INTRODUCTION

Consultancy Brief

The Commonwealth Commission of Inquiry into Shoalwater Bay (Commission of Inquiry 1994) recommended equal priority be given to conservation and defence force training use in the Shoalwater Bay area, and that integrated management plans be developed for the terrestrial and marine environments. The Great Barrier Reef Marine Park Authority (GBRMPA) was given responsibility for developing management plans for a special Shoalwater Bay Marine Park. The GBRMPA commissioned a number of studies of marine resource inventories and use patterns in the Shoalwater Bay area for marine park zone planning. The present Spring and Autumn baseline surveys of seagrass resources is one of these studies.

Seagrasses have seasonal differences in distribution and abundance, so two baseline surveys - Spring (pre-wet) and Autumn (post-wet) - were recommended. This report presents the results of the two surveys conducted September 1995 and April 1996. The objectives were:

1. *To map the distribution of seagrass meadows in Shoalwater Bay during the Spring and Autumn periods.*
2. *To estimate seagrass species biomass for the major seagrass meadows.*
3. *To identify juvenile prawn and fish species present on selected seagrass areas.*
4. *To provide quantitative data on seagrass communities of Shoalwater Bay for use as a baseline for future monitoring of seagrass species composition, area or biomass.*

Site Description

Shoalwater Bay is located in the southern section of the Great Barrier Reef Marine Park World Heritage Area (Figure 1). The Shoalwater Bay Area covers 520 000 ha, of which approximately 50 % is marine (Commonwealth Commission of Inquiry 1994). There is relatively little human disturbance (coastal towns and development, *etc.*) and it is a largely intact natural system. The area has been reserved for defence force training since 1965. The most notable feature of the Shoalwater Bay area is the massive tidal range - up to 7 metres(Queensland Department of Transport 1995), which in some places has the effect of creating extensive tidal banks.

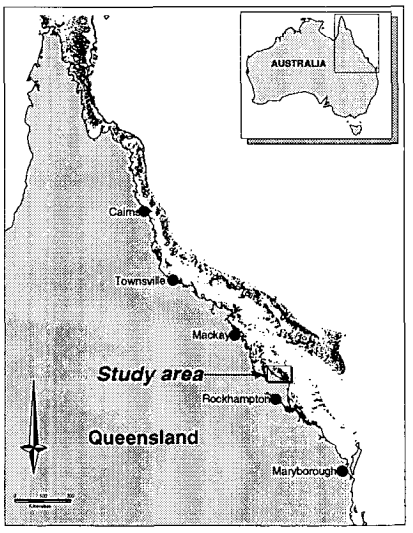

Figure 1. Location of Shoalwater Bay study area.

The area supports several inshore fishing industries. The Shoalwater Bay area produces less than 2% of the state's prawn and fin-fish production, but between 7-8% of the states commercial mud crab production (Fitzsimmons 1996). The low fish production in Shoalwater Bay is largely for reasons to do with the remoteness of the region and access problems posed for both recreational and commercial fishers, rather than low fish abundance (Fitzsimmons 1996). Seagrasses and mangroves in the Shoalwater Bay area are considered regionally important as nursery habitats for species of commercial and recreational fishing value.

The soils of the region are generally leached and infertile (Commission of Inquiry 1994). Some soils have potential acid sulphate properties. Rainfall is seasonal and highly variable between years. The south-eastern section is generally the wettest, and the coastal areas are wetter than inland areas, where long drought periods are reasonably frequent. Winds are south-easterly trade in the dry, cooler months of the year and light northerly winds occur during the summer monsoon season.

General Seagrass Ecology

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

The growth of seagrasses depends on several factors including the availability of light (Dennison 1987; Williams and Dennison 1990), nutrients (Orth 1977; Erftemeijer 1994) and water temperature (Bulthuis 1987). Activities that lead to a change in these factors, such as runoff from agriculture and turbidity from dredging, could potentially have a negative impact on seagrass growth and distribution. Seagrasses show measurable growth responses to changes in ambient water quality conditions and can therefore be used as effective indicators of environmental health (Dennison *et al.* 1993; Dennison and Kirkman 1996).

Tropical seagrass meadows are subject to natural temporal changes, varying seasonally and between years (Mellors *et al.* 1993; McKenzie 1994). The potential for widespread seagrass loss has been well documented and the causes of loss can be natural such as cyclones and floods (Poiner *et al.* 1989), or due to human influences such as agricultural runoff (Preen *et al.* 1995), industrial runoff (Shepherd *et al.* 1989), oil spills (Jackson *et al.* 1989) and dredging (Pringle 1989).

Shoalwater Bay seagrasses

Seagrass meadows in and around Shoalwater Bay were first mapped during a broad scale survey from Bowen to Water Park Point in March and April 1987 (Coles *et al.* 1987b; Lee Long *et al.* 1993) and large areas of patchy and dense seagrass were found on the shallow banks within the bay.

The present surveys were designed to obtain detailed assessments of the seagrass resources for marine park planning. A separate collection of seagrass specimens, including fruit and flowers, were taken from Stannage Bay; immediately north west of the Shoalwater Bay area. Seagrass plants in Stannage Bay are possibly a new species which was first identified from collections from this locality in the Queensland Department of Primary Industries 1987 seagrass survey.

The present surveys also provide a qualitative measure of the prawn nursery habitat value of selected meadows. Local populations of fish, dugong and green sea-turtles also depend on these seagrasses; information on which are the subject of other reports (Fitzsimmons 1996).

METHODS

Survey Methods

The survey area for the purposes of this study was from Macdonald Point in the north of Shoalwater Bay, across the northern tip of Townshend Island and then to Port Clinton (Map1). The Cannibal Group of islands was also included in the April 1996 survey (Map 2).

Aerial photography, and helicopter reconnaissance flights prior to both dive-based surveys, were used to scope the extent of seagrass meadows, identify the priority areas to be surveyed and aid in the mapping of meadow boundaries. As large tidal ranges in the survey region limit access to the wide, shallow tidal flats for many hours each day, the helicopter was used to survey and check upper intertidal areas. The lower intertidal and sub-tidal seagrasses were surveyed by divers.

A field sampling design was developed to estimate area and biomass of seagrasses. The design was stratified by depth and meadow, taking into account the topography of the bay, time and tide constraints. On intertidal banks, survey sites were sampled approximately every 150-200 m along transects and at selected spots between transects. Transects were approximately 1-1.5 km apart. In subtidal areas, survey sites were sampled approximately 1.5-2.0 km apart along selected transects which traversed the bay.

A more detailed sampling regime was applied to seven "monitoring meadows", which represented the major seagrass habitat types found in the survey area, to give more precise estimates of species biomass at those locations and to be used as a management tool. At these meadows, sites were surveyed every 50 m haphazardly. These monitoring meadows will be used as baselines against which change in seagrass biomass can be compared and monitored in Shoalwater Bay.

Sampling was conducted between 13- 20 September 1995 and between 3 - 11 April 1996 (Maps 1 & 2). At each survey site estimates of above-ground seagrass biomass (3-5 replicates of a 0.25 m^2 quadrat), seagrass species composition, % cover of algae and sediment characteristics were recorded. The relative proportion of biomass of each seagrass species within each survey quadrat was also recorded.

Above-ground biomass was determined by a "visual estimates of biomass" technique described by Mellors (1991). At each site, divers recorded an estimated rank of seagrass biomass. To convert above-ground biomass estimates into grams dry weight per metre of meadow (g DW m^{-2}), each diver's ranks were calibrated against a set of harvested quadrats.

Seagrass species were identified according to Kuo and McComb (1989). Voucher specimens of seagrass were also collected for later taxonomic verification where necessary. Sediment characteristics were described using visual estimates of grain size: shell grit, rock gravel, coarse sand, sand, fine sand and mud.

A differential Global Positioning System (GPS) was used to accurately determine geographic location of survey sites (±5 m). Depths of survey sites were recorded with a depth sounder standardised to depth below Mean Sea Level (MSL), corrected to tidal plane datum (Queensland Department of Transport 1995). Tidal plane and time differences for the southern section of Shoalwater Bay and in Island Head Creek are not accurately known and corrected depth values for sites in these areas were approximated.

Additional sampling was conducted by staff from the Great Barrier Reef Marine Park Authority on 11- 18 December 1995 (Map 1) as part of a survey of Shoalwater Bay fringing reef habitats. At each survey site observers recorded seagrass presence/absence, seagrass species composition, estimate of seagrass cover and sediment characteristics. These results were used to assist with determining species distributions.

Macrofaunal communities

Qualitative sampling using beam trawls was conducted to produce an inventory of seagrass-associated macrofauna and to provide an indication of the importance of Shoalwater Bay seagrasses for species of commercial fisheries importance. Further monitoring of macrofauna abundance would require frequent, intensive sampling to be effective, because most species are seasonal in abundance. This is beyond the scope of this program.

Four trawling sites were chosen for macrofauna collection based on the representative seagrass communities of the survey area (Table 1, Maps 1 & 2). A fifth trawl site was sampled at Marquis Island in April 1996. 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 100 m transects at approximately 0.5 m s^{-1} (cf. Coles *et al.* 1993). Three or four replicate trawls were conducted at each site, once in September 1995 and once in April 1996.

Time constraints limited sampling to beam trawling and the species list may not include larger or fast moving seagrass inhabitants that are able to avoid a slow moving trawl net.

Table 1. Description of beam trawl sites in the Shoalwater Bay survey area.

Dates	Site	Seagrass species	Substrate	Depth (m)
13/9/95 3/4/96	Macdonald Pt	*Zostera capricorni, Halodule uninervis, Halodule pinifolia*	Sand/Mud	2.53
16/9/95 6/4/96	Triangular Is.	*Halodule uninervis, Halodule pinifolia*	Sand/Mud	3.71
18/9/95 8/4/96	Island Head Ck.	*Zostera capricorni*	Mud/Sand	1.27
19/9/95 9/4/96	Port Clinton	*Zostera capricorni*	Mud/Sand	0.52
7/4/96	Marquis Is	*Halodule uninervis (wide)* *Halophila ovalis*	Mud/Shell	3.05

All Penaeidae (prawns) were identified to species according to Dall (1957) and Grey *et al.* (1983). Carapace length was measured (posterio-dorsal margin of the carapace to the orbit of the eye) to the nearest 0.1 mm. All fish were identified as far as possible and standard length (tip of snout to last vertebra) measured to the nearest 0.1 mm for the largest and smallest individuals from each taxa in September 1995, and for all individuals collected in April 1996.

Numbers of Brachyura (crabs), squid, sepiolids (cuttlefish) and miscellaneous crustaceans (shrimps, isopods, amphipods, stomatopods) were pooled and recorded for each trawl. Dry weight biomass of crustacea from each trawl was determined by drying (60°C, 48 hrs) and weighing samples. Molluscs, polychaetes and other phyla were not examined.

Geographic Information System

All data from the surveys were entered onto a Geographic Information System (GIS). A GIS base map using a Thematic Mapper Satellite image (provided by Dr Brian Tunstall, CSIRO) was rectified to World Geodetic System (WGS) co-ordinates. A GIS of seagrass community distribution was created in ArcInfo® and MapInfo®.

Errors in GIS maps include those associated with digitising and rectifying aerial photographs onto basemaps and with Global Positioning System (GPS) fixes for survey sites. Thematic Mapper satellite images are based on 30 m^2 pixels and coastal outlines are accurate to 1:200 000 scale. The point at which divers estimated bottom vegetation may be up to 5 m from the point at which a GPS fix was obtained. Differentially corrected GPS fixes were also only precise to within 5 m.

Each seagrass meadow was assigned a qualitative mapping value, determined by the data sources and likely accuracy of mapping. A rank system for mapping quality was used, based on the range of mapping information available for each area and associated estimates of reliability in mapping meadow boundaries (Table 2). A mapping quality rank of 1 is the highest. Estimates of reliability in mapping meadow boundaries ranged from 5 m to 30 m.

Table 2. Ranks of mapping quality for seagrass meadows mapped in Shoalwater Bay.

Map Quality	Data Sets	Comments
1	Helicopter reconnaissance & aerial photos & TM satellite image & dive survey.	Detailed checking of meadow boundary during dive surveys. Images and photos of high resolution.
2	Helicopter reconnaissance & aerial photos, TM image, dive survey.	Some meadow boundaries checked, and several transects during dive survey. Images and photos of suitable resolution.
3	Helicopter reconnaissance & aerial photos, TM image & dive survey.	Occasional meadow boundaries checked during dive survey. Reasonable definition in images and photos.
4	Helicopter reconnaissance & dive survey.	No image or photo available at required resolution, some meadow boundaries checked in dive survey. High reliance on video from low level helicopter flight and dive survey data.
5	Dive survey only.	Subtidal meadows not visible in remote-sensing images. Data density generally low and reliant solely on dive surveys.
6	Helicopter reconnaissance & aerial photos only.	Photos of suitable resolution. Meadow boundaries checked by helicopter reconnaissance, no dive survey.

Analysis

Standard parametric tests were used for analysis of data (Sokal and Rohlf 1987). All divers had significant linear regressions and $r^2 > 0.85$ for most divers when calibrating above-ground biomass estimates against a set of harvested quadrats (Appendix 1, Table 8).

We used a measure of precision to test that the seagrass biomass data set was adequate as a baseline from which a monitoring program could be established to measure change. Precision is a function of the Standard Error (SE) of a sample and the measure of precision used in this study was the ratio of the standard error to the mean ($SE/\bar{x}$). The level of precision which field programs usually aim for is 0.1 to no more then 0.2 (Downing and Anderson 1985; Thresher and Gunn 1986).