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Queensland COASTAL WETLAND RESOURCES

Sand Bay to Keppel Bay

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EXECUTIVE SUMMARY

Protection of coastal wetland environments is an important prerequisite to effective and sustainable inshore fisheries management and conservation of habitats for use by future generations. Mangroves, saltmarshes, seagrasses and non-vegetated habitats directly support local and regional inshore and offshore fisheries through the provision of food, shelter, breeding and nursery grounds. As such, these wetland environments have significant economic value as well as their intrinsic aesthetic and ecological values.

Approximately 85% of the wetland resources of the Queensland coastline have been mapped or are currently being mapped by the Assessment and Monitoring Unit, Queensland Fisheries Service, Department of Primary Industries Queensland. The mapping undertaken to date consistently uses the protocol developed in-house (Danaher 1995a) which has been recognised (Ward *et al.* 1998) as an appropriate model for a national approach to coastal wetlands mapping. This process is being undertaken in order to provide a baseline dataset for Fish Habitat Area (FHA) declaration, Ramsar site nomination and future monitoring of these important fish habitats. This report summarises the results of the mapping undertaken in the Central Queensland Coast from Sand Bay to Keppel Bay (hereafter referred to as the Study Area). The study was undertaken in order to:

1. document and map the coastal wetland communities along the Queensland coastline from Sand Bay (20.93°S, 149.04°E) to Keppel Bay (23.65°S, 151.07°E);
2. document levels of existing disturbance to and protection of the wetlands;
3. examine existing recreational and commercial fisheries in the region; and
4. evaluate the conservation values of the areas investigated from the viewpoint of fisheries productivity and as habitat for important and/or threatened species.

Project Rationale

There is a need to identify and map fish habitats for the management and conservation of the resource through the declaration of Marine Protected Areas (MPAs) (e.g. FHAs) and Ramsar sites, as well as a requirement for conducting further research into the interactions between fauna and the habitat. Studies combining data on coastal wetland primary productivity, connectivity between habitat types, fish species associated with particular habitats and feeding strategies of these fish species and will contribute to a better understanding of the value of particular habitats to local and regional fisheries productivity. Completion of mapping of the coastal wetland communities of the Queensland coastline will provide quantitative data for incorporation into these studies. Additionally, it provides the base information required for monitoring short term and long term changes in coastal wetland habitats and planning appropriate management measures.

Results

Coastal Wetlands of the Study Area

In most estuaries in the Study Area, Closed *Rhizophora*, located on the seaward margin, is the dominant community. Closed *Ceriops* is generally located directly landward of the Closed *Rhizophora* zone. In more upstream locations, where freshwater input is highest, Closed Mixed communities line the stream banks. Saltpans are usually limited to a narrow band in the upper intertidal zone, except where low coastal plains and a dry environment allow further development of a hypersaline environment. Saline Grasslands usually only occur in the upper intertidal zone where there are freshwater swamps adjacent.

Saltpans are the dominant coastal wetland community by area in this Study Area. However, the majority of these Saltpan communities are found in only two locations, Broad Sound and the Fitzroy River Delta. Both areas have extensive low coastal plains and a dry climate. Inundation by the tide and subsequent evaporation create a hypersaline environment in which very little vegetation can survive. On a regional scale such Saltpan development is relatively unique as the majority of the tropical environments in Queensland receive high annual rainfall and riverine freshwater input, which limits Saltpan development.

In both the Broad Sound region and the Fitzroy River Delta, the extensive Saltpans are drained by mangrove-lined creeks, which are generally dominated by Closed *Ceriops* or Closed Mixed communities. These communities are generally very narrow (less than 30 m wide) and are often unmappable by this technique (Section 4.3).

TABLE I Areas of coastal wetland communities in the Study Area.

	AREA OF COASTAL WETLAND COMMUNITIES (ha)	PERCENT OF TOTAL
Closed *Rhizophora*	30590	20.5
Closed *Avicennia*	7697	5.2
Open *Avicennia*	627	0.4
Closed *Ceriops*	20536	13.7
Open *Ceriops*	81	0.1
Closed *Aegiceras*	148	0.1
Closed *Rhizophora*/*Avicennia*	25	0.0
Closed *Avicennia*/*Ceriops*	1002	0.7
Open *Avicennia*/*Ceriops*	1	0.0
Closed Mixed	13188	8.8
Closed *Ceriops* Dieback	41	0.0
Saline Grassland	10185	6.8
Saltpan	64520	43.1
Samphire-dominated Saltmarsh	961	0.6
Total	149594	

Within the Study Area, the coastal wetlands of Shoalwater Bay are of particular regional significance. The Shoalwater Bay Military Training Area (SWBMTA) is the largest coastal wilderness area between Nadgee (southern NSW) and the Cape Melville/Starke Holding area on Cape York Peninsula (ANCA 1996). The area is species rich due to the fact that it is a significant overlap zone for tropical, subtropical and temperate species in all fauna groups (ANCA 1996). The coastal wetlands and surrounding terrestrial vegetation is in virtually pristine condition. For these reasons the Shoalwater Bay region is one of great value for scientific research and as a conservation area.

Recommendations

The current study confirms the fisheries value for the declared FHAs in this Study Area and identifies the need for expansion of the existing marine protected area network. In particular, the following recommendations for new FHAs in the Study Area should be considered as a priority:

- It is strongly recommended that the coastal wetland vegetation of the Fitzroy River Delta, including the extensive Saltpans and the mangrove-lined feeder creeks from Balaclava Island to the western side of Curtis Island be gazetted as a FHA. These important fish habitats are representative of the Fitzroy River Delta and are relatively undisturbed. Other coastal wetland communities of the Fitzroy River Delta have been modified extensively through the construction of levees for pondage systems and salt evaporation ponds.
- The diverse characteristics of the coastal wetlands of the Shoalwater Bay region promote it as an area suitable for protection within a FHA. It is recommended that the requirement for a FHA in this region be investigated further, in collaboration with the land managers (the Australian Army).

Recommendations for Further Investigations

Continuation of the coastal wetlands mapping to complete the remainder (15%) of the Queensland coastline is recommended to:

- Provide baseline habitat data for FHA declaration and Ramsar site nomination;
- Provide a basis for future monitoring of the spatial and composition changes in tidal coastal wetland communities on a local, bioregional and State-wide basis;
- As a resource for incorporation into studies of the relationships of specific marine fauna to particular coastal wetland habitats;
- Provide baseline habitat data for Local Government Planning Schemes prepared under the provisions of the *Integrated Planning Act 1997*.

Effectiveness of the Project

The method of investigating and mapping relatively large coastal regions, utilised in this study, has proven to be cost effective with a high degree of accuracy (approximately 90%) for coastal wetland communities at this scale. The information presented in the report has been provided to the DPI Fisheries, Marine Habitat Unit staff responsible for FHA declaration, for the purpose of incorporation into FHA planning processes relevant to the study area.

It has been demonstrated, in this and previous studies, that the technique developed for coastal wetlands mapping is transferable to similar coastal wetland systems. Landsat TM data is widely available. However, limitations to the technique apply. The minimum mapping unit is a 25 x 25 m Landsat TM pixel. Consequently, a community smaller than this size is not mappable. Additionally, polygons of less than 0.5 ha are eliminated in the mapping process. The mapping technique is generally more accurate in areas where clear zonation in coastal wetland communities occurs.

An overall evaluation of the project is included in Appendix 9.

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SECTION 1 INTRODUCTION

1.1 Project Scope

Marine, estuarine and freshwater systems in Queensland are managed under the provisions of the *Queensland Fisheries Act 1994* and *Fisheries Regulation 1995*. This legislation provides for the *'management, use, development and protection of fisheries resources and fish habitats'*. All marine plants throughout Queensland are specifically protected under this legislation. Key fish habitats are further protected through the declaration of Fish Habitat Areas (FHAs). FHAs are part of the on-going management of fisheries resources within Queensland and are specifically declared to ensure continuation of productive recreational, indigenous and commercial fisheries in a region through habitat protection. Declaration publicly proclaims the value of the area from a fisheries viewpoint, and increases the statutory level of protection of the wetlands for community fisheries benefits. Appendix 1 displays the current distribution of declared FHAs of both Management A and B status in Queensland. Appendix 2 gives further details on FHA declaration and management.

Further protection of significant wetland areas is achieved through the declaration of Ramsar sites. Formal listing of Ramsar sites was the result of the Convention on Wetlands of International Importance. Coastal wetland resources are an important consideration in the nomination of these Ramsar sites. Further details of the criteria for the assessment of wetlands for Ramsar nomination can be found in Appendix 3.

This report provides key resource data for the ongoing assessment of the requirement for additional Marine Protected Areas (e.g. FHAs under the *Queensland Fisheries Act 1994*) in regions of high established fish habitat value. Additionally, the study provides baseline information on the coastal wetlands from Sand Bay to Keppel Bay for Ramsar site nomination. The project aims are:

1. document and map the coastal wetland communities along the Queensland coastline from Sand Bay (20.93°S, 149.04°E) to Keppel Bay (23.65°S, 151.07°E);
2. document levels of existing disturbance to and protection of the wetlands;
3. examine existing recreational, indigenous and commercial fisheries resources in the region;
4. evaluate the conservation values of the areas investigated from the viewpoint of fisheries productivity and as habitat for important and/or threatened species for future FHA/MPA declaration.

1.2 Current Progress of Queensland Coastal Wetland Resource Mapping

Approximately 85% of Queensland's coastal wetland resources have been or are currently being mapped by the Department of Primary Industries, Queensland Fisheries Service as a baseline resource for FHA declaration and continued monitoring of these environments (as of Dec 2000). The areas that have been completed or are currently being mapped are displayed in Figure 1. A summary of this work and the resulting MPA declarations are included in Appendix 4.

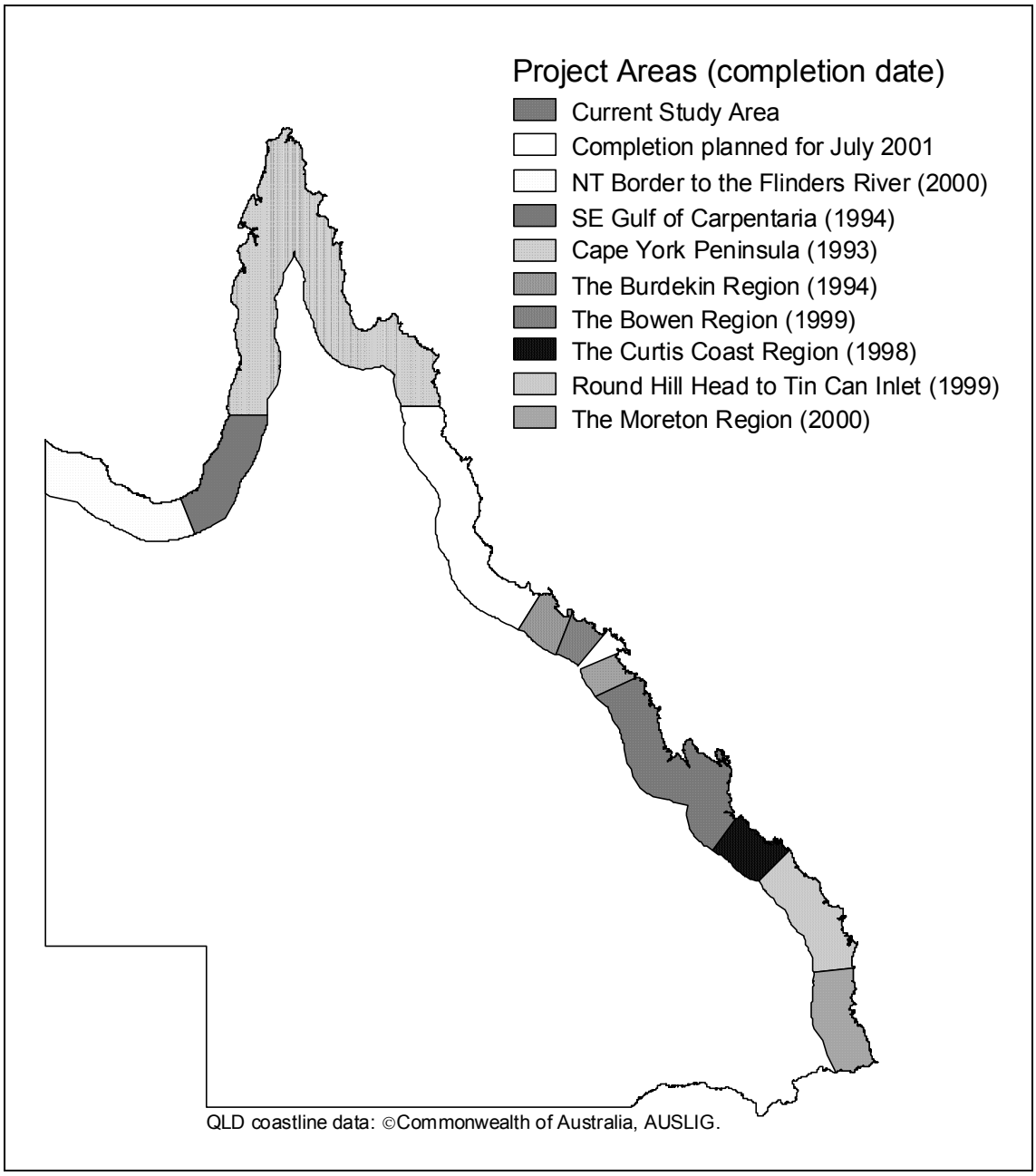

FIGURE 1.1 Queensland coastal wetland resource mapping projects.

SECTION 2 BACKGROUND

2.1 The Study Area

The Study Area lies in the tropical environment of Queensland's central coastline. Extending from Andrews Point, Sand Bay to Ramsay Crossing, the Narrows (Keppel Bay), the Study Area encompasses large bays with extreme tidal ranges of up to 9m, extensive stretches of coastline with small estuaries and numerous sandy islands and offshore reefs. The outer reefs of the Great Barrier Reef provide protection from open ocean wave action for the coastal wetland communities in the Study Area.

Mackay (149.18°E, 21.15°S) and Rockhampton (150.56°E, 23.34°S) are the two main urban centres within the Study Area. These two cities have populations of approximately 45 000 and 58 000, respectively (ABS 1996). Mackay is the major retail and wholesale centre for the Mackay/Whitsunday region, and is the main transport and administrative hub, catering for the surrounding sugar and coal mining industries (QDCILGP 2000). The coal industry, cattle industry and meat processing, railways, education and medical services provide the majority of employment in Rockhampton (QDCILGP 2000).

Cattle grazing, agriculture and mining are the main industries within the Study Area. The region surrounding Rockhampton, from the southern limit of the Study Area to St Lawrence, is heavily utilised as cattle grazing country. Agriculture, primarily sugar cane production, is the main land use of the region surrounding Mackay. Wheat, cotton, and pineapple plantations along with irrigated crops such as citrus, sunflower and soya beans all contribute to the growing agricultural sector of the central Queensland region. Coal mining is a major contributor to the economy of the region, being a key employer in the central Queensland region and accounting for around 78% of Queensland's coal production (QDCILGP 2000).

The tourism industry makes a significant contribution to the economy of the Mackay region and is emerging as a significant industry further south in the Study Area, in the Rockhampton/Yeppoon area (QDCILGP 2000). The area has a diversity of attractions, including providing access to the Great Barrier Reef and numerous islands, which entice a large number of visitors to the region each year.

The Mackay region has an average maximum temperature of 26°C and an average minimum of 17°C. Rainfall in the region is seasonal with the majority of the annual rainfall of around 2000 mm falling in the summer months. Within the Study Area, mean annual rainfall ranges from 800 mm to 2000 mm, with the lowest rainfalls recorded in the Rockhampton and St Lawrence regions. Further details of the mean annual rainfall recorded in estuaries of the Study Area are listed in Table 2.1. Between 10 and 15 cyclones per decade are reported to occur in the Study Area (IMCRA Technical Group 1998).

Tides in the Study Area range from 4 m to 9 m, with the greatest tidal range occurring within the Broad Sound Region (IMCRA Technical Group 1998). Further details of the tidal ranges of estuaries within the study area, as reported by Digby *et al.* 1999, are listed in Table 2.1.

The majority of the Study Area, from Mackay to Ramsay Crossing falls within the Shoalwater Coast Bioregion (SCT) as defined in the Interim Marine and Coastal Regionalisation for Australia (IMCRA Technical Group 1998). The remainder of the

Study Area to the north of Mackay falls in the Lucinda-Mackay Coast Bioregion (LMC). The Study Area lies adjacent to the Brigalow Belt North (BBN), Central Mackay Coast (CMC) and South Brigalow (BBS) Regions as defined in the Interim Biogeographic Regionalisation of Australia (Thackway and Cresswell 1995).

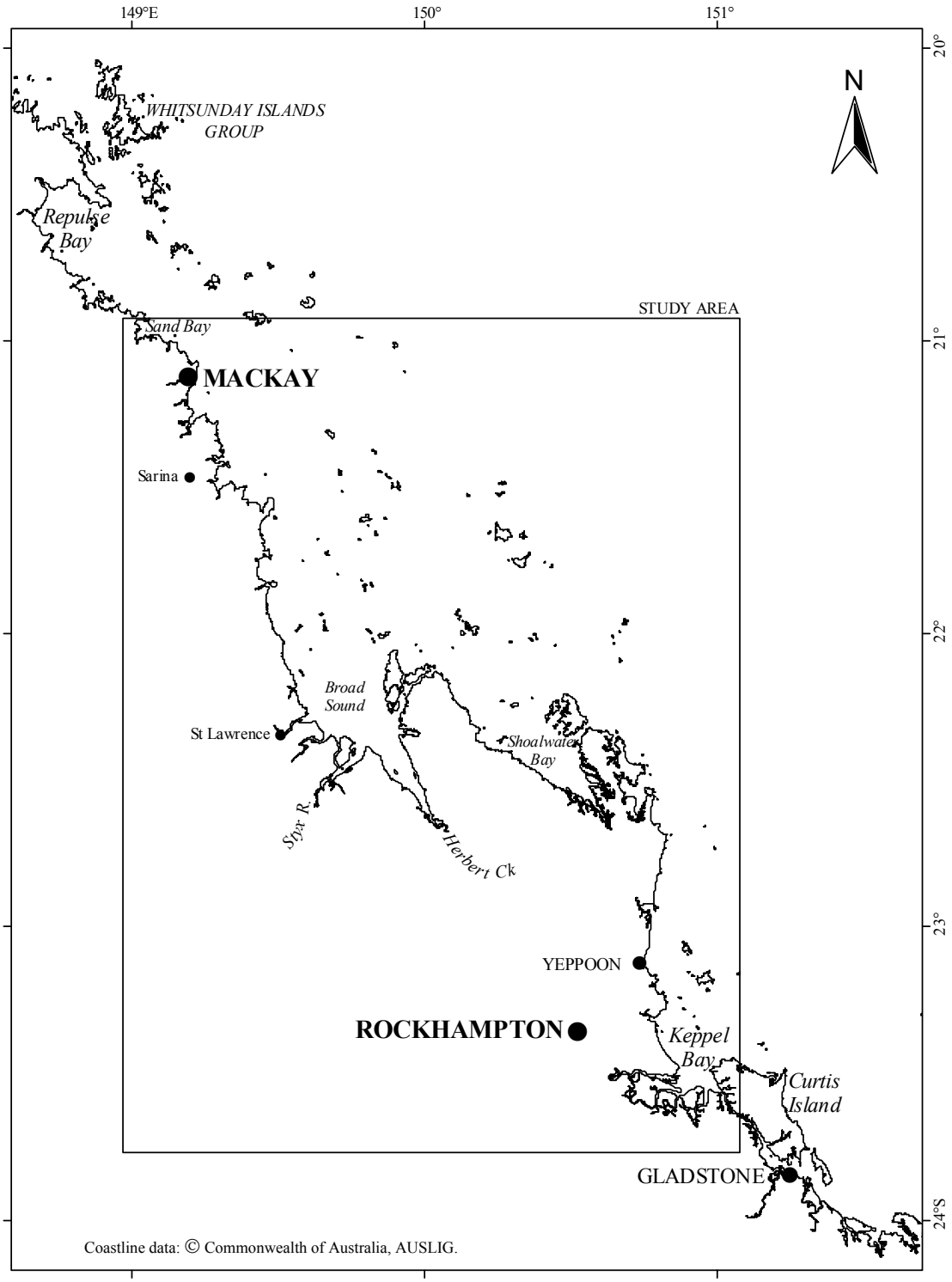

FIGURE 2.1 Site map of the study area, Sand Bay to Keppel Bay, central Queensland.

TABLE 2.1 Hydrology and catchment details for the main estuaries within the study area.

WETLAND	MEAN ANNUAL RAINFALL (mm)	RUNOFF COEFFICIENT	EXTREME TIDAL RANGE (m)	CATCHMENT AREA (km²)
Constant Creek	1785	0.36	6.1	139
Leila Creek	1785	0.36	6.1	88
Pioneer River	1666	0.41	6.1	1580
Baker's Creek	1359	0.44	6.1	230
Sandy Creek	1359	0.38	6.4	678
Louisa Creek	1359	0.38	6.4	33
Castrades Inlet	1819	0.29	6.4	45
Sarina Inlet	1819	0.29	6.3	144
Rocky Dam Creek	1819	0.29	6.3	539
Coconut Creek	1474	0.35	6.3	16
Cape Creek	1474	0.35	6.3	51
Knobler Creek	1474	0.35	6.3	17
Walter Hill Creek	1474	0.35	6.3	9
Marion Creek	1474	0.35	6.3	107
Basin Creek	1474	0.35	6.3	110
West Hill Creek	1430	0.36	6.3	143
Carmila Creek	1430	0.36	7.5	150
Feather Creek	1430	0.36	7.5	49
Thirsty Sound	1052	0.19	7.4	311
Clairview Creek	1052	0.49	7.5	264
Canoe Passage	1745	0.21	6.4	56
St. Lawrence Creek	1052	0.21	7.4	469
Island Head Creek	1745	0.21	6.4	138
Waverley Creek	1052	0.21	7.4	506
Styx River	822	0.27	7.4	1890
Ross Creek	902	0.22	6.4	57
Herbert Creek	902	0.22	7.4	2286
Raspberry Creek	902	0.22	6.4	64
Wadallah Creek	1745	0.21	6.4	22
Oyster Creek	1745	0.11	6.4	108
Port Clinton	1745	0.21	5.1	257
East Creek	1745	0.21	6.4	67
Shoalwater Creek	1745	0.11	6.4	443
Head Creek	1745	0.21	6.4	224
George's Creek	1745	0.21	6.4	127
Corio Bay	1745	0.21	5.1	514
Causeway Lake	1353	0.27	5.1	32
Cawarral Creek	1084	0.33	4.9	169
Pumpkin Creek	1084	0.33	4.9	104
Fitzroy River	805	0.06	4.9	142733
The Narrows	805	0.12	5.0	2668

Data compiled from the Australian Estuarine Database (Digby *et al.* 1999).
Data for minor estuaries within the study area were not included in the database.

2.2 Coastal Wetland Environments

Mangrove, saltmarsh and seagrass communities are recognised for their value to fisheries production. These marine plants establish habitats that directly support local and regional inshore and offshore fisheries through the provision of food, shelter, breeding and nursery areas. Previous DPI research (Quinn 1992) has estimated that the estuarine habitats provided by mangroves and seagrasses are critical to more than 75% by weight of commercially and recreationally important fish and crustacean species during some stage of their life cycle (eg. mud and blue swimmer crabs, prawns, barramundi, threadfins, whiting, flathead, bream and mullet). Mangrove and seagrass communities form only part of a range of coastal habitats (along with saltmarshes, intertidal flats, rocky foreshores and coral reefs) that all provide a diversity of environments maintaining marine and estuarine ecosystems.

Fish Habitats Mapped in this Study

For the purposes of this study, environments located between the highest astronomical tide contour and the low water mark (ie. the intertidal communities) are described collectively as coastal wetlands. The coastal wetlands mapped in this study include mangrove and saltmarsh communities.

The absence of a universally accepted definition of a mangrove community leads to many different interpretations of areal extents of "mangroves". Here, the term mangrove community refers to any community within the intertidal zone that is dominated by trees and shrubs. Saltmarshes are intertidal plant communities that are dominated by salt tolerant herbs and low shrubs, such as samphires and salt couches (Hopkins *et al.* 1998). Two subsets of this vegetation type are recognised in this study. Saltpans are those hypersaline areas that range from unvegetated claypans to those areas dominated by samphire vegetation. Saline Grasslands are those areas that are dominated by *Sporobolus virginicus* (salt couch).

Mangroves

Mangroves are a diverse group of predominantly tropical shrubs and trees growing in the marine tidal zone (Duke 1992). These marine plants serve a wide variety of functions (Claridge and Burnett 1993; Ewel *et al.* 1998) including:

- physical protection of the coastal fringe from erosion and flooding;
- sediment trapping;
- nutrient uptake and transformation;
- provision of food, shelter, breeding and nursery areas for a wide variety of marine and terrestrial animal species.

At a regional scale, the distribution of mangrove species is determined by a number of factors including temperature, rainfall, catchment area and tides. It has been shown that mangrove species are limited in their latitudinal distribution by their physiological tolerance to low temperatures (Duke *et al.* 1998). The majority of mangrove species are limited to tropical environments where the mean winter temperatures are higher than 20^{o}C. Consequently, mangrove species diversity generally decreases with increasing latitude.

Additionally, areas of high freshwater availability (both as rainfall and runoff from riverine catchments) tend to support more species rich estuarine mangrove communities than areas of low freshwater availability. In Queensland this phenomenon is clearly

demonstrated in the north of the State. The relatively dry coastline of the southern Gulf of Carpentaria (from the Northern Territory border to Flinders River) supports less than 20 species of mangrove (Bruinsma and Duncan 2000) whereas more than 30 species have been recorded for areas of similar latitude on the wetter eastern coastline of Australia (Lovelock 1993).

Mangrove species are also variable in their tolerance to the variety of environmental parameters experienced in the intertidal zone, including salinity, soil type, frequency of inundation (both tidal and fresh) and wave action. Accordingly, mangrove species distribution within an estuary can generally be related to the variation of these factors and typical mangrove zones often result. For example, Closed *Rhizophora* zones (or communities) within Queensland generally occur on the water's edge where they receive inundation with every high tide. In contrast, Open or Closed *Ceriops* communities, which occur towards the landward mangrove edge, are generally only inundated on the spring tides that occur once or twice per month.

The primary production of mangroves varies between different communities. Factors affecting net primary productivity and forest growth include soil nutrient status and redox potential, salinity, temperature, light intensity, associated fauna and tidal flushing (Clough 1992; Amarasinghe and Balasubramaniam 1992). Important detrital, marine food webs, which are supported by primary production from mangrove trees in turn, support economically important commercial and recreational fisheries. Unfortunately, there is a lack of quantitative information regarding the direct benefits gained from the various mangrove forest community types. Section 2.3 contains further details of the relationships between coastal wetland communities and marine fauna.

The following 22 mangrove species have been reported from the Study Area (Lovelock 1993; Wells 1983):

- *Acanthus ilicifolius* L. — Holly mangrove
- *Acrostichum speciosum* Willd. — Mangrove fern
- *Aegialitis annulata* R. Br. — Club mangrove
- *Aegiceras corniculatum* (L.) Blanco — River mangrove
- *Avicennia marina* (Forsk) Vierh. — Grey mangrove
- *Bruguiera exaristata* Ding Hou — Rib-fruited orange mangrove
- *Bruguiera gymnorrhiza* L. Lam. — Large–leafed orange mangrove
- *Bruguiera parviflora* (Roxb.) Griffith — Small–leafed orange mangrove
- *Ceriops tagal* C. T. White — Yellow mangrove
- *Crinum pedunculatum* R.Br. — Mangrove lily
- *Cynometra iripa* Kostel. — Wrinkle pod mangrove
- *Excoecaria agallocha* L. — Milky mangrove
- *Heritiera littoralis* Aiton — Looking-glass mangrove
- *Hibiscus tiliaceus* L. — Native hibiscus
- *Lumnitzera racemosa* Willd. — Black mangrove
- *Osbornia octodonta* F. Muell. — Myrtle mangrove
- *Rhizophora apiculata* Blume — Tall–stilted red mangrove
- *Rhizophora lamarckii* Montr. — Stilted mangrove
- *Rhizophora stylosa* Griff. — Red mangrove
- *Sonneratia alba* Sm. — Mangrove apple
- *Xylocarpus granatum* Koen — Cannonball mangrove
- *Xylocarpus moluccensis* Pierre — Cedar Mangrove

Saltmarshes

Saltmarshes are intertidal plant communities that are dominated by salt tolerant herbs and low shrubs, such as samphires and salt couches (Hopkins *et al.* 1998). In contrast to mangrove species, saltmarsh species diversity and community complexity in Queensland increases with increasing latitude (Zeller 1998).

Although saltmarsh environments generally experience limited inundation with the high tides they can play an important role as fish habitat. In these environments, interactions of the soil, water and air provide optimal environmental conditions, which under specific circumstances allow fisheries resources to feed, grow and reproduce to complete their lifestyle (Beumer *et al.* 1997). Specifically, shallow tidal pools within the saltmarshes provide transitory feeding habitat for larval and juvenile fishes, and may support a variety of invertebrates (Zeller 1998).

Unvegetated claypans can be important for the life cycles of certain fishes (eg. barramundi). In the Gulf of Carpentaria extensive claypans are flooded during the monsoon season. Major spawning of barramundi occurs just before or early in the wet season so that the juveniles can take maximum advantage of this temporary wetland habitat. The inundated claypans also allow extensive, seasonal migrations of juvenile and spawning fish moving along and among stream channels, tidal pools and coastal waters.

Connolly (1999) recently studied the use by fish species of subtropical saltmarsh habitat. In this study it was confirmed that both vegetated and non-vegetated subtropical saltmarsh habitats are utilised by abundant and diverse communities of both estuarine-resident and estuarine-marine fish species. More than half of the fish species caught on the saltmarsh habitat were of direct economic importance, and several of these species were common without dominating the catch numerically. The distribution of fish on saltmarshes was found to be most strongly influenced by proximity to intertidal, mangrove-lined feeder creeks, with more species and more individuals near to creeks than further away (Connolly 1999).

Other Fish Habitats Not Mapped in this Study

Seagrasses

Seagrasses are productive flowering plants, which are able to complete their life cycle completely submerged beneath marine waters (Mateer 1998). In order to establish a healthy community, seagrasses require minimum exposure to air, shelter from high-energy waves, sufficient light penetration for photosynthesis and marine salinities. Consequently, coastal and surface topography, water depth and turbidity, and freshwater run-off all influence seagrass distribution and abundance patterns.

Seagrass beds play an important role in coastal marine and estuarine systems. They provide food, habitat and shelter for many marine species (in particular, prawns and dugong) and contribute a large proportion of the primary production of coastal systems.

Coles *et al.* (1987) mapped the broad distribution of seagrasses meadows in the coastal inshore waters and around the islands located between Bowen and Water Park Point, Corio Bay. The following 10 species were reported in the present Study Area:

- *Cymodocea serrulata* (R. BR.) Aschers. and Magnus
- *Halodule pinifolia* (Miki) den Hartog
- *Halodule uninervis* (Forsk.) Aschers
- *Halophila decipiens* Ostenfeld
- *Halophila ovalis* (R. Br.) Hook.f.
- *Halophila ovata* Gaud.
- *Halophila spinulosa* (R. Br.) Aschers.
- *Halophila* sp. (identification uncertain)
- *Syringodium isoetifolium* (Aschers.) Dandy
- *Zostera capricorni* Aschers.

Lee Long *et al.* (1992) mapped the broad distribution of seagrasses in October 1988 from Water Park Point to Hervey Bay. Lee Long *et al.* (1997) mapped the distribution of seagrass meadows in the Shoalwater Bay during spring (September) 1995 and autumn (April) 1996.

Natural variability in the species composition, density and biomass of seagrass communities over time results from the different responses of seagrasses to environmental parameters such as temperature, water turbidity, sediment stability and nutrient levels (English *et al.* 1994). For this reason, distribution patterns from previous studies can only be considered as 'snapshots' of seagrass distribution in a window of time. However, as these regions have supported seagrass communities in the past, it is possible that they may do so in the future, provided the environmental conditions for colonisation and maintenance of the meadows are favourable.

Intertidal Flats, Rocky Foreshores and Coral Reefs

Despite their often unrecognised role in primary production, 'non-vegetated' habitats such as intertidal flats, rocky foreshores and coral reefs are important fish habitats. Intertidal flats are defined as the zone exposed at low tide and submerged at high tide (Bird 1968), and may be non-vegetated sand or mud or colonised by seagrass or algal beds. Erftemeijer and Lewis (1999) recognised that intertidal mudflats constitute an important habitat that support a high biodiversity and biomass of benthic invertebrates, sustain productive fisheries and provide important feeding grounds for migratory and other shorebirds.

Rocky foreshores provide a hard substrate for the attachment of algal flora as well as the long-term attachment of sessile invertebrates (such as barnacles, oysters and tube worms) (Zeller 1998). Both macro and micro algae, particularly benthic microalgae, play a key role in primary production and may in total contribute more than half of the total net production (Alongi 1998).

Coral reefs provide shelter and food for reef and pelagic animals that colonise or are attracted to these biological structures (eg. sponges, coral and fish).

2.3 Project Rationale

There is a need to identify and map fish habitat for the management and conservation of the resource through the planning and declaration of Marine Protected Areas (MPAs) (e.g. FHAs) and Ramsar sites, as well as a requirement for conducting further research into the

interactions between fauna and the habitat. Studies combining data on coastal wetland primary productivity, connectivity between habitat types, fish species associated with particular habitats and feeding strategies of these fish species and will contribute to a better understanding of the value of particular habitats to fisheries productivity. Continuation of the mapping of the coastal wetland communities of the Queensland coastline will provide quantitative data for incorporation into these studies. Additionally, it provides the base information required for monitoring short and long term changes in coastal wetland habitats and implementing appropriate management measures.

SECTION 3 METHODS

3.1 Data

Maps of coastal wetland communities were produced from Landsat 5 Thematic Mapper (TM) satellite imagery. Three full scenes and two quarter scenes were required to map the entire study area. The areas mapped from each of these scenes are listed below.

- Mackay (16 July 1997 full scene): Sand Bay to Ince Bay,
- Sarina (20 July 1995 quarter scene): Ince Bay to West Hill,
- St Lawrence (20 July 1995 full scene): West Hill to Port Clinton,
- Yeppoon (13 July 1995 quarter scene): Port Clinton to Yeppoon
- Gladstone (16 June 1997 full scene): Yeppoon to Ramsay Crossing, The Narrows

Landsat TM scenes of the same date were not used due to the limited availability of data. The imagery used in this study was obtained with final radiometric correction and geometric rectification using ground control points already complete. The scenes were rectified to the Australian Map Grid (Zone 55 and 56) using the Australian National Spheroid and the Australian Geodetic Datum 1984.

The spatial resolution of Landsat TM data is 25 m x 25 m. The spectral characteristics of the data, as well as details of the Landsat satellites are outlined in Appendix 5.

Aerial photography was used to aid in the classification of the satellite imagery. The photography used in this study is listed in Table 3.1. The approximate coverage of these aerial photos is included in Figure 3.1

TABLE 3.1 Aerial photography utilised in the study.

AERIAL PHOTOGRAPHY	YEAR	SCALE
BPA St Lawrence to Townsville	1993	1: 50 000
BPA Urangan to St Lawrence	1996	1: 50 000
BPA Urangan to St Lawrence	1996/1997	1: 12 000
BPA Urangan to St Lawrence	1992	1: 12 000

3.2 Mapping Methods

The satellite imagery was processed using ERDAS Imagine® 8.3.1 on a PC with a MS Windows NT operating system. Six TM bands (excluding Band 6 — the thermal band) were contrast stretched using a linear stretch and breakpoints to highlight the intertidal regions. All water bodies were spectrally masked out using a TM band 4 (near infrared) image. In order to limit the area of the classification to the coastal wetland environments, the terrestrial land features were masked out manually. The upper limit of the intertidal zone was identified using a false colour composite of TM bands 1, 4 and 5 (through blue, green and red colour guns, respectively) in conjunction with colour aerial photography, topographic maps and fieldwork. The greenness and wetness bands of a tasselled cap analysis were also used to assist in defining the extent of the coastal wetland communities.

The remaining imagery, which included the intertidal zone and a small strip of adjacent coastal land, was processed using an unsupervised classification procedure. ERDAS

Imagine uses the Iterative Self-Organising Data Analysis Technique (ISODATA) classification algorithm in order to create clusters of pixels that are spectrally similar. The ISODATA utility repeats the clustering of the image until either a maximum number of iterations has been performed, or a maximum percentage of unchanged pixels (convergence threshold) has been reached between two iterations (ERDAS 1997). A limit of thirty iterations or a convergence threshold of 99% was set in this classification. The resulting classes were labelled according to their dominant cover type with the aid of the aerial photography. Clumps of pixels less than 0.5 ha were eliminated and the image was smoothed using a three by three pixel, moving kernel.

The classification was converted from raster to vector format using ARC/INFO® GIS software. To improve cartographic presentation of the data, the jagged vector boundaries were splined and generalised and polygons with areas under 0.5 ha were excluded. The coverage was then converted to an ESRI shapefile and projected to geographics. Appendix 6 contains the metadata for this shapefile. The shapefiles were overlaid on a Band 3 (visible red) Landsat TM image. Maps were produced using ARCVIEW® GIS Version 3.2 at a scale of 1: 100 000 (Appendix 7: Sheets 1–23).

3.3 Field Methods

The computer-based community classification was validated with fieldwork conducted during August 1999 and December 1999. One hundred and forty-nine sites were selected on the basis of their accessibility by either vessel, 4WD vehicle or on foot. At each of these sites, information on mangrove community floristics and structure was documented. At each site data recorded included the specific composition of mangroves, dominant genus, estimated density (Projective Foliage Cover – PFC) of each vegetation layer, composition and hardness of substrate, and presence/absence of seedlings, samphires, grasses, algae, leaf litter, roots, ferns, epiphytes, sedges and ponds. The distribution of field sites accessed in this Study is displayed in Figure 3.1. The detail of the species composition at each of these sites is included in Appendix 8.

A Garmin 4S XL Personal Navigator Global Positioning System (GPS) was used to determine the latitude and longitude of each field site. The average estimated error recorded by the GPS was 25 m (~1 pixel) with a maximum error of 133 m and a minimum error of 21 m.

The amount of fieldwork undertaken was limited by accessibility to the mangroves and by time and budget constraints. The information collected from the fieldwork was used to aid in the classification of the satellite image and the interpretation of the aerial photography. As the field sites were used to derive the final wetland classification they were not used in assessing its accuracy. Rather a set of random points was generated in order to assess the accuracy of the classification (Section 3.5).

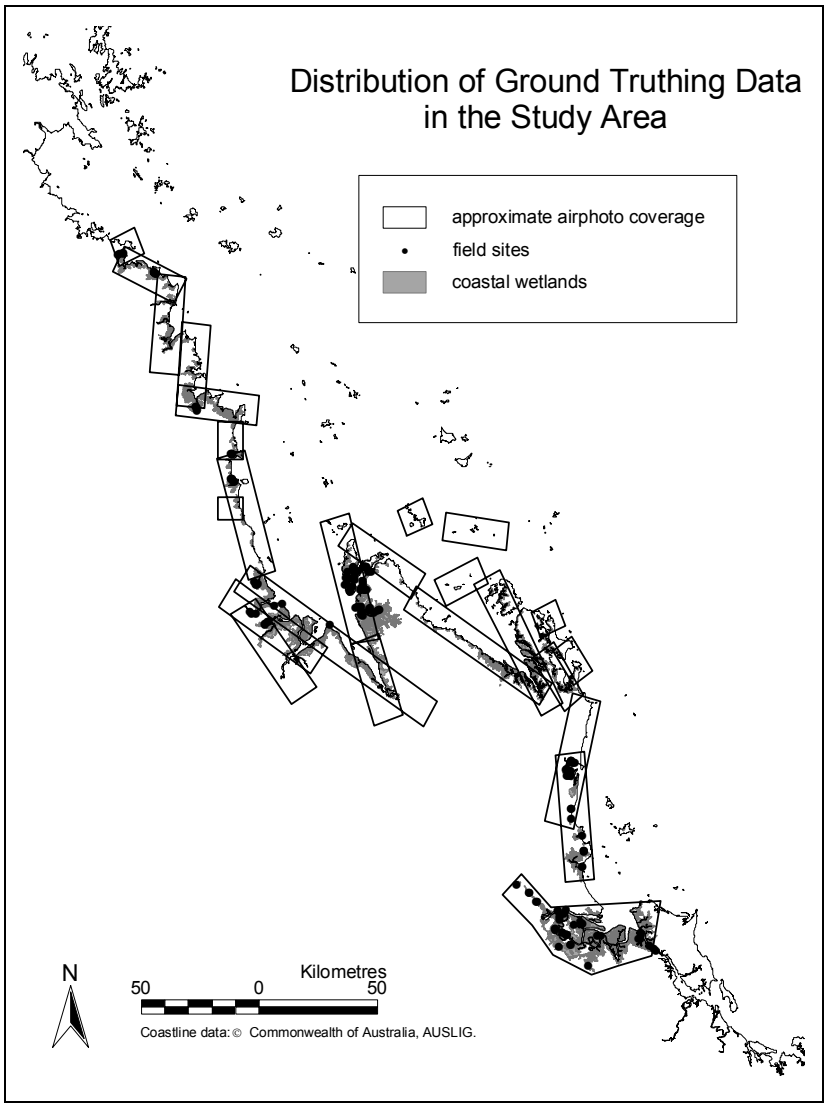

FIGURE 3.1 Distribution of ground truthing data utilised in this study.

3.4 Classification Details

Mangroves were classified to the community level on the basis of dominant genus present and relative densities of the whole community. The density of the community was determined by estimating the PFC. A canopy cover of greater than 50% was classified as closed, while less than 50% was identified as open.

The standard Specht (1987) vegetation categories of 'forest' and 'shrub', which are based on height, were not included in this classification. This is due to the fact that community height cannot be determined from the Landsat TM data.

Only areas subject to tidal inundation were included in this mapping exercise. Excluded classes included permanent pools of water and elevated land containing terrestrial vegetation. Tidally exposed intertidal flats and seagrass beds were also excluded.

3.5 Accuracy Assessment

A set of 320 accuracy assessment points was generated using a random stratified sampling procedure on ERDAS Imagine. The community present at each of these points was determined from the aerial photography and this was compared to the class assigned on the maps. An error matrix using this data was generated and the overall accuracy along with user's accuracy and producer's accuracy was calculated.

The overall classification accuracy is a measure of the number of correct pixels in the error matrix. User's accuracy is the probability that a pixel classified on the map actually represents that category on the ground and producer's accuracy calculates the probability of a reference pixel being correctly classified (how well a certain area can be classified) (Jensen 1996).

An overall evaluation of the project is included in Appendix 9.

3.6 Overview Map of Fish Habitats

An overview map of fish habitats was created from various sources using ARCVIEW ® Version 3.2 GIS software. Along with the mangrove and saltmarsh communities mapped as part of this study, spatial datasets of seagrass meadows, intertidal foreshore flats, reefs and coral cays were obtained. A list of the datasets obtained, their source and currency is included in Table 3.2.

TABLE 3.2 Details of digital datasets used in the fish habitats overview map.

TITLE	CUSTODIAN	CURRENCY	DESCRIPTION
Coral cays	Great Barrier Reef Marine Park Authority (GBRMPA)	unknown	Major coral cays in the GBR region
Reefs	GBRMPA	13-01-1994	Major coral reef structures in the GBR region
Foreshore flats	GBRMPA	unknown	Intertidal foreshore areas
Seagrass beds-Bowen to Water Park Point	Queensland Department of Primary Industries (QDPI)	March 1986	Seagrass meadows
Seagrass beds-Water Park Point to Hervey Bay	Queensland Department of Primary Industries (QDPI)	October 1988	Seagrass meadows
Freshwater swamps	Australian Land, Survey and Information Group (AUSLIG)	~1988	Freshwater swamps theme from the digital GEODATA TOPO-250K topographic map series.
Dams and Weirs	Queensland Department of Natural Resources (QDNR)	31-12-1994	Location of major dams and weirs in Queensland.

The AUSLIG GEODATA product, from which the freshwater swamps theme was taken, is primarily sourced from the 1: 250 000 scale National Topographic Map Series, which was completed in 1988. In this series, swamps are defined as land that is so saturated with water that it is not suitable for agricultural or pastoral use and presents a barrier to free passage. It is often covered with characteristic grass and reed growths, and the degree of wetness may vary with season (AUSLIG 1994).

3.7 Overview of Existing Conservation Measures

The extent of existing conservation measures in the Study Area was investigated using data from various sources using ARCVIEW® Version 3.2 GIS software. A list of the spatial datasets, their source, currency and a brief description is included in Table 3.3.

TABLE 3.3 Details of digital datasets used in examining existing conservation measures.

TITLE	CUSTODIAN	CURRENCY	DESCRIPTION
GBRMP Zones	GBRMPA	1984, correct as of 01-01-1999	Management zones of the GBRMP
Protected Areas	Environmental Protection Agency (EPA)	17-12-1999	National parks and resources reserves gazetted under the Nature Conservation Act 1992 up to 17-12-1999. Nature refuges and coordinated conservation areas are stored in another dataset.
Dugong Protection Areas	GBRMPA	01-11-1998	Dugong protection areas gazetted from Hinchinbrook to Great Sandy Strait.
Fish Habitat Areas	QDPI	13-08-1999	Fish Habitat Areas in Queensland gazetted under the Fisheries Act 1994.
Ramsar sites of Queensland	EPA	22-07-1999	Important wetland sites declared under the Ramsar Convention 1971.

3.8 Assessment of Coastal Wetlands for FHA Nomination

The suitability of various coastal wetland systems for nomination as candidate areas for FHA declaration is currently assessed on the basis of the following criteria:

1. Size
2. Diversity of or specific habitat features
3. Diversity of or specific marine fauna and flora
4. Level of existing and future disturbances
5. Unique features
6. Existing or potential fishing grounds
7. Protected species

The details of the methods of assessment of these criteria are included in Table 3.4.

TABLE 3.4 Details of the methods of the coastal wetland significance assessment.

CRITERIA	SUBCATEGORIES	DETAILS
Size		Area of mangrove and saltmarsh communities, calculated in hectares.
Diversity of or specific habitat features	Diversity of Mangrove and Saltmarsh Communities	**High (H)**: 11–14 mangrove and saltmarsh communities present
		Medium (M): 5–10 mangrove and saltmarsh communities present
		Low (L): 1–4 mangrove and saltmarsh communities present
		The number of mangrove and saltmarsh communities was calculated on the basis of the mapping conducted for this investigation. See Section 4.1 for the descriptions of these mapping units.
	Presence of Intertidal Flats	Comments on the extent of intertidal flats along the coastline were based the GBRMPA foreshore flats coverage as well as 1: 50 000 aerial photograph interpretation.
	Adjacent Freshwater Swamps	**Presence (Y)** or **absence (N)** of freshwater swamps adjacent to the coastal wetland communities. **O** indicates freshwater swamps nearby but not adjacent. The "swamp" coverage from the AUSLIG 1: 250 000 digital topographic series was used. See Map 5.1.
Diversity of or specific marine fauna and flora		Comprehensive surveys of species diversity for each wetland system were not conducted as part of this investigation. Specific, noteworthy marine flora communities have been described in Section 5.8 and are recorded as unique features (see below). Information concerning the diversity of fauna was not included in this evaluation.
Level of existing and future disturbances	Significant Dams and Weirs	**Presence (Y)** or **absence (N)** of significant dams or weirs on the river or creek. The locations of dams and weirs in Queensland collected by the Dept. of Natural Resources. See Map 5.1.
	Disturbance to Adjacent Terrestrial Vegetation	**Near Pristine (NP)** : natural cover >90%
		Largely Unmodified (LU) : natural cover ~65–90%
		Modified (M) : natural cover ~35–65%
		Severely Impacted (SI) : natural cover <35%
		Adjacent terrestrial vegetation refers to the vegetation within 5km of the upper intertidal limit.
Unique Features		**Presence (Y)** of unique features. The details of these features are included in Section 5.8.
Existing or potential fishing grounds	Significant/Important Fishing Grounds	**Significant (Y)** fishing grounds. Assessed from local knowledge of each coastal wetland system and/or from literature review. Further details of important fisheries in the region are reported in Section 8.
Protected species	Not included in this evaluation.	All marine plants are protected under fisheries legislation. Other information on protected species was not included in this evaluation.

SECTION 4 RESULTS

4.1 Description of the Mapping Units

CLOSED *RHIZOPHORA*	FIGURE 4.1
Habitat	Occurs fringing waterways low in intertidal zone with roots submerged during high tides.
Canopy	Usually dominated by tall, mature *Rhizophora* spp. which form a dense canopy (approximately 5–6 m) with a Projective Foliage Cover (PFC) greater than 50%. Other species that may occur in this community are *A. marina* (emergent), *B. gymnorrhiza*, and *C. tagal*.
Shrub layer	Poorly developed or completely absent.
Ground cover	*Rhizophora* spp. stilt roots with a sparse cover of *Rhizophora* spp. seedlings.

CLOSED *AVICENNIA*	FIGURE 4.2
Habitat	Can be found in a diverse range of intertidal environments from the seaward edge (as a pioneer), to accreting banks (as a fringe), to the landward edge.
Canopy	*A. marina,* with occasional *C. tagal* and *Rhizophora* spp., forming a dense canopy with a PFC of greater than 50%. Heights less than 10 m often around 5 m.
Shrub layer	May have *A. corniculatum* and *C. tagal* forming an understorey.
Ground cover	*A. marina* pneumatophores and seedlings form a ground cover.

OPEN *AVICENNIA*	
Habitat	Found on the seaward edge as a pioneer and on the landward edge that is only inundated by the highest spring tide.
Canopy	*A. marina* plants form a canopy that has a PFC of less than 50%. Height varies, generally <1 m in areas bordering on Saltpans and up to 10 m in pioneering zones.
Shrub layer	Generally absent.
Ground cover	Occasional presence of samphires (on the landward edge) and a sparse coverage of *A. marina* pneumatophores.

CLOSED *CERIOPS*	FIGURES 4.3
Habitat	Generally occur on upstream creek edges and towards the upper intertidal limit landward of *Rhizophora* spp. communities on more elevated land. Only inundated by the spring tides.
Canopy	Dominated by *C. tagal* with occasional *A. marina*, *B. gymnorrhiza* and *L. racemosa*. Height of the canopy across sites varies (from approximately 1–4 m) however at an individual site is generally remarkably uniform. PFC greater than 50%.
Shrub layer	Generally absent.
Ground cover	Consists of sparse cover of seedlings and roots of the species present.

OPEN *CERIOPS*	
Habitat	Occurs on the landward edge of the intertidal zone and is inundated by only the high spring tides. This community often surrounds Saltpans and is rarely on the water's edge, except on eroding banks.
Canopy	A community dominated by *C. tagal* with occasional *A. marina* emergents. The PFC is less than 50%; height varies from <1 m in the extremely saline areas to approximately 3 m.
Shrub layer	Occasional presence of other species such as *A. corniculatum* and *A. marina*.
Ground cover	Consists of seedlings of the species present along with a sparse to open coverage of samphires and grasses.

FIGURE 4.1 Closed *Rhizophora* along a creek at Mangrove Island.

FIGURE 4.2 Closed *Avicennia* at Rocky Dam Creek.

CLOSED *AEGICERAS*	FIGURE 4.4
Habitat	Occurs in the upper tidal reaches and on accreting banks of creeks and rivers over a wide range of salinities.
Canopy	Dominated by *A. corniculatum*, often with *A. marina* emergents and *A. annulata* as a subdominant.
Shrub layer	Generally absent.
Ground cover	Samphires, salt couch and the mangrove fern *A. speciosum* are often found in the understorey of this community type.

CLOSED *RHIZOPHORA/AVICENNIA*	FIGURE 4.5
Habitat	Generally occurring within Closed *Rhizophora* communities.
Canopy	A mixed community of *A. marina* and *Rhizophora* spp. together forming a closed canopy with a PFC of greater than 50%.
Shrub layer	The understorey may consist of *A. annulata*, *A. marina* and *Rhizophora* spp.
Ground cover	Roots and seedlings of the canopy species.

CLOSED *RHIZOPHORA/AEGICERAS*	
Habitat	Found in sheltered areas with considerable marine influence e.g. close to the mouths of rivers and creeks.
Canopy	A closed canopy of *Rhizophora* spp. forms a large component of this community. A low *A. corniculatum* community sometimes forms a narrow fringe on the water's edge.
Shrub layer	The understorey in this community is dominated by *A. corniculatum*, which forms a considerable component of the community.
Ground cover	*Rhizophora* spp. roots and seedlings of the species present.

CLOSED *AVICENNIA/CERIOPS*	FIGURE 4.6
Habitat	Commonly bordering Saltpans in areas only inundated during spring tides.
Canopy	A mixed community of *A. marina* and *C. tagal* forming a canopy with a PFC of greater than 50%. Generally a low community with a canopy of <1.5 m.
Shrub layer	*A. annulata*, *A. corniculatum* and *L. racemosa* may be present.
Ground cover	Occasional presence of samphires and seedlings of the species present.

OPEN *AVICENNIA/CERIOPS*	
Habitat	Commonly bordering Saltpans in areas only inundated during spring tides.
Canopy	A mixed community of *A. marina* and *C. tagal* forming a canopy with a PFC of less than 50%. Generally a low community with a canopy of <1.5 m.
Shrub layer	*A. annulata*, *A. corniculatum* and *L. racemosa* may be present.
Ground cover	Presence of samphires and seedlings of the species present.

CLOSED MIXED	FIGURE 4.7
Habitat	Generally found on the landward edges of mangrove communities and in the upper tidal reaches of creeks and rivers.
Canopy	A closed mix of species in which a variety of the 22 species present in this region may occur.
Shrub layer	A shrub layer consisting of juveniles of the various canopy species may be present.
Ground cover	Seedlings and roots of the various species along with sparse samphires and grasses.

FIGURE 4.3 Closed *Ceriops* on Long Island.

FIGURE 4.4 A Closed *Aegiceras* fringe at Price's Landing, with Closed *Rhizophora* behind.

FIGURE 4.5 Closed *Rhizophora*/*Avicennia* along a waterway on Mangrove Island.

CLOSED *CERIOPS* DIEBACK	**FIGURE 6.2**
Habitat	Occurs in only two locations in the Study Area, Clairview and Bar Plains, St Lawrence.
Canopy	Dense community of dead C. tagal where canopy cover would have been >50% when the community was living.
Shrub layer	Generally absent.
Ground cover	Ranging from no vegetation to an open cover of samphires and mangrove seedlings.

SAMPHIRE-DOMINATED SALTMARSH	
Habitat	Occurs along the landward edge of the intertidal zone in a hypersaline environment that is only inundated by the highest spring tides.
Canopy	Generally absent.
Shrub layer	Absent.
Ground cover	Dense coverage of samphires within which a sparse coverage of salt couch (*Sporobolus virginicus*) and sedges may also occur.

SALTPAN	**FIGURE 4.8**
Habitat	Occurs along the landward edge of the intertidal zone in a hypersaline environment that is only inundated by the highest spring tides.
Canopy	Sparse stunted (<1 m) individuals of various mangrove species may occur (e.g. *C. tagal*, *A. marina*).
Shrub layer	Some samphire species may be present as very small shrubs.
Ground cover	Ranging from no vegetation to closed samphires and algae, commonly an open coverage of samphires.

SALINE GRASSLAND	**FIGURE 4.9**
Habitat	Occurs along the landward edge of the intertidal zone in a hypersaline environment that is only inundated by the highest spring tides. Sometimes extends past the upper intertidal limit into open *Casuarina* communities.
Canopy	Generally absent.
Shrub layer	Absent.
Ground cover	Ranging from sparse to dense coverage of salt couch (*Sporobolus virginicus*) within which a sparse coverage of samphires and sedges may also occur.

FIGURE 4.6 Closed *Avicennia*/*Ceriops* at Rocky Dam Creek.

FIGURE 4.7 Closed Mixed along a waterway on Mangrove Island.

FIGURE 4.8 A Saltpan community at Charon Point.

FIGURE 4.9 A Saline Grassland community at Rocky Dam Creek.

4.2 Accuracy Assessment

The overall accuracy of the coastal wetland coverage was calculated at 90.31%. The user's and producer's accuracy are included in Table 4.1. Due to the random stratified sampling procedure used, no accuracy assessment points were automatically collected by Imagine for the following classes: Open *Ceriops*, Closed *Aegiceras*, Closed *Rhizophora*/*Avicennia*, Closed *Ceriops* dieback and Samphire-dominated Saltpans. These classes have not been included in this accuracy assessment.

TABLE 4.1 User's and producer's accuracy for each of the coastal wetland communities.

CLASS	USER'S ACCURACY	PRODUCER'S ACCURACY
Closed *Rhizophora*	95.38	91.19
Closed *Avicennia*	63.64	82.35
Open *Avicennia*	100.00	100.00
Closed *Ceriops*	82.69	89.58
Closed *Avicennia*/*Ceriops*	100.00	83.33
Closed Mixed	84.85	77.78
Saline Grassland	100	83.33
Saltpan	95.69	97.37

4.3 Limitations of the Mapping Technique

This mapping technique is limited by the 25 x 25 m pixel resolution of the Landsat TM satellite imagery. The smallest community that can be detected by the Landsat sensor is a community equal to or larger than a pixel. For this reason it is not possible to detect some typical mangrove zones, such as narrow seaward fringes, small mangrove communities within a Saltpan or Saline Grassland (e.g. *A. marina*) or narrow fringing Closed Mixed communities in upstream locations. While these communities do occur within the Study Area they are generally linear or small and therefore, are not large enough to be mapping units.

For example, the Broad Sound and the Fitzroy River Delta are characterised by many narrow linear mangrove communities that extend through the Saltpans. The 25 x 25 m pixel size of Landsat imagery results in much of the fine detail of the composition of these coastal wetland systems being lost in the mapping process. It is necessary to note therefore that in some communities in these areas that are classified as Closed Mixed, monospecific stands of some mangrove species (for example Closed *Avicennia*), Saltpan and Saline Grassland may occur and vis versa.

Additionally, any communities less than 0.5 hectares (approximately 3 contiguous pixels) are purposefully eliminated in the mapping process. This step enhances the cartographic representation of the data. However, small details of communities present at particular locations are removed.

The resolution of the satellite imagery and the mapping process used results in a product that should not be interpreted at scales larger than 1: 100 000.

The boundary between tidal saltmarshes and freshwater swamps within the Study Area was often difficult to determine. In a number of locations, most notably at Big Sandy Creek, the tidal wetlands and freshwater wetlands merge without a clear spectral distinction between the two. Topographic maps sheets were consulted to assist with the determination of the tidal extent of these wetlands. However, consistency between topographic maps sheets was lacking. Although these freshwater swamps represent an important habitat from a fisheries perspective they have not been included in this mapping as they are not subject to tidal influence.

Over time, the distribution of freshwater swamps can vary markedly. In periods of high freshwater input, freshwater swamp vegetation, such as water-loving terrestrial grasses and sedges, may grow well into the tidal zone of the wetlands. Alternatively, in dry periods, the lack of freshwater input creates a saline environment in which only saltmarsh species can survive. For these reasons, the boundary between freshwater swamps and saltmarshes assigned in this mapping should be considered as a diffuse, rather than a distinct, boundary.

Due to the similar spectral characteristics of their foliage, *B. gymnorrhiza* cannot be easily separated from *Rhizophora* spp., from satellite imagery or aerial photography.

Cloud cover over a small portion of the St Lawrence image caused difficulties in mapping the coastal wetland vegetation associated with Island Head Creek. In particular, a large area of coastal wetlands on the eastern side of the mouth of the creek was obscured by cloud as well as other smaller areas further upstream in the estuary. The areas which were obscured by cloud were edited in manually using aerial photograph interpretation and previous mangrove and saltmarsh vegetation community mapping of the Shoalwater Bay/Port Clinton region (Byron and Hall 1998).

SECTION 5 DISTRIBUTION AND SIGNIFICANCE OF THE COASTAL WETLAND COMMUNITIES

5.1 Overview of Coastal Wetland Community Distribution

The coastal wetland systems from Sand Bay to Keppel Bay represent a wide variety of community assemblages and a diversity of habitat types. Even the two "twin bays" of the Broad Sound and Shoalwater Bay, which have very similar tidal ranges and sheltered environments, exhibit markedly different coastal wetland community assemblages due to the difference in climate regime, freshwater influence and topography of adjacent terrestrial land.

In most estuaries in the Study Area, Closed *Rhizophora*, located on the seaward margin, is the dominant community. Closed *Ceriops* is generally located directly landward of the Closed *Rhizophora* zone. In more upstream locations, where freshwater input is highest, Closed Mixed communities line the stream banks. Saltpans are usually limited to a narrow band in the upper intertidal zone, except where low coastal plains and a dry environment allow further development of a hypersaline environment. Saline Grasslands usually only occur in the upper intertidal zone where there are freshwater swamps adjacent. The typical zonation of the intertidal zone in the majority of the estuaries of the Study Area is illustrated in Figure 5.1.

Unfortunately, due to the limitations of the mapping technique, narrow Closed Mixed communities in the upper tidal reaches of streams are often eliminated in the mapping process. These communities can often be quite diverse. Additionally, the boundary between freshwater swamp and Saline Grassland is often difficult to determine (Section 4.3).

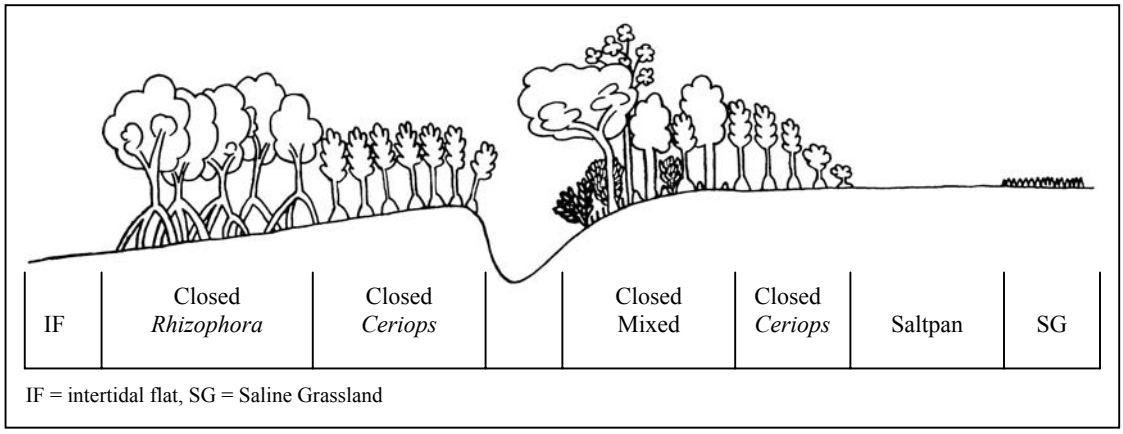

FIGURE 5.1 Transect of a typical coastal wetland system in the Study Area across the tidal profile (seaward-left, landward-right). Not to scale.

The area of each coastal wetland community type within the Study Area is listed in Table 5.1. Saltpans are the dominant coastal wetland community type by area in this Study Area. However, the majority (approximately 80%) of these Saltpan communities are found in only two locations, Broad Sound and the Fitzroy River Delta. Both areas have

extensive low coastal plains and a dry climate. Inundation by the tide and subsequent evaporation creates a hypersaline environment in which very little vegetation can survive. In both the Broad Sound region and the Fitzroy River Delta, the extensive Saltpans are drained by mangrove-lined creeks, which are generally dominated by Closed *Ceriops* or Closed Mixed communities. These communities are very narrow and are often unmappable by this technique (Section 4.3). Figure 5.2 illustrates the typical zonation of the vast Saltpan environments in the Broad Sound region.

An overview of the distribution of coastal and marine environments in the Study Area, which have value as fish habitat is displayed in Map 5.1 (refer to CD). These habitats include the coastal wetland communities as mapped in this study (mangroves and saltmarshes) as well as seagrass meadows, intertidal foreshore flats, coral reefs and cays. These coverages have been obtained from various sources and reflect the distribution of the community at a particular date. An explanation of these datasets, including their currency, is given in Section 3.6.

TABLE 5.1 Areas of coastal wetland communities in the Study Area.

	AREA OF COASTAL WETLAND COMMUNITIES (ha)	PERCENT OF TOTAL
Closed *Rhizophora*	30590	20.5
Closed *Avicennia*	7697	5.2
Open *Avicennia*	627	0.4
Closed *Ceriops*	20536	13.7
Open *Ceriops*	81	0.1
Closed *Aegiceras*	148	0.1
Closed *Rhizophora*/*Avicennia*	25	0.0
Closed *Avicennia*/*Ceriops*	1002	0.7
Open *Avicennia*/*Ceriops*	1	0.0
Closed Mixed	13188	8.8
Closed *Ceriops* Dieback	41	0.0
Saline Grassland	10185	6.8
Saltpan	64520	43.1
Samphire-dominated Saltmarsh	961	0.6
Total	149594	

The distribution of freshwater swamps within the Study Area is also included in Map 5.1. Although the direct benefit of freshwater swamps to fisheries productivity has not been quantified, these habitats are important for fish movement and for various stages in the life cycles of many fish species (e.g. barramundi, mullet, bass). In locations where freshwater swamps merge directly with tidal coastal wetland systems, the swamps contribute nutrients to the tidal zone, especially in times of substantial freshwater flow. These communities add to the diversity of environments that support coastal fisheries productivity.

Further details of the distribution of the coastal wetland communities mapped as part of this study are included in the sections below. The coastal wetland communities have been broken up into 6 reporting regions as follows: Sand Bay to Cape Palmerston, Cape

Palmerston to Clairview Bluff, Broad Sound, Shoalwater Bay, Stockyard Point to Cattle Point and the Fitzroy River Delta. These divisions have been chosen to reflect the general characteristics of the coastline in each of these sections as follows: a diverse coastline of small bays and peninsulas, a relatively exposed coastline, a bay, a bay, a relatively exposed coastline and a river delta (respectively).

In the Study Area, agricultural cultivation and urban development extends to the upper intertidal limit in various locations. Where this occurs, please refer to the maps of coastal wetland vegetation in Appendix 7, where the Landsat TM image background displays the distribution of these land uses. On a Landsat TM Band 3 background, as used in these maps, agricultural cultivation appears as relatively large boxes of white interspersed with boxes of varying colours of grey. Urban development appears as very small dense boxes of bright areas, interspersed with small amounts of grey.

Terrestrial vegetation adjacent to the coastal wetland communities is described in the following sections. Here, adjacent terrestrial vegetation refers to the vegetation located up to 5 km from the upper intertidal limit, in order to maintain consistency with the FHA assessment criteria details as listed in Table 3.4.

5.2 Sand Bay to Cape Palmerston

The diverse shoreline from Sand Bay to Cape Palmerston includes sandy beaches, rocky peninsulas and small sheltered bays. The numerous small sheltered estuaries and embayments support a diverse range of coastal wetland environments.

Of the coastal wetland environments present in this area, Sand Bay, the Baker's Creek-Sandringham Bay Aggregation and the Sarina Inlet-Ince Bay Aggregation have been recognised by the ANCA (1996) as wetlands of national importance. Further details of the conservation significance of these areas are included in Section 7.7 (Table 7.3).

Sand Bay

The fish habitats at Sand Bay include extensive areas of intertidal mud flats, which are backed by dense mangrove forests. Closed *Rhizophora* and Closed *Ceriops* are the dominant coastal wetland communities of this bay. Closed *Rhizophora* occurs mainly on the seaward margin, with Closed *Ceriops* occupying the more landward zone. Smaller communities of Closed *Avicennia* occur in both the foreshore environment and in more upstream locations. Diverse Closed Mixed communities are also found in upstream locations where freshwater input, rather than tidal movement, dominates.

The majority of the coastal wetland communities (3 499 ha) of the Bay are currently protected in the Sand Bay FHA (Management A). The ANCA (1996) identified this bay as being an important area for local fishing and recreation.

A small area of mangrove is included in the Cape Hillsborough National Park. The adjacent terrestrial vegetation to these mangroves is well protected. The Reliance Creek National Park protects a small area of riparian vegetation along Reliance Creek. Outside this area of protection, agricultural development has occurred to the upper tidal limit in a number of locations. This cultivation is evident on Sheet 1, Appendix 7. ANCA (1996) identified continued development of the land adjacent to the mangroves as a potential threat to the hydrology of the wetlands and the ecological integrity of the site.

Northern Beaches

The estuaries at Eimeo and Black's Beach support small coastal wetland communities which are dominated by Closed *Rhizophora* and Closed *Ceriops* at Eimeo and Closed *Ceriops* at Black's Beach. Agricultural and urban development surrounding the coastal wetland communities has extended to the tidal boundary in many locations. The terrestrial vegetation adjacent to the coastal wetland communities has been modified through clearing for urban, agricultural and industrial development. A prawn farm facility abutts and discharges into Eimeo Creek.

Bassett Basin

The coastal wetland communities of the Bassett Basin are under considerable pressure from the development of the city of Mackay (Section 6.2). In the past, the expansion of the city has resulted in considerable losses of coastal wetland vegetation (Table 5.2). Very little natural terrestrial vegetation remains as a buffer between land uses and the coastal wetland vegetation. In most areas, urban development and, to a less extent, agricultural cultivation extends to the coastal wetland vegetation. Existing and proposed residential subdivisions in the Mackay coastal area have the potential to increase the pressure on the adjacent coastal wetland communities (pers. comm. Kylie Dodds, QFS, Mackay, 2000).

TABLE 5.2 Area of coastal wetland communities in the Bassett Basin: 1953, 1993 and 1997.

YEAR	SOURCE	AREA OF MANGROVE COMMUNITIES (HA)	AREA OF SALTMARSH COMMUNITIES (HA)	TOTAL AREA (HA)
1953	Unpublished departmental data (1: 25 000)	785	224	1009
1993	Unpublished departmental data (1: 25 000)	619	118	737
1997	Present study (1: 100 000)	541	52	593

Today, the Bassett Basin estuary is characterised by a mix of communities including Closed *Rhizophora* on the seaward margin, Closed Mixed and Closed *Ceriops* communities further landward, and large areas of Closed *Avicennia* in more upstream locations. Large areas of Closed *Avicennia* have recently been affected by dieback. Considerable concern has been expressed over the cause for this dieback and the implications it may have for the ecological integrity of the system. This issue is discussed further in Section 6.4.

The Bassett Basin FHA (Management B) protects approximately 430 ha of coastal wetland vegetation (mangrove and saltmarsh communities) in this estuary. Further details of the fisheries value of the Bassett Basin are included in Section 7, Table 7.2.

Bakers Creek-Sandringham Bay Aggregation

The important environments associated with the Baker's Creek-Sandringham Bay aggregation include extensive expanses of intertidal and shallow water habitat, and mangrove communities. The coastal wetland communities are quite mixed and do not exhibit the dominance of Closed *Rhizophora* and Closed *Ceriops* throughout the estuary as in other local estuaries. Closed *Rhizophora* is mainly limited to the mouths of the main waterways on the seaward margin. Saline Grasslands and Saltpans inhabit the upper intertidal zone where the boundary between terrestrial grasses and saline grasses is often difficult to determine.

A large proportion of the terrestrial land immediately surrounding the coastal wetland environments has been cultivated for agricultural purposes (Sheet 2, Appendix 7). The ANCA (1996) identified that continuation of the cultivation of land to the edge of the mangroves, along with extensive clearing in adjacent upland areas, has the potential to reduce the overall area of mangroves and alter the hydrology of the system. The Bakers Creek Conservation Park protects a small area of land, including some coastal wetland vegetation, at the mouth of Bakers Creek.

The Baker's Creek-Sandringham Bay aggregation of wetlands is recognised as a locally important recreational fishing and boating area. However, there is currently no managed protected area over these wetlands.

Dalrymple Bay

The small area of coastal wetland communities located at Dalrymple Bay is associated with the estuary of Louisa Creek. This estuary is dominated by Closed *Rhizophora* communities, with small communities of Closed *Ceriops* and Saltpan occurring on the landward margin.

The adjacent terrestrial vegetation on the northwestern edge of the wetlands is relatively untouched. A small amount of this vegetation is protected within the Mount Hector Conservation Park. Low-density development exists on the southeastern edge of the wetland.

Sarina Inlet-Ince Bay Aggregation

Sarina Inlet, Llewellyn Bay and Ince Bay and the numerous small waterways draining into them provide sheltered environments suitable for the establishment of relatively large communities of coastal wetland vegetation. Closed *Rhizophora* is once again the dominant community on the seaward margin, with Closed *Ceriops* establishing in large communities further landward. Closed Mixed communities can be found in the upstream locations. Saline Grasslands and Saltpans have established quite extensively on the landward margin. The boundary between the terrestrial (freshwater) grasslands and the Saline Grasslands is indistinct.

Dieback of Closed *Avicennia* communities has been reported at the mouth of Boundary Creek, Llewellyn Bay (pers. comm. Kylie Dodds, QFS, Mackay, 2000). This issue of the dieback of Closed *Avicennia* communities in this region is discussed further in Section 6.4.

Levees have been constructed in the tidal zone in a number of locations on Rocky Dam Creek. These banks have limited the development of Saltpans in this low coastal area. Freshwater wetlands exist on the landward side of these levees (Figure 5.2).

The terrestrial vegetation adjacent to the coastal wetland communities associated with Sarina Inlet and Llewellyn Bay has been cultivated for agricultural purposes. A large proportion of the coastal wetland vegetation and the surrounding terrestrial vegetation at Ince Bay is included within the Cape Palmerston National Park. The presence of natural terrestrial vegetation adjacent to the coastal wetland communities provides a buffer between the coastal habitats and the dominant land uses in the area, in this instance agriculture.

The ANCA (1996) states that the aggregation is a good example of a diverse, hydrologically related aggregation of marine, estuarine and freshwater wetlands within the Central Mackay Coast bioregion.

The Cape Palmerston (Management A) and the Rocky Dam (Management B) FHAs protect over 6 500 ha of coastal wetland habitats. This area represents approximately 65% of the coastal wetland vegetation located in the Sarina-Ince Bay aggregation.

FIGURE 5.2 Freshwater wetlands at Rocky Dam Creek.

TABLE 5.3 Areas of coastal wetland communities from Sand Bay to Cape Palmerston.

	SAND BAY	EIMEO	BLACKS BEACH	BASSETT BASIN	BAKERS CREEK	SANDRINGHAM BAY	DALRYMPLE BAY	SARINA	INCE BAY	TOTAL	PERCENT OF TOTAL
Closed *Rhizophora*	929	94	56	76	61	225	170	506	1544	3662	20.1
Closed *Avicennia*	126	9	33	249	12	94	8	32	178	742	4.1
Open *Avicennia*	33	0	10	1	20	7	1	1	51	125	0.7
Closed *Ceriops*	1579	69	260	80	82	513	26	346	2667	5621	30.8
Open *Ceriops*	0	0	0	0	0	0	0	0	0	0	0.0
Closed *Aegiceras*	0	0	0	3	0	0	0	0	0	3	0.0
Closed *Rhizophora/ Avicennia*	0	0	0	0	0	5	0	0	2	7	0.0
Closed *Avicennia/Ceriops*	16	0	0	7	0	238	0	5	0	266	1.5
Open *Avicennia/Ceriops*	0	0	0	0	0	0	0	0	0	0	0.0
Closed Mixed	198	0	32	125	170	316	0	57	478	1376	7.5
Closed *Ceriops* Dieback	0	0	0	0	0	0	0	0	0	0	0.0
Saline Grassland	272	2	59	45	125	284	0	15	530	1331	7.3
Saltpan	607	44	82	6	71	372	73	311	3562	5128	28.1
Samphire-dominated saltmarsh	0	0	0	0	0	0	0	0	0	0	0.0
TOTAL	3761	219	532	593	542	2053	278	1273	9011	18260	

5.3 Cape Palmerston to Clairview Bluff

The stretch of coastline from Cape Palmerston to Clairview Bluff is a less diverse and more exposed coastline than that of the region from Sand Bay to Cape Palmerston. The coastal wetland communities in this area are associated with small waterways and extend into coastal plains. The areas of coastal wetland communities in this region are listed in Table 5.4.

Between Cape Palmerston and Clairview Bluff a number of small estuaries are described collectively in the following regions. The Yarrawonga Point region includes all the coastal wetland communities from Cape Palmerston to Yarrawonga Point, including the wetlands associated with Marion Creek. West Hill coastal wetland communities are calculated from Yarrawonga Point to West Hill Creek and include the communities on West Hill itself. The coastal wetlands of the Carmilla region include all of the small estuaries from West Hill to Oaky Creek approximately 24 km to the south of West Hill. The coastal wetland communities between this point and Clairview Bluff are reported on as the Clairview coastal wetlands. The coastal wetlands of Clairview Bluff (associated with Clairview Creek) are continuous with the communities on the northern bank of St Lawrence Creek. As such these communities are reported on together as the Clairview Bluff coastal wetlands.

The Marion (Management B), West Hill (Management A) and Carmilla (Management B) FHAs protect a continuous stretch of coastline (approximately 33 km) from Yarrawonga Point to Carmilla. Together these three FHAs protect some 2 652 ha of coastal wetland communities, approximately 78% of the coastal wetlands found in this area.

Yarrawonga Point

The peninsula at Yarrawonga Point and the small island of West Hill provide shelter to the mangroves in this exposed section of coastline. The coastal wetland communities in this region are associated with Knobbler Creek, an unnamed creek, Walter Hall Creek and Marion Creek (from north to south). The dominant community type in this region is Closed *Rhizophora*. At Marion Creek Closed *Ceriops* and Closed *Avicennia*, further landward and upstream respectively, form a larger proportion of the coastal wetland assemblage.

The terrestrial vegetation adjacent to the coastal wetland communities in the Yarrawonga Point region is largely unmodified. The Cape Palmerston National Park protects this coastal vegetation in the northern section of this region. A small area of agricultural cultivation occurs close to Yarrawonga Point. However, in most areas this clearing for cultivation has not extended to the upper intertidal boundary and a buffer of terrestrial vegetation adjacent to the coastal wetland vegetation remains.

West Hill

The estuaries of Kelly Creek, Basin Creek, West Hill Creek and Marion Creek provide shelter for small coastal wetland communities in the West Hill region. These estuaries are dominated by Closed *Ceriops*, Closed *Avicennia* and Closed Mixed communities. The largest area of Saltpans in this region occurs at West Hill and Five Mile Creeks.

Although these coastal wetland systems are quite isolated from urban development, agricultural development has extended into the coastal plains adjacent to the wetlands in

some locations (Sheet 4, Appendix 7). West Hill National Park protects the majority of the coastal wetland communities on the southern bank of Three Mile Creek as well as the coastal dune vegetation. West Hill is entirely protected by this National Park.

Carmilla

Small coastal wetland communities in the Carmilla region occupy the mouths of the estuaries of Carmilla Creek, Feather Creek, Flaggy Rock Creek, Stockyard Creek, Lantana Creek, Bluewater Creek and Oaky Creek (from north to south). The coastal wetland communities associated with these creeks are dominated by Closed *Ceriops*. There is a general absence of Closed *Rhizophora* communities in the foreshore areas. Saltpans form a large proportion of these small coastal wetland communities, except at Carmilla Creek where the majority of Saltpan has been converted to freshwater wetland by the construction of levees in the tidal zone.

Although no National Parks are present in this region to protect the natural vegetation, the land adjacent to the coastal wetland communities is largely unmodified. Some land between Carmilla Creek and Feather Creek, and near Flaggy Rock Creek has been cleared for agricultural purposes (Sheet 5, Appendix 7). Cultivation of the land adjacent to the coastal wetlands extends to the upper intertidal boundary at these locations.

Clairview

In the Clairview region, small coastal wetland communities can be found at the mouths of Dry Creek, Turner Creek, Sand Fly Creek, Case Creek, Dingo Creek and along the northern foreshore of Clairview Bluff. These very small communities are dominated by Saltpans and Closed *Ceriops*. The terrestrial vegetation adjacent to the coastal wetlands at Clairview is largely unmodified.

Clairview Bluff

Closed *Ceriops* communities and Saltpans dominate the coastal wetland assemblages at Clairview Bluff. Small Closed *Rhizophora* communities are located towards the seaward margin and Closed Mixed communities are interspersed through the wetland area. *Ceriops* tagal forms narrow communities along the small waterways through the Saltpans, which are virtually devoid of vegetation. Small Saline Grassland communities are located on the landward edge of these Saltpans.

A relatively large area of dead Closed *Ceriops* is present at this location. It is suggested that this dieback has resulted from a natural, rather than man-made, disturbance event. See Section 6.4 for further details.

The coastal wetland vegetation at Clairview Creek is quite isolated from human activity and the surrounding terrestrial vegetation is largely unmodified. The majority of the coastal wetlands found here are protected within the Broad Sound FHA (Management A).

This isolated area of coastal wetlands is utilised as a local fishing and recreation spot.

TABLE 5.4 Areas of coastal wetland communities from Cape Palmerston to Clairview Bluff.

	YARRAWONGA POINT	WEST HILL	CARMILLA	CLAIRVIEW	CLAIRVIEW BLUFF	TOTAL	PERCENT OF TOTAL
Closed *Rhizophora*	221	99	19	1	137	476	5.9
Closed *Avicennia*	51	138	49	1	108	347	4.3
Open *Avicennia*	14	5	2	6	29	56	0.7
Closed *Ceriops*	182	399	169	25	869	1645	20.4
Open *Ceriops*	0	6	0	0	0	6	0.1
Closed *Aegiceras*	0	0	0	0	0	0	0.0
Closed *Rhizophora/Avicennia*	0	0	0	0	0	0	0.0
Closed *Avicennia/Ceriops*	0	0	0	0	0	0	0.0
Open *Avicennia*/*Ceriops*	0	0	0	0	0	0	0.0
Closed Mixed	11	209	206	7	185	618	7.7
Closed *Ceriops* Dieback	0	0	0	0	17	17	0.2
Saline Grassland	55	47	28	2	221	351	4.4
Saltpan	372	775	338	134	2928	4548	56.3
Samphire-dominated saltmarsh	0	0	0	0	15	15	0.2
TOTAL	906	1679	810	176	4507	8079	

5.4 Broad Sound Region (Clairview Bluff to Stanage)

The Broad Sound has been recognised as good example of an estuarine and marine wetland complex within a large sheltered embayment and adjacent to a broad coastal plain (ANCA 1996). The creeks and rivers in this region experience the largest tidal range of any area on the Queensland coastline. The Broad Sound itself is shallow, less than 10 m deep throughout, with many even shallower bars (ANCA 1996). At low tide the wide channels of the Broad Sound and associated creeks and rivers (St Lawrence Creek, Waverley Creek and Styx River) become very shallow and extensive intertidal flats are exposed. Marine plants must therefore cope with a wide variety of daily environmental conditions ranging from total inundation to total exposure. Figure 5.3 and Figure 5.4 illustrate the extent to which the creek bottoms of St Lawrence Creek and Waverley Creek (respectively) are exposed at low tide.

The land surrounding the coastal wetlands in the Broad Sound is utilised extensively for cattle grazing. Large areas of the low coastal plain (an estimated 6 500 ha of marine plants, [Cummins 1991]) have been converted from tidal areas to freshwater pastures suitable for cattle grazing by the construction of levees in the tidal zone. Concerns have been raised of the effect of these pondage systems on important fish habitats and fisheries (in particular, on barramundi migrations) in the region. This issue is discussed further in Section 6.3.

This large embayment has been divided into three reporting regions. St Lawrence refers to the area from the southern bank of the St Lawrence Creek east to Charon Point. Broad Sound contains the coastal wetland systems east of Charon Point to Stanage. The coastal wetland communities of Long Island and the associated islands at the mouth of the Broad Sound are referred to in the Long Island section.

The Broad Sound FHA (Management A) protects the 53 910 ha of coastal wetland communities in the Broad Sound and includes the area of wetlands at Clairview Bluff. This area represents approximately 96% of the coastal wetland vegetation that is found in the Broad Sound region, including the Clairview Bluff coastal wetlands.

FIGURE 5.3 St Lawrence Creek at low tide. The water volume present in the creek at low tide is such that the majority of the creek bottom is exposed.

FIGURE 5.4 Waverley Creek at low tide. The Creek bottom is almost fully exposed.

St Lawrence

Saltpans that are virtually devoid of vegetation dominate the coastal wetland communities of St Lawrence. The low coastal plain is generally inundated on the highest tides, leaving a shallow body of water that is quickly evaporated in this generally hot, dry environment. The resulting hypersaline conditions create an environment where vegetation generally cannot survive. In less saline regions of the Saltpans dense samphire vegetation grows.

Closed *Ceriops* communities generally do not inhabit the seaward margin of a coastal wetland system. However, in the Broad Sound tall Closed *Ceriops* communities are found on the foreshore. In some areas narrow communities of Closed *Rhizophora* and Closed or Open *Avicennia* lie seaward of this broad Closed *Ceriops* zone. The sediments of this environment are highly unstable due to the extensive movement of the tides, as well as occasional floods and cyclones. Closed *Rhizophora* communities appear to be remnants of what were once much larger seaward zones but have since been destroyed by the disturbance of the sediments. In periods of accretion in this region pioneering *A. marina* begins to establish on the new sediments.

As noted above, a large area of coastal wetlands in this area have been altered by the construction of levees in the tidal zone to create pondage systems. A small area of coastal wetland vegetation associated with Waverley Creek has been included in the Newport Conservation Park.

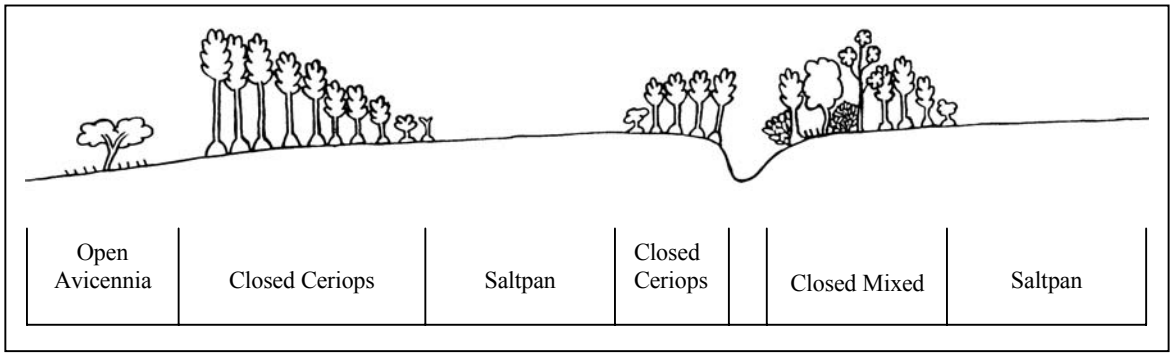

FIGURE 5.5 Transect of a typical Saltpan dominated coastal wetland system across the tidal profile (seaward-left, landward-right). Not to scale.

Broad Sound

The coastal wetland communities on the western bank of the Albert River mimic the general pattern of zonation in the Broad Sound region, with very narrow Closed *Rhizophora* communities inhabiting the foreshore and Closed *Ceriops* communities following drainage channels through the Saltpans. However, further upstream Closed *Avicennia* communities dominate the riverbank, with Closed *Ceriops* and a mixture of Saltpans and Saline Grasslands forming a broad zone on the landward edge.

Coastal wetland vegetation forms a continuous zone on the eastern bank of the Albert River all the way to Stanage, with an extensive area of vegetated tidal wetlands occurring along Big Sandy Creek. A large lowland coastal plain occurs behind this extensive area of marine vegetation. Saline Grasslands merge with freshwater swamp areas creating difficulty in determining where the tidal boundary lies (Section 4.3).

North of Big Sandy Creek, both Closed *Rhizophora* communities in the seaward zone and Closed Mixed communities further landward become more common. Closed *Ceriops* also occupies a large proportion of the intertidal zone, with Saltpans existing on the landward edge. Higher relief of the adjacent terrestrial land limits the extent of Saltpan development. As such, the Saltpans to the north of Big Sandy Creek are much narrower than elsewhere in the Broad Sound.

The terrestrial vegetation adjacent to the coastal wetland communities of the Broad Sound is largely unmodified. The Charon Point Conservation Park protects the terrestrial vegetation adjacent to coastal wetlands systems for approximately 6 km to the southeast of Charon Point. The majority of the coastal wetland vegetation along the western bank of Albert Creek has been limited to a narrow strip due to the construction of pondage systems. The modified terrestrial land adjacent to these levees is utilised heavily as grazing land. Very little modification of the vegetation adjacent to the coastal wetlands on the eastern bank of the Albert River has occurred.

Long Island

The coastal wetland communities on Long Island are more diverse than those of the area described above. *A. corniculatum* and *A. annulata* often form a narrow low fringe on the seaward margin succeeded by dense Closed *Rhizophora* communities, which may have other species (such as *O. octodonta*) interspersed within the community. Further landward, a dense zone of Closed Mixed occurs. Mangroves species found in this mixed assemblage include *A. corniculatum*, *A. annulata*, *A. marina*, *C. tagal*, *E. agallocha*, *Bruguiera* spp., *O. octodonta*, *Rhizophora* spp. and *X. moluccensis*. The Closed Mixed zone is generally succeeded by a Closed *Ceriops* zone, which progressively decreases in height as the distance from the waterway increases. The Closed *Ceriops* community is eventually succeeded by a narrow band of Saltpan.

The adjacent terrestrial vegetation on Long Island and other islands within this group is virtually pristine. The upland slopes are well forested and human development has caused very little disturbance to these communities. Some terrestrial land along with some coastal wetland vegetation on the southern half of Long Island and on other smaller islands in the Broad Sound are protected within the Broad Sound Islands National Park.

TABLE 5.5 Areas of coastal wetland communities in the Broad Sound Region.

	ST LAWRENCE	BROAD SOUND	LONG ISLAND	TOTAL	PERCENT OF TOTAL
Closed *Rhizophora*	351	1332	1862	3545	6.9
Closed *Avicennia*	698	923	0	1621	3.1
Open *Avicennia*	232	14	0	247	0.5
Closed *Ceriops*	4592	6015	415	11023	21.4
Open *Ceriops*	0	13	3	17	0.0
Closed *Aegiceras*	0	54	91	144	0.3
Closed *Rhizophora*/*Avicennia*	0	0	0	0	0.0
Closed *Avicennia*/*Ceriops*	400	267	0	667	1.3
Open *Avicennia*/*Ceriops*	0	0	0	0	0.0
Closed Mixed	31	1296	1930	3257	6.3
Closed *Ceriops* Dieback	25	0	0	25	0.1
Saline Grassland	205	6737	0	6942	13.4
Saltpan	12329	9842	1034	23205	44.9
Samphire-dominated saltmarsh	946	0	0	946	1.8
TOTAL	19809	26493	5336	51638	

5.5 Shoalwater Bay (Stanage to Stockyard Point)

Shoalwater Bay, from Stanage to Stockyard Point, is a unique environment within the Study Area due to the extensive coastal wetland habitats that exist in a virtually pristine state. The majority of the terrestrial land adjacent to the coastal wetland communities in Shoalwater Bay lies within the Shoalwater Bay Military Training Area (SWBMTA). The management of this area by the Australian Army, for defence training purposes, has limited the development of the catchment. For this reason, the terrestrial vegetation adjacent to the coastal wetland communities in this entire region, including Townshend and Leicester Islands, Island Head and Port Clinton, is near pristine. Additionally, coastal wetland communities are generally undisturbed and development of the shoreline is minimal.

The ANCA (1996) has recognised both Shoalwater Bay and the Island Head Creek–Port Clinton Area as wetlands of national importance. Further details of their recognised value are included in Section 7.7. Additionally, the Australian Government (1994) Commonwealth Commission of Inquiry Shoalwater Bay found that the marine and estuarine parts of the area are very important as a nursery for commercial fisheries because of their undisturbed and intact nature relative to degraded fish nursery habitat areas elsewhere on the Queensland coast. Byron and Hall (1998) reported that the extensive areas of mangrove forest, intertidal flats and saltmarsh provide habitat for migratory waders, commercially important fish species, marine turtles and dugong.

Shoalwater Bay

For approximately 50 km east of Stanage the coastal wetland communities that occur are generally very small and are located only in the shelter of the estuaries at the mouths of creeks and small waterways. The foreshore of this section of Shoalwater Bay is mainly vast stretches of sandy beaches interspersed by small rocky headlands. In this section of the Bay, Closed *Rhizophora* communities have established on the seaward margin and are generally succeeded directly by Saltpan. Closed Mixed communities may also occur in more upstream locations along these waterways. The Shoalwater Bay Conservation Park protects some of the coastal wetland communities and adjacent terrestrial land in this section of Shoalwater Bay.

South east of this section of coastline, the coastal wetland communities become progressively more extensive and are no longer restricted to the mouths of creeks and rivers. The extreme tidal range and the minimal intertidal topography of the area facilitate the maintenance of large intertidal wetlands (Byron and Hall 1998). In some areas, the coastal wetland communities extend up to approximately 8 km from the shoreline in a dense continuous band.

In contrast to the Broad Sound, Shoalwater Bay has very limited Saltpan development. The land adjacent to the intertidal zone is generally of high relief. Additionally, the area experiences a relatively high mean annual rainfall (approximately 1745 mm in comparison to 800–1000 mm in the Broad Sound region). These two factors contribute to the restriction of the Saltpan environments to a very narrow landward rim. Small Closed *Ceriops* communities are often associated with these Saltpans on the landward rim. However, these communities are very narrow and are not mappable by this technique in most locations.

The Shoalwater Bay Conservation Park protects a number of small estuaries in this region, the coastal wetland vegetation associated with these estuaries and the adjacent terrestrial vegetation.

Townshend and Leicester Islands

The largest area of coastal wetland communities on Townshend and Leicester Islands occurs in Canoe Passage, which separates the two islands, and on the southwestern coast of Townshend Island. Smaller areas of coastal wetlands are also located in very small embayments on the southeast of Townshend Island and on the east of Leicester Island.

Closed *Rhizophora* occupies the seaward zone of the intertidal area and is the dominant coastal wetland community by area on the Islands. Areas of Closed Mixed communities occupy more upstream locations on these islands and Saltpans generally occur on the landward edge.

Island Head

The relatively small area of mangrove associated with Island Head Creek is dominated by Closed *Rhizophora*. Other community types within this region, (Closed *Ceriops*, Open *Ceriops*, Open *Avicennia*/*Ceriops*, Closed Mixed and Saltpan) represent only 11% of the vegetated intertidal habitats, as mapped in this study.

Port Clinton

Closed *Rhizophora* dominates the coastal wetland communities of Port Clinton, occupying a large seaward zone. Closed *Ceriops* communities and small Saltpans occur in the more saline areas. More diverse Closed Mixed communities occur as a landward zone along the South Arm and in the northwestern extent of the coastal wetland system.

TABLE 5.6 Areas of coastal wetland communities of Shoalwater Bay.

	SHOALWATER BAY	TOWNSHEND AND LEICESTER ISLANDS	ISLAND HEAD	PORT CLINTON	TOTAL	PERCENT OF TOTAL
Closed *Rhizophora*	11412	1014	1218	3287	16931	72.1
Closed *Avicennia*	2	0	0	5	7	0.0
Open *Avicennia*	16	0	0	0	16	0.1
Closed *Ceriops*	308	7	24	605	944	4.0
Open *Ceriops*	0	0	20	38	58	0.3
Closed *Aegiceras*	0	0	0	0	0	0.0
Closed *Rhizophora*/*Avicennia*	0	0	0	18	18	0.1
Closed *Avicennia*/*Ceriops*	0	0	0	24	24	0.1
Open *Avicennia*/*Ceriops*	0	0	1	0	1	0.0
Closed Mixed	1341	104	51	309	1804	7.7
Closed *Ceriops* Dieback	0	0	0	0	0	0.0
Saline Grassland	22	0	0	0	22	0.1
Saltpan	2908	305	57	377	3647	15.5
Samphire-dominated Saltmarsh	0	0	0	0	0	0.0
TOTAL	16008	1430	1370	4663	23471	

5.6 Stockyard Point to Cattle Point

Of the coastal wetland environments present within this section of the coastal, the ANCA (1996) has recognised Corio Bay, the Yeppoon–Keppel Sands Tidal wetlands and Water Park Point wetlands as wetlands of national importance. Further details of the conservation significance of these wetlands as listed by the ANCA, is included in Section 7.7 (Table 7.3).

Corio Bay

Corio Bay is situated in an exposed stretch of coastline and provides shelter for a diverse range of community types. Shallow water habitats, intertidal flats, seagrass beds, mangrove lined creeks and adjacent freshwater wetlands all contribute to the diversity of environments which provide habitat for fisheries species.

Large areas of coastal plains at Corio Bay have been separated from tidal influence through the construction of levee banks. The freshwater wetlands that now occur in these locations have remnants of marine vegetation (salt couch and samphire vegetation) growing among the water loving terrestrial grass and sedge species. Mangrove vegetation grows to the levee bank, the man-made extent of tidal inundation.

The freshwater influence on Water Park Creek on the northern side of Corio Bay, remains unaltered. Although Closed *Rhizophora* dominates the seaward margin in this area, there is also a large proportion of diverse Closed Mixed communities. Mangrove species present within these communities generally include *A. corniculatum, A. marina, C. tagal, E. agallocha*, *O. octodonta*, *Rhizophora* spp. and *X. moluccensis*. Closed Mixed communities also exist on the southern side of the Bay. These communities consist of mainly *A. marina*, *C. tagal*, *E. agallocha*, *Rhizophora* spp. and sparse *X. moluccensis*.

The terrestrial vegetation surrounding the Corio Bay wetlands is largely unmodified. The region to the north of the Bay is protected by the Byfield National Park and is densely forested. However, the construction of levees in the intertidal zone has altered the hydrology and vegetation of a large proportion of wetlands on the southern side of the bay. A large area of coastal wetland vegetation (2 327 ha) is protected in the Corio Bay FHA.

Yeppoon–Cawarral Creek

The coastal wetland communities in this region include those habitats associated with Yeppoon, Shoal Bay and Cawarral Creek (Keppel Sands). The area has been recognised by the ANCA (1996) as a very popular area for fishing and crabbing. The coastal wetlands are described as relatively undisturbed in an otherwise highly disturbed and increasingly populated area. Approximately 80% (2 543 ha) of the coastal wetlands associated with Cawarral Creek are included in the Cawarral Creek FHA. The Causeway Lake Conservation Park and the Keppel Sands Conservation Park protect small areas of coastal wetland vegetation at Shoal Bay and Cawarral Creek respectively. Some of coastal vegetation in this region is protected in the Capricorn Coast National Park.

Closed *Avicennia* communities and Saltpans dominate the coastal wetlands at Yeppoon and Shoal Bay. The vegetated wetlands associated with Cawarral Creek are dominated by Closed *Rhizophora* and Closed *Avicennia*. Approximately 50% of the coastal wetland habitat at Cawarral Creek is Saltpan.

The terrestrial vegetation adjacent to the coastal wetlands at Yeppoon has been severely impacted by urban development at Yeppoon and by agricultural land use in the surrounding area. The vegetation surrounding the coastal wetlands of Shoal Bay and Cawarral Creek has been modified by the clearing for agricultural and urban development.

Great Keppel Island

A small coastal wetland system exists on the northern shoreline of Great Keppel Island. This system is dominated by Closed *Rhizophora* and Saltpan communities. Closed *Avicennia* communities are also present. The island is well forested and the terrestrial vegetation surrounding the coastal wetland communities is near pristine.

TABLE 5.7 Areas of coastal wetland communities from Stockyard Point to Cattle Point.

	CORIO BAY	YEPPOON	SHOAL BAY	CAWARRAL CREEK	GREAT KEPPEL ISLAND	TOTAL	PERCENT OF TOTAL
Closed *Rhizophora*	800	38	8	703	18	1567	22.1
Closed *Avicennia*	379	56	125	797	9	1367	19.2
Open *Avicennia*	20	0	22	32	0	74	1.0
Closed *Ceriops*	332	0	0	15	0	347	4.9
Open *Ceriops*	0	0	0	0	0	0	0.0
Closed *Aegiceras*	0	0	0	0	0	0	0.0
Closed *Rhizophora*/*Avicennia*	0	0	0	0	0	0	0.0
Closed *Avicennia*/*Ceriops*	44	0	0	0	0	44	0.6
Open *Avicennia*/*Ceriops*	0	0	0	0	0	0	0.0
Closed Mixed	441	0	0	0	0	441	6.2
Closed *Ceriops* Dieback	0	0	0	0	0	0	0.0
Saline Grassland	742	0	84	95	0	921	13.0
Saltpan	379	8	364	1568	27	2345	33.0
Samphire-dominated Saltmarsh	0	0	0	0	0	0	0.0
TOTAL	3138	102	602	3211	54	7106	

5.7 The Fitzroy River Delta (Cattle Point to Ramsay Crossing)

The Fitzroy River Delta includes the Fitzroy River, Raglan Creek, Casuarina Creek, Connor Creek and the Narrows north of Ramsay Crossing, all of which discharge into Keppel Bay just east of Rockhampton, central Queensland. The tidal reaches of the Fitzroy River extend to a barrage built in 1970 located 59.6 km upstream from the mouth of the river (Fabbro and Duivenvoorden 1996). The coastal wetlands from this tidal barrage to Ramsay Crossing including the western coastline of Curtis Island to Station Point are included in this area. Curtis Island protects the coastal wetlands associated with these rivers and creeks from the prevailing wind and wave action. The coastal plain is subjected to regular flooding during the summer months from the Fitzroy River.

The Fitzroy River delta is characterised by extensive Saltpans and Closed Mixed communities. The Closed Mixed communities generally follow drainage lines through the expansive Saltpans that are otherwise almost entirely devoid of vegetation. Although in some places within the Closed Mixed communities monospecific stands (such as Closed *Avicennia* or Closed *Ceriops*) exist, these monospecific regions are generally quite small and as such are not mappable by this technique. The following species can be

found in this mixed environment: *A. annulata*, *A. corniculatum*, *A. marina*, *Bruguiera* spp., *C. tagal*, *E. agallocha*, *L. racemosa*, *O. octodonta*, *Rhizophora* spp. and *Xylocarpus* spp. Additionally, *A. ilicifolius*, the Holly mangrove, can be found in Closed Mixed communities on the southern and northern banks of the Fitzroy River.

Closer to the water's edge, Closed *Rhizophora* and Closed *Avicennia* communities dominate. *A. marina* is found towards the upper tidal reaches of the Fitzroy River whereas *Rhizophora* spp. dominates closer to the estuary mouth.

The presence and abundance of different coastal wetland communities divides the Fitzroy River Delta into three distinct areas. Area 1 is dominated by Closed *Avicennia* and Closed Mixed communities and has a relatively low occurrence of Saltpans. In contrast, Area 2 is dominated by Saltpans with Closed Mixed and Closed *Ceriops* communities. Area 3 is once again dominated by Saltpan. However, Closed Mixed and Closed *Rhizophora* (rather than Closed *Ceriops*) are the main mangrove communities found here. The three areas are discussed in further detail below.

Area 1. Rockhampton to Pirate Point (including the northern bank of the Fitzroy River)
The northern and southern banks of the Fitzroy River, from Rockhampton to Pirate Point, are dominated by Closed Mixed and Closed *Avicennia* communities. The Closed Mixed typical of the area consists of *A. ilicifolius* (close to its southern distributional limit), *A. corniculatum*, *A. marina* and *E. agallocha*. In some areas, the mangrove communities along the bank of the Fitzroy River appear to be flood damaged. The regrowth communities typically have an understorey of young *A. marina* with *E. agallocha* emergents (up to 9 m) as well as *A. corniculatum* and *Bruguiera* spp. (Section 6.4).

The wetland communities located on the northern bank of the Fitzroy River have been altered by the creation of levees that prevent saline water entering the pastures behind. Freshwater wetland environments exist landward of these levees with saline extending to the seaward edge of the levee in most places. Some vegetation typical of saline environments (e.g. samphires and salt couch) extends past the levees. However, it has not been included in this study of coastal wetland vegetation, as it is not influenced by the tide.

Narrow Closed *Rhizophora*, Closed *Avicennia* and Closed Mixed communities extend along the northern bank of the Fitzroy River from Thompson Point to Rundles Beach. Although small Saltpan and Saline Grassland areas are found in this area, the banks of the Fitzroy River are generally lacking these community types. On both the southern and northern banks of the Fitzroy River mangrove vegetation and terrestrial vegetation merge without a significant Saltpan or Saline Grassland separating the two. A thin transition zone, with both terrestrial and marine plants, is often present.

A large Saltpan on the northern bank of the Fitzroy River at the river mouth is the only extensive Saltpan environment in Area 1. This Saltpan extends approximately 3 km from the Fitzroy River along Barramundi Creek. Thin Closed Mixed communities follow the creek. However, the majority of the area is unvegetated, indicating sparse freshwater input.

Islands within the Fitzroy River consist of Closed *Rhizophora* and Closed *Avicennia*. In areas where sediment has been deposited (eg. the front of Mud Island) *A. marina* is pioneering, forming an open community.

The terrestrial vegetation is this area has been modified by the creation of pondage systems and through clearing for pasture land.

Area 2. Pirate Point to Raglan Creek

The region extending from Pirate Point to Raglan Creek consists of Closed *Avicennia* on the seaward margin, with Closed *Ceriops* and Closed Mixed communities behind. The Closed Mixed communities tend to follow drainage lines through the Saltpans whereas Closed *Ceriops* communities are found on more elevated land. The boundary between Saltpan and Closed *Ceriops* is often characterised by individual dead *C. tagal* plants.

Pondage systems and other man-made structures interfere with the water flow regime creating an environment in which the tidal limits are obscure. The terrestrial vegetation adjacent to the coastal wetlands has also been modified by the construction of these features.

Extensive Saltpans characterise the coastal wetlands associated with Raglan Creek. Large salt evaporation ponds that occupy approximately 2 700 ha of the intertidal area interrupt these Saltpans. Thin mangroves communities and some Saline Grassland along the upper reaches of Raglan Creek were noted but were below the minimum mapping unit used in this study.

Area 3. Raglan Creek to Ramsay Crossing (including western Curtis Island)

Area 3, from the mouth of Raglan Creek east to Ramsay Crossing and including western Curtis Island, is characterised by Closed *Rhizophora* communities on the seaward margin, extensive Saltpans to the landward edge and thin dendritic Closed Mixed communities. Accretion banks within the creeks of this wetland environment are occupied by Closed *Avicennia*. Large stands of Closed *Ceriops* are generally not found in this region despite the fact that *Ceriops* forms a significant component of the Closed Mixed communities.

The Saltpans in this area extend all the way to the Rundle and Mount Larcom Ranges and Ramsay Range on Curtis Island. As such the tidal limit is very clearly defined. Saline Grassland is relatively sparse in this region.

The terrestrial vegetation adjacent to the Area 3 coastal wetlands is largely unmodified. The terrestrial vegetation on the eastern border of the Connor Creek coastal wetlands is protected in the Rundle Range National Park and as such is densely forested.

TABLE 5.8 Areas of coastal wetland communities of the Fitzroy River Delta.

	AREA 1	AREA 2	AREA 3	TOTAL	PERCENT OF TOTAL
Closed *Rhizophora*	322	100	3987	4409	10.7
Closed *Avicennia*	741	2436	437	3614	8.8
Open *Avicennia*	38	58	14	110	0.3
Closed *Ceriops*	1	955	0	956	2.3
Open *Ceriops*	0	0	0	0	0.0
Closed *Aegiceras*	0	0	0	0	0.0
Closed *Rhizophora*/*Avicennia*	0	0	0	0	0.0
Closed *Avicennia*/*Ceriops*	0	0	0	0	0.0
Open *Avicennia*/*Ceriops*	0	0	0	0	0.0
Closed Mixed	514	2513	2665	5693	13.9
Closed *Ceriops* Dieback	0	0	0	0	0.0
Saline Grassland	138	470	10	618	1.5
Saltpan	776	15509	9362	25647	62.5
Samphire-dominated Saltmarsh	0	0	0	0	0.0
TOTAL	2531	22041	16474	41046	

5.8 Regional Significance of the Coastal Wetland Environments

Within the Study Area, the coastal wetlands of Shoalwater Bay are of particular regional significance. The Shoalwater Bay Military Training Area (SWBMTA) is the largest coastal wilderness area between Nadgee (southern NSW) and the Cape Melville/Starke Holding area on Cape York Peninsula (ANCA 1996). The area is species rich due to the fact that it is a significant overlap zone for tropical, subtropical and temperate species in all fauna groups (ANCA 1996). The coastal wetlands and surrounding terrestrial vegetation is in virtually pristine condition. For these reasons the Shoalwater Bay region is one of great value for scientific research and as a conservation area.

Within the Study Area, the dominant community type by area is Saltpan. However, the majority (approximately 80%) of the Saltpan environments within the Study Area is located at Broad Sound and the Fitzroy River Delta. These two areas are both dry environments with large coastal plains where extensive virtually unvegetated Saltpans have developed on the hypersaline flats. On a regional scale such Saltpan development is relatively unique as the majority of the tropical environments in Queensland receive high annual rainfall and riverine freshwater input, which limits Saltpan development. Other extensive Saltpan habitats occur in tropical Queensland at Princess Charlotte Bay and on the southern coastline of the Gulf of Carpentaria.

Distribution of Mangrove Species

Mangrove species distribution is limited latitudinally by the physiological tolerance of each species to low temperatures (Duke *et al.* 1998). The Study Area is the southern limit of distribution for a number of tropical mangrove species. Port Clinton has been reported as the southern distributional limit of 4 species, *B. exaristata*, *R. lamarkii*, *R. apiculata* and *S. alba*. Duke and Bunt (1979) suggest that it is probable that *R. lamarkii* and *R. apiculata*

occur further to the south. Mackay is recorded as the southern limit of *C. iripa* (Wells 1983). Fieldwork for the present study confirms this as this species was only sighted at Reliance Creek and Constant Creek, north of Mackay. Wells (1983) reports that the southern limit of both *A. ilicifolius* and *H. littoralis* occurs at St Lawrence. However, in the present study *A. ilicifolius* was observed on the bank of the Fitzroy River, approximately 170 km south-east of St. Lawrence.

Twenty-two species of mangrove have been reported within the Study Area (Lovelock 1993; Wells 1983). Fieldwork conducted as part of this investigation confirms the presence of the following 17 species in the Study Area:

- *A. annulata*
- *A. corniculatum*
- *A. ilicifolius*
- *A. speciosum*
- *A. marina*
- *B. gymnorrhiza*
- *C. tagal*
- *C. pedunculatum*
- *C. iripa*
- *E. agallocha*
- *H. tiliaceus*
- *L. racemosa*
- *O. octodonta*
- *R. apiculata*
- *R. stylosa*
- *X. granatum*
- *X. moluccensis*

The species identified at each of the field sites are included in Appendix 8.

SECTION 6 DISTURBANCE OF AND THREATS TO COASTAL WETLAND VEGETATION IN THE STUDY AREA

6.1 Specific Disturbance of and Threats to Coastal Wetland Vegetation

Increasing human population poses a continual threat, both directly and indirectly, to coastal wetland environments worldwide. In many regions of the world various development activities have resulted in large losses of valuable coastal wetland environments. For example, development such as waterfront housing estates, marinas and aquaculture ventures often target areas adjacent to or within coastal wetlands.

Marine plants in Queensland are protected from physical disturbance under Fisheries legislation. Any proposed disturbance of marine plants requires approval under the *Fisheries Act 1994*, with most larger scale developments also being subject to intensive whole of government assessment (via an Environmental Impact Statement or through the Integrated Development Assessment System (IDAS)). These assessment procedures seek to ensure that development impacts are minimised and retained within a localised area. Details of known development proposals within the Study Area that have the potential to have minor impacts on coastal wetland vegetation are included in Table 6.1.

TABLE 6.1 Development proposals that may impact upon coastal wetland vegetation.

LOCATION	DETAILS
BAKERS CREEK	A marine aquaculture facility proposed for area abutting Bakers Creek.
DALRYMPLE BAY	The proposed expansion of the Dalrymple Bay Coal Terminal has the potential to impact further on the Louisa Creek system.
MACKAY–SLADE POINT AREA	Extensive industrial development proposed for Port Authority lands, majority of land is comprised of extensive freshwater wetlands and upper tidal reaches of Bassett Basin Fish Habitat Area. Recent marina development and associated roads and spoil disposal areas, etc required reclamation of tidal land and marine plant clearing.
MACKAY COASTAL AREA	Extensive residential subdivisions existing and proposed for coastal areas, ie. abutting tidal creeks and foreshore, dunal areas. Potential impacts upon adjacent marine habitats. River Improvement Trust levee proposed for North Mackay. Marine plant clearing and tidal land reclamation required for upper reaches of Bassett Basin Fish Habitat Area. Multipurpose Community Complex proposed for mouth of Pioneer River on dunal lands, adjacent to extensive marine plant areas.
BURDEKIN–ST LAWRENCE	Ongoing interest in aquaculture development along this section of coast. Aquaculture site identification study undertaken for this section of coast.

A number of facilities, including aquaculture, sewage disposal and bio-dunder facilities, discharge into various creeks within the Study Area. If these facilities are managed poorly, the discharges from these facilities have the potential to impact upon sensitive coastal wetland ecosystems. Table 6.2 includes a list of facilities within the Study Area that discharge into various creeks and waterways.

TABLE 6.2 Existing developments that may be a potential threat to coastal wetlands if poorly managed.

LOCATION	DETAILS
EIMEO CREEK	A prawn farm abutts and discharges into Eimeo Creek.
BAKERS CREEK	An abattoir, aquaculture facility and sewage treatment plant discharge into Bakers Creek.
CAMPWIN CREEK	Marine aquaculture facility.
LLEWELLYN BAY	A distillery, sugar mill and aquaculture facility discharge into Llewellyn Bay.
PLANE CREEK	Bio-dunder facility discharges wastewater from processing into Plane Creek.
WEST HILL	An aquaculture facility is being constructed in the Marion Creek area and requires the removal of marine plants for the construction of the intake and discharge structure.

6.2 Catchment-wide Threats to Coastal Wetland Vegetation

Although the threat of direct removal of coastal wetland systems is an important management consideration, the ongoing indirect effects caused by increased urban and agricultural development within a catchment are potentially more significant. The deterioration of water quality through inappropriate land management and alterations to water flow characteristics are primary concerns. Poor land management practices that facilitate erosion may result in changes to sedimentation and turbidity characteristics of the waterways. Agricultural herbicides, pesticides and fertilisers carried into the waterways, as well as sewage and industrial discharge, create changes in water quality. Increases in water usage, the construction of dams to meet water supply needs and increases in urban runoff may all cause alterations to water flow characteristics in the catchment.

The damage to aquatic ecosystems, and in particular to fisheries and fish habitats, arising from various human induced changes is largely unquantified and remains poorly understood. However, the potential for these processes to have deleterious effects on coastal wetland systems is recognised. The threshold of tolerance of fisheries and fish habitats to these changes, before major alterations in the physical nature of these systems occur, requires further study.

The following provides a summary of issues that have been identified as being of concern within the major catchments of the study area. The three major catchments examined here are the Pioneer River Catchment Area, the Shoalwater Bay–Sarina Catchment Area and the Fitzroy River Catchment Area.

Pioneer River Catchment Area

Population expansion in the Pioneer River Catchment Area and the development of the city of Mackay has resulted in a number of issues of concern for catchment management. The city of Mackay has developed along the banks of the Pioneer River, with a large percentage of the Mackay population residing along both the northern and southern banks. A number of facilities servicing the population of Mackay are located along the Pioneer River and other smaller waterways of the Bassett Basin. These include the Mackay City Dump, the Sewage Treatment Plant and various industrial developments that discharge into the upper and lower catchment area of the Pioneer River.

In addition to this urban and industrial development, the Pioneer River Catchment Area is utilised extensively for sugar cane production. Erosion from agricultural land within the catchment leads to the input of sediment, herbicides, pesticides, fertilisers and organic material to the waterways. Very little natural vegetation remains as a buffer between land uses and the coastal wetland vegetation.

The potential for the deterioration of the quality of the water within the catchment and the effect this change may have on floral and faunal aquatic communities has not been studied extensively. However, mangrove dieback within the Bassett Basin has recently become an issue of great public concern (Section 6.4).

The natural water flow regime of the Pioneer River has been altered significantly by the construction of three weirs along the river, the Dumbleton Rocks, Marion and Mirani Weirs. These weirs have been constructed with the purpose of maintaining a water supply for the city of Mackay as well as providing for irrigation and industrial purposes. However, these weirs, along with levee banks, alter the natural hydrology of the river. Concerns have been raised over the impact of weirs and levees on the sustainability of fish communities and their habitats.

The Department of Primary Industries, Queensland (1993) identified the future expansion of urban areas and tourism in the Mackay region, as a potential threat to coastal wetland vegetation at the mouth of the Pioneer River. Additionally, expansion of grazing land to the tidal flats along the coast, with the construction of levee banks to exclude salt water, was also identified as a potential concern.

Extensive sand extraction within the freshwater and tidal sections of the Pioneer River occurs.

Sarina–Shoalwater Bay Catchment Area

The Sarina–Shoalwater Bay Catchment Area includes the catchments of the major creeks and rivers including Plan Creek, the Styx River, Shoalwater Creek and Water Park Creek. Within the catchment area there are a number of land management issues that already, or have the potential to, impact upon coastal wetland systems.

Grazing lands in the northern portion of the catchment area, from Marlborough to Sarina, show signs of overgrazing and inappropriate land-clearing practices leading to erosion. Additionally, floodplains utilised for sugar cane production along the coastal strip experience serious erosion particularly during periods of high rainfall (QDPI 1993). Erosion has the potential to impact on coastal wetland systems through siltation of waterways and estuaries, resulting in altered water flow and environmental characteristics for fish communities and habitats. Nutrient inputs derived from agricultural areas may also contribute to the eutrophication of wetlands.

Disturbances to the coastal wetland vegetation and altered hydrology and salinity regimes have resulted from cattle grazing in tidal areas and the construction of pondage systems. Pondage systems are a particular concern to the management of coastal fisheries and fish habitats in this catchment area. This issue is dealt with further in Section 6.3.

Several tourist resorts and residential subdivisions have been proposed for coastal areas (Cape Palmerston, Freshwater Point and Greenhills) adjacent to fish habitat.

Fitzroy River Catchment Area

The major rivers within the Fitzroy River Catchment Area are the Dawson, Fitzroy, Isaac, MacKenzie, Nogoa and Comet. All of these major rivers, excluding the Isaac River, have multiple weirs on them (QDPI 1993). Additionally, numerous water storage facilities, including the largest, Fairbairn Dam, have been constructed within this catchment. The

water-storage structures constructed along rivers ensure the continued supply of water for irrigation, and urban, stock and industrial uses. However, both the weirs and dams create alterations to the natural water-flow characteristics of the environment, thus raising concerns over the impact of these changes to instream communities, including fishes and fish habitats. For example, there are reports of diminished catches of barramundi in the lower reaches of the Fitzroy River since the construction of the Fitzroy Barrage built in 1970 (QDPI 1993). Sawynok (1998) reported that if flows in the Fitzroy River are altered so that these flows are reduced significantly in size, or the frequency of such flow events is extended, then this will reduce barramundi recruitment, movement and growth.

The hydrology and salinity regimes of areas adjacent to coastal wetland communities have been altered due to the construction of pondage systems. Concerns over the impact of these pondage systems on coastal wetland and fish communities are discussed further in Section 6.3.

Extensive land clearing for cattle grazing and agriculture within the Fitzroy River Catchment Area has been identified as an issue for management consideration (QDPI 1993). Land clearing has the potential to impact upon coastal wetland environments through erosion and subsequent siltation of waterways. Chemical products from agricultural fertilizers and pesticides may be carried into the waterways along with the eroded topsoil, particularly during flood periods, impacting on water quality.

A large area (approximately 2 890 ha) of the Saltpan environments of the Fitzroy River Delta have been converted for use as salt evaporation ponds. This area represents approximately 11% of the Saltpans at the mouth of the Fitzroy River.

Buffer Zones as a Management Tool

A buffer zone is a vegetated filter strip located between natural resources and adjacent areas subject to human alteration (Castelle *et al.* 1994). Current Queensland Fisheries Service policy recommends the retention of a minimum buffer width of 100 m (a starting point from which site specific requirements can be negotiated) adjacent to coastal wetland communities. This buffer zone is measured from the Highest Astronomical Tide (HAT) line and incorporates natural vegetation and other buffer elements (Bavins et al 2000). The benefits of buffer zones include erosion and sedimentation control, filtration of nutrients, fertilisers, pesticides and heavy metals, maintenance of water quality, wildlife corridors and provision and protection of fish and wildlife habitats.

Cultivation and clearing have extended to the tidal boundary in a large number of coastal wetland systems in the Study Area. Additionally, a number of landuses within the catchments of the Study Area have been identified as potential threats to coastal wetland systems. For example, the ANCA (1996) identified continued development of the land adjacent to the Sand Bay coastal wetlands as a potential threat to the ecological integrity of the site. The coastal wetland vegetation is protected within the Sand Bay FHA. However, the adjacent terrestrial land has been extensively cultivated for agricultural purposes.

The maintenance of buffer zones adjacent to coastal wetland vegetation will serve to protect these important fish habitats from the effects of human development in the catchment and ensure the long-term sustainability of Queensland's fisheries resources. The ecological, economic and social viability of revegetation of cleared areas adjacent to coastal wetland vegetation should be investigated.

6.3 Pondage Systems

Pondage systems have been developed in Queensland with the intention of improving the grazing potential of lowland areas during the dry season. The creation of pondage systems in tidal areas has the potential to impact on coastal wetland environments and the fisheries that they support.

Fisheries management concerns regarding the creation of pondage systems in tidal areas include the loss of fish habitats, interference with fish movement and interference with nutrient and sediment flows. Research to validate these concerns is currently being undertaken by DPIQ. The Ponded Pastures Steering Committee (1995) provides a more detailed discussion of the issues involved in ponded pasture management.

On 18 July 1991, a moratorium in the construction of impoundments on tidally affected land was declared with the specific intention of halting further development. Policy options to prevent any potentially detrimental effects of pondage systems on fish and fish habitats are being developed (Ponded Pastures Steering Committee 1996).

Pondage systems have been developed throughout the Fitzroy catchment (in particular, the Broad Sound region and the Fitzroy River Delta) in central Queensland for cattle production and in coastal areas of the Mackay region for a variety of purposes (Hyland and White 1996). In the Broad Sound region alone approximately 6 500 ha of pondage systems have been constructed (Cummins 1991). The extensive Saltpans in this region are not only highly suitable sites for the construction of pondage systems, they are also valuable fish habitat, for barramundi in particular. Hyland and White (1996) have identified that in coastal regions, the location of pondage banks in or adjacent to barramundi nursery areas are likely to restrict the movement of barramundi and increase the risk of entrapment under certain flow regimes. Nursery areas for other species e.g. mullet and penaeid prawns, may also be restricted.

6.4 Mangrove Dieback within the Study Area

Mangrove Dieback of the Bassett Basin and Surrounding Estuaries

Large areas of dieback have occurred in the Bassett Basin and surrounding estuaries in recent years. Estuaries affected by the dieback include: Barnes Creek, which drains into Bassett Basin, and throughout the entire Pioneer River estuary; Fursden Creek; Constant Creek; Reliance/Leila Creeks; McCready's Creek; Bakers Creek and Sandringham Bay Sandy/Alligator Creeks. Preliminary surveys by Duke *et al.* (2000) identified that approximately 3 127 ha of mangrove communities in a 20 km radius of the Bassett Basin were affected by dieback.

The extent and severity of this dieback event are of considerable concern for natural resource managers due to the extreme habitat deterioration, associated erosion and tidal creek infilling that has resulted. Surveys conducted in June 2000 showed that the dieback was restricted largely to *A. marina* communities with other species being largely unaffected. At this time, the dieback of *A. marina* had affected at least 66% of mangrove forests in the Pioneer River estuary alone, an area of approximately 500 ha (Duke *et al.* 2000).

Possible causes for the severe dieback of mangrove communities in this area are currently being investigated (Duke *et al.* 2000) and include: fluctuating rainfall patterns over the last 5–10 years; high nutrient loads from sewage discharge; heavy metals in sediments; pesticides; pathogens and insect herbivory.

The dieback in the Bassett Basin was not detectable in this study due to the resolution and date of the satellite imagery used (i.e. 1997). Although it is suspected that the dieback had begun to occur at this date, higher resolution imagery is required to map the small communities affected. Currently the areal estimate of the dieback is 500 ha within the Bassett Basin alone, suggesting that the current dieback situation may be mappable using this technique with more recent Landsat TM imagery.

Other Areas of Natural Mangrove Dieback

Relatively large areas of Closed *Ceriops* dieback were identified in two locations of the Study Area, at Clairview Bluff (Figure 6.1) and Bar Plains, Broad Sound (Figure 6.2). At both sites, Closed *Ceriops* communities were totally defoliated and showed little evidence of any regeneration. Anecdotal reports suggest that the dieback at Bar Plains dates back to around 1994/95 when a severe hail storm damaged the coastal wetland vegetation. At this time, other species in this coastal wetland system were affected by the storm but have since regrown or recolonised. Only *C. tagal* has failed to re-establish at the site.

Although the cause of the dieback at Clairview Bluff is unknown, it is suggested that this dieback has occurred due to a similar natural event. The coastal wetland vegetation at Clairview Creek is quite isolated from human activity and the surrounding terrestrial vegetation is intact. Although some seedlings have established below the dead canopy, no regeneration of the Closed *Ceriops* community is apparent.

The dead Closed *Ceriops* community at Bar Plains may provide a suitable opportunity for monitoring natural mangrove regeneration in a dry, hypersaline environment. The approximate date of the disturbance of these mangroves is known and the site is relatively easy to access.

The area of Closed *Ceriops* dieback as mapped in this study for both the Clairview Bluff and Bar Plains areas is listed in Table 6.3.

TABLE 6.3 Area of Closed *Ceriops* dieback within the Study Area.

LOCATION	APPROXIMATE LAT/LONG	AREA OF CLOSED *CERIOPS* DIEBACK (ha)
Clairview Bluff	22.23015°S/149.52719°E	16.5
Bar Plains, Broad Sound	22.31261°S/149.59574°E	24.5
Total mapped in this study		41.0

FIGURE 6.1 Closed *Ceriops* dieback at Clairview Bluff.

FIGURE 6.2 Closed *Ceriops* dieback at Bar Plains, Broad Sound.

Fitzroy River Delta Regrowth Communities

In some areas, the mangrove communities along the northern bank of the Fitzroy River appear to be flood damaged. The regrowth communities typically have an understorey of young *A. marina* with *E. agallocha* emergents (up to 9 m) as well as *A. corniculatum* and *Bruguiera* spp. The vegetation adjacent to these communities has also been cleared extensively for grazing. Figure 6.1 displays the regrowth communities along the northern bank of the Fitzroy River in August 1999.

FIGURE 6.3 A regrowth community on the northern bank of the Fitzroy River which is infested with rubbervine.

6.5 Pests

Rubber vine

Rubber vine (*Cryptostegia grandiflora*) is a declared plant under the *Rural Lands Protection Act 1985*. For the majority of Queensland it is declared as category P2 declared plant where the plant must be destroyed by the landowner. Rubbervine has been recognised as a threat due to its rapid spread and colonisation of waterways and its ability to smother riparian vegetation (DNR 1999). In addition to being prevalent on terrestrial areas within the Study Area rubber vine has invaded the coastal wetland environments. During fieldwork, rubber vine was particularly evident in the Fitzroy River Delta along the banks of the Fitzroy River where disturbance of the riparian zone due to clearing and flood damage was evident (Figure 6.1).

Feral Pigs

Landowners are legally obliged to control feral pigs (*Sus scrofa*) in Queensland under the *Rural Lands Protection Act 1985*. Feral pigs damage crops, stock and property, spread weeds and transmit diseases (DNR 1998). The majority of the Study Area has been identified as having a relatively low density of feral pigs (DNR 1998). Disturbance of the coastal wetland vegetation by feral pigs was evident during fieldwork particularly around the St. Lawrence region. Wallowing and digging by pigs in the coastal wetland environment creates erosion, damages vegetation and allows the establishment of weeds. In turn, the establishment of weeds such as rubber vine provides shelter for feral pigs.

SECTION 7 EXISTING CONSERVATION MEASURES AND CONSERVATION VALUES

The coastal wetlands in the Study Area have been recognised for their diversity and conservation significance by a wide variety of conservation measures, including FHAs, National Parks (NPs) and Marine Parks (MPs). Each of these conservation types is declared over significant ecosystems and protects the area on the basis of management regimes specific to that conservation type. Numerous coastal wetland areas have also been recognised as wetlands of international (Ramsar sites) and national importance (Directory of Important Wetlands in Australia (Australian Nature Conservation Agency)) or as areas which are significant dugong habitat (Dugong Protection Areas (DPAs)). Table 7.1 presents a summary of the conservation measures undertaken within the Study Area for each coastal wetland system. The conservation type listed in this table may include either some or all of the coastal wetland vegetation, or some or all of the adjacent terrestrial vegetation. Further details of the area protected by FHAs and National Parks are contained in Section 5 under the relevant coastal wetland system heading.

7.1 Fish Habitat Areas

Fish Habitat Areas have been declared throughout coastal Queensland to sustain existing and future fishing activities and to protect the habitat upon which fish and other aquatic fauna depend (Beumer *et al.* 1997). Ten FHAs, six of management A status and 4 of management B status, are currently declared within the study area (Table 7.1, 7.2, Figure 9.1 and Appendix 1) following a field assessment of the coastline between Corio Bay and Repulse Bay in the mid-1980s. Details of the management strategies for FHAs of both of these categories are outlined in Appendix 2. Table 7.2 summarises the fisheries values and the habitat types of each of the coastal wetlands ecosystems protected by FHAs within the study area.

The FHAs from Bassett Basin south are included in the Shoalwater Coast IMCRA bioregion. The Sand Bay FHA lies in the Lucinda Mackay Coast IMCRA bioregion.

7.2 Ramsar Sites

In March 1996, Shoalwater Bay and Corio Bay were included in the Ramsar list of Wetlands of International Importance (5AU044). The area's terrestrial and five major estuarine and marine environments represent the largest area in central east Queensland containing representative coastal, subcoastal, aquatic landscapes and ecosystems which are relatively undisturbed habitat areas for significant floral and faunal assemblages, including populations of rare and threatened species (Environment Australia 1997).

The adjacent land is contained within the Shoalwater Bay Military Training Area and as such the catchment area is relatively undisturbed and the habitat areas are virtually pristine (Section 7.5).

The habitats included in the Shoalwater Bay and Corio Bay Ramsar Sites support a large variety of marine and estuarine fish species (ANCA 1996). It is also an important region for migratory waders and shorebirds. A total of 26 bird species listed under JAMBA, and 27 species listed under the CAMBA, are reported from the area.

TABLE 7.1 Summary of existing conservation measures in the Study Area.

WETLAND	EXISTING FISH HABITAT AREA (MANAGEMENT A OR B)	OTHER CONSERVATION MEASURES TAKEN
Sand Bay to Cape Palmerston		
Sand Bay	Sand Bay FHA (A)	Cape Hillsborough NP, Reliance Creek NP, Sand Bay DPA, Mackay/Capricorn MP
Eimeo		
Blacks Beach		
Bassett Basin	Bassett Basin FHA (B)	
Baker's Creek		Baker's Creek Conservation Park
Sandringham Bay		
Dalrymple Bay		Mount Hector Conservation Park
Sarina		
Llewellyn/Ince Bay	Cape Palmerston FHA (A) Rocky Dam FHA (B)	Cape Palmerston NP, Llewellyn Bay DPA, Ince Bay DPA, Mackay/Capricorn MP
Cape Palmerston to Clairview Bluff		
Yarrawonga Point	Marion FHA (B)	Mackay/Capricorn MP
West Hill	West Hill FHA (A)	West Hill NP, Mackay/Capricorn MP
Carmilla	Carmilla FHA (B)	Mackay/Capricorn MP
Clairview	Carmilla FHA (B)	Clairview Region DPA, Mackay/Capricorn MP
Clairview Bluff	Broad Sound FHA (A)	Mackay/Capricorn MP
Clairview Bluff to Stanage (Broad Sound)		
St Lawrence	Broad Sound FHA (A)	Newport Conservation Park
Broad Sound	Broad Sound FHA (A)	Charon Point Conservation Park
Long Island	Broad Sound FHA (A)	Broad Sound Islands Conservation Park
Stanage to Stockyard Point (Shoalwater Bay)		
Shoalwater Bay		SWBMTA, Shoalwater Bay Ramsar site, Shoalwater Bay Conservation Park
Townshend and Leicester Islands		SWBMTA, Shoalwater Bay Ramsar site
Island Head		SWBMTA, Shoalwater Bay Ramsar site
Port Clinton		SWBMTA, Shoalwater Bay Ramsar site
Stockyard Point to Cattle Point		
Corio Bay	Corio Bay FHA (A)	Corio Bay Ramsar site, Byfield NP
Yeppoon		
Shoal Bay		Causeway Lake Conservation Park, Capricorn Coast NP
Cawarral Creek	Cawarral Creek FHA (A)	Keppel Sands Conservation Park
Great Keppel Island		
Fitzroy Delta–Cattle Point to Ramsay Crossing		
Area 1		
Area 2		
Area 3		Rundle Range NP, Mackay/Capricorn MP

TABLE 7.2 Fisheries values and habitat types of Fish Habitat Areas (both A and B) within the study area.

FHA NAME	A/B	FISHERIES VALUE	MAJOR HABITAT TYPES
SAND BAY	A	Barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, school mackerel, whiting	Mangrove-lined creeks with *A. corniculatum*, *A. marina*, *C. tagal*, *E. agallocha* and *R. stylosa*; intertidal flats and seagrass areas.
CAPE PALMERSTON	A	Barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, sea mullet, school mackerel, whiting, mud crabs	Extensive mangrove and saltmarsh areas along estuary with *A. marina*, *C. tagal* and *Rhizophora* sp, present; fringing inshore reef and seagrass beds within Ince Bay; large sandy bay that dries at low tide to estuarine sandbars and channels; area characterised by a high tide range.
WEST HILL	A	Barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, sea mullet, school mackerel, whiting, mud crab	Extensive intertidal flats and mangrove areas; salt flats also present; *Zostera* sp. and *Halophila* sp. beds; fringing inshore reef.
BROAD SOUND	A	Barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, sea mullet, school mackerel, whiting, banana prawns, mud crab	Extensive mangroves and salt marshes around estuary; mangrove-lined creeks and seagrass beds; high tidal range with extensive intertidal areas exposed at low tide.
CORIO BAY	A	Barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, jewfish, mangrove jack, queenfish, sea mullet, school mackerel, whiting, banana prawns, anguillid eels	Extensive sandy shallows with enclaves of mangrove shrubland dominated by *Rhizophora* sp and *C. tagal*. Rocky outcrops; seagrass beds present on intertidal flats and extensive salt marshes occur around Fishing Creek.
CAWARRAL CREEK	A	Barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, jewfish, king salmon, mangrove jack, queenfish, sea mullet, school mackerel, whiting, banana prawns	Tidal creeks dominated by *Rhizophora* sp. With patchy *A. marina* and *C. tagal*; estuary dominated by salt marsh.
BASSETT BASIN	B	Barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, school mackerel, whiting, mud crab, tiger prawns	Open *Rhizophora* shrubland, sand bars and tidal channels.
ROCKY DAM	B	Barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, school mackerel, whiting, banana prawns, oysters	Extensive Rhizophora sp., *A. marina* and *C. tagal* zones and intertidal flats border the estuary.
MARION	B	Barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, school mackerel, whiting	Extensive mangrove stands and salt marshes associated with the estuary; some intertidal flats; *Zostera* sp. and *Halophila* sp. beds
CARMILLA	B	Barramundi, blue salmon, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, sea mullet, school mackerel, whiting	Extensive mangrove stands along the northern shoreline, tending towards patchiness around Feather Creek.

Source: Compiled from Declared Fish Habitat Areas in Queensland (Beumer *et al.* 1997).

7.3 National Parks

National parks, conservation parks and resources reserves are gazetted under the *Nature Conservation Act 1992*. There are fourteen coastal national parks and conservation parks that lie adjacent to or over coastal wetland communities in the Study Area. From north to south, these protected estates are as follows: Cape Hillsborough National Park, Reliance Creek National Park, Baker's Creek Conservation Park, Cape Palmerston National Park, West Hill National Park, Newport Conservation Park, Charon Point Conservation Park, Broad Sound Islands Conservation Park, Shoalwater Bay Conservation Park, Byfield National Park, Capricorn Coastal National Park, Keppel Sands Conservation Park, Causeway Lake Conservation Park and Rundle Range National Park. National and conservation parks that lie over or directly adjacent to coastal wetland systems are discussed in Section 5.

7.4 Marine Parks

The Great Barrier Reef Marine Park and World Heritage Area

The Great Barrier Reef, extending from Cape York Peninsula along the eastern coastline of Queensland to Rockhampton, has been recognised internationally as an area of global ecological significance.

The Great Barrier Reef Marine Park (GBRMP) was declared in 1975 to protect the values of the Reef and to manage activities within the Marine Park area. The Great Barrier Reef Marine Park Authority (a Commonwealth statutory body) in conjunction with the Queensland Environmental Protection Agency manages the GRBMP. The GBRMPA has the legislative obligation of ensuring the protection, wise use, understanding and enjoyment of the Great Barrier Reef in perpetuity through the development and care of the GBRMP (Cook 1995).

Various management Zoning Plans have been gazetted under the *Great Barrier Reef Marine Park Act 1975*, in order to provide for as of right activities, prohibited activities, and activities that can be undertaken with consent (Cook 1995). These zones also reflect the ecological and biological values of particular areas.

In most areas, the boundary of the GBRMP extends only to the low water mark along the eastern coastline of Queensland and as such coastal wetland communities are excluded from the marine park. However, the majority of the marine waters, reefs and coral cays adjacent to the Study Area are managed under Great Barrier Reef Marine Park zoning.

The many values of the Great Barrier Reef have been recognised by its inscription on the UNESCO World Heritage List in 1981. The declared World Heritage Area encompasses the Great Barrier Reef Marine Park (93%), continental islands within the Marine Park boundary (5%) and the adjoining tidal waters outside the Marine Park (2%).

State Managed Marine Parks

The Queensland managed Mackay–Capricorn Marine Park also falls within the Study Area. There is considerable overlap in some regions between the GBRMP and this Marine Park. However, management regimes and practices in these areas of overlap are generally complementary.

7.5 Shoalwater Bay Military Training Area

The Shoalwater Bay Military Training Area (SWBMTA) has a land area of approximately 170 000 ha and includes a large portion of marine waters of Shoalwater Bay. The area was purchased by the Australian Government in 1965 and is managed by the Australian Army. The area is utilised as an independent and joint training area for the Australian Army, Navy and Air Force, as well as periodically for training for other nations.

The SWBMTA represents the largest tract of relatively pristine coastal land between Nadgee (southern New South Wales) and the Cape Melville/Starke Holding area on Cape York Peninsula (ANCA 1996). The extensive areas of coastal wetland habitats within the SWBMTA, including mangrove forests, intertidal foreshore flats, rocky foreshores, reefs and seagrass meadows, provide habitat for commercially important fisheries species, turtles, dugong and numerous migratory wader species of national and international importance.

The Shoalwater Bay Inquiry (Australian Government 1994) required, in essence, that "by reason of the outstanding National Estate and World Heritage Values, in particular its biodiversity and wilderness values and ecological integrity of the whole area, including land and sea, the Area be considered as an area of national, state and regional significance". The management of the permissible uses and activities in the area should recognise the conservation use of the area as a whole.

7.6 Directory of Important Wetlands in Australia (Australian Nature Conservation Agency)

Numerous coastal wetland systems within the Study Area have been declared by the Australian Nature Conservation Agency (ANCA) to be important wetlands for the various conservation values that they possess. Although the ANCA has declared that these wetland systems are important for various reasons, the level of conservation measures taken may vary. The wetland systems in the Study Area that are considered as important by the ANCA are listed in Table 7.3. ANCA (1996) lists further details of the conservation significance of these sites in terms of notable flora and fauna and social and cultural values.

TABLE 7.3 Conservation significance of wetlands of national importance (ANCA 1996).

SITE NAME (WETLAND REFERENCE NO.)	CONSERVATION SIGNIFICANCE
Sand Bay (CMC009QL)	The site, which is a good example of a marine and estuarine wetland complex of the Central Mackay Coast, has a diverse shoreline, where extensive areas of intertidal mudflat are backed by mangrove forest. It is particularly important as a fish and shorebird habitat.
Sandringham Bay–Bakers Creek Aggregation (CMC010QL)	The site is a good example of marine and estuarine wetlands of the Central Mackay Coast bioregion. It is significant because of the very extensive expanse of intertidal and shallow water habitat and the diversity of the shoreline and the extent of the mangroves. It is recognised as a nationally important area for shorebirds.
Sarina Inlet–Ince Bay Aggregation (CMC011QL)	The site is a good example of a diverse hydrologically related aggregation of marine, estuarine and freshwater wetlands within the Central Mackay Coast bioregion. It is also recognised as a nationally important area for shorebirds.
Broad Sound (BBN003QL)	A good example of a marine and estuarine wetland complex within a large sheltered embayment adjacent to a broad coastal plain.
Shoalwater Bay (CMC012QL)	The Shoalwater Bay site is a particularly good example of shallow marine and estuarine wetland type within the South Eastern Queensland bioregion. It is particularly significant because of the extent and richness of the marine and estuarine habitats due to the extreme tidal range, the sheltered environment of these habitats and the relatively undisturbed nature of the area. The area is distinct from the effects of large rivers with highly disturbed catchments and the local catchment is well protected.
Island Head Creek–Port Clinton Area (CMC006QL)	The site is part of the Shoalwater Bay Military Training Area, which is the largest coastal wilderness area in the central Queensland Coastline. The area is distant from the effects of large rivers with highly developed catchments and the local catchment is well protected.
Corio Bay Wetlands (CMC001QL)	The Corio Bay Wetlands are a good example of a complex of marine, estuarine and freshwater wetland types within the South Eastern Queensland bioregion. It is significant for the diversity of habitat present due to the extensive areas wither tidally influenced or subject to freshwater inundation and the corresponding diversity of fauna. The bay is of considerable importance as a nursery for juvenile fish and crustaceans, particularly *Penaeus merguiensis*.
Iwasaki Wetlands (CMC007QL)	Extensive freshwater and saline wetlands with distinct boundaries, providing habitat for vast numbers of waterbirds and shorebirds, as well as many opportunities for research recreation and tourism.
Yeppoon–Keppel Sands Tidal Wetlands (BBS014QL)	The wetlands in this aggregation provide an important source of recreation for the local population as well as a relatively undisturbed habitat in an otherwise highly disturbed and increasingly populated area.
Fitzroy River Delta (BBS003QL)	The Fitzroy Delta represents the terminus of the largest river system in Queensland; the condition of the tidal zone is mostly pristine (Stock *et al.* 1988).
The Narrows (BBS013QL)	The Narrows is a unique landform feature being one of only four tidal passages in Australia.

Source: ANCA 1996

SECTION 8 EXISTING RECREATIONAL, INDIGENOUS AND COMMERCIAL FISHING RESOURCES IN THE STUDY AREA

8.1 Recreational and Indigenous Fisheries Resources

Very limited information on recreational and indigenous fishing activities is available for the Study Area. There is currently no quantitative data available on indigenous fishing effort in the Study Area. Additionally, there have been no quantitative studies of recreational fishing activities by area in Queensland. Previous research has established experimental recreational catch estimates for Queensland residents based on where they live (Higgs 1997). In this study the need for an investigation into the allocation of recreational fish catches to specific fishing regions around the state was identified.

The estuaries in the Study Area are utilised for recreational fishing to varying degrees. The concentration of population in the coastal zone in this area has resulted in the heavy utilisation of most creeks and estuaries for recreational purposes. Even remote estuaries within the Study Area, such as Shoalwater Bay, are utilised by recreational fishers who enjoy the area because of its wilderness qualities (Jennings 1997).

In their assessment of important Queensland wetlands, the ANCA (1996) identified a number of areas within the Study Area which are important estuaries for local recreational fishing and boating activities. These coastal wetland systems are listed in Table 8.1.

TABLE 8.1 Coastal wetland systems in the Study Area which have been recognised by the ANCA as important local fishing areas.

COASTAL WETLAND SYSTEM	ANCA COMMENT
Sand Bay	an important local fishing and recreation area
Sandringham Bay–Baker's Creek Aggregation	locally important as a recreational fishing and boating area
Sarina Inlet–Ince Bay Aggregation	recreational and commercial fishing and crabbing occur over the marine areas, low level impact from fishing and recreation
Broad Sound	utilised for recreational fishing
Fitzroy River Delta	important area for recreational fishing and mud crabbing, some pressure on fisheries stocks
The Narrows	a major recreational fishing and crabbing area
Yeppoon–Keppel Sands tidal wetlands	very popular for fishing and crabbing, a popular tourist destination, heavy pressure on mud crabs and other species from local crabbing/fishing activities
Corio Bay wetlands	the bay is an important area for recreation, particularly fishing
Island Head Creek–Port Clinton Area	recreational fishing/crabbing
Shoalwater Bay	recreational fishing/crabbing

8.2 Commercial Fisheries Resources

Typically 120 commercial fishing boats are operating in the Study Area in a year with an average of 50 days fished per boat per year. This represents almost 11% of the total boats operating along the entire Queensland coast. The days fished per boat per year in the Study Area is less than the average number of days fished per boat per year for the whole of Queensland.

The major species of importance to the commercial fisheries in the Study Area are banana prawns, barramundi, blue threadfin and mud crabs. The total catch of banana prawns, blue threadfins and mud crabs in the Study Area represent a significant proportion of the total catch of these fisheries state-wide. These species are estuary dependent at some stage of their lifestyle (Section 8.3).

The total catch of banana prawns in the Study Area in 1999 (195 tonnes) represented approximately 24% of the state-wide banana prawn catch. Over the past 12 years the banana prawn catch in the Study Area has averaged at approximately 16% of the total Queensland catch, with a low of 8% in 1998. Variability in the catch of banana prawns shows a strong positive correlation with annual rainfall (pers. comm. Lew Williams, QFS, Brisbane, 2000).

The total catch of both blue threadfins and mud crabs within the Study Area represents on average approximately 20% of the total catch of these fisheries state-wide. The total catch of banana prawns, mud crabs and blue threadfins in the Study Area and in Queensland, over the last 12 years is displayed in Figure 8.1.

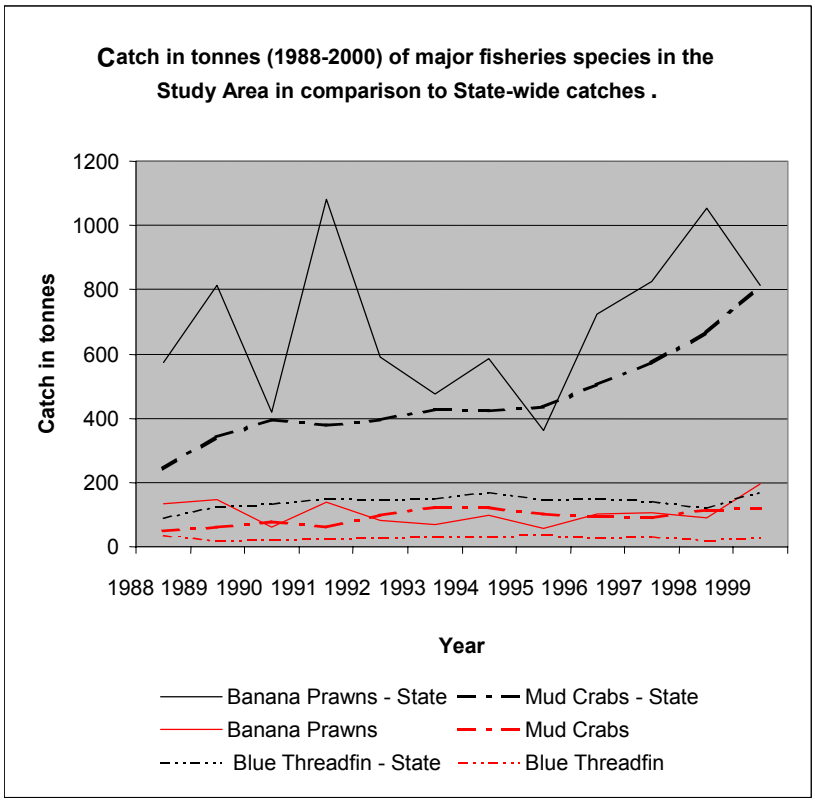

FIGURE 8.1 Catch in tonnes (1988–2000) of major fisheries species in the Study Area in comparison to state-wide catches.

Barramundi is also recognised as a species of importance to the fisheries of the Study Area. However, the total catch of barramundi within the Study Area is only a small proportion of the total Queensland catch of this species. The majority of the catch of barramundi is taken from the Gulf of Carpentaria. Along the eastern Queensland coastline the main catches of barramundi in 1998 occurred in Princess Charlotte Bay, Cairns,

Hinchinbrook Island to Bowen, Repulse Bay, the Broad Sound and the Fitzroy River Delta (Figure 8.2).

Extensive Saltpans, such as those at Broad Sound and the Fitzroy River Delta provide important habitat for barramundi. Spawning of barramundi occurs in coastal waters, near the mouths of creeks and rivers. Habitats such as coastal swamps, supralittoral Saltpans, marine plains or low-lying coastal flood plains serve as nursery areas for the juveniles (Coates and Unwin 1991). Major spawning of barramundi occurs just before or early in the wet season so that the juveniles can take advantage of the temporary wetland habitat.

The Saltpans at Broad Sound in particular and to a lesser extent on Fitzroy River Delta have been modified due to the extensive construction of levees in the intertidal zone for pondage systems. The impact of these pondage systems on fish, specifically barramundi nursery areas, is an issue of concern for fisheries managers (Section 6.3). The Fitzroy River Saltpans have also been altered by the construction of salt evaporation ponds in the intertidal zone (Section 6.2).

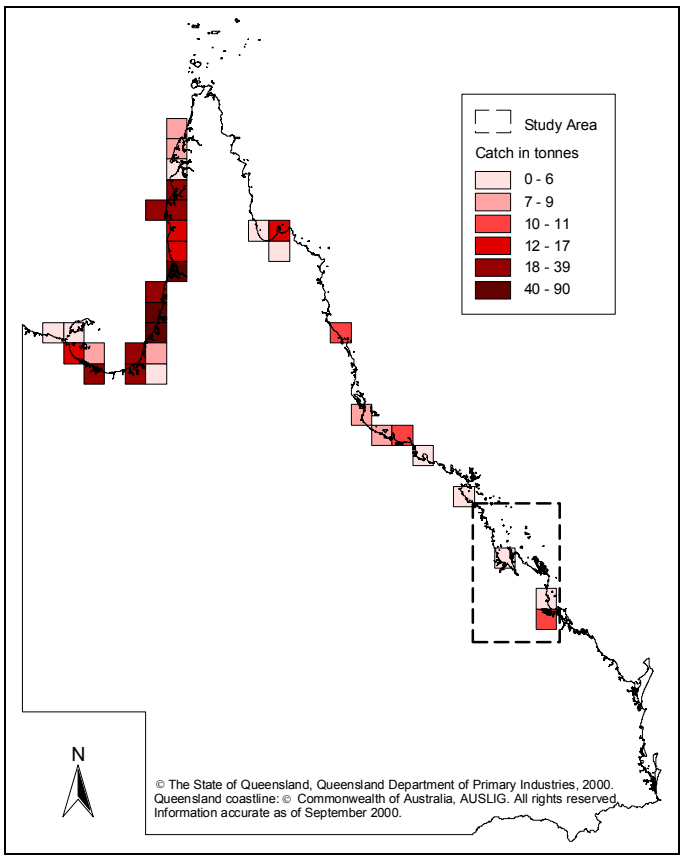

FIGURE 8.2 Total catch in tonnes of barramundi by 30 minute grid, 1998.

Further details of the fisheries resources of the region from Carmilla to the Fitzroy River Delta are reported in Walker (1997).

8.3 Fisheries Resources and their Habitat Requirements

Many of the species targeted in the fisheries of the Study Area rely on coastal wetland environments for food sources and habitat requirements at some stage of their life cycle (Table 8.2). The coastal wetland environments in this region are particularly important to the life cycles of four important fisheries resources: banana prawns, barramundi, blue threadfins and mud crabs.

TABLE 8.2 Habitat requirements for selected fisheries resources of importance to the Study Area.

SPECIES	SPAWNING HABITAT	EGG AND LARVAL HABITAT	POST LARVAL AND JUVENILE HABITAT	ADULT HABITAT
BANANA PRAWNS	Inshore waters	Inshore waters	Mud flats in mangrove-lined estuaries	Turbid nearshore waters to a depth of 20 m
BARRAMUNDI	Creek and river mouths	Estuarine and coastal swamps	Coastal swamps, Saltpans, lowlying plains	Freshwater streams and estuaries
BLUE THREADFIN	Inshore waters and estuaries	Coastal waters	Lower estuaries and nearshore waters	Nearshore waters
MUD CRABS	Offshore waters	Coastal waters	Intertidal waters in mangrove-lined estuaries	Subtidal waters in estuaries

Source: Zeller 1998

SECTION 9 APPLICATION OF THE DATASET TO FHA PLANNING

9.1 Fish Habitat Area Declaration Process

FHAs are part of the on-going management of fisheries resources within Queensland and are declared with the specific intent to ensure continuation of productive recreational, indigenous and commercial fisheries in a region. The declaration of a FHA generally follows the process outlined below:

1. Nomination of an area as a candidate for declaration as a FHA.
2. Review of nomination and assessment of its priority for further investigation.
3. Site investigation/field habitat surveys, literature searches and reviews, assessment of fish catch records and preliminary discussions with user groups (e.g. commercial fishers, recreational fishers, indigenous groups, local authority, other community groups, etc.) to determine if the nominated area meets FHA declaration criteria.
4. Preparation of an Area of Interest Plan and draft of known management issues.
5. Initial consultation with interested parties and relevant agencies.
6. Revision of information gathered during the initial consultation phase and preparation of a draft FHA Plan and a draft management strategy with recommendation of an appropriate management level (either 'A' or 'B', and use of a location-specific management plan).
7. Second round of consultation with interested parties and relevant agencies.
8. Revision of information gathered during the second round of consultation.
9. Preparation of a Declaration Plan of FHA Boundaries and submission of a proposal for declaration.
10. Provision of Plan and Submission to the Department of Primary Industries legal section.
11. Provision of Plan and Submission to the Minister for Primary Industries
12. Provision of Plan and Submission to the Governor in Council for declaration under the *Fisheries Regulation*.

The suitability of various coastal wetland systems for nomination as candidate areas for FHA declaration (i.e. step 1), is currently assessed by Queensland Fisheries Service officers on the basis of the following criteria:

1. Size
2. Diversity of or specific habitat features
3. Diversity of or specific marine fauna and flora
4. Level of existing and future disturbances
5. Unique features
6. Existing or potential fishing grounds
7. Protected species

A summary of the assessment of the coastal wetlands from Sand Bay to Keppel Bay, on the basis of these criteria, is included in Table 9.2. Details of the assessment methods and the category details are included in Table 9.1. This report concentrates on the identification of suitable areas for fisheries conservation from a coastal wetland community perspective.

TABLE 9.1 Details of the methods of the coastal wetland significance assessment.

CRITERIA	SUBCATEGORIES	DETAILS
Size		Area of mangrove and saltmarsh communities, calculated in hectares.
Diversity of or specific habitat features	Diversity of Mangrove and Saltmarsh Communities	**High (H)**: 11–14 mangrove and saltmarsh communities present
		Medium (M): 5–10 mangrove and saltmarsh communities present
		Low (L): 1–4 mangrove and saltmarsh communities present
		The number of mangrove and saltmarsh communities was calculated on the basis of the mapping conducted for this investigation. See Section 4.1 for the descriptions of these mapping units.
	Presence of Intertidal Flats	Comments on the extent of intertidal flats along the coastline were based the GBRMPA foreshore flats coverage as well as 1: 50 000 aerial photograph interpretation.
	Adjacent Freshwater Swamps	**Presence (Y)** or **absence (N)** of freshwater swamps adjacent to the coastal wetland communities. **O** indicates freshwater swamps nearby but not adjacent. The "swamp" coverage from the AUSLIG 1: 250 000 digital topographic series was used. See Map 5.1.
Diversity of or specific marine fauna and flora		Comprehensive surveys of species diversity for each wetland system were not conducted as part of this investigation. Specific, noteworthy marine flora communities have been described in Section 5.8 and are recorded as unique features (see below). Information concerning the diversity of fauna was not included in this evaluation.
Level of existing and future disturbances	Significant Dams and Weirs	**Presence (Y)** or **absence (N)** of significant dams or weirs on the river or creek. The locations of dams and weirs in Queensland collected by the Dept. of Natural Resources. See Map 5.1.
	Disturbance to Adjacent Terrestrial Vegetation	**Near Pristine (NP)** : natural cover >90%
		Largely Unmodified (LU) : natural cover ~65–90%
		Modified (M) : natural cover ~35–65%
		Severely Impacted (SI) : natural cover <35%
		Adjacent terrestrial vegetation refers to the vegetation within 5km of the upper intertidal limit.
Unique Features		**Presence (Y)** of unique features. The details of these features are included in Section 5.8.
Existing or potential fishing grounds	Significant/Important Fishing Grounds	**Significant (Y)** fishing grounds. Assessed from local knowledge of each coastal wetland system and/or from literature review. Further details of important fisheries in the region are reported in Section 8.
Protected species	Not included in this evaluation.	All marine plants are protected under fisheries legislation. Other information on protected species was not included in this evaluation.

9.2 Assessment of Coastal Wetland Habitats for FHA Declaration Purposes

TABLE 9.2 Summary of coastal wetland characteristics from Sand Bay to Keppel Bay.

WETLAND	AREA OF COASTAL WETLAND COMMUNITIES (HA)	DIVERSITY OF MANGROVE/ SALTMARSH COMMUNITIES	INTERTIDAL FLATS	ADJACENT F/W SWAMPS	SIGNIFICANT DAMS AND WEIRS	DISTURBANCE TO ADJACENT TERRESTRIAL VEGETATION	RECOGNISED/ IMPORTANT FISHING GROUNDS	UNIQUE FEATURES	EXISTING FHA
Sand Bay to Cape Palmerston			Bays and headlands are sheltered areas where intertidal flats form important fish habitat						
Sand Bay	3761	M (8)	Wide intertidal flats in the shelter of Sand Bay	**Y**	**N**	**LU**			Y
Eimeo	219	M (5)	Exposed coastline with a relatively small area of intertidal flat habitat	N	**N**	M			
Blacks Beach	532	M (7)	Exposed coastline with a relatively small area of intertidal flat habitat	**Y**	**N**	M			
Bassett Basin	593	M (9)	Large intertidal flats at the mouth of Pioneer R	**Y**	Y	SI			Y
Baker's Creek	542	M (7)	Large intertidal flats extending from the mouth of Pioneer R to Baker's Ck	**Y**	Y	SI			
Sandringham Bay	2053	M (9)	Moderately large intertidal flats in the Bay	N	Y	SI			
Dalrymple Bay	278	M (5)	Small intertidal flats in the Bay	N	**N**	M			
Sarina	1273	M (8)	More exposed coastline with small intertidal flats, larger flats within the inlet	**Y**	Y	M			
Llewellyn/Ince Bay	9011	M (8)	Moderately large intertidal flats in the bays	**Y**	**N**	M/**NP**[a]			Y
Cape Palmerston to Clairview Bluff			Relatively large intertidal flats extending along most of this coastline						
Yarrawonga Point	906	M (7)	Small intertidal flats from Cape Palmerston to Yarrawonga Point	N	**N**	**LU**			Y
West Hill	1679	M (8)	Relatively wide intertidal flats extend along this section of coastline	N	**N**	M			Y
Carmilla	811	M (7)	As above	N	Y	M			Y
Clairview	176	M (7)	As above	N	**N**	**LU**			
Clairview Bluff	4507	M (8)	As above	N	**N**	M			Y
Clairview Bluff to Stanage (Broad Sound)			Large tidal range exposes extensive mud flats on low tide throughout this section of coastline						
St Lawrence	19809	M (9)	As above	O	**N**	M			Y
Broad Sound	26493	M (10)	As above	**Y**	**N**	**LU**			Y
Long Island	5336	M (6)	As above	N	**N**	**NP**			Y
Stanage to Stockyard Point (Shoalwater Bay)			Large tidal range exposes extensive mud flats on low tide throughout this section of coastline				Y	Y	
Shoalwater Bay	16008	M (7)	As above	N	**N**	**NP**			
Townshend and Leicester Islands	1430	L (4)	As above	N	**N**	**NP**			
Island Head	2893	M (7)	As above	N	**N**	**NP**			
Port Clinton	3140	M (8)	As above	O	**N**	**NP**			
Stockyard Point to Cattle Point			Intertidal flats along the coastline from Stockyard Pt to Corio Bay and in bays and estuaries						
Corio Bay	3138	M (8)	Intertidal flats in the Bay are an important fish habitat	**Y**	**N**	**LU**	Y		Y
Yeppoon	102	L (3)	Insignificant intertidal flat habitat	N	**N**	SI			
Shoal Bay	602	M (5)	Small intertidal flats in the Bay	N	**N**	M			
Cawarral Creek	3211	M (6)	Small intertidal flats at the mouth of the Creek	N	**N**	M			Y
Great Keppel Island	54	L (3)	Insignificant intertidal flat habitat	N	**N**	**NP**			
Fitzroy Delta–Cattle Point to Ramsay Crossing							Y		
Area 1	2531	M (7)	Insignificant intertidal flat habitat	**Y**	Y	M			
Area 2	22041	M (7)	Insignificant intertidal flat habitat	**Y**	Y	M			
Area 3	16474	M (6)	Insignificant intertidal flat habitat	N	**N**	**LU**		Y	

* The terrestrial vegetation adjacent to the coastal wetlands of the majority of Ince Bay is protected within the Cape Palmerston National Park and as such, is near pristine. The remainder of the area has been modified through extensive agricultural land use.

The locations of the dams and weirs within the coastal zone of the Study Area are listed in Appendix 10. This information, provided by the Department of Natural Resources, is current to 31-12-1994.

9.3 Coastal Wetland Communities Currently Included in FHAs

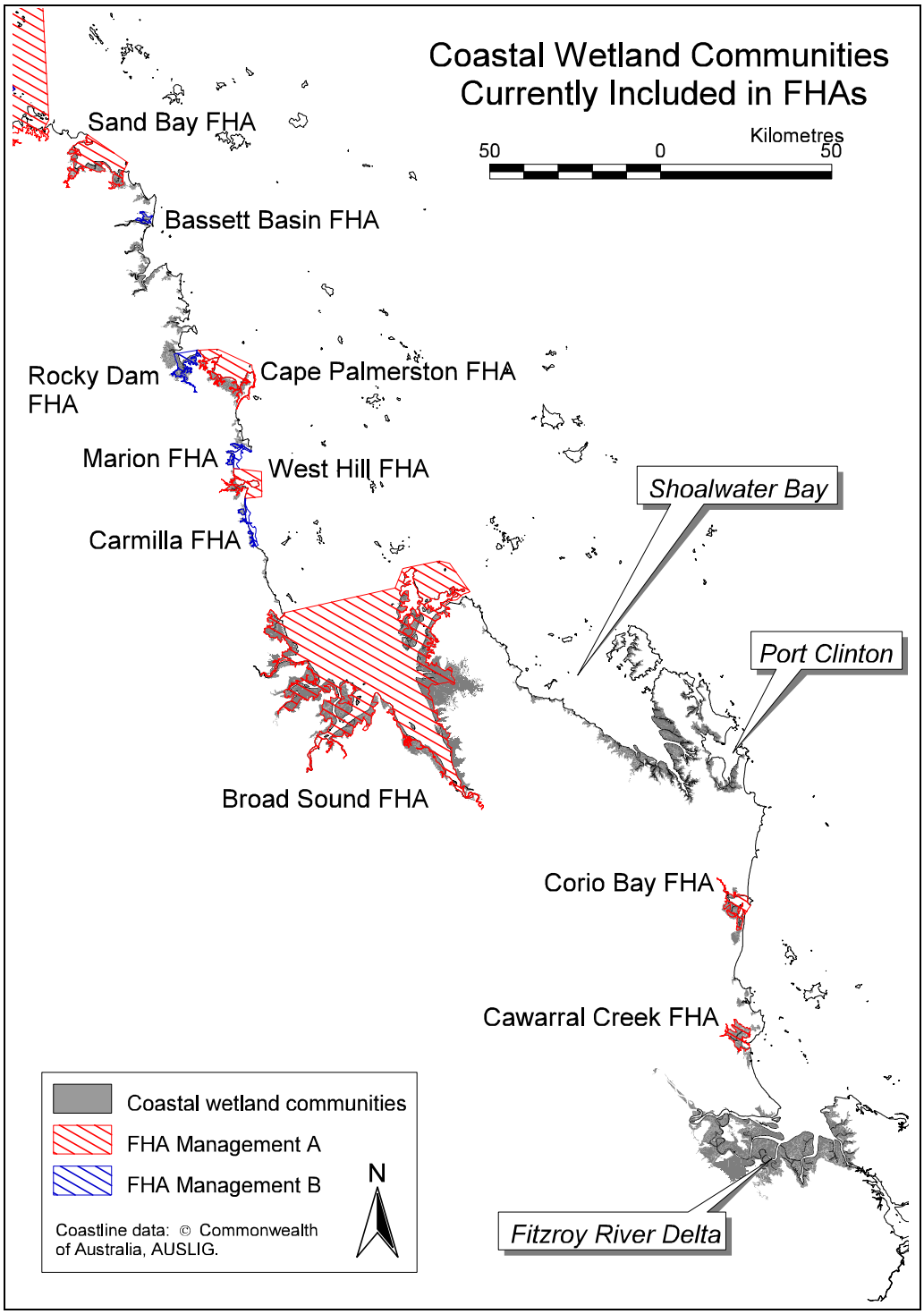

FIGURE 9.1 Coastal wetland communities currently included in FHAs.

Important fish habitats within this Study Area are well represented in existing declared FHAs. The assessment of the coastal wetland characteristics of these fish habitats supports their inclusion in the MPA network. However, some important fish habitats have so far not been the focus of detailed FHA investigation. The current gaps in the protected area network and the importance of protecting these areas are discussed below. The areas of coastal wetland communities as mapped in this study (i.e. mangroves and saltmarshes) within each of the FHAs in the Study Area are listed in Table 9.3.

TABLE 9.3 Area of coastal wetland communities protected within declared FHAs in the Study Area (hectares).

COASTAL WETLAND COMMUNITY / FHA	SAND BAY	BASSETT BASIN	CAPE PALMERSTON	ROCKY DAM	MARION	WEST HILL	CARMILA	BROAD SOUND	CORIO BAY	CAWARRAL CREEK	TOTAL
Closed *Rhizophora*	907	60	280	483	84	83	7	3595	740	617	6856
Closed *Avicennia*	96	156	24	11	96	72	33	1655	181	604	2929
Open *Avicennia*	30	0	14	8	13	5	2	247	12	25	356
Closed *Ceriops*	906	65	365	688	250	158	85	10474	316	3	13312
Open *Ceriops*	0	0	0	0	0	6	0	14	0	0	20
Closed *Aegiceras*	0	0	0	0	0	0	0	142	0	0	142
Closed *Rhizophora*/*Avicennia*	0	0	0	2	0	0	0	0	0	0	2
Closed *Avicennia*/*Ceriops*	12	7	0	0	0	0	0	631	0	0	651
Open *Avicennia*/*Ceriops*	0	0	0	0	0	0	0	0	0	0	0
Closed Mixed	127	74	28	124	26	178	135	3412	245	0	4348
Closed *Ceriops* dieback	0	0	0	0	0	0	0	35	0	0	35
Saline Grassland	232	8	1	31	3	1	0	605	183	53	1117
Saltpan	329	0	183	201	22	79	42	11763	40	1025	13684
Samphire-dominated Saltmarsh	0	0	0	0	0	0	0	522	0	0	522
Total	2640	371	895	1549	493	582	304	33096	1716	2326	**43972**

9.4 Representative Areas to be Considered as Potential FHAs

The Fitzroy River Delta

The extensive coastal wetland communities of the Fitzroy River Delta have not been protected via FHA declaration. Within this wetland system, "Area 3" of the Fitzroy River Delta is suitable for further protection under Fisheries legislation. Unlike the majority of the coastal wetlands of the Fitzroy River Delta the communities in this region have not been affected by the construction of pondage pasture banks or salt evaporation ponds in the intertidal zone. Additionally, the adjacent terrestrial land is largely unmodified. There is a low level of existing and potential disturbance to the area, due to the protection of some of this adjacent land within the Rundle Range National Park.

The importance of the coastal wetlands of the Fitzroy River Delta for fisheries productivity has already been discussed briefly in Section 8.3. Further to being important habitat for barramundi, it is also an important region within Queensland for blue salmon, banana prawns and mud crabs. Both recreational and commercial fisheries are important to the areas' economy. The ANCA (1996) identified that there is some pressure on fishery

stocks. Although the declaration of a FHA over this region would not alter the pressure on fish stocks, a significant proportion of the habitat on which these fish stocks depend would be protected.

Some of the coastal wetland communities of the Fitzroy River Delta, namely the western side of Curtis Island and the Narrows, have already been included in the Mackay/Capricorn Marine Park. The majority of this area has been zoned as General Use A, with the Narrows being zoned as Conservation and Mining Resources. Although, this important fish habitat has been protected within the Mackay/Capricorn Marine Park, an increased level of protection through a FHA is warranted in order to recognise and protect the value of this region as fish habitat.

A large area of significant coastal wetland habitat in this area has been excluded from the Mackay/Capricorn Marine Park. It is strongly recommended that a FHA be declared to protect the fisheries values of this area.

Shoalwater Bay, Townshend and Leicester Islands

The characteristics of the coastal wetlands of the Shoalwater Bay region promote it as an area suitable for protection within a FHA. This region exists in a virtually pristine state due to its management as a Military Training Area. Additionally, the terrestrial vegetation adjacent to the coastal wetlands of this region is near pristine. The extensive areas of coastal wetland habitats within the SWBMTA, including mangrove forests, intertidal foreshore flats, rocky foreshores, reefs and seagrass meadows, provide habitat for commercially important fisheries species, turtles, dugong and numerous migratory wader species of national and international importance (ANCA 1996).

The Shoalwater Bay area supports only small scale commercial, charter and recreational fisheries compared to the rest of the Queensland east-coast. Nevertheless, the area provides extensive breeding and nursery grounds, food and shelter to a large number of fish species. These fisheries make an important contribution to the local economy (DPIQ 1996). The disproportionately small commercial catch in relation to the extensive area of fish habitat in Shoalwater Bay can be attributed to the remoteness of the area, the large number of Defence closures, the zoning restriction to trawling in most of Shoalwater Bay proper and navigational difficulties due to the large tidal range (DPIQ 1996).

Other Gaps

Some coastal wetland systems have not been protected in gazetted FHAs (Table 9.2). Although these coastal wetland systems have value as fish habitats, they have not been recommended as suitable for inclusion in the protected area network due to their failure to meet the criteria specified in Section 9.1 from the information collected in this study. These areas have not been recommended due to characteristics of the coastal wetland vegetation, which is the focus of this study.

SECTION 10 RECOMMENDATIONS AND FURTHER INVESTIGATIONS

The current study confirms the requirement for existing FHAs and identifies the need for expansion of the marine protected areas network. In particular, the following recommendations for new FHAs in the Study Area should be considered as a priority.

- It is strongly recommended that the coastal wetland vegetation of the Fitzroy River Delta, including the extensive Saltpans and the mangrove-lined feeder creeks from Balaclava Island to the western side of Curtis Island (Area 3) be gazetted as a FHA. This important fish habitat is representative of the Fitzroy River Delta and is relatively undisturbed. Other similar environments within the Delta have been modified extensively through the construction of levees and salt evaporation ponds.

- The characteristics of the coastal wetlands of the Shoalwater Bay region promote it as an area suitable for protection within a FHA. It is recommended that the requirement for a FHA in this region be investigated further, in collaboration with the land managers (the Australian Army).

Further Investigations

The study confirms the value of coastal wetland habitat mapping for monitoring of changes in communities and for the identification of dieback events. Remote sensing is a valuable tool for monitoring the long-term changes in these communities. Continuation of the coastal wetlands mapping via remote sensing to complete the remainder of the Queensland coastline is recommended to:

- Provide baseline data for FHA declaration and Ramsar site nomination;
- Provide a basis for future monitoring of the spatial and composition changes in tidal coastal wetland communities on a local, bioregional and State-wide basis;
- As a resource for incorporation into studies of the relationships of specific marine fauna to particular coastal wetland habitats;
- Provide baseline habitat data for Local Government Planning Schemes prepared under the provisions of the *Integrated Planning Act 1997*.

The current mapping of Queensland's coastal wetland habitats is useful for monitoring changes in communities at the appropriate scale. However, these studies need to be augmented with large-scale studies of particular areas (such as the Bassett Basin, Clairview and Bar Plains) in order to document, understand and successfully manage changes in communities due to man-made or natural disturbance events.

Investigations into the cause of the large-scale dieback of the coastal wetland habitats of the Bassett Basin have already commenced. This investigation will aid in determining the effect of certain disturbances on coastal wetland systems.

It is recommended that the areas of Closed *Ceriops* dieback at Bar Plains and Clairview be used as sites to monitor the natural recovery of mangrove communities in a dry environment after a natural disturbance event. These two sites provide an opportunity for the scientific investigation of mangrove regeneration in an area that is relatively isolated from human activity and disturbance.

Current Queensland Fisheries Service policy recommends the retention of a 100m minimum buffer zone adjacent to coastal wetland vegetation to protect the ecological integrity of fish habitat. Cultivation and clearing have extended to the tidal boundary in a large number of coastal wetland systems in the Study Area. The ecological, economic and social viability of revegetation of cleared areas adjacent to coastal wetland vegetation should be investigated, particularly adjacent to FHAs.

Other Queensland Coastal Wetland Mapping Projects:

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Bruinsma, C, Danaher, K, Treloar, P and Sheppard, R (1999) Coastal Wetland Resources of the Bowen Region: Cape Upstart to Gloucester Island. Department of Primary Industries Queensland, Brisbane.

Danaher, K (1995a) Marine Vegetation of Cape York Peninsula. Cape York Peninsula Land Use Strategy, Office of Co-ordinator General of Queensland, Brisbane, Department of the Environment, Sport and Territories, Canberra, and Department of Primary Industries Queensland, Brisbane.

Danaher, K (1995b) Coastal Wetlands Resources Investigation of the Burdekin Delta for Declaration as Fisheries Reserves: Report to Ocean Rescue 2000. Department of Primary Industries Queensland, Brisbane.

Danaher, K and Stevens, T (1995) Resource Assessment of the Tidal Wetland Vegetation of Western Cape York Peninsula, North Queensland, Report to Ocean Rescue 2000. Department of Primary Industries Queensland, Brisbane.

Danaher, K, Bruinsma, C and O'Neill, M (in progress) Queensland Coastal Wetland Resources of the Curtis Coast Region: Cape Keppel to Round Hill Head. Department of Primary Industries Queensland, Brisbane.

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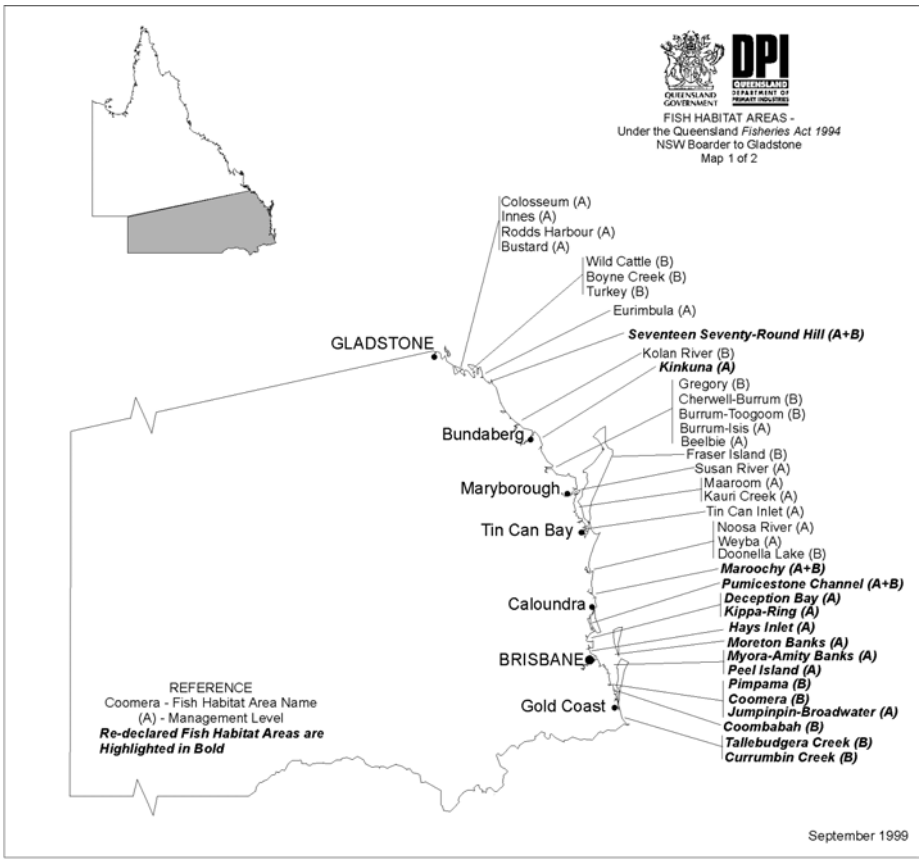
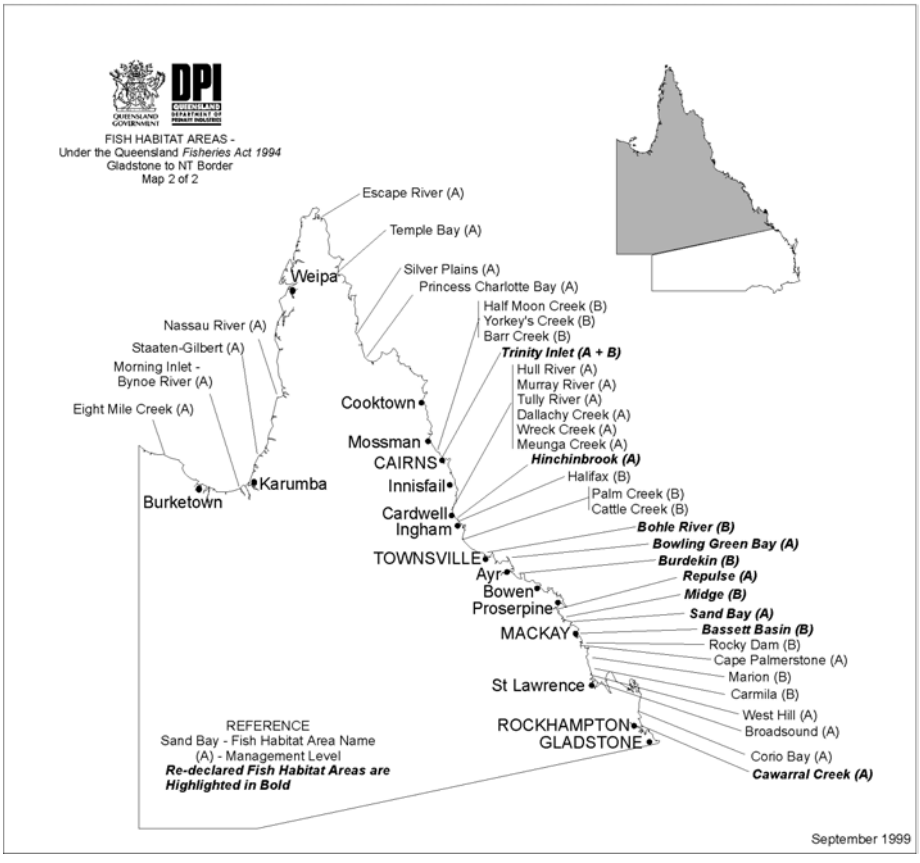

FISH HABITAT AREAS -
Under the Queensland Fisheries Act 1994
NSW Boarder to Gladstone
Map 1 of 2
Colosseum (A)
Innes (A)
Rodds Harbour (A)
Bustard (A)
Wild Cattle (B)
Boyne Creek (B)
Turkey (B)
Eurimbula (A)
GLADSTONE
Seventeen Seventy-Round Hill (A+B)
Kolan River (B)
Kinkuna (A)
Gregory (B)
Cherwell-Burrum (B)
Burrum-Toogoom (B)
Burrum-Isis (A)
Beelbie (A)
Bundaberg
Fraser Island (B)
Susan River (A)
Maaroom (A)
Kauri Creek (A)
Maryborough
Tin Can Inlet (A)
Noosa River (A)
Weyba (A)
Doonella Lake (B)
Tin Can Bay
Maroochy (A+B)
Pumicestone Channel (A+B)
Deception Bay (A)
Kippa-Ring (A)
Caloundra
Hays Inlet (A)
Moreton Banks (A)
Myora-Amity Banks (A)
BRISBANE
Peel Island (A)
Pimpama (B)
Coomera (B)
Jumpinpin-Broadwater (A)
Gold Coast
Coombabah (B)
Tallebudgera Creek (B)
Currumbin Creek (B)
REFERENCE
Coomera - Fish Habitat Area Name
(A) - Management Level
Re-declared Fish Habitat Areas are
Highlighted in Bold
September 1999


FISH HABITAT AREAS -
Under the Queensland Fisheries Act 1994
Gladstone to NT Border
Map 2 of 2
Escape River (A)
Temple Bay (A)
Weipa
Silver Plains (A)
Princess Charlotte Bay (A)
Half Moon Creek (B)
Yorkey's Creek (B)
Barr Creek (B)
Trinity Inlet (A + B)
Nassau River (A)
Staaten-Gilbert (A)
Morning Inlet -
Bynoe River (A)
Hull River (A)
Murray River (A)
Tully River (A)
Cooktown
Eight Mile Creek (A)
Dallachy Creek (A)
Wreck Creek (A)
Meunga Creek (A)
Mossman
CAIRNS
Hinchinbrook (A)
Halifax (B)
Karumba
Burketown
Innisfail
Palm Creek (B)
Cattle Creek (B)
Cardwell
Ingham
Bohle River (B)
Bowling Green Bay (A)
TOWNSVILLE
Burdekin (B)
Repulse (A)
Ayr
Bowen
Midge (B)
Proserpine
Sand Bay (A)
Bassett Basin (B)
MACKAY
Rocky Dam (B)
Cape Palmerstone (A)
Marion (B)
St Lawrence
Carmila (B)
West Hill (A)
ROCKHAMPTON
Broadsound (A)
GLADSTONE
Corio Bay (A)
Cawarral Creek (A)
REFERENCE
Sand Bay - Fish Habitat Area Name
(A) - Management Level
Re-declared Fish Habitat Areas are
Highlighted in Bold
September 1999

Fisheries Information Leaflet

FISH HABITAT AREA

DECLARATION PROCESS AND MANAGEMENT OPTIONS

What is a Fish Habitat Area

Fish Habitat Areas form an important component of the ongoing protection and management of fisheries resources and wetland habitats in Queensland. The Areas are declared with the specific intent of ensuring the continuation of productive recreational, commercial and traditional fisheries in a region.

A Fish Habitat Area may be declared in both marine and freshwater environments to protect important juvenile and adult fish habitats. These habitats include sand bars, shallow water areas, undercut banks, snags, rocky outcrops, pools, riffles, seagrass beds, mangrove stands, yabby banks etc.

Declaration of a Fish Habitat Area complements the existing and more general fisheries habitat management (e.g. protection of all marine plants) by:
providing additional statutory protection to critical freshwater and unvegetated marine habitats,
publicising the fisheries value of the area, and
providing guidelines on fish habitat management to other management groups and members of the community proposing works within or adjacent to the Declared Area.

Fish Habitat Areas are declared and managed under the *Fisheries Act 1994* and the *Fisheries Regulation 1995* by the Department of Primary Industries. Management provides for community use and enjoyment of the area (e.g. commercial, recreational and traditional fishing, boating etc.) whilst restricting activities which may have negative impacts on the fisheries and habitat values of the area (e.g. dredging, reclamation, discharging/drainage etc.).

While an individual Fish Habitat Area (FHA) is nominated and declared on the basis of its specific habitat and fisheries values, each FHA extends the statewide network of Fish Habitat Areas. These Areas combine to help protect the regional viability of Queensland's fish and crustacean stocks by supporting adjacent and offshore fishing grounds (via primary production inputs, protection of nursery areas and feeding grounds, and protection of spawning locations).

Why is it important to protect fish habitat?

Considerable research has been undertaken during the last 20 years to investigate the associations and interrelationships between fish stocks and coastal and freshwater habitats. This research has documented that many species of fish and crustaceans have specific habitat requirements and that these habitat requirements often change as the individual moves through its life cycle. Studies estimate that approximately 75% (by weight) of all seafood landed commercially in Queensland is from species dependent on estuarine habitats during part of their life cycle. Similarly, a high proportion of species targeted by the recreational fishing sector and indigenous fishers is also dependent on estuarine and freshwater habitats during part or all of their life cycles.

Ever increasing pressure for both coastal and inland industrial, residential and agricultural development has and continues to have a major impact on Queensland's freshwater and inshore fisheries habitats. The permanent losses and/or alterations of these fisheries habitats have led to effects on fisheries productivity. For example, CSIRO researchers (Staples D.J., Vance D.J. and Heales D.S. 1984), in relation to commercial prawn fisheries in northern Queensland, concluded that "Any changes

QUEENSLAND DPI QUEENSLAND EDFISH The Wetlands Education Project

to the nursery habitat will have a corresponding effect on the offshore catch." The nursery habitats referred to include seagrass flats, algal beds and mud-banks immediately adjacent to the mangrove fringe.

The following examples taken from research data again illustrate the degree of habitat disturbance in recent times:

- during the period 1974 to 1987, 8.4% of the mangrove habitat and 10.5% of the saltmarsh-claypan habitat between Coolangatta and Caloundra have been lost to development (Hyland S.J. and Butler C.T. 1988)
- during the period 1951 to 1992, 60% of the wetlands (including both freshwater and marine wetlands) within the Johnstone River Catchment have been lost (Russell D.J. and Hales P.W. 1993)
- during the period 1941 to 1989, 2.5% (approx. 650ha) of the mangrove forest and 5.5% (approx. 990ha) of coastal saltflats along the Curtis Coast have been lost (QDEH, 1994)

Given the degree of existing development impacts on fisheries habitat and the likely pressures for future impacts on these habitats, it is clear that management and protection of the most significant of these habitats are essential/necessary. Declaring these areas as Fish Habitat Areas, is an important measure in sustaining important and valuable* commercial, recreational and traditional fisheries stocks.

* At a wholesale level the product value of the Queensland commercial fishing industry in 1996 was estimated to be $300 million. The recreational fishing industry value has been estimated to be at least equal to that of the commercial industry.

Who owns a Fish Habitat Area?

In Tidal Areas

Fish Habitat Areas in tidal areas are generally declared over Unallocated State Land (USL). The areas are not declared over tenured land (e.g. freehold or leasehold) unless a specific agreement is reached between the DPI and the holder of the tenure. A Fish Habitat Area is a fisheries habitat management measure for protection of habitat, not a form of tenure.

As the majority of land over which a Fish Habitat Area is usually declared is State Land, **community** use and enjoyment of these areas is a primary consideration in their management. It should be noted however, that if tenured land is included in a Fish Habitat Area, through specific agreement, the **rights of the tenure holder** is a primary management consideration and community use of the tenured portion of the Fish Habitat Area may be severely restricted. Protection of and the use of the habitat by fish in these lands is the key management concern.

In Freshwater Areas

As with tidal areas, freshwater Fish Habitat Areas are not a tenure but a Fisheries management measure. They can be declared over USL and, may be declared over tenured land if a specific agreement is reached between the DPI and the holder of the tenure. Given the nature of landuse and tenure arrangements around freshwater rivers and streams throughout Queensland, it is likely that freshwater Fish Habitat Area proposals may involve more tenured land than those in tidal areas.

It is envisaged that freshwater Fish Habitat Areas will focus on critical areas of fisheries habitat within a catchment and that these areas will complement existing and future whole of catchment management initiatives.

What criteria are used to determine if an area is suitable for declaration as a Fish Habitat Area?

An area may be proposed for declaration as a Fish Habitat Area by a range of interested parties or individuals. A number of recent proposals have been submitted by community groups, recreational and commercial fishing groups, local authorities and by staff from within the Department of Primary Industries.

Selection criteria currently used by DPI to assess the suitability of an area to be declared as a Fish Habitat Area are outlined below:

- size (larger areas being seen as more viable in the long-term)
- existing or potential fishing grounds
- diversity of or specific fish habitat features
- diversity of or specific marine flora and fauna
- level of existing and likely future disturbances
- unique features
- protected species

Management categories

A Fish Habitat Area may be declared under either **Management 'A'** (the highest level of protection) or **Management 'B'**. These two management categories have associated management frameworks.

In general terms, a Fish Habitat Area 'A' is declared over areas that contain fish habitats that are **critical** for fisheries productivity and sustainable fishing in the short and long term and to maintain the ecological character and integrity of undisturbed fisheries habitats. This management level does not impact on the normal day to day uses of the area by the community (e.g. boating and fishing), but does severely restrict development related disturbances.

A Fish Habitat Area 'B' is declared over areas that contain fish habitats that are **important** for productive and sustainable fishing in the short and long term and to minimise the impacts of non-fisheries related disturbance to important fisheries habitat. Declaration of an area as a Fish Habitat Area 'B' is often proposed to act as a buffer between a Fish Habitat Area 'A' and existing or future disturbances (e.g. residential or industrial development). This management level allows for Permits to be granted for construction of certain private and public facilities subject to minimal impacts on the habitats.

(A guide to management policies for activities within Fish Habitat Area 'A' and 'B' is provided on page 4-5 of this document).

Additional management may occur through a location-specific management plan, once the Fish Habitat Area has been declared. This management may be most suitable in freshwater areas, which are likely to have specific management issues (e.g. extractive industry).

A decision regarding the most appropriate management category is usually made following the first round of community consultation, at which time all relevant issues should be available for consideration.

The declaration process

The declaration of a Fish Habitat Area generally follows the process outlined below:

1. Nomination of an area as a candidate for declaration as a Fish Habitat Area.
2. Review of nomination and assessment of its priority for further investigation *[Period of time between Stage 2 and 3 will be determined by the prioritisation process]*
3. Site investigation/field habitat surveys, literature searches and reviews, assessment of fish catch records and preliminary discussions with user groups (e.g. commercial fishers, recreational fishers, indigenous groups, local authority, other community groups etc.) to determine if the nominated area meets Fish Habitat Area declaration criteria.
4. Preparation of an Area of Interest Plan and draft of known management issues.
5. Initial consultation with interested parties and relevant agencies.
6. Revision of information gathered during the initial consultation phase, preparation of a draft Fish Habitat Area Plan and a draft management strategy with recommendation of an appropriate management level (either 'A' or 'B', and use of a location-specific management plan).
7. Second round of consultation with interested parties and relevant agencies.
8. Revision of information gathered during the second round of consultation.
9. Preparation of a Declaration Plan of Fish Habitat Area Boundaries and a submission of proposal for declaration
10. Provision of Plan and submission to the Department of Primary Industries legal section.
11. Provision of Plan and submission to the Minister for Primary Industries.
12. Provision of Plan and submission to the Governor in Council for declaration under *Fisheries Regulation*.

It is expected that the declaration process from Step 4 to the final declaration should take a period of approximately 12 months to complete, however this will depend on the complexity of the issues associated with the individual area.

What are the restrictions to the user groups/adjoining land holders of the declaration of an area as a Fish Habitat Area ?

It should be noted that the management guidelines for Fish Habitat Areas 'A' and 'B' outlined below have been developed from the legislative powers and provisions of the Fisheries Act 1994 and Fisheries Regulation 1995.

Any works within a Fish Habitat Area require approval under the Fisheries Act. Each application is assessed on its individual merits and the manner in which it complies with current fisheries legislation and management policies.

ACTIVITY	FHA 'A'	FHA 'B'
Community access	✓	✓
Boating	✓	✓
Commercial and recreational fishing by lawful line or net	✓	✓
Commercial and recreational crabbing by lawful dilly or pot	✓	✓
Traditional Fishing	✓	✓
Yabby pumping	✓	✓
Worm digging	✗	✗
Collection of molluscs	✗	◆
Public works for fisheries infrastructure benefit (e.g. public jetty, public boat ramp), where there is an existing need	✓✪	✓✪
Minimal impact public works for community infrastructure benefit, with full restoration of habitat (e.g. fully buried water, power or sewerage lines)	✓✪	✓✪
Major impact public works for community infrastructure benefit (e.g. road bridge, rail bridge etc.)	✗	✗
Maintenance of existing structures	✓✪	✓✪
General placement of mooring piles or blocks	✗	✗
Placement of mooring piles or blocks directly adjacent to proponents tenured property	✗	✓✪
Construction of private access facilities for fisheries purposes into FHA from proponents tenured property (e.g. jetty, pontoon, boat ramp)	✗	✓✪
Construction of new private access facilities for other than fisheries purposes (e.g. ferry loading / boarding facilities)	✗	✗
Placement of structures for the restoration of fish habitat or of natural processes (e.g. placement of baffles or booms to revegetated marine plants)	✗	✓✪
Construction of residential canal estates	✗	✗
Mining (including sand mining)	✗	✗
Minimal impact exploratory surveys of potential mineral deposits	✗	✓✪
Extractive industry operations (including gravel dredging)	✗	✗
Dredging tidal lands for a private purpose (including channel dredging)	✗	✗
Disposal of dredge spoil	✗	✗
Revetment works where there is visible proof of bank erosion or slumping	✗	✓✪
Revetment works where there is no visible proof of bank erosion or slumping	✗	✗
Beach replenishment to control erosion for community fisheries purposes	✓✪	✓✪
Beach replenishment to control erosion for other than fisheries purposes	✗	✓✪
Reclamation of any land (e.g. for car parks, vessel trailer parks, restaurants, airport runways etc.)	✗	✗
Construction of tidal gates, weirs and baffles	✗	✗
Drainage or flood mitigation works affecting natural water flows	✗	✗
Reclamation of any land within the FHA for aquaculture purposes (including for pond construction and/or cage culture)	✗	✗
Dredging of a aquaculture water intake or outlet channel	✗	✗
Placement of underground aquaculture inlet and outlet pipes or elephant trunk systems	✗	✓✪
New facilities for discharge of sewage effluent or unfiltered stormwater	✗	✗
Collection of dead wood	✗	✗
Any proposal having only minor benefit in terms of management, public use and enjoyment of any declared Fish Habitat Area for fisheries purposes not justifying the impacts	✗	✗

Key to Symbols

✓ Unrestricted Activity

✓✪ Activity considered compatible with FHA declaration, subject to DPI Permit consideration

✗ Activity considered incompatible with FHA declaration

◆ Under review

How does community infrastructure requirements (e.g. road, rail bridges) relate to the management of a Fish Habitat Area?

Infrastructure for community benefit (e.g. bridge pylons, powerline support structures), permanently alters the natural fisheries habitat values of the localized area, without offering fisheries management benefits to the area. Therefore, these structures are not seen as compatible with the intent of Fish Habitat Area declaration. In addition, any impacts on intertidal habitats as a result of regular maintenance of these structures to ensure community and structural safety may require statutory approvals from the DPI.

For the reasons outlined above DPI management seeks to exclude present and planned community infrastructure from Fish Habitat Areas. This is generally achieved through prior negotiation with the individual government agencies to incorporate strategically located community infrastructure corridors through the Fish Habitat Area. These corridors are not part of the Fish Habitat Area and not subject to its management.

It should be noted that public jetties and public boat ramps providing boat access to fisheries resources are considered compatible with the intent of Fish Habitat Area declaration, therefore these facilities are generally not excluded from the declared Areas.

The Revocation Process

The declaration of a Fish Habitat Area is seen as long-term management of an area of important fisheries habitats. It is recognised when adopting this style of management that with time, community needs may change and additional community infrastructure (e.g. a road / rail bridge duplication) may be required. A whole-of-government and community approach to acceptance of these needs may then require removal of part of a declared Fish Habitat Area for the agreed purpose. Excision of an area of habitat from within a declared Fish Habitat Area requires formal revocation.

Details of the process for revocation are available from the DPI Fisheries Group. The process is structured and open to public scrutiny and includes such elements as a requirement for the submission of a 'Revocation Support Study' and an appropriate amendment of the Fisheries Regulation by Governor-in-Council.

For further information please contact:

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PO Box 76 (13 Beach Road)
DECEPTION BAY Q 4508
telephone- (07) 3817 9500

Northern Fisheries Centre
PO Box 5396 (38-40 Tingira Street, Portsmith)
CAIRNS Q 4870
telephone (07) 4035 0126

References

Hyland, S.J. and Butler, C.T. (1988). *The Distribution and Modification of Mangroves and Saltmarsh - Claypans in Southern Queensland*, Queensland Department of Primary Industries Information Series, Brisbane, 74pp.

Queensland Department of Environment and Heritage (1994) *Curtis Coast Study Resource Report*, Queensland Department of Environment and Heritage Resource Report, 180pp.

Russell, D.J. and Hales, P.W. (1993). *Stream Habitat and Fisheries Resources of the Johnstone River Catchment*, Queensland Department of Primary Industries, Cairns, 59pp.

Staples, D.J., Vance, D.J. and Heales, D.S. (1984) *Habitat Requirements of Juvenile Penaeid Prawns and their Relationship to Offshore Fisheries* pp 47-54, In: P.C. Rothlisberg, B.J. Hill and D.J. Staples (Editors), Second Aust. Nat. Prawn Sem., NPS2, Cleveland, Australia

(Source: http://www.fws.gov/r9dia/global/Ramsarfr.html, accessed 1st Sep 1999)

The text of the Ramsar Convention (Article 2.2) states that:

"Wetlands should be selected for the List [of Wetlands of International Importance] on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology" and indicates that *"in the first instance, wetlands of international importance to waterfowl at any season should be included."*

To facilitate the implementation of this provision, the Conference of the Parties has adopted the following four clusters of criteria for the identification of wetlands of international importance:

1. Criteria for representative or unique wetlands
   A wetland should be considered internationally important if:

   (a) it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region; or
   (b) it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region; or
   (c) it is a particularly good representative example of a wetland which plays a substantial hydrological, biological or ecological role in the natural functioning of a major river basin or coastal system, especially where it is located in a transborder position; or
   (d) it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region.

2. General criteria based on plants or animals
   A wetland should be considered internationally important if:

   (a) it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species; or
   (b) it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna; or
   (c) it is of special value as the habitat of plants or animals at a critical stage of their biological cycle; or
   (d) it is of special value for one or more endemic plant or animal species or communities.

3. Criteria based on waterfowl
   A wetland should be considered internationally important if:

   (a) it regularly supports 20,000 waterfowl; or
   (b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity; or
   (c) where data on populations are available, it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl.

4. Criteria based on fish
   A wetland should be considered internationally important if:

(a) it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity; or
(b) it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetlands or elsewhere, depend.

Each cluster of criteria is supplemented by guidelines for its application. The guidelines can be obtained from the Ramsar Bureau or on the Ramsar Web site.

APPENDIX 4: MPA DECLARATIONS AND NOMINATIONS RESULTING FROM QUEENSLAND COASTAL WETLANDS MAPPING PROJECTS

AREA	FUNDING	STATUS OF MAPPING	STATUS OF REPORT	NEW MPA DECLARATION?
SE GULF OF CARPENTARIA	OR2000 G007/93	Completed 1994	Completed 1995	Recommendations for additional Fish Habitat Areas to regional implementation staff.
CAPE YORK PENINSULA	CYPLUS	Completed 1993	Completed 1994	Annan River–FHA declaration scheduled for late 2000. Kirke River–FHA consultation (NHT funded) complete by late 2000. Starke River–initial FHA consultation (NHT funded) underway, FHA declaration proposal for late 2001. Margaret Bay–FHA consultation scheduled to commence early 2001.
THE BURDEKIN REGION	OR2000 G006/93	Completed 1994	Completed 1995	Burdekin FHA declared in August, 1999.
THE BOWEN REGION	MPA G019/96b	Completed 1999	Completed 1999	Edgecumbe Bay–FHA consultation scheduled to commence late 2000.
REPULSE BAY	QDPI Fisheries	Completed 1995	Draft report in preparation.	N/A–confirmation of the fisheries conservation values of existing extensive FHAs only
THE CURTIS COAST REGION	MPA G019/96a	Completed 1998	Initial report complete, undergoing revision for publication.	Narrows / Fitzroy Delta–under further investigation.
ROUND HILL HEAD TO TIN CAN INLET	MPA 97/98 funding	Completed 1999	Completed 1999	Baffle Creek–FHA declaration scheduled for late 2000. Elliott River–initial FHA consultation underway, FHA declaration proposal for early 2001.
THE MORETON REGION	QDPI Fisheries	Completed 2000	Completed 2000	N/A–confirmation of the fisheries conservation values of existing FHAs only
CENTRAL QLD	MPA 98/99 funding	Completed 2000	Completed 2000	Recommendations for additional FHAs to regional implementation staff.
GULF OF CARPENTARIA	MPA 98/99 funding	Completed 2000	Completed 2000	Recommendations for additional FHAs to regional implementation staff.
WHITSUNDAYS TO EDGECUMBE BAY	MPA 99/00 funding	Scheduled to commence late 2000.	-	Awaiting mapping and report
CAPE BOWLING GREEN TO COOKTOWN	MPA 99/00 funding	Scheduled to commence late 2000.	-	Awaiting mapping and report

The Landsat 5 satellite, launched by the US government, orbits at 705 km above the earth's surface and takes 16 days to sense the whole of the earth's surface. Its instrument, the Thematic Mapper (TM), digitally scans "scenes" which are 185 x 185 km. The scanned scenes are made up of digital values recorded from the amount of light reflected from the Instantaneous Field of View (IFOV) or pixel. TM pixels represent an area of 25 x 25 m on the ground. Thus objects of interest must be at least this size in order to be detected by the sensor. For every pixel, the Landsat TM sensor records light in seven different wavebands. These bands and some general applications for their use are outlined in Table 2.

TABLE 1 Landsat Thematic Mapped Sensor System Characteristics (Jensen 1996).

SENSOR CHARACTERISTIC	DETAILS
IFOV (Instantaneous Field of View) at nadir	25 x 25 m for bands 1 to 5, 7 120 x 120 m for band 6
Data rate	85 MB/s
Quantisation levels	8 bits, 256 levels
Earth coverage	16 days Landsat 4 and 5
Altitude	705 km
Swath width	185 km
Inclination	98.2^{o}

TABLE 2 Characteristics of Landsat Thematic Mapper Bands (Acres 1989)

TM BAND	MICROMETERS	GENERALISED APPLICATION
1 (blue)	0.45–0.52	Coastal water mapping, soil/vegetation differentiation
2 (green)	0.52–0.60	Green reflectance by healthy vegetation
3 (red)	0.63–0.69	Chlorophyll absorption for plant species differentiation
4 (reflective infrared)	0.76–0.90	Biomass surveys, water body delineation
5 (mid-infrared)	1.55–1.75	Vegetation moisture measurement
6 (thermal infrared)	10.40–12.5	Plant heat stress mapping, sea surface temperatures
7 (mid-infrared)	2.08–2.35	Hydrothermal mapping

APPENDIX 6: METADATA

Dataset
Title: Coastal Wetland Vegetation: Sand Bay to Keppel Bay
Legal Owner: Queensland Fisheries Service - Assessment & Monitoring Unit
Custodian: Queensland Fisheries Service - Assessment & Monitoring Unit
Jurisdiction: QLD

Description
Abstract: Coastal wetlands mapping including mangrove communities, saltpans and saline grasslands. Mapping extends from Sand Bay (Cape Hillsborough) south to Keppel Bay. The Fitzroy River Delta mapping (10272) completes the coverage of the reporting region, ie Sand Bay to Keppel Bay (Ramsay Crossing, the Narrows).
Search Word(s): Mangroves, Remote Sensing, Saltmarshes, Vegetation Geographic
Extent Name(s): Queensland Central Coast Geographic
Extent Polygon: 149.100 -23.680,151.120 -23.680,151.120 -21.420,149.100 -21.420 Coordinates:
North: -21.42
South: -23.68
East: 151.12
West: 149.1
Beginning date: 1/9/1999
Ending date: 30/9/2000

Dataset Status
Progress: Complete Maintenance and update frequency: Not Required

Access
Stored Data Format: DIGITAL - ARC/INFO
Available Format Type: DIGITAL
Access Constraint: QFS data - release outside QFS on completion of a licence agreement

Data Quality
Lineage: Landsat 5 TM satellite imagery processed using ERDAS Imagine 8.3.1. Landsat imagery used: Sand Bay to Ince Bay - 16 July 1997, Ince Bay to West Hill - 20 July 1995, West Hill to Port Clinton - 20 July 1995, Port Clinton to Yeppoon - 13 July 1995 and Yeppoon to Ramsay Crossing, the Narrows - 16 June 1997. 6 bands contrast stretched using linear stretch with breakpoints to highlight intertidal regions. Water bodies and terrestrial features masked out. Remaining imagery processed using an unsupervised classification procedure (ISODATA). Classes labelled using aerial photograph interpretation. Photography used = BPA St Lawrence to Townsville 1993, 1: 50 000, BPA Urangan to St Lawrence 1996, 1: 50 000, BPA Urangan to St Lawrence 1996/7, 1: 12 000, BPA Urangan to St Lawrence 1992, 1: 12 000. Classification converted from raster to vector format using ARC/INFO GIS software. Jagged vector boundaries were splined and polygons with areas under 0.5 hectares were excluded.
Positional Accuracy: Landsat scene rectified to AMG with final radiometric correction and GCPs Datum AGD84 ANS
Attribute Accuracy: Overall accuracy 90.31%. See report for further user's and producer's accuracy for each class.
Logical Consistency: As no evidence to the contrary has been ascertained, it is considered that this dataset is logically consistent
Completeness: The dataset is complete

Contact Information
Contact Organisation: Queensland Fisheries Service - Assessment & Monitoring Unit
Contact Position: Remote Sensing Officer Mail Address: Level 2 80 Ann Street
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Metadata Creation
Creation Date: 6/11/2000

Other
Scale: 1:100 000

Program
Program Name: Queensland Coastal Wetlands Mapping - Marine Protected Areas Program
Program Coordinator: Malcolm Dunning
Program Coordinator Organisation: Environment Australia - MPA Program

Documentation
Reference: Bruinsma, C (2000) Queensland Coastal Wetland Resources: Sand Bay to Keppel Bay. Department of Primary Industries Queensland, Brisbane

Sheet 1: Sand Bay
Sheet 2: Sandringham Bay
Sheet 3: Ince Bay
Sheet 4: Yarrawonga Point
Sheet 5: Carmilla
Sheet 6: Clairview Bluff
Sheet 7: Rosewood Island
Sheet 8: Charon Point
Sheet 9: Herbert Creek
Sheet 10: Big Sandy Creek
Sheet 11: Long Island
Sheet 12: West Bight
Sheet 13: Shoalwater Bay
Sheet 14: Townshend Island
Sheet 15: Port Clinton (a)
Sheet 16: Port Clinton (b)
Sheet 17: Stockyard Point
Sheet 18: Corio Bay
Sheet 19: Shoal Bay
Sheet 20: Fitzroy River
Sheet 21: Keppel Bay
Sheet 22: Port Alma
Sheet 23: Balaclava Island

Maps of coastal wetland community distribution are included on the attached CD in .pdf format. Two files exist for each map. One has been created using print optimised settings (<sheet number>_p) and the other has been created using screen optimised settings (<sheet number>_s).

APPENDIX 8: FIELD DATA

DATE	LOCALITY	LATITUDE	LONGITUDE	GPS ACCURACY	COMMUNITY CLASSIFICATION	OTHER SPECIES PRESENT
12/02/1999	Reliance Ck	-21.02290	149.13087	43	Closed *Rhizophora*	Cer, Brug, Av, Cyn
12/02/1999	Reliance Ck	-21.02600	149.13294	36	Closed *Ceriops*	Brug
12/02/1999	Reliance Ck	-21.02686	149.13388	74	Closed *Ceriops*	
12/02/1999	Reliance Ck	-21.02970	149.13569	23	Closed *Ceriops*	
12/02/1999	Reliance Ck	-21.03075	149.14052	32	Saline Grassland	Exco, Brug
12/02/1999	Constant Ck	-20.95100	149.01195	60	Closed *Rhizophora*	Av
12/02/1999	Constant Ck	-20.95089	149.01247	35	Closed *Ceriops*	Av
12/02/1999	Constant Ck	-20.95539	148.99258	26	Closed mixed	Cyn, Lum, Exco, Acan, Av, Brug, Cer, Acros
12/02/1999	Constant Ck	-20.95420	148.99685	29	Closed mixed	Av, Rhiz, Cyn, Cer, Exco, Lum, Osb
12/03/1999	Rocky Dam Ck	-21.56040	149.29706	72	Closed *Excoecaria*	Av, Brug, Acan
12/03/1999	Rocky Dam Ck	-21.54809	149.29811	24	Saline Grassland	Exco
12/03/1999	Rocky Dam Ck	-21.54335	149.29283	32	Closed Av/Cer	Rhiz, Osb
12/03/1999	Rocky Dam Ck	-21.54354	149.29301	91	Closed mixed	Rhiz, Cer, Aeg, Av, Osb, Exco
12/03/1999	Not recorded	-21.72334	149.43145	39	Closed *Ceriops*	Exco, Av, Brug
12/03/1999	Not recorded	-21.72540	149.43276	36	Closed Av/Cer	Exco
12/03/1999	Not recorded	-21.72629	149.43243	62	Closed *Avicennia*	Aeg
12/03/1999	Not recorded	-21.72483	149.43084	31	Closed *Ceriops*	Av
12/03/1999	Hill Ck	-21.82251	149.43018	24	Closed mixed	Av, Exco, Lum, Cer, Aeg, Osb
12/03/1999	Hill Ck	-21.82188	149.43126	31	Closed *Ceriops*	
12/03/1999	Hill Ck	-21.82138	149.43150	65	Closed mixed	Cer, Brug, Exco, Acan
12/03/1999	Hill Ck	-21.82537	149.43445	24	Saltpan	
12/03/1999	Hill Ck	-21.83366	149.44163	21	Closed mixed	Av, Rhiz, Cer, Aeg
12/03/1999	Bar Plains	-22.31261	149.59574	37	Closed *Ceriops*	
12/03/1999	Bar Plains	-22.30389	149.62886	19	Open *Avicennia*	
12/04/1999	Clairview Bluff	-22.23015	149.52719	51	Closed *Ceriops* (dead)	
12/04/1999	Clairview Bluff	-22.22980	149.53410	46	Closed *Ceriops* (dead)	Brug, Av
12/04/1999	Clairview Bluff	-22.23074	149.52663	28	Saltpan	
12/04/1999	Clairview Bluff	-22.22259	149.51872	55	Closed *Ceriops*	Av, Exco, Aeg
12/04/1999	Waverley Ck	-22.37631	149.57467	70	Closed *Avicennia*	Cer
12/04/1999	Waverley Ck	-22.37560	149.57306	22	Closed *Ceriops*	Av, Exco
12/04/1999	Meatworks Ck	-22.38409	149.56185	35	Closed *Ceriops*	Av
12/04/1999	St Lawrence Ck	-22.33736	149.50145	49	Closed mixed	Cer, Brug, Exco, Av, Aeg
12/04/1999	St Lawrence Ck	-22.34444	149.51008	33	Closed Av/Cer	
12/04/1999	St Lawrence Ck	-22.34310	149.52549	47	Closed Av/Cer	
12/05/1999	Charon Point	-22.38822	149.81219	30	Closed *Rhizophora*	
12/07/1999	Egg Island	-22.17933	149.92464	92	Closed *Rhizophora*	Av, Aeg, Osb
12/07/1999	Long Island	-22.18764	149.91035	44	Closed mixed	Osb, Brug, Rhiz, Xylo, Cer
12/07/1999	Long Island	-22.18576	149.90839	56	Closed mixed	Rhiz, Cer, Osb, Aeg, Xylo m
12/07/1999	Long Island	-22.16312	149.90340	46	Closed *Ceriops*	Brug, Av
12/07/1999	Long Island	-22.16457	149.90344	28	Closed mixed	Cer, Av, Brug, Osb, Aeg, Xylo m
12/07/1999	Long Island	-22.17426	149.90221	26	Closed mixed	Osb, Xylo, Cer, Av, Aeg, Rhiz, Brug
12/07/1999	Long Island	-22.18509	149.88263	36	Closed mixed	Aeg, Osb, Rhiz
12/07/1999	Long Island	-22.20229	149.88043	33	Closed *Rhizophora*	Av
12/07/1999	Long Island	-22.20419	149.87518	39	Closed *Rhizophora*	Osb
12/07/1999	Long Island	-22.23308	149.08457	33	Closed *Rhizophora*	Osb, Aeg
12/07/1999	Long Island	-22.22861	149.87808	31	Closed *Rhizophora*	Osb, Aeg
12/07/1999	Long Island	-22.23235	149.87171	32	Closed *Rhizophora*	Av
12/07/1999	Mangrove Island	-22.25972	149.89181	42	Closed *Rhizophora*	Av, Osb
12/07/1999	Mangrove Island	-22.25768	149.88984	31	Closed *Rhizophora*	Av, Osb
12/07/1999	Mangrove Island	-22.23740	149.89888	28	Closed Rhiz/Av	Osb, Aeg
12/07/1999	Long Island B	-22.20754	149.89931	29	Closed mixed	Rhiz, Av, Cer, Osb, Xylo m
12/07/1999	Long Island B	-22.20780	149.90081	66	Closed mixed	Osb, Rhiz, Aeg, Xylo, Cer
12/07/1999	Long Island B	-22.20753	149.90226	28	Closed mixed	Cer, Rhiz, Osb, Aeg, Av
12/07/1999	Long Island B	-22.21236	149.90919	32	Closed *Rhizophora*	Aeg, Xylo m
12/07/1999	Quail Island	-22.16127	149.95350	31	Closed mixed	Rhiz, Osb, Av, Cer
12/07/1999	Quail Island	-22.16210	149.95119	45	Closed mixed	Cer, Osb, Rhiz, Aeg
12/07/1999	Quail Island	-22.16232	149.94924	31	Closed mixed	Rhiz, Aeg, Osb, Cer
12/07/1999	Quail Island	-22.16230	149.94385	31	Closed mixed	Osb, Rhiz, Cer, Av
12/08/1999	~Price's Landing	-22.17708	149.96237	133	Closed *Rhizophora*	Aeg, Aegl
12/08/1999	Big Sandy (A)	-22.32066	149.93384	36	Closed *Ceriops*	Av
12/08/1999	Big Sandy (A)	-22.31667	149.92678	49	Closed mixed	Av, Brug, Cer, Rhiz, Aeg
12/08/1999	Big Sandy (A)	-22.31514	149.92400	46	Closed mixed	Cer, Rhiz, Aeg, Av, Osb, Brug
12/08/1999	Big Sandy (A)	-22.31400	149.92095	37	Closed mixed	Osb, Cer, Brug, Av, Rhiz, Aeg
12/08/1999	Big Sandy (B)	-22.32832	150.00283	28	Saline Grassland	Cer, Av
12/08/1999	Big Sandy (B)	-22.32794	150.00234	33	Closed *Ceriops*	Av
12/08/1999	Big Sandy (B)	-22.33340	149.99760	25	Closed *Avicennia*	Cer
12/08/1999	Big Sandy (B)	-22.33886	149.98236	26	Closed *Ceriops*	
12/08/1999	Big Sandy (B)	-22.33176	149.96577	26	Closed *Avicennia*	Osb, Cer
12/08/1999	Big Sandy (C)	-22.32100	149.96720	65	Closed *Ceriops*	Exco, Brug, Av
12/08/1999	Big Sandy (C)	-22.32526	149.96537	28	Closed *Ceriops*	Osb, Av, Brug
12/08/1999	Big Sandy	-22.33525	149.93186	32	Closed *Rhizophora*	Av
12/08/1999	Big Sandy	-22.33639	149.93843	32	Closed *Avicennia*	Osb, Cer, Brug
12/08/1999	Big Sandy	-22.35449	149.93916	39	Closed mixed	Cer, Brug, Av, Osb, Exco
12/08/1999	Big Sandy	-22.34991	149.93193	30	Closed *Avicennia*	Osb, Cer, Rhiz, Brug
12/08/1999	Big Sandy	-22.32311	149.91422	32	Closed *Rhizophora*	Av
12/08/1999	Thirsty Sound	-22.25332	149.93027	22	Closed *Avicennia*	Aeg
12/08/1999	Thirsty Sound	-22.24794	149.95539	50	Closed *Ceriops*	Osb, Av, Brug, Xylo

Date	Locality	Latitude	Longitude	GPS Accuracy	Community Classification	Other Species Present
12/08/1999	Thirsty Sound	-22.24782	149.94796	26	Closed *Ceriops*	Osb, Av, Exco, Xylo m, Rhiz
12/08/1999	Thirsty Sound	-22.24169	149.93424	27	Closed *Avicennia*	Aeg
12/08/1999	Thirsty Sound	-22.22483	149.93946	31	Closed *Rhizophora*	Av
12/08/1999	Thirsty Sound	-22.24979	149.94604	24	Closed *Ceriops*	Rhiz
12/08/1999	Thirsty Sound	-22.24940	149.94237	30	Closed *Rhizophora*	Aeg, Osb
12/08/1999	Thirsty Sound	-22.21936	149.94108	26	Closed *Rhizophora*	Rhiz
12/08/1999	~Price's Landing	-22.18219	149.96995	31	Closed *Ceriops*	Osb
12/08/1999	~Price's Landing	-22.18339	149.96280	31	Closed *Rhizophora*	Osb
03/08/1999	Causeway	-23.20258	150.78784	92	Closed *Avicennia*	Cer, Rhiz, Aegl, Aeg, samphires
03/08/1999	Cawarral Ck	-23.26252	150.79612	21	Saltpan	Samphires, Av, Cer
03/08/1999	Cawarral Ck	-23.26399	150.79682	29	Closed Mixed	Av, Cer, Brug, Xylo, Rhiz
03/08/1999	Cawarral Ck	-23.26254	150.79676	21	Open *Melaleuca*	Cer, Lum, Exco, Spor
03/08/1999	Cawarral Creek	-23.32500	150.78746	27	Closed *Avicennia*	
03/08/1999	Cawarral Creek	-23.32450	150.78833	28	Closed *Avicennia*	
03/08/1999	Fitzroy R	-23.39324	150.53397	34	Closed *Avicennia*	
04/08/1999	Farnborough	-23.09654	150.74579	25	Saline Grassland	Av, sedges
04/08/1999	Farnborough	-23.09657	150.74668	76	Closed Mixed	Brug, Av, Aeg
04/08/1999	Fig Tree Ck	-23.13710	150.74701	29	Closed *Avicennia*	Rhiz, Cer, Exco
04/08/1999	Sandfly Ck	-22.96876	150.73198	21	Saline Grassland	Exco, Av Brug, samphires, sedges
04/08/1999	Sandfly Ck	-22.97018	150.72965	28	Open *Avicennia*	
04/08/1999	Greenslopes Ck	-22.91353	150.74762	36	Closed Mixed	Exco, Rhiz, Av, Xylo
04/08/1999	Greenslopes Ck	-22.91416	150.74712	38	Open *Avicennia*	
04/08/1999	Greenslopes Ck	-22.91643	150.74817	26	Closed *Rhizophora*	Av, Xylo, Exco
04/08/1999	Greenslopes Ck	-22.91939	150.75144	25	Closed *Ceriops*	Osb, Av
04/08/1999	Corio Bay	-22.92184	150.75977	47	Closed Mixed	Av, Rhiz, Cer, Aeg, Exco
04/08/1999	Corio Bay	-22.91975	150.75516	23	Closed Mixed	Av, Aeg , Rhiz, Cer, Osb
04/08/1999	Corio Bay	-22.97397	150.74234	47	Closed *Avicennia*	Cer
04/08/1999	Corio Bay	-22.97155	150.74220	59	Closed Mixed	Rhiz, Exco, Aeg
04/08/1999	Corio Bay	-22.96096	150.74263	45	Closed Mixed	Rhiz, Av, Exco
04/08/1999	Corio Bay	-22.95248	150.74318	?	Closed *Rhizophora*	
04/08/1999	Corio Bay	-22.94819	150.72455	41	Closed Mixed	Av, Exco, Xylo, Cer, Spor, samphires
04/08/1999	Corio Bay	-22.94523	150.72811	28	Closed *Avicennia*	Rhiz
05/08/1999	Fitzroy R	-23.42498	150.58341	50	Saline Grassland	Aeg, Exco, Acan,
05/08/1999	Fitzroy R	-23.42433	150.58331	52	Closed *Aegiceras*	Exco, Acan, Crin
05/08/1999	Fitzroy R	-23.45970	150.61329	27	Closed Mixed	Aeg, Exco, Av, Acan
05/08/1999	Fitzroy R	-23.45812	150.61170	27	Closed *Avicennia*	Aeg, Exco, Acan, Brug, Spor, sedges
05/08/1999	Dunlop Island	-23.50614	150.71984	54	Closed Mixed	Rhiz, Av, Exco, Aeg
05/08/1999	Thunder Island	-23.51403	150.70073	33	Closed Mixed	Xylo, Av, Aeg, Rhiz, samphires
05/08/1999	Thunder Island	-23.52755	150.70322	34	Closed *Avicennia*	samphires
05/08/1999	Not recorded	-23.56554	150.68389	25	Saltpan	
05/08/1999	Not recorded	-23.56504	150.68339	21	Closed *Ceriops*	Av, Brug, samphires
05/08/1999	Not recorded	-23.56486	150.68565	29	Closed *Ceriops*	Av
05/08/1999	Not recorded	-23.57704	150.71194	26	Closed Mixed	Lum, Aeg, Av, Cer, Osb
05/08/1999	Not recorded	-23.58381	150.72770	25	Closed *Ceriops*	Av
05/08/1999	Not recorded	-23.58498	150.72865	21	Closed Av/Cer	
05/08/1999	Not recorded	-23.58440	150.72974	33	Saltpan	
05/08/1999	Alligator Ck	-23.54618	150.75845	47	Closed Mixed	Rhiz, Aeg, Cer, Av, Osb
05/08/1999	Alligator Ck	-23.54382	150.78898	46	Closed *Avicennia*	Rhiz, samphires
05/08/1999	Alligator Ck	-23.53575	150.78178	50	Closed Mixed	Av, Rhiz, Exco, Cer, Osb
05/08/1999	Alligator Ck	-23.54378	150.78786	26	Closed *Ceriops*	Xylo
06/08/1999	Fitzroyvale	-23.48986	150.69435	25	Saline Grassland	Av, samphires, sedges
06/08/1999	Fitzroyvale	-23.49028	150.69633	22	Closed Mixed	Av, Exco, Aegl, Aeg, Lum, Rhiz, Acan
06/08/1999	Fitzroyvale	-23.48699	150.72611	24	Closed Mixed	Av, Lum, Exco, Aegl, Aeg
06/08/1999	Port Alma	-23.62422	150.74466	27	Closed Av/Cer	samphires
06/08/1999	Port Alma	-23.62361	150.74425	23	Saltpan	
06/08/1999	Port Alma	-23.63298	150.69962	34	Saltpan	samphires
11/11/1996	Deception Ck	297600	7390362	?	Closed Mixed	Xylo, Rhiz, Cer, Avi, Osb, Aeg
11/11/1996	Deception Ck	296779	7388338	?	Closed Mixed	Species details not recorded
11/11/1996	Deception Ck	297394	7391314	?	Closed Mixed	Species details not recorded
11/11/1996	Narrows	297428	7388382	?	Closed *Rhizophora*	Species details not recorded
11/11/1996	The Narrows	300919	7385811	?	Open Mixed	Species details not recorded
13/11/1996	Port Alma	281623	7389626	?	Closed Mixed	Species details not recorded
13/11/1996	W of Port Alma	280377	7389760	?	Closed Mixed	Species details not recorded
13/11/1996	Raglan Ck	277196	7376422	?	Closed Mixed	Species details not recorded
13/11/1996	Ramsay's Crssg	302858	7384203	?	Closed *Rhizophora*	Av
13/11/1996	Ramsay's Crssg	303420	7383601	?	Closed *Rhizophora*	

Abbreviations:

Acan – *Acanthus ilicifolius*
Acros – *Acrostichum speciosum*
Aegl – *Aegialitis annulata*
Aeg – *Aegiceras corniculatum*
Av – *Avicennia marina*
Brug – *Bruguiera gymnorrhiza*
Cer – *Ceriops tagal*
Crin – *Crinum pedunculatum*
Cyn – *Cynometra iripa*
Exco – *Excoecaria agallocha*
Hib – *Hibiscus tiliaceus*
Lum – *Lumnitzera racemosa*
Osb – *Osbornia octodonta*
Rhiz – *Rhizophora* spp.
Spor – *Sporobolus virginicus*
Xylo – *Xylocarpus* spp.

Outcomes

The acquisition and interpretation of digital satellite imagery and aerial photography undertaken as part of this study, has provided a community based classification of the coastal wetland communities from Sand Bay to Keppel Bay. This classification forms a component of the baseline assessment of Queensland's coastal wetland resources, to be completed in June 2001. The project has provided key information and recommendations for the declaration of additional managed, Marine Protected Areas in Queensland (Section 9) and for the ongoing management of existing protected areas (Fish Habitat Areas, Marine Parks) and, as appropriate, may form a basis for nomination of Ramsar sites.

Appropriateness

The current study uses the protocol developed by the Department of Primary Industries Queensland, Queensland Fisheries Service (Danaher 1995a) which has been recognised (Ward *et al.* 1998) as an appropriate model for a national approach to coastal wetlands mapping. For the Queensland coast, this coastal wetland resource mapping is an ongoing process, underway since the mid-1980s. To date, approximately 85% of the coastal wetlands have been mapped using this technique (Danaher 1995b; Danaher and Stevens 1995; Danaher personal communication 1999; and Bruinsma *et al.* 1999).

Effectiveness

The method of investigating and mapping relatively large coastal regions, utilised in this study, has proven to be cost effective with a high degree of accuracy (approximately 90%) for coastal wetland communities at this scale. The information presented in the report has been provided to the DPI Fisheries, Marine Habitat Unit staff responsible for FHA declaration, for the purpose of incorporation into FHA planning processes relevant to the study area.

Transferability

It has been demonstrated, in this and previous studies, that the technique developed for coastal wetlands mapping is transferable to similar coastal wetland systems. Landsat TM data is widely available. However, limitations to the technique apply. The minimum mapping unit is a 25 x 25 m Landsat TM pixel. Consequently, a community smaller than this size is not mappable. Additionally, polygons of less than 0.5 ha are eliminated in the mapping process. The mapping technique is generally more accurate in areas where clear zonation in coastal wetland communities occurs.

Fulfilment of Project Specifications

This project has been highly successful in meeting the requirements of the project specifications included in the schedule of work. The success of each task has resulted in the production of coastal wetland community maps from Sand Bay to Keppel Bay with information suitable for use in GIS systems. Additionally, information has been collated regarding the levels of existing disturbance to and protection of the wetlands and existing recreational and commercial fisheries in the region. As a result of this project numerous environments have been identified in the study area, which have a high conservation value. Actions to protect these environments through FHA declaration have been recommended.

Demonstration/Communication Activities Undertaken

The results of the study have been communicated to DPI Fisheries Marine Habitat Unit, Northern and Southern Fisheries Centres and other regional DPI Fisheries staff. Copies of the report will be available through the QDPI Library.

APPENDIX 10: DAMS AND WEIRS IN THE STUDY AREA

NAME	STREAM	X_COORD	Y_COORD	NAME	STREAM	X_COORD	Y_COORD
Finch Hatton Ck d/s 4.0	Finch Hatton Ck.	148.63400	-21.10800	**Carmila Creek d/s 23.9**	Carmila Ck.	149.31111	-21.90139
Finch Hatton Ck d/s 3.2	Finch Hatton Ck.	148.63400	-21.11300	**Carmila Creek d/s 12.9**	Carmila Ck.	149.39444	-21.92222
Cattle Creek d/s 37.0	Cattle Ck.	148.53864	-21.13557	**Flaggy Rock Creek d/s 9.0**	Flaggy Rock Ck.	149.41667	-21.98611
Marian Weir	Pioneer R.	148.93300	-21.14300	**Mt Bridget d/s**	Connors R.	149.11100	-22.05000
Pioneer River w/s 17.7	Pioneer R.	149.06300	-21.14500	**St Lawrence Weir**	St Lawrence Ck.	149.50816	-22.34406
Dumbleton Rocks Weir	Pioneer R.	149.07600	-21.14600	**Tartrus Weir**	MacKenzie R.	149.41800	-22.94800
Mirani Weir	Pioneer R.	148.82700	-21.18000	**Bundoora Dam**	German Ck.	148.52700	-22.95400
Cattle Creek w/s 1.1	Cattle Ck.	148.81500	-21.18300	**Stanwell w/s**	Fitzroy R.	150.03889	-23.06528
Pioneer River w/s 47.1	Pioneer R.	148.82000	-21.18900	**Fitzroy River w/s 159.7**	Fitzroy R.	150.02361	-23.06806
Middle Creek d/s 1.2	Middle Ck.	148.66667	-21.20000	**Fitzroy River w/s 164.5**	Fitzroy R.	149.98750	-23.08472
Kinchant Dam	Sandy Ck. Nth B	148.89889	-21.20917	**Bingegang Weir**	MacKenzie R.	149.03000	-23.08500
Sandy Creek w/s 13.3	Sandy Ck.	149.12180	-21.20976	**Fitzroy River w/s 164.2**	Fitzroy R.	149.99000	-23.08611
Teemburra Creek d/s 20.5	Teemburra Ck.	148.66200	-21.22300	**Fitzroy Gap d/s**	Fitzroy R.	150.10900	-23.08800
Blacks Creek d/s 90.5	Pioneer R. Blacks	148.70278	-21.25417	**Eden Bann Weir**	Fitzroy R.	150.11806	-23.09028
Blacks Creek d/s 83.4	Pioneer R. Blacks	148.72600	-21.27800	**MacKenzie River w/s 504.5**	MacKenzie R.	149.00833	-23.15278
Pioneer River w/s 58.3	Pioneer R.	148.82300	-21.27900	**MacKenzie River w/s 391.0**	MacKenzie R.	149.53889	-23.18889
Blacks Creek d/s 82.1	Pioneer R. Blacks	148.73700	-21.29200	**MacKenzie River w/s 518.8**	MacKenzie R.	148.94444	-23.23611
Pioneer River d/s 60.5	Pioneer R.	148.83400	-21.30000	**MacKenzie River w/s 531.9**	MacKenzie R.	148.87222	-23.26250
Blacks Creek d/s 79.5	Pioneer R. Blacks	148.75100	-21.30400	**Fitzroy River w/s 78.9**	Fitzroy R.	150.42917	-23.26389
Blacks Creek d/s 79.2	Pioneer R. Blacks	148.75300	-21.30500	**Fitzroy River w/s 208.9**	Fitzroy R.	149.93417	-23.27833
Blacks Creek d/s 77.2	Pioneer R. Blacks	148.76000	-21.32000	**Fitzroy River w/s 212.7**	Fitzroy R.	149.92361	-23.31667
Blacks Creek d/s 68.4	Pioneer R. Blacks	148.81100	-21.33400	**Bedford Weir**	MacKenzie R.	148.87000	-23.34200
Blacks Creek d/s 66.1	Pioneer R. Blacks	148.82900	-21.33400	**Fitzroy River Barrage**	Fitzroy R.	150.52600	-23.38500
Alligator Creek d/s 26.2	Alligator Ck.	149.13413	-21.42529	**Stanwell P/S**		150.09727	-23.44257
Alligator Creek d/s 27.3	Alligator Ck.	149.12500	-21.43056	**MacKenzie River w/s 592.0**	MacKenzie R.	148.64167	-23.47778
Sarina Weir	Plane Ck.	149.20044	-21.44258	**MacKenzie River d/s 592.1**	MacKenzie R.	148.64028	-23.47778
Tara Creek d/s 3.8	Tara Ck.	149.13056	-21.45000	**Utah w/s**	MacKenzie R.	148.58194	-23.53333
Tara Creek d/s 3.0	Tara Ck.	149.13611	-21.45417	**Reilly's Crossing w/s**	MacKenzie R.	148.58889	-23.54028
Middle Creek Dam	Middle Ck.	149.10667	-21.46823	**Comgoa w/s**	MacKenzie R.	148.53750	-23.55694
Douglas Gully d/s	Douglas Gully	149.20750	-21.47694	**Comet Weir**	Comet R.	148.54900	-23.62000
Denison Creek d/s 32.5	Denison Ck.	148.80833	-21.75410	**Comet River d/s 14.5**	Comet R.	148.55700	-23.64100
Spencer d/s	Denison Ck.	148.79600	-21.76600	**Bajool Weir**	Inkerman Ck. 8 Mile	150.65800	-23.64400
Waitara d/s	Funnel Ck.	148.93000	-21.78300	**Columbia Creek Weir**	Columbia Ck.	149.20677	-23.64761
Funnel Creek w/s 76.3	Funnel Ck.	148.94639	-21.78333	**Raglan Creek w/s 47.2**	Raglan Ck.	150.85278	-23.73472
Bee Creek d/s	Bee Ck.	148.53300	-21.84300	**Fletcher Creek w/s**	Fletcher Ck.	150.36400	-23.76300
Spider Creek d/s 10.6	Spider Ck.	149.36667	-21.88889	**Wura d/s**	Dee R.	150.34500	-23.79400
List compiled from data supplied by and used with the permission of the Department of Natural Resources.				**Raglan Creek d/s 65.7**	Raglan Ck.	150.79722	-23.81667