitats including *Zostera capricorni, Halodule uninervis* (wide) or *Cymodocea* spp sampled in Shoalwater Bay also in Autumn and Spring (April and September), approximately 120km south of Ince Bay (Lee Long *et al.* 1997) supported a greater abundance of juvenile prawns and fish.

Dugong

Ince Bay is an important area for dugong. Ince Bay contains significant areas of seagrass species preferred by dugong (*Halophila* species and *Halodule uninervis*) and abundant feeding trails indicates the area is frequented by dugong.

The intensive grazing in these meadows may also maintain the seagrass community in a "colonising" state, dominated by fast reproducing and fast growing *Halophila* and *Halodule* species. Grazing may improve the capacity of the meadows to provide better "quality" food than areas supporting few or no dugong and that rely only on natural turnover rates for recycling and redistribution of nutrients (Aragones and Marsh, 2000). The high-energy physical disturbances associated with climate and tidal forces in Ince Bay could contribute to low biomass, fast growing *Halodule uninervis* dominated meadows, remaining suitable for dugong feeding.

The majority of seagrasses in this region are restricted to intertidal banks which could limit the tidal period in which dugong can gain access to their food resource. This represents an important limit to the potential for dugong survival and population capacity in the area.

The seagrass resources in Llewellyn Bay do not appear to be favoured for feeding by dugong or turtles as no individuals nor any evidence of feeding was observed during the aerial reconnaissance or dive surveys. Deepwater seagrass patches observed in Llewellyn Bay during the video survey however may provide suitable habitat for dugong feeding, and should be considered potentially important for dugong.

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5. SEAGRASS RESOURCES OF THE CLAIRVIEW REGION DUGONG PROTECTION AREA - RECONNAISSANCE 1999

Chantal Roder, Rob Coles, Len Mckenzie & Warren Lee Long

BACKGROUND

Description of Study Locality

The Clairview region Dugong Protection Area (DPA) is located in the southern section of the Great Barrier Reef World Heritage Area. The DPA is approximately 130 km south of the city of Mackay, and 205km north of Rockhampton. It extends from just north of Carmila Creek to Clairview Bluff at its southern limit (Map 5.1).

Mean annual rainfall in the Clairview region is 1028 mm and minimum and maximum daily temperatures range from 10.8°C in July to 31.7°C in January (St Lawrence) (59.2 year average, Australian Bureau of Meteorology 2001). Winds are predominantly south-easterly in the dry cooler months of the year and light northerly winds during the summer wet season months.

Northern and southern parts of the Clairview region DPA are within Fish Habitat Areas (Carmila 033-025A and Broad Sound 015-045A) (Map 5.1). Fish Habitat Areas have been declared throughout coastal Queensland to enhance existing and future fishing activities and to protect the habitat upon which fish and other aquatic fauna depend. Offshore waters of Clairview region DPA are zoned Marine Park General Use A (Map 5.1), while no Marine Park zoning exists for most of the inshore section.

To protect the dugong and their habitat in the Clairview region, the area was declared a level a "B" DPA on 12th January 1998 (Map 5.1). The "B" level DPA restriction include limits on the length, placement and attendance of offshore, foreshore and river set nets as well as the allowance of a new rocky foreshore (headlands) set net. River set net use is less restrictive in "B" than "A" DPAs. The DPA boundaries were based on information on dugong population numbers and seagrasses suitable for dugong feeding mapped in 1987. The number of dugong in this area (from Sarina Inlet to Stannage Bay) fell from 542 ±293 in 1987 to 82 ± 60 in 1994, representing a decline of 85% (Marsh *et al.* 1996). Preen and Morrissette (1997) note that the Clairview region DPA is one of the two coastal areas (the other area including Sarina Inlet/ Ince Bay and Llewellyn Bay) where dugongs are commonly seen.

The Clairview region DPA covers approximately 35 km of coastline and 26, 390 ha in area (Map 5.1). The DPA is characterised by wide intertidal flats (up to 3km) with sand cays and islands (Aquila and Flock Pigeon) in offshore areas (Map 5.1). The remainder of the DPA is mostly shallow (<10m) and subtidal. The most notable feature of the Clairview region is the large tidal range for the area of up to 8.5 m (Queensland Department of Transport, 2001). Small creeks (including Carmila Ck, Flaggy Rock Creek and a number of intermittent creeks) drain into the north and the township of Clairview is situated on the southern coast of the DPA (Map 5.1). The predominant land use in the area is dryland grazing by livestock. The permanent human population of Clairview is less than 50. The area is a popular destination for recreational anglers and holidaymakers.

Seagrasses of the Clairview Region

Seagrass meadows in the Clairview region were first mapped during a broad scale survey of seagrasses from Bowen to Water Park Point in March and April 1987 (Coles *et al.* 1987a, Lee Long *et al.* 1993, Coles *et al.* 2001). A total of 1880 ha of seagrass meadows were mapped (1476 ha of <10% cover and 404 ha of 10% cover) in the Clairview region (Map 5.3). Five species of seagrass were identified in this region, including *Halophila ovalis, Halophila spinulosa, Halodule uninervis* (narrow leaf form), *Halodule pinifolia* and *Zostera capricorni* (Lee Long *et al.* 1993, Coles *et al.* 2001).

The seagrass meadows mapped in 1987 in the Clairview region are within 1 km from boat ramps (Map 5.3). The average range of recreational fishing trips in the area is 30km per trip (Great Barrier Reef Marine Park Authority, 1997) and seagrass meadows within this DPA have a potential to be valuable sources of fisheries productivity.

The present survey is a reconnaissance survey only of the inshore intertidal seagrasses species present in the Clairview region DPA in April 1999. It is not a new comprehensive baseline set of maps and information of seagrasses in the Clairview region.

RESULTS

Seagrass Species, Distribution and Abundance

Two seagrass species (from 2 families) were found during the April 1999 helicopter survey of the inshore intertidal reaches of the Clairview region DPA. (Table 5.1).

Table 5. 1 Seagrass species present, mean above-ground seagrass biomass and number of sites where seagrass species were present, in the Clairview region Dugong Protection Area April 1999.

Seagrass Family	Seagrass Species	Mean± SE (range) (g DW m^{-2})	No. of sites present
CYMODOCEACEAE Taylor	*Halodule uninervis* (narrow leaf morph) (Forsk.) Aschers.	6.1±0.90 (3.3-10.7)	7
HYDROCHARITACEAE Jussieu	*Halophila ovalis* (R. Br.) Hook. *f*	1.1 (no SE) (0.1-2.2)	2

12 coastal sites were ground truthed in April 1999 and seagrass was present at 7 of these sites (Map 5.2). *Halodule uninervis* was the most common species present at these sites. No shallow subtidal or deepwater sites were surveyed.

Seagrass was found present along most of the wide coastal band of exposed intertidal sandbanks (up to 3km perpendicular from shore) in Clairview region DPA (Map 5.2).

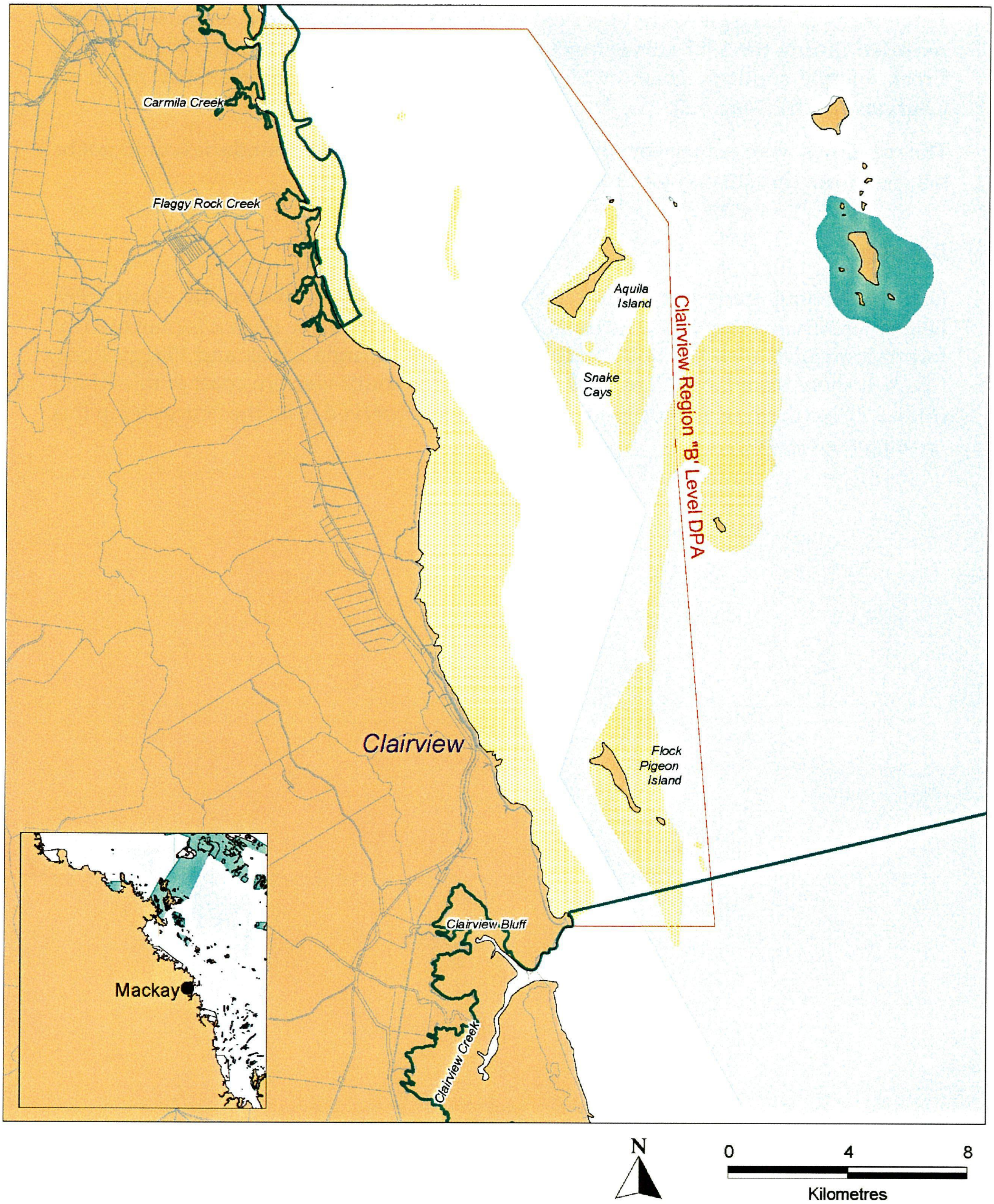
Three areas of seagrass were observed on intertidal banks where seagrass was not recorded during the 1987 survey (including areas between Carmila and Flaggy Rock Creek, off the southern coast of Flock Pigeon Island and in a small bay north of Clairview Bluff) (Map 5.2).

The meadows were not surveyed at a fine scale, and meadow boundaries could not be mapped form this survey with reliability (Map 5.2).

Dugong

Dugong feeding trails were observed in three main areas during the April 1999 helicopter survey (Map 5.2). The trails were sighted in *Halodule uninervis* (narrow leaf form) dominated meadows on sandbanks between Carmila Creek and Flaggy Rock Creek, inshore from Flock Pigeon Island and off the south-western coast of this Island (Map 5.2). No dugong, sea turtles or dolphins were observed from the helicopter in this reconnaissance study.

Map 5.1 Clairview Dugong Protection Area



LEGEND

- Sandbanks
- Dugong Protection Area Boundary
- Fish Habitat Area Boundary
- Marine Park - General Use A
- Marine Park - General Use B

Source: Roder, C.A., Coles, R.G., McKenzie, L.J. and Lee Long, W.J. (2001). Seagrass Resources of the Clairview Dugong Protection Area - Reconnaissance 1999. In. "Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Llewellyn/Ince Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 5, pp 117-124. (DPI, Cairns).

Report to the Great Barrier Reef Marine Park Authority. (Queensland Department of Primary Industries: Northern Fisheries Centre, Cairns).

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

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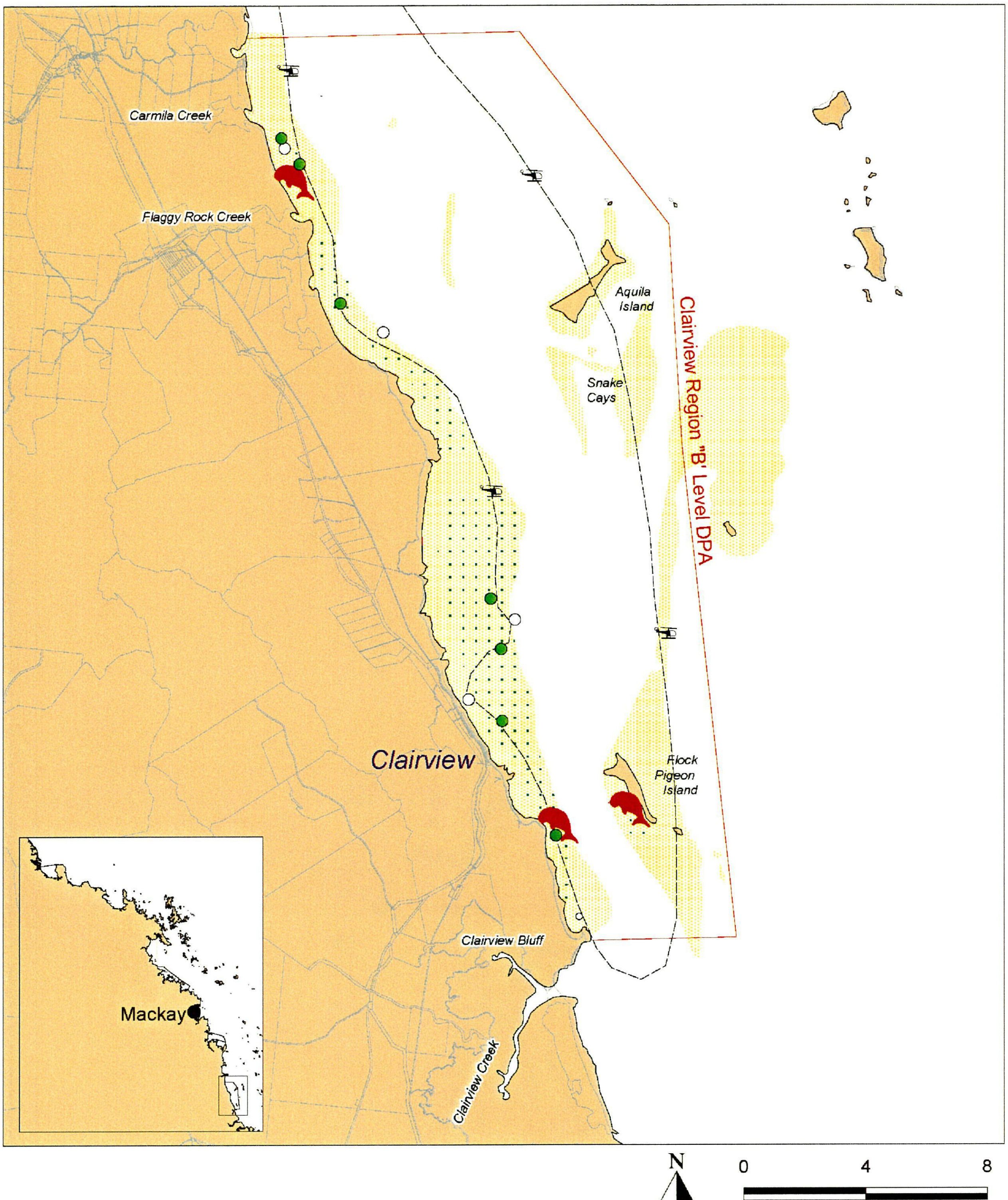
Map 5.2

Survey sites and intertidal seagrass resources in the Clairview Dugong Protection Area - April 1999



LEGEND

- Sandbanks
- Dugong Feeding Trails
- Seagrass (approximate area)
- Seagrass - ground truth site
- No seagrass - ground truth site
- Helicopter flight path

Source: Roder, C.A., Coles, R.G., McKenzie, L.J. and Lee Long, W.J. (2001). Seagrass Resources of the Clairview Dugong Protection Area - Reconnaissance 1999. In. "Seagrass and Marine Resources in the Dugong Protection Areas of Upstart Bay, Newry Region/Sand Bay, Llewellyn/Ince Bays and the Clairview Region, April/May 1999 and October 1999.' (Eds. R.G. Coles, W.J. Lee Long, L.J. McKenzie and C.A. Roder) Section 5, pp 117-124. (DPI, Cairns).

Report to the Great Barrier Reef Marine Park Authority. (Queensland Department of Primary Industries: Northern Fisheries Centre, Cairns).

Sampling dates: Helicopter survey 27-28 April 1999

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

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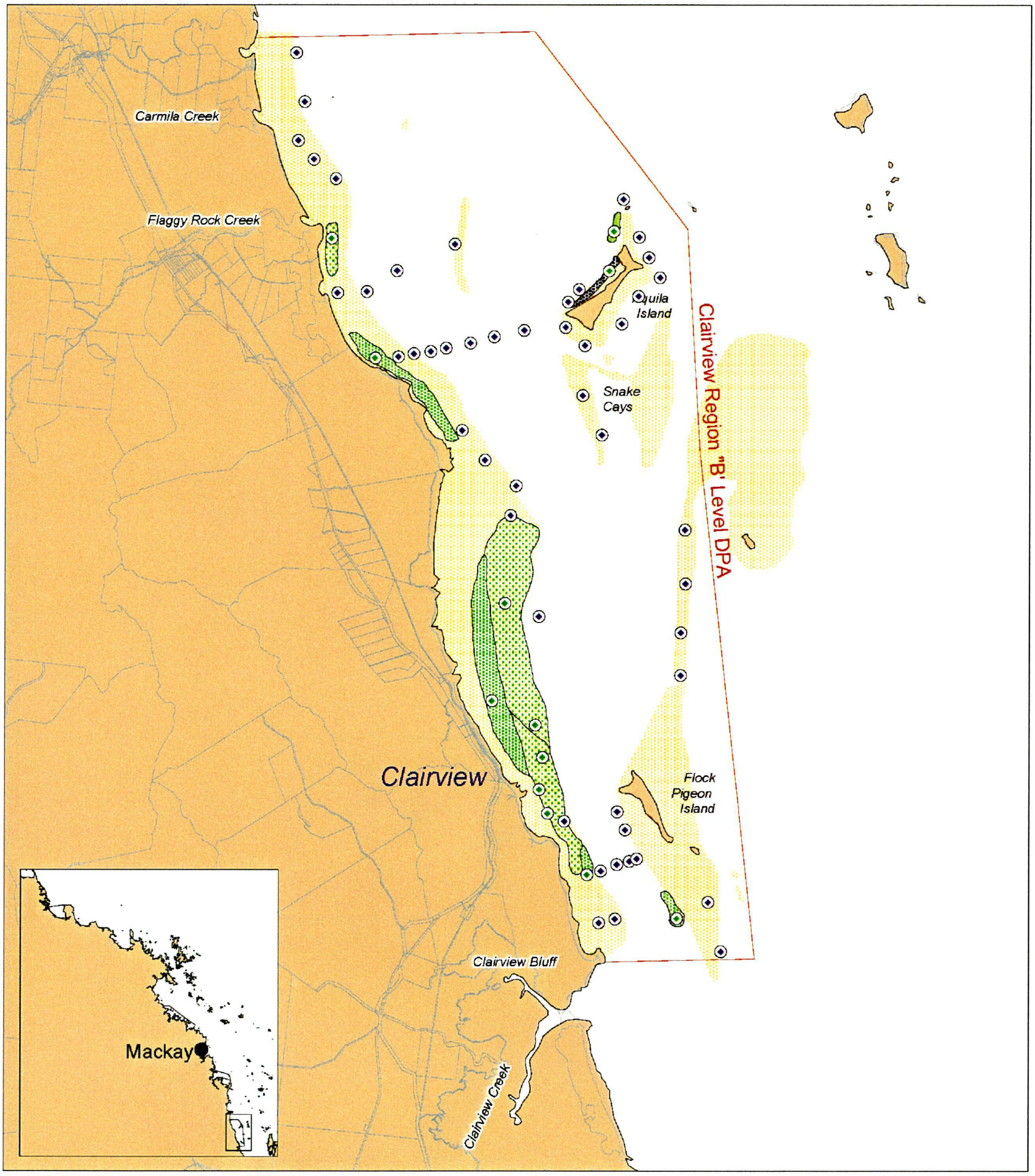
Map 5.3

Survey sites and seagrass meadows in the Clairview Dugong Protection Area - March 1987



LEGEND

- Sandbanks
- Seagrass
- No seagrass
- *Halodule uninervis (1%)*
- *Halodule/Halophila (1-10%)*
- *Halodule/Halophila (10%)*
- *Halophila spinulosa(1-10%)*

Source: Coles, R.G., McKenzie, L.J. & Yoshida, R.L. (2001) Validation and GIS of seagrass surveys between Bowen to Water Park Point - April 1987.

Sampling dates: Dive survey 22-23 March1987

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

Queensland Government Department of Primary Industries

DISCUSSION

Seagrass

The distribution of seagrass meadows along intertidal inshore areas of the Clairview region DPA in the present reconnaissance was similar to seagrass distribution mapped in the 1987 survey. The 1987 survey mapped an extensive seagrass meadow (approximately 11 km in length) along the inshore sandbank directly in front of the Clairview township. The present reconnaissance ground truthed 4 sites within this meadow, and seagrass was present at all sites. Most of the other intertidal seagrass meadows mapped along the coastal sandbanks in the 1987 survey were observed in the 1999 reconnaissance.

Three additional intertidal areas of seagrass were observed in April 1999 where no seagrass was observed during the 1987 survey. These areas are located between Carmila and Flaggy Rock Creek, off the southern coast of Flock Pigeon Island and a small north facing bay of Clairview Bluff.

Seagrass species (*Halodule uninervis* and *Halophila ovalis*) observed in Clairview Region DPA in 1999, are those preferred by dugong for food (Preen, 1995). Extensive meadows of these species were found along the coastal sandbanks of the Clairview region DPA.

Subtidal areas were not surveyed in the 1999 reconnaissance. Anecdotal reports suggest concentrations of dugong occur at low tides, indicating the possible presence of subtidal seagrass meadows. The large tidal range (up to 8.5 m) in this region exposes all intertidal seagrasses making the majority of food in this region unavailable for dugong during low spring tides. Subtidal seagrasses habitat in the Clairview region would therefore be important for feeding dugong during low spring tides. Current and fine-scale information on subtidal seagrasses resources in the Clairview region DPA is not available.

The seagrass resources in the Clairview region "B" DPA appear to be of similar value as the Ince Bay "A" DPA. Based on available seagrass resources and anecdotal information of the dugong usage of this area, we suggest that a fine-scale survey of seagrass resources (particularly subtidal areas) of the Clairview region DPA be undertaken.

Dugong

Anecdotal information indicates extensive use of the Clairview region DPA by many dugong, including herds of up to 20 individuals (S. Fisher, Queensland Parks and Wildlife Service, Pers. Comm.). Local fishers and rangers have reported seeing dugong frequenting a deepwater hole just south of Aquila Island during low tides, and have noted herds of dugong migrating from Clairview to Sarina Inlet. Clairview region seagrasses provide extensive seagrass habitat to dugong in this region. Dugong are noted to move up to 600km (Preen, 2001), and the Clairview region is likely an important habitat for dugong migrating between Shoalwater Bay and Ince Bay.

Dugong feeding trails were observed in *Halodule uninervis* dominated meadows, in the Clairview region DPA on intertidal sandbanks. While anecdotal evidence suggests that dugong inhabit subtidal areas south-west of Aquila Island, these areas were not sampled in this survey. No observations of dugong themselves were made from the helicopter.

A fine-scale survey of the seagrass resources of Clairview region and study into the migration of dugong from Clairview to Sarina Inlet would provide a more useful information base for the management of the Clairview region DPA.

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Appendix 1. Results of linear regressions of each divers biomass estimation with harvested above-ground biomass (g D W m^{-2}) in May 1999 and October 1999.

Diver	May 1999 low biomass calibration			May 1999 high biomass calibration		
	r^2	F	p	r^2	F	p
Matt Hollis	0.89	33.02	0.005	-	-	-
Michael Rasheed	0.91	38.54	.003	0.98	131.26	.002
Chantal Roder	0.91	39.51	.003	0.96	72.48	.003
Anthony Roelofs	0.92	46.76	.002	0.98	176.26	<<0.001
Ross Thomas	0.91	38.26	.004	0.93	38.78	.008

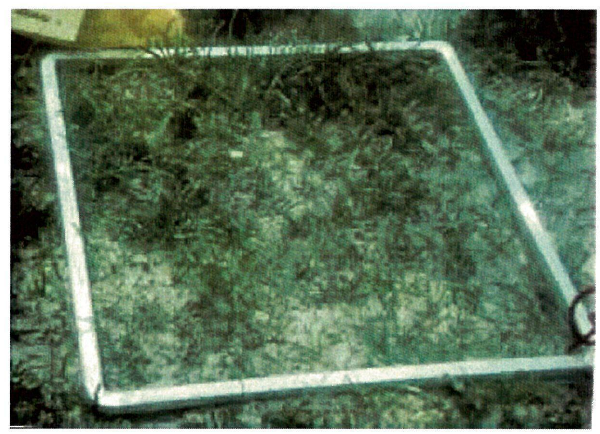
Diver	Oct 1999 low biomass calibration			Oct 1999 high biomass calibration		
	r^2	F	p	r^2	F	p
Michael Baer	0.90	36.06	0.004	0.89	23.88	0.02
Michael Rasheed	0.89	31.13	0.005	0.99	442.68	<<0.001
Chantal Roder	0.96	85.06	<<0.001	0.88	22.07	0.02
Anthony Roelofs	0.81	16.85	0.01	0.96	70.06	0.004
Ross Thomas	0.91	40.89	.003	0.97	83.00	0.003

Appendix 2. Examples of seagrass above-ground biomass, from reference photos of a 0.25 m^2 quadrat.

Halophila ovalis **3.12 g DW m^{-2}**

Halodule uninervis **(wide) 6.44 g DW m^{-2}**

Halodule uninervis **(wide) 12.92 g DW m^{-2}**



Halodule uninervis **(wide) 36.24 g DW m^{-2}**

Syringodium isoetifolium/
Halodule uninervis **(wide) 51.04 g DW m^{-2}**

Halophila spinulosa **58.16 g DW m^{-2}**

Kinetica