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Queensland COASTAL WETLAND RESOURCES

Cape Tribulation to Bowling Green Bay

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The views and opinions expressed in this report are those of the author and do not reflect those of the Commonwealth Government, the Minister for the Environment or the Director of National Parks and Wildlife.

Landsat TM satellite imagery was acquired by the Australian Centre for Remote Sensing (ACRES), a business unit of the Australian Surveying and Land Information Group (AUSLIG), Australia's national mapping agency. *http://www.auslig.gov.au*

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EXECUTIVE SUMMARY

This report provides key resource data for the ongoing assessment of the requirement for additional Marine Protected Areas (e.g. Fish Habitat Areas (FHAs) under the *Queensland Fisheries Act 1994*) in regions of high fish habitat value in northern Queensland from Cape Tribulation to Bowling Green Bay (hereafter referred to as the Study Area). The study also provides baseline information on the coastal wetlands within this Study Area for consideration in the Ramsar site nomination process. The project aimed to:

1. document and map the coastal wetland communities of the Study Area;
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.

The mapping of Queensland's coastal wetland environments by the Queensland Department of Primary Industries (QDPI), Queensland Fisheries Service (QFS) has been an ongoing process, underway since the mid-1990s. The current mapping of the region from Cape Tribulation to Bowling Green Bay marks the completion of the spatial assessment of the coastal wetland resources of the entire Queensland coastline. This systematic exercise has been undertaken using a standard protocol that was developed by the QFS (Danaher 1995a) and has been recognised (Ward et al. 1998) as an appropriate model for a national approach to coastal wetland mapping.

The QFS Queensland Coastal Wetland Mapping Project has been supported by funding from the Cape York Peninsula Land Use Strategy (CYPLUS), the Great Barrier Reef Marine Park Authority (GRBMPA) through Ocean Rescue 2000 and Environment Australia through the Natural Heritage Trust *Coasts and Clean Seas* Marine Protected Areas Program. The project has been undertaken in a number of phases. The current study forms the last stage of a three-year phase that has been supported by funding from Environment Australia through the Natural Heritage Trust *Coasts and Clean Seas* Marine Protected Areas Program. Table I summarises the details of this project. Figure 1, Section 1 displays the project areas.

Project Effectiveness and Limitations

The method of investigating and mapping coastal wetland communities of relatively large coastal regions, utilised in this study, has proven to be cost effective at this scale with a high degree of accuracy (90%). The information presented in the report has been provided to the QDPI Queensland Fisheries Service, 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 departmental studies (see Table 1), that this technique developed for broad scale coastal wetlands mapping is transferable to similar coastal wetland systems. Landsat TM data is widely available. However, the spatial and spectral resolutions of the Landsat TM sensor result in some limitations. The smallest community that can be detected by the Landsat TM sensor is a community equal to or larger than a pixel (that is, 25 x 25 m). The spectral resolution of the data is too low (seven wide bands of information collected) to be able to distinguish spectrally similar species. 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. The resolution of the satellite imagery and the mapping process used results in a product that should not be interpreted at more detailed scales, that is larger than 1: 100 000. An overall evaluation of the project is included in Appendix 7.

TABLE I Details of the Queensland coastal wetland resources project supported by funding from Environment Australia through the Natural Heritage Trust *Coasts and Clean Seas* Marine Protected Areas Program.

SPECIFIC PROJECT AREA	FUNDING DETAILS	REPORT	MPA DECLARATION?	FUNDING AGENCY CONTRIBUTION	QFS CONTRIBUTION
A) Stage 1 Noosa to Town of Seventeen Seventy (southern Queensland) (1998-1999)					
Round Hill Head to Tin Can Inlet	MPA 97/98 funding	Bruinsma, C and Danaher, K (2000). Queensland Coastal Wetland Resources: Round Hill Head to Tin Can Inlet. QI99081. Department of Primary Industries, Queensland, Brisbane, 101 pp.	Baffle Creek – FHA declared Sep 2001. Elliott River – initial FHA consultation nearing completion, FHA declaration proposed for early 2002.	$56 985	$79 949
B.1) Stage 2 Fitzroy River to St Helens (Central Queensland) (1999-2000)					
Sand Bay to Keppel Bay, Central Queensland	MPA 98/99 funding	Bruinsma, C (2000). Queensland Coastal Wetland Resources: Sand Bay to Keppel Bay. QI00100. Department of Primary Industries, Queensland, Brisbane, 94 pp.	Narrows / Fitzroy Delta – seeking NHT funding, FHA consultation to commence early 2002.	$64 504 (= total for Stage 2)	$77 908 (= total for Stage 2)
B.2) Stage 2 Flinders River to the Northern Territory Border (Gulf of Carpentaria) (1999-2000)					
The Northern Territory Border to Flinders River	MPA 98/99 funding	Bruinsma, C and Duncan, S (2000). Queensland Coastal Wetland Resources: the NT border to Flinders River. QI00099. Department of Primary Industries, Queensland, Brisbane, 72 pp.	Recommendations for additional FHAs to regional implementation staff.	AS ABOVE	AS ABOVE
C.1) Stage 3 Whitsundays to Edgecumbe Bay (2000-2001)					
Cape Gloucester to Conway Inlet (*does not include Edgecumbe Bay*)	MPA 99/00 funding	Bruinsma, C and Danaher, K (2001). Queensland Coastal Wetland Resources: The Whitsunday region. QI01065. Department of Primary Industries, Queensland, Brisbane.	Recommendations for additional FHAs to regional implementation staff.	$61 478 (= total for Stage 3)	$59 152 (= total for Stage 3)
C.2) Stage 3 Cape Bowling Green to Cooktown (North Queensland) (2000-2001)					
Cape Tribulation to Bowling Green Bay	MPA 99/00 funding	Bruinsma, C (2001). Queensland Coastal Wetland Resources: Cape Tribulation to Bowling Green Bay. QI01064. Department of Primary Industries, Queensland, Brisbane, 85 pp.	Recommendations for additional FHAs to regional implementation staff.	AS ABOVE	AS ABOVE

Coastal Wetland Communities of the Study Area

The coastal wetland communities of the Study Area are characterised by high species diversity and a general absence of Saltpans. The warm climate and large volume of freshwater entering the estuaries due to high rainfall within the catchments support a large number of mangrove species and mangrove associates throughout the intertidal zone. Drier catchments at the southern extent of the Study Area, such as the Black, Ross and Haughton, have a larger proportion of Saltpan within the intertidal zone. Hypersaline

conditions within these coastal wetland systems inhibit the growth of mangrove species and allow a greater area of Saltpan development.

The two largest contiguous areas of coastal wetland vegetation within the Study Area can be found in the Hinchinbrook Channel region and Bowling Green Bay. However, these two coastal wetland systems are considerably different in the species assemblages that are present. High rainfall in the Hinchinbrook region promotes the growth of many mangrove species and communities that reach heights of up to 30 m. In contrast, the coastal wetland vegetation in Bowling Green Bay area is characterised by low communities (generally less than 10 m) and large areas of Saltpan.

Within the entire Study Area, Closed *Rhizophora* is the dominant community type in terms of area, followed by Saltpan, Closed *Ceriops* and Closed Mixed. However, within individual estuaries the dominance of these community types may be quite varied. Diverse Closed Mixed communities dominate some areas, particularly those coastal wetland systems in high rainfall catchments (e.g. Tully catchment). Although a single species (e.g. *Ceriops tagal*) may be quite common throughout the intertidal zone in these areas, mappable monospecific communities consisting of just this species (e.g. Closed *Ceriops*) are rare.

TABLE II Areas of coastal wetland communities within the Study Area.

	AREA (ha)	% OF TOTAL
Closed *Rhizophora*	20 974	27.60
Closed *Avicennia*	2 037	2.68
Open *Avicennia*	113	0.15
Closed *Ceriops*	14 885	19.59
Open *Ceriops*	237	0.31
Closed *Rhizophora*/*Avicennia*	76	0.10
Closed *Avicennia*/*Ceriops*	98	0.13
Open *Avicennia*/*Ceriops*	5	0.01
Closed Mixed	11 340	14.92
Closed *Bruguiera*	1 769	2.33
Saline Grassland	1 219	1.60
Saltpan	20 216	26.60
Samphire-dominated Saltpan	3 030	3.99
TOTAL	75 999	

Threats to Coastal Wetland Communities

Current threats to coastal wetland communities in the Study Area range from local threats due to coastal development to catchment-wide threats due to poor land management practices. Grazing and agricultural cultivation are the dominant land uses within the catchments of the Study Area. These land uses can potentially have a detrimental impact on water resources and habitats in the catchment.

The focus of this study has been *tidal* coastal wetland systems. The area of tidal coastal wetland vegetation in many catchments in the Study Area has remained relatively static over the past few decades. However, a general trend in *freshwater* wetland habitat loss in the Study Area has been identified. This trend is current throughout Queensland. State of Environment Queensland reporting has identified loss of freshwater wetlands as a key issue in the coastal zone with only freshwater wetlands on the more

remote coasts escaping some degree of modification or loss (EPA 1999a). Increasing usage of coastal plains for urban and agricultural landuses creates a pressure on these important fish habitats.

To date, efforts for fish habitat protection (through FHAs) have focused on tidal coastal wetland habitats and adjacent freshwater habitats have been largely excluded. Freshwater coastal wetlands provide habitat for fisheries species at various life cycle stages and contribute nutrients to the other tidal habitats, particularly in periods of high freshwater flow.

Protection of Coastal Wetland Communities

Important fish habitats within this Study Area are well represented in existing declared FHAs, Marine Parks and National Parks. Of the approximately 76 000 ha of coastal wetland vegetation in the Study Area, 15 175 ha is currently protected within declared FHAs. The Bowling Green Bay coastal wetlands are also recognised as wetlands of international importance under the Ramsar Convention. Recommendations to extend the current protected area network in areas where important habitats are not protected are made below.

Fisheries Resources of the Study Area

The coastal wetland habitats of the Study Area support productive commercial, recreational and indigenous fisheries. In 2000, the gross value of production of the main species of the inshore and estuarine commercial fishery alone was close to $4 million. The main species contributing to this fishery in the Study Area include shark, mud crab, barramundi, grey mackerel, mullet, blue and king threadfin, queenfish and gar. The trawl fishery, targeting prawns and saucer scallops is also very productive in the Study Area. In particular, the catch of banana prawns in the Study Area represents a significant proportion of the statewide catch of this species.

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 (Section 9.4). The following recommendations for new FHAs in the Study Area should be considered:

- No FHAs have been declared north of Half Moon Creek FHA in the Wet Tropic Coast Interim Marine and Coastal Regionalisation for Australia (IMCRA) region. In this region, the coastal wetland vegetation of Alexandra Bay and the Daintree River are important fish habitat, suitable for consideration for FHA status.
  - Consideration should be given to establishing a FHA in the Daintree catchment to cover tidal and adjacent freshwater wetlands currently excluded from Marine Parks.
  - The fish habitat values of the coastal wetland vegetation of Alexandra Bay, as well as the biodiversity and naturalness values of this estuary should be recognised and management measures to protect these values investigated.
- Within the Study Area, a large gap in the FHA network exists from the Trinity Inlet FHA to the Hull River FHA.
  - In this region, the estuaries of the Mulgrave–Russell Rivers, Moresby River and Maria Creek should be considered for inclusion in FHAs.
- The fish habitats of Cleveland Bay, including a large area of coastal wetland vegetation, which is currently tenured as State Land, should be considered for inclusion in a FHA.

Extension of some existing FHAs is also recommended:

- Of a high priority is the extension of the Tully River FHA to include the diverse coastal wetland vegetation in this estuary that is not currently protected by either a Marine Park or a National Park. The current Tully River FHA does not include a large proportion of coastal wetland vegetation.
- Extension of the Bowling Green Bay FHA to include both freshwater and tidal wetlands should be considered as a priority. In particular, fish habitat along the Haughton River, upstream of the existing Marine Park should be considered. This area is currently recognised as wetland of international importance (Bowling Green Bay Ramsar site). However, this area is excluded from protection in the Bowling Green Bay FHA, National Park and Marine Park.
- The Hull River, Palm Creek and Cattle Creek FHAs contain only a very small area of the coastal wetland vegetation in these estuaries. Consideration should be given to extending these FHAs to include coastal wetland vegetation adjacent to the current boundary. In particular, both tidal and freshwater wetlands in the Halifax Bay area (adjacent to the Palm Creek and Cattle Creek FHAs) should be considered for inclusion in FHAs.

The focus of this study has been tidal coastal wetlands, namely mangrove and saltmarsh communities. However, the study has highlighted the need for protection of freshwater coastal wetlands. Within the Study Area, freshwater coastal wetlands have decreased significantly in area over the past few decades. Protection of any remaining freshwater wetlands in the Study Area is recommended as a priority, in order to provide protection for a wide variety of habitats necessary for the life cycles of fisheries species and maintain the connectivity between these habitats.

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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). The FHA concept focuses on the inclusion, linkage and management of all available habitat types within an area as a single unit, rather than simply protecting individual specific habitat types (McKinnon and Sheppard 2001).

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 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 the FHA declaration process and management options.

Coastal wetland environments are important habitat for many species of birds, reptiles and marine life, which depend on these habitats for the provision of food, shelter, breeding and nursery areas. Different types of Marine Protected Areas have been established to protect and manage the various ecological, aesthetic, economic, social and cultural values of wetland habitats. FHAs fall within Category IV of the World Conservation Union (IUCN) categories for protected areas.

Significant wetland areas are also protected 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 fish habitat value in northern Queensland from Cape Tribulation to Bowling Green Bay (hereafter referred to as the Study Area). The study also provides baseline information on the coastal wetlands within this Study Area for consideration in the Ramsar site nomination process. The project aimed to:

1. document and map the coastal wetland communities of the Study Area;
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 Project Rationale and Status

The mapping of Queensland's coastal wetland environments by the Department of Primary Industries, Queensland Fisheries Service (QFS) has been an ongoing process, underway since the mid-1990s. The current mapping of the region from Cape Tribulation to Bowling Green Bay marks the completion of the spatial assessment of the coastal wetland resources of the entire Queensland coastline. This systematic exercise has been undertaken using a standard protocol that was developed by the QFS (Danaher 1995a) and has been recognised (Ward et al. 1998) as an appropriate model for a national approach to coastal wetland mapping. The results of other mapping exercises are summarised by mapping region in Table 1. Mapping regions are illustrated in Figure 1.

There is a need to identify and map fish habitat for the management and conservation of fisheries resources through the declaration of MPAs (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 habitat primary productivity, fish species associated with these habitats and feeding strategies of fish species will contribute to a better understanding of the relationships of particular habitats to fisheries productivity.

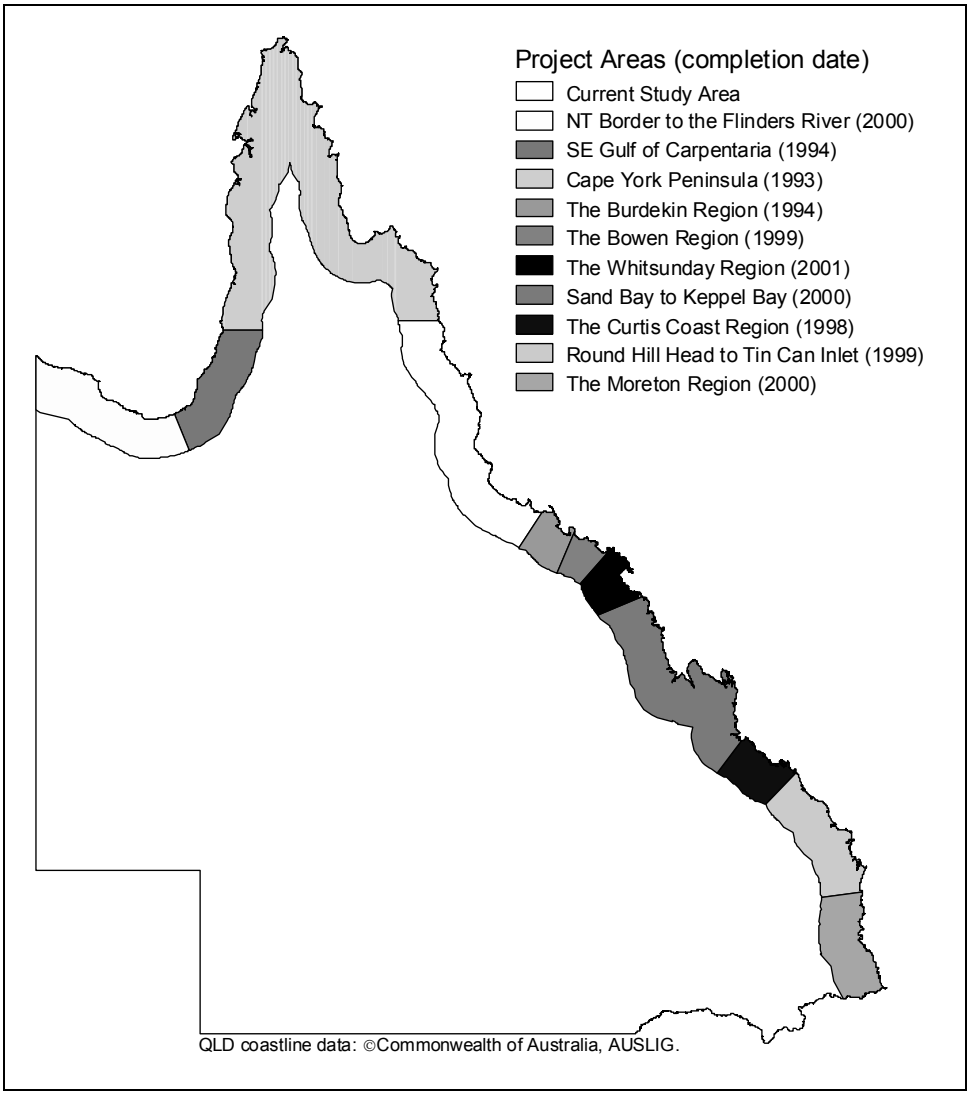

FIGURE 1 Queensland coastal wetland mapping regions.

TABLE 1 Details of the Queensland Fisheries Service Queensland coastal wetland mapping projects.

AREA	PROJECT FUNDING	DATA CURRENCY (=DATE OF IMAGERY USED)	REPORT REFERENCE	NEW MPA DECLARATION?
Marine Protected Areas Program, *Coast and Clean Seas*, Natural Heritage Trust (1998-2001)				
A) ROUND HILL HEAD TO TIN CAN INLET	MPA 97/98	1997	Bruinsma, C and Danaher, K (2000). Queensland Coastal Wetland Resources: Round Hill Head to Tin Can Inlet. QI99081. Department of Primary Industries, Queensland, Brisbane, 101 pp.	Baffle Creek – FHA declared Sep 2001. Elliott River – initial FHA consultation nearing completion, FHA declaration proposed for early 2002.
B.1) NT BORDER TO FLINDERS RIVER	MPA 98/99	1995	Bruinsma, C and Duncan, S (2000). Queensland Coastal Wetland Resources: the NT border to Flinders River. QI00099. Department of Primary Industries, Queensland, Brisbane, 72 pp.	Recommendations for additional FHAs to regional implementation staff.
B.2) CENTRAL QLD	MPA 98/99	1995 1997	Bruinsma, C (2000). Queensland Coastal Wetland Resources: Sand Bay to Keppel Bay. QI00100. Department of Primary Industries, Queensland, Brisbane, 94 pp.	Narrows / Fitzroy Delta – seeking NHT funding, FHA consultation to commence early 2002.
C.1) CAPE TRIBULATION TO BOWLING GREEN BAY	MPA 99/00	1997 1998 1999	Bruinsma, C (2001). Queensland Coastal Wetland Resources: Cape Tribulation to Bowling Green Bay. QI01064. Department of Primary Industries, Queensland, Brisbane, 85 pp.	Recommendations for additional FHAs to regional implementation staff.
C.2) THE WHITSUNDAY REGION	MPA 99/00	1997	Bruinsma, C and Danaher, K (2001). Queensland Coastal Wetland Resources: The Whitsunday region. QI01065. Department of Primary Industries, Queensland, Brisbane.	Recommendations for additional FHAs to regional implementation staff.
Marine Protected Areas Program (1996/1997) Project Number GO19/96				
THE CURTIS COAST REGION	MPA G019/96a	1997	Danaher, K, Bruinsma, C, Treloar, P and O'Neill, M (unpublished report). Queensland Coastal Wetland Resources of the Curtis Coast Region: Raglan Creek to Round Hill Head. Department of Primary Industries, Queensland, Brisbane.	Narrows / Fitzroy Delta – as above.
THE BOWEN REGION	MPA G019/96b	1994 1995	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.	Edgecumbe Bay – seeking NHT funding, FHA consultation scheduled to commence Jan 2002.
SE GULF OF CARPENTARIA	OR2000 G007/93	1987 1988 1991 1992	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.	Recommendations for additional FHAs to regional implementation staff.
Other Mapping Projects				
CAPE YORK PENINSULA	CYPLUS	1986 1987 1988 1991	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.	Annan River – consultation complete. FHA declaration scheduled for late 2001. Kirke River – FHA consultation (NHT funded) is ongoing. Starke River – first round of FHA consultation (NHT funded) complete, FHA declaration during 2002. Margaret Bay – preliminary FHA consultation commenced.
THE BURDEKIN REGION	OR2000 G006/93	1991	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.	Burdekin FHA declared in August, 1999.
REPULSE BAY	Queensland Fisheries Service	1989	Bruinsma, C and Danaher, K (2001). Queensland Coastal Wetland Resources: The Whitsunday region. QI01065. Department of Primary Industries, Queensland, Brisbane.	Recommendations for additional FHAs to regional implementation staff.
MORETON REGION	Queensland Fisheries Service	1995	Duncan, S and Bruinsma, C (in progress). Queensland Coastal Wetland Resources: South East Queensland. Department of Primary Industries, Queensland, Brisbane.	N/A - confirmation of the fisheries conservation values of existing extensive FHAs only.

SECTION 2 BACKGROUND

2.1 The Study Area

The Study Area extends from Cape Tribulation (16° 6'S, 145° 24'E) to Bowling Green Bay (19° 30'S, 147° 24'E) in tropical north Queensland. Eleven coastal sub-basin catchments (as defined by the Department of Natural Resources) fall within this north Queensland Study Area. Figure 2.1 illustrates the catchments included in this investigation and the main estuarine systems within them. The hydrology and catchment characteristics of estuaries within the Study Area are listed in Table 2.1.

In general, tropical north Queensland is characterised by a rich floral and faunal species diversity and high world heritage value. The Study Area is no exception. The Wet Tropics World Heritage Area covers much of the rainforest covered coastal ranges from Cape Tribulation to just south of Ingham. The Great Barrier Reef Marine Park World Heritage Area encompasses coastal waters from Cape York in the north to Baffle Creek in the south, including waters adjacent to the Study Area. Australia's largest island national park, Hinchinbrook Island, falls within the Study Area and forms the outer barrier island of a unique passage landscape, Hinchinbrook Channel.

Within the region, the predominant land-uses along the coast are agricultural production and cattle grazing. Coastal plains in the wetter catchments are largely utilised for sugar-cane and banana production. In the drier catchments in the south of the Study Area, cattle grazing is the dominant land-use. Throughout the Study Area, large proportions of the coastal ranges are forested and managed as timber reserves or protected areas.

Cairns, in the north, and Townsville, in the south, are the two main urban centres in the Study Area. The population of these centres as calculated in the 1996 census was approximately 92 300 and 109 900 respectively (ABS 1996). The average summer temperature in Cairns ranges from a minimum of 24°C to a maximum of 32°C. In winter, temperatures fall to an average minimum of 18°C and a maximum of 25°C. In Townsville, temperatures range from 20°C to 32°C in summer and 13°C to 27°C in winter.

The regions from Cape Tribulation to Lucinda, and from Lucinda to Bowling Green Bay, lie respectively within the Wet Tropic Coast (WTC) region and the Lucinda–Mackay Coast (LMC) region, as defined in the Interim Marine and Coastal Regionalisation for Australia. The section of coastline falling within the WTC region is characterised by a high average annual rainfall (ranging from approximately 1800 mm, to 4000 mm in the Innisfail–Tully area) and a high occurrence of cyclones in the summer season (averaging ~15 cyclones/decade) (IMCRA Technical Group 1998). The region of coastline from Lucinda to Bowling Green Bay lies within a rain shadow and experiences a much lower average annual rainfall than the WTC region (from approximately 900 mm to 1800 mm). The LMC region also experiences approximately 15 cyclones/decade (IMCRA Technical Group 1998).

The Study Area lies adjacent to the terrestrial Wet Tropics and Brigalow Belt North Bioregions as defined in the Interim Biogeographic Regionalisation of Australia (Thackway and Cresswell 1995).

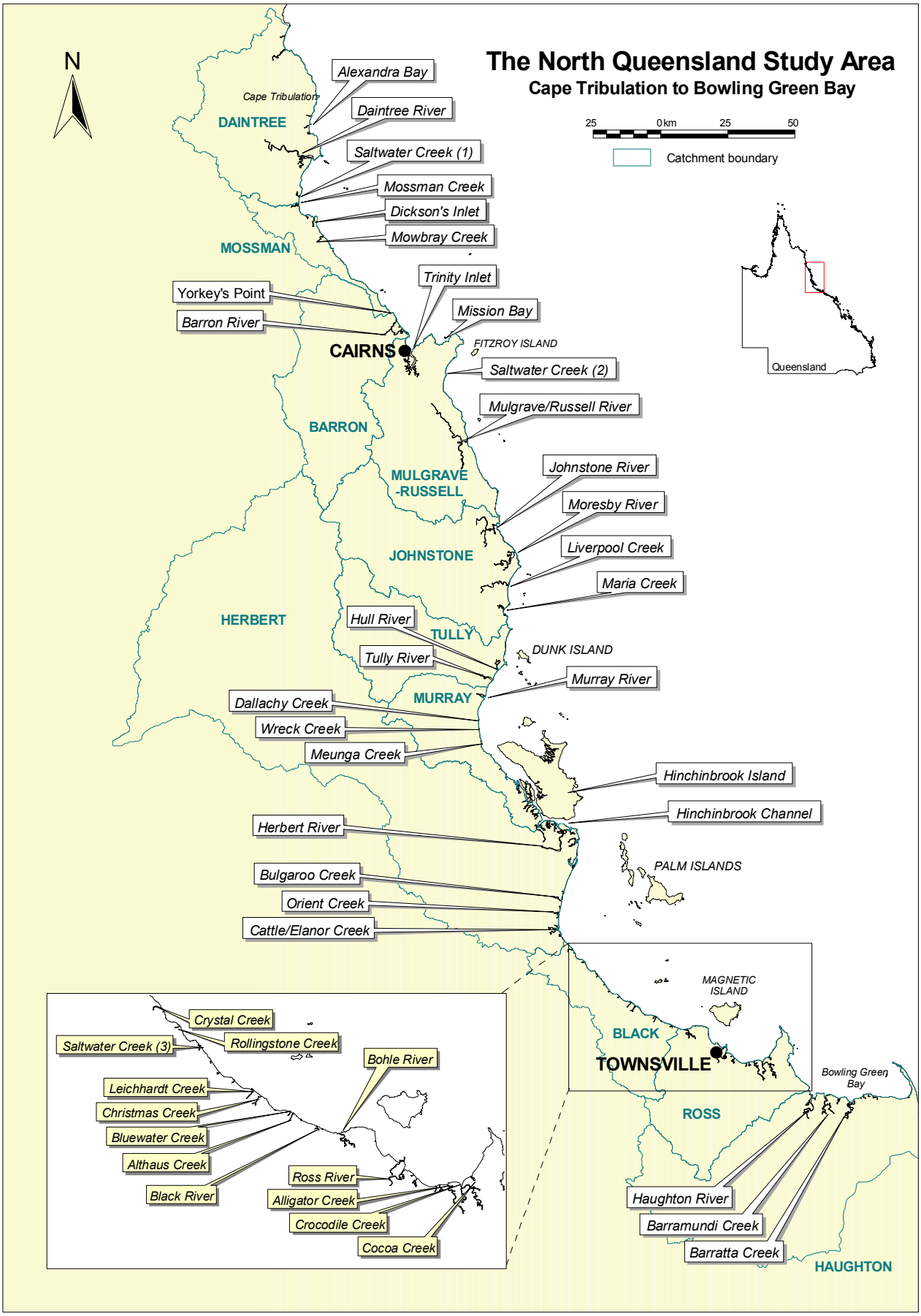

FIGURE 2.1 The Study Area: stretching from Cape Tribulation to Bowling Green Bay in tropical north Queensland.

TABLE 2.1 Hydrology and catchment characteristics of estuaries within the Study Area.

NAME	CATCHMENT AREA (km^2)	MEAN ANNUAL RAINFALL (mm)	RUNOFF COEFFICIENT	EXTREME TIDAL RANGE (m)	FISHERIES VALUE	CONSERVATION THREAT
Noah Creek	33	1873	0.84	2.5	low	none
Cooper Creek	29	1873	0.84	2.5	moderate	none
MacKenzie Creek	40	2370	0.66	2.5	moderate	none
Daintree River	1120	2370	0.57	2.8	high	perceived
Saltwater Creek	102	2370	0.66	2.8	moderate	perceived
Mossman River	256	2370	0.70	2.8	moderate	perceived
Dickson's Inlet	17	1971	0.84	2.8	moderate	perceived
Mowbray River	119	1971	0.84	2.8	moderate	perceived
Half Moon Creek	25	2224	0.21	3.1	moderate	perceived
Barron River	2159	2224	0.21	3.1	moderate	real
Trinity Inlet	330	2224	0.67	3.2	high	real
Mulgrave/Russell River	1393	2518	0.59	3.0	moderate	perceived
Johnstone River	1674	3641	0.60	2.9	moderate	perceived
Moresby River	117	3392	0.64	3.0	high	perceived
Liverpool Creek	313	3302	0.65	3.0	low	perceived
Maria Creek	180	4321	0.65	3.0	low	perceived
Hull River	155	4321	0.48	3.2	high	perceived
Tully River	1441	4321	0.52	3.2	high	perceived
Murray River	602	2129	0.71	3.2	high	perceived
Dallachy Creek	99	2129	0.71	3.1	high	perceived
Wreck Creek	20	2129	0.71	3.1	high	perceived
Meunga Creek	226	2129	0.71	3.1	moderate	none
Hinchinbrook Channel	9455	1236	0.34	3.5	high	perceived
Missionary Bay	169	2129	0.68	3.1	high	none
Coral Creek	16	2129	0.68	3.1	moderate	none
Deep Creek	58	2129	0.68	3.1	moderate	none
Zoe Bay	39	2127	0.68	3.5	low	none
Gentle Annie Creek	30	2127	0.21	3.5	moderate	perceived
Victoria Creek	78	2127	0.21	3.5	moderate	perceived
Palm Creek	220	2034	0.23	3.5	moderate	perceived
Orient Creek	19	1826	0.24	3.5	moderate	perceived
Cattle Creek	513	1826	0.24	3.5	moderate	perceived
Fig Tree Creek	42	1826	0.24	3.5	moderate	perceived
Crystal Creek	119	1826	0.24	3.1	low	none
Ollera Creek	74	1826	0.24	3.1	low	perceived
Rollingstone Creek	115	1198	0.37	3.1	low	none
Leichhardt Creek	66	1198	0.47	3.1	moderate	none
Sleeper Log Creek	61	1198	0.47	3.1	moderate	none
Bluewater Creek	150	1198	0.47	3.1	low	none
Althaus Creek	81	1198	0.47	3.1	moderate	perceived
Black River	293	1198	0.47	3.7	moderate	none
Bohle River	305	1198	0.23	3.7	moderate	perceived
Ross River	881	1032	0.34	3.7	moderate	perceived
Sandfly Creek	113	1198	0.23	3.7	moderate	none
Alligator Creek	149	1198	0.17	3.7	moderate	perceived
Crocodile Creek	131	1200	0.17	3.7	moderate	perceived
Haughton River	2111	946	0.29	3.5	moderate	none
Barramundi Creek	20	1200	0.19	3.5	high	none
Barratta Creek	1466	1200	0.17	3.5	low	none

Source: Australian Estuarine Database (Digby et al. 1999)

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 inshore and offshore fisheries through the provision of food, shelter, breeding and nursery areas. Previous DPI research (Quinn 1992) has established that the estuarine habitats provided by mangroves and seagrasses are critical to many commercially and recreationally important fish and crustacean species during some stage of their life cycle. Species that are estuarine dependent include 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 unvegetated to samphire-dominated Saltpans, Saline Grasslands, 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 level and the low water mark (i.e. the intertidal communities) are described collectively as coastal wetlands. The coastal wetlands mapped in this study are 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 mangrove 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). Three subsets of this vegetation type are recognised in this study. Saltpans are those hypersaline areas that are virtually unvegetated or have a sparse ground cover of samphire vegetation or algae. Samphire-dominated Saltpans are Saltpans that have a dense ground cover of samphire vegetation. Saline Grasslands are those areas that are dominated by *Sporobolus virginicus* (salt couch). Coastal wetland communities in this study refer to tidal wetlands only. Freshwater wetlands, such as *Melaleuca* swamp or sedgelands, have not been included.

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;
- primary production, 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 tidal regime. 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 is clearly demonstrated in the north of the state. The relatively dry coastline of the Gulf of Carpentaria supports less than twenty species of mangrove (Bruinsma and Duncan 2000). In comparison, more than thirty species have been recorded for areas of similar latitude (i.e. the Study Area) on the wetter eastern coastline of Australia.

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 waters 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 only 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). Economically important detrital marine food webs are supported by primary production from mangrove trees. There is a lack of quantitative information regarding the direct benefits to primary productivity gained from the various mangrove community types discussed here.

Duke (1997) reports that 31 species of mangroves are found within the Study Area. These are:

- *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
- *Bruguiera sexangula* (Lour.) Poir. — orange mangrove
- *Ceriops australis* (C.T.White) Ballment, T.J.Sm. & J.A.Stoddart — yellow mangrove
- *Ceriops decandra* Ding Hou — yellow mangrove
- *Ceriops tagal* C.T.White — yellow (or spurred) mangrove
- *Cynometra iripa* Kostel. — wrinkle pod mangrove
- *Excoecaria agallocha* L. — milky mangrove
- *Heritiera littoralis* Aiton — looking–glass mangrove
- *Lumnitzera littorea* (Jack) Voigt — black mangrove (red flowered)
- *Lumnitzera racemosa* Willd. — black mangrove (white flowered)
- *Lumnitzera X rosea* (Gaudich.) C.Presl — black mangrove (hybrid)
- *Nypa fruticans* Wurmb — mangrove palm
- *Osbornia octodonta* F. Muell. — myrtle mangrove
- *Pemphis acidula* J.R.Forst. & G.Forst. — pemphis

- *Rhizophora apiculata* Blume — tall–stilted red mangrove
- *Rhizophora X lamarckii* Montr. — stilted mangrove
- *Rhizophora mucronata* Lam. — red mangrove
- *Rhizophora stylosa* Griff. — red mangrove
- *Scyphiphora hydrophylacea* C.F.Gaertn. — yamstick mangrove
- *Sonneratia alba* Sm. — mangrove apple
- *Sonneratia X gulngai* N.C.Duke — white flower mangrove apple
- *Sonneratia caseolaris* (L.) Engl. — mangrove apple
- *Xylocarpus granatum* Koen — cannonball mangrove
- *Xylocarpus moluccensis* Pierre — cedar mangrove

Lovelock (1993) also lists the following four species as occurring in the Study Area:

- *Barringtonia asiatica* (L.) Kurz — freshwater mangrove
- *Barringtonia racemosa* (L.) Spreng. — freshwater mangrove
- *Crinum pedunculatum* R.Br. — mangrove lily
- *Hibiscus tiliaceus* L. — native hibiscus

For the purposes of this study, *H. tileaceus* is considered to be a "marginal mangrove species" as in some instances it is found growing in the marine tidal zone, whereas in other locations it may be found growing in terrestrial areas.

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 are generally only inundated 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).

Even 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 saltmarsh habitats are utilised by surprisingly 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.

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). Seagrass communities play an important role in coastal marine and estuarine systems. Previous studies have shown that seagrass beds support large populations of juvenile commercial prawns (e.g. tiger and endeavour prawns) and fish and crab species (Coles et al. 1992). They provide food, habitat and shelter for marine species, act as substrate stabilizers and contribute a large proportion of the primary production of coastal systems.

Large seagrass beds mainly occur in sheltered bays and estuaries within the Study Area. Broad scale studies have been conducted of seagrass distribution from Cape York to Cairns in November 1984 (Coles et al. 1985) and Cairns to Bowen in 1987 (Coles et al. 1992). More detailed studies have recently been undertaken in order to complement broad scale studies and contribute further understanding of both the distribution and the variability of seagrass communities. Studies on the distribution of seagrasses in Cairns Harbour and Trinity Inlet in December 1993 (Lee Long et al. 1996), the Hinchinbrook region (from Dunk Island to Cleveland Bay) in October 1996 (Lee Long et al. 1998) and Oyster Point Cardwell between 1995 and 1998 (Lee Long et al. 1999) have been undertaken.

Natural seasonal and annual variability in the species composition, density and biomass of seagrass communities 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 will do so in the future, provided the environmental conditions for colonisation and maintenance of the meadows remain favourable.

The following thirteen species of seagrasses have been recorded in the Study Area (Coles et al. 1992; Lee Long et al. 1998):

- *Cymodocea rotundata* Ehrenb. et Hempr. ex Aschers.
- *Cymodocea serrulata* (R. Br.) Aschers. and Magnus
- *Halodule uninervis* (wide and narrow leaf) (Forsk.) Aschers.
- *Halodule pinifolia* (Miki) den Hartog
- *Halophila decipiens* Ostenfeld
- *Halophila ovalis* (R. Br.) Hook F.
- *Halophila ovata* Gaud.
- *Halophila spinulosa* (R. Br.) Aschers.
- *Halophila tricostata* (Greenway)
- *Halophila* sp. undescribed
- *Syringodium isoetifolium* (Aschers.) Dandy
- *Thalassia hemprichii* (Enrenb.) Aschers.
- *Zostera capricorni* Aschers.

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 are 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 an essential role in primary production and may contribute in total more than half of the total net production (Alongi 1998).

The Great Barrier Reef Marine Park Authority has mapped the distribution of intertidal flats and coral reefs within the Great Barrier Reef Marine Park. The coral reefs of this region are recognised globally as ecologically significant and are world heritage listed. They provide shelter and food for a high diversity of reef and pelagic animals that colonise or are attracted to these biological structures (e.g. sponges, coral and fish).

Freshwater Coastal Wetlands

The Australian Land Information Group (AUSLIG 1994) defines freshwater coastal wetlands (swamps) 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. These habitats include *Melaleuca* wetlands, sedgelands and communities in which a mixture of marine plants and freshwater plants grow.

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.

Connectivity

Connectivity of fish habitats and water flow between them is an important consideration for fisheries managers. As many fish, crab and shellfish species need to move between different habitats in various life cycle stages, it is important to protect each of the different habitats that are required to allow for this movement. The FHA concept focuses on the inclusion, linkage and management of all available habitat types within an area as a single unit, rather than simply protecting individual specific habitat types (McKinnon and Sheppard 2001).

SECTION 3 METHODS

3.1 Data

The distribution of coastal wetland communities in the Study Area was investigated using remote sensing data from the Landsat 5 Thematic Mapper (TM) sensor. Five 'scenes' were required to map the Study Area. The scenes required to map each catchment area are listed in Table 3.1. 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 Map Grid of Australia (Zone 55) using the Australian National Spheroid and the Geodetic Datum of Australia 1994. Images acquired on the same date were not used for this study due to limited availability of data and cloud cover on available images of the same date.

TABLE 3.1 Landsat TM satellite imagery utilised in this study.

LANDSAT SCENE	DATE	CATCHMENTS MAPPED
Atherton	7 September 1997	Daintree and Mossman
Cairns	28 June 1997	Barron and Mulgrave–Russell
Ingham	28 June 1997	Johnstone, Tully, Murray and Herbert
Charters Towers	14 August 1999	Black
Townsville	24 June 1998	Ross and Haughton

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 4.

Aerial photography was used as reference data to aid in the classification of the coastal wetland vegetation. The photography used in this study was 1: 50 000 Townsville to Cooktown (1993/1994) and St Lawrence to Townsville (1990, 1993) photography flown by the Beach Protection Authority. More recent aerial photography was not available for use in this study. In some areas, the available aerial photography did not provide a complete coverage of the coastal wetlands in the study area. The distribution of reference data in the Study Area, including aerial photography and field data, is illustrated in Figure 3.1.

Local scale, historical mapping of particular estuaries within the Study Area was used to complement the information obtained through air photo interpretation and field surveys. The datasets used are listed in Table 3.2.

TABLE 3.2 Historical mapping used to aid the current mapping exercise.

REFERENCE	SCALE OF MAPPING	ESTUARIES
Le Cussan, J (1991). A report on the intertidal vegetation of the Daintree, Endeavour, and Russell/Mulgrave Rivers. An internal report for the Queensland National Parks and Wildlife Service, 139 pp.	1: 15 000	Daintree Russell/ Mulgrave
Olsen, HF (1983). Biological resources of Trinity Inlet and Bay, Queensland. Department of Primary Industries, Queensland Bulletin QB83004. Department of Primary Industries, Queensland, Brisbane, 64 pp.	1: 25 000	Trinity Inlet

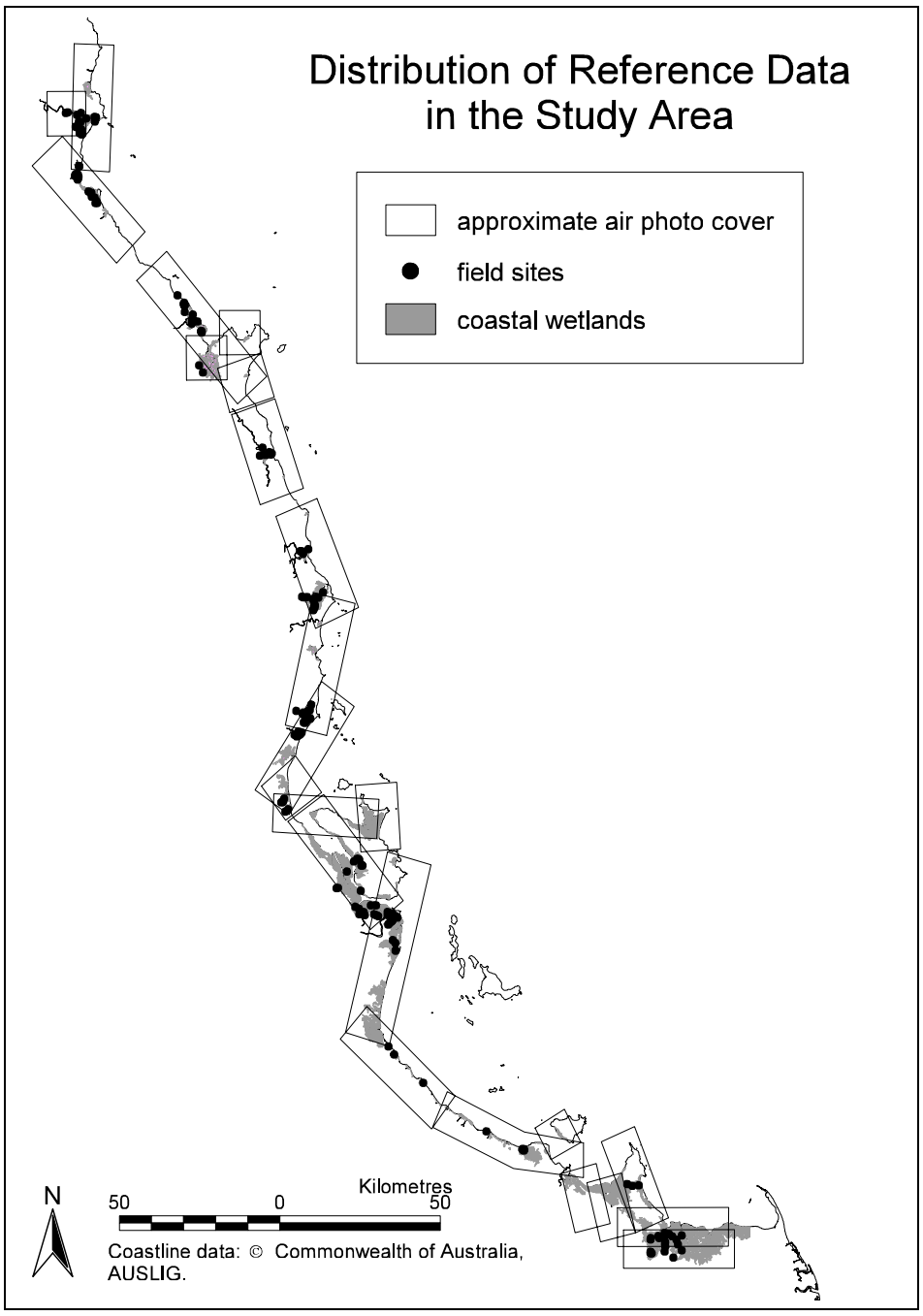

FIGURE 3.1 Distribution of reference data utilised in this study.

3.2 Mapping Methods

The satellite imagery was processed using ERDAS Imagine® 8.4 on a PC with a Microsoft® Windows NT operating system. Six bands of information (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 use of brightness and wetness bands of a tasselled cap analysis also assisted in defining the tidal boundary.

The remaining imagery of the intertidal zone 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. Appendix 5 contains the metadata for the resultant coverage. The coastal wetlands coverage was overlaid on a Band 3 (visible red) Landsat TM image for presentation. Maps were produced using ArcView® GIS Version 3.2 software at a scale of 1: 100 000. Further details of these maps are included in Appendix 6.

3.3 Field Methods

The computer-based coastal wetland community classification was validated with fieldwork conducted during April and June 2001. The distribution of 190 sites, which were accessed by boat or four wheel drive vehicle, is illustrated in Figure 3.1. At each site, information on mangrove community floristics and structure was documented. The 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.

A Garmin 4S XL Personal Navigator Global Positioning System (GPS) was used to determine the latitude and longitude of each field site. The estimated errors recorded by the GPS were on average between 15 m and 20 m (less than 1 pixel) with a maximum error of 49 m and a minimum error of 9 m.

The time available, budget requirements and accessibility to the mangroves limited the amount of fieldwork. 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 coastal wetland classification, they were not used to assess its accuracy. Rather a set of random points was generated in order to assess the accuracy of the classification (Section 3.5).

3.4 Classification Details

Mangroves were classified to the community level based on dominant genus present and canopy density 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 vegetation 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 non-vegetated intertidal flats along with seagrass or algal beds were also excluded.

3.5 Accuracy Assessment

A set of 269 random points was generated using ERDAS Imagine® for accuracy assessment. The community present at each of these points was determined from the aerial photography and this was compared to the class assigned on the computer-classified 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. 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 7.

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 3.3.

The AUSLIG GEODATA product, from which the land subject to inundation and freshwater swamps themes were 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. Land subject to inundation is described as lowlying land usually adjacent to watercourse or waterbody features, which is regularly covered with flood water for short periods either annually or during at least one year in ten (AUSLIG 1994).

TABLE 3.3 Details of digital datasets used in the overview map of fish habitats.

TITLE	CUSTODIAN	CURRENCY	DESCRIPTION
Coral reefs	GBRMPA	13-01-1994	Major coral reef structures in the GBR region
Intertidal foreshore flats	GBRMPA	unknown	Intertidal foreshore areas
Seagrass meadows	Department of Primary Industries, Queensland (QDPI)	00-11-1984	Seagrass meadows between Cape York and Hervey Bay
Freshwater swamps and areas subject to inundation	Australian Land, Survey and Information Group (AUSLIG)	~1988	Themes from the digital GEODATA TOPO-250K topographic map series.
Dams and Weirs	Queensland Department of Natural Resources and Mines (QDNRM)	31-12-1994	Location of major dams and weirs in Queensland.

3.7 Assessment of Coastal Wetland Characteristics

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:

- Size
- Diversity of or specific habitat features
- Diversity of or specific marine fauna and flora
- Level of existing and future disturbances
- Unique features
- Existing or potential fishing grounds
- Protected species

The details of the methods of assessment of these criteria are included in Table 9.2. The results of the assessment are summarised in Table 9.1.

SECTION 4 RESULTS

4.1 Description of the Mapping Units

The coastal wetland communities are classified on the basis on the dominant genus present. The actual species mix associated with each class varies from estuary to estuary and even within estuaries. The mapping units used in this study are described in general below. For further specific details of the species found in particular locations, refer to the field data listed in Appendix 8.

CLOSED *RHIZOPHORA*	**FIGURE 4.1**
Habitat	Occurs along the seaward edge, low in intertidal zone with roots regularly submerged during high tides.
Canopy	Usually dominated by tall, mature *Rhizophora* spp. which form a dense canopy (approximately 10–15 m) with a Projective Foliage Cover (PFC) greater than 50%. Other species that may occur in this community are *A. marina* (emergent), *Bruguiera* spp. and *Ceriops* spp.
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 *Ceriops* spp. and *Rhizophora* spp., forming a dense canopy with a PFC of greater than 50%. Heights vary depending on position within the intertidal zone (taller on seaward edge, shorter on landward edge).
Shrub layer	Seaward edge communities tend to have no shrub layer. Communities further landward may have other species such as *A. corniculatum* or *C. tagal* forming an understorey.
Ground cover	*A. marina* pneumatophores and seedlings and samphires often form a sparse 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*	**FIGURE 4.3**
Habitat	Generally occurs on erosion banks and towards the upper intertidal limit, on more elevated land. Only inundated by the spring tides.
Canopy	Dominated by *Ceriops* spp., often with *A. marina*, *Bruguiera* spp., *L. racemosa, Xylocarpus* spp. Height of the canopy across sites varies (from approximately 2–10 m) however at an individual site is generally remarkably uniform. PFC greater than 50%. More species diverse on creek banks, more monospecific on Saltpan edges.
Shrub layer	Generally absent.
Ground cover	Consists of sparse cover of seedlings and roots of the species present.

FIGURE 4.1 Closed *Rhizophora* in the Moresby River.

FIGURE 4.2 Closed *Avicennia* at Half Moon Creek.

FIGURE 4.3 Closed *Ceriops* at Seymour River.

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 *Ceriops* spp. 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*.
Ground cover	Consists of seedlings of the species present along with a sparse to open coverage of samphires and grasses.

CLOSED *RHIZOPHORA/AVICENNIA*	**FIGURE 4.4**
Habitat	Occurs on the seaward edge, generally within a Closed *Rhizophora* zone, or on a riverbank towards the mouth of the estuary.
Canopy	A mixed community of *A. marina* and *Rhizophora* spp. together forming a closed canopy with a PFC of greater than 50%. Heights of between 6–15 m are common.
Shrub layer	The understorey may consist of *A. marina* and *Rhizophora* spp.
Ground cover	Roots and seedlings of the canopy species.

CLOSED *AVICENNIA/CERIOPS*	
Habitat	Usually surrounded by Saltpans or on the landward edge, in areas only inundated during spring tides.
Canopy	A mixed community of *A. marina* and *Ceriops* spp. forming a canopy with a PFC of greater than 50%. Generally a low community with a canopy of <4 m.
Shrub layer	Other species such as *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	Uncommon in the Study Area, generally bordering Saltpans in areas only inundated during spring tides.
Canopy	A mixed community of *A. marina* and *Ceriops* spp. forming a canopy with a PFC of less than 50%. A low community with a canopy of <3 m.
Shrub layer	Other species such as *A. annulata*, *A. corniculatum* and *L. racemosa* may be present.
Ground cover	Occasional presence of samphires and seedlings of the species present.

CLOSED MIXED	**FIGURE 4.5**
Habitat	Generally found on the landward edges of mangrove communities and in the upper tidal reaches of creeks and rivers where there is a high freshwater influence.
Canopy	A closed mix (PFC > 50%) in which a variety of the species present in this region may occur without being dominated by one genus in particular. Often reaching heights of 10–20 m.
Shrub layer	Shrub layer often consists of *A. ilicifolius*, *A. speciosum* and *C. pedunculatum*. Juveniles of the various canopy species may also be present. Epiphytes (including orchids and ferns) on the mangrove plants are common.
Ground cover	Seedlings and roots of the various species along with sparse samphires and grasses.

FIGURE 4.4 Closed *Rhizophora/Avicennia* on the bank of Alligator Creek.

FIGURE 4.5 Closed Mixed on the bank of Enterprise Channel at high tide.

FIGURE 4.6 Closed *Bruguiera* at Mosquito Creek.

CLOSED *BRUGUIERA*	FIGURE 4.6
Habitat	Commonly occurs in the mid intertidal zone behind Closed *Rhizophora* communities or along river banks in upstream locations.
Canopy	Canopy dominated by *Bruguiera* spp. (mainly *gymnorrhiza* and *parviflora*) with other species such as *H. littoralis, Rhizophora* spp. and *Xylocarpus* spp.
Shrub layer	Generally absent.
Ground cover	Knees roots of *Bruguiera* spp. form a dense ground cover.

SALINE GRASSLAND	FIGURE 4.7
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.

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. *A. marina, C. tagal* and *L. racemosa*).
Shrub layer	Some samphire species may be present as very small shrubs.
Ground cover	Commonly an open coverage of samphires. However may be virtually unvegetated or have an algal covering.

SAMPHIRE-DOMINATED SALTPAN	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.
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.

FIGURE 4.7 Saline Grassland near the mouth of Ross River.

FIGURE 4.8 Saltpan at Blacksoil Creek.

FIGURE 4.9 Samphire-dominated Saltpan at Barramundi Creek.
Flowering *Limonium australe* in the foreground.

4.2 Accuracy Assessment

The overall accuracy of the coastal wetland classification was calculated to be 90%. The error matrix of accuracy assessment points is displayed in Table 4.1 and the user's and producer's accuracy for each of the coastal wetland classes is included in Table 4.2. Most of the user's accuracy figures are above 88% indicating a high reliability of the maps for the user in each class. A very small number of accuracy assessment points were collected for some of the classes (e.g. Open *Avicennia* and Closed *Rhizophora*/*Avicennia*). The user's and producer's accuracy of these classes is therefore a less reliable indicator of accuracy then the statistics for those classes for which a large number of points were assessed. No assessment points were selected for the class Open *Avicennia*/*Ceriops* due to the low occurrence of the class.

The low user's accuracy for the Samphire-dominated Saltpan class is most likely a result of the few sample points that were randomly selected for this class. Based on the assessment points available, the error matrix (Table 4.2) shows that misclassified Samphire-dominated Saltpan areas are most likely to be Saltpan.

Although the user's accuracy for the Open *Avicennia* class is very high, the producer's accuracy for this class is low. Again, this is most likely due to the very small number of accuracy assessment points that were randomly gathered for this class.

TABLE 4.1 Error matrix for the accuracy assessment of the coastal wetlands coverage.

REFERENCE DATA \ CLASSIFIED DATA	Closed *Rhizophora*	Closed *Avicennia*	Open *Avicennia*	Closed *Ceriops*	Open *Ceriops*	Closed *Rhizophora*/*Avicennia*	Closed *Avicennia*/*Ceriops*	Closed Mixed	Closed *Bruguiera*	Saline Grassland	Saltpan	Samphire-dominated Saltpan	CLASSIFIED TOTALS
Closed *Rhizophora*	56												56
Closed *Avicennia*		12		1									13
Open *Avicennia*			4										4
Closed *Ceriops*	1			39				3			1		44
Open *Ceriops*					3						1		4
Closed *Rhizophora*/*Avicennia*						3							3
Closed *Avicennia*/*Ceriops*	1						4						5
Closed Mixed	1							39					40
Closed *Bruguiera*									21				21
Saline Grassland			1	1						9	1		12
Saltpan				1							56		57
Samphire-dominated Saltpan			1								4	5	10
REFERENCE TOTALS	59	12	6	42	3	3	4	42	21	9	63	5	269

TABLE 4.2 Accuracy assessment of the coastal wetlands coverage.

CLASS NAME	REFERENCE TOTALS	CLASSIFIED TOTALS	NUMBER CORRECT	PRODUCERS ACCURACY	USERS ACCURACY
Closed *Rhizophora*	59	56	56	94.92	100.00
Closed *Avicennia*	12	13	12	100.00	92.31
Open *Avicennia*	6	4	4	66.67	100.00
Closed *Ceriops*	42	44	39	92.86	88.64
Open *Ceriops*	3	4	3	100.00	75.00
Closed *Rhizophora*/*Avicennia*	3	3	3	100.00	100.00
Closed *Avicennia*/*Ceriops*	4	5	4	100.00	80.00
Closed Mixed	42	40	39	92.86	97.50
Closed *Bruguiera*	21	21	21	100.00	100.00
Saline Grassland	9	12	9	100.00	75.00
Saltpan	63	57	56	89.89	98.25
Samphire-dominated Saltpan	5	10	5	100.00	50.00

4.3 Limitations of the Mapping Technique

In comparison to modern hyper-spectral sensors, Landsat TM imagery has a very low spectral resolution with only seven, wide bands of information collected (see Appendix 4). The resolution of the data is too low to be able to distinguish spectrally similar species. For example, *Rhizophora stylosa* and *Bruguiera gymnorrhiza* (family *Rhizophoraceae*) have very similar foliage and are thus difficult to tell apart from both aerial photography and Landsat TM imagery. Ground truthing and knowledge of positions in the intertidal zone that species typically grow is used to aid in distinguishing classes where species have been confused spectrally.

This mapping technique is also limited by the spatial resolution of the Landsat TM satellite imagery, that is, the 25 x 25 m pixel size. The smallest community that can be detected by the Landsat TM 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 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.

Additionally, any communities less than 0.5 hectares 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 produced results that should not be interpreted at scales larger than 1: 100 000.

SECTION 5 DISTRIBUTION AND SIGNIFICANCE OF THE COASTAL WETLANDS

5.1 General Distribution

The coastal wetland communities of the northern Queensland Study Area are characterised by high species diversity and an absence of Saltpans in the majority of areas. The warm climate and large volume of freshwater entering the estuaries due to high rainfall within the catchments, support a large number of mangrove species and mangrove associates throughout the intertidal zone. Drier catchments at the southern extent of the Study Area, such as the Black, Ross and Haughton, have a larger proportion of Saltpan within the intertidal zone. Hypersaline conditions within these coastal wetland systems inhibit the growth of mangrove species and allow a greater area of Saltpan development.

The two largest contiguous areas of coastal wetland vegetation within the Study Area can be found in the Hinchinbrook Channel region and Bowling Green Bay. However, these two coastal wetland systems are considerably different in the species assemblages that are present. High rainfall in the Hinchinbrook region promotes the growth of many mangrove species and communities that reach heights of up to 30 m. In contrast, the coastal wetland vegetation in Bowling Green Bay area is characterised by low communities and large areas of Saltpan.

Within the entire Study Area Closed *Rhizophora* is the dominant community type, followed by Saltpan, Closed *Ceriops* and Closed Mixed. However, within individual estuaries the dominance of these community types may be quite varied. Diverse Closed Mixed communities dominate some areas, particularly those coastal wetland systems in high rainfall catchments (e.g. Tully catchment). Although a single species (e.g. *Ceriops tagal*) may be quite common throughout the intertidal zone in these areas, mappable monospecific communities consisting of just this species (e.g. Closed *Ceriops*) are rare.

TABLE 5.1 Area of coastal wetland communities within the Study Area.

	AREA (ha)	% OF TOTAL
Closed *Rhizophora*	20 974	27.60
Closed *Avicennia*	2 037	2.68
Open *Avicennia*	113	0.15
Closed *Ceriops*	14 885	19.59
Open *Ceriops*	237	0.31
Closed *Rhizophora*/*Avicennia*	76	0.10
Closed *Avicennia*/*Ceriops*	98	0.13
Open *Avicennia*/*Ceriops*	5	0.01
Closed Mixed	11 340	14.92
Closed *Bruguiera*	1 769	2.33
Saline Grassland	1 219	1.60
Saltpan	20 216	26.60
Samphire-dominated Saltpan	3 030	3.99
TOTAL	75 999	

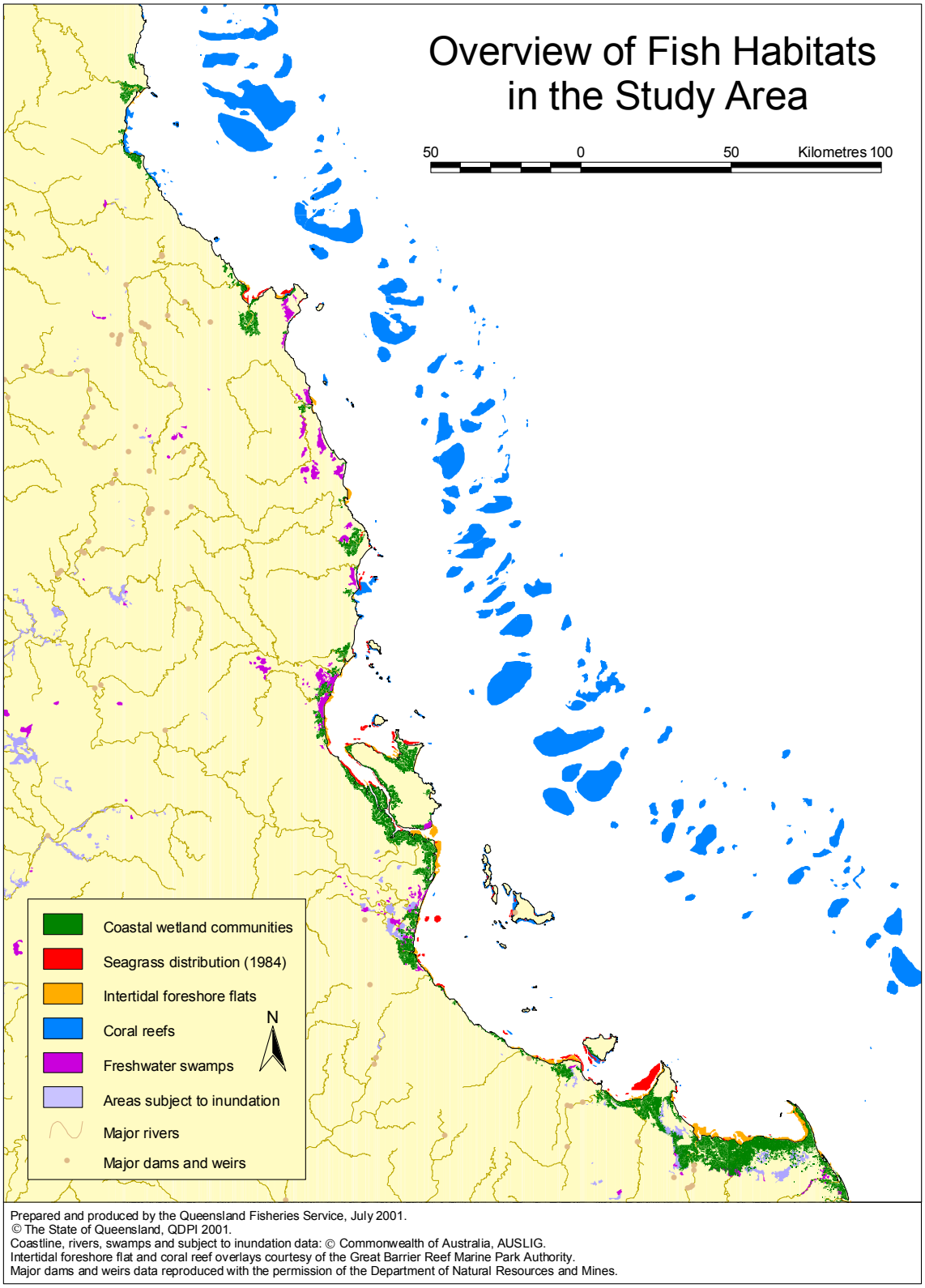

FIGURE 5.1 Overview of fish habitats in the Study Area.

Specific coastal and marine habitats which have value as fish habitats are displayed in Figure 5.1. These habitats include coastal wetland communities as mapped in this study, as well as seagrass meadows, intertidal foreshore flats, coral reefs, freshwater swamps and land subject to inundation. These datasets have been collated from various sources and represent the distribution of the habitat type at a particular date in time. The sources and currency of each dataset is included in Table 3.3.

5.2 Coastal Wetland Distribution by Catchment

The following catchment by catchment assessment provides further details of the coastal wetland communities found in the Study Area. The catchments reported on are the sub-basin catchments as defined by the Department of Natural Resources and Mines.

Terrestrial vegetation adjacent to the coastal wetland communities is also 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 9.2.

Within the Study Area, agricultural cultivation and urban development extend to the upper intertidal limit in various locations. When this occurs, please refer to the maps of coastal wetland vegetation included on the CD available with this report, where the Landsat TM image background displays the distribution of these landuses. On a Landsat TM band 3 background, as used in these maps, agricultural fields appear as relatively large rectangles of varying colours of grey. Bright areas are bare fields and darker areas are cultivated fields. Urban development appears as bright areas of very dense small shapes.

Daintree Catchment

Within the Daintree catchment, the largest area of coastal wetland vegetation occurs at the mouth of the Daintree River. Other small coastal wetland systems exist at Alexandra Bay to the north of the Daintree River and Saltwater Creek (1) to the south. The area of each community type occurring in these locations is listed in Table 5.2.

The coastal wetland communities of the Daintree Catchment are characterised by high species diversity. The majority of the intertidal zone consists of Closed Mixed communities. Closed *Rhizophora* communities are generally dominant on the seaward margin. However, these communities are relatively narrow and rapidly give way to Closed Mixed and Closed *Bruguiera* communities. Closed *Ceriops* communities are found towards the landward margin of the coastal wetlands where inundation usually only occurs on the spring tides.

Further details of the specific locations of various species as confirmed by fieldwork are included in Appendix 8. Fieldwork in the Daintree River confirmed the presence of narrow, fringing coastal wetland communities in the upper tidal reaches of the river, which are tall and generally mixed with terrestrial rainforest species. Although these communities are important in terms of species diversity they were not mappable due to the spatial resolution of the Landsat TM data used (see Section 4.3).

TABLE 5.2 Area (in hectares) of coastal wetland communities within the Daintree Catchment.

COMMUNITY	ALEXANDRA BAY	DAINTREE RIVER	SALTWATER CREEK (1)	TOTAL	PERCENT OF TOTAL
Closed *Rhizophora*	36	223	19	277	10.5
Closed *Avicennia*	0	0	0	0	0.0
Open *Avicennia*	0	0	0	0	0.0
Closed *Ceriops*	140	589	48	777	29.4
Open *Ceriops*	0	23	0	23	0.9
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	334	776	70	1 180	44.6
Closed *Bruguiera*	62	300	8	370	14.0
Saline Grassland	0	0	0	0	0.0
Saltpan	3	16	0	19	0.7
Samphire-dominated Saltpan	0	0	0	0	0.0
TOTAL	575	1 927	145	2 647	

Adjacent Terrestrial Land

The terrestrial vegetation adjacent to the Alexandra Bay coastal wetlands is in near pristine condition. Some of this vegetation, along with virtually all the mangrove communities present in this area, is protected within the Daintree National Park. The majority of the land adjacent to the Daintree River coastal wetlands is well forested. However, agricultural cultivation has occurred on the Daintree River flood plain. In some places, cultivation of the land has occurred to the tidal boundary. The majority of the coastal plain adjacent to the coastal wetlands of Saltwater Creek (1) is utilised for agricultural purposes. Consequently, the natural terrestrial vegetation adjacent to the coastal wetland communities has been severely impacted.

Existing FHA

No FHAs are currently declared within the Daintree catchment.

Mossman Catchment

Coastal wetland communities within the Mossman Catchment include vegetation at Mossman Creek, Mowbray Creek, Dickson's Inlet and Hartleys Creek. The dominant community type within this catchment is Closed *Rhizophora*.

In comparison to coastal wetland communities to the north (in the Daintree catchment) and to the south (in the Barron catchment), coastal wetlands within Dickson's Inlet and the Mowbray Creek estuary are less diverse. In particular, there is a noticeable absence of significant Closed Mixed and Closed *Bruguiera* communities in Dickson's Inlet. Closed *Rhizophora* and Closed *Ceriops* dominate with Saltpans (both samphire-dominated and virtually bare) occurring in the more hypersaline areas. The comparatively low diversity of these coastal wetland systems can be explained by the drier conditions experienced in these catchments. The annual average rainfall within the Dickson's Inlet and Mowbray Creek catchments are lower than that of the surrounding estuaries.

TABLE 5.3 Area (in hectares) of coastal wetland communities within the Mossman catchment.

	MOSSMAN CREEK	DICKSON'S INLET	MOWBRAY CREEK	HARTLEY'S CREEK	TOTAL	PERCENT OF TOTAL
Closed Rhizophora	25	616	102	5	748	51.9
Closed Avicennia	4	0	2	0	5	0.4
Open Avicennia	0	12	0	0	12	0.8
Closed Ceriops	18	304	38	0	360	25.0
Open Ceriops	0	0	0	0	0	0.0
Closed Rhizophora/Avicennia	0	0	1	0	1	0.1
Closed Avicennia/Ceriops	0	0	10	0	10	0.7
Open Avicennia/Ceriops	5	0	0	0	5	0.3
Closed Mixed	39	1	15	0	55	3.8
Closed Bruguiera	18	2	0	0	20	1.4
Saline Grassland	0	0	0	0	0	0.0
Saltpan	0	25	3	0	28	1.9
Samphire-dominated Saltpan	0	197	0	0	197	13.7
Total	108	1 157	170	5	1 440	

Adjacent Terrestrial Land

The coastal plain of the Mossman catchment has largely been utilised for agricultural cultivation. The terrestrial vegetation adjacent to the coastal wetland communities of Mossman Creek, Dickson's Inlet and Mowbray Creek has been modified to allow for this cultivation. In general, there is no natural vegetation buffer between the coastal wetland systems and this land use. However, the coastal ranges within the catchment remain well forested.

Existing FHA

No FHAs are currently declared within the Mossman catchment.

Barron Catchment

The Barron catchment includes the coastal wetland vegetation of the Barron River and smaller estuaries from Trinity Beach to Yorkey's Knob. The small estuarine communities of the beaches of the Cairns region are dominated by Closed *Ceriops* and Closed Mixed communities.

The largest area of coastal wetland vegetation within the Barron catchment grows at the mouth of the Barron River, to the south past Ellie point and into Cairns Harbour. A wide Closed *Rhizophora* zone occurs on the seaward edge on the western foreshore of the Harbour. Closed *Ceriops* can be found further landward and Closed Mixed communities on the banks of the Barron River. Development of the Cairns Airport has resulted in the reduction of the area of mangroves on the landward edge of this coastal wetland system.

TABLE 5.4 Area (in hectares) of coastal wetland communities within the Barron catchment.

	CAIRNS BEACHES	TRINITY BEACH	YORKEYS KNOB	BARRON RIVER	TOTAL	PERCENT OF TOTAL
Closed Rhizophora	78	2	65	244	388	40.6
Closed Avicennia	11	0	18	31	60	6.3
Open Avicennia	0	0	1	0	1	0.1
Closed Ceriops	62	0	110	100	272	28.4
Open Ceriops	0	0	0	0	0	0.0
Closed Rhizophora/Avicennia	0	0	0	0	0	0.0
Closed Avicennia/Ceriops	0	0	0	1	1	0.1
Open Avicennia/Ceriops	0	0	0	0	0	0.0
Closed Mixed	43	3	5	119	169	17.7
Closed Bruguiera	0	0	0	30	30	3.1
Saline Grassland	0	0	0	0	0	0.0
Saltpan	2	0	1	3	6	0.7
Samphire-dominated Saltpan	0	0	10	18	28	3.0
Total	196	4	210	545	956	

Adjacent Terrestrial Land

The lowland plain adjacent to the coastal wetland communities at Yorkey's Point and Barron River is utilised for both agricultural and urban development. The natural terrestrial vegetation adjacent to the wetlands has been cleared to allow for these land uses. In some areas, a natural vegetation buffer remains separating the coastal wetlands from adjacent land uses. However, cultivation of the land directly adjacent to the coastal wetlands has also taken place in a number of locations, with no natural vegetation buffer remaining.

Existing FHA

Three FHAs (Half Moon Creek, Yorkey's Creek and Barr Creek) protect 239 ha of coastal wetland vegetation in the Barron catchment (see Section 9.3).

Mulgrave–Russell Catchment

Trinity Inlet, Mission Bay, Saltwater Creek (2) and the Mulgrave–Russell Rivers all fall within the Mulgrave–Russell catchment.

Strong zonation exists in the coastal wetland communities of Trinity Inlet. Closed *Rhizophora* occurs on the seaward edge of the intertidal zone, with Closed *Ceriops* occurring further landward. Closed *Bruguiera* is often found between these two zones. On the eastern side of Trinity Inlet at the mouth of the Inlet, bunding has isolated a large area from tidal influence. Previous mapping indicates that Closed *Ceriops* and Closed Mixed communities once occurred in this area. Today, only a small Closed Mixed community remains alive in this region (see Section 6 for further details).

In comparison to the strong zonation of the Trinity Inlet mangroves, the coastal wetland vegetation of the Mulgrave–Russell Rivers is not well zoned. Closed Mixed communities consisting largely of *Rhizophora* spp., *Bruguiera* spp., *Heritiera littoralis*, *Excoecaria agallocha*, *Sonneratia alba* and *Acrostichum speciosum* dominate the intertidal zone.

Narrow Closed *Rhizophora* communities also exist at the seaward edge and Closed *Bruguiera* along the Mulgrave River.

TABLE 5.5 Area (in hectares) of coastal wetland communities within the Mulgrave–Russell catchment.

	TRINITY INLET	MISSION BAY	SALTWATER CREEK (2)	MULGRAVE –RUSSELL RIVERS	TOTAL	PERCENT OF TOTAL
Closed Rhizophora	1 730	111	0	72	1 913	47.1
Closed Avicennia	15	5	0	0	20	0.5
Open Avicennia	0	0	0	0	0	0.0
Closed Ceriops	995	53	33	53	1 134	27.9
Open Ceriops	15	0	0	0	15	0.4
Closed Rhizophora/Avicennia	27	0	0	0	27	0.7
Closed Avicennia/Ceriops	0	0	0	0	0	0.0
Open Avicennia/Ceriops	0	0	0	0	0	0.0
Closed Mixed	82	63	37	374	556	13.7
Closed Bruguiera	338	4	0	28	371	9.1
Saline Grassland	0	0	0	0	0	0.0
Saltpan	18	0	0	0	18	0.4
Samphire-dominated Saltpan	4	0	0	0	4	0.1
Total	3 225	236	70	527	4 058	

Adjacent Terrestrial Land

The city of Cairns is situated on the banks of Trinity Inlet. The majority of the terrestrial vegetation directly adjacent to the coastal wetland communities of Trinity Inlet has been modified extensively through residential, commercial, industrial and agricultural development. A large proportion of the flood plain of Trinity Inlet is utilised for agricultural cultivation with bunding occurring in some locations to prevent salt water intrusion to the agricultural fields.

The terrestrial vegetation adjacent to the coastal wetlands of Mission Bay and Saltwater Creek (2) is near pristine. The natural vegetation adjacent to the Mulgrave–Russell Rivers is largely unmodified, with some clearing for agricultural fields occurring on the coastal plain. A natural vegetation buffer between the coastal wetlands and the agricultural land use remains in most places. The Russell River National Park protects some of the adjacent terrestrial vegetation and coastal wetland communities in this area. Additionally, a large proportion of the vegetation of this catchment is protected within the Grey Peaks, Wooroonooran, Eubenangee Swamp and Ella Bay National Parks.

Existing FHA

Two FHAs protect the coastal wetlands of Trinity Inlet, one of management A status and one of management B status. Together these FHAs protect a large proportion of the coastal wetland vegetation of the Inlet (3 216 ha).

Johnstone Catchment

A number of small coastal wetland systems exist in the Johnstone catchment, including at the mouth of an un-named creek, Johnstone River, Moresby River, Liverpool Creek, Maria Creek and a tidal wetland near Garners Beach. Closed Mixed communities are the

Dominant coastal wetland vegetation within the catchment. However, the species composition of these Closed Mixed communities can vary largely between systems.

The Closed Mixed communities that can be found in the Johnstone River estuary are relatively unique for the Study Area. The canopy in the landward edge Closed Mixed communities is often dominated by *Xylocarpus granatum* and *Bruguiera gymnorrhiza* creating a tall community (15 – 20 m) with a dense ground cover of roots.

The Closed Mixed communities of the Moresby River are commonly found on the landward edge of the intertidal zone. Within these communities *Lumnitzera racemosa, Ceriops tagal, Excoecaria agallocha, Heritiera littoralis, Bruguiera* spp.*, Xylocarpus* spp. and *Rhizophora* spp. are commonly found.

TABLE 5.6 Area (in hectares) of coastal wetland communities of the Johnstone catchment.

	UN-NAMED	JOHNSTONE RIVER	MORESBY RIVER	LIVERPOOL CREEK	MARIA CREEK	GARNERS BEACH	TOTAL	PERCENT OF TOTAL
Closed Rhizophora	3	21	616	21	25	8	693	21.1
Closed Avicennia	0	0	0	0	0	0	0	0.0
Open Avicennia	0	0	0	0	0	0	0	0.0
Closed Ceriops	2	6	816	15	46	2	886	27.0
Open Ceriops	0	0	19	0	0	0	19	0.6
Closed Rhizophora/Avicennia	0	0	0	0	0	0	0	0.0
Closed Avicennia/Ceriops	0	0	0	0	0	0	0	0.0
Open Avicennia/Ceriops	0	0	0	0	0	0	0	0.0
Closed Mixed	67	89	891	18	213	24	1 303	39.7
Closed Bruguiera	0	17	0	29	18	0	64	1.9
Saline Grassland	0	0	0	0	0	0	0	0.0
Saltpan	0	0	297	1	2	0	300	9.1
Samphire-dominated Saltpan	0	0	21	0	0	0	21	0.7
Total	71	133	2 660	85	304	34	3 286	

Adjacent Terrestrial Land

Clearing for agricultural cultivation on the coastal lowlands has removed the natural terrestrial vegetation adjacent to the coastal wetland communities in the Johnstone catchment. In many locations, this cultivation has extended to the mangrove communities with no natural vegetation buffer existing. However, within the catchment large areas of natural vegetation still exist on adjacent slopes and hills. Moresby Range, Kurrimine Beach, Maria Creek and Clump Mountain National Parks protect some of the vegetation within the catchment.

Existing FHA

No FHAs are currently declared within the Johnstone catchment.

Tully Catchment

The Tully catchment experiences the highest mean average annual rainfall in the Study Area. Falling within this catchment are Hull River and Tully River, the coastal wetlands systems of which are both diverse and tall.

Within the Tully catchment, Closed *Rhizophora* communities are generally found in the seaward zone, with Closed Mixed communities occupying the landward edge and upstream locations. Closed *Ceriops* communities occupy elevated regions within the intertidal profile and form a large component of the coastal wetland systems in the Hull River. The Tully River is dominated by Closed Mixed communities throughout the intertidal profile.

The Closed Mixed communities within this catchment are characterised by a high diversity of mangrove species including: *Bruguiera* spp., *Aegiceras corniculatum*, *Xylocarpus* spp., *Rhizophora* spp., *Excoecaria agallocha*, *Lumnitzera* spp., *Heritiera littoralis*, *Sonneratia alba* and *Ceriops tagal*. Often a diverse understorey of *Acanthus illicifolius*, *Acrostichum speciosum*, *Crinum pedunculatum* and *Aegialitis annulata* is also present. The communities are also tall, with some species (*S. alba* and *H. littoralis* in particular) reaching heights of 20 to 30 m in the Tully River. The high species diversity and tall communities are indicative of a catchment that receives a high mean annual rainfall.

TABLE 5.7 Area (in hectares) of coastal wetland communities of the Tully catchment.

	BINGAL BAY	HULL RIVER	TULLY RIVER	TOTAL	PERCENT OF TOTAL
Closed Rhizophora	1	213	15	229	13.7
Closed Avicennia	0	0	0	0	0.0
Open Avicennia	0	2	0	2	0.1
Closed Ceriops	0	316	46	361	21.7
Open Ceriops	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	0	578	255	833	49.9
Closed Bruguiera	0	83	159	242	14.5
Saline Grassland	0	0	0	0	0.0
Saltpan	0	0	0	0	0.0
Samphire-dominated Saltpan	0	1	0	1	0.1
Total	1	1 192	474	1 668	

Adjacent Terrestrial Land

The terrestrial vegetation adjacent to the coastal wetland communities of Hull River and Tully River is largely unmodified. A small proportion of the land is utilised for agricultural production and rural development. The Hull River and Edmund Kennedy National Parks protect some of the coastal vegetation in this catchment, including nearly all of the coastal wetland vegetation of the Hull River estuary.

Existing FHA

Important fish habitats located at both Hull River and Tully River are protected by FHAs. The Hull River FHA protects approximately 60% and the Tully River FHA protects just over 5% of the coastal wetland vegetation of these river systems, respectively.

Murray Catchment

The Murray catchment has a very large area of coastal wetland vegetation. Hinchinbrook Island lies offshore of this catchment and provides a protective barrier, sheltering the large area of mangrove communities that have established in Hinchinbrook Channel. The extensive mangrove communities within the Channel are dominated by Closed *Rhizophora*. Some small Closed Mixed, Closed and Open *Ceriops* and Saltpan communities occur on the landward edge.

Within the Murray catchment area, Murray River, Dallachy Creek, Wreck Creek and Meunga Creek all discharge to the north of Hinchinbrook Channel. Closed Mixed communities dominate the coastal wetland vegetation associated with these estuaries. Closed *Rhizophora* occurs at the mouth of these estuaries, often with Closed *Bruguiera* behind.

TABLE 5.8 Area (in hectares) of coastal wetland communities of the Murray catchment, including Hinchinbrook Island.

	MURRAY RIVER	DALLACHY-WRECK CREEKS	MEUNGA CREEK	HINCHINBROOK CHANNEL	HINCHINBROOK ISLAND	TOTAL	PERCENT OF TOTAL
Closed Rhizophora	290	116	21	6 030	6 148	12 604	73.3
Closed Avicennia	0	0	0	0	0	0	0.0
Open Avicennia	0	0	0	0	0	0	0.0
Closed Ceriops	258	228	22	743	617	1 867	10.9
Open Ceriops	21	0	0	93	44	158	0.9
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	406	566	78	202	497	1 749	10.2
Closed Bruguiera	192	128	11	4	11	346	2.0
Saline Grassland	28	17	0	0	0	45	0.3
Saltpan	14	23	0	218	144	399	2.3
Samphire-dominated Saltpan	0	21	0	0	0	21	0.1
Total	1 208	1 099	132	7 289	7 461	17 189	

Adjacent Terrestrial Land

The vegetation adjacent to the coastal wetland systems of Murray River, Dallachy Creek, Wreck Creek and Meunga Creek is near pristine. Small areas of land have been cleared. However, the majority of the area surrounding these wetland systems is well forested. Development at Cardwell and further south has resulted in the loss of some natural vegetation adjacent to coastal wetland communities. Hinchinbrook Island is also near pristine due to the existence of the Hinchinbrook Island National Park, which protects the vegetation of the entire Island. A large area of coastal vegetation is also protected within the Lumholtz and Edmund Kennedy National Parks.

Existing FHA

A number of FHAs protect important fish habitats in the Murray Catchment. Approximately 31% of the coastal wetlands of the Murray River are protected within the

Murray River FHA. Only a very small area of coastal wetland vegetation is included in the Dallachy/Wreck/Meunga FHAs (less than 1% of the total). The Hinchinbrook FHA protects almost 6 000 ha of coastal wetland vegetation which constitutes just under half of the total area of the FHA.

Herbert Catchment

The coastal wetland vegetation of the southern end of Hinchinbrook Channel, on the Herbert River floodplain, is more diverse than the main channel. The majority of the coastal wetland vegetation associated with the Herbert River floodplain is Closed Mixed, with Closed *Ceriops* occurring on the landward edge. *Rhizophora* spp., *Bruguiera* spp., *Xylocarpus* spp., *Heritiera littoralis*, *Sonneratia alba* and *Avicennia marina* are common canopy species within these Closed Mixed communities, with an understorey of *Aegiceras corniculatum*, *Acrostichum speciosum* and *Crinum pedunculatum* also very common.

The mangrove palm (*Nypa fruticans*) can be found within the Herbert catchment. This mangrove species is usually found in far north Queensland (north of Lockhart River). However, it occurs in the protected waters of Enterprise Channel. There have been no recordings of this species between Herbert River and McIvor River (just north of Cooktown). The unique occurrence of *Nypa fruticans* this far south adds to the biodiversity value of this region.

The coastal wetland communities to the south of the Herbert River floodplain, that is Bulgaroo, Orient, Cattle and Elanor Creeks, are dominated by Closed *Ceriops* and Saltpans. The individual catchments of these creeks (see Table 2.1) are drier than those catchments to the north and the coastal wetland communities reflect this change in hydrology.

The land directly adjacent to the coastal wetland communities from Bulgaroo to Elanor Creek is subject to inundation in the wetter summer months. Freshwater swamps are also found adjacent to the tidal wetland systems. 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.

Adjacent Terrestrial Land

The coastal lowlands of the Herbert River catchment are utilised extensively for agricultural purposes. In particular, the land adjacent to the existing coastal wetland communities of the Herbert River has been cleared, with no natural vegetation buffer existing between the important fish habitats and the agricultural fields. This land use poses a threat to the diverse mangrove communities on the Herbert River floodplain. To a lesser extent, this is also the case for the remaining coastal wetland communities. The Halifax Bay Wetlands National Park provides protection for a small proportion of the coastal wetlands located in the southern half of the catchment.

Existing FHA

Four FHAs protect important fish habitats in this catchment. The Hinchinbrook FHA (discussed above) protects some of the coastal wetlands of the Herbert River. Additionally, the Halifax FHA protects 1 582 ha of coastal wetland vegetation of the Herbert River floodplain. Palm Creek and Cattle Creek FHAs together protect approximately 40% of the coastal wetland communities associated with the Bulgaroo/Orient/Cattle/Elanor Creeks system.

TABLE 5.9 Area (in hectares) of coastal wetland communities of the Herbert catchment.

	HERBERT RIVER	BULGAROO-ORIENT-CATTLE-ELANOR CREEKS	TOTAL	PERCENT OF TOTAL
Closed Rhizophora	1 117	832	1 950	15.9
Closed Avicennia	296	418	714	5.8
Open Avicennia	5	8	13	0.1
Closed Ceriops	1 993	1 238	3 230	26.4
Open Ceriops	22	0	22	0.2
Closed Rhizophora/Avicennia	0	0	0	0.0
Closed Avicennia/Ceriops	2	0	2	0.0
Open Avicennia/Ceriops	0	0	0	0.0
Closed Mixed	2 957	744	3 701	30.3
Closed Bruguiera	327	0	327	2.7
Saline Grassland	88	730	818	6.7
Saltpan	30	1 230	1 260	10.3
Samphire-dominated Saltpan	0	192	192	1.6
Total	6 837	5 392	12 229	

Black Catchment

Small areas of coastal wetland communities at Crystal Creek, Rollingstone Creek, Saltwater Creek, an un-named creek, Leichhardt Creek, Christmas Creek, Bluewater Creek, Althaus Creek and Black Creek all lie within Black catchment. The dominant community type within this catchment is Closed Mixed.

TABLE 5.10 Area (in hectares) of coastal wetland communities of the Black catchment.

	CRYSTAL CREEK	ROLLINGSTONE CREEK	SALTWATER CREEK 3	UN-NAMED	LEICHHARDT-CHRISTMAS CREEKS	BLUEWATER-ALTHAUS-BLACK CREEKS	TOTAL	PERCENT OF TOTAL
Closed Rhizophora	0	4	6	0	10	2	22	2.8
Closed Avicennia	2	0	7	1	0	1	11	1.4
Open Avicennia	0	0	0	0	0	0	0	0.0
Closed Ceriops	3	1	10	3	40	54	112	14.2
Open Ceriops	0	0	0	0	0	0	0	0.0
Closed Rhizophora/Avicennia	0	0	0	0	0	0	0	0.0
Closed Avicennia/Ceriops	0	0	0	0	0	11	11	1.4
Open Avicennia/Ceriops	0	0	0	0	0	0	0	0.0
Closed Mixed	55	66	55	30	106	121	433	55.1
Closed Bruguiera	0	0	0	0	0	0	0	0.0
Saline Grassland	0	0	0	0	0	0	0	0.0
Saltpan	1	3	2	33	44	113	196	25.0
Samphire-dominated Saltpan	0	0	0	0	0	0	0	0.0
Total	61	74	80	67	200	303	785	

Adjacent Terrestrial Land

The terrestrial vegetation adjacent to the small coastal wetland communities in the Black catchment is in either near pristine or largely unmodified condition. The majority of the northern half of the catchment is well forested with little development. The southern portion of the catchment, closer to the city of Townsville, has more development and the natural vegetation surrounding the coastal wetland vegetation has been modified.

Existing FHA

There are currently no declared FHAs within the Black catchment. The area of coastal wetland communities in this catchment is small in comparison to the other catchments.

Ross Catchment

Ross Catchment is one of the driest catchments in the Study Area. The coastal wetland communities are dominated by Saltpans and Closed *Ceriops* communities. Mangrove communities are generally limited to a narrow zone of frequent inundation close to the waterways and drainage lines. Extensive Saltpans lie landward of these narrow water's edge communities. Narrow Closed *Rhizophora* communities generally occupy the foreshore in this catchment.

Coastal wetland communities have established on the protected southwestern foreshore of Magnetic Island. This area is dominated by Closed *Rhizophora* communities on the foreshore, with Saltpans further landward. Small areas of Closed *Ceriops* and Closed Mixed communities also occupy some regions on the landward edge of the intertidal profile. Pioneering Closed *Avicennia* communities are also present on the foreshore.

TABLE 5.11 Area (in hectares) of coastal wetland communities of the Ross catchment, including Magnetic Island.

	BOHLE RIVER	CLEVELAND BAY	CHUNDA BAY	SHELLY BEACH	PALLARENDA	MAGNETIC ISLAND	TOTAL	PERCENT OF TOTAL
Closed Rhizophora	74	533	125	24	0	111	867	7.1
Closed Avicennia	102	347	3	0	6	20	478	4.0
Open Avicennia	0	4	3	0	0	0	7	0.0
Closed Ceriops	124	895	250	0	2	15	1 286	10.5
Open Ceriops	0	0	0	0	0	0	0	0.0
Closed Rhizophora/Avicennia	21	0	0	0	0	1	22	0.2
Closed Avicennia/Ceriops	0	0	11	0	0	0	11	0.1
Open Avicennia/Ceriops	0	0	0	0	0	0	0	0.0
Closed Mixed	118	325	2	13	7	18	483	3.9
Closed Bruguiera	0	0	0	0	0	0	0	0.0
Saline Grassland	32	94	35	0	5	0	165	1.3
Saltpan	1 293	6 809	310	2	106	52	8 572	69.7
Samphire-dominated Saltpan	10	212	154	0	12	1	389	3.2
Total	1 775	9 220	893	39	137	218	12 292	

Adjacent Terrestrial Land

The city of Townsville is located on the banks of the Ross River. The natural terrestrial vegetation adjacent to the coastal wetland communities no longer remains as a buffer between important fish habitats and the adjacent land uses. The Townsville Town Common Conservation Park protects some coastal vegetation along with the wetlands to the east of the mouth of the Black River.

Further east of Townsville and south of Cleveland Bay, there is currently limited development adjacent to coastal wetland systems. The land adjacent to the Cleveland Bay coastal wetland vegetation is zoned for future industrial development. Such a development may impact on the habitat in this area.

Existing FHA

The Bohle River FHA protects important fish habitats associated with the estuarine environments at the mouth of the Bohle River. Approximately 35% of the total coastal wetlands are protected within this FHA. Fish habitats on the western side of Bowling Green Bay, lying within this catchment, are protected in both the Bowling Green Bay FHA and the Bowling Green Bay National Park.

Haughton Catchment

The lowlying coastal plains of Bowling Green Bay provide extensive areas for the establishment of coastal wetland vegetation. However, the Haughton catchment is relatively dry in comparison to the northern catchments in the Study Area. The proportion of Saltpan in this catchment is much higher as the lack of freshwater influence creates hypersaline areas in which mangrove plants do not survive. Closed *Rhizophora* inhabits the foreshore with extensive Closed *Ceriops* further landward. In the upstream locations of the rivers that discharge into Bowling Green Bay, Closed Mixed communities dominate.

Because of the dry conditions in the Haughton catchment, some communities of mangroves are limited to a narrow zone directly adjacent to waterways. These narrow communities are often difficult to map at the scale used in this study.

Only the coastal wetland communities from the western side of Bowling Green Bay to Barratta Creek were mapped as part of this study. The area of coastal wetland vegetation of all of Bowling Green Bay was calculated based on this mapping and previous departmental mapping using the same technique (Danaher 1995b).

Adjacent Terrestrial Land

The Bowling Green Bay National Park protects a significant proportion of coastal wetland vegetation. The terrestrial land directly adjacent to the Bowling Green Bay coastal wetland vegetation is subject to inundation in the wetter (summer) months. This land is not heavily utilised for this reason. Grazing and agriculture are the predominant landuses on the land that is not subject to inundation. Although the land has been cleared somewhat, natural vegetation remains. Urban and industrial development has not encroached on the coastal wetland habitats to any significant degree.

Existing FHA

Important marine fish habitats in the Bay are protected within the Bowling Green Bay FHA. The Bowling Green Bay FHA protects almost 70 000 ha of marine fish habitat. However, this includes only 190 ha (less than 1%) of coastal wetland vegetation of Bowling Green Bay. The majority of coastal wetland vegetation of Bowling Green Bay is included in the Bowling Green Bay National Park.

TABLE 5.12 Area (in hectares) of coastal wetland communities in the Haughton catchment.

	WESTERN BGB TO BARRATTA CREEK	BOWLING GREEN BAY TOTAL	PERCENT OF TOTAL
Closed Rhizophora	1 283	1 931	6.6
Closed Avicennia	749	848	3.8
Open Avicennia	78	169	0.4
Closed Ceriops	4 600	5 122	23.6
Open Ceriops	0	0	0.0
Closed Rhizophora/Avicennia	26	26	0.1
Closed Avicennia/Ceriops	63	63	0.3
Open Avicennia/Ceriops	0	0	0.0
Closed Mixed	877	1 128	4.5
Closed Bruguiera	0	0	0.0
Saline Grassland	191	191	1.0
Saltpan	9 418	11 659	48.4
Samphire-dominated Saltpan	2 175	2 177	11.2
Total	19 461	23 315	

5.3 Comparison of Coastal Wetland Communities in IMCRA Regions

Coastal wetland communities of the Study Area fall within two IMCRA regions, the Wet Tropics Coast (WTC) region and Lucinda–Mackay Coast (LMC) region. The Black, Ross, Haughton and the majority of the Herbert catchments lie adjacent to the LMC region. Rainfall within this region is mostly between 1000 mm and 1400 mm except in the Whitsundays-Mackay area where it is slightly higher (between 1400 mm to over 2000 mm). The remaining catchments in the Study Area to the north lie adjacent to the WTC region. The WTC region is a higher rainfall area with annual average rainfall ranging from 2000 mm to over 4000 mm in the Innisfail-Tully area.

The coastal wetland communities in the WTC region are characterised by high species diversity and an absence of Saltpans in the majority of areas. The warm climate and high rainfall within the catchments support a high diversity of mangrove species and mangrove associates. The mean annual rainfall of the Tully Catchment is the highest of the catchments within the Study Area. Coastal wetland communities within this catchment are extremely diverse and tall.

The LMC region experiences a drier climate. As such, coastal wetland communities in the Black, Ross and Haughton catchments have a larger proportion of Saltpan. Hypersaline conditions within these coastal wetland systems inhibit the growth of mangrove species and allow a greater area of Saltpan development.

A comparison of the coastal wetland communities in three Queensland IMCRA regions is included in Table 5.15. This table also lists the proportion of coastal wetland communities in the Shoalwater Coast (SWC) region further south, from Mackay to Baffle Creek where rainfall is between 1000 mm and 1400 mm annually. Although, rainfall is comparable to the LMC region, temperatures in the SWC region are cooler than in the WTC and LMC regions. Mangrove species distribution is limited latitudinally by the physiological

tolerance of each species to low temperatures (Duke et al. 1998). The comparatively lower proportion of diverse Closed Mixed communities in the SWC region reflects this difference in temperature.

The boundary of the two IMCRA regions within the Study Area falls at Lucinda within the Herbert catchment. The coastal wetland vegetation of this catchment is correspondingly transitional between the typical vegetation of these two regions. The coastal wetland vegetation in the north of the catchment (on the Herbert River floodplain) is characteristic of the Wet Tropics IMCRA region. However, vegetation from Bulgaroo Creek south is more characteristic of the drier Lucinda–Mackay catchment.

TABLE 5.13 Coastal wetland communities by IMCRA region.

	IMCRA REGION		
COASTAL WETLAND COMMUNITIES	Wet Tropic Coast	Lucinda Mackay Coast	Shoalwater Coast
TOTAL AREA (HA)	35 874	88 593	173 802
PERCENT OF TOTAL IN REGION			
Closed *Rhizophora*	49.8	20.3	23.4
Closed *Avicennia*	0.3	3.8	5.8
Open *Avicennia*	0.1	0.5	0.5
Closed *Ceriops*	18.1	16.5	11.4
Open *Ceriops*	1.1	0.1	0.1
Closed *Aegiceras*	0.0	0.0	0.1
Closed *Rhizophora*/*Ceriops*	0.6	0.0	0.0
Closed *Rhizophora*/*Avicennia*	0.1	0.1	0.0
Closed *Avicennia*/*Ceriops*	0.0	0.3	0.9
Open *Avicennia*/*Ceriops*	0.1	0.0	0.0
Closed Mixed	20.8	14.2	7.9
Closed *Bruguiera*	4.7	0.1	0.0
Saline Grassland	0.1	1.7	5.8
Saltpan	4.1	42.4	44.0

5.4 Mangrove Species Diversity

Duke (1997) reports that 37 taxa of 19 families of mangroves occur within the Great Barrier Reef World Heritage Area, of which 31 species occur in the Study Area (see Section 2.2). This number represents a significant proportion of the variation of mangrove species in the world. Worldwide, there are 70 taxa belonging to 21 families of mangrove plants. These include ferns, a palm, trees and shrubs.

Duke (1997) records the southern distributional limit of a number of mangrove species within the Study Area. *Sonneratia caseolaris* and *Sonneratia X gulngai* can be found north of the Murray River. *Bruguiera sexangula*, *Ceriops decandra*, *Lumnitzera littorea*, *Lumnitzera X rosea*, *Nypa fruticans* and *Rhizophora mucronata* are found north of Herbert River/Hinchinbrook Channel.

The southern distributional limit of the mangrove palm, *Nypa fruticans*, falls within the Study Area. This mangrove species is primarily found upstream in rivers of the wet topical areas of north Queensland where there are low salinities and calm water (Lovelock 1993). This species is commonly found north of Lockhart River approximately 700 km north of Hinchinbrook Channel. It also occurs in the McIvor River just north of Cooktown and in

the Herbert River (Duke 1997). In the Study Area, *N. fruticans* only occurs in the Herbert River coastal wetland communities.

Although species diversity of mangroves is an important consideration in biodiversity management, the aim of this Study was to provide a broad scale evaluation of coastal wetland communities, rather than an assessment of mangrove species diversity. The spatial and spectral resolution of Landsat TM satellite imagery limits the detail obtainable in terms of species diversity. Under greater freshwater influence, upstream communities are often more species diverse than communities in the seaward zone. These communities are generally small and narrow and are therefore, not mappable using this technique.

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

6.1 Disturbance of Coastal Wetland Vegetation in the Study Area

Changes to Coastal Wetland Vegetation

Throughout the Study Area, agricultural production in the coastal zone has encroached on coastal wetland vegetation to varying degrees. This can be seen particularly in the Herbert River catchment, where agricultural fields extend to the tidal boundary and cultivation is often on marginal lands. This phenomenon has already been discussed in Section 5. Despite this fact, agricultural land use has not led to any direct significant losses of coastal wetland vegetation on the eastern side of Trinity Inlet.

In 1972, Colonial Sugar Refining Company constructed bunds in the tidal area on the eastern side of Trinity Inlet in order to convert these lands to cane land. A large area of coastal wetland vegetation in this region was isolated from tidal influence and has since died. Dieback of the mangrove vegetation on the seaward side of the bund has also occurred due to a reduction in freshwater flow. The process of bunding has also severely degraded the waterway on both sides of the bund and acid sulphate soils are now becoming a problem (Clarke and Tyson 1997). Currently, this land has little value as agricultural land and steps are now being taken to return this area to wetland habitat.

A series of studies have been undertaken in the Study Area which document changes to coastal wetland habitats. These reports include assessments of the tidal and freshwater wetlands in the Barron (Russell et al. 2000), Moresby (Russell et al. 1996a), Mulgrave–Russell (Russell et al. 1996b) and Johnstone catchments (Russell and Hales 1993). Very few large net losses in tidal coastal wetland communities were identified. The major loss of mangrove and Saltpan communities within these catchments occurred in the Barron catchment due to the construction of the Cairns International Airport.

Area of coastal wetland vegetation in some catchments increased due to mangrove colonisation at the mouths of creeks or rivers. For example, in the Barron catchment, changes in sedimentation at the mouth of the Barron River has resulted in an increase of mangrove communities. In the Moresby catchment, an increase in mangrove communities resulted from saltwater intrusion into areas that were previously described as non-tidal. Hopkins et al. (1979) identified possible causes for this increase in the tidal area of the Moresby River estuary. Possible explanations include increased tide levels, a decrease in freshwater runoff as a result of agricultural drainage, an increase in storm surges or by changes in tidal flushing patterns caused by the deepening of Mourilyan Harbour.

Although tidal coastal wetland communities in these catchments have been relatively stable in area over the past few decades, these studies have identified a trend of freshwater wetland habitat loss. Agricultural and urban development in the coastal plain has largely been responsible for this loss. Freshwater wetland habitats provide important areas 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.

Studies of historical changes to wetland communities have not been undertaken in all catchments of the Study Area. However, this general trend in freshwater wetland habitat loss can be seen throughout Queensland. State of Environment Queensland reporting has identified loss of freshwater wetlands as a key issue in the coastal zone with only freshwater wetlands on the more remote coasts escaping some degree of modification or loss (EPA 1999a). Increasing usage of coastal plains for urban and agricultural landuses creates a pressure on these important fish habitats.

To date, efforts for fish habitat protection (through FHAs) have focused on tidal coastal wetland habitats and adjacent freshwater habitats have been largely excluded. Freshwater coastal wetlands provide habitat for fisheries species at various life cycle stages and contribute nutrients to the other tidal habitats, particularly in periods of high freshwater flow. Protection of these habitats is critical and should be considered as a priority.

Buffer Zones as a Management Tool

The fertile soils and level land of the coastal plain in the Study Area are heavily utilised for agricultural production and urban development. Cultivation and clearing have extended up to the tidal boundary of many coastal wetland systems in the Study Area. A series of studies by Russell et al. (Russell and Hales 1993; Russell et al. 1996a; Russell et al. 1996b; Russell and Hales 1997; Russell et al. 1998 and Russell et al. 2000) have identified that some landuses adjacent to coastal wetland systems and stream habitats in the Study Area have a negative impact on the quality of fish habitat. 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.

A buffer zone is a vegetated filter strip located between natural resources and adjacent areas subject to human alteration (Castelle et al. 1994). 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.

The ecological, economic and social viability of revegetation of cleared areas adjacent to coastal wetland vegetation should be investigated.

6.2 Current Threats to Coastal Wetland Vegetation

General 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. In Queensland, approximately 85% of the population live in the coastal zone (EPA 1999a), placing a considerable pressure on the resources of this region.

Marine plants in Queensland are protected from physical disturbance under Fisheries legislation. Any proposed disturbance of marine plants requires approval under the *Queensland 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 impacts on coastal wetland vegetation are included in Table 6.1.

TABLE 6.1 Development proposals that may impact upon coastal systems.

LOCATION	DETAILS
MOSSMAN CATCHMENT	Dickson's Inlet – historically dredging spoil has been dumped in the coastal wetland communities. Although there is no immediate threat of this occurring, the problem of where to put future dredging spoils remains.
BARRON CATCHMENT	Northern Beaches – increasing tourism and residential development e.g. Palm Cove. Cairns Airport – possibility that a second runway may be required in the future, no short term threat. Ongoing disturbance of mangroves as part of airport runway management.
MULGRAVE–RUSSELL CATCHMENT	Trinity Inlet – Proposal for road through FHA requiring clearing of approximately 30 ha of mangrove.
JOHNSTONE CATCHMENT	Moresby River – focus for aquaculture with a number of large applications for development of facilities. Upgrade of Mourilyan Harbour proposed.
HULL CATCHMENT	Hull River – increase in aquaculture facilities upstream of FHA and development of rural residential land adjacent to FHA.
MURRAY CATCHMENT	Cardwell – Expansion of Port Hinchinbrook development, airport and golf course planned.
HERBERT CATCHMENT	Herbert River – marina proposal at Dungeness, permit for mangrove removal.
ROSS CATCHMENT	Bluewater – aquaculture application requiring removal of some marine plants. Bohle River – sand extraction is beginning to cause concern for residents of the area. Extractive industries upstream may impact on water quality. Nelly Bay – new marina development with minimal marine plant disturbance. Townsville – Townsville Port Access Road – 150 m wide x 20 km long corridor through coastal wetland vegetation requiring bunding but allowing for tidal inundation. Bridge across Ross River and marina requiring clearing of regrowth communities at the mouth of the Ross River. Ross River – possible future expansion of the Stuart Industrial area. Area of tidal land as well as land adjacent to the coastal wetland systems may be developed in the future for industrial purposes. Possibility of future sand extraction, trial at Rooney's bridge. Alligator Creek – minimal disturbance from urban development adjacent to Saltpans.
HAUGHTON CATCHMENT	Barratta Creek – infrastructure development at Gerona may require minor disturbance to marine plants.

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. Possible deterioration of water quality through inappropriate land management and alterations to water flow characteristics are primary concerns for coastal fisheries management.

Grazing and agricultural cultivation are the dominant land uses within the catchment of the Study Area. These land uses can potentially have a detrimental impact on water resources and habitats in the catchment. For example, poor land management practices that facilitate erosion may result in changes to sedimentation and turbidity characteristics of the waterways and alter instream habitats. Agricultural herbicides, pesticides and fertilisers carried into the waterways, as well as sewage and industrial discharge, create changes in water quality. Additionally, the increase in human population within a catchment increases the demands on water resources. 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 (both volumes and timing of flows) in the catchment.

The historical impacts to aquatic ecosystems, and in particular to fisheries and fish habitats, arising from various human induced changes are largely unquantified and remain 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.

Table 6.2 lists the major landuses in the catchments of the Study Area and provides a summary of issues that have been identified as being of concern.

TABLE 6.2 Major landuses and catchment management issues in the Study Area.

CATCHMENT	LANDUSE 1993 (% OF CATCHMENT AREA)				ISSUES
	GRAZING	CROPPING	STATE FOREST	NATIONAL PARKS	
DAINTREE-MOSSMAN	20	4	46	30	Clearing of land in the lower Daintree has resulted in significant streambank erosion and siltation problems. Agricultural runoff to the Mossman River of concern. Increasing tourism resulting in spread of urban facilities to agricultural land and undisturbed forests.
BARRON	55	>1	35	2	Erosion of cultivated land is a major concern. High nutrient loads due to runoff from agricultural and urban lands. Increase in urbanisation.
MULGRAVE–RUSSELL	8	2	28	21	High risk of erosion on cultivated land. Significant pressure on the sand resources of the Mulgrave River. Issues of concern include flooding siltation, drainage of swampland, river course management techniques, de-snagging and channel straightening.
JOHNSTONE	24	15	33	6	A large percentage of the catchment is contained within State Forest. Threat to water quality from agricultural activity is an issue. Loss of agricultural land and changed and lost habitat are threats to the ecological integrity of the catchment.
TULLY-MURRAY	19	5	60	9	Erosion problems due to frequent flooding. Drainage of freshwater wetlands and construction of levees altering hydrology of the system. Land clearing and agricultural runoff threats to water quality and fish nurseries.
HERBERT	79	4	12	4	Grazing in the Herbert catchment accounts for aproximately 80% of the landuse in the catchment. This land is considered in relatively good condition with only minor erosion and pasture degradation
BLACK-ROSS	29	>1	8	11	Grazing lands, which account for a large proportion of the catchment land use, are in relatively good condition with only minor erosion problems. Sand and gravel extraction from the Black River creating an instream environmental effect. Drainage of swampland and installation of floodgates detrimental to fish nurseries. Persistent water weeds.
BURDEKIN - HAUGHTON	87	1	>1	>1	Soil erosion on grazing lands widespread and severe and contributes to instream habitat degradation. Potential salinity problems in cleared areas. Weed infestation of pastureland. Burdekin River Irrigation Project may impact wetlands and water quality and quantity.

Source: QDPI 1993

SECTION 7 EXISTING CONSERVATION MEASURES AND CONSERVATION VALUES

7.1 Fish Habitat Areas

Fish Habitat Areas (FHAs) 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). Details of the management strategies for FHAs (both management A and B) are outlined in Appendix 2.

The following nine FHAs of management A status and eight of management B status are currently declared over important fish habitats in the Study Area:

Management A

- Trinity Inlet
- Hull River
- Tully River
- Murray River
- Dallachy Creek
- Wreck Creek
- Meunga Creek
- Hinchinbrook
- Bowling Green Bay

Management B

- Half Moon Creek
- Yorkey's Creek
- Barr Creek
- Trinity Inlet
- Halifax
- Palm Creek
- Cattle Creek
- Bohle River

Table 8.2 summarises the fisheries values and the habitat types of each of the coastal wetlands ecosystems protected by FHAs within the Study Area.

7.2 Ramsar Sites

In October 1993, the wetlands associated with Bowling Green Bay were included in the Ramsar list of Wetlands of International Importance. The site encompasses approximately 35 500 ha of coastal habitats and includes the mountainous areas of Cape Cleveland, the elevated parallel dune systems, the lowlying coastal plain and the sand spit of Cape Bowling Green. The site has been recognised for its diverse complex of coastal wetland systems. It is typified by communities whose dominant ecological characteristic is tolerance of saline conditions (Blackman and Spain 2001).

7.3 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 government manages the GRBMP. The GBRMPA has the legislative responsibility 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

Queensland Marine Parks are gazetted under the *Queensland Marine Parks Act 1982* and its Regulations and include the Cairns Marine Park and the Townsville-Whitsunday Marine Park.

Cairns Marine Park

The Cairns Marine Park covers a 500 km long, narrow stretch of foreshore between Murdoch Point, south of Cooktown, and Clump Point near Mission Beach. It lies alongside the Great Barrier Reef off shore and protects numerous estuarine systems (EPA 1999b). The coastal wetland vegetation included in this Marine Park includes the communities along the Daintree River, Dickson's Inlet, Mowbray Creek, Trinity Inlet, Mulgrave–Russell Rivers, Johnstone River and Moresby River.

Townsville–Whitsunday Marine Park

The Townsville Whitsunday Marine Park covers 600 km of coastline from Clump Point in the north to Midge Point in the south, and covers 200 continental islands. The area has a number of sites of cultural heritage significance including Aboriginal occupation, maritime exploration, and early European use (EPA 1999b). The coastal wetland communities of Hinchinbrook Island, Magnetic Island and some of Bowling Green Bay are included in this Marine Park.

7.4 National Parks

National parks, conservation parks and resources reserves are gazetted under the *Queensland Nature Conservation Act 1992*. A large number of national parks exist in the coastal region of the Study Area. Some parks directly protect coastal wetland vegetation, whereas other parks protect the terrestrial vegetation adjacent to the coastal wetland communities, providing a buffer between important fish habitats and the terrestrial land uses. The National Parks that have been declared adjacent to or over coastal wetland communities within the Study Area and the vegetation that they protect are described in Section 5 under the adjacent terrestrial land headings for each coastal wetland system.

7.5 Directory of Important Wetlands in Australia

The Directory of Important Wetlands in Australia is a cooperative project between the Commonwealth, State and Territory Governments of Australia, coordinated by Environment Australia with input from conservation agencies from all jurisdictions, to identify nationally important wetlands (Environment Australia 2001). The wetland systems in the Study Area that have been listed in the directory are listed in Table 7.1. Further details of the conservation significance of these sites in terms of notable flora and fauna and the social and cultural values of these important wetlands can be found online at *http://www.environment.gov.au/wetlands/wet.html*.

TABLE 7.1 Conservation significance of important wetlands in Australia.

SITE NAME	CONSERVATION SIGNIFICANCE
QLD137 ALEXANDRA BAY	An excellent example of the merging of freshwater and saline wetland communities that can occur on coastal plains in high rainfall areas. The mangrove area is large and diverse. The mixing of fresh and saline waters has created conditions suitable for a wide range of different mangrove communities within a relatively small area. There is a very high diversity of epiphytes on the mangroves and melaleucas.
QLD154 LOWER DAINTREE RIVER	The site contains a well defined array of geomorphological features that are representative of coastal expansion within a confined space. The tall Closed *Rhizophora stylosa* forest that lines the mid-tidal reaches of the site is an outstanding example of the type. The paperbark swamps of the northern bank are an outstanding and spectacular example of this type of forest. They may also be the most significant breeding areas for the estuarine crocodile in the Wet Tropic Coast bioregion.
QLD157 PORT OF CAIRNS AND TRINITY INLET	Although the site is adjacent to a major urban area, the critical energy pathways and food chains of the wetlands remain essentially intact. The overall water quality remains fairly good and they support large populations of birds, fish and prawns. They represent an extremely valuable resource for the city of Cairns, as an area providing research opportunities, an area of recruitment for commercial fish stocks and as a natural area that increases the quality of life in the region.
QLD158 RUSSELL RIVER	The site is one of four remaining in the Wet Tropics that have predominantly organic soil and natural vegetation. The beach ridge-swale communities, rainforest and melaleuca communities on the isolated coastal plain to the north of Mulgrave/Russell River are amongst the best developed and least disturbed remaining in the Wet Tropics bioregion. The palm dominated swamp forest in the south (including the Alexander Palm Forest) is the only significant area of this type remaining in the Wet Tropics.
QLD149 INNISFAIL AREA	The site is one of four areas on the wet tropical coast that have predominantly organic soils and retain some natural vegetation.
QLD144 ELLA BAY SWAMP	Ella Bay Swamp is unique amongst the remaining wetland on the coastal plain in the Wet Tropics bioregion in that its whole catchment is relatively undisturbed. The site contains one of the largest and least disturbed areas of *Melaleuca quinquenervia* open forest remaining in the region.
QLD161 TULLY RIVER-MURRAY RIVER FLOODPLAINS	The site contains good examples of floodplain swamps and lagoons that are considered one of the most seriously threatened habitat types in the Wet Tropics bioregion. It also contains examples of regionally threatened vegetation communities including complex mesophyll vine forest and palm forest on alluvial soils, broad-leaved paperbark woodlands and remnants of the swampy coastal plain vegetation complex and the coastal plain and piedmont slope vegetation complex. Sites of cultural and historical significance for the Girramay Aboriginal people occur within the site as well as a range of rare, vulnerable and endangered flora and fauna.
QLD143 EDMUND KENNEDY WETLANDS	The site is a particularly good example of a coastal lowland complex of the southern Wet Tropics bioregion. It is also significant because of the diversity of wetland types contained and as habitat for rare and endangered species. It is an extension of the wetlands between the Tully and Murray River, which is one of the largest remnants of swampy coastal plain vegetation mosaic in the Wet Tropics bioregion. *Eleocharis* spp. dominated sedge swamp is not common in the Wet Tropics bioregion and is important waterbird habitat here.
QLD148 HINCHINBROOK CHANNEL	The site is one of the best examples of a major estuarine system in the southern Wet Topics.
QLD155 MISSIONARY BAY	The site is a spectacular example of a floristically rich estuarine system of the southern Wet Tropics bioregion. It is also significant because of the diversity of the wetland types in this environment, and as a habitat for rare and endangered species. The site is considered to be of high fisheries value.
QLD146 HERBERT RIVER FLOODPLAIN	The seaward edge of the delta is part of the most diverse and complex mangrove area in Australia (Missionary Bay-Hinchinbrook Channel-Halifax Bay) and is of international importance. The coastal edge of the delta forms part of an almost continuous strip of natural vegetation that runs along Hinchinbrook Channel and south along the shore of Halifax Bay towards Townsville. This strip provides a representative example of northern coastal wetland vegetation, which has become uncommon as a result of its location clash with human interests. The wetlands of the Herbert floodplain play a significant role in recharging groundwater and maintaining water quality in the river.
QLD005 BURDEKIN TOWNSVILLE COASTAL AGGREGATION	The Burdekin-Townsville Coastal wetland aggregation forms one of the most expansive wetland complexes on the east coastal of Australia. The aggregation is of international significance as migratory wader habitat; regionally important for breeding waterfowl and waterbird populations; habitat for a number of endangered and vulnerable fauna species; and supports important recreational and commercial fisheries.
QLD181 RAAF TOWNSVILLE	A unique wetland habitat. The site is recognised as a waterbird refuge and flora/fauna habitat. In particular, the area provides a drought refuge and breeding and feeding area for waterbirds.
QLD002 BOWLING GREEN BAY	The Bowling Green Bay wetland site lies within one of the most expansive wetland complexes on the east coast of Australia. It is of international significance as migratory wader habitat, an important stronghold for a number of endangered and vulnerable marine fauna species, regionally important for breeding waterfowl and waterbird populations and supports important recreational and commercial fisheries.
QLD100 GREAT BARRIER REEF MARINE PARK	The reef is the worlds largest and most complex expanse of living coral reefs, encompassing many unique forms of life. The area is recognised for its seagrass beds, estuarine wetlands, mangrove woodlands, island cays and coral atolls.

Source: Directory of Important Wetlands in Australia. 3rd Edition. *http://www.environment.gov.au/wetlands/wet.html*

SECTION 8 FISHERIES RESOURCES IN THE STUDY AREA

8.1 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 8.1 lists the habitat requirements for selected species of importance to the fisheries of the Study Area. The discussion of fisheries within the Study Area in the following sections focuses on species that are dependent on coastal wetland ecosystems at some stage of their life cycle.

TABLE 8.1 Habitat requirements for selected species of importance to the fisheries of the Study Area.

SPECIES	SPAWNING HABITAT	EGG AND LARVAL HABITAT	POST LARVAL AND JUVENILE HABITAT	ADULT HABITAT
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
FLATHEAD	Estuary mouths and nearshore sand bars	Estuarine waters	Estuaries and ocean beaches	Estuaries and ocean beaches
SAND WHITING	Mouths of estuaries and surf bars	Nearshore waters	Estuarine sandflats and ocean beaches	Estuarine sandflats and ocean beaches
SEA MULLET	Offshore coastal waters between Townsville and NSW border	Coastal waters	Tidal, brackish, and fresh waters	Estuarine and ocean beaches
SOOTY GRUNTER	Shallow eddies adjacent to rapids in coastal streams	Gravel beds in coastal freshwater streams	Coastal freshwater streams	Flowing, still, clear and turbid coastal waters
BLUE SWIMMER CRAB	Inshore waters and estuaries	Inshore waters and estuaries	Shallow estuaries and sand banks	Inshore waters
MUD CRAB	Offshore waters	Coastal waters	Intertidal waters in mangrove-lined estuaries	Subtidal waters in estuaries
BANANA PRAWNS	Inshore waters	Inshore waters	Mudflats in mangrove-lined estuaries	Turbid nearshore waters
BLUE-LEGGED ENDEAVOUR PRAWN	Nearshore waters	Inshore waters	Seagrasses and algal beds in estuaries and inshore waters	Inshore waters of GBR lagoon
BROWN TIGER PRAWN	Offshore waters	Offshore waters	Lower estuaries and inshore marine waters associated with seagrass beds	Inshore to offshore marine waters

Source: Zeller 1998

The fisheries values and the major habitat types of the coastal wetland systems that are currently declared as FHAs in this region are summarised in Table 8.2.

TABLE 8.2 Fisheries values and major habitat types protected within FHAs in the Study Area.

FHA NAME	FISHERIES VALUES	MAJOR HABITAT TYPES
TRINITY INLET	Barramundi, blue threadfin, bream, estuary cod, flathead, garfish, grey mackerel, queenfish, grunter, mangrove jack, whiting, tiger prawns, mud crabs	Extensive mangrove zones including *Rhizophora*, *Avicennia* and *Ceriops*; patchy areas of saltmarsh; intertidal flats
HULL RIVER	Barramundi, blue threadfin, bream, estuary cod, grey mackerel, grunter, mangrove jack, queenfish, school mackerel, whiting, blue-legged king prawns, tiger prawns, mud crabs	Extensive stands of mangroves present throughout the estuary with some *Melaleuca* swamps also present; sedge swamps and grasslands present
TULLY RIVER	Barramundi, blue threadfin, bream, estuary cod, grey mackerel, grunter, mangrove jack, queenfish, sooty grunter, school mackerel, whiting	Extensive *Rhizophora* stands associated with the estuary; *Melaleuca* forests present; sub-tidal and intertidal flats; vegetated and unvegetated salt flats and a sandy mouth
MURRAY RIVER	Barramundi, blue threadfin, bream, estuary cod, grey mackerel, grunter, mangrove, jack, queenfish, school mackerel, whiting, tiger prawns	Extensive *Rhizophora* zone associated with the estuary; *Melaleuca* forests present; sub-tidal and intertidal flats; vegetated and unvegetated salt flats; sandy foreshores and mouth
DALLACHY CREEK	Barramundi, blue threadfin, bream, estuary cod, grey mackerel, grunter, mangrove jack, queenfish, school mackerel, whiting	Extensive *Rhizophora* stands associated with the estuary; *Melaleuca* forests; sub-tidal and intertidal flats; vegetated and unvegetated salt flats
WRECK CREEK	Barramundi, blue threadfin, bream, estuary cod, grey mackerel, grunter, mangrove jack, queenfish, school mackerel, whiting	Extensive *Rhizophora* stands associated with the estuary; *Melaleuca* forests; sub-tidal and intertidal flats; vegetated and unvegetated salt flats
MEUNGA CREEK	Barramundi, blue threadfin, bream, estuary cod, grey mackerel, grunter, mangrove jack, queenfish, school mackerel, whiting	Extensive *Rhizophora* zone associated with the estuary; *Melaleuca* forests present; sub-tidal and intertidal flats; vegetated and unvegetated salt flats
HINCHINBROOK	Barramundi, blue threadfin, bream, estuary cod, grey mackerel, mangrove jack, queenfish, school mackerel, whiting, blue-legged king prawns, tiger prawns, aquaculture brood and culture stock, banana prawns	Extensive stands of mangroves including *Avicennia*, *Bruguiera*, *Rhizophora* and *Ceriops*; patchy salt marshes associated with the estuary with extensive seagrass beds recorded; deep water channels, island and bank shoals; deltaic mangrove systems
BOWLING GREEN BAY	Barramundi, blue threadfin, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, school mackerel, whiting, tiger prawns, banana prawns	Closed *Rhizophora* and *Ceriops* dominated mangrove stands with extensive areas of salt marsh; sparse seagrass beds have been recorded within the bay; exposed banks and freshwater lagoons
HALF MOON CREEK	Barramundi, blue threadfin, bream, estuary cod, grunter, mangrove jack, queenfish, whiting, recreational fishing, tiger prawns	Extensive stands of mangrove along creek and small bar zone
YORKEY'S CREEK	Barramundi, blue threadfin, bream, estuary cod, grunter, mangrove jack, queenfish, whiting, recreational fishing, tiger prawns	Mangrove-lined creek
BARR CREEK	Barramundi, blue threadfin, bream, estuary cod, grunter, mangrove jack, queenfish, whiting, recreational fishing, tiger prawns	Mangrove-lined creek
TRINITY INLET	Barramundi, blue threadfin, bream, estuary cod, flathead, garfish, grey mackerel, grunter, mangrove jack, queenfish, whiting, recreational fishing, tiger prawns, mud crabs	Extensive mangrove zones including *Rhizophora* *Avicennia* and *Ceriops*; seagrass beds are reported in the area of Redbank Creek; patchy areas of saltmarsh
HALIFAX	Barramundi, blue threadfin, bream, estuary cod, flathead, garfish, grey mackerel, grunter, mangrove jack, queenfish, recreational fishing, school mackerel, tiger prawns	Mangrove swamp with *Melaleuca* stands, *Rhizophora*, *Avicennia* and *Acanthus*
PALM CREEK	Barramundi, blue threadfin, bream, estuary cod, flathead, garfish, grey mackerel, grunter, mangrove jack, queenfish, recreational fishing, school mackerel, tiger prawns	Extensive stands of mangroves with *Rhizophora*, *Avicennia*, and Acanthis being dominant and patchy areas of salt marsh associated with the estuary; Ti-tree swamps and shallow watercourse also present; seagrass beds reported at the creek mouth
CATTLE CREEK	Barramundi, blue threadfin, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, school mackerel, tiger prawns	Extensive *Rhizophora* and *Avicennia* stands and salt marshes associated with the estuary; tidal channels and flats
BOHLE RIVER	Barramundi, blue threadfin, bream, estuary cod, flathead, grey mackerel, grunter, mangrove jack, queenfish, recreational fishing, sea mullet, school mackerel, tiger prawns, banana prawns, blue-legged king prawns	Extensive stands of mangrove, saltmarsh and unvegetated claypans along estuary

8.2 Commercial Fishing Activities

Trawl Fishery

The trawl fishery is the largest commercial fishery in Queensland in terms of catch. Target species include a number of species of prawns as well as saucer scallops. Some byproduct from the trawl fishery, including bugs, sand crabs and squid, is also kept for sale. A variety of prawn species contributes to the trawl fishery in the Study Area including tiger, endeavour, king and banana prawns. The catch of banana prawns in the Study Area represents a significant proportion of the statewide catch of this species (Figure 8.1). Banana prawns are typically taken in coastal waters adjacent to major estuaries, which act as nursery areas for this species (Williams 1997). The Study Area represents the southern limit of the most productive fishing grounds for tiger prawns in Queensland (Figure 8.1). Post larval and juvenile brown tiger prawns utilise lower estuaries and inshore marine waters associated with seagrass beds.

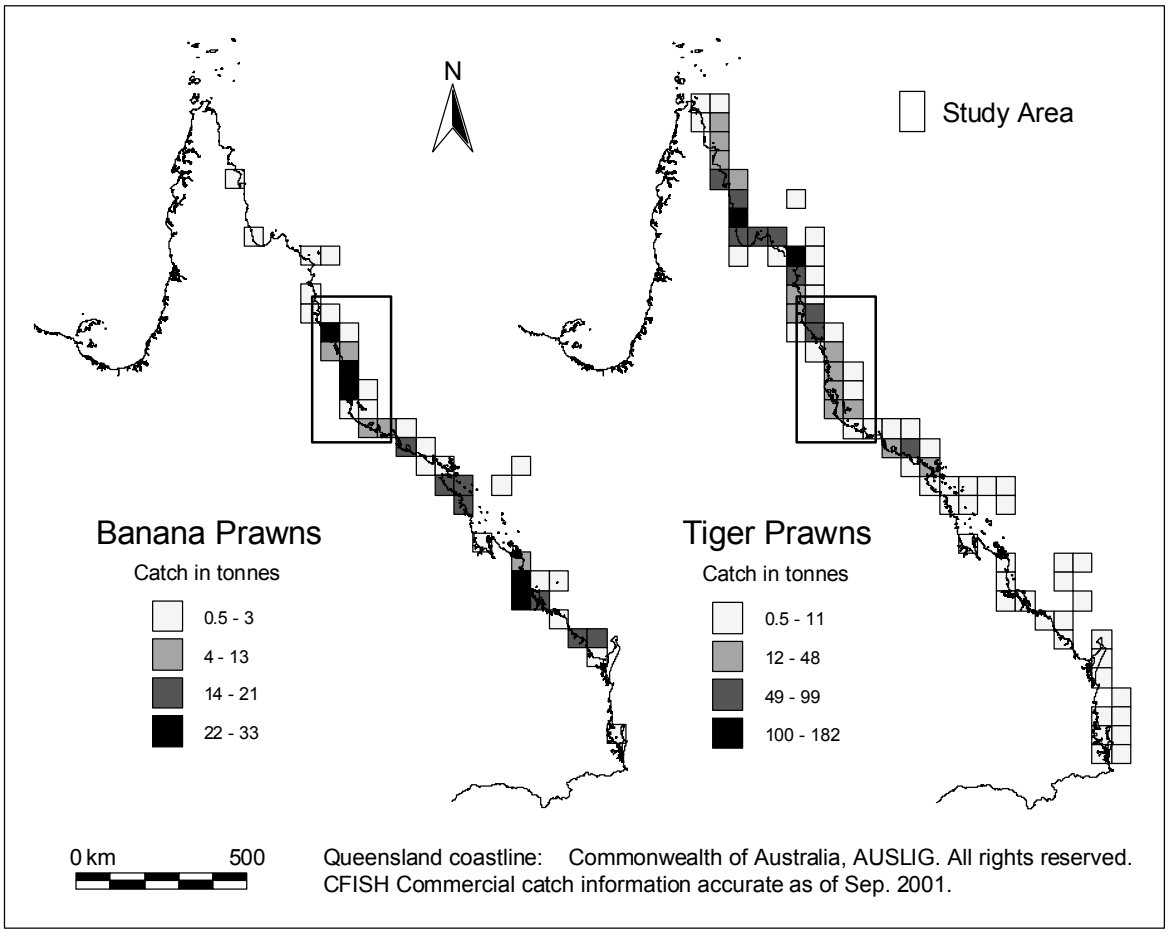

FIGURE 8.1 Commercial catch in tonnes of banana and tiger prawns by 30 minute grid, 2000.

Tropical Inshore and Estuarine Fishery

In tropical Queensland, the main commercial species targeted in the inshore and estuarine fishery are barramundi, king threadfin, blue threadfin, shark, mullet, and grey, school and spotted mackerel. In the Study Area, shark, mud crab, barramundi, grey mackerel, mullet, blue threadfin, queenfish, gar, and king threadfin are the main species that contribute to

the total catch of this fishery. Table 8.3 lists the total catch of these species within the Study Area over the past decade and the gross value of production (GVP) in the year 2000.

Figure 8.2 illustrates the total catch throughout Queensland of four of these species, which are particularly important to the fisheries of the Study Area. These species utilise estuarine habitats during their life cycle.

Extensive Saltpans and freshwater swamps from the Herbert River to Bowling Green Bay are 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.

Hinchinbrook Channel is particularly important habitat within the Study Area for mud crabs. The wide intertidal flats and extensive mangrove communities within the channel provide important habitat for both juvenile and adult mud crabs.

The total catch of both shark and threadfin in the Study Area represent a considerable proportion of the statewide catch of these species.

TABLE 8.3 Total catch and Gross Value of Production (2000) of the main species of importance to the tropical inshore and estuarine fishery in the Study Area.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	GVP ($K) 2000
SHARK - ALL	67	59	68	74	64	61	112	81	146	196	1174
MUD CRAB	62	58	54	44	55	62	86	159	184	162	1698
BARRAMUNDI	65	42	40	44	50	45	62	66	67	75	525
GREY MACKEREL	39	28	35	41	29	36	79	35	35	13	77
MULLET - ALL	42	31	39	36	35	34	32	35	36	43	130
BLUE THREADFIN	29	22	25	33	26	23	28	20	22	31	126
QUEENFISH	18	16	17	14	15	10	17	18	15	19	56
GAR - ALL	9	11	9	11	15	25	17	16	18	14	84
KING THREADFIN	15	9	11	9	9	10	12	15	20	15	59

Other Studies

Studies undertaken in specific estuaries have identified species of importance to the fisheries in the Study Area (Russell and Hales 1993; Russell et al. 1996a; Russell et al. 1996b; Russell and Hales 1997; Russell et al. 1998 and Russell et al. 2000). Species of importance to the commercial fishery of the Barron River include barramundi, threadfin, mullet, garfish, and mud crab (Russell et al. 2000). Barramundi, grunter and threadfins are targeted in the Moresby catchment (Russell et al. 1996a) and the Liverpool, Maria and Hull catchments (Russell and Hales 1997). In the Mossman and Mowbray catchments, barramundi, threadfin and mullet were identified as the main target species for commercial fishers (Russell et al. 1998). Commercial fishing in Hinchinbrook Channel targets barramundi, mullet, blue and king threadfin and shark (Johns 1997). Prawns are also targeted in offshore waters throughout the Study Area.

An inventory of the fisheries resources of the region from Tully to Bowen has been compiled (Ludescher 1997). This study identifies the multi-species prawn fishery as being the most important fishery in the region, in terms of tonnage landed. The main estuarine fish species of importance is barramundi. The main fishing grounds for this species (located within the current Study Area) are situated adjacent to estuaries including Missionary Bay, Hinchinbrook Channel, Cattle Creek, Bohle River, Ross River, Alligator Creek, Haughton River and Barratta Creek (Ludescher 1997). Mud crabs were also identified as an important species for the commercial fisheries of the region. The main fishing grounds (located within the current Study Area) are located in Hinchinbrook Channel, Missionary Bay and Bowling Green Bay.

8.3 Recreational and Indigenous Fishing Activities

Very limited information on recreational and indigenous fishing activities is available for the Study Area. Recreational fishing occurs to varying degrees in most accessible creeks and estuaries in the Study Area and along the beach near population centres. Indigenous fishing is undertaken for recreation and subsistence along beaches, in the creeks and estuaries, around the Palm Islands and at some nearshore reefs. Fish, shellfish, turtles and dugongs are important food sources for the Palm Island Aboriginal community (Ludescher 1997).

The Bramble Reef Study by the GBRMPA documents the extent of indigenous fishing in the Hinchinbrook area (Ludescher 1997). Other quantitative data on indigenous fishing in the Study Area is not available. 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 1999). In this study, the need for an investigation into the allocation of estimated recreational fish catches to specific fishing regions around the state was identified.

Some studies undertaken in the Study Area document species targeted in the recreational fishery in various catchments. Recreational species targeted in the Barron catchment include barramundi, mangrove jack, threadfin salmon, whiting, sooty grunter, pikey bream, silver bream, flathead, trevally, silver jewfish, mullet, queenfish, blue swimmer crabs and mud crabs (Russell et al. 2000). Species of importance to the recreational fishery in Hinchinbrook Channel include grunter, mangrove jack, barramundi and fingermark bream and to a lesser extent bream, whiting and flathead (Johns 1997).

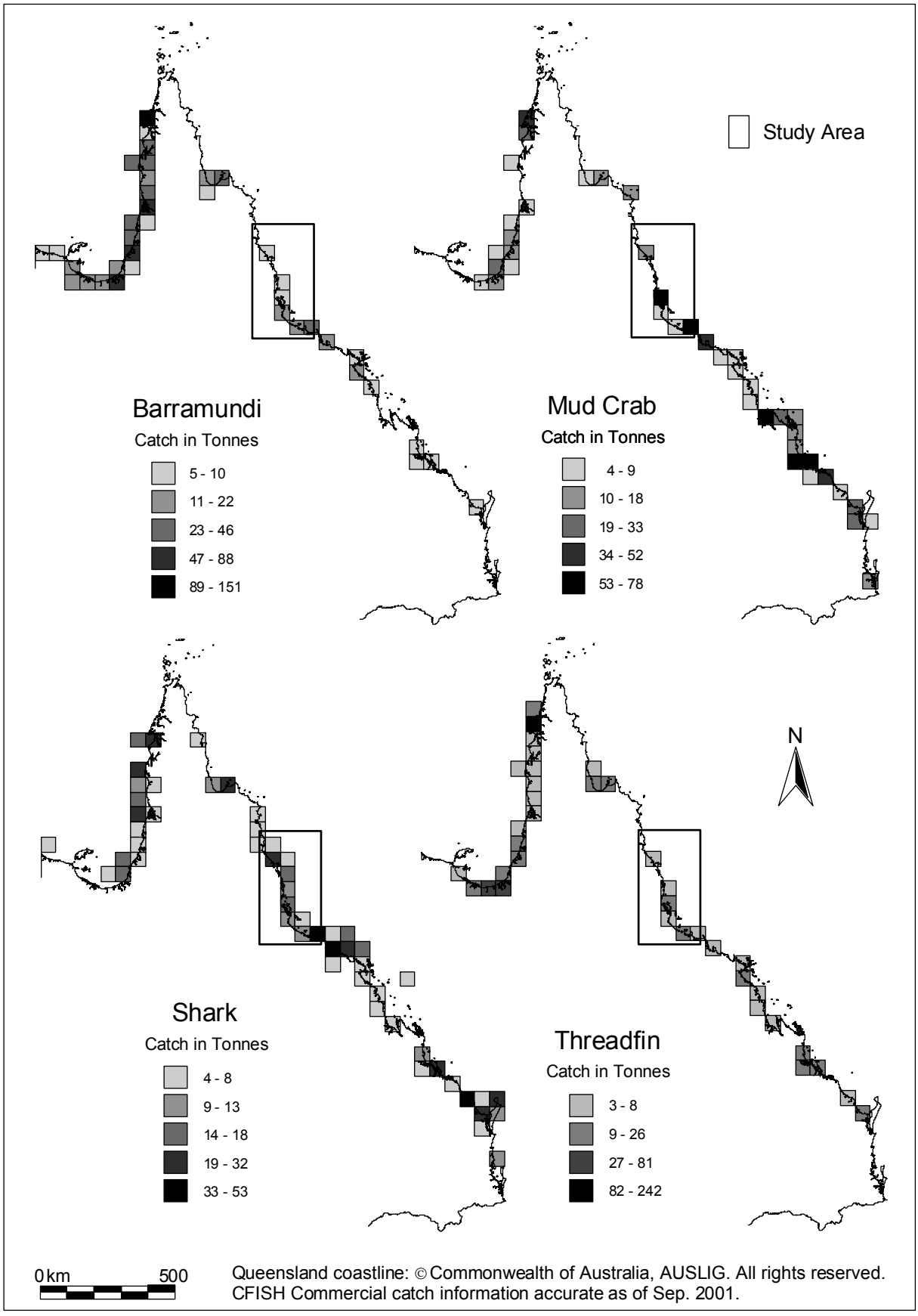

FIGURE 8.2 Commercial catch in tonnes of barramundi, mud crab, shark and threadfin by 30 minute grid, 2000.

SECTION 9 APPLICATION OF THE DATASET TO FISH HABITAT AREA (FHA) PLANNING

9.1 FHA Declaration Process

FHAs are part of the on-going management of fisheries resources within Queensland and are declared with the specific intent to ensure the sustainability 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, Queensland 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 on the basis of the following criteria:

- Size
- Diversity of / or specific habitat features
- Diversity of / or specific marine fauna and flora
- Level of existing and future disturbances
- Unique features
- Existing or potential fishing grounds
- Protected species

A summary of the characteristics of coastal wetlands of the Study Area, based on these criteria, is included in Table 9.1. Details of the categories are included in Table 3.4 and Table 9.2.

Further details of the significance of specific coastal wetland communities are outlined in Section 5. This report concentrates on the identification of suitable areas for fisheries conservation from a coastal wetland community perspective.

9.2 Coastal Wetland Characteristics

TABLE 9.1 Summary of characteristics of coastal wetlands of the Study Area, as described in Table 9.2.

WETLAND	AREA OF COASTAL WETLAND COMMUNITIES (ha)	DIVERSITY OF MANGROVE /SALTMARSH COMMUNITIES (#)	INTERTIDAL FLATS	SEAGRASS COMMUNITIES	ADJACENT FRESHWATER SWAMPS	MANGROVE SPECIES DIVERSITY (DUKE 1997)	SIGNIFICANT DAMS AND WEIRS	DISTURBANCE TO ADJACENT TERRESTRIAL VEGETATION	RECOGNISED/IMPORTANT FISHING GROUNDS	UNIQUE FEATURES	SUITABLE FOR FHA NOMINATION	EXISTING FHA
DAINTREE CATCHMENT	2 64											
Alexandra Bay	**575**	M				-		**NP**		✔	✔	
Daintree River	**1 927**	M	✔			27		**LU**		✔	✔	
Saltwater Creek (1)	145	L				-		M				
MOSSMAN CATCHMENT	1 44											
Mossman Creek	108	M				-		M				
Dickson's Inlet	**1 157**	M	✔			-		M				
Mowbray Creek	170	M	✔			-		M				
Hartley's Creek	5	L				-		**NP**				
BARRON CATCHMENT	95											
Cairns Beaches (including Trinity Beach)	200	M				-		M	✔			✔
Yorkey's Knob	210	M				-		M	✔			
Barron River	**545**	M	✔			-	✔	M				✔
MULGRAVE–RUSSELL CATCHMENT	4 05											
Trinity Inlet	**3 225**	M	✔	✔		24		SI	✔	✔	✔	✔
Mission Bay	236	M	✔	✔	✔	-		**NP**				
Saltwater Creek (2)	70	L		✔	✔	-		**NP**				
Mulgrave–Russell River	**527**	L	✔		✔	20		**LU**		✔	✔	
JOHNSTONE CATCHMENT	3 28											
Un–named Creek	71	L			✔	-		**NP**				
Johnstone River	133	L	✔			-	✔	M		✔		
Moresby River	**2 660**	M		✔	✔	21		M			✔	
Liverpool Creek	85	M		✔	✔	-		M				
Maria Creek	**304**	M		✔		-		M		✔	✔	
Garners Beach	34	L	✔			-		M				
TULLY CATCHMENT	1 66											
Bingal Bay	1	L	✔	✔		-		M				
Hull River	**1 192**	M	✔			21		**LU**		✔	✔	✔
Tully River	**474**	L	✔		✔	18	✔	**LU**		✔	✔	✔
MURRAY CATCHMENT	9 72											
Murray River	**1 208**	M	✔		✔	27		**NP**		✔	✔	✔
Dallachy–Wreck–Meunga Creek	**1 231**	M	✔		✔	-		**NP**			✔	✔
Hinchinbrook Island	**7 461**	M	✔	✔	✔	25		**NP**	✔	✔	✔	✔
Hinchinbrook Channel	**7 289**	M	✔	✔		21		**LU**	✔	✔	✔	✔
HERBERT CATCHMENT	12 22											
Herbert River	**6 837**	H	✔			11	✔	SI		✔	✔	✔
Bulgaroo–Orient–Cattle–Elanor Creek	**5 392**	M	✔	✔	✔	-		M	✔		✔	✔
BLACK CATCHMENT	78											
Crystal Creek	61	L	✔			-		**LU**				
Rollingstone Creek	74	L	✔			-		**NP**				
Saltwater (3)–Un-named Creek	147	M	✔			-		**LU**				
Leichhardt–Christmas Creek	200	L		✔		-		**LU**				
Bluewater–Althaus–Black Creek	**303**	M	✔			-	✔	M				
ROSS CATCHMENT	12 28											
Bohle River	**1 775**	M	✔	✔	✔	-		**LU**	✔		✔	✔
Shelly Beach	39	L	✔	✔		-		**NP**				
Pallarenda	137	M				-		M				
Cleveland Bay	**9 220**	M	✔	✔	✔	16	✔	M	✔	✔	✔	
Chunda Bay	**893**	M		✔		-		**LU**				
Magnetic Island	218	M	✔	✔		-		**NP**				
HAUGHTON CATCHMENT	19 46											
Bowling Green Bay (this study)	**19 461**	H	✔	✔	✔	10	✔	M	✔	✔	✔	✔

TABLE 9.2 Details of the coastal wetland significance assessment.

CRITERIA	SUBCATEGORIES	DETAILS
Size	Area of Coastal Wetland Communities	**Area in hectares of coastal wetland communities** as mapped in this study. Large areas of coastal wetland communities make a significant contribution to the primary productivity of estuarine areas. Areas over 300 ha were considered suitable (1pt), and areas over 500 ha were considered most suitable (2pt) for FHA nomination.
Diversity of or specific habitat features	Diversity of Mangrove and Saltmarsh Communities	**High (H)**: 10–13 mangrove and saltmarsh communities present (1pt)
		Medium (M): 5–9 mangrove and saltmarsh communities present (1pt)
		Low (L): 1–4 mangrove and saltmarsh communities present
		The number of mangrove and saltmarsh communities, calculated based on the coastal wetland mapping conducted for this study. Protecting a variety of mangrove and saltmarsh habitats will ensure a comprehensive suite of habitats that support fisheries species.
	Presence of Intertidal Flats	**Existence of significant intertidal flats (✔)** (1pt). Intertidal flats are one of a range of habitats that support fisheries species (see Section 2.2). Comments are based on aerial photograph interpretation and the foreshore flats coverage of the digital GEODATA TOPO-250K topographic map series (AUSLIG 1994).
	Presence of Seagrass Communities	**Area where seagrass communities have been identified within the Study Area (✔)**(1pt). Seagrass meadows are one of a range of habitats that support fisheries species (see Section 2.2). The distribution of seagrass meadows within the reporting areas was determined from information gathered from literature review (Coles et al. 1985, Coles et al. 1992, Lee Long et al. 1996, Lee Long et al. 1998 and Lee Long et al. 1999). Seagrasses may inhabit other regions within the Area, however these regions have not been surveyed in the literature reviewed.
	Adjacent Freshwater Swamps	**Presence of freshwater swamps (✔) adjacent to coastal wetland communities.** Freshwater swamps are one of a range of habitats that support fisheries species (see Section 6.1). The "swamp" coverage from the digital GEODATA TOPO-250K topographic map series (AUSLIG 1994) was used.
Diversity of or specific marine fauna and flora	Diversity of Mangrove Species	**Mangrove species diversity after Duke 1997**. Information for all estuaries was not available. Comprehensive surveys of species diversity for each coastal wetland system were not conducted as part of this investigation. Information concerning the diversity of fauna was not included in this evaluation.
Level of existing and future disturbances	Significant Dams and Weirs	**Presence (✔) of significant dams or weirs** on the river or creek. Dams and weirs in the Study Area have the potential to impact on fish migrations and available fish habitat, depending on the type of obstruction within the river. For example, weirs on the Haughton River have prevented breeding migrations, which have caused the disappearance of jungle perch populations from upstream tributaries (Ludescher 1997). The locations of major dams and weirs in the Study Area, collected by the Dept. of Natural Resources and Mines are displayed in Figure 5.1.
	Disturbance to Adjacent Terrestrial Vegetation	**Near Pristine (NP)** : natural cover >90% (1pt)
		Largely Unmodified (LU) : natural cover ~65–90% (1pt)
		Modified (M) : natural cover ~35–65%
		Severely Impacted (SI) : natural cover <35% (-1pt)
		Some landuses adjacent to coastal wetland systems and stream habitats may have a negative impact on the quality of fish habitat. Adjacent terrestrial vegetation serves to protect coastal wetlands from the effects of human development in the catchment. Adjacent terrestrial vegetation refers to the vegetation within 5 km of the upper intertidal limit and is described in Section 5.
Unique Features	Unique Features	**Presence (✔) of unique features** (2pt). The details of these features are included in Section 5 and are listed in Table 7.1.
Existing or potential fishing grounds	Recognised/ Important Fishing Grounds	**Significant (✔) fishing grounds** (1pt). Assessed from local knowledge of each coastal wetland system and/or from literature review. Further details are included 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 collected as part of this study.
Suitable for FHA Nomination		Score of >5 for an estuary based on the points allocated to the criteria above.
Existing FHA		Presence of existing declared FHA of either management A or B status.

Note: Symbols presented here (e.g. ✔) refer to symbols used to summarise the results of the coastal wetland assessment in Table 9.1.

9.3 Coastal Wetland Communities Currently Included in FHAs

Of the approximately 76 000 ha of coastal wetland vegetation in the Study Area, a large area (15 175 ha) is currently protected within declared FHAs. 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.

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 (see Table 9.1). However, some important fish habitats have so far not been the focus of detailed FHA investigation. The current gaps in the protected area network are discussed below.

TABLE 9.3 Area of coastal wetland communities within FHA's in the Study Area.

	AREA OF COASTAL WETLAND COMMUNITIES IN FHA (ha)														
	CLOSED *RHIZOPHORA*	CLOSED *AVICENNIA*	OPEN *AVICENNIA*	CLOSED *CERIOPS*	OPEN *CERIOPS*	CLOSED *RHIZOPHORA*/*AVICENNIA*	CLOSED *AVICENNIA*/*CERIOPS*	OPEN *AVICENNIA*/*CERIOPS*	CLOSED MIXED	CLOSED *BRUGUIERA*	SALINE GRASSLAND	SALTPAN	SAMPHIRE-DOMINATED SALTPAN	TOTAL AREA OF COASTAL WETLAND COMMUNITIES	TOTAL AREA OF FHA
WTC IMCRA region															
Half Moon Creek	56	17	1	94	0	0	0	0	2	0	0	1	7	178	214
Yorkey's Creek	16	0	0	6	0	0	0	0	0	0	0	0	0	22	29
Barr creek	21	4	0	7	0	0	0	0	5	0	0	2	0	39	52
Trinity Inlet	1 756	33	0	965	10	27	0	0	66	347	0	10	3	3 216	7 310
Hull River	113	0	2	225	0	0	0	0	331	28	0	0	0	699	1 153
Tully River	2	0	0	0	0	0	0	0	9	12	0	0	0	24	162
Murray River	141	0	0	105	3	0	0	0	72	57	0	0	0	378	1 010
Dallachy Creek	12	0	0	2	0	0	0	0	28	20	0	0	1	63	126
Wreck Creek	1	0	0	2	0	0	0	0	8	7	0	0	0	18	239
Meunga Creek	7	0	0	0	0	0	0	0	1	0	0	0	0	8	294
Hinchinbrook	3 810	7	0	746	10	0	2	0	1 220	199	0	6	0	5 999	12 274
LMC IMCRA region															
Halifax	224	24	0	591	2	0	0	0	704	28	8	0	0	1 582	3 342
Palm Creek	236	71	0	131	0	0	0	0	158	0	58	19	6	678	1 070
Cattle Creek	204	83	2	477	0	0	0	0	201	0	47	381	59	1 454	2 247
Bohle River	59	27	0	111	0	16	0	0	83	0	22	304	5	627	1 309
Bowling Green Bay	92	36	6	45	0	3	0	0	8	0	0	1	0	190	68 627

9.4 Representative Areas to be Considered as Potential FHAs

Figure 9.1 illustrates the extent of FHAs in the Wet Tropic Coast and Lucinda–Mackay Coast IMCRA regions with a particular focus on the Study Area. No FHAs have been declared north of Half Moon Creek in the Wet Tropic Coast IMCRA region. Mangrove species diversity is particularly high in this region. In this region, the coastal wetland vegetation of Alexandra Bay and the Daintree River are important fish habitat, suitable for consideration for FHA status.

The coastal wetland vegetation of Alexandra Bay is already protected as National Park and as such, investigations of this area for inclusion in a FHA should not be considered as a high priority. However, the fish habitat values, as well as the biodiversity and naturalness values of this estuary should be recognised.

Twenty-seven species of mangrove have been recorded in the Daintree River estuary (Duke 1997). The coastal wetland vegetation in this estuary is diverse and relatively undisturbed. Large areas of the Daintree catchment have been protected in National Parks. Additionally, Marine Parks cover a significant proportion of the estuarine communities of the Daintree River. However, significant coastal wetland vegetation on the northern bank of the Daintree River is currently not included in any of these protected areas. Russell et al. (1998) suggested that consideration should be given to establishing a FHA in the Daintree catchment to cover tidal and freshwater wetlands currently excluded from Marine Parks. The results of this study support the establishment of a FHA along the Daintree River. The land tenure of the section of the Daintree River estuary that is not protected in a Marine Park or National Park is Freehold.

Within the Study Area, a large gap in the FHA network exists from the Trinity Inlet FHA to the Hull River FHA. Moreover, no coastal wetland communities of the Johnstone catchment are represented in FHAs. The main coastal wetland communities in this region include those in Mission Bay, Saltwater Creek (2), the Mulgrave–Russell River, Johnstone River, Moresby River, Liverpool Creek and Maria Creek. The estuaries of the Mulgrave–Russell Rivers, Moresby River and Maria Creek have been identified in this Study as potential areas for future FHA declaration. A large proportion of the coastal wetland vegetation of these systems is already protected in National Parks or Marine Parks. However, the value of these areas as fish habitat should be recognised. Both the Moresby and Maria Creek systems fall in the Johnstone catchment and should be considered for inclusion in FHAs.

Russell et al. (1996a) also suggested an investigation into the potential for extending the Marine Park and/or establishing a Fish Habitat Area in the Moresby River region, to include both non-tidal wetlands and the remainder of the tidal wetlands not already protected. Tidal wetlands include areas along Walters Creek, major seagrass beds in the main estuary and tidal parts of the Moresby River upstream of the existing Marine Park. Non-tidal wetlands, including areas of *Melaleuca* forest, adjacent to but excluded from existing Marine Park, should also be considered for inclusion in a new FHA. The coastal wetland communities of Walters Creek are currently tenured as State Land.

Russell and Hales (1997) suggested an investigation into the establishment of a new FHA over the wetlands and seagrass meadows near the Maria Creek estuary. The coastal wetland vegetation of this area is currently protected in the Maria Creek National Park.

The coastal wetland vegetation of the Tully River experiences the highest annual rainfall in the Study Area. Consequently, the coastal wetland vegetation is both diverse and tall. This unique area is currently not protected by National Park or Marine Park. Additionally, the Tully River FHA protects only an insignificant proportion of the coastal wetland vegetation present in the estuary. The adjacent terrestrial vegetation is largely unmodified, with National Park protecting vegetation to the south of the estuary. The protection of the coastal wetland vegetation within this estuary should be considered as a high priority.

The large area of coastal wetland vegetation in Cleveland Bay is part of a variety of fish habitats that are represented in the area. Although the development of Townsville has occurred close to the coastal wetland vegetation on the western side of the Bay, terrestrial vegetation adjacent to the coastal wetland vegetation on the eastern side of the Bay is largely unmodified. Some of the coastal wetland vegetation here is already protected by National Park. However, a large area is currently tenured as State Land. This area should be considered for inclusion in a FHA. A reserve currently exists between the coastal wetland vegetation here and the Freehold land of the Stuart Industrial Area. This reserve may provide a suitable buffer between future industrial development of this area and fish habitats in the Bay.

Although Saltpan communities represent a large proportion of coastal wetland communities in the Study Area (approx. 30%), very little of this habitat is currently protected as fish habitat. The largest area of Saltpan within the Study Area is at Bowling Green Bay. The Bowling Green Bay FHA protects very small areas of coastal wetland communities. Most of the Saltpan here is protected in the Bowling Green Bay National Park. However, these Saltpans have not been recognised specifically for their value as fish habitat. Saltpans such as these are important seasonal habitat for barramundi.

Fish habitat along the Haughton River, upstream of the existing Marine Park, is currently recognised as wetland of international importance (Bowling Green Bay Ramsar site). However, this area is excluded from protection in the Bowling Green Bay National Park and Marine Park. The establishment of a FHA in this region, including both freshwater and tidal wetlands, should be considered as a priority.

A number of existing FHAs contain only a very small area of coastal wetland vegetation (e.g. Hull River, Palm Creek and Cattle Creek FHAs). Consideration should be given to extending these FHAs to include coastal wetland vegetation adjacent to the current boundary. Russell and Hales (1997) also suggested the extension of the Hull River FHA. Both tidal and freshwater wetlands in the Halifax Bay area (adjacent to the Palm Creek and Cattle Creek FHAs) should be considered for inclusion in FHAs. A large area of coastal wetland vegetation in this region is currently tenured as State Land.

The potential to include any freshwater habitats adjacent to existing or future FHAs should be considered. Freshwater wetlands within the Study Area have decreased significantly in area over the past few decades. Protection of any remaining freshwater wetlands in the Study Area is recommended as a priority. Freshwater wetlands adjacent to the Cattle Creek and Palm Creek FHA may be suitable for inclusion in protected areas. Habitats such as the coastal swamps and low-lying coastal flood plains in the Halifax Bay area may serve as nursery areas for the juvenile barramundi in the region.

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.

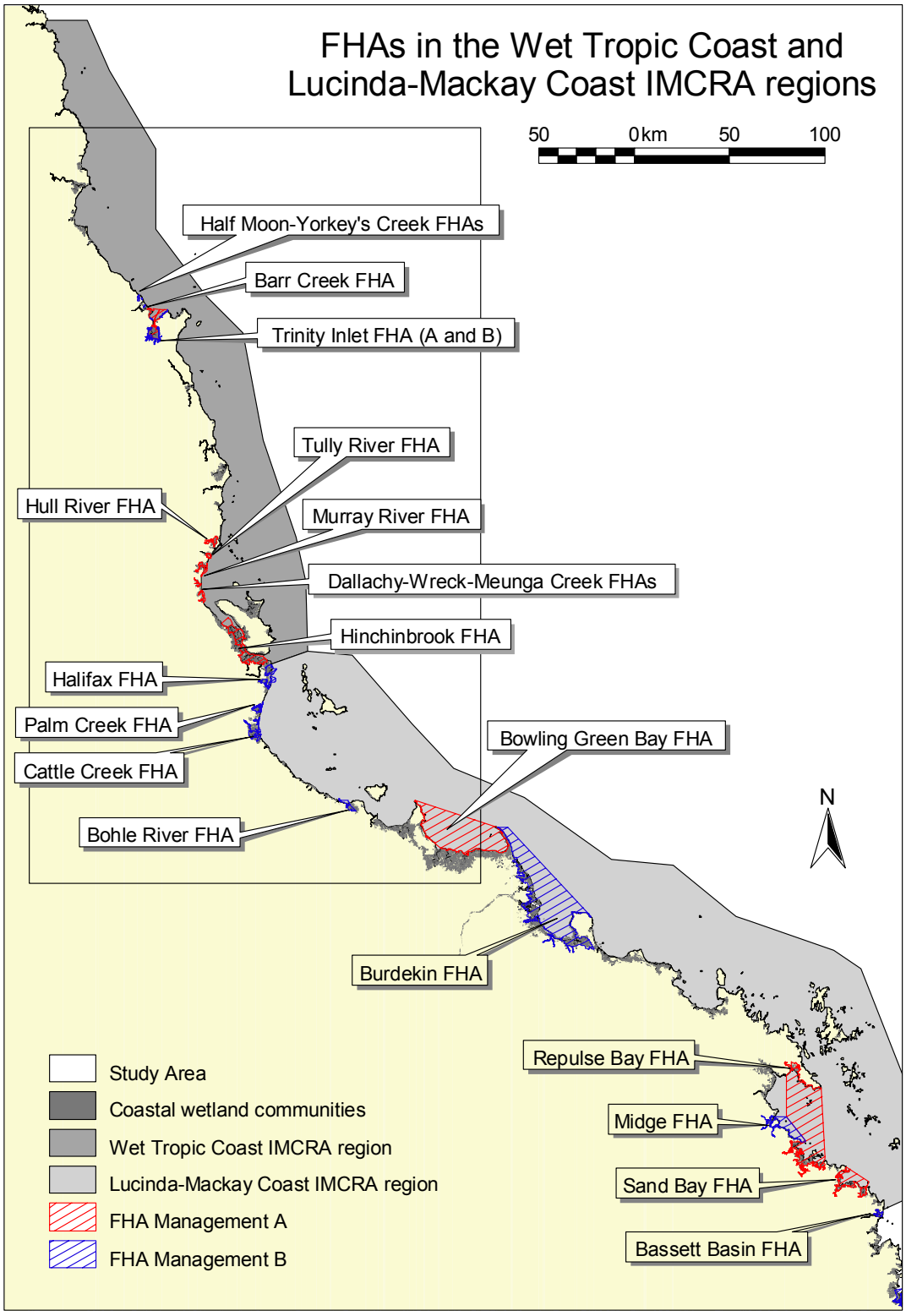

FIGURE 9.1 FHAs in the Wet Tropic Coast and Lucinda–Mackay Coast IMCRA regions.

SECTION 10 RECOMMENDATIONS

Important fish habitats within this Study Area are well represented in existing declared FHAs, Marine Parks and National Parks. Of the approximately 76 000 ha of coastal wetland vegetation in the Study Area, 15 175 ha is currently protected within declared FHAs. 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 (Section 9.4).

The following recommendations for new FHAs in the Study Area should be considered:

- No FHAs have been declared north of Half Moon Creek FHA in the Wet Tropic Coast IMCRA region. In this region, the coastal wetland vegetation of Alexandra Bay and the Daintree River are important fish habitat, suitable for consideration for FHA status.
  - Consideration should be given to establishing a FHA in the Daintree catchment to cover tidal and freshwater wetlands currently excluded from Marine Parks.
  - The fish habitat values of the coastal wetland vegetation of Alexandra Bay, as well as the biodiversity and naturalness values of this estuary should be recognised.
- Within the Study Area, a large gap in the FHA network exists from the Trinity Inlet FHA to the Hull River FHA.
  - In this region, the estuaries of the Mulgrave–Russell Rivers, Moresby River and Maria Creek should be considered for inclusion in FHAs.
- The fish habitats of Cleveland Bay, including a large area of coastal wetland vegetation, which is currently tenured as State Land, should be considered for inclusion in a FHA.

Extension of some existing FHAs is also recommended:

- Of a high priority is the extension of the Tully River FHA to include the diverse coastal wetland vegetation in this estuary, which is not currently protected by either Marine Park or National Park. The current Tully River FHA does not include a large proportion of coastal wetland vegetation.
- Extension of the Bowling Green Bay FHA to include both freshwater and tidal wetlands should be considered as a priority. In particular, fish habitat along the Haughton River, upstream of the existing Marine Park should be considered. This area is currently recognised as wetland of international importance (Bowling Green Bay Ramsar site). However, this area is excluded from protection in the Bowling Green Bay FHA, National Park and Marine Park.
- The Hull River, Palm Creek and Cattle Creek FHAs contain only a very small area of coastal wetland vegetation. Consideration should be given to extending these FHAs to include coastal wetland vegetation adjacent to the current boundary. In particular, both tidal and freshwater wetlands in the Halifax Bay area (adjacent to the Palm Creek and Cattle Creek FHAs) should be considered for inclusion in FHAs.

The focus of this study has been tidal coastal wetlands, namely mangrove and saltmarsh communities. However, the study has highlighted the need for protection of freshwater coastal wetlands. Within the Study Area, freshwater coastal wetlands have decreased significantly in area over the past few decades. Protection of any remaining freshwater wetlands in the Study Area is recommended as a priority, in order to provide protection for a wide variety of habitats necessary for the life cycles of fisheries species and maintain the connectivity between these habitats.

Reports in the Queensland Coastal Wetland Resources Series:

This report contributes to a series of reports outlining the status of coastal wetland resources in Queensland. Other reports in the series include:

Bruinsma, C (2000). Queensland Coastal Wetland Resources: Sand Bay to Keppel Bay. Information Series QI00100. Department of Primary Industries, Queensland, Brisbane.

Bruinsma, C and Duncan, S (2000). Queensland Coastal Wetland Resources: the Northern Territory Border to the Flinders River. Information Series QI00099. Department of Primary Industries, Queensland, Brisbane.

Bruinsma, C and Danaher, K (2000). Queensland Coastal Wetland Resources: Round Hill Head to Tin Can Inlet. Information Series QI99081. Department of Primary Industries, Queensland, Brisbane.

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.

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Duncan, S and Bruinsma, C (unpublished report). Queensland Coastal Wetland Resources: South East Queensland. Department of Primary Industries, Queensland, Brisbane.

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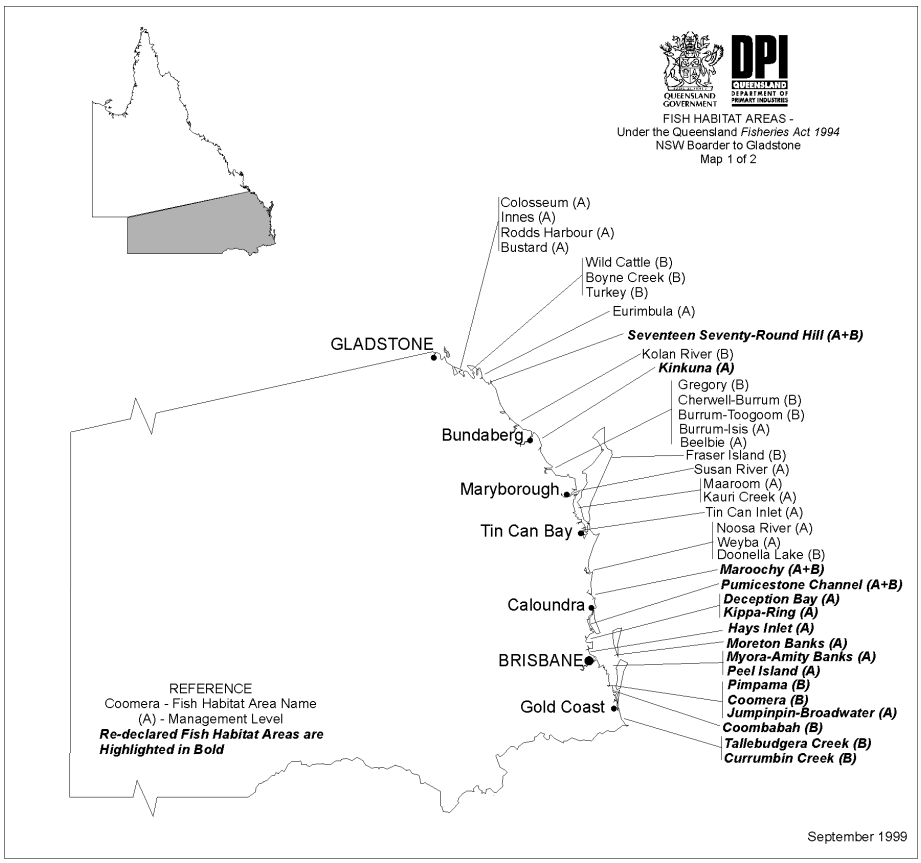
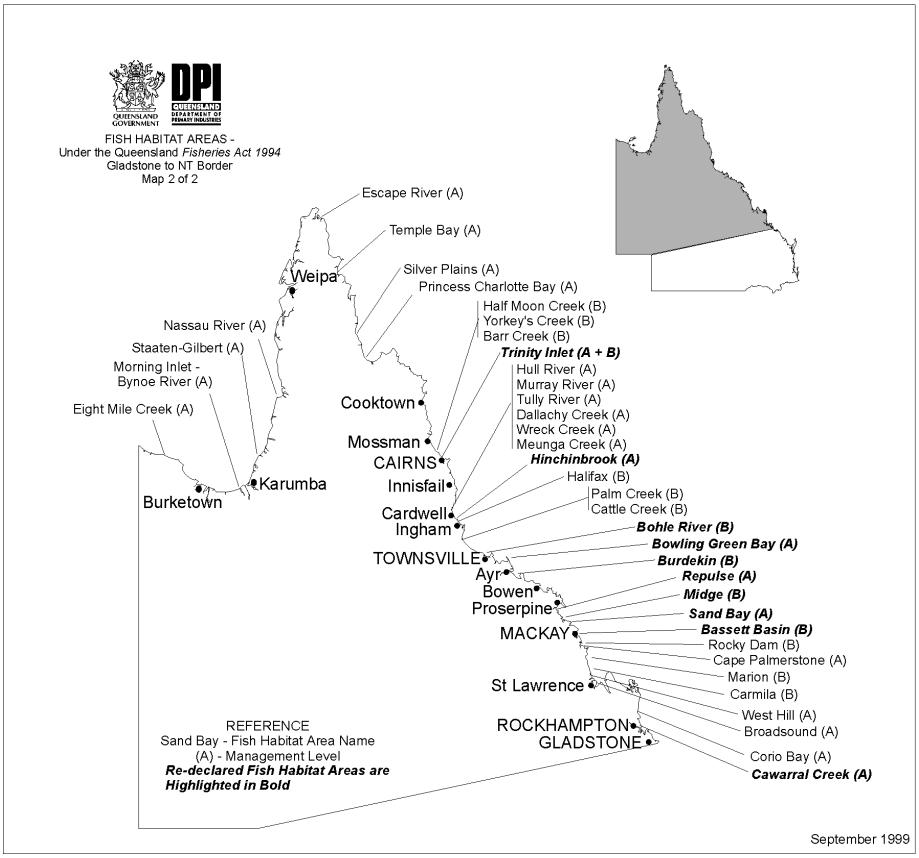
APPENDIX 1: DECLARED FHAS IN QUEENSLAND





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

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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:

Southern Fisheries Centre
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

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(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.

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 30 x 30 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 5: METADATA LISTING

Dataset	DSIN	10402
	Title:	Queensland Coastal Wetland Vegetation: Cape Tribulation to Bowling Green 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 Cape Tribulation to Bowling Green Bay.
	Search Word(s):	Mangrove, Remote Sensing, Coastal Wetland Vegetation, Saltpans, Saltmarshes.
	Geographic Extent:	Wet Tropics
	Geographic Extent Coordinates:	North: 16.1 South: 19.5 East: 147.3 West: 145.4
	Beginning date:	1/9/2000
	Ending date:	1/8/2001
Dataset Status	Progress:	Complete
	Maintenance and update frequency:	Not Required
Access	Stored Data Format:	DIGITAL - ARC/INFO, DIGITAL - pdf, NON DIGITAL - Printed maps, A3
	Available Format Type:	DIGITAL - ARC/INFO, DIGITAL - ArcView Shapefile (.shp), DIGITAL - pdf, NON DIGITAL - Printed maps, A3
	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: Atherton 07-09-1997 (Daintree and Mossman catchments), Cairns 28-06-1997 (Barron and Mulgrave–Russell catchments), Ingham 28-06-1997 (Johnstone, Tully, Murray and Herbert catchments), Townsville 24-06-1998 (Ross and Haughton catchments) and Charters Towers 08-1999 (Black catchment). 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 and 1990, 1: 50 000, BPA Townsville to Cooktown 1993/1994. 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 TM imagery rectified to MGA with final radiometric correction and GCP's. DATUM GDA94 ANS
	Attribute Accuracy:	Overall accuracy 90%. See report for users and producers 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
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Metadata Creation:	Creation Date:	21/8/2001
	Created By:	bruinsc
Metadata Update:	Last Update Date:	21/8/2001
	Last Updated By:	bruinsc
Other	Scale:	1:100 000
Program	Program Name:	Queensland Coastal Wetlands Mapping Project
	Program Coordinator:	Malcolm Dunning
Documentation	Reference:	Bruinsma (2001). Queensland Coastal Wetland Resources: Cape Tribulation to Bowling Green Bay, North Queensland. Department of Primary Industries, Queensland, Brisbane.
	Online Link:	
Funding	Funding organisation:	Environment Australia – Marine Protected Areas Program, Coast and Clean Seas
	Funding Contact:	Prue Gaffey

APPENDIX 6: DISTRIBUTION OF COASTAL WETLAND COMMUNITIES IN THE STUDY AREA

Maps displaying the distribution of coastal wetland vegetation in the Study Area are included on the CD available with this report. Two files for each map are available in .pdf format, one created with print optimised settings and the other created with screen optimised settings. The map sheets are labelled from north to south as follows:

Sheet 01: Cape Tribulation
Sheet 02: Daintree River
Sheet 03: Port Douglas
Sheet 04: Hartley's Creek
Sheet 05: Barron River
Sheet 06: Trinity Inlet
Sheet 07: Mulgrave River
Sheet 08: Mulgrave–Russell Rivers
Sheet 09: Johnstone River
Sheet 10: Moresby River
Sheet 11: Maria Creek
Sheet 12: Hull River
Sheet 13: Cardwell
Sheet 14: Missionary Bay
Sheet 15: Hinchinbrook Channel
Sheet 16: Herbert River
Sheet 17: Victoria Creek
Sheet 18: Bulgaroo Creek
Sheet 19: Rollingstone Creek
Sheet 20: Black River
Sheet 21: Magnetic Island
Sheet 22: Alligator Creek
Sheet 23: Cape Ferguson
Sheet 24: Haughton River
Sheet 25: Barratta Creek

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 of northern Queensland, from Cape Tribulation to Bowling Green Bay. This classification contributes the final component of the baseline assessment of Queensland's coastal wetland resources. 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-1990s. The coastal wetlands of the entire Queensland coastline have been mapped using this technique.

Effectiveness

The method of investigating and mapping relatively large coastal regions, utilised in this study, has proven to be cost effective and highly accurate (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 Cape Tribulation to Bowling Green 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, indigenous and commercial fisheries in the region. As a result of this project, numerous environments have been identified in the study area that 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 and the Coastal Habitat Resource Information System website (*http://chrisweb.dpi.qld.gov.au/chris/*).

APPENDIX 8: FIELD DATA

Date	Locality	Site #	Latitude	Longitude		Community Classification	Species Present
06/04/01	Cromarty Ck	1A	-19.48944	147.11889	?	Closed Mixed	Ds Xylo m, op Rhiz sp, Av, Exco & Aeg
06/04/01	Cromarty Ck	1B	-19.47444	147.12111	?	Closed Mixed (8m)	Op Xylo, Av, Exco, Aeg & sp Rhiz
06/04/01	Cromarty Ck	1C	-19.46806	147.11972	?	Closed Av (5m)	Op Xylo & Aeg, sp Rhiz
06/04/01	Cromarty Ck	2A	-19.49417	147.07694	?	Closed Mixed (6m)	ds Av, op Cer, Exco & Aegl
06/04/01	Cromarty Ck	2B	-19.49417	147.08028	?	Closed Mixed	ds Av, op Rhiz, Xylo g, Exco, sp Acan & Lum
06/04/01	Cromarty Ck	2C	-19.49000	147.07750	?	Closed Cer (6m)	ds Cer
06/04/01	Haughton R	3A	-19.46278	147.12111	?	Closed Cer (~7m)	ds Cer, op Av
06/04/01	Burrum Bush Ck	4A	-19.44306	147.12056	?	Closed Rhiz (7m)	ds Rhiz
06/04/01	Burrum Bush Ck	4B	-19.45083	147.07806	?	Closed Mixed (8m)	op Xylo , Exco, Av, Aeg, sp Her & Rhiz
06/04/01	Burrum Bush Ck	4C	-19.45528	147.07722	?	Closed Mixed (7m)	op Exco, Rhiz, Xylo, Cer, Av, Aeg
06/04/01	Burrum Bush Ck	4D	-19.43972	147.13222	?	Closed Rhiz/Xylo (7m)	Op Rhiz & Xylo, sp Aeg, Av & Exco
06/04/01	Burrum Bush Ck	4E	-19.44528	147.10056	?	Closed Cer	ds Cer, op Xylo, sp Av & Rhiz
06/04/01	Burrum Bush Ck	4F	-19.45083	147.10306	?	Closed Cer (10m)	ds Cer, op Xylo, sp Av & Rhiz
06/04/01	Shortcut	5A	-19.43667	147.11917	?	Closed Rhiz (8m)	ds Rhiz
06/04/01	Shortcut	5B	-19.44333	147.16944	?	Closed Cer	ds Cer
06/04/01	Barramundi Ck	6B	-19.48611	147.16917	?	Closed Cer (6m)	ds Cer
06/04/01	Barramundi Ck	6C	-19.46889	147.15833	?	Closed Cer	Ds Cer, op Av, sp Lum
06/04/01	Shortcut	7A	-19.45611	147.15444	?	Closed Cer	ds Cer, op Rhiz
06/04/01	Shortcut	7B	-19.44639	147.14083	?	Closed Rhiz	ds Rhiz, op Av
06/04/01	Shortcut	7C	-19.50639	147.14444	?	Closed Av/ Rhiz	ds Av, Rhiz, op Cer, sp Brug & Xylo
06/04/01	Blacksoil Ck	8A	-19.30194	147.04167	?	Closed Cer	ds Cer, op Av & Rhiz
06/04/01	Blacksoil Ck	8B	-19.29861	147.00750	?	Closed Rhiz	ds Rhiz, op Xylo & Osb & sp Av
06/04/01	Cocoa Ck	9A	-19.30306	147.02361	?	Saltpan	
07/04/01	Bohle R boat ramp	1A	-19.20145	146.69968	19	Closed Mixed	op Cer, Rhiz, Av, Xylo & Osb
07/04/01	Bohle R boat ramp	1B	-19.20134	146.69874	13	Closed Cer (5m)	ds Cer
07/04/01	Bohle R boat ramp	1C	-19.19940	146.70170	9	Closed Rhiz (6m)	ds Rhiz, op Cer & Av & sp Lum
07/04/01	Bohle R boat ramp	1D	-19.20245	146.70167	36	Closed Cer (6m)	ds Cer
07/04/01	Bohle R boat ramp	1E	-19.20279	146.70193	33	Closed Mixed	op Rhiz, Av & Osb, sp Aeg & Xylo
07/04/01	Bohle R boat ramp	1F	-19.20008	146.69694	?	Closed Mixed (8m)	op Av, Rhiz, Osb & Cer, sp Xylo
07/04/01	Bohle R boat ramp	1G	-19.19941	146.69689	14	Closed Rhiz (8m)	ds Rhiz & op Av
07/04/01	Bluewater Ck	2A	-19.14887	146.59004	22	Closed Mixed (7m)	op Lum, Brug & Osb, sp Rhiz, Exco, Hib & Av
07/04/01	Balgal	3A	-19.01145	146.40356	20	Closed Rhiz	ds Rhiz & sp Av
07/04/01		4A	-18.90808	146.30146	?	Closed Rhiz (10m)	ds Rhiz, op Av, sp Lum
07/04/01		4B	-18.93036	146.31799	42	Closed Rhiz	ds Rhiz, sp Xylo & Av
09/04/01	Road to Lucinda	1A	-18.56336	146.30167	19	Closed Av	ds Av, op Brug, Exco, Aeg, sp Hib & Aegl
09/04/01	Road to Lucinda	1B	-18.56094	146.30383	15	Closed Mixed (8m)	op Brug, Av, Rhiz & Lum, sp Xylo & Hib
09/04/01	Road to Lucinda	1C	-18.55750	146.30770	?	Closed Av	ds Av, op Lum & Exco, sp Brug
09/04/01	Road to Lucinda	1D	-18.55402	146.31083	27	Closed Mixed	ds Av, op Exco & Lum, sp Xylo, Brug, Cer & Aeg
09/04/01	Road to Lucinda	1E	-18.55307	146.31178	31	Closed Rhiz (8m)	ds Rhiz
09/04/01	Road to Lucinda	1F	-18.55161	146.31369	13	Closed Brug/Av/Cer	op Brug, Av, Cer
09/04/01	Road to Lucinda	1G	-18.55097	146.31440	13	Closed Cer (8m)	ds Cer, sp Av (9m)
09/04/01	Enterprise Channel	2A	-18.53149	146.31462	27	Closed Mixed	op Xylo, Brug, Cer & Av, sp Exco & Lum
09/04/01	Enterprise Channel	2B	-18.54402	146.32895	15	Closed Mixed	op Brug, Rhiz, Xylo, Lum & Av, sp Aeg & Sonn
09/04/01	Enterprise Channel	2C	-18.54047	146.32596	19	Closed Mixed	op Xylo, Her, Brug, Exco, sp Av
09/04/01	Enterprise Channel	2D	-18.53896	146.31961	18	Closed Rhiz (25m)	ds Rhiz
09/04/01	Enterprise Channel	3A	-18.52723	146.30060	24	Closed Mixed	op Brug p, Rhiz, Av & Xylo
09/04/01	Enterprise Channel	3B	-18.53667	146.29980	15	Closed Rhiz	ds Rhiz
09/04/01	Enterprise Channel	4A	-18.53978	146.27268	25	Closed Mixed	ds Rhiz, op Aeg, Exco, Her, sp Av & Nypa
09/04/01	Shortcut	5A	-18.53740	146.26863	25	Closed Mixed	ds Brug, op Rhiz, Sonn, Aeg
09/04/01	Shortcut	5B	-18.53579	146.26637	15	Closed Mixed	ds Rhiz, op Brug, Her & Aeg
09/04/01	Seaforth Ck	6A	-18.53367	146.26019	12	Closed Brug	ds Brug p, op Her, Xylo & Rhiz
09/04/01	Seaforth Ck	6B	-18.50856	146.26585	18	Closed Rhiz	ds Rhiz
09/04/01	Seaforth Ck	6C	-18.50829	146.25113	15	Closed Cer (6m)	ds Cer
09/04/01	Catasti's Ck	7A	-18.53600	146.23272	16	Closed Mixed	op Brug, Rhiz, Aeg & sp Sonn
09/04/01	Catasti's Ck	7B	-18.52708	146.22979	15	terrestrial spot	
09/04/01	Catasti's Ck	7C	-18.51847	146.21609	14	Closed Rhiz	ds Rhiz & sp Brug
09/04/01	Seymour R	8A	-18.53354	146.21672	?	fringe community	op Aeg & Av, sp Exco & Hib
09/04/01	Seymour R	8B	-18.51209	146.20505	15	Closed Cer (5m)	ds Cer, sp Brug
09/04/01	Sandstone Ck	9A	-18.46693	146.22153	16	Closed Rhiz (5m)	ds Rhiz
09/04/01	Taylor's Beach	10A	-18.63668	146.32314	16	Closed Rhiz (10m)	ds Rhiz
09/04/01	Taylor's Beach	10B	-18.63589	146.32375	14	Closed Mixed	op Her, Rhiz, Cer, Brug & Exco
09/04/01	Taylor's Beach	10C	-18.61543	146.32275	49	Closed Av (7m)	ds Av, op Brug
09/04/01	Taylor's Beach	10D	-18.60671	146.31484	32	Closed Av	ds Av, op Brug p
10/04/01		1A	-18.41234	146.18088	11	Closed Rhiz	ds Rhiz, sp Av & Aeg
10/04/01	Gayundah Ck	2A	-18.37915	146.21779	19	Closed Mixed	ds Rhiz, op Brug, Av, Aeg & Aegl
10/04/01	Gayundah Ck	2B	-18.37691	146.21501	28	Closed Rhiz (3m)	ds Rhiz, op Brug, sp Sonn & Av
10/04/01	Gayundah Ck	2C	-18.37733	146.21097	35	Closed Cer	ds Cer, op Brug & Rhiz
10/04/01	Paluma Ck	3A	-18.39529	146.22652	?	Closed Mixed	op Rhiz, Exco, Aeg, Osb, Av, Brug & sp Sonn
10/04/01	Paluma Ck	3B	-18.39455	146.22452	17	Closed Rhiz (3-4m)	ds Rhiz, op Sonn, sp Av
10/04/01	Paluma Ck	3C	-18.39542	146.22302	20	Closed Cer	ds Cer, op Brug & Osb, sp Av
10/04/01	Paluma Ck	3D	-18.38404	146.20097	11	Closed Rhiz (8-10m)	ds Rhiz
10/04/01	Fishers Ck	4A	-18.45881	146.15463	23	Closed Rhiz (5m)	ds Rhiz
10/04/01	Fishers Ck	4B	-18.45912	146.14972	12	Closed Mixed	op Rhiz, Exco, Av, Brug, sp Osb
10/04/01	Wreck Ck	5A	-18.21645	145.98798	18	Closed Rhiz	ds Rhiz, op Brug, Xylo & Aeg, sp Lum
10/04/01	Wreck Ck	5B	-18.21532	145.99283	27	Closed Rhiz	ds Rhiz, op Xylo, Av & Brug
10/04/01	Wreck Ck	5C	-18.21264	145.99303	?	Closed Brug (p)	ds Brug p, op Her, Xylo & Rhiz
10/04/01	Wreck Ck	5D	-18.20554	145.99714	19	Closed Cer	ds Cer, op Brug, sp Xylo
10/04/01	Meunga Ck	6A	-18.24185	145.99978	22	terrestrial	
10/04/01	Meunga Ck	6B	-18.23603	146.00824	21	Closed Mixed (9m)	op Brug, Cer, Xylo g, Exco
11/04/01	Mosquito Ck	1A	-17.99043	146.05539	29	Closed Brug	ds Brug p, op Brug g, Rhiz & Xylo g, sp Xylo m
11/04/01	Mosquito Ck	1B	-17.99176	146.05880	16	Closed Rhiz	ds Rhiz, op Brug, sp Sonn & Av
11/04/01	Mosquito Ck	1C	-17.98882	146.06154	?	Closed Brug	ds Brug, op Xylo g & m, sp Rhiz

11/04/01	Hull R north Arm	2A	-17.94028	146.07775	17	Closed Mixed (7-8m)	ds Rhiz, op Brug p & g, Aeg, Xylo g, sp Exco
11/04/01	Hull R north Arm	2B	-17.95513	146.07377	25	Closed Brug p	ds Brug p, op Brug g, sp Xylo m
11/04/01	Hull R north Arm	2C	-17.95927	146.06816	28	Closed Cer	ds Cer, op Brug g & p, sp Xylo m
11/04/01	Hull R north Arm	2D	-17.96503	146.06400	11	Closed Cer (4m)	ds Cer, op Rhiz & Brug p
11/04/01	Hull R north Arm	2E	-17.97921	146.07486	28	Closed Rhiz	ds Rhiz, op Brug p
11/04/01	Hull R	3A	-17.96673	146.06404	15	Closed Cer	ds Cer, op Brug p & g, sp Xylo g
11/04/01	Hull R	3C	-17.95788	146.03338	11	Closed Mixed	op Aeg, Xylo g, Brug, Her, Exco
11/04/01	Hull R	3D	-17.96603	146.05201	13	Closed Mixed	op Brug g & p, Cer, sp Her & Rhiz
11/04/01	Hull R	3E	-17.96583	146.05366	11	Closed Cer	ds Cer, op Xylo g, sp Brug p & Exco
11/04/01	Hull R	3F	-17.96304	146.05492	14	Closed Mixed	op Brug g, Exco, Her, Xylo g, sp Aeg
11/04/01	off Hull R	4A	-17.97056	146.05834	?	Closed Mixed	ds Rhiz, op Xylo g, Cer, Brug g & sp Xylo m
11/04/01	off Hull R	4B	-17.97112	146.06148	14	Closed Rhiz/Brug	ds Rhiz, op Brug p, sp Xylo m, Brug g & Av
11/04/01	Hull R	5A	-17.97353	146.06149	14	Closed Brug	ds Brug p, op Brug g, Cer & Xylo g, sp Rhiz, Exco & Xylo m
11/04/01	Hull R	5B	-17.97786	146.06932	27	Closed Mixed	op Rhiz, Cer, Brug, sp Exco, Xylo g & m
11/04/01	Hull R	5C	-17.98137	146.06678	?	Closed Rhiz	ds Rhiz
11/04/01	Tully R	6A	-18.02387	146.04426	12	Closed Mixed	op Lum, Brug p & Her
11/04/01	Tully R	7A	-18.02966	146.03500	19	Closed Mixed	op Brug, Her, Xylo g & m, Aeg & sp Sonn (25m), Exco & Rhiz
11/04/01	Tully R	7B	-18.02451	146.02862	16	Closed Mixed	op Her, Rhiz, Brug, sp Sonn (25m) & Aeg
11/04/01	Tully R	8A	-18.01563	146.03970	16	Closed Mixed	op Xylo g, Her, Rhiz, Brug g & p, sp Aeg & Exco
11/04/01	Tully R	9A	-18.01840	146.04959	25	Closed Mixed	ds Xylo g, op Rhiz, Brug p & g, & sp Aeg & Av
12/06/01	Trinity Boat Ramp	1A	-16.99907	145.76520	18	Closed Brug/Cer (10m)	ds Brug spp, op Cer, sp Av, u/s of op Acros
12/06/01	Rubbish dump	2A	-16.97804	145.75496	38	Closed Rhiz (16m)	ds Rhiz, op Brug & Exco
12/06/01	Airport	3A	-16.88331	145.76268	12	Smph-dominated Saltpan	sp Av
12/06/01	Airport	3B	-16.88323	145.76309	10	Closed Av/Cer	Op Av (2m), Op Cer (1.5m), sp Aegl (1m)
12/06/01	Airport	3C	-16.88146	145.76135	19	Closed Rhiz	ds Rhiz, Op Xylo & Brug, sp Cer
12/06/01	Airport	3D	-16.88182	145.76247	12	Closed Cer	ds Cer, op Rhiz & Av
12/06/01	Airport	3E	-16.88244	145.76206	10	Closed Cer/Av	ds Cer (2m) op Av emgts (4m)
12/06/01	Airport	3F	-16.88499	145.76281	?	Closed Rhiz (10m)	ds Rhiz, op Xylo m, sp Cer
12/06/01	Airport	3G	-16.88458	145.76188	36	Closed Cer	ds Cer, sp Av
12/06/01	Machans Beach	4A	-16.85434	145.75036	11	Closed Brug dieback	ds Brug
12/06/01	Machans Beach	5A	-16.85981	145.73462	12	Closed Av (6m)	ds Av, u/s of op Brug g, Lum & Cer (2m)
12/06/01	Machans Beach	5B	-16.85931	145.73346	10	Saltpan	
13/06/01	Daintree R	1A	-16.32268	145.41623	15	Closed Mixed (4m)	op Sonn, Brug g, Rhiz sp, Her, Lum & Exco, u/s of op Acros
13/06/01	Daintree R	1B	-16.32126	145.41762	16	Closed Rhiz/ Brug	ds Rhiz, op Brug & Xylo g, sp Exco & Nypa
13/06/01	Daintree R	2A	-16.27454	145.45836	17	Closed Mixed	ds Brug g, Rhiz, Xylo g, sp Cer
13/06/01	Daintree R	2B	-16.27400	145.45457	16	Closed Mixed	ds Brug g, op Xylo g & Rhiz, sp Aeg, u/s of op Acros
13/06/01	Daintree R	2C	-16.27669	145.45426	18	Closed Brug	ds Brug g, op Brug p & Cer, sp Lum & Exco
13/06/01	Daintree R	2D	-16.27790	145.45593	20	Closed Cer (9-10m)	ds Cer, op Brug, sp Rhiz & Xylo g.
13/06/01	Daintree R	3A	-16.28652	145.45499	16	Closed Mixed	op Rhiz, Cer, Brug, sp Xylo m, Hib & Av, sp Crin
13/06/01	Daintree R	3B	-16.27742	145.42991	20	Closed Rhiz (12m)	ds Rhiz, op Brug
13/06/01	Daintree R	4A	-16.26238	145.41518	?	Closed Mixed (12m)	ds Brug g, op Xylo g, Rhiz, sp Her & Lum, op u/s of Acros.
13/06/01	Daintree R	4B	-16.26808	145.40356	11	Closed Rhiz/ Aeg	op Rhiz, Aeg & Sonn
13/06/01	Daintree R	4C	-16.26008	145.37672	19	Closed Mixed	op Rhiz, Brug, Hib & Her, sp Exco
13/06/01	Daintree R	4D	-16.26218	145.37035	14	terrestrial	
13/06/01	Daintree R	4E	-16.28828	145.40932	14	Closed Brug	op Brug g, Brug p, Xylo g & m, u/s op Acros
13/06/01	Daintree R	5A	-16.28617	145.40904	15	Closed Mixed	op Cer, Brug p & g, Xylo g & Lum
13/06/01	Daintree R	5B	-16.28753	145.41419	14	Closed Cer (5-6m)	ds Cer, sp Rhiz
13/06/01	Daintree R	5C	-16.30072	145.39856	23	Closed Rhiz (10m)	ds Rhiz
13/06/01	Daintree R	5D	-16.30211	145.40105	18	Closed Rhiz	ds Rhiz, op Brug
13/06/01	Daintree R	5E	-16.30834	145.41531	16	Closed Rhiz	ds Rhiz, op Sonn
13/06/01	Drain	6A	-16.31926	145.41033	17	Closed Mixed	op Her, Exco & Lum, u/s of op Acros
13/06/01	Drain	6B	-16.31795	145.41052	13	Closed Cer	ds Cer, op Exco & Lum
13/06/01	Mossman R	7A	-16.43600	145.40400	15	Closed Sonn/Av	ds Sonn, op Rhiz & Av
13/06/01	Mossman R	7B	-16.44231	145.40577	17	Closed Mixed	op Xylo g & m, Cer, Brug g, sp Exco & Aeg
13/06/01	Mossman R	7C	-16.44057	145.39666	15	Closed Mixed	op Rhiz, Xylo g, Exco, Aeg, sp Brug p & g, sp Sonn emgts
13/06/01	Mossman R	7D	-16.43859	145.39614	14	Closed Rhiz	ds Rhiz
13/06/01	Mossman R	7E	-16.43560	145.39805	20	Closed Brug	ds Brug g, op Brug p, sp Rhiz, Xylo g, Aeg & Av
13/06/01	Mossman R	7F	-16.43380	145.40093	15	Closed Cer	ds Cer, op Xylo g & sp Xylo m & Exco
13/06/01	Coop Ck	8A	-16.41250	145.40820	17	Closed Cer/Brug (10m)	op Cer, Brug, sp Her
13/06/01	Coop Ck	8B	-16.41302	145.40784	15	Closed Cer (4-6m)	ds Cer, op Xylo m
13/06/01	Coop Ck	8C	-16.41266	145.40876	13	Closed Mixed	op Aeg, Av, Sonn, Rhiz & Osb
13/06/01	Mossman R	9A	-16.44734	145.40471	22	Closed Cer (4-5m)	ds Cer, sp Av emgts
13/06/01	Mossman R	9B	-16.45062	145.40351	18	Closed Av	ds Av, op Lum, Brug, sp Exco, op u/s of Acros
14/06/01	Dicksons Inlet	1A	-16.51719	145.46020	14	Closed Rhiz (8m)	ds Rhiz
14/06/01	Dicksons Inlet	1B	-16.51706	145.45524	16	Closed Rhiz	ds Rhiz, sp Brug g
14/06/01	Dicksons Inlet	1C	-16.51536	145.45700	26	Closed Cer (4=5m)	ds Cer, op Brug, sp Rhiz
14/06/01	Dicksons Inlet	1D	-16.51187	145.45768	14	Closed Cer	op Cer, Rhiz, sp Xylo m
14/06/01	Dicksons Inlet	1E	-16.49898	145.44440	17	Closed Rhiz (6-8m)	ds Rhiz
14/06/01	Dicksons Inlet	1F	-16.50182	145.45229	41	Closed Cer	ds Cer, op Xylo m & Rhiz
14/06/01	Muddy Ck	2A	-16.48999	145.44276	13	Closed Cer (4-6m)	ds Cer, op Rhiz, Xylo m
14/06/01	Muddy Ck	2B	-16.48806	145.44387	10	Smph-dominated Saltpan	
14/06/01	Muddy Ck	2C	-16.48470	145.43484	20	Smph-dominated Saltpan	ds smph
14/06/01	Trinity Beach	3A	-16.77989	145.69278	18	Closed Rhiz	ds Rhiz, op Osb & Aeg, sp Aegl
14/06/01	Half Moon Ck	4A	-16.80452	145.71007	14	Closed Mixed	op Exco, Rhiz, Av, Cer, op u/s of Acros
14/06/01	Half Moon Ck	4B	-16.80086	145.71233	?	Closed Mixed	op Osb, Aeg Aegl, Rhiz, sp Av emgts
14/06/01	Half Moon Ck	5A	-16.82715	145.71343	12	Closed Av (4-5m)	ds Av, sp Rhiz
14/06/01	Half Moon Ck	5B	-16.80811	145.71359	10	Op Av (3-4m)	op Av, sp Cer
14/06/01	Half Moon Ck	5C	-16.80818	145.71283	11	Closed Cer (3-4m)	ds Cer, sp Av (on Saltpan edge)
14/06/01	Half Moon Ck	5D	-16.80944	145.71316	12	Closed Rhiz (8-9m)	ds Rhiz
14/06/01	Holloways Beach	6A	-16.83430	145.73758	15	Closed Rhiz (15-17m)	ds Rhiz
14/06/01	Holloways Beach	6B	-16.84926	145.73367	10	Closed Av (8m)	ds Av, sp Brug (ldward edge)
15/06/01	Russel/Mulgrave Rs	1A	-17.22548	145.95909	11	Closed Mixed (6-8m)	op Rhiz, Brug p & g

15/06/01	Russel/Mulgrave Rs	1B	-17.22834	145.96600	12	Closed Rhiz	ds Rhiz, sp Av & Brug p
15/06/01	Russel/Mulgrave Rs	1C	-17.23214	145.96306	12	Closed Rhiz	ds Rhiz, op Brug p & g, sp Exco, Xylo g, Lum, Av, Osb, Her & Sonn
15/06/01	Russel/Mulgrave Rs	1D	-17.23473	145.93112	41	Closed Mixed	ds Rhiz, op Brug p, Her, Xylo g, sp Exco & Sonn, u/s of op Acros
15/06/01	Russel/Mulgrave Rs	1E	-17.23233	145.94147	18	Closed Cer	ds Cer, op Her, Xylo g, Brug g, sp Lum, u/s of op Acros & sp Crin
15/06/01	Russel/Mulgrave Rs	1F	-17.23283	145.94896	14	Closed Rhiz	ds Rhiz, op Brug p & sp Av
15/06/01	Russel/Mulgrave Rs	1G	-17.21227	145.93894	13	Closed Mixed	ds Aeg, op Rhiz, Exco, Brug & sp Av
15/06/01	Johnstone R	2A	-17.91662	?	?	Closed Cer (2-3m)	ds Cer
15/06/01	Johnstone R	2B	-17.50043	146.07158	16	Closed Rhiz	ds Rhiz, op Brug p, sp Aeg
15/06/01	Johnstone R	2C	-17.50599	146.04832	16	Closed Mixed	op Brug g, sp Xylo g, ds Acros u/s
15/06/01	Johnstone R	3A	-17.50591	146.05204	37	Closed Mixed (15 - 20)	ds Xylo g, op Brug g & p, Aeg
15/06/01	Johnstone R	3B	-17.51294	146.05608	11	Closed Brug p	ds Brug p, op Rhiz, subcanopy of Aeg
15/06/01	Moresby R	4A	-17.63484	146.05237	40	Closed Mixed fringe	ds Xylo g, op Brug g, Rhiz & Exco
15/06/01	Moresby R	4B	-17.63649	146.05642	14	Closed Cer	ds Cer, op Lum
15/06/01	Moresby R	4C	-17.63584	146.06732	16	Closed Mixed	op Xylo g, Brug g, Rhiz, sp Aeg & Exco, op u/s of Acros
15/06/01	Moresby R	4D	-17.64382	146.08536	?	Closed Cer	ds Cer
15/06/01	Moresby R	4E	-17.64191	146.08750	?	Closed Rhiz (8-10m)	ds Rhiz
15/06/01	Moresby R	4F	-17.63798	146.08974	16	Closed Mixed (4-5m)	op Lum, Cer, Brug, Xylo m, Rhiz & sp Exco
15/06/01	Moresby R	5A	-17.63659	146.09799	17	Closed Mixed	ds Cer, op Xylo g & Brug g
15/06/01	Moresby R	5B	-17.63739	146.10094	12	Closed Rhiz (8-10m)	ds Rhiz
15/06/01	Moresby R	6A	-17.67165	146.08533	12	Closed Rhiz	ds Rhiz, sp Lum
15/06/01	Moresby R	6B	-17.67266	146.08546	14	Closed Rhiz (8m)	ds Rhiz, sp Lum
15/06/01	Moresby R	6C	-17.66477	146.08933	12	Closed Mixed	ds Cer, op Her, sp Rhiz & Lum, op Exco emgts
15/06/01	Moresby R	6D	-17.65970	146.08864	14	Closed Mixed (6-8m)	op Cer, Xylo g, Brug g, Lum & sp Xylo m
15/06/01	Moresby R	6E	-17.65834	146.09010	19	Closed Cer (5-6m)	ds Cer, op Brug p & Xylo g, sp Brug g
15/06/01	Moresby R	6F	-17.62205	146.11420	?	Closed Rhiz (4-5m)	ds Rhiz, op Cer, Brug g

Abbreviations:
ds – dense
sp – sparse
op – open
u/s – understorey
smph – samphire

Acan – *Acanthus ilicifolius*
Acros – *Acrostichum speciosum*
Aegl – *Aegialitis annulata*
Aeg – *Aegiceras corniculatum*
Av – *Avicennia marina*
Brug g – *Bruguiera gymnorrhiza*
Brug p – *Bruguiera parviflora*
Cer – *Ceriops tagal*
Crin – *Crinum pedunculatum*
Exco – *Excoecaria agallocha*
Her – *Heritiera littoralis*
Hib – *Hibiscus tiliaceus*
Lum – *Lumnitzera racemosa*
Osb – *Osbornia octodonta*
Rhiz – *Rhizophora* spp.
Sonn – *Sonneratia alba*
Spor – *Sporobolus virginicus*
Xylo g – *Xylocarpus granatum*
Xylo m – *Xylocarpus moluccensis*