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Queensland Coastal Wetland Resources

Round Hill Head to Tin Can Inlet

C Bruinsma
and
K Danaher

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Manager, DPI Publications
Department of Primary Industries
GPO Box 46
Brisbane Qld 4001

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EXECUTIVE SUMMARY

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

Approximately 70% of the wetland resources of the Queensland coastline have been mapped or are currently being mapped by the Resource Condition and Trend Unit, Fisheries Group, Department of Primary Industries Queensland. This process is being undertaken in order to provide a baseline dataset for Fish Habitat Area (FHA) declaration, Ramsar site nomination and continued monitoring of these important fish habitats. This report summarises the results of the mapping undertaken from Round Hill Head to Tin Can Inlet. The study was undertaken in order to:

1. document and map the coastal wetland communities from Round Hill Head (24°S) to Tin Can Inlet (26°S);
2. document levels of existing disturbance to and protection of the wetlands;
3. examine existing recreational and commercial fisheries in the region; and
4. evaluate the conservation values of the areas investigated from the viewpoint of fisheries productivity and as habitat for important and/or threatened species.

The coastline from Round Hill Head to Tin Can Inlet can be divided into three main regions based on the exposure to wind and wave energy and the corresponding extent of coastal vegetated wetland community development:

1. The most sheltered region containing the largest area of coastal wetlands and intertidal flats extends northward from Tin Can Inlet, through Great Sandy Strait and up to the Burrum River. The sand mass of Fraser Island shelters this area from open ocean wave action.
2. The coastline from Burrum Heads to Round Hill Head is more exposed. In this section of the study area, coastal wetland communities have established in the protected estuaries of creeks and rivers. These estuaries also provide the most extensive intertidal flats along this section of coastline.
3. The eastern shoreline of Fraser Island and the mainland to the south from Bullock Point to Double Island Point is exposed to open ocean wave action. With the exception of seasonal lagoons, no suitable environments for the establishment of coastal wetland communities exist in this section of the coastline.

The dominant coastal wetland community type for the study area is Closed *Rhizophora*. This community is mainly found within Great Sandy Strait, the north-west coast of Fraser Island, Kauri Creek and Tin Can Inlet. This area also exhibits the highest degree of zonation with Closed *Rhizophora* occupying the seaward zone and Closed *Avicennia*/*Ceriops* establishing behind. In the more exposed section of coastline, there is a general absence of Closed *Rhizophora* forming a distinct seaward zone. Instead, the dominant communities of Closed *Ceriops* and Closed *Avicennia* grade slowly into more mixed assemblages. Saltpans are found throughout the study area with the greatest proportion occurring in Great Sandy Strait.

TABLE 1 Areas of coastal wetland communities from Round Hill Head to Tin Can Inlet.

COMMUNITY	AREA (ha)	% of TOTAL
Closed *Rhizophora*	6599	27.60
Closed *Avicennia*	3407	14.25
Open *Avicennia*	750	3.14
Closed *Ceriops*	1735	7.26
Open *Ceriops*	5	0.02
Closed *Aegiceras*	1005	4.20
Open *Bruguiera*	37	0.16
Closed *Rhizophora/Avicennia*	293	1.23
Closed *Rhizophora/Aegiceras*	648	2.71
Closed *Avicennia/Ceriops*	1864	7.80
Open *Avicennia/Ceriops*	706	2.95
Closed *Mixed*	481	2.01
Saline Grassland	923	3.86
Saltpan	5454	22.81
Total	23907	

Significant Coastal Wetland Communities

The major coastal wetland systems which are considered to be important environments within the study area that should be protected are as follows: Baffle Creek, Kolan River, Elliott River, Burrum River, Mary River and Susan River, Great Sandy Strait, Kauri Creek and Tin Can Inlet. Reasons for their significance are varied. However, all can be considered important in terms of their contributions to fisheries productivity. Many of these areas are already protected by declared FHAs of either management A or B types. Areas that are not already protected within a FHA should be considered as a priority for gazettal under Fisheries legislation.

Broadwater Creek, Littabella Creek and Beelbi Creek are smaller coastal wetland systems within the study area. Although these three coastal wetland systems may have a lower significance to fisheries productivity due to their smaller individual size, they are linked to other, larger important coastal wetland systems (Baffle Creek, Kolan River and Burrum River). Protecting these environments in conjunction with the larger systems nearby would serve to increase the diversity of habitats protected.

Recommendations

1. The coastal wetlands of both Baffle Creek and Elliott River are important environments in this region which warrant enhanced protection. The gazettal of these areas as FHAs is recommended as a priority. Broadwater Creek is a relatively small coastal wetland environment. However, the protection of this environment in conjunction with Baffle Creek would serve to increase the diversity of coastal wetland habitats protected in this region.

2. The coastal wetlands from the west head of Puthoo Creek to the north head of Bennett Creek on Fraser Island are not currently included in a FHA of either management A or B status. The inclusion of these coastal wetland communities in either the Maaroom A or Fraser Island B FHA (depending on the appropriate management level) is recommended due to the unique coastal wetland communities in these locations.

3. Inclusion of Pelican Bay in the Kauri Creek FHA is recommended due to the its importance as a shallow water nursery habitat for numerous commercially and recreationally targeted fish and crab species.

4. Further inclusion of the intertidal flats as a buffer to the coastal wetlands from Burrum Heads to Urangan, including the sand spit at Dayman's Point, is recommended to increase the diversity of fisheries habitats included in FHAs in this area.

5. In recognition of the dynamic nature of the coastal environment, regular review (perhaps every 5 years) of FHA boundaries, particularly the seaward boundary, is recommended in order to ensure these boundaries maintain their usefulness over time.

6. Continuation of coastal wetlands mapping to complete the remainder of the Queensland coast is strongly recommended to:
    - provide baseline data for FHA declaration and Ramsar site nomination;
    - monitor spatial and composition changes in communities on a local, bioregional and State-wide basis;
    - as a resource for incorporation into studies of the relationships of specific marine fauna to particular coastal wetland habitats.

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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'*. Marine vegetation communities including seagrasses, mangroves and saltmarshes are all protected under the legislation by limiting the impacts of works able to be undertaken in fish habitats and through the declaration of Fish Habitat Areas (FHAs), a form of Marine Protected Area. 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 FHA declaration and management.

Further protection of significant wetland areas is achieved through the declaration of Ramsar sites. Formal listing of Ramsar sites was the result of the Convention on Wetlands of International Importance. Coastal wetland resources are an important consideration in the nomination of these Ramsar sites. In order for a site to be eligible for nomination as a Ramsar site the following four clusters of criteria have been developed.

1. Criteria for representative or unique wetlands;
2. General criteria based on plants or animals;
3. Specific criteria based on waterfowl;
4. Specific criteria based on fish.

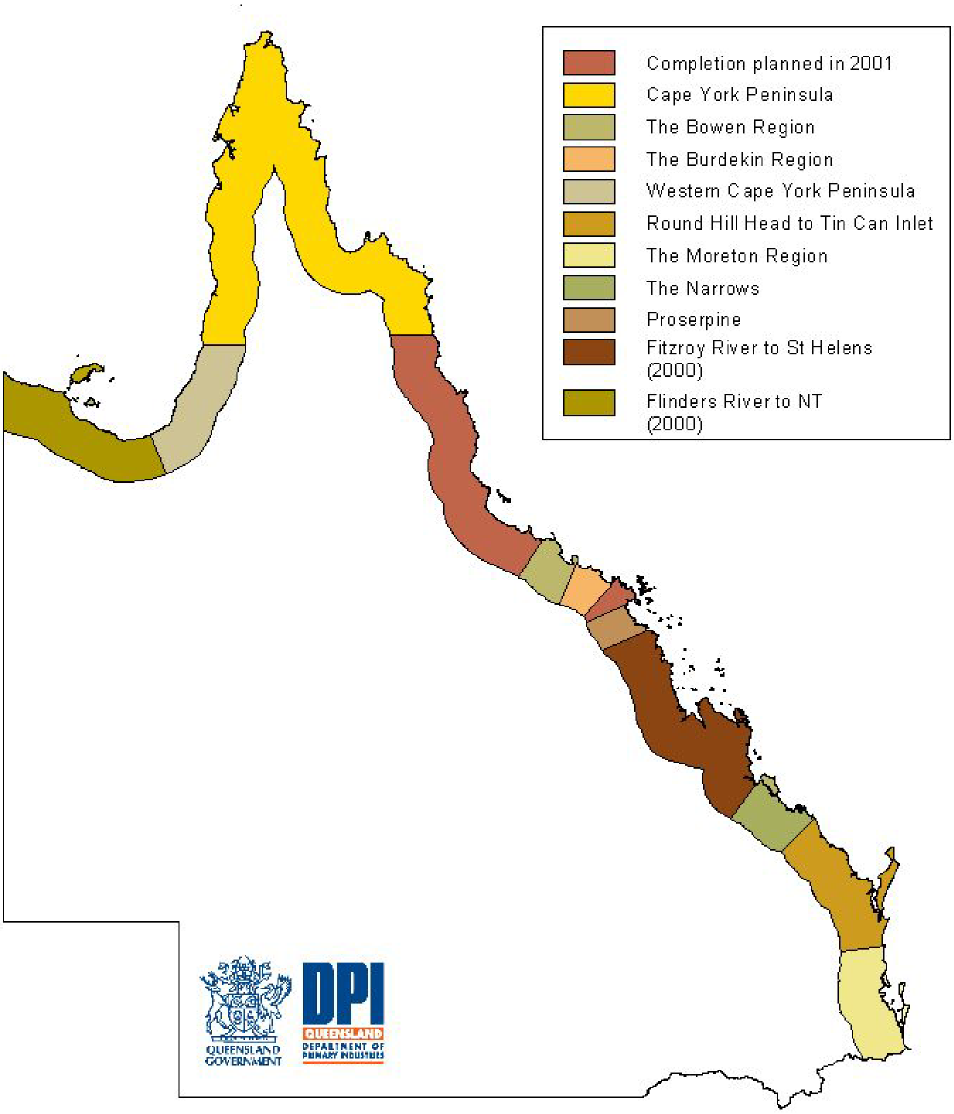
Further details of these criteria can be found in Appendix 3.

This report provides key resource data for the ongoing assessment of the requirement for additional Marine Protected Areas (FHAs) in regions of high fish habitat value. Additionally, the study provides baseline information on the coastal wetlands from Round Hill Head to Tin Can Inlet for Ramsar site nomination. The project aims were to:

1. document and map the coastal wetland communities from Round Hill Head to Tin Can Inlet;
2. document levels of existing disturbance to and protection of the wetlands;
3. examine existing recreational 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.

1.2 Current Progress of Queensland Coastal Wetland Resource Mapping

Approximately 70% of Queensland's coastal wetland resources have been or are currently being mapped by the Department of Primary Industries Queensland Fisheries Group as a baseline resource for FHA declaration and continued monitoring of these environments. The areas that have been completed or are currently being mapped are displayed in Figure 1.1. This work resulted in FHAs being recommended for South-east Gulf of Carpentaria, Cape York, the Burdekin and the Narrows (Bruinsma et al. 1999; Bruinsma and Danaher, 1999; Danaher 1995a; Danaher 1995b; Danaher and Stevens 1995; Danaher personal communication 1999). The Burdekin FHA was declared in August, 1999.



Coastline data: © Commonwealth of Australia, AUSLIG.

FIGURE 1.1 Queensland coastal wetland resource mapping projects.

SECTION 2. BACKGROUND

2.1 The Study Area

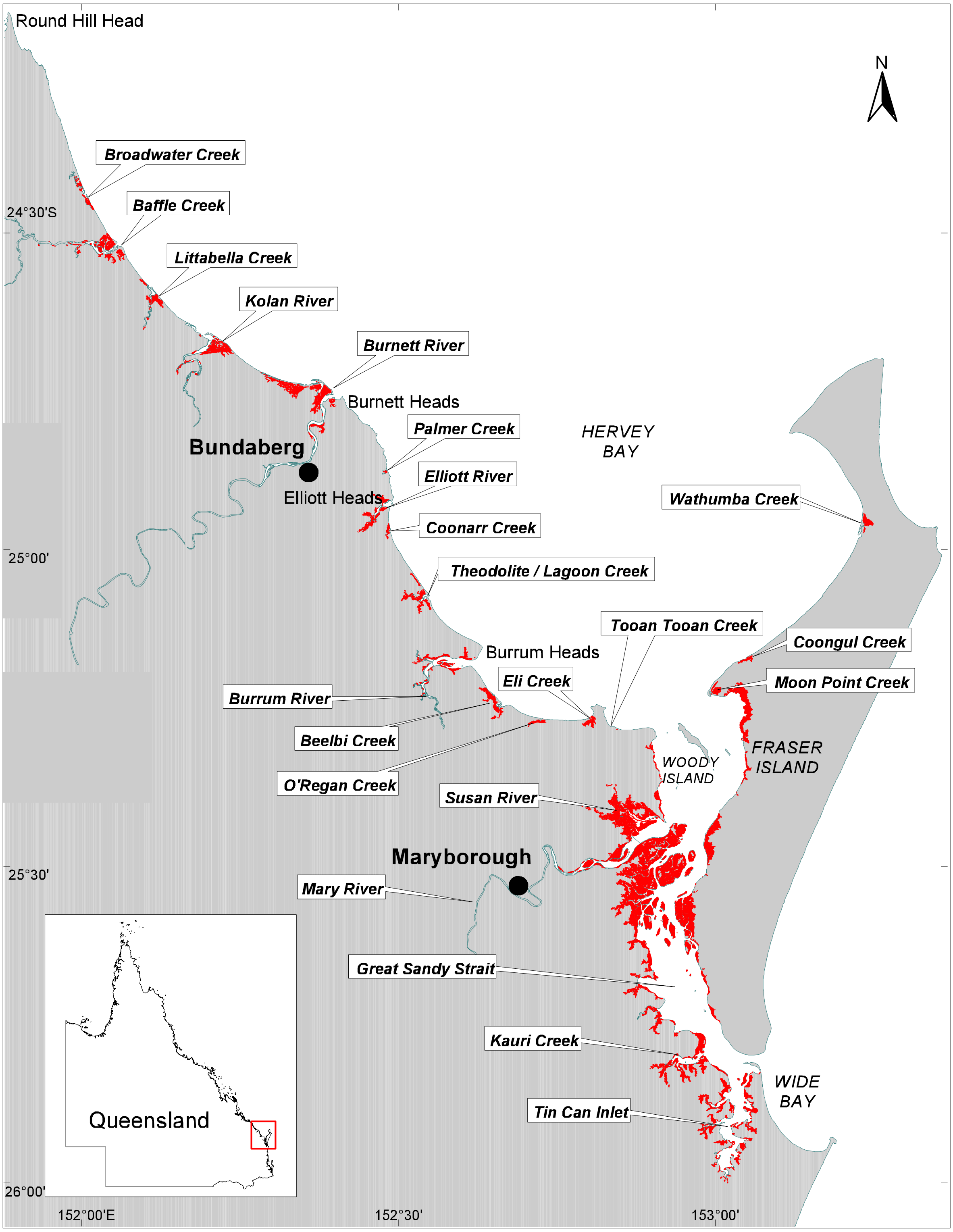
The study area extends from a rocky headland at Round Hill Head south to the sheltered environment of Tin Can Inlet, between latitudes 24° and 26°S (Figure 2.1). The region contains a diverse range of coastal environments, including a large sand island (Fraser Island), a unique passage landscape (Great Sandy Strait), a large bay (Hervey Bay) and exposed coastline. Fraser Island, the largest sand island in the world, provides protection from open ocean waves for most of the coastal environments within this study area. Wave action gradually increases as the coastline becomes more exposed to the north. Consequently, the coastal features in the southern section of the study area are predominantly tidal, grading to more wave dominated features further north (BPA 1989).

Bundaberg (152.3°E, 24.8°S) and Maryborough (152.6°E, 25.5°S) are the two main urban centres within the study area. These two towns have populations of approximately 41 000 and 21 000, respectively (ABS 1996). Land use surrounding Bundaberg is predominantly agricultural with extensive land clearing occurring for sugar cane production. Much of the mainland coastal strip bordering Great Sandy Strait and Tin Can Inlet is devoted to agricultural practices and plantation forestry (Fisheries Research Consultants 1993b).

The climate of the region is classified as maritime subtropical and characterised by an absence of temperature extremes. On average, summer daily temperatures range from 21–29 °C in Bundaberg and 19–30 °C in Maryborough. Average daily winter temperatures range from 11–22 °C in Bundaberg and 9–22 °C in Maryborough. Rainfall within the region is highly variable and exhibits marked seasonality, with a dry period generally occurring in the cooler winter months. Mary River and Burnett River frequently flood between January and March. The weather of Hervey Bay may be affected by cyclonic activity between December and May. However, cyclones are generally distant from the Bay. The Beach Protection Authority (1989) provides further details of the meteorology of the Hervey Bay area.

Tides in the Hervey Bay area are mixed, mainly semi-diurnal, with a period of about 12 hours and 25 minutes (Fisheries Research Consultants 1993b). The extreme tidal range of the main estuaries within the study area, along with hydrology and catchment details, included in Table 2.1, were compiled from information in the Australian Estuarine Database (Digby et al. 1999).

The study area falls within the Tweed-Moreton Bioregion (TMN) as defined in the Interim Marine and Coastal Regionalisation for Australia (IMCRA Technical Group 1998) and lies adjacent to the South-east Queensland Bioregion as defined in the Interim Biogeographic Regionalisation of Australia (Thackway and Cresswell 1995).



Coastline data: © Commonwealth of Australia, AUSLIG.

FIGURE 2.1 Site map of the study area, Round Hill Head to Tin Can Inlet, Queensland.

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

WETLAND	MEAN ANNUAL RAINFALL (mm)	RUNOFF COEFFICIENT	EXTREME TIDAL RANGE (m)	CATCHMENT AREA (km^2)
Broadwater Creek	1190	0.2	3.7	268
Baffle Creek	1190	0.2	3.2	2652
Littabella Creek	1147	0.21	3.2	189
Kolan River	1129	0.16	3.2	2823
Burnett River	1024	0.05	3.2	33323
Elliott River	1174	0.17	3.2	293
Coonarr Creek	1174	0.17	3.2	62
Theodolite/Lagoon Creek	1101	0.18	4	240
Burrum River	1101	0.18	4	2368
Beelbi Creek	1101	0.18	4	155
Great Sandy Strait	1197	0.22	2.5	11636

Data compiled from the Australian Estuarine Database (Digby et al. 1999). Data for minor estuaries within the study area were not included in the database. Mary River, Susan River, Tin Can Inlet and Kauri Creek are included within Great Sandy Strait.

2.2 Coastal Wetland Environments

Mangrove, saltmarsh and seagrass communities are recognised for their value to fisheries production. These mangrove 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 estimated that the estuarine habitats provided by mangroves and seagrasses are critical to more than 75% of commercially and recreationally important fish and crustacean species during some stage of their life cycle (e.g. mud and blue swimmer crabs, prawns, barramundi, 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. However, mangrove communities are under continued pressure from coastal, urban and agricultural development (see Section 2.4).

For the purposes of this study, environments located between the highest astronomical tide contour and the low water mark (i.e. the intertidal communities) are described collectively as coastal wetlands. The absence of a universally accepted definition of a mangrove community leads to many different interpretations of areal extents of "mangroves". Here, the term mangrove community refers to any community within the intertidal zone that is dominated by trees and shrubs. Saltmarshes are intertidal plant communities that are dominated by salt tolerant herbs and low shrubs, such as samphires and salt couches (Hopkins et al. 1998). Two subsets of this vegetation type are recognised in this study. Saltpans are those hypersaline areas that range from unvegetated claypans to areas dominated by samphire vegetation. Saline grasslands are those areas that are dominated by *Sporobolus virginicus* (salt couch).

Mangroves

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

- physical protection of the coastal fringe from erosion and flooding;

- sediment trapping;
- nutrient uptake and transformation;
- provision of a variety of plant and animal products;
- establishment of habitat for wildlife such as birds and crocodiles.

Mangrove species often have distinct distributional ranges at different geographic scales (Duke 1992). The physiological tolerance of each species to low temperature is the chief limiting factor to their latitudinal distribution (Duke et al. 1998). Consequently, species diversity generally decreases with increasing latitude.

Intertidal areas are subject to an extreme range of environmental parameters including salinity, soil type, frequency of inundation (both tidal and fresh) and wave action. As mangrove species are variable in their tolerance to these factors a pattern of species distribution known as zonation often occurs for these plants (Lovelock 1993). Mangrove zones in Queensland can vary from almost bare saltpans to dense forests more than 30 metres tall. By studying mangrove zonation at a particular location, indirect information can be derived on the extent of tidal inundation, and hence the direct utilisation by marine fauna. For example, Closed *Rhizophora* zones (or communities) which occur on the waters edge generally receive inundation with every high tide (twice a day for this region). 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. Unfortunately, there is a lack of quantitative information regarding the direct benefits gained from the various mangrove forest community types.

Thirteen mangrove species have been recorded in the study area (DEH 1990). These are:

- *Acrostichum speciosum* Willd. — Mangrove fern
- *Aegialitis annulata* R. Br. — Club mangrove
- *Aegiceras corniculatum* (L.) Blanco — River mangrove
- *Avicennia marina* (Forsk) Vierh. — Grey mangrove
- *Bruguiera gymnorrhiza* L. Lam. — Large-leafed orange mangrove
- *Ceriops tagal* C. T. White — Yellow mangrove
- *Crinum pedunculatum* R.Br. — Mangrove lily
- *Excoecaria agallocha* L. — Milky mangrove
- *Hibiscus tiliaceus* L. — Native hibiscus
- *Lumnitzera racemosa* Willd. — Black mangrove
- *Osbornia octodonta* F. Muell. — Myrtle mangrove
- *Rhizophora stylosa* Griff. — Red mangrove
- *Xylocarpus granatum* Koen — Cannonball mangrove

Within the Tweed-Moreton Bioregion, mangrove communities are more speciose north of the Great Sandy Strait and less diverse in NSW (IMCRA Technical Group 1998).

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 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).

Arthrocnemum spp., *Salicornia quinqueflora*, *Suavela* sp. and *Sporobolus virginicus* (Fisheries Research Consultants 1993b) typically dominate Saltmarsh communities in the study area. A total of eight saltmarsh species are found within the Tweed-Moreton Bioregion (IMCRA Technical Group 1998).

Seagrasses

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

A number of seagrass surveys have been conducted in the study region. The general distribution of seagrass in October 1988 from Water Park Point to Hervey Bay is presented in Lee-Long et al. (1992). Fisheries Research Consultants (1993a) also report on the seagrass distribution in the study area in 1992. Lennon and Luck (1990) describe the distribution of seagrass within Great Sandy Strait in 1988, as mapped from Landsat 5 TM imagery. Dredge et al. (1977) report on the seagrass distribution in Tin Can Inlet and Great Sandy Strait in 1973.

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

Fisheries Research Consultants (1993b) report a notable contraction in the distribution of seagrass within the southern portion of Great Sandy Strait and Tin Can Inlet, and a general reduction in density and cover, over the past twenty to thirty years. Although there is no clear cause for this decline, it was suggested that an increase in the amount of fine sediment has smothered the seagrasses. The possibility that agricultural herbicides carried into the Strait and Inlet have impacted on seagrass beds was also suggested.

Seven species of seagrasses are known to occur in the sheltered waters of Hervey Bay–Great Sandy Strait (Mateer 1998). These are:

- *Cymodocea serrulata* (R. Br.) Ascherson and Magnus
- *Halodule uninervis* (Forsk.) Ascherson

- *Halophila decipiens*. Ostenfeld
- *Halophila ovalis* (R. Br.) Hook f.
- *Halophila spinulosa* (R. Br.) Ascherson
- *Syringodium isoetifolium* (Ascherson) Dandy
- *Zostera capricorni* Ascherson

Other Habitats

Despite their often unrecognised role in primary production, 'non-vegetated' habitats such as rocky shores and intertidal flats are important fisheries habitats. Both macro and micro algae, particularly benthic microalgae, play a key role in primary production and may in total contribute more than half of the total net production (Alongi, 1998). Erftemeijer and Lewis (1999) recognised that intertidal mudflats constitute an important habitat that support a high biodiversity and biomass of benthic invertebrates, sustain productive fisheries and provide important feeding grounds for migratory shorebirds. 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.

Natural and artificial reefs within the study area are also important habitats for species that support the reef fishery. Small natural fringing coral reefs occur off Burnett Heads, Elliott Heads and Woodgate. Artificial reefs have been established with car bodies, unseaworthy vessels and concrete pipes and blocks in several locations in Hervey Bay including areas off Woodgate, off Barolin, to the north of the Burnett River and off Woody Island (Hyland 1993).

2.3 Fisheries Resources

The coastal habitats within this study area support important recreational and commercial fisheries. Detailed studies of these fisheries have been undertaken over the past 10 years. Morton and Healy (1992) and Hyland (1993) investigated the fisheries resources of the Fraser Island region and the Hervey Bay region, respectively. Beumer and Halliday (1994) characterised the estuarine and marine fauna associated with undisturbed and disturbed fisheries habitats at selected sites within Tin Can Inlet/Great Sandy Strait region. Fisheries resource assessments of Baffle Creek (Lupton and Heidenreich 1996), Burnett River (Lupton and Heidenreich 1999) and Elliott River (Lupton 1993) have also been undertaken.

The Hervey Bay area supports an important trawl fishery for prawns and scallops as well as commercial and recreational fisheries based on estuarine, inshore reef and pelagic species (see Hyland 1993 for details). Blue swimmer crabs are actively targeted by commercial fishers in several areas in Hervey Bay, particularly Burrum Heads, Gataker's Bay and the area to the north of Urangan. Spanner crabs are taken commercially from Platypus Bay north of Wathumba Creek and south of Rooney Point. In general crabbing occurs throughout the Strait. Mud crabs are generally taken from the central portions of the Strait and fringing creeks (especially Kauri Creek) and blue swimmer crabs are taken from the more oceanic areas near the northern and southern ends (e.g. Pelican Bay) of the Strait.

The extensive seagrass beds and mangrove communities in the Great Sandy Strait region represent major nursery grounds and areas of high primary production. Specific areas on Fraser Island have been identified as particularly important for certain fisheries. The section of Fraser Island offshore between Indian Head and Waddy Point is an important area for schools of tailor and is closed to fishing in September to protect the adults during spawning. Wathumba Creek is a popular camping area and many anglers, especially recreational fishing clubs, use the area. The intertidal flats immediately south of Moon Point provide one of the more important commercial net fishing grounds (Morton and Healy 1992).

Beumer and Halliday (1994) report a similar species composition in Tin Can Inlet as in other subtropical mangrove estuaries in south Queensland. Of the 100 species of fish caught, 39 species were of commercial or recreational importance. Additionally, four commercial prawn species were observed to use Tin Can Inlet as a nursery site.

Both the Baffle Creek and the Elliott River systems have been identified as important areas for future habitat protection due to their pristine status and high fisheries productivity (Lupton 1993; Lupton and Heidenreich 1996).

In their assessment, Lupton and Heidenreich (1996) identified a total of 55 fish and 9 crustacean species from the lower estuarine reaches of Baffle Creek of which 60%, including blue-tail mullet, sand mullet, flat-tail mullet, whiting and bream, were of economic importance (i.e. targeted by commercial and recreational fishers). Two thirds of the 63 fish and 10 crustacean species sampled from the upper estuarine areas of Baffle Creek were of economic importance. These species included gar, bream, whiting, tiger mullet and flat-tail mullet.

Of the 65 species of fish found in the middle estuarine section of Elliott River 54% were of economic importance. Adult fish included bream, whiting and mullet, while gar, flathead, emperor (sweetlip) and whiting were the dominant juveniles present. In the upper estuarine reaches 53% of the 63 species sampled were of economic importance. Barramundi, queenfish, mullet and barracuda adults and juvenile gar, flathead, mangrove jack, emperor (sweetlip) and whiting were the dominant species identified in this region of the river. Thirteen species of crustaceans were sampled from Elliott River of which 10 species were of economic importance. The mouth section of Elliott River, in the form of large shallow intertidal sand bars and flats with pockets of seasonal seagrass cover, was identified as providing ideal nursery habitats for juvenile whiting, bream, emperor (sweetlip), and post-larval king prawns (Lupton 1993).

Lupton and Heidenreich (1999) assessed the fisheries resources of Burnett River system. A total of 101 estuarine fish and 15 crustacean species were sampled from the Burnett River system over a period of 12 months. Half of the fish and crustacean species found in the lower estuarine areas were of economic importance. These species included flag-tailed mullet, fan-tailed mullet, jewfish, whiting, and banana and bay prawns. A total of 57% of the fish and crustacean species sampled from the upper estuarine areas were of economic importance. These species included catfish, flathead, javelin fish, whiting, jewfish, sea and fan-tailed mullet and banana and bay prawns. Despite the existence of these economically important species, the Burnett River system was identified as too degraded to warrant any increased fisheries habitat protection.

The fisheries value of various coastal wetlands, which have been declared as FHAs in the study region, is included in Table 2.2.

TABLE 2.2 Fisheries values and habitat types of Fish Habitat Areas (both A and B) within the study area.

FHA NAME	A/B	FISHERIES VALUE	MAJOR HABITAT TYPES
KINKUNA	A	Bream, whiting, flathead, barramundi	Closed *C. tagal* and *A. marina* forests along with saltpans on the landward rim and intertidal flats along the estuary
BEELBI	A	Bream, estuary cod, flathead, gar, luderick, mangrove jack, sea mullet, tailor, whiting, banana prawns, king prawns, mud crabs	Extensive mangrove stands with low closed *A. marina* and *A. annulata* shrubs and open mixed forests; seagrass areas; shallow littoral flats; patches of saltmarsh
SUSAN RIVER	A	Bream, estuary cod, flathead, gar, grunter, luderick, mangrove jack, sea mullet, tailor, whiting, banana prawns, mud crabs	Closed *R. stylosa* and *A. marina*, low *C. tagal* shrubland; intertidal sand flats and claypan
MAAROOM	A	Bream, estuary cod, flathead, gar, grunter, luderick, mangrove jack, sea mullet, tailor, whiting, banana prawns, king prawns, tiger prawns, mud crabs, oysters	Extensive mangrove zones and saltmarsh along estuary with *A. marina*, *C. tagal* and *A. annulata* recorded; mangrove islands and banks; muddy shoals; extensive seagrass meadows in Great Sandy Strait
KAURI CREEK	A	Bream, estuary cod, flathead, gar, grunter, luderick, mangrove jack, sea mullet, tailor, whiting, eastern king prawns	Extensive mangrove zones and saltmarsh along estuary with *A. marina*, *C. tagal* and *A. annulata* recorded; extensive seagrass meadows in Tin Can Inlet
TIN CAN INLET	A	Bream, estuary cod, flathead, gar, grunter, luderick, mangrove jack, sea mullet, tailor, whiting, eastern king prawns, greasy back prawns, mud crabs	Extensive sea grass meadows; intertidal flats; the upper Inlet contains brackish and freshwater elements associated with the wallum heath and swamps of adjacent catchment; extensive mangrove zones and saltmarsh along estuary with *A. marina*, *C. tagal* and *A. annulata* recorded
KOLAN RIVER	B	Bream, estuary cod, flathead, gar, grunter, grey mackerel, mangrove jack, sea mullet, school mackerel, whiting, banana prawns	Extensive mangrove stands along estuary with some channel islands/sandbars present
GREGORY	B	Bream, estuary cod, flathead, mangrove jack, sea mullet, tailor, whiting, anguillid eels, mud crabs	Closed *R. stylosa* and *A. marina* lined river with patches of low *C. tagal*, saltmarsh and intertidal sandflat
CHERWELL-BURRUM	B	Bream, estuary cod, flathead, gar, mangrove jack, sea mullet, tailor, mud crabs	Closed *R. stylosa* and *A. marina* lined river with patches of low *C. tagal*, saltmarsh, intertidal sandflat and shallow littoral areas
BURRUM – TOOGOOM	B	Barramundi, bream, estuary cod, flathead, gar, grey mackerel, mangrove jack, sea mullet, school mackerel, tailor, whiting, mud crabs	Closed *R. stylosa* and *A. marina* with patches of low *C. tagal*, saltmarsh and seagrass areas
FRASER ISLAND	B	Bream, estuary cod, flathead, luderick, mangrove jack, sea mullet, grey mackerel, school mackerel, spotted mackerel, swallow tail dart, tailor, whiting, eastern king prawns	*A. marina*, *A. corniculatum*, *C. tagal* and *R. stylosa* are the dominant mangrove species with extensive sheltered tidal flats; steep rocky cliffs and sandy ocean beaches

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

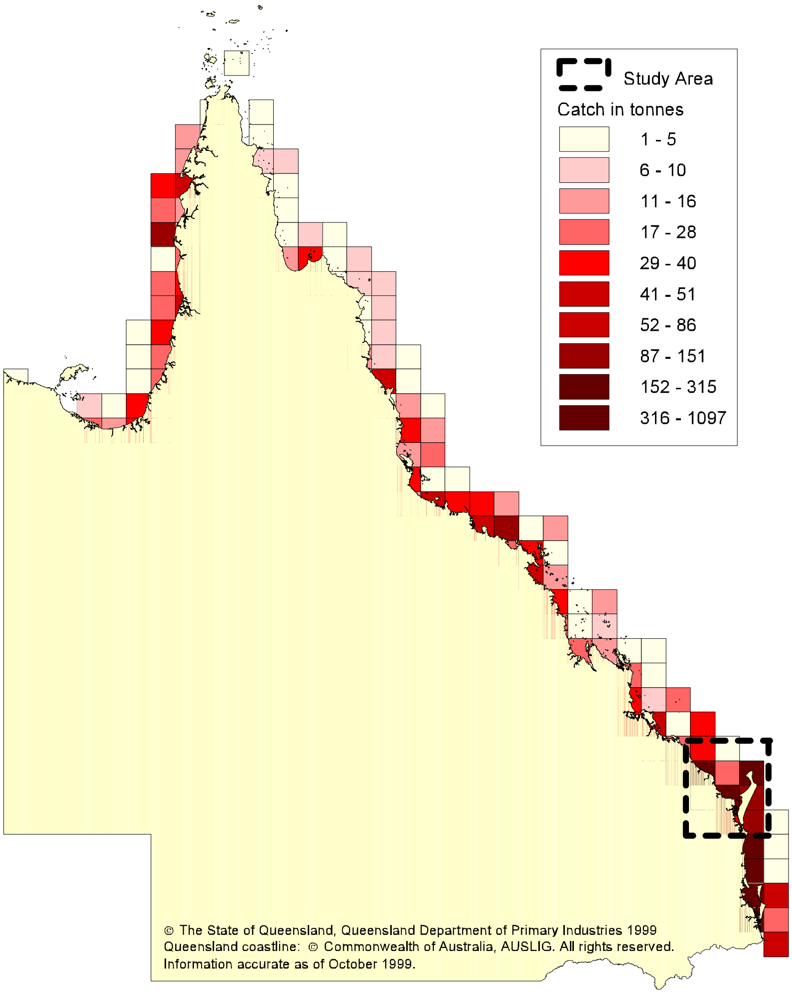


FIGURE 2.2 Queensland net fishery catch by 30minute grid, 1998.

The total catch by 30-minute grid for the net fishery in 1998 is displayed in Figure 2.2. The majority of the species targeted in the net fishery rely on coastal wetland environments for food sources and habitat requirements at some stage of their life cycle. The study area roughly represents the northern limit for higher levels of production of sub-tropical species in the net fishery. These species include mullet, bream, whiting, tailor, gar and spotted and school mackerel. Barramundi, blue and king threadfin, grey mackerel and sharks dominate the tropical Queensland net fishery, from the Curtis Coast north.

2.4 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 targets areas adjacent to coastal wetlands.

There are a variety of pressures on fisheries habitats relating to population growth within the region from Round Hill Head to Tin Can Inlet. The popularity of the region for residential and recreational purposes is increasing. The Great Sandy Strait Management Plan (FIU 1994) identified that if current trends continue, many rural properties will be subject to subdivision to cater for increased expansion of urban and tourist centres adjacent to Great Sandy Strait.

Fortunately, marine plants in Queensland are protected from large-scale removal for human developments under Fisheries legislation. Any proposed disturbance of marine plants requires approval under the *Fisheries Act*, 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 attempt to ensure that development impacts are minimised and retained within a localised area. Details of known development proposals within the study area that have the potential to have minor impacts on coastal wetland vegetation are included in Table 2.3.

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

The damage to aquatic ecosystems, and in particular to fisheries and fish habitats, arising from various human induced changes is largely unquantified. 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, should be investigated.

In recent years, cane expansion has occurred within the study area and areas of forest have been converted to cane production. There is a continual input of nutrients and sediment to the waterways relating to agricultural land use. In particular, the Burnett River catchment and to a lesser extent Baffle Creek, Elliott River and Mary River catchments have a large proportion of agricultural land use. The impacts of this land use within the Burnett River catchment is reflected in the reduced water quality of this system and its negative impacts on fisheries (outlined in Lupton and Heidenreich 1999). DOE

(1997) reported that there might be future pressure to expand sugar cane farming land along the Susan River, which is likely to impact on adjacent wetlands.

Other human induced impacts include dredging operations (e.g. sand and gravel from Mary River) and shellgrit and coral extraction (e.g. Point Vernon and Dundowran, and Woody Island respectively). Additionally, the demand for mosquito and biting midge control may lead to a draining of saltmarsh areas for social acceptance and health reasons (Hyland 1993).

TABLE 2.3 Development threats to coastal wetland vegetation.

LOCATION	DETAILS
BAFFLE CREEK	There is a major marine prawn aquaculture facility under construction within Baffle Creek. A dam has been proposed for Oyster Creek.
LITTABELLA CREEK	A prawn farming facility exists and there is the potential for expansion of this facility. It is expected that any expansions will have minimal impacts to any marine plants. There are no further aquaculture proposals for Littabella Creek, only occasional interest.
BURNETT RIVER	An aquaculture proposal for the Burnett River has the capacity for significant impact on marine plants due to the creation of sediment ponds within the mangrove zone. Additionally, extractive industry has been proposed. The narrow fringe of mangroves near the port lands is under threat from dredging spoil disposal.
ELLIOTT RIVER	There are a number of existing marine prawn farming facilities present on Elliott River. Community groups have proposed deepening of the Elliott River channel to allow easier vessel access. If this eventuates there is the potential for further impacts in the form of a marina.
COONARR CREEK	A coal loading facility near Coonarr Creek has been proposed. Additionally, mining leases on tidal lands to the south of the Coonarr Creek mouth have the potential to impact on coastal wetland vegetation should these leases be used.
BURRUM RIVER	There is existing as well as proposed aquaculture for Burrum River. A large agriculture and aquaculture facility on the southern bank of the Burrum River is proposed. However, this proposal involves minimal direct disturbance to marine vegetation.
BEELBI CREEK	A council proposal for erosion protection and a boardwalk on Martin's Creek involves a minor threat to marine vegetation. Additionally, beach nourishment in this region poses a minor threat to coastal wetland systems. Residential pressure at Toogoom also exists.
ELI CREEK	Eli Waters development will impact on saline grasslands in this coastal wetland system.
PULGUL CREEK	Although there are no current development applications there is continuing interest in this region for marina/industrial development which could have a significant impact on the coastal wetland vegetation of this creek. There is also minor residential development pressure on the foreshores south of Pulgul Creek.
RIVER HEADS	A marina has been proposed at River Heads. The freehold block associated with this development application has been cleared of mangrove vegetation (see Sheet 12, Appendix 7).
SUSAN RIVER	There is interest in aquaculture development in Susan River. However, the coastal wetlands are protected within the Susan River FHA.
POONA	A boat ramp proposal involving some reclamation poses a minor threat to the marine vegetation at Poona.
FRASER ISLAND	There is ongoing interest for additional access to Fraser Island in the form of barge landing sites at various locations. A proposal for a barge-landing site at Moon Point has the potential to impact on the seagrass beds and intertidal flats in this area. It is not expected that the barge-landing site will have an impact on mangrove vegetation if it goes ahead. Another barge landing, with minor impacts to marine vegetation is proposed for a site near Woonggoolba Creek.
TIN CAN INLET	Interest for marina development within the Tin Can Inlet is continuing. Various locations have been proposed, for example from Inskip Point to Pelican Bay, Carlo Point and the spit at Tin Can Inlet. A marina within the Inlet has the potential to impact on the intertidal flats as well as minor areas of coastal wetland vegetation. Tin Can Inlet is subject to a relatively low level of human impact, with some impacts occurring at Carlo Point due to a sewage discharge and at Tin Can Inlet and Pelican Bay due to vessel activity and mooring.

2.5 Existing Conservation Measures and Conservation Values

Fish Habitat Areas

Fish Habitat Areas have been declared throughout coastal Queensland to enhance existing and future fishing activities and to protect the habitat upon which fish and other aquatic fauna depend (Beumer et al. 1997). Eleven FHAs are currently declared within the study area (see Appendix 4). Table 2.2 summarises the fisheries values and the habitat types of each of the wetlands protected by FHAs within the study region.

Directory of Important Wetlands and Marine Parks in Australia

Several sections of coastline in the study area have been listed in the National Directory of Important Wetlands. These include the Great Barrier Reef Marine Park (wetland reference GBR003QL), Burrum Coast (wetland reference SEQ001QL), Fraser Island (wetland reference SEQ006QL) and Great Sandy Strait (wetland reference SEQ007QL).

The section of coastline north of Baffle Creek is included within the Great Barrier Reef Marine Park. This region is managed as a General Use ‘A’ Zone.

The Burrum Coast wetland comprises the coastline and estuaries between and including, Beelbi and Theodolite Creeks. The mangroves and seagrass beds of this wetland are recognised as a vital breeding and refuge habitat for fish and crustaceans, as well as feeding grounds for shorebirds, dugong and turtles. The wetland also has high Aboriginal cultural value and is popular for fishing and boating.

The Fraser Island wetlands have been noted for their distinctness. They are listed as the best example of a complex of wetlands characteristic of the South-east Queensland Bioregion. A number of rare, endangered and unusual species of flora and fauna occur in this area, including the rare fish honey blue-eye (*Pseudomugil mellis*), listed in the *Nature Conservation Act, 1994*.

The Great Sandy Strait wetland is a large and complex wetland system containing intertidal flats, seagrass beds, mangrove forests and saltmarshes. Kauri Creek and Tin Can Inlet are considered to be significant wetlands at the southern end of the Great Sandy Strait. This wetland provides important habitat for large numbers of wader birds (including trans-equatorial migratory waders), dugongs and turtles. Moreover, it is the southern distributional limit of three mangrove species (*A. annulata, O. octodonta* and *X. granatum*).

Ramsar Site

In June 1999, Great Sandy Strait (including Great Sandy Strait, Tin Can Bay, and Tin Can Inlet) was included in the Ramsar list of Wetlands of International Importance. This area is the largest area of tidal swamps within the South-east Queensland Bioregion, consisting of intertidal sand and mud flats, extended seagrass beds, mangrove forests, salt flats, and saltmarshes, and often contiguous with freshwater *Melaleuca* wetlands and coastal wallum swamps. It was noted as an exceptionally important feeding ground for migratory shorebirds and important for a wide range of other shorebirds, waterfowl and seabirds, marine fish, crustaceans, oysters, dugong, sea turtles, and dolphins.

National Parks

Numerous National Parks and Conservation Parks within the study area protect the coastal vegetation above tidal influence. The majority of the coastal wetland vegetation at Broadwater Creek lies within the Broadwater Creek Conservation Park. Other Conservation Parks at the mouth of Baffle Creek, the mouth of Kolan River, Barubbra Island and O'Regan Creek protect the majority of the coastal wetland vegetation at these locations. The Burrum Coast National Park protects a small portion of coastal wetland vegetation associated with Coonarr Creek, a larger proportion of Theodolite Creek, some coastal wetlands at the mouth of Burrum River and almost all of Beelbi Creek. Great Sandy Strait National Park covers coastal wetland vegetation on Fraser Island including Wathumba Creek, Coongul Creek and Moon Point. The Great Sandy Conservation Park and Poona National Park protect small areas adjacent to coastal wetland vegetation within the Strait and Tin Can Inlet (Appendix 8).

World Heritage Area

Fraser Island was inscribed to the World Heritage List in December 1992. The island was recognised for the outstanding, universal value of its ancient and magnificent sand dune systems and its spectacular forests and freshwater lakes (WCMC 1998). The boundary of the region is given as 500m below high water mark, in order to include important areas of beaches, wetlands and mangroves, and part of the extensive seagrass beds in the Great Sandy Strait, which extend to more than 12 500 ha (DASETT 1991; Sinclair and Morrison 1990).

Dugong Sanctuaries – Fisheries Closures

The Hervey Bay and Great Sandy Strait dugong sanctuaries, declared in 1998 under the *Fisheries Act*, are both of management Zone 'A' types. Unlike other Zone 'A' Dugong Sanctuaries, the use of offshore set, foreshore set and drift nets are allowed in these two dugong sanctuaries. Specialised fish netting practises are allowed to continue, with modifications. The use of river set nets is also allowed to continue, with modifications.

SECTION 3. METHODS

3.1 Data

Maps of coastal wetland communities were produced from Landsat 5 Thematic Mapper (TM) satellite imagery. Three scenes, Lady Musgrave Island (12 August 1997), Bundaberg (12 August 1997) and Fraser (6 September 1997) were required to map the three regions of Round Hill Head to Burnett River, Elliott River to Point Vernon and Urangan to Tin Can Inlet, respectively. Landsat TM scenes of the same date were not used due to the limited availability of data.

The spatial resolution of Landsat TM data is 30 m x 30 m. The spectral characteristics of the data as well as details of the Landsat satellites are outlined in Appendix 5.

Aerial photography was used to aid in the classification of the satellite imagery. The photography used in this study is listed in Table 3.1.

TABLE 3.1 Aerial photography utilised in the study.

AERIAL PHOTOGRAPHY	YEAR	SCALE
BPA Tweed Heads to Urangan	1994	1: 50 000
BPA Urangan to Saint Lawrence	1996	1: 50 000
BPA Urangan to Saint Lawrence	1975	1: 12 000
Hervey Bay	1976	1: 12 000
Wide Bay Burnett Resource Study	1976/1977	1: 12 000

3.2 Mapping Methods

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

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

The classification was converted from raster to vector format using ARC/INFO ® GIS software. To improve cartographic presentation of the data, the jagged vector boundaries were splined and generalised and polygons with areas under 0.5 ha were excluded. The coverage was then converted to an ESRI shapefile and projected to geographics. Appendix 6 contains the metadata for this shapefile. The shapefiles were overlaid on a Band 3 (visible red) Landsat TM image. Maps were produced using ARCVIEW ® GIS Version 3.1 at a scale of 1: 100 000 (Appendix 7: Sheets 1–14).

Coastal wetland communities were also overlaid on the Digital Cadastral Database (DCDB) to produce a 1: 250 000 map of tenure within the study region (Appendix 8: Sheets 1–4).

3.3 Field Methods

The computer-based community classification was validated with fieldwork conducted during February 1999 and May 1999. Sites were selected on the basis of their accessibility by either boat, 4WD vehicle or on foot. At selected sites information on mangrove community floristics and structure was documented. At each site data recorded included the specific composition of mangroves, dominant genus, estimated density (Projective Foliage Cover – PFC) of each vegetation layer, composition and hardness of substrate, and presence/absence of seedlings, samphires, grasses, algae, leaf litter, roots, ferns, epiphytes, sedges and ponds.

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 generally between 20 m and 30 m (1 pixel) with a maximum error of 69 m and a minimum error of 19 m.

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

3.4 Classification Details

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

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

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

3.5 Accuracy Assessment

A set of 255 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 maps. An error matrix using this data was generated (Appendix 9) and the overall accuracy along with user's accuracy and producer's accuracy was calculated.

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

An overall evaluation of the project is included in Appendix 10.

3.6 Intertidal Flats and Freshwater Swamps

The foreshore flats and swamps themes from the digital GEODATA TOPO-250K topographic map series (AUSLIG 1994) were used to create maps of intertidal flats and freshwater swamps (Appendix 11: Sheets 1–4). The GEODATA product is primarily sourced from the 1: 250 000 scale National Topographic Map Series, which was completed in 1988. Foreshore flats and swamps from the Bundaberg, Sandy Cape, Maryborough and Wide Bay map sheets were combined into one ESRI shapefile using ARCVIEW Version 3.1 software. Foreshore flats are defined as part of the seabed between mean high water and the line of low water. Swamps are defined as land that is so saturated with water that it is not suitable for agricultural or pastoral use and presents a barrier to free passage. It is often covered with characteristic grass and reed growths, and the degree of wetness may vary with season (AUSLIG 1994). Areas of intertidal flats and swamps have not been calculated from this data as this coverage is current only to 1988 and intertidal flats and swamps can be variable in distribution. The coverages are included to provide an overview of intertidal flats and freshwater swamps in the study area and should not be considered as an accurate present day distribution. Overlaying the foreshore flats coverage on the Landsat TM image gives an indication of where the spatial distribution of intertidal flats has changed since the coverage was created (1988). Areas of significant change are mentioned in Section 5.

3.7 Comments on Changes to Coastal Wetland Communities

Comments on changes that have occurred to the coastal wetland communities were made on the basis of comparisons of current and historical aerial photographs (Table 3.1) and previous unpublished departmental mapping of the region.

3.8 Assessment of Coastal Wetlands for FHA Nomination

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

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

The details of the methods of assessment of these criteria are included in Table 3.2.

TABLE 3.2 Details of the methods of the coastal wetland significance assessment.

CRITERIA	SUBCATEGORIES	DETAILS
Size		Area of mangrove and saltmarsh communities, calculated in hectares.
Diversity of or specific habitat features	Diversity of Mangrove and Saltmarsh Communities	**High (H)**: 11–14 mangrove and saltmarsh communities present
		Medium (M): 5–11 mangrove and saltmarsh communities present
		Low (L): 1–4 mangrove and saltmarsh communities present
		The number of mangrove and saltmarsh communities was calculated on the basis of the mapping conducted for this investigation. See Section 4.1 for the descriptions of these mapping units.
	Presence of Intertidal Flats	Comments on the extent of intertidal flats along the coastline were based on aerial photograph interpretation. Further comments on each of the coastal wetland systems are included in sections 5.2–5.11.
	Presence of Rocky Foreshores	Comments on the location and extent of rocky foreshore features were based on 1: 50 000 aerial photograph interpretation and 1: 100 000 topographic map details. Comments were not made for each individual coastal wetland, as interpretation of finer resolution aerial photography was not undertaken.
	Adjacent Freshwater Swamps	**Presence (Y)** or **absence (N)** of freshwater swamps adjacent to the coastal wetland communities. O indicates freshwater swamps nearby but not adjacent. The "swamp" coverage from the AUSLIG 1: 250 000 digital topographic series was used. See Appendix 11.
Diversity of or specific marine fauna and flora		Comprehensive surveys of species diversity for each wetland system were not conducted as part of this investigation. Specific, noteworthy marine flora communities have been described in Section 7.2 and are recorded as unique features (see below). Information concerning the diversity of fauna was not included in this evaluation.
Level of existing and future disturbances	Significant Dams and Weirs	**Presence (Y)** or **absence (N)** of significant dams or weirs on the river or creek. The locations of dams and weirs in Queensland collected by the Dept. of Natural Resources.
	Disturbance to Adjacent Terrestrial Vegetation	**Near Pristine (NP)** : natural cover >90%
		Largely Unmodified (LU) : natural cover ~65–90%
		Modified (M) : natural cover ~35–65%
		Severely Impacted (SI) : natural cover <35%
		Adjacent terrestrial vegetation refers to the vegetation within 5km of the upper tidal limit.
Unique Features		**Presence (Y)** of unique features. The details of these features are included in Section 7.2.
Existing or potential fishing grounds	Significant/Important Fishing Grounds	**Significant (Y)** fishing grounds. Assessed from local knowledge of each coastal wetland system and/or from literature review.
Protected species	Not included in this evaluation.	All marine plants are protected under fisheries legislation. Other information on protected species was not available.

SECTION 4. RESULTS

4.1 Description of the Mapping Units

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

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

OPEN *AVICENNIA*	FIGURE 4.3
Habitat	Found on the seaward edge as a pioneer and on the landward edge that is only inundated by the highest spring tide.
Canopy	*A. marina* plants form a canopy that has a PFC of less than 50%. Height varies, generally <1 m in areas bordering on saltpans and up to 10 m in pioneering zones.
Shrub layer	Generally absent.
Ground cover	Occasional presence of samphires (on the landward edge) and a sparse coverage of *A. marina* pneumatophores.

CLOSED *CERIOPS*	FIGURES 4.4 and 4.5
Habitat	Generally occur on upstream creek edges and towards the upper intertidal limit on land more elevated than *R. stylosa* communities and landward of *R. stylosa* communities. Only inundated by the spring tides.
Canopy	Dominated by *C. tagal* with occasional *A. marina*, *B. gymnorrhiza* and *L. racemosa*. Height of the canopy across sites varies (from approximately 1–4m) however at an individual site is generally remarkably uniform. PFC greater than 50%.
Shrub layer	Generally absent.
Ground cover	Consists of sparse cover of seedlings and roots of the species present.

OPEN *CERIOPS*	FIGURE 4.6
Habitat	Occurs on the landward edge of the intertidal zone and is inundated by only the high spring tides. This community often surrounds saltpans and is rarely on the water's edge, except on eroding banks.
Canopy	A community dominated by *C. tagal* with occasional *A. marina* emergents. The PFC is less than 50%; height varies from <1 m in the extremely saline areas to approximately 3 m.
Shrub layer	Occasional presence of other species such as *A. corniculatum* and *A. marina*.
Ground cover	Consists of seedlings of the species present along with a sparse to open coverage of samphires and grasses.

CLOSED *AEGICERAS*	**FIGURE 4.7**
Habitat	Occurs in the upper tidal reaches and on accreting banks of creeks and rivers over a wide range of salinities.
Canopy	Dominated by *A. corniculatum*, often with *A. marina* emergents and *A. annulata* as a subdominant.
Shrub layer	Generally absent.
Ground cover	Samphires, salt couch and the mangrove fern *A. speciosum* are often found in the understorey of this community type.

OPEN *BRUGUIERA*	**FIGURES 4.8 and 4.9**
Habitat	Generally occurring in the landward zone in areas with some freshwater input.
Canopy	Dominated by *B. gymnorrhiza,* with a canopy with a PFC of less than 50%.
Shrub layer	Generally absent.
Ground cover	*B. gymnorrhiza* seedlings and knee roots of mature *B. gymnorrhiza* individuals

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

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

CLOSED *AVICENNIA*/*CERIOPS*	**FIGURE 4.10**
Habitat	Commonly bordering saltpans in areas only inundated during spring tides.
Canopy	A mixed community of *A. marina* and *C. tagal* forming a canopy with a PFC of greater than 50%. Generally a low community with a canopy of <1.5 m.
Shrub layer	*A. annulata*, *A. corniculatum* and *L. racemosa* may be present.
Ground cover	Occasional presence of samphires and seedlings of the species present.

OPEN *AVICENNIA*/*CERIOPS*	**FIGURE 4.11**
Habitat	Commonly bordering saltpans in areas only inundated during spring tides.
Canopy	A mixed community of *A. marina* and *C. tagal* forming a canopy with a PFC of less than 50%. Generally a low community with a canopy of <1.5 m.
Shrub layer	*A. annulata*, *A. corniculatum* and *L. racemosa* may be present.
Ground cover	Presence of samphires and seedlings of the species present.

CLOSED MIXED	**FIGURE 4.12**
Habitat	Generally found on the landward edges of mangrove communities and in the upper tidal reaches of creeks and rivers.
Canopy	A closed mix of species in which a variety of the 13 species present in this region may occur.
Shrub layer	A shrub layer consisting of juveniles of the various canopy species may be present.
Ground cover	Seedlings and roots of the various species along with sparse samphires and grasses.

SALTPAN	**FIGURES 4.13 and 4.14**
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 (0.2–0.8 m) plants of *A. marina*, *C. tagal* and *A. annulata* may occur.
Shrub layer	Absent.
Ground cover	Ranging from no vegetation to closed samphires and algae, commonly an open coverage of samphires such as *Athrocnemum* spp., *Salicornia quinqueflora,* and *Suavela* sp.

SALINE GRASSLAND	**FIGURES 4.4 and 4.13**
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 tidal limit into open *Casuarina* communities.
Canopy	Generally absent.
Shrub layer	Absent.
Ground cover	Ranging from sparse to dense coverage of salt couch (*Sporobolus virginicus*) within which a sparse coverage of samphires and sedges may also occur.

FIGURE 4.1 A narrow Closed *Rhizophora* community along a drainage line at Baffle Creek.

FIGURE 4.2 A Closed *Avicennia* community on the bank of Moon Creek, Fraser Island.

FIGURE 4.3 An Open *Avicennia* community at Point Vernon.

FIGURE 4.4 A Closed *Ceriops* community bordering on a Saline Grassland community at Baffle Creek.

FIGURE 4.5 A Closed *Ceriops* community on an eroding bank in Moon Creek.

FIGURE 4.6 An Open *Ceriops* community on the bank of Theodolite Creek.

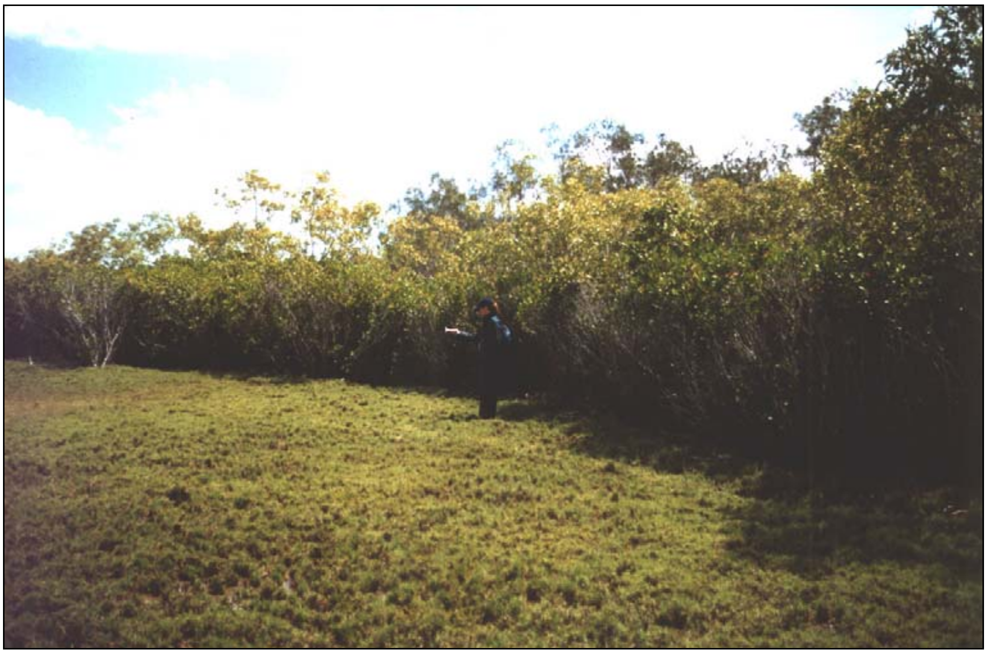


FIGURE 4.7 A Closed *Aegiceras* community with *A. marina* emergents, bordering on a Saline Grassland community on Mary River.

FIGURE 4.8 An Open *Bruguiera* community at Carlo Point, Tin Can Inlet.

FIGURE 4.9 An Open *Bruguiera* community with a groundcover of closed sedges at Carlo Point.

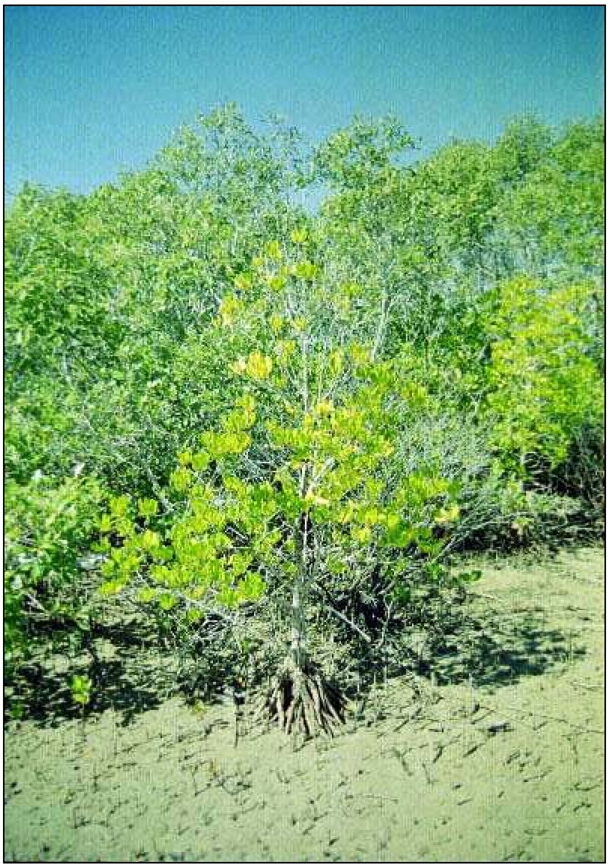


FIGURE 4.10 A small Closed *Avicennia*/*Ceriops* community on the landward rim of the coastal wetland system at Point Vernon.

FIGURE 4.11 A small Open *Avicennia/Ceriops* community on Burrum River.

FIGURE 4.12 A Closed Mixed community on Rocky Creek consisting of *A. annulata*, *A. corniculatum*, *A. marina* and *O. octodonta*.

FIGURE 4.13 A small Saltpan community with a Saline Grassland community behind it, at Beelbi Creek.

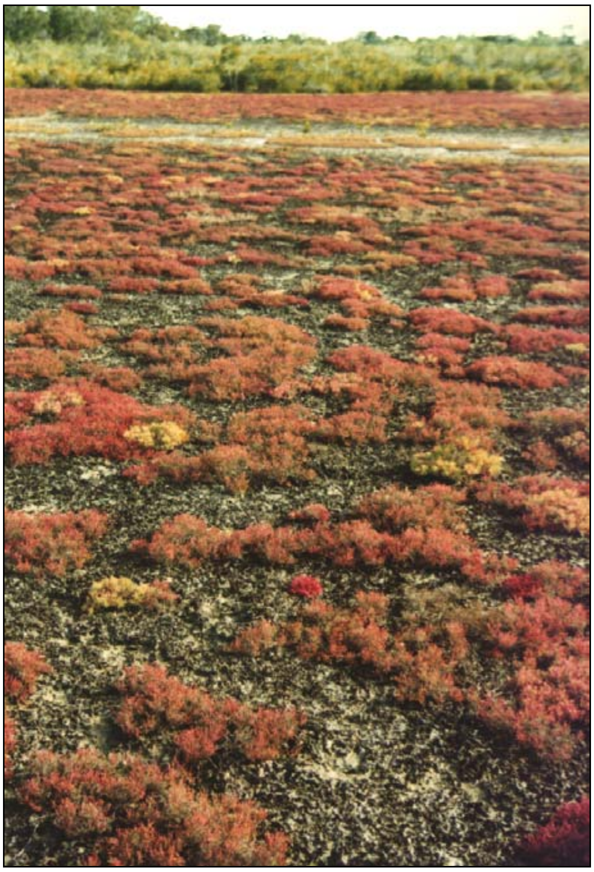


FIGURE 4.14 A Saltpan dominated by samphire vegetation at Theodolite Creek.

4.2 Accuracy Assessment

The overall accuracy of the coastal wetland coverage was calculated at 89.4%. The user's and producer's accuracies are included in the table below. The error matrix used in these calculations, showing the number and class distribution of accuracy assessment points, is included in Appendix 9. The Susan River accuracy assessment was conducted using older photography (1975–77) due to the absence of more recent photography.

TABLE 4.2 User's and producer's accuracies for each of the coastal wetland communities.

CLASS	USER'S ACCURACY	PRODUCER'S ACCURACY
Closed *Rhizophora*	98.31	96.67
Closed *Avicennia*	85.71	80
Open *Avicennia*	100	85.71
Closed *Ceriops*	75	75
Open *Ceriops*	None recorded	None recorded
Closed *Aegiceras*	100	90
Open *Bruguiera*	None recorded	None recorded
Closed *Rhizophora/Avicennia*	60	75
Closed *Rhizophora/Aegiceras*	66.67	50
Closed *Avicennia/Ceriops*	91.3	100
Open *Avicennia/Ceriops*	100	50
Closed Mixed	100	77.78
Saline Grassland	100	100
Saltpan	96.55	94.92

4.3 Limitations of the Mapping Technique

Some typical mangrove zones, such as narrow seaward fringes and small mangrove communities within a Saltpan or Saline Grassland (e.g. *A. marina*) were not identified in this mapping process. While these communities do occur they are generally linear or small and therefore, are not large enough to be mapping units (that is 30 m wide).

Due to the similar spectral characteristics of their foliage, *B. gymnorrhiza* cannot be easily separated from *R. stylosa*, from satellite imagery or aerial photography. Ground truthing and unpublished departmental mapping work was used to identify significant Open *Bruguiera* communities and to thus separate these community types.

A unique environment in Tin Can Inlet, specifically at Carlo Point, was difficult to characterise. An Open *Bruguiera* community with a ground cover of closed sedges (Figure 4.9) gradually became a closed sedge environment on the landward rim of the coastal wetland system. This community type is spectrally very similar to saline grasslands, which are also present in this location, i.e. the landward rim of these coastal wetlands. For this reason these communities were not separated but labelled as Saline Grassland or, where appropriate, Open *Bruguiera.*

SECTION 5. DISTRIBUTION AND SIGNIFICANCE OF THE COASTAL WETLAND COMMUNITIES

5.1 General Distribution

The coastline from Round Hill Head to Tin Can Inlet can be divided into three main regions based on the exposure to wind and wave energy and the corresponding extent of coastal wetland community development. The most sheltered region containing the largest area of coastal wetlands and intertidal flats extends from Tin Can Inlet, through Great Sandy Strait and up to Burrum River. Fraser Island ensures that this area is sheltered from open ocean wave action. The region of coastline from Burrum Heads to Round Hill Head is a more exposed section of coastline. In this area, coastal wetland communities have established in the protected estuaries of creeks and rivers. These estuaries also provide the most extensive intertidal flats in the region.

The sandy eastern shoreline of Fraser Island and the mainland from Bullock Point to Double Island Point is exposed to open ocean wave action. No suitable environments for the establishment of coastal wetland communities exist in this section of the coastline.

The dominant community type for the study area is Closed *Rhizophora*. This community is mainly found within Great Sandy Strait, the north-west coast of Fraser Island, Kauri Creek and Tin Can Inlet. This area also exhibits the highest degree of zonation with Closed *Rhizophora* inhabiting the seaward zone and Closed *Avicennia*/*Ceriops* establishing behind. In the more exposed section of coastline, there is a general absence of Closed *Rhizophora* forming a distinct seaward zone. Instead, the dominant communities Closed *Ceriops* and Closed *Avicennia* grade slowly into more mixed assemblages. Saltpans are found throughout the study area with the greatest proportion occurring in Great Sandy Strait.

TABLE 5.1 Areas of coastal wetland communities from Round Hill Head to Tin Can Inlet.

COMMUNITY	AREA (ha)	% of TOTAL
Closed *Rhizophora*	6598.43	27.60
Closed *Avicennia*	3405.34	14.25
Open *Avicennia*	750.01	3.14
Closed *Ceriops*	1734.60	7.26
Open *Ceriops*	5.24	0.02
Closed *Aegiceras*	1005.25	4.21
Open *Bruguiera*	37.25	0.16
Closed *Rhizophora*/*Avicennia*	292.83	1.22
Closed *Rhizophora*/*Aegiceras*	647.85	2.71
Closed *Avicennia*/*Ceriops*	1864.19	7.80
Open *Avicennia*/*Ceriops*	706.14	2.95
Closed Mixed	481.14	2.01
Saline Grassland	923.17	3.86
Saltpan	5453.95	22.81
Total	23905.38	

5.2 Round Hill Head to Kolan River

The 63 km stretch of coastline from Round Hill Head to the northern bank of the mouth of Kolan River is an exposed region dominated by wave action. The coastal wetlands within this region are associated with the estuaries of Broadwater Creek, Baffle Creek and Littabella Creek and are sheltered by narrow, sandy dune ridges. Intertidal flats in this area are generally narrow along the coastline with slightly more extensive flats developing at the mouth of Baffle Creek and Littabella Creek.

Rocky foreshores occur intermittently in the northern section of this coastline from the rocky headland at Round Hill Head to Wreck Rock. This headland provides a sheltered environment for the coastal wetlands of Round Hill Creek. However, these wetlands fall outside the current study area and are described in a separate report on the coastal wetlands of the Curtis Coast (Danaher personal communication 1999).

Broadwater Creek

The wetland associated with Broadwater Creek runs parallel to the coastline for approximately 8 km. Blackwater Creek and Deepwater Creek merge at the northern end of the wetland to form what is called Broadwater Creek. Mitchell Creek drains the southern portion of this wetland system and merges with Broadwater Creek close to the mouth. On the eastern side of the wetland a thin dune ridge separates the wetland from the ocean. The location of the mouth of Broadwater Creek has been relatively stable over the last two decades.

Closed *Ceriops* forms the dominant wetland community type in this area with large stands close to the mouth of Broadwater Creek and smaller stands further upstream. Communities dominated by *A. marina*, *A. annulata* and *R. stylosa* along with Saline Grasslands are also represented in the area. The zonation between these community types is not distinct. There are no extensive Saltpans within this wetland.

Small communities of Closed *Aegiceras* can be found on accretion banks of Deepwater Creek before it merges with Blackwater Creek. However, these communities are less than 0.5 ha and were thus eliminated in the mapping process. Additionally, fringing communities of Closed *Rhizophora* are present in some sections of Broadwater Creek. However, these stands were too narrow to be mapped using the current method.

A tidal channel meanders through intertidal flats towards the mouth of Broadwater Creek. These intertidal flats form a considerable proportion of this small wetland and represent an important habitat from a fisheries perspective.

A significant freshwater wetland to the north of the Broadwater Creek mouth is drained by Deepwater Creek. Another smaller freshwater wetland to the west of the creek mouth is drained by Blackwater Creek. Both of these freshwater wetland environments may contribute to the productivity of the estuary and are an important environment to consider for increased protection under Fisheries legislation.

Comparison of the 1975 B.P.A. aerial photography with that from 1996 reveals that little change has occurred in the coastal wetland communities of this region over the past 20 years.

Riparian vegetation along the banks of Deepwater and Blackwater Creeks appears to be intact. Closer to the wetland some clearing has occurred. However, a narrow riparian strip has been maintained along the riverbanks. Non-tidal vegetation merges directly with mangroves at several points on the western edge of the wetland.

Baffle Creek

The mouth of Baffle Creek is located approximately 44 km north-west of the Port of Bundaberg (Lupton and Heidenreich 1996). Euleilah Creek, draining from the north, merges with Baffle Creek approximately 16 km from the mouth. A sand spit on the southern edge of the estuary mouth and a dune ridge to the north provide shelter from wave action for the wetland vegetation.

Closed *Ceriops* is the dominant community in this wetland aggregation. The Closed *Ceriops* is interspersed with narrow Closed *Rhizophora* stands, which follow drainage channels through the wetlands (Figure 4.1). Both Saltpans and Saline Grasslands lie behind the Closed *Ceriops* communities towards the landward edge of the wetlands. Saltpans on the southern banks of the Creek follow old drainage patterns. In the upper tidal reaches of Baffle Creek, Closed *Avicennia* communities fringe the waterway. Although *A. marina* forms the dominant species within these communities *A. corniculatum* is also a significant component. Closed *Rhizophora* is also present. However, these communities were too narrow to be mapped at this scale. The mangrove communities within the wetlands of Baffle Creek do not exhibit a high degree of zonation.

The total area of coastal wetlands associated with Baffle Creek is comparatively high for a wetland located in this exposed stretch of coastline. The estuary provides a large sheltered environment for marine vegetation to colonise and establish.

Large intertidal flats occur at the mouth of Baffle Creek and as islands within the creek. The distribution and area of these exposed banks has changed considerably over the past two decades. Slumping of large portions of the bank into the creek has resulted in sedimentation and shallowing of the estuary as the sediment load has not escaped to the ocean (Dr Merike Johnston, Wide Bay Burnett Conservation Council [WBBCC], personal communication 1999). The changes are evident in Appendix 11: Sheet 1, which illustrates the coverage of foreshore flats in 1988 compared to the 1997 distribution represented by the Landsat TM image.

Changes have also occurred in the species composition of mangrove communities at the mouth of Baffle Creek. In 1978, the area to the south of the creek mouth consisted of exposed sandbanks and communities of *A. corniculatum, C. tagal* and *O. octodonta*. Today, this area largely consists of Closed *Ceriops* and Closed *Rhizophora* communities with a mixed fringe of *A. annulata*, *A. corniculatum, A. marina* and *L. racemosa*.

The riparian vegetation surrounding the Baffle Creek wetland has been cleared for agricultural development in many locations. Dune vegetation on the eastern edge of the wetland and small riparian strips in some locations remain intact. However, clearing has extended to the upper tidal limit in various places. In particular, clearing for agriculture and grazing has occurred along both Eulielah Creek and Baffle Creek, before they merge.

Littabella Creek

Littabella Creek discharges approximately 10 km to the south of the mouth of Baffle Creek. Over the past two decades the position and morphology of the creek mouth have changed significantly. Previously, the creek mouth existed approximately 2 km north of its current location and a sand spit extended from the southern edge. Closure of the old creek mouth and sedimentation near the current mouth, has created a lagoon environment behind the old spit. The new creek mouth has broken through the spit, resulting in a southward shift of the creek mouth. Coastal wetland vegetation has established on the northern side of the lagoon and intertidal flats exist at the southern end. Mangroves have also established on the flats to the south of the Littabella Creek mouth. They are protected from wave action by a very narrow dune ridge, the remains of the old sand spit.

Closed *Avicennia* and Closed *Ceriops* are the dominant community types within the Littabella Creek wetland system. However, distinct zonation is not evident. Communities of mixed *A. marina, C. tagal* and *R. stylosa* are interspersed within monospecific stands. A large area of Saltpan and Saline Grassland lies between the mangroves on the southern bank of the Creek and a freshwater *Melaleuca* wetland, further south. Hegerl (1993) suggested that a causeway impeding freshwater flow from the *Melaleuca* forests could have a detrimental effect on the flora and fauna of this wetland.

Small mangrove islands are located within the Creek near the mouth where mainly *A. marina* has established on exposed intertidal flats. Thin fringing communities of *A. marina* and *A. corniculatum* can be found further upstream. However, these areas are too small to be mapped using this technique.

Despite the complex changes in the mouth of the creek, the distribution of mangrove communities in this region is relatively similar to the distribution 20 years ago. Pioneering *A. marina* communities have established on new intertidal flats that resulted from the shift in the creek mouth. However, these communities are smaller than the minimum mapping unit and have therefore been eliminated in the mapping process.

Intertidal flats occur at the mouth of Littabella Creek and within the creek itself. As mentioned previously, the intertidal flats towards the mouth of the creek serve to isolate a lagoon environment. This area provides an important habitat for juvenile fish and crustaceans and is a significant component of this wetland aggregation.

Agriculture and aquaculture developments have resulted in clearing of vegetation surrounding the Littabella Creek wetlands. Cultivation extends to the upper tidal limit along much of the tidal reaches of the creek.

TABLE 5.2 Areas of coastal wetland communities from Round Hill Head to Kolan River.

	Broadwater Creek		Baffle Creek		Littabella Creek	
COMMUNITY	**AREA (ha)**	**% of TOTAL**	**AREA (ha)**	**% of TOTAL**	**AREA (ha)**	**% of TOTAL**
Closed *Rhizophora*	4.40	3.03	100.76	15.40	0.00	0.00
Closed *Avicennia*	22.69	15.63	55.77	8.52	60.44	24.36
Open *Avicennia*	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Ceriops*	72.98	50.27	284.84	43.52	52.20	21.04
Open *Ceriops*	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Aegiceras*	2.09	1.44	2.30	0.35	0.00	0.00
Open *Bruguiera*	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Rhizophora/Avicennia*	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Rhizophora/Aegiceras*	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Avicennia/Ceriops*	0.00	0.00	6.78	1.04	0.00	0.00
Open *Avicennia/Ceriops*	0.00	0.00	0.00	0.00	0.00	0.00
Closed Mixed	0.00	0.00	0.00	0.00	21.46	8.65
Saline Grassland	30.84	21.24	64.10	9.79	23.79	9.59
Saltpan	12.18	8.39	139.92	21.38	90.21	36.36
Total	145.18		654.47		248.11	

5.3 Kolan River to Burnett River

The coastline between Kolan River and Burnett River stretches for approximately 25 km. Coastal wetland communities within this region are associated with the Kolan and Burnett River deltas and the tidal creeks at Moore Park. Sand spits extending from the south of both the Kolan River and the Burnett River mouths provide protection for the coastal wetlands from exposure to wave action. Additionally, a narrow sand barrier at Moore Park provides shelter for the coastal wetlands behind. Narrow intertidal flats occur along this coastline separating the two river channels. Generally, beaches in this region have coarser sand and are more exposed to wave action than other beaches within the study area to the south (BPA 1989).

Although the wetlands of Moore Park Creek and Burnett River fall within different catchments, they have been combined in this report, as they are virtually continuous wetland systems.

Kolan River

The mouth of Kolan River is located approximately 25 km north-west of the city of Bundaberg. A sand spit, extending northwards past the mouth of the river, has created a sheltered environment in which a large mangrove stand has established. The mangroves are presently protected from ocean wave action by a very narrow dune ridge.

Large Closed *Ceriops* stands and Closed *Avicennia* stands are interspersed by narrow Closed *Rhizophora* communities, which follow drainage channels through the wetlands. However, these Closed *Rhizophora* communities were not mappable at this project's scale. Other small mangrove stands, mainly Closed *Avicennia* (*A. marina* with some *A. annulata*) and Closed *Ceriops*, can be found further upstream on accreting banks within the river. Small areas of Saline Grassland are located on the landward edge of some mangrove stands. The zonation between these coastal wetland communities is not distinct.

The extent of intertidal flats around the Kolan River mouth has changed considerably in the past two decades. The sand spit, which shelters the coastal wetlands, has extended to the north. The position of the river mouth has also migrated northward. Open *Avicennia* communities are pioneering on intertidal flats within this sheltered environment. The changes in the coastline in this area are evident in Appendix 11: Sheet 1, which displays the 1988 foreshore flats coverage and the August 1997 distribution of intertidal flats represented by the satellite imagery.

A large proportion of the vegetation adjacent to the mangroves of Kolan River and in the low-lying areas of this catchment has been cleared for sugar cane production. In many areas cultivation extends to the upper tidal boundary of the wetlands. Consequently, the surface waterflow of much of this low-lying area has been altered (Hegerl 1993). Additionally, the construction of weirs along Kolan River and Yandaran Creek has led to extensive modification of the freshwater input to the coastal wetland system. Drainage into the southern large stand of mangroves is relatively natural.

The Kolan River FHA (Management B) protects the coastal wetland vegetation of this system.

Moore Park Creek and Burnett River

Extensive alterations to the wetlands at Burnett River have occurred over the past 40 years. Between 1958 and 1959 significant changes were made to the mouth of the river. Prior to modification, Barubbra Island separated what were two main channels through the wetland, one discharging in a northerly direction and the other to the east (BPA 1989). The river was re-routed to discharge to the east with rock walls forming training walls for industrial and port development (Lupton and Heindenreich 1999). Additionally, in 1933 and 1976 tidal barrages were constructed in the river 42.4 km (Bingera Weir) and 26 km (Ben Anderson Tidal barrage and fishway) from the river mouth. The Ben Anderson tidal barrage, separating estuarine and freshwater reaches of the Burnett River effectively reduced the tidal prism by 40% (Lupton and Heindenreich 1999).

Barubbra Island consists of a narrow, low level spit and dune backed by extensive Closed *Ceriops* and Closed *Avicennia* communities. A large stand of Closed *Avicennia* forms an island within the old northern river channel. The Moore Park Creek coastal wetlands have developed in many wide swales of the sandy coastal beach ridge system that runs sub-parallel to the existing shoreline (BPA 1989). Closed *Ceriops* and Closed *Avicennia* communities are interspersed by small Saltpans and dune systems.

Despite the clearing of some mangrove communities to make way for industrial and port development a large stand still exists on the southern bank of the river at the mouth. Once again, Closed *Avicennia* and Closed *Ceriops* communities dominate the area. The grassland located landward of the mangrove forest is dominated by *Sporobolus virginicus*. However, on elevated regions some terrestrial grasses can be found. Stunted *A. marina* and small patches of Saltpan also exist in this location.

Narrow Closed *Avicennia* communities fringe the Burnett River in certain areas further upstream as far as the Ben Anderson tidal barrage. However, most of these communities are not mappable at this project's scale (i.e. 1: 100 000).

Extensive intertidal flats occur behind the Barubbra Island sand spit. Both the distribution and the total area of these intertidal flats have changed in the last two decades (Appendix 11: Sheet 1).

Riparian vegetation surrounding the coastal wetlands associated with Moore Park Creek and Burnett River has been cleared for sugar cane production in most places. Roads and a system of drainage ditches through the sugar-growing area have resulted in changes to the freshwater input to the area. Extensive clearing for urban and industrial development (Bundaberg) and sugar cane production has occurred in the low-lying region of the Burnett River catchment.

TABLE 5.3 Areas of coastal wetland communities from Kolan River to Burnett River.

	Kolan River		Burnett River	
COMMUNITY	**AREA (ha)**	**% of TOTAL**	**AREA (ha)**	**% of TOTAL**
Closed *Rhizophora*	0.00	0.00	0.00	0.00
Closed *Avicennia*	394.31	66.10	588.20	47.29
Open *Avicennia*	3.59	0.60	3.61	0.29
Closed *Ceriops*	153.27	25.69	434.34	34.92
Open *Ceriops*	0.00	0.00	0.00	0.00
Closed *Aegiceras*	0.00	0.00	0.00	0.00
Open *Bruguiera*	0.00	0.00	0.00	0.00
Closed *Rhizophora/Avicennia*	11.73	1.97	0.00	0.00
Closed *Rhizophora/Aegiceras*	0.00	0.00	0.00	0.00
Closed *Avicennia/Ceriops*	0.00	0.00	1.68	0.14
Open *Avicennia/Ceriops*	0.00	0.00	0.00	0.00
Closed Mixed	10.13	1.70	0.00	0.00
Saline Grassland	14.43	2.42	53.35	4.29
Saltpan	9.11	1.53	162.64	13.08
Total	596.56		1243.82	

5.4 Burnett River to Elliott River

The 24 km stretch of coastline from Burnett River to Elliott River is a region of exposed coastline consisting of rocky foreshores of Hummock Basalt with occasional sandy beaches (BPA 1989). The region has only one small coastal wetland system associated with Palmer Creek. Palmer Creek discharges approximately 6 km to the north of Elliott River. This wetland is a very small area dominated by Closed *Avicennia* with small Saltpans occurring on the landward edge. The wetland is surrounded by cleared land.

TABLE 5.4 Areas of coastal wetland communities of Palmer Creek.

COMMUNITY	AREA (ha)	% of TOTAL
Closed *Rhizophora*	0.00	0.00
Closed *Avicennia*	7.69	59.75
Open *Avicennia*	0.00	0.00
Closed *Ceriops*	0.00	0.00
Open *Ceriops*	0.00	0.00
Closed *Aegiceras*	0.00	0.00
Open *Bruguiera*	0.00	0.00
Closed *Rhizophora/Avicennia*	0.00	0.00
Closed *Rhizophora/Aegiceras*	0.00	0.00
Closed *Avicennia/Ceriops*	0.00	0.00
Open *Avicennia/Ceriops*	0.00	0.00
Closed Mixed	0.00	0.00
Saline Grassland	0.00	0.00
Saltpan	5.18	40.25
Total	12.86	

5.5 Elliott River to Burrum River

The coastline between Elliott River and Burrum River consists of sandy beaches with intertidal flats that are much narrower than the flats from Burrum River to Point Vernon further south. There are three coastal wetland systems within this 35 km section of coastline, associated with Elliott River, Coonarr Creek and Theodolite/Lagoon Creek. Fraser Island provides some protection for these wetlands from open ocean wave action from a southerly to easterly direction.

Elliott River and Coonarr Creek

The Elliott River mouth is located approximately 14 km south-east of the town of Bundaberg. A rocky island, Dr Mays Island, at the mouth of Elliott River is joined to the mainland to the south by intertidal sand flats. Coonarr Creek discharges approximately 5 km south of the mouth of Elliott River.

The wetlands at Elliott River are comprised of mainly Closed *Ceriops* and Closed *Avicennia* stands with some Saltpan behind. Closed *Rhizophora/Avicennia* communities line the river in some locations. Closed *Avicennia*, Closed *Ceriops* and Saltpan communities also dominate the small wetland associated with Coonarr Creek.

Riparian vegetation on the southern boundary of the Elliott River coastal wetlands is largely intact. In contrast, clearing for agricultural purposes (sugarcane production) and urban development has taken place on the northern bank of the Elliott River coastal wetlands and extends to the upper intertidal limit in many areas. Further upstream, cultivation occurs on both the southern and northern banks of the river. However, a narrow riparian strip has been maintained in most areas. The Coonarr Creek coastal wetlands are included in the Kinkuna FHA (Management A).

Theodolite/Lagoon Creek

Theodolite Creek discharges into Hervey Bay approximately 18 km south of the mouth of Elliott River. The creek causes a local seaward bulge in the coastline where its ebb tide delta interrupts sand movement along the beach (BPA 1989). A new entrance to the creek established in 1986, breaking through a small sand spit that once existed on the northern bank of the creek. This sand spit has now eroded entirely leaving a wide shallow creek mouth. Lagoon (or House) Creek merges with Theodolite Creek close to the mouth and mangrove communities follow these waterways for a short distance. Tidal movement in House Creek appears to have been restricted by causeway construction.

Closed *Ceriops* is the dominant community type in this coastal wetland. Closed *Avicennia* and Saltpans are also found in this area. One Mile Creek runs parallel to the coastline for approximately 2.5 km just south of the Theodolite Creek mouth. A narrow dune ridge separates this small community of Closed *Avicennia* and Saltpans from the ocean. Intertidal flats at the mouth of the creek form a significant component of this coastal wetland environment.

Riparian vegetation is intact around the majority of the coastal wetland system. The Kinkuna National Park exists to the north of the wetland and protects this coastal vegetation. The coastal wetland vegetation is protected within the Kinkuna FHA (Management A). The township of Woodgate to the south of the wetland poses an urban development threat in the future.

TABLE 5.5 Areas of coastal wetland communities from Elliott River to Burrum River.

	Elliott River		Coonarr Creek		Theodolite/Lagoon Creek	
COMMUNITY	**AREA (ha)**	**% of TOTAL**	**AREA (ha)**	**% of TOTAL**	**AREA (ha)**	**% of TOTAL**
Closed *Rhizophora*	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Avicennia*	101.76	24.65	12.99	22.88	38.96	9.91
Open *Avicennia*	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Ceriops*	152.31	37.21	14.08	24.79	168.61	42.91
Open *Ceriops*	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Aegiceras*	0.00	0.00	0.00	0.00	0.00	0.00
Open *Bruguiera*	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Rhizophora/Avicennia*	50.16	12.15	0.00	0.00	0.00	0.00
Closed *Rhizophora/Aegiceras*	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Avicennia/Ceriops*	0.00	0.00	0.00	0.00	0.00	0.00
Open *Avicennia/Ceriops*	0.00	0.00	0.00	0.00	0.00	0.00
Closed Mixed	0.00	0.00	0.00	0.00	0.00	0.00
Saline Grassland	0.00	0.00	0.00	0.00	0.00	0.00
Saltpan	105.05	25.67	29.72	52.33	185.39	47.18
Total	409.28		56.79		392.96	

5.6 Burrum River to Urangan

The 39 km section of coastline stretching from the mouth of the Burrum River to Urangan contains numerous small coastal wetland communities and a series of low beach ridges. Additionally, the region contains significant wide intertidal flats comprised of fine sediments which are colonised by mangrove plants in more sheltered regions. The area is well sheltered from oceanic wave action by Fraser Island. Additional shelter for the wetlands associated with Eli Creek is provided by the rocky headland at Point Vernon and for the wetlands associated with Burrum River by the coastline to the north. Coastal wetland communities within this region are found associated with the ebb tide deltas of

Burrum River, Beelbi Creek, O'Regan Creek and Eli Creek. A small area of wetland also exists at Tooan Tooan Creek.

Rock walls have been constructed along about 1.5km of this region of coastline both inside the Burrum River entrance and along the shoreline (BPA 1989). Construction of these walls was for the purpose of protecting the town of Burrum Heads from foreshore erosion problems.

Burrum-Isis FHA and Beelbi FHA (Management A) and Gregory FHA, Cherwell-Burrum FHA and Burrum-Toogoom FHA (Management B) protect the coastal wetland environments in this region.

Burrum River
Burrum River is located 40 km north of Maryborough. The coastal dune system on the northern bank of the mouth of the river produces a noticeable seaward bulge in the coastline. Mangroves occur immediately behind the frontal dune barrier. Large intertidal flats extend from this sandy headland around the mouth of the river.

Although Closed *Avicennia* communities form the largest proportion of coastal wetlands associated with the Burrum River delta, the area is relatively mixed. Small zones of various community types contribute to a diversity of habitats. Within the Closed Mixed communities of this area, smaller monospecific stands of Closed Ceriops and Closed Avicennia exist. However, these communities are below the minimum mapping unit for this study and as such these communities are aggregated and labelled as Closed Mixed. Both Closed *Avicennia* and Closed *Aegiceras* are the dominant community types upstream in Burrum, Isis and Gregory Rivers.

Extensive intertidal flats at the mouth of Burrum River add to the diversity of habitats present in this region. These flats are the largest flats present along the coastline from Urangan to Round Hill Head. No major changes in the mouth of Burrum River in the past 2 decades are apparent. However, slight changes in the distribution of the intertidal flats have occurred.

Riparian vegetation on the northern edge of the coastal wetland is protected within the Woodgate National Park and a smaller section on the southern edge is contained within Burrum River National Park. Some clearing of riparian vegetation has occurred further upstream for agricultural purposes.

TABLE 5.6.1 Areas of coastal wetland communities of Burrum River.

COMMUNITY	AREA (ha)	% of TOTAL
Closed *Rhizophora*	2.45	0.49
Closed *Avicennia*	125.80	25.22
Open *Avicennia*	0.00	0.00
Closed *Ceriops*	43.43	8.71
Open *Ceriops*	0.00	0.00
Closed *Aegiceras*	37.64	7.54
Open *Bruguiera*	0.00	0.00
Closed *Rhizophora/Avicennia*	46.89	9.40
Closed *Rhizophora/Aegiceras*	0.00	0.00
Closed *Avicennia/Ceriops*	58.96	11.82
Open *Avicennia/Ceriops*	0.00	0.00
Closed Mixed	55.18	11.06
Saline Grassland	8.14	1.63
Saltpan	120.37	24.13
Total	498.85	

Beelbi Creek, O'Regan Creek, Eli Creek and Tooan Tooan Creek

The coastal wetlands at Beelbi Creek, O'Regan Creek and Eli Creek are mainly comprised of Closed *Avicennia/Ceriops* with varying areas of Saltpan communities. Small patches of Saline Grassland occur towards the upper intertidal limit. The Saline Grassland is often interspersed by terrestrial grass patches. Individual stands of Closed *Avicennia* occur within the Closed *Avicennia/Ceriops* communities. However, these communities are smaller than the minimum mapping unit and as such the entire region has been labelled as Closed *Avicennia/Ceriops* due to the dominance of these two species. A very small coastal wetland system exists at Tooan Tooan Creek. This community is mainly comprised of *A. marina.*

The coastal wetlands associated with Beelbi Creek have a significantly higher proportion of Saltpan relative to the other systems in this region. These saline flats have resulted from the southward migration of the mouth of Beelbi Creek and subsequent accretion. A narrow, sandy barrier fronts the coastal wetlands and tidal channel. The Beach Protection Authority (1989) records movements in the mouth of both Beelbi and O'Regan Creeks.

Urban development along the coastline in this region is encroaching on the coastal wetland systems. Riparian vegetation surrounding the Eli Creek, O'Regan Creek and Tooan Tooan Creek wetlands has been largely altered. The Burrum River National Park lies adjacent to the Beelbi Creek coastal wetland and as such the riparian vegetation has not been cleared.

TABLE 5.6.2 Areas of coastal wetland communities of Beelbi, O'Regan, Eli and Tooan Tooan Creeks.

	Beelbi Creek		O'Regan Creek		Eli Creek		Tooan Tooan Creek	
COMMUNITY	**AREA (ha)**	**% of TOTAL**	**AREA (ha)**	**% of TOTAL**	**AREA (ha)**	**% of TOTAL**	**AREA (ha)**	**% of TOTAL**
Closed *Rhizophora*	0.69	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Avicennia*	2.91	0.81	9.25	10.13	0.00	0.00	1.8	100.00
Open *Avicennia*	0.00	0.00	0.00	0.00	2.75	1.84	0.00	0.00
Closed *Ceriops*	2.64	0.74	0.00	0.00	0.00	0.00	0.00	0.00
Open *Ceriops*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Aegiceras*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open *Bruguiera*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Rhizophora/Avicennia*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Rhizophora/Aegiceras*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Closed *Avicennia/Ceriops*	57.34	15.96	44.21	48.44	65.14	43.51	0.00	0.00
Open *Avicennia/Ceriops*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Closed Mixed	0.00	0.00	7.30	8.00	0.00	0.00	0.00	0.00
Saline Grassland	4.80	1.34	7.22	7.91	3.44	2.30	0.00	0.00
Saltpan	290.83	80.96	23.29	25.52	78.38	52.36	0.00	0.00
Total	359.21		91.28		149.71		1.8	

5.7 North-west Fraser Island

Fraser Island is the largest sand island in the world. Both Great Sandy Strait and Fraser Island have been formed from sand deposited by rivers of northern New South Wales and southern Queensland, which have migrated northward along the coast (FIU 1994). The eastern side of the island is very exposed to open ocean wind and wave action. Therefore, this section of the island is characterised by narrow intertidal flats and no coastal wetland communities. In contrast, coastal wetland communities are well established in the more sheltered environment on the western side of the island.

Only the coastal wetlands on the northern half of the island (that is, north of Moon Point) have been included in the area calculations for the North-west Fraser Island region. The remaining coastal wetlands associated with the central and southern parts of the western shore of Fraser Island (Moon Point south) are included within Great Sandy Strait (Section 5.8).

The two small coastal wetland communities occurring on the northern half of Fraser Island are located at Wathumba Creek and Coongul Creek, approximately 37 km and 9 km from Moon Point, respectively. The Wathumba Creek coastal wetlands occur within the shelter of Platypus Bay. A narrow dune ridge and a large area of intertidal flats at the mouth of the creek shelters the mangrove communities which occur further landward. A small tidal area at Coongul Creek provides a suitable environment for mangrove communities. A shift in the position of the Creek mouth appears to have created a similar environment to Beelbi Creek, where saltpans have developed along the coast as the creek mouth changes.

Closed *Rhizophora* and Closed *Ceriops* are the dominant mangrove communities at Wathumba Creek, whereas Closed *Avicennia* and Saltpan constitute the majority of the coastal wetland at Coongul Creek. Both of these coastal wetland environments are surrounded by coastal dune vegetation, which is protected within the Fraser Island National Park.

The coastal wetland at Wathumba Creek is surrounded by a freshwater swamp, which merges directly with the mangrove or Saline Grassland communities on the northern edge. Another freshwater swamp adjacent to Coongul Creek also merges with the coastal wetland in this area. These communities add to the diversity of environments that support coastal fisheries productivity.

The Fraser Island FHA (Management B) protects the coastal wetlands in this region.

TABLE 5.7 Areas of coastal wetland communities on North-west Fraser Island.

	Coongul Creek		Wathumba Creek	
COMMUNITY	**AREA (ha)**	**% of TOTAL**	**AREA (ha)**	**% of TOTAL**
Closed *Rhizophora*	1.87	2.62	65.23	36.93
Closed *Avicennia*	24.54	34.38	0.00	0.00
Open *Avicennia*	0.00	0.00	0.00	0.00
Closed *Ceriops*	0.00	0.00	58.84	33.31
Open *Ceriops*	0.00	0.00	0.00	0.00
Closed *Aegiceras*	0.00	0.00	0.00	0.00
Open *Bruguiera*	0.00	0.00	0.00	0.00
Closed *Rhizophora/Avicennia*	0.00	0.00	10.05	5.69
Closed *Rhizophora/Aegiceras*	0.00	0.00	0.00	0.00
Closed *Avicennia/Ceriops*	6.12	8.57	0.00	0.00
Open *Avicennia/Ceriops*	1.49	2.09	0.00	0.00
Closed Mixed	0.00	0.00	0.00	0.00
Saline Grassland	0.00	0.00	19.12	10.82
Saltpan	37.36	52.34	23.40	13.25
Total	71.38		176.64	

5.8 Great Sandy Strait

Great Sandy Strait is one of the few passage landscapes in Australia where an offshore barrier island has formed sufficiently close to the mainland to divert the flow of a substantial river system (i.e. Mary River) (FIU 1994). A tidal interface within this double-ended estuary exists at approximately the position of Moonboom Islands (Dredge et al.1977). Significant quantities of pure fresh water drain from the Fraser Island and Cooloola sandmasses into Great Sandy Strait via small creeks and drainage lines (DOE 1997).

For this report, Great Sandy Strait has been divided into three areas due to differences in the abundance and distribution of coastal wetland communities. The first area (Area 1) extends from Urangan south to River Heads on the western side of the Strait and from Moon Point to Wanggoolba Creek on the eastern side of the Strait. This northern area is the widest section of the Strait, which contains only a small area of mangrove communities and extensive intertidal flats.

Two islands are found within this area of Great Sandy Strait: Woody Island and Little Woody Island. Little Woody Island has a narrow rim of Closed Mixed mangrove community on the northern shore, which was not mappable at this project's scale. Species present include *A. annulata, A. corniculatum, A. marina* and *R. stylosa*. A narrow sand spit extends from the southern point of the island and large intertidal flats exist adjacent to the northern shore of the island. No mappable mangrove communities exist on Woody Island. However, large intertidal flats extend from the southern shore of the island to the western edge of the Strait.

Closed *Rhizophora* dominates the coastal wetlands in Area 1 on the eastern shore of Fraser Island. Substantial Saltpans and small communities of Open *Bruguiera* and Closed Mixed are found to the landward edge of the Closed *Rhizophora*. Large intertidal flats at Moon Point follow the shoreline for approximately 20 km to the south.

The second area (Area 2) extends from River Heads to Boonooroo on the mainland and the adjacent western shore of Fraser Island. This region contains many islands and has the largest areas of coastal wetland communities within the Strait.

The extensive mangrove stands within Area 2 display more typical mangrove zonation with Closed *Rhizophora* lining the seaward edge, Closed or Open *Avicennia* and/or *Ceriops* behind and Saltpans isolated within a mangrove periphery or on the landward edge. In many areas, Closed *Avicennia*/*Ceriops* is a low community with individual mangrove trees reaching an average height of around 1 m. The spectral characteristics of both Closed and Open *Avicennia*/*Ceriops* communities are similar and so the distinction between the two was made on the basis of aerial photograph interpretation.

Extensive wetlands at the tidal interface near the Moonboom Islands trap sediment and assist in the maintenance of water quality south of Mary River. Sedimentation from major river floods in the past two decades has created new environments on which *A. marina* is establishing. In particular, comparison of aerial photography has shown that Bookar Island has grown in size in the past two decades with *A. marina* establishing on intertidal flats and Closed *Rhizophora* communities growing seaward.

The southern portion (Area 3) of Great Sandy Strait extends from Boonooroo to Tinnanbar north of Kauri Creek and to the southern tip of Fraser Island. Within this region mangrove communities are confined to small areas on the edges of the Strait, behind wide intertidal flats. Narrow Closed *Rhizophora*/*Avicennia* communities fringe the coastline on the southern end of Fraser Island. These communities extend for the majority of the Fraser Island coastline in this area but they are too narrow to be mapped at this project's scale.

The division between Area 2 and Area 3 roughly represents the tidal division of the estuary. The extensive coastal wetland communities in Area 2 in the north have established on sediments flowing from Mary and Susan Rivers and trapped within this portion of the Strait. In contrast, Area 3 has a relatively smaller area of sediment islands and intertidal flats.

Apart from changes in the intertidal flats and mangrove communities near Moonboom Islands, very little change in the coastal wetland communities was observed from a comparison of aerial photography taken in the past two decades. The distribution of mangroves and sediments within the Strait is relatively stable.

Freshwater swamps on the landward edge of Saline Grasslands or Saltpans on Fraser Island are quite common (Appendix 11: Sheet 4). These environments may represent important habitat to consider from a fisheries perspective.

The riparian vegetation has remained intact on the eastern side of Great Sandy Strait on Fraser Island. However, clearing has taken place adjacent to coastal wetland communities along a large proportion of the western edge of the Strait. Encroaching urban development and clearing for agriculture poses a threat to the maintenance of riparian vegetation along the western side of the Strait.

The majority of the coastal wetlands within Great Sandy Strait are included in the Maaroom FHA (Management A).

TABLE 5.8 Areas of coastal wetland communities in Great Sandy Strait.

	Area 1		Area 2		Area 3	
COMMUNITY	AREA (ha)	% of TOTAL	AREA (ha)	% of TOTAL	AREA (ha)	% of TOTAL
Closed *Rhizophora*	651.53	43.33	4144.48	41.92	247.12	29.59
Closed *Avicennia*	119.39	7.94	757.53	7.66	131.41	15.74
Open *Avicennia*	46.76	3.11	147.86	1.50	13.24	1.59
Closed *Ceriops*	4.56	0.30	258.64	2.62	8.73	1.05
Open *Ceriops*	0.00	0.00	5.24	0.05	0.00	0.00
Closed *Aegiceras*	0.00	0.00	2.64	0.03	0.00	0.00
Open *Bruguiera*	15.11	1.00	4.62	0.05	2.82	0.34
Closed *Rhizophora/Avicennia*	101.96	6.78	39.26	0.40	18.90	2.26
Closed *Rhizophora/Aegiceras*	0.00	0.00	113.63	1.15	0.00	0.00
Closed *Avicennia/Ceriops*	74.78	4.97	1435.23	14.52	25.16	3.01
Open *Avicennia/Ceriops*	88.98	5.92	360.14	3.64	24.43	2.93
Closed Mixed	18.57	1.23	205.69	2.08	9.18	1.10
Saline Grassland	24.55	1.63	39.62	0.40	7.42	0.89
Saltpan	357.52	23.78	2372.23	23.99	346.66	41.51
Total	1503.72		9886.83		835.09	

5.9 Mary River and Susan River

Mary River and Susan River discharge into the northern end of Great Sandy Strait approximately 26 km north-east of Maryborough. These rivers flood regularly and sediment from cleared land and bank-slumping upstream is carried into Great Sandy Strait.

Closed *Aegiceras* exists in most of the upstream areas of both the Mary River and the Susan River. Although *A. corniculatum* dominates this community, it is a relatively mixed community as numerous other species (e.g. *A. marina, C. tagal* and *R. stylosa*) also form part of the species assemblage.

Closed *Avicennia* occurs on accretion banks within Susan River. Behind this community there is generally a mixed community of *A. corniculatum, A. marina, C. tagal* and *R. stylosa*. This community grades gradually into either Closed *Aegiceras* or Closed *Rhizophora*/*Aegiceras*. On more elevated areas within the wetlands of the Susan River Open *Avicennia*/*Ceriops* exists bordering on Saltpans.

The zonation within this area is indistinct with Closed Mixed communities grading gently into more monospecific stands of *A. corniculatum* or *A. marina*. Defining the boundaries of these communities was therefore quite difficult and the "boundaries" between species assemblages as shown on these maps should be considered as a diffuse boundary rather than a distinct one.

Riparian vegetation along the banks of Mary River has been cleared extensively for both agricultural purposes, grazing and urban development. On both Mary River and Susan River open grassland communities generally back the mangrove communities. The limit of tidal lands in these areas is difficult to determine as Saline Grasslands merge directly with terrestrial grasslands.

The majority of the coastal wetlands associated with Mary River and Susan River are protected within the Susan River FHA (Management A).

TABLE 5.9 Areas of coastal wetland communities of Mary River and Susan River.

COMMUNITY	AREA (ha)	% of TOTAL
Closed *Rhizophora*	232.71	6.61
Closed *Avicennia*	519.38	14.75
Open *Avicennia*	20.60	0.59
Closed *Ceriops*	20.84	0.59
Open *Ceriops*	0.00	0.00
Closed *Aegiceras*	957.25	27.19
Open *Bruguiera*	0.00	0.00
Closed *Rhizophora/Avicennia*	8.98	0.25
Closed *Rhizophora/Aegiceras*	534.22	15.17
Closed *Avicennia/Ceriops*	67.36	1.91
Open *Avicennia/Ceriops*	189.34	5.38
Closed Mixed	153.63	4.36
Saline Grassland	415.69	11.81
Saltpan	400.81	11.38
Total	3520.81	

5.10 Kauri Creek

Kauri Creek discharges into the southern end of Great Sandy Strait, approximately 42 km south-east of Maryborough. The coastal wetland is well sheltered from wave action by the southern end of Fraser Island. Mosquito Creek merges with Kauri Creek approximately 9 km from the mouth. Wide intertidal flats at the mouth of the creek are colonised by mangrove communities.

The coastal wetlands of Kauri Creek are characterised by two main zones: a seaward Closed *Rhizophora* zone and a landward Saltpan. Closed or Open *Avicennia* and

Avicennia/Ceriops occasionally forms a narrow zone between these two distinct communities. Small stands of Open *Bruguiera* are located further upstream on Mosquito Creek, adjacent to Saline Grasslands. Closed *Aegiceras* communities can also be found in the upper tidal reaches of the river. However, these areas are often too small to be mapped at this project's scale.

The intertidal flats within Kauri Creek are an important component of the wetland environment. As in Tin Can Inlet, a narrow creek channel is edged by wide intertidal flats, which are colonised by mangrove vegetation in some locations. The extent of these intertidal flats has not changed significantly during the last two decades. Changes in the creek channel and expansion of intertidal flats at the mouth of the creek are evident from a comparison of the 1988 foreshore flats information (AUSLIG 1994) and the 1997 satellite image data.

The vegetation surrounding the Kauri Creek wetland is largely undisturbed, with the exception of some clearing towards the town of Tinnanbar. The vegetation to the south of the Creek falls within a Military Training Area and to the north within State Forest tenure. No clearing of riparian vegetation adjacent to the Kauri Creek wetlands is evident.

The Kauri Creek FHA (Management A) protects the coastal wetlands associated with Kauri Creek as well as the majority of the coastal wetland environments within Tin Can Inlet.

TABLE 5.10 Areas of coastal wetland communities of Kauri Creek.

COMMUNITY	AREA (ha)	% of TOTAL
Closed *Rhizophora*	550.04	44.59
Closed *Avicennia*	172.38	13.98
Open *Avicennia*	136.16	11.04
Closed *Ceriops*	4.28	0.35
Open *Ceriops*	0.00	0.00
Closed *Aegiceras*	3.33	0.27
Open *Bruguiera*	8.93	0.72
Closed *Rhizophora/Avicennia*	4.90	0.40
Closed *Rhizophora/Aegiceras*	0.00	0.00
Closed *Avicennia/Ceriops*	14.39	1.17
Open *Avicennia/Ceriops*	23.48	1.90
Closed Mixed	0.00	0.00
Saline Grassland	83.13	6.74
Saltpan	232.40	18.84
Total	1233.43	

5.11 Tin Can Inlet

Located at the southern end of the Great Sandy Strait, Tin Can Inlet is a large estuarine system with relatively little freshwater input (Beumer and Halliday 1994). The Inlet is a very sheltered environment with protection from wind and wave action being provided by Fraser Island, Great Sandy Strait and the sand spit at Inskip Point. It is characterised by wide intertidal flats and a deep narrow tidal channel.

The zonation of mangrove communities within Tin Can Inlet is quite distinct. Stands of mangroves form thin communities that lie between extensive intertidal flats on the seaward side and Saltpans on the landward side. Closed *Rhizophora* is the dominant community type with Closed or Open *Avicennia* or *Avicennia*/*Ceriops* behind. In some regions the boundary between Saltpan and intertidal flat is difficult to delineate (as no mangrove communities exist between the two) indicating a hypersaline environment with little freshwater input.

The Open *Avicennia* communities within Tin Can Inlet range from having a fairly closed canopy of around 50% PFC to a very sparse canopy coverage where *A. marina* is pioneering on sand banks within the Inlet. In some areas the canopy coverage is extremely sparse and so communities have been labelled as intertidal flat rather than mangrove. Consequently, they could not be included in the mapping.

A large freshwater swamp and two smaller freshwater swamps exist on the eastern and western sides of Tin Can Inlet, respectively. The impact of these swamps on coastal wetland productivity is unknown. However, as these two environments merge directly in many locations it is likely that the swamps contribute nutrients to Tin Can Inlet, especially in times of substantial freshwater flow. Generally, small communities of Saline Grassland and Open *Bruguiera* exist at the boundary between the coastal wetlands and the freshwater swamps.

A sand spit extends along the coastline and provides shelter to Pelican Bay. The intertidal flats and shallow waters of the Bay are ideal nursery habitat for numerous recreationally and commercially targeted species including whiting, mullet, flathead and bream. This Bay has also been noted as habitat for blue swimmer crabs (Hyland 1993). Pelican Bay is a popular area for recreational fishing and camping.

Very little clearing of riparian vegetation surrounding the Tin Can Inlet coastal wetlands has occurred. The majority of the surrounding vegetation on the eastern side of the Inlet is protected within the Cooloola National Park. The Military Training Area occurs on the western side of the Inlet and extends to Kauri Creek. Urban development at the townships of Tin Can Inlet and Cooloola Village has resulted in some clearing of wetland vegetation. However, this is relatively small. Future expansion of these urban developments poses a minor threat to the western side of this coastal wetland system.

The coastal wetlands of Tin Can Inlet are protected within the Kauri Creek FHA (Management A) and the Tin Can Inlet FHA (Management A).

TABLE 5.11 Areas of coastal wetland communities of Tin Can Inlet.

COMMUNITY	AREA (ha)	% of TOTAL
Closed *Rhizophora*	597.14	32.84
Closed *Avicennia*	259.94	14.29
Open *Avicennia*	375.44	20.65
Closed *Ceriops*	0.00	0.00
Open *Ceriops*	0.00	0.00
Closed *Aegiceras*	0.00	0.00
Open *Bruguiera*	5.76	0.32
Closed *Rhizophora/Avicennia*	0.00	0.00
Closed *Rhizophora/Aegiceras*	0.00	0.00
Closed *Avicennia/Ceriops*	7.03	0.39
Open *Avicennia/Ceriops*	18.28	1.01
Closed Mixed	0.00	0.00
Saline Grassland	123.54	6.79
Saltpan	431.29	23.72
Total	1818.41	

SECTION 6. DISCUSSION

6.1 Regional Significance of the Coastal Wetland Environments

Mangrove species distribution is limited latitudinally by the physiological tolerance of each species to low temperatures (Duke et al. 1998). The region from Round Hill Head to Tin Can Inlet is an important transition region between subtropical and temperate climates. Consequently, it is the southern distributional limit of three mangrove species, namely *A. annulata*, *O. octodonta* and *X. granatum* (Lovelock 1993).

A. annulata was observed mainly in the northern section of the study area (e.g. Baffle Creek and Elliott River). Within Great Sandy Strait *A. annulata* was identified at Turkey Island and in Rocky Creek on Fraser Island. *O. octodonta* is most common within the study area from Great Sandy Strait to Tin Can Inlet. In particular, a Closed *Osbornia*/*Ceriops* community was noted at Moon Point and Rocky Creek. However, this community was below the minimum mapping unit and as such, did not constitute a separate community type at this project's scale. *O. octodonta* was also noted within communities on Turkey Island, in Tin Can Inlet and at Carlo Point. *X. granatum* is not common within the study area. Observations of *X. granatum* during fieldwork were confined to upstream communities on Fraser Island at Rocky Creek and Poyungan Creek. These communities were mixed with an open canopy of *A. corniculatum*, *A. marina*, *B. gymnorrhiza* and *E. agallocha*. *X. granatum* was also noted along Mary River in an upstream location, within a narrow, fringing Closed Mixed community.

A summary of the sites visited during fieldwork, and the species found at each location, is included in Appendix 12.

IMCRA Technical Group (1998) has recognised the importance of the study area within the Tweed-Moreton Bioregion stating that mangrove communities are more diverse north of the Great Sandy Strait. Thirteen species of mangroves are found in the region from Round Hill Head to Tin Can Inlet. In comparison, in the Cape York Peninsula region to the north of the study area, thirty-six mangrove species have been identified, whereas only nine species of mangrove are found in the Moreton region, further to the south.

The coastal wetland communities found from Tin Can Inlet to Urangan represent a significant proportion of the total area of coastal wetlands within the Tweed-Moreton Bioregion.

6.2 Intertidal Flats

While our knowledge of their relative values as fisheries habitats is limited, unvegetated intertidal flats adjacent to coastal wetlands are important, acting as feeding areas for high value fish species such as sand whiting, yellow fin bream, thread-fin salmon and flathead. These high value fish species feed on benthic crustaceans, bivalve molluscs and polychaetes abundant in these areas.

The intertidal flats in Great Sandy Strait, Kauri Creek and Tin Can Inlet have been relatively stable during the last 20 years. In comparison, many of the river and creek mouths and the associated intertidal flats north of Urangan have changed quite considerably. The more stable sediment locations are characterised by a dominance of Closed *Rhizophora* communities. However, in areas of increased sediment instability, *A. marina* tends to dominate in pioneering communities.

The low water mark has been used to define the seaward limit of many FHAs. The use of this boundary may not be appropriate due to significant changes that occur at the mouths of creeks and rivers due to the deposition of sediment and the shifting of these sediments with water currents. This study has highlighted the fact that the intertidal flats at many creek and river mouths have changed significantly over the past twenty years and will continue to do so in the future. Consequently, to ensure the continued inclusion of these habitats within FHAs requires the use of appropriate seaward boundaries. Extension of the seaward boundary of FHAs to well beyond the low water mark, perhaps a fixed distance from the coastline or to particular coordinates, would allow the inclusion of these dynamic environments. Additionally, important fisheries habitats that may be located below the low water mark, such as seagrass beds, would also be further protected. Regular review (perhaps every 5 years) of these boundaries, particularly the seaward boundary, would be required in order to ensure the boundary maintains its usefulness over time.

The Beach Protection Authority (1989) has identified numerous areas that have been classified as suitable sand reserves for beach renourishment in the Hervey Bay region. These areas include the sand spit extending from Dayman’s Point at Urangan, the shoals between Moon Point on Fraser Island and Middle Banks in Great Sandy Strait. The intertidal flats at the mouth of the Burrum River and the Elliott River have also been identified as possible sources. However, these areas are part of the active beach system and it is therefore recommended that sand from these areas only be removed from these systems as a “last resort”. Beach nourishment activities, which utilise sand from intertidal flats, have the potential to impact on an important fisheries habitat.

SECTION 7. APPLICATION OF THE DATASET TO FHA PLANNING

7.1 Fish Habitat Area Declaration Process

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

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

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

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

A summary of the assessment of the coastal wetlands from Round Hill Head to Tin Can Inlet, on the basis of these criteria, is included in Table 7.1. Details of the assessment methods and the category details are included in Table 3.2, Section 3.2.

Further details of the significance of specific coastal wetland communities are outlined in Section 7.2. This report concentrates on the identification of suitable areas for fisheries conservation from a coastal wetland community perspective.

Tenure of adjacent land is an important consideration in the FHA declaration process. Appendix 8: Sheets 1–4 display the land tenure of the coastal strip from Round Hill Head to Tin Can Inlet with the coastal wetland communities overlaid.

TABLE 7.1 Summary of coastal wetland characteristics from Round Hill Head to Tin Can Inlet.

WETLAND	AREA OF COASTAL WETLAND COMMUNITIES (ha)	DIVERSITY OF MANGROVE/SALTMARSH	INTERTIDAL FLATS	ROCKY FORESHORES	ADJACENT F/W SWAMPS	SIGNIFICANT DAMS AND WEIRS	DISTURBANCE TO ADJACENT TERRESTRIAL VEGETATION	RECOGNISED/IMPORTANT FISHING GROUNDS	UNIQUE FEATURES
Round Hill Head to Kolan River			Narrow, more extensive at Creek mouths	Intermittent from Round Hill Head to Wreck Rock					
Broadwater Creek	145	M	See S 5.2		Y	N	LU		
Baffle Creek	655	M	5.2		N	Y*	LU	Y	Y
Littabella Creek	248	M	5.2		Y	Y	LU		Y
Kolan River to Burnett River			Narrow	Rocky foreshore of Hummock basalt					
Kolan River	597	M	See S 5.3		N	Y	M	Y	
Burnett River	1244	M	5.3		N	Y	SI		
Burnett River to Elliott River			Narrow	Rocky foreshore of Hummock basalt					
Palmer Creek	13	L	See S 5.4		N	N	SI		Y
Elliott River to Burrum River				Small rocky island at the mouth of Elliott River					
Elliott River	409	L	See S 5.5		N	N	M	Y	
Coonarr Creek	57	L	5.5		O	N	NP		
Theodolite/Lagoon Creek	393	L	5.5		O	N	LU		
Burrum River to Point Vernon			Wide	Rocky headland at Point Vernon					
Burrum River	499	M	See S 5.6		O	Y	LU		Y
Beelbi Creek	359	M	5.6		Y	N	LU		Y
O'Regan Creek	91	M	5.6		N	N	M		
Eli Creek	150	L	5.6		N	N	SI		
Tooan Tooan Creek	2	L	5.6		N	N	SI		
North-west Fraser Island			Narrow, large sand spit						
Coongul Creek	71	M	See S 5.7		Y	N	NP		Y
Wathumba Creek	177	M	5.7		Y	N	NP	Y	Y
Great Sandy Strait			Extensive	Rocky foreshores around Round Island and Woody Island					
Area 1	1504	H	See S 5.8		Y	N	SI**	Y	Y
Area 2	9887	H	5.8		Y	N	M**	Y	Y
Area 3	835	H	5.8		Y	N	LU**	Y	Y
Mary River/Susan River	3521	H	See S 5.9		O	Y	SI		Y
Kauri Creek	1233	H	See S 5.10		N	N	NP	Y	Y
Tin Can Inlet	1818	M	See S 5.11		Y	N	LU	Y	Y

* Lupton and Heidenreich (1999) note that this river system is one of the last few in this region whose integrity has not been compromised by any weirs or tidal barrages that regulate flow characteristics, interrupt fish migrations and severely alter the instream and estuarine productivity of fisheries habitats.
** Refers only to the western edge of the Strait, NP on Fraser Island.

7.2 Significant Coastal Wetland Communities from Round Hill Head to Tin Can Inlet

The following coastal wetland systems are considered to be important environments within the study area that should be protected. Reasons for their significance are varied. However, all can be considered important in terms of their contribution to fisheries productivity. Many of these areas are already protected by FHA status of either management A or B types. Areas that are not already protected within a FHA should be considered for gazettal under Fisheries legislation.

Baffle Creek, Kolan River and Elliott River
Of the more exposed coastline within the study area, that is, from Round Hill Head to Burrum River, the largest coastal wetland communities are associated with Baffle Creek, Kolan River and Elliott River (and Burnett River, see Section 7.3). Intertidal flats along the coastline from Round Hill Head to Elliott River are relatively narrow due to the exposure of this section of coastline to wave action. Therefore, the intertidal flats within the protection of Baffle Creek, Kolan River and Elliott River provide important habitat that is relatively scarce within this stretch of coastline. There is a medium diversity of habitat types represented in these systems (e.g. intertidal flats, a number of mangrove community types and saltpans). Additionally, Elliott River has a small rocky island at the mouth of the river.

Elliott River and Baffle Creek are the two remaining rivers in the Wide Bay Burnett region that have no weirs, barrages or other devices that regulate water flow or physically disrupt fish migrations. These two systems have been identified as important areas for future habitat protection due to their pristine status and high fisheries productivity (Lupton 1993; Lupton and Heidenreich 1996).

Theodolite/Lagoon Creek
The vegetation surrounding Theodolite/Lagoon Creek is protected within the Burrum Coast National Park. The adjacent vegetation of the Theodolite/Lagoon Creek coastal wetlands is largely unmodified. Most of the coastal wetland system is comprised of Closed *Ceriops* and Saltpans. However, a relatively large area of intertidal flats exists at the mouth of the Creek.

Burrum River
Burrum River is the largest coastal wetland system existing in the coastal section from Burrum River to Urangan. This section of coastline is significant due to the wide intertidal flats that exist on the foreshore. Intertidal flats north of Burrum River are relatively insignificant. The high diversity of habitat types, as well as the very low level of disturbance to riparian vegetation, contributes to the significance of this wetland system.

Broadwater Creek, Littabella Creek and Beelbi Creek
Although these coastal wetlands are relatively smaller, movements of the mouths of these creeks have resulted in unique coastal environments for this region. Significant intertidal flats exist at Broadwater Creek, a coastal lagoon environment occurs at Littabella Creek and a high proportion of Saltpan exists at Beelbi Creek. Additionally, the riparian vegetation in all these locations is largely unmodified.

Although these coastal wetlands may have a lower significance to fisheries productivity due to their smaller individual size, they are linked to other, larger important coastal wetland systems (Baffle Creek, Kolan River and Burrum River). Protecting these environments in conjunction with the larger systems nearby would serve to increase the diversity/area of habitats protected.

Mary River and Susan River

The coastal wetlands associated with Mary River and Susan River are a unique environment within the study area. The large area of mangrove and saltmarsh communities contains a high diversity of individual habitats. The riverine system has major freshwater input, often associated with seasonal floods, and a significant contribution of sediment from the Mary River and Susan River catchments. Of particular note is the presence of Closed *Aegiceras* in the upstream areas and a Closed *Rhizophora*/*Aegiceras* mix closer to the river mouth. Neither of these habitats is represented as extensively within the study area as they are within the Mary and Susan River coastal wetland system.

North-west Fraser Island

Although small, the coastal wetlands associated with Wathumba Creek and Coongul Creek are significant in that they are the only examples of coastal wetland vegetation in Platypus Bay. The large freshwater swamps surrounding these systems adds to their value in terms of fisheries productivity.

Great Sandy Strait

The ecological significance of the Great Sandy Strait, from Urangan to Tin Can Inlet, has been recognised in many ways and for various attributes. This study confirms the importance of this region from a fisheries perspective. This portion of the coastline exhibits the largest stands of mangroves and the highest diversity of coastal wetland communities, including extensive intertidal flats. Of particular significance is the high proportion of Closed *Rhizophora* within the Strait (compared to its relative insignificance elsewhere in the study region) and the presence of extensive, well zoned mangrove communities on tidal islands.

Freshwater influence from Fraser Island has a significant impact on the coastal wetland communities found in landward locations on the western edge of the Strait. Unique Closed Mixed communities, found in upstream locations, (e.g. Poyungan Creek) are comprised of *A. corniculatum, A. marina, B. gymnorrhiza, E. agallocha* and *X. granatum*. It was noted during fieldwork, that individual mangroves within these communities were generally taller than individuals found anywhere else in the region. Heights of up to 16 m were recorded for *B. gymnorrhiza, E. agallocha* and *X. granatum* trees.

The diversity of species found in the communities on Fraser Island was high. Although *R. stylosa* tended to dominate the seaward zone in monospecific stands, mixed communities were often found on the edges of creeks further upstream. Species identified in these areas include *A. annulata, A. corniculatum, A. marina, B. gymnorrhiza, C. tagal*, *C. pedunculatum*, *E. agallocha, L. racemosa*, *R. stylosa,* and *X. granatum*. Additionally, the greatest proportion of Open *Bruguiera* communities, which are not common within the study region, is found on Fraser Island.

The tall and highly diverse mangrove forests on Fraser Island support the observation by Duke et al. (1998) that areas of higher coastal rainfall and high riverine inputs of freshwater tend to support more diverse and taller mangrove forests. Not all creeks were visited during fieldwork. However, it is expected that most coastal wetlands on Fraser Island would exhibit similar high diversity and exceptional heights, especially in areas adjacent to freshwater swamps, due to the input of freshwater.

Intertidal flats form a significant component of the coastal wetlands in the Strait. Gataker's Bay at the northern entrance of the Strait has been recognised as an important recreational fishing area.

Kauri Creek and Tin Can Inlet
Both Kauri Creek and Tin Can Inlet are relatively pristine environments with low disturbance of riparian vegetation. The extensive intertidal flats form a significant component of these coastal wetlands (especially the intertidal flats at Pelican Bay and the mouth of Kauri Creek). Small Open *Bruguiera* communities exist on the landward edges of the coastal wetland communities in upstream locations.

Tin Can Inlet is the southern distributional limit for three species, *A. annulata*, *O. octodonta* and *X. granatum*.

7.3 Further Comments

Burnett River
The Burnett River has a large area of coastal wetlands associated with it, the largest by far in this northern exposed section of coastline in the study area. The geomorphology of the coastline surrounding the Burnett River mouth is relatively unique. Rocky foreshores of Hummock basalt exist rather than sandy beaches or intertidal flats. However, extensive clearing of adjacent vegetation and major alterations to the river channel and entrance have occurred.

Lupton and Heidenreich (1999) suggested that Burnett River was too degraded to warrant protection through a FHA. Poor fish recruitment and biodiversity levels and the poor condition of estuarine fish habitats of Burnett River were sited as reasons for the limited potential for fisheries protection. It was concluded that the feasibility of a rehabilitation project for the Burnett catchment should be investigated.

SECTION 8. RELATIONSHIP OF COASTAL WETLAND COMMUNITIES TO MARINE FAUNA

The importance of mangroves and seagrasses to marine fauna and fisheries productivity is well recognised. Robertson and Blaber (1992) have summarised the utilisation of mangrove communities by fish. Mangrove communities provide shelter from predators for juvenile fish and prawns through the structural complexity provided by prop roots, pneumatophores and fallen logs and branches. The increased turbidity in the adjacent waters also provides protection from predators. Mangrove communities are also important feeding sites for fish and increase the supply of food available to juvenile fish through primary production. The food provided may not be directly from the mangroves but through associated and dependent plankton or epibenthos.

Although the ecological background to the claim that mangroves are important for fisheries productivity is well documented, rigorously quantified relationships are surprisingly few (Baran in press). In Australia, Staples et al. (1985) found a correlation between the extent of mangrove lined rivers and the annual catch of banana prawns. Pauly and Ingles (1986) reported that the most important part of the variance of the maximum sustainable yield of penaeids (53% of the variance) could be explained by a combination of area of mangrove habitats and latitude. However, these studies do not conclusively prove the relationship unless the real dependency of fisheries resources on the mangrove environment is examined. For example, is the mangrove zone essential for a given species; what are its trophic or reproductive relationships with this zone; are there alternative areas for its development (Baran in press)? Beumer and Halliday (1994) were able to demonstrate different feeding patterns exhibited by different species of fish. However, the extent to which these patterns reflect the dependence of the species on different intertidal zones was unclear.

Fringe and riverine forests are considered particularly important as habitat for juvenile and adult fish due to their accessibility and the level of nutrient export (Ewel et al. 1998). Portions of basin forests where tidal channels provide access are also considered important for the same reasons. Beumer and Halliday (1994) reported that the direct use of subtropical *R. stylosa* mangrove forest by fish in Tin Can Inlet is less than that recorded for other types of mangrove forests elsewhere in Australia. The low catch rates in these forests were attributed to a reluctancy or inability of fish to enter and use the available forest due to the root structure of *R. stylosa* which is not as open and unrestricted as *A. marina* forests. A study undertaken in Townsville (Robertson and Duke 1990) recorded a higher density of fish in tropical mangrove communities than that of subtropical mangrove communities. The fish species were of little direct economic importance in Australia but they contribute as prey species to the production of economic species in adjacent open water. Table 8.1 is a comparison of fish density and standing crop (weight) for studies of fish within mangrove communities along the east coast of Australia.

TABLE 8.1 Comparison of fish density (number per m^2) and standing crop (grams per m^2) for studies of fish within mangrove forests along the east coast of Australia.

MANGROVE FOREST TYPE OR COMPLEX	NET TYPE	AREA SAMPLED (M^2)	DENSITY (no.m^{-2}) (% ECONOMIC)	STANDING CROP (g. m^2) (% ECONOMIC)	LOCATION	SOURCE
***R. stylosa* (subtropical)**	Block	1000	0.05 ± 0.01 **(61)**	2.01 ± 0.30 **(80)**	Tin Can Bay	Beumer and Halliday (1994)
***A. marina* (temperate)**	Block	~1000	~0.094 **(38)**	~6.4 **(32)**	Botany Bay	Bell et al. (1984)
***A. marina* (subtropical)**	Block	3340	0.27 ± 0.14 **(75)**	25.3 ± 20.4 **(94)**	Moreton Bay	Morton (1990)
***R. stylosa, C. tagal, A. marina* (tropical)**	Trap		3.5 ± 2.4[a] **(<6)**	10.9 ± 4.5[b] **(<36)**	Townsville	Robertson and Duke (1990)

Source: Beumer and Halliday (1994)
a = no.m^{-3} as water depth varied greatly in this study
b = g. m^{-3} as water depth varied greatly in this study

Ewel et al. (1998) recognised that different kinds of mangrove forest provide different goods and services. In the study, coastal wetland systems are divided into three extremes based on dominant physical processes. Tide-dominated mangroves are referred to as fringe mangroves, river-dominated mangroves as riverine mangroves and interior mangroves as basin mangroves. Productivity (generally measured by litterfall in these forests) is closely related to water turnover, with riverine >fringe >basin. Higher productivity and relatively shorter residence times of litter in riverine and fringe mangroves, both associated with higher frequency of inundation, make them particularly important, except where basin zones are much larger. Amarasinghe and Balasubramaniam (1992) found that the annual rate of Net Primary Production (NPP) in the waterfront zones of the mangrove stands (that is, estuarine and fringing stands) was greater than that of the backwater mangrove zones. Variations were once again attributed to differences in tidal flushing and influence of freshwater in the different localities.

Table 8.2 compares studies determining the primary production (through leaf litter) of different mangrove communities. Robertson and Daniel (1989) found that in tropical *C. tagal* forests, much of the leaf litter is removed by crabs (71%) with a microbial turnover being very low (<1% yr^{-1}). Less *A. marina* leaf litter is consumed by crabs (33%) with microbial turnover being much higher (32%) and tides exporting approximately 21% of the annual production. The leaves of *R. stylosa* and *C. tagal* have low initial nitrogen concentration, high C: N ratios and very high tannin concentrations. This results in decay rates slower than that of *A. marina* leaves which have high initial nitrogen concentrations, low C: N ratio and low tannin content (Robertson 1988). Although leaf litter production of *R. stylosa* mangroves is similar to that of *A. marina*, the greater export of its leaves and their relatively slower release of carbon and nitrogen, suggests that *R. stylosa* may be of less importance for primary production within communities than are *A. marina* mangroves (Beumer and Halliday 1994).

Despite the data concerning the different rates of primary production and nutrient export there is still not enough quantitative information to rate the fisheries value of different communities (or habitats) in importance against one another. Considerable variation in measuring mangrove leaf litter (Hutchings and Saenger 1987), along with the temporal nature of some habitats (e.g. seagrass beds (Mellors et al. 1993, Poiner et al. 1989)) make quantification of the relative values of different species/densities difficult. Additionally, the assumption that dense communities (both mangroves and seagrasses) are more important than less dense communities does not always hold true. Beumer and Halliday (1994) found that shallow water habitats do not have to be continually covered with seagrass to be of value to fisheries. In terms of fish production, intertidal areas like those found in Tin Can Inlet can be as productive as adjacent mangrove areas.

As noted previously, the crab fauna is a significant contributor to leaf litter decomposition and hence is an integral component in nutrient cycling in these mangrove systems. The substrate in which the mangroves are growing (e.g. sand, mud, and rocky rubble) could significantly effect the potential abundance of crustacean fauna, and thus the nutrient cycling process itself.

TABLE 8.2 Comparison of studies determining the primary production of mangroves as leaf litter.

MANGROVE SPECIES	PRIMARY PRODUCTION ($g. m^{-2}.yr^{-1}$)	SOURCE
***R. stylosa* (tropical)**	556	Robertson (1986)
***R. mucronata* (tropical)**	441	Amarasinghe and Balasubramaniam (1992)
***A. marina* (tropical)**	519	Robertson and Daniel (1989)
***A. marina* (tropical)**	374	Amarasinghe and Balasubramaniam (1992)
***A. marina* (subtropical)**	580	Goulter and Allaway (1979)
***C. tagal* (tropical)**	822	Robertson and Daniel (1989)

Further Investigation

There is a need to identify and map fisheries habitat for the management and conservation of the resource, as well as a requirement for conducting further research into the interactions between fauna and the habitat. Studies combining data on mangrove forest primary productivity, fish species associated with these mangrove stands and feeding strategies of these fish species will contribute to a better understanding of the value of particular habitats to fisheries productivity. Continuation of the mapping of the coastal wetland communities of the Queensland coastline will provide quantitative data for incorporation into these studies. Additionally, it provides the base information required for monitoring short and long term changes in coastal wetland habitats and implementing appropriate management measures.

SECTION 9. RECOMMENDATIONS

1. The coastal wetlands of both Baffle Creek and Elliott River are important environments in this region which warrant enhanced protection. The gazettal of these areas as FHAs is recommended as a priority. Broadwater Creek is a relatively small coastal wetland environment. However, the protection of this environment in conjunction with Baffle Creek would serve to increase the diversity of coastal wetland habitats protected in this region.

2. The coastal wetlands from the west head of Puthoo Creek to the north head of Bennett Creek on Fraser Island are not currently included in a FHA of either management A or B status. The inclusion of these coastal wetland communities in either the Maaroom A or Fraser Island B FHA (depending on the appropriate management level) is recommended due to the unique coastal wetland communities in these locations.

3. Inclusion of Pelican Bay in the Kauri Creek FHA is recommended due to the its importance as a shallow water nursery habitat for numerous commercially and recreationally targeted fish and crab species.

4. Further inclusion of the intertidal flats as a buffer to the coastal wetlands from Burrum Heads to Urangan, including the sand spit at Dayman's Point, is recommended to increase the diversity of fisheries habitats included in FHAs in this area.

5. In recognition of the dynamic nature of the coastal environment, regular review (perhaps every 5 years) of FHA boundaries, particularly the seaward boundary, is recommended in order to ensure these boundaries maintain their usefulness over time.

6. Continuation of coastal wetlands mapping to complete the remainder of the Queensland coast is strongly recommended to:
   - ♦ provide baseline data for FHA declaration and Ramsar site nomination;
   - ♦ monitor spatial and composition changes in communities on a local, bioregional and State-wide basis;
   - ♦ as a resource for incorporation into studies of the relationships of specific marine fauna to particular coastal wetland habitats.

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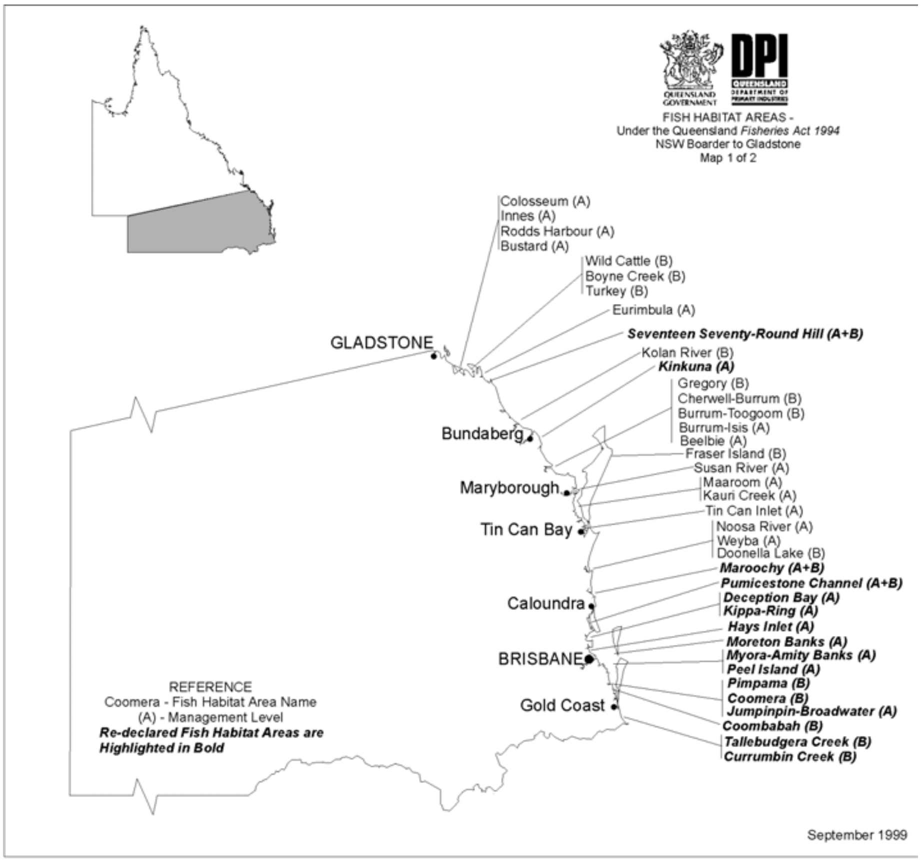
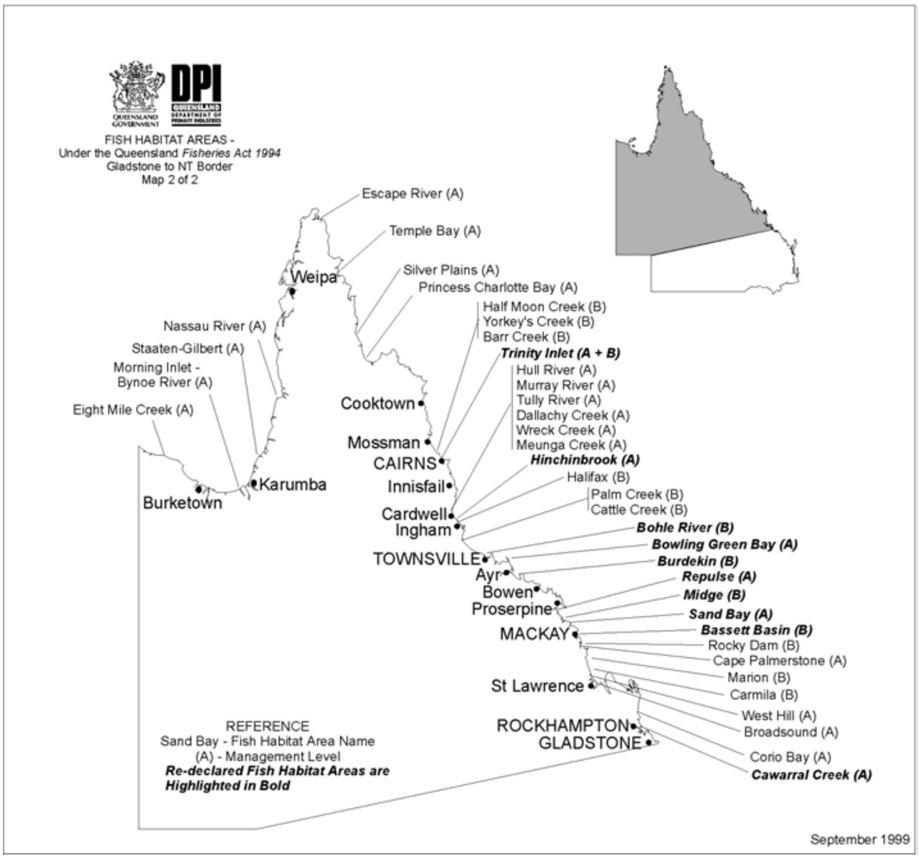
APPENDIX 1: DECLARED FHAS IN QUEENSLAND





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

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

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

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

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

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

Who owns a Fish Habitat Area?

In Tidal Areas

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

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

In Freshwater Areas

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

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

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

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

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

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

Management categories

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

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

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

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

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

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

The declaration process

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

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

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

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

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

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

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

Key to Symbols

✓ Unrestricted Activity

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

✗ Activity considered incompatible with FHA declaration

◆ Under review

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

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

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

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

The Revocation Process

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

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

For further information please contact:

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

APPENDIX 3: CRITERIA FOR RAMSAR SITE NOMINATION

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

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX 4: FHAS FROM ROUND HILL HEAD TO TIN CAN INLET

Management A
Kinkuna
Burrum-Isis
Beelbi
Susan River
Maaroom
Kauri Creek
Tin Can Inlet

Management B
Kolan River
Gregory
Cherwell-Burrum
Burrum-Toogoom
Fraser Island

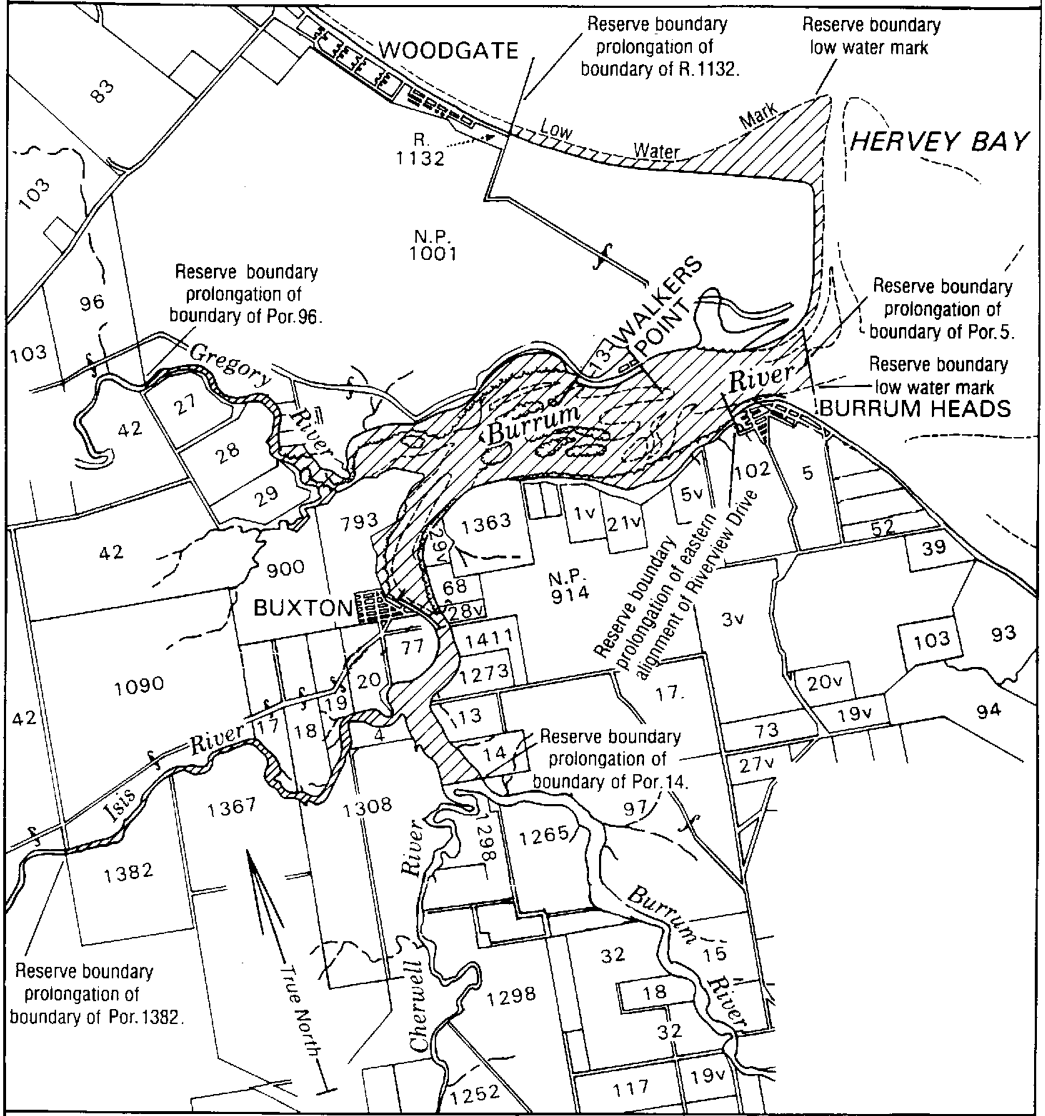
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT AREA

Name: **BURRUM—ISIS**

Locality: **BURRUM RIVER**

015-046A



NOTE:

NOTE

1 0 1 2 Kilometres 4 5 6 7

Co-ordinates of approx midpoint: 25° 15′ 28″ S 152° 33′ 18″ E

1 : 100 000 Map Reference Number: **9447**

Plan Number: **015-046A**

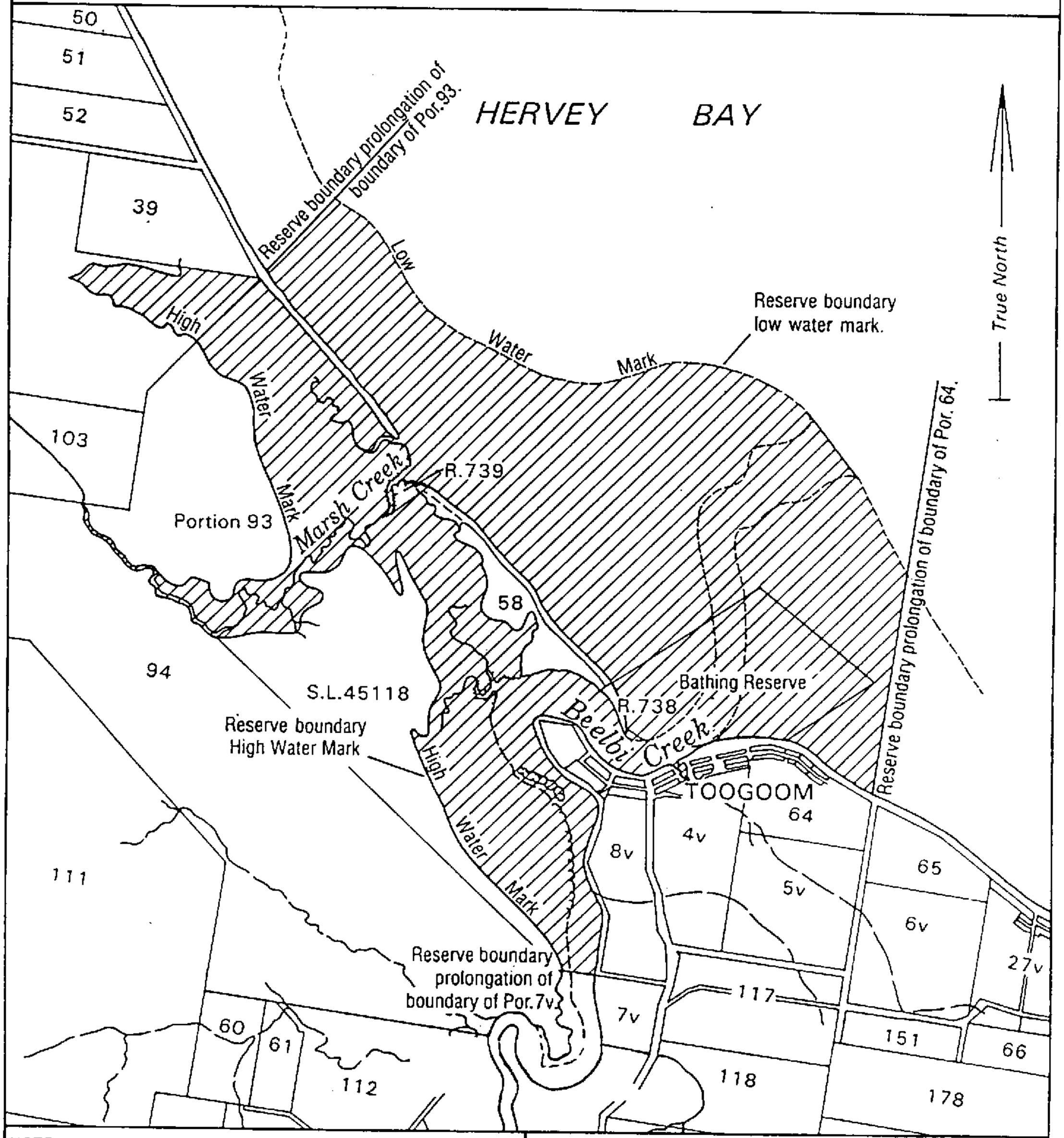
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT AREA

Name: **BEELBI**

Locality: **HERVEY BAY**

015-047A



NOTE:

NOTE

1 0 Kilometres 1 2

Co-ordinates of approx midpoint: 25° 13′ 54″ S 152° 39′ 13″ E

1 : 100 000 Map Reference Number 9447

Plan Number

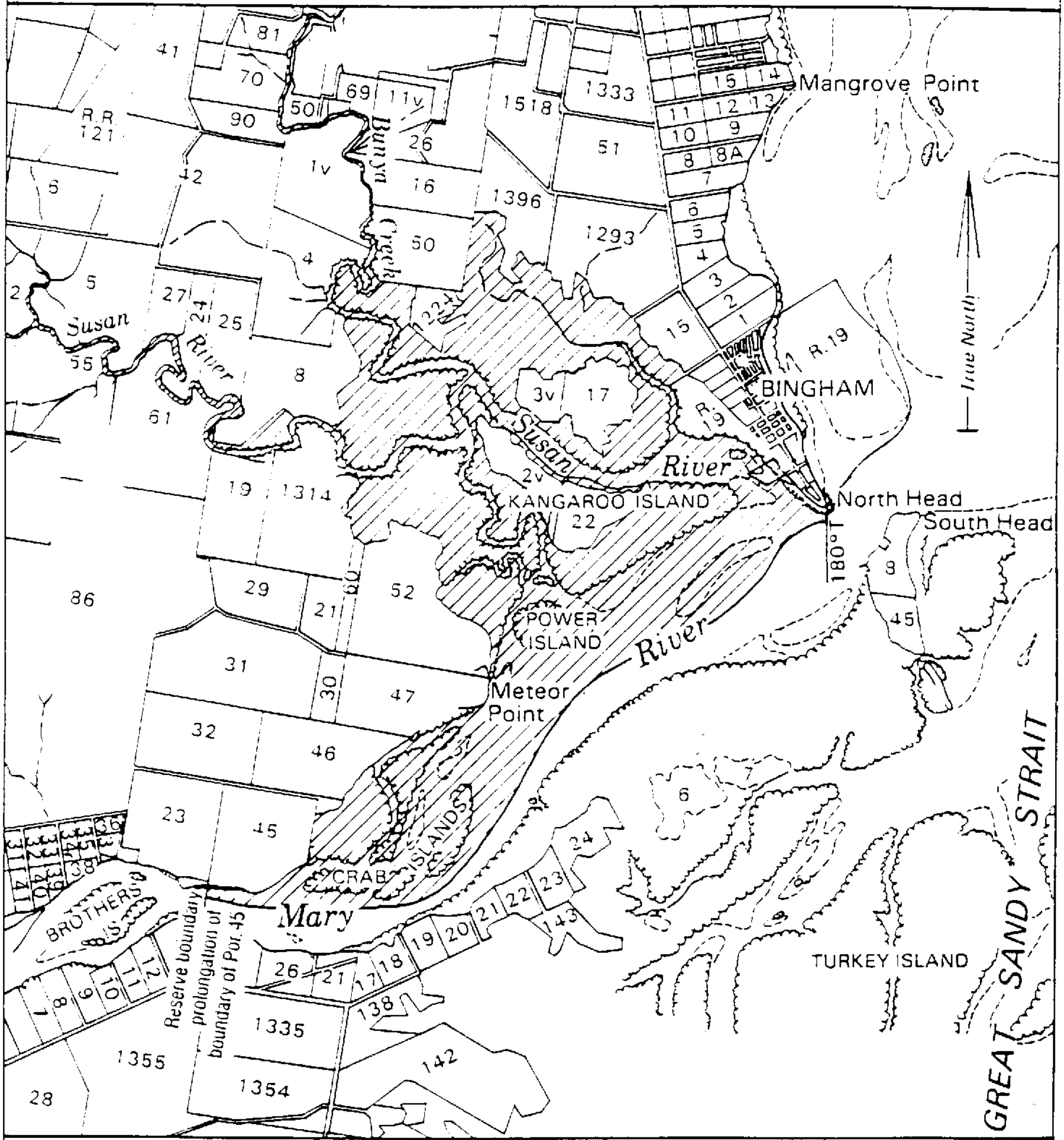
015-047A

QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT AREA

Name: **SUSAN RIVER** **015-048A**

Locality: **GREAT SANDY STRAIT**



NOTE

NOTE

1 0 1 2 Kilometres 4 5 6 7

Co-ordinates of approx midpoint: 25° 25′ 20″ S 152° 52′ 42″ E

1 : 100 000 Map Reference Number **9447**

Plan Number

015-048A

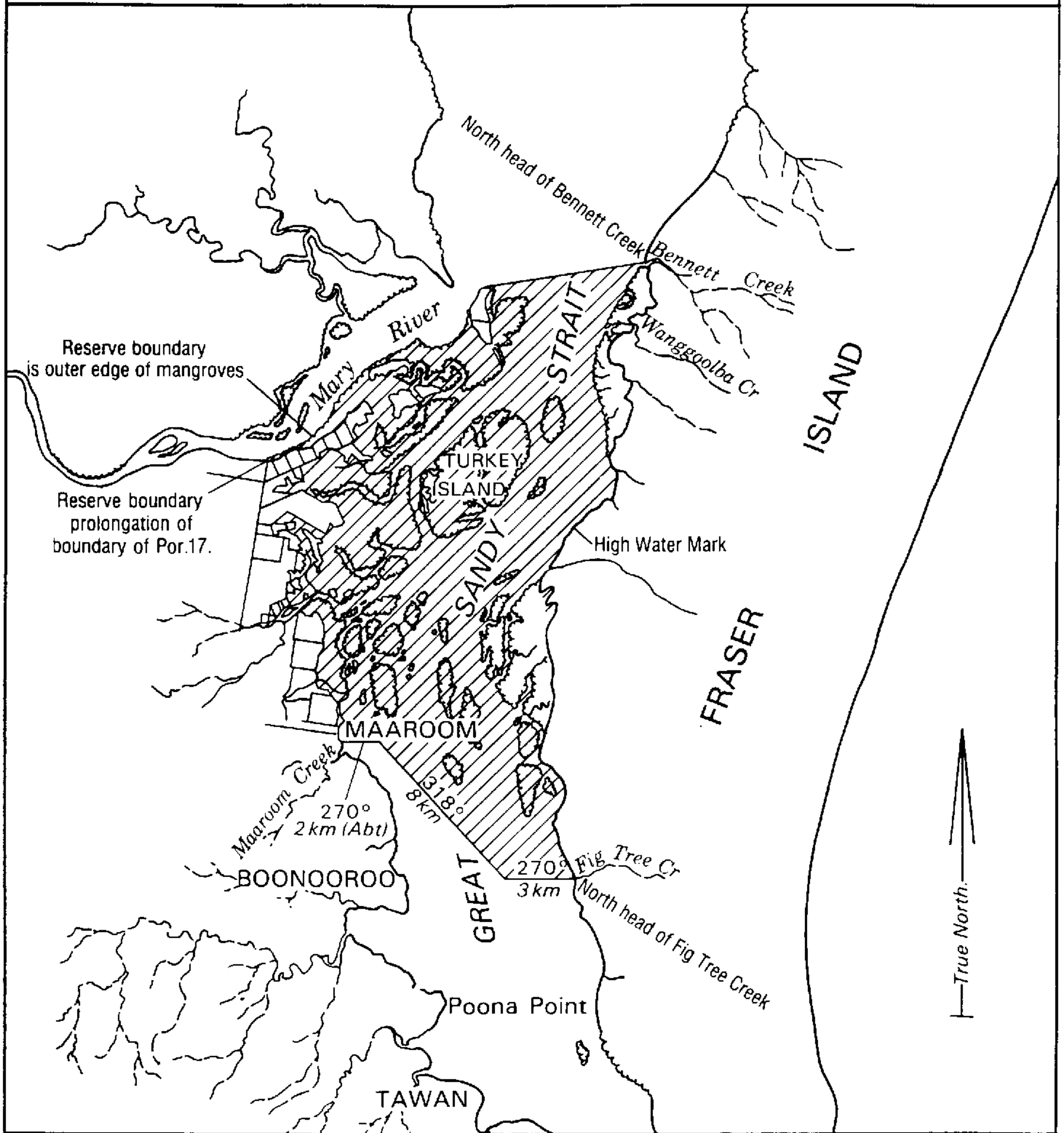
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT AREA

Name: **MAAROOM**

Locality: **GREAT SANDY STRAIT**

015-021A



NOTE:

NOTE:

5 0 Kilometres 5 10 15

Co-ordinates of approx midpoint: 25° 32′ 00″ S 152° 55′ 46″ E
1 : 100 000 Map Reference Number: 9446

Plan Number:
015-021A

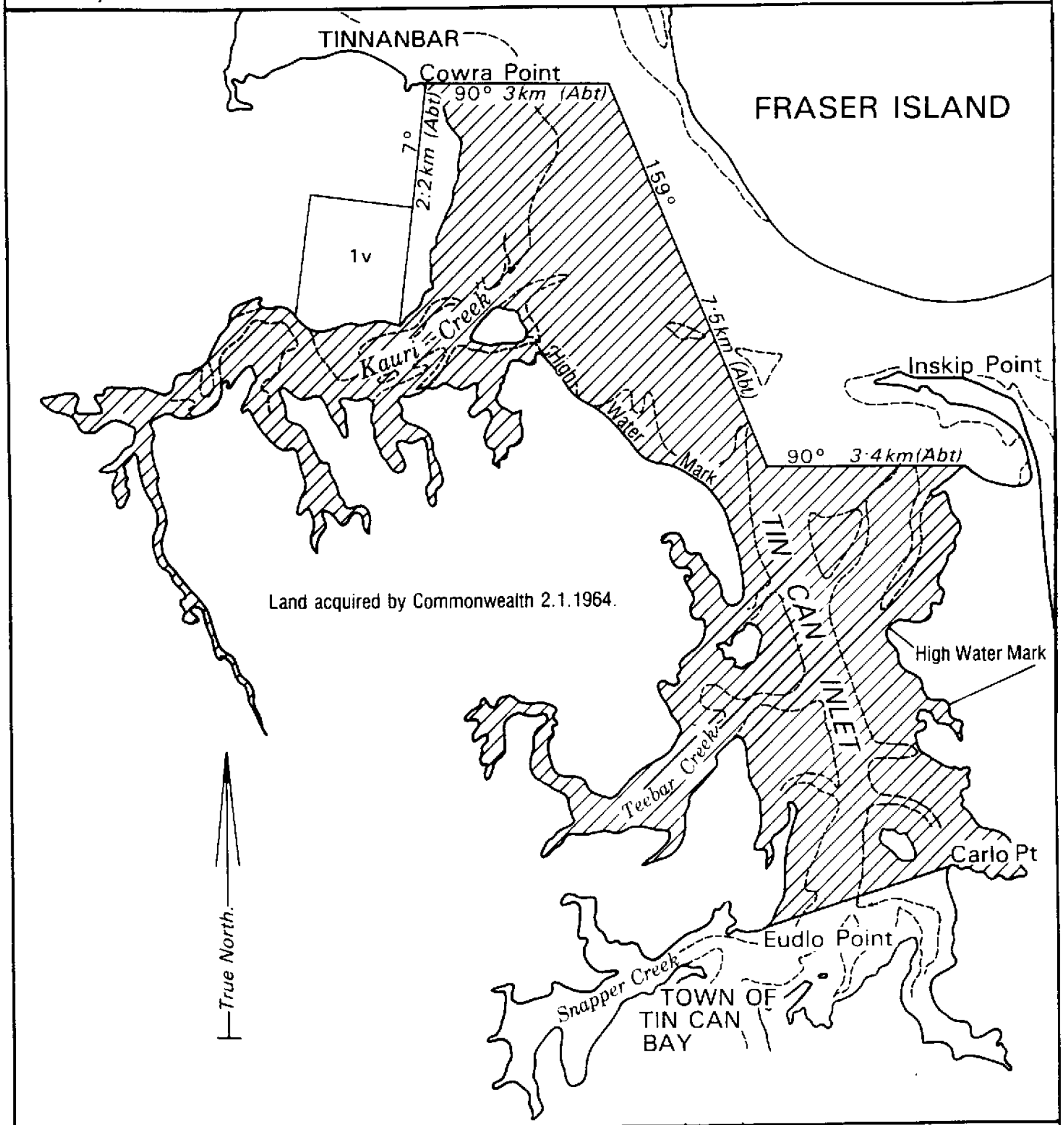
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT AREA

Name: **KAURI CREEK**

Locality: **TIN CAN INLET**

015-022A



NOTE:

NOTE:

2 1 0 Kilometres. 2 4 6

Co-ordinates of approx midpoint: 25° 49′ 34″ S 153° 01′ 11″ E

1 : 100 000 Map Reference Number: 9546

Plan Number:

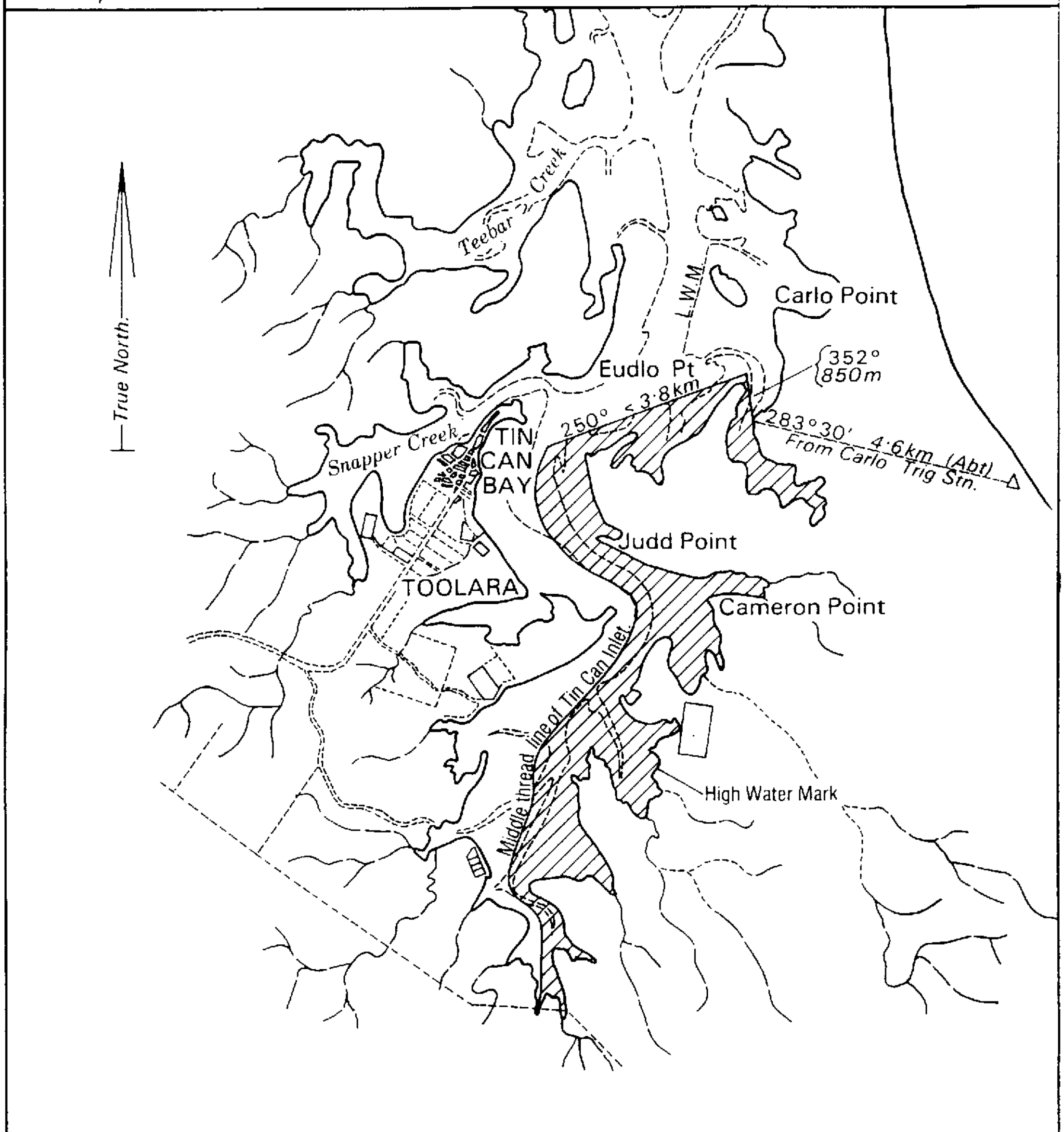
015-022A

QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT AREA

Name: **TIN CAN INLET** **015-023A**

Locality: **TIN CAN INLET**



NOTE:

NOTE:

2 1 0 Kilometres 2 4 6

Co-ordinates of approx midpoint: 25° 56′ 49″ S 153° 01′ 48″ E

1 : 100 000 Map Reference Number: **9546**

Plan Number: **015-023A**

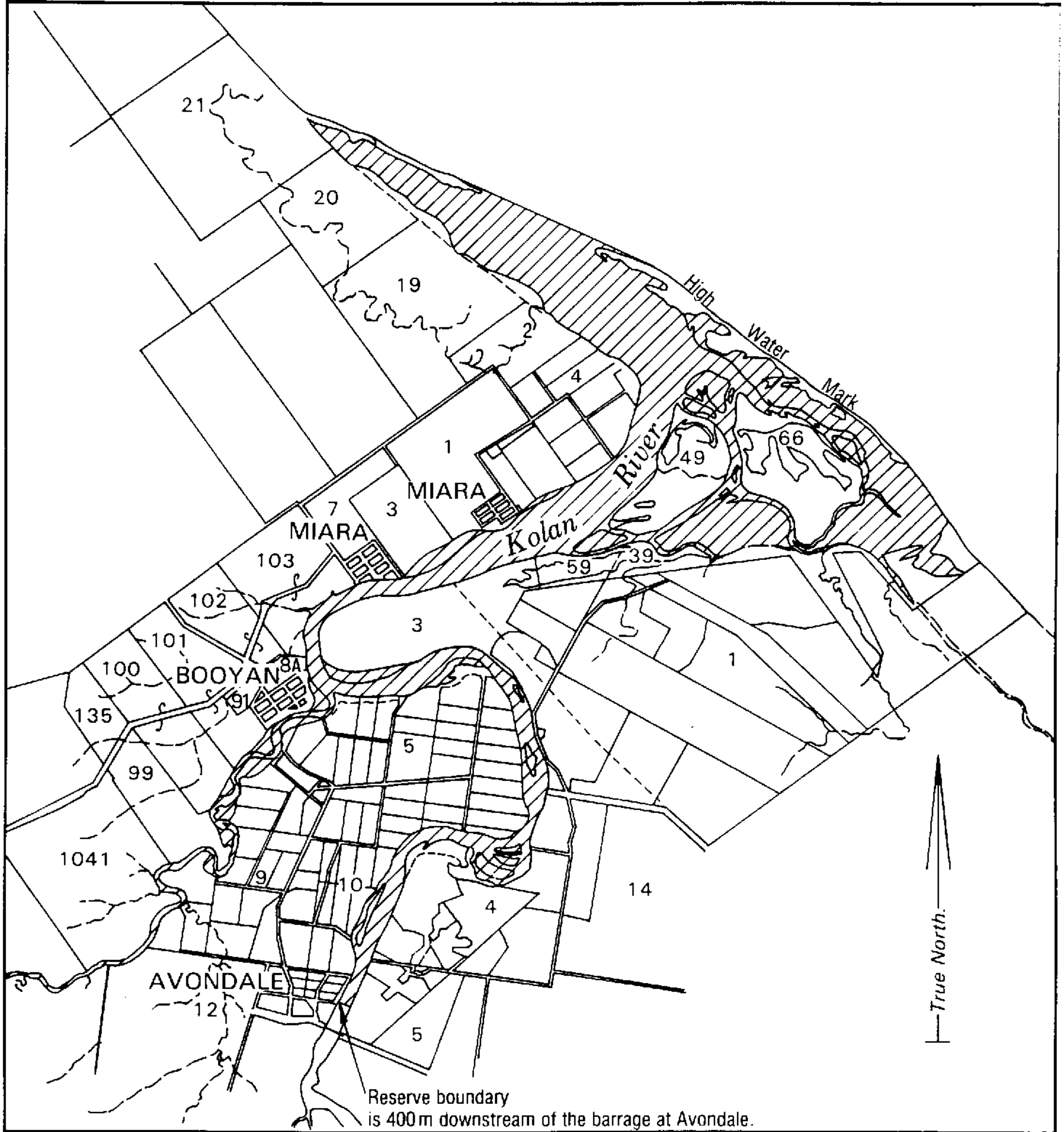
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT AREA

Name: **KOLAN RIVER**

Locality: **BUNDABERG**

033-017A



NOTE:

NOTE:

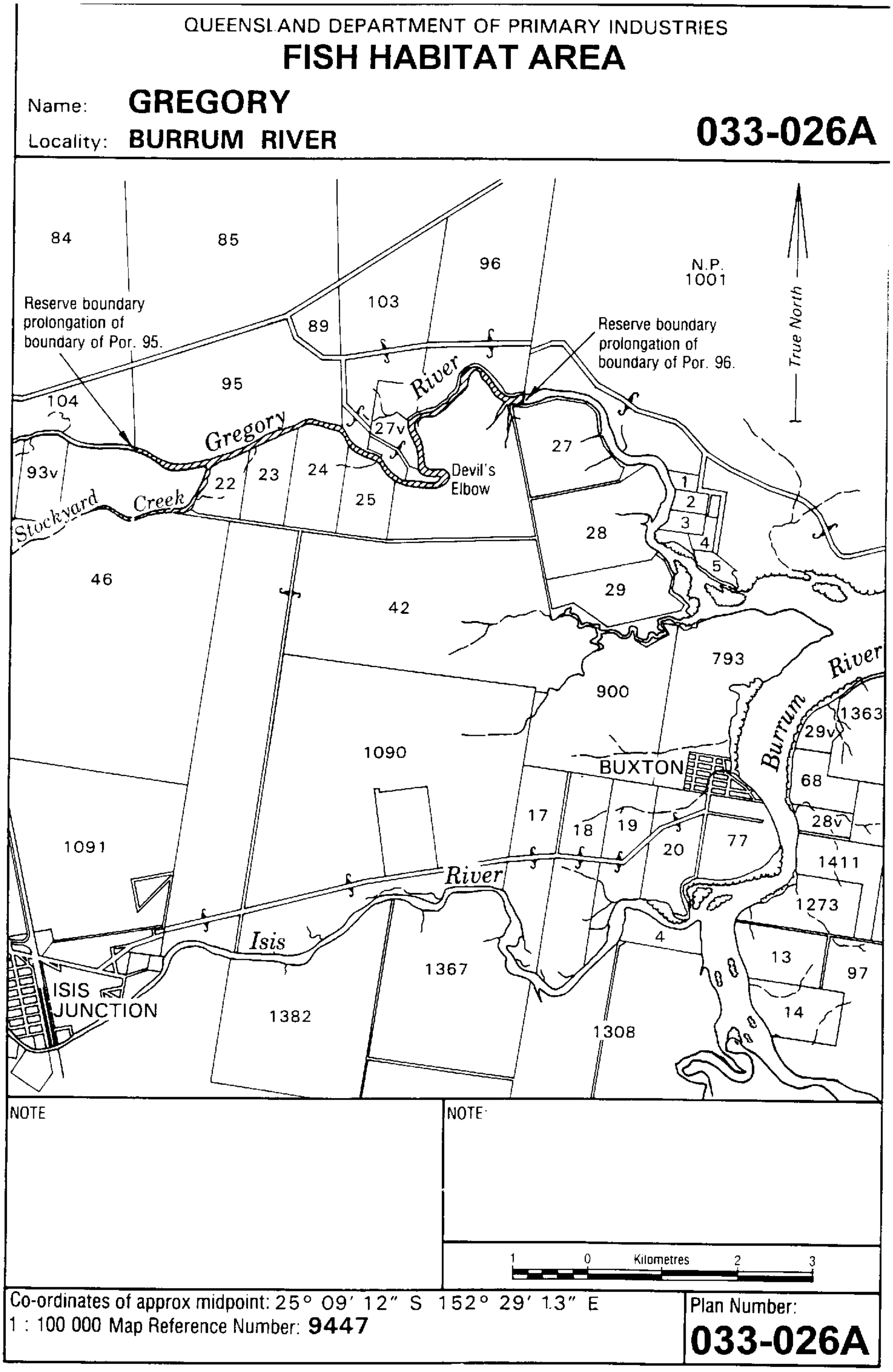
1 0 Kilometres 1 2 3 4

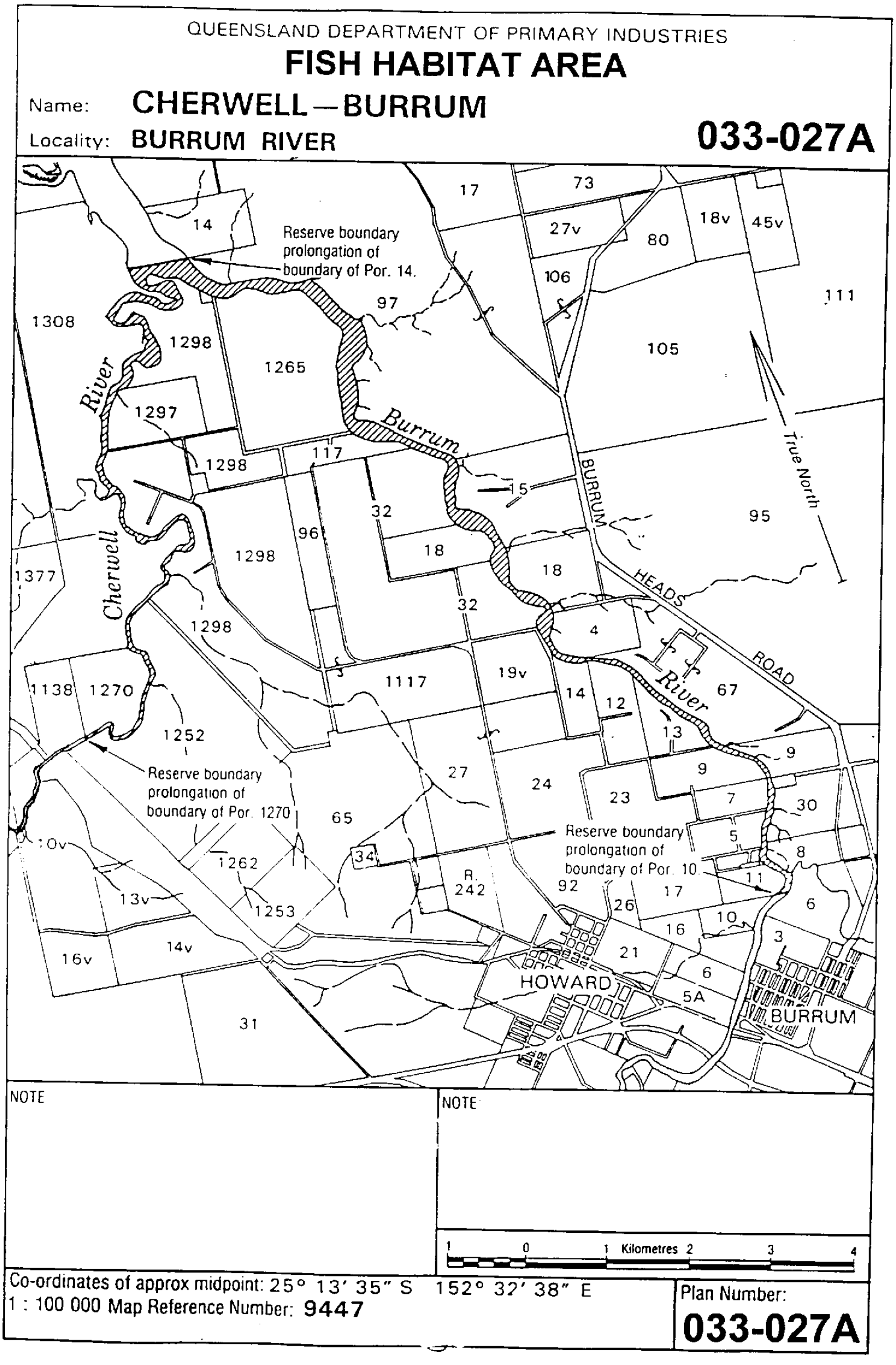
Co-ordinates of approx midpoint: 24° 41′ 03″ S 152° 51′ 06″ E

1 : 100 000 Map Reference Number: 9348

Plan Number:

033-017A


QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
FISH HABITAT AREA
Name: GREGORY
Locality: BURRUM RIVER
033-026A
Reserve boundary prolongation of boundary of Por. 95.
Reserve boundary prolongation of boundary of Por. 96.
True North
Gregory River
Stockyard Creek
Devil's Elbow
Burrum River
Isis River
BUXTON
ISIS JUNCTION
N.P. 1001
84
85
96
103
89
95
104
93v
22
23
24
27v
25
27
28
29
1
2
3
4
5
46
42
793
900
1090
1363
29v
68
28v
1411
1273
17
18
19
20
77
1091
1367
1382
1308
13
97
14
NOTE
NOTE
Kilometres
1 0 2 3
Co-ordinates of approx midpoint: 25° 09′ 12″ S 152° 29′ 13″ E
1 : 100 000 Map Reference Number: 9447
Plan Number: 033-026A

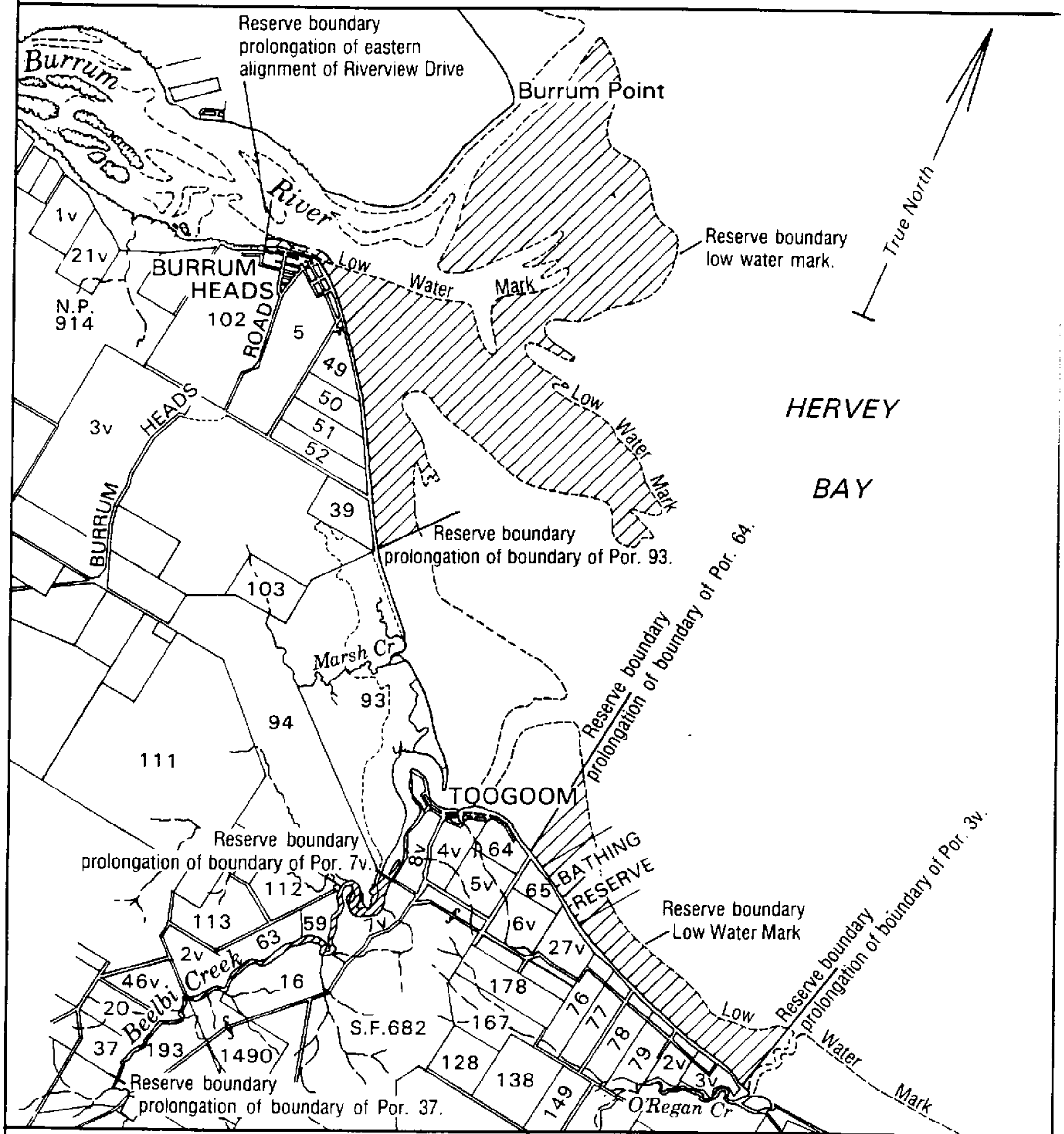

QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
FISH HABITAT AREA
Name: CHERWELL – BURRUM
Locality: BURRUM RIVER
033-027A
Reserve boundary prolongation of boundary of Por. 14.
Reserve boundary prolongation of boundary of Por. 1270
Reserve boundary prolongation of boundary of Por. 10.
Cherwell
River
Burrum
River
BURRUM
HEADS
ROAD
True North
HOWARD
BURRUM
NOTE
NOTE
Kilometres
Co-ordinates of approx midpoint: 25° 13′ 35″ S 152° 32′ 38″ E
1 : 100 000 Map Reference Number: 9447
Plan Number:
033-027A

QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT AREA

Name: **BURRUM – TOOGOOM**

Locality: **HERVEY BAY** **033-028A**



NOTE

NOTE

Co-ordinates of approx midpoint: 25° 15′ 35″ S 152° 39′ 44″ E

1 : 100 000 Map Reference Number: **9447**

Plan Number:

033-028A

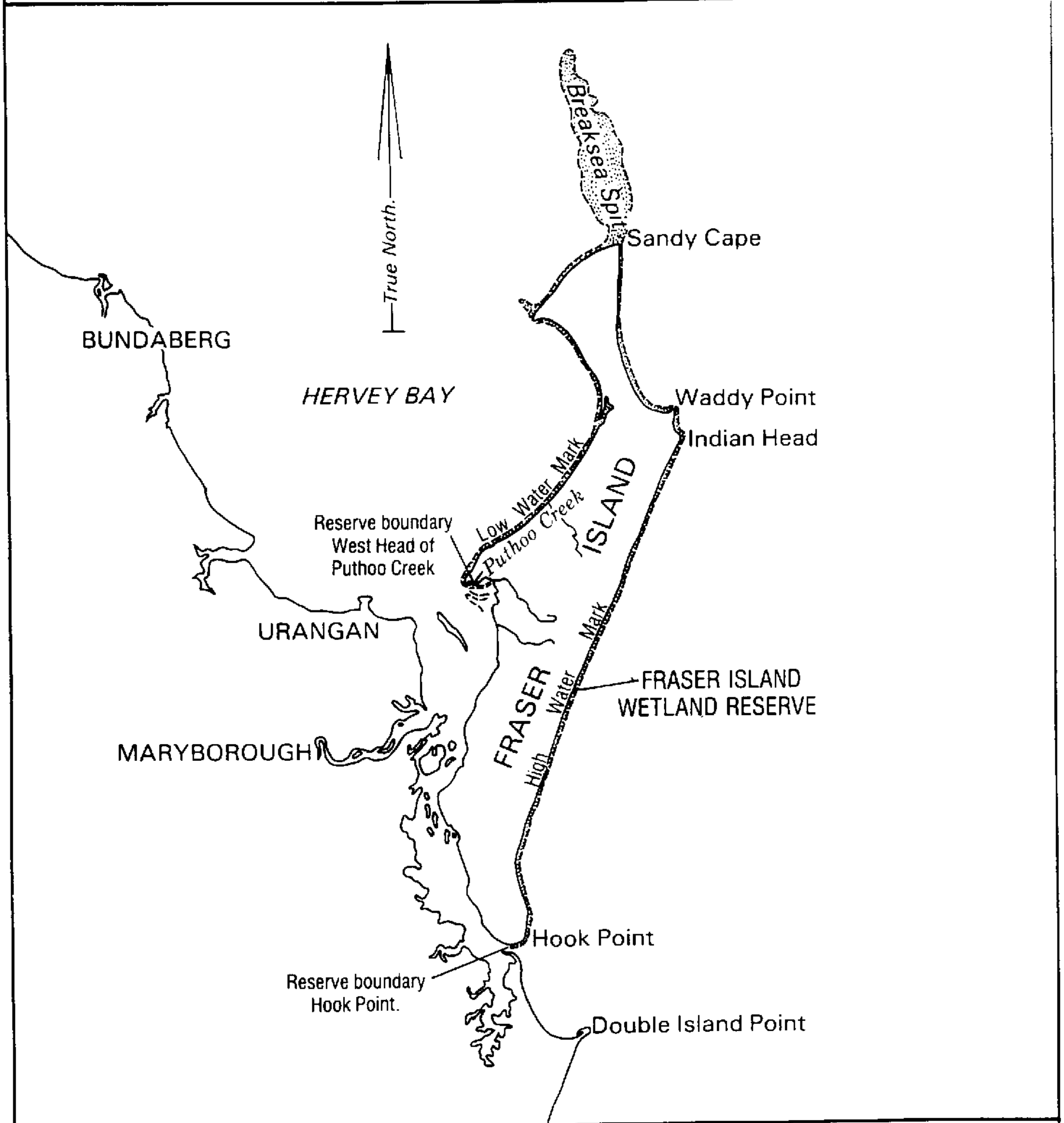
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT AREA

Name: **FRASER ISLAND**

Locality: **FRASER ISLAND**

033-009A



NOTE:

NOTE:

10 0 Kilometres. 20 30 40 50 60 70

Co-ordinates of approx midpoint: 25° 27′ 39″ S 153° 08′ 57″ E

1 : 100 000 Map Reference Number: **9548**

Plan Number: **033-009A**

APPENDIX 5: SATELLITE REMOTE SENSING

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	30 x 30 m for bands 1 to 5, 7 120 x 120 m for band 6
Data rate	85 MB/s
Quantisation levels	8 bits, 256 levels
Earth coverage	16 days Landsat 4 and 5
Altitude	705 km
Swath width	185 km
Inclination	98.2^{o}

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

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

APPENDIX 6: METADATA

Title: Coastal Wetland Communities: Round Hill Head to Tin Can Inlet
Custodian: Department of Primary Industries Queensland Fisheries Group
Resource Condition and Trend Unit
Jurisdiction: Australia

Description

Abstract: Coastal wetland mapping including mangrove communities, saltpans and saline grasslands. Mapping includes coastal wetlands from Round Hill Head to Tin Can Inlet, Queensland.
Search Words: Habitat, Mangroves, Saltmarshes
Geographic Extent: Queensland Coast
Bounding:
North: -24.40
West: 151.90 **East**: 153.50
South: -26.00

Data Currency

Beginning: 21-10-1999
Ending: 21-10-1999

Dataset Status

Progress: Complete
Maintenance Frequency: As required

Access

Stored Data Format: Digital – ARC/INFO
Available Format: Digital – ARC/INFO
Access: Release with the written permission of the custodian

Data Quality

Lineage: Landsat 5 TM satellite imagery processed using ERDAS Imagine 8.3.1 software. Three scenes, Lady Musgrave Island (12 August 1997), Bundaberg (12 August 1997) and Fraser Island (6 September 1997) were required to map the three regions of Round Hill Head to Burnett River, Burnett River to Point Vernon and Urangan to Tin Can Inlet, respectively. Six bands contrast streched 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). Resulting classes labelled according to their dominant cover type with the aid of 1: 50 000 (1994 and 1996) BPA aerial photography. Clumps of pixels <0.5ha eliminated. Image smoothed using 3 x 3 kernel. Converted from raster to vector format using ARC/INFO software. Splined and polygons <0.5ha eliminated.
Positional Accuracy: Landsat scenes rectified to AMG with final radiometric correction and GCPs
Attribute Accuracy: Overall accuracy 89%. User's and producer's accuracies for each class included in report.
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: Department of Primary Industries Queensland Fisheries Group
Resource Condition and Trend Unit
OIN:
Contact Position: Remote Sensing Scientist
Address: 9th Floor Forestry House, 160 Mary Street
Locality: Brisbane
State: QLD **Postcode**: 4001 **Country**: Australia
Telephone: (07) 3224 8112 **Facsimile**: (07) 3224 2805
Email: bruinsc@dpi.qld.gov.au

Additional Metadata

Date: 19-10-1999 **Person**: Christina Bruinsma

Organisation: Department of Primary Industries Queensland Fisheries Group
Resource Condition and Trend Unit

Publication

Documentation: Bruinsma, C and Danaher, K (1999) Queensland Coastal Wetland Resources: Round Hill Head to Tin Can Inlet. Department of Primary Industries Queensland, Brisbane.

APPENDIX 7: DISTRIBUTION OF COASTAL WETLAND COMMUNITIES FROM ROUND HILL HEAD TO TIN CAN INLET

Sheet 1: Round Hill Head
Sheet 2: Baffle Creek
Sheet 3: Kolan River
Sheet 4: Burnett River
Sheet 5: Elliott River
Sheet 6: Burrum River
Sheet 7: Point Vernon
Sheet 8: Fraser Island
Sheet 9: Moon Point
Sheet 10: Wathumba Creek
Sheet 11: Sandy Cape
Sheet 12: Great Sandy Strait (a)
Sheet 13: Great Sandy Strait (b)
Sheet 14: Tin Can Inlet

APPENDIX 8: LAND TENURE FROM ROUND HILL HEAD TO TIN CAN INLET

Sheet 1: Round Hill Head
Sheet 2: Hervey Bay
Sheet 3: Fraser Island
Sheet 4: Tin Can Inlet

APPENDIX 9: ACCURACY ASSESSMENT ERROR MATRIX

Reference Data \ Classification	Closed *Rhizophora*	Closed *Avicennia*	Open *Avicennia*	Closed *Ceriops*	Open *Ceriops*	Closed *Aegiceras*	Closed *Bruguiera*	Closed *Rhizophora*/*Avicennia*	Closed *Rhizophora*/*Aegiceras*	Closed *Avicennia*/*Ceriops*	Open *Avicennia*/*Ceriops*	Closed Mixed	Saline Grassland	Saltpan	Terrestrial	Column Total
Closed *Rhizophora*	58	1													1	60
Closed *Avicennia*		36		5				2						1	1	45
Open *Avicennia*			6											1		7
Closed *Ceriops*		3		15						1					1	20
Open *Ceriops*					0											0
Closed *Aegiceras*		1				9										10
Closed *Bruguiera*							0									0
Closed *Rhizophora*/*Avicennia*								3							1	4
Closed *Rhizophora*/*Aegiceras*		1							2						1	4
Closed *Avicennia*/*Ceriops*										21						21
Open *Avicennia*/*Ceriops*										1	1					2
Closed Mixed	1								1			7				9
Saline Grassland													9			9
Saltpan														56	3	59
Terrestrial															5	5
Row Total	59	42	6	20	0	9	0	5	3	23	1	7	9	58	13	255

APPENDIX 10: PROJECT EVALUATION

Outcomes
The acquisition and interpretation of digital satellite imagery and aerial photography undertaken as part of this study, has provided a community based classification of the coastal wetland communities from Round Hill Head to Tin Can Inlet. This classification forms a component of the baseline assessment of Queensland's coastal wetland resources, to be completed in June 2001. The project has provided key information and recommendations for the declaration of additional managed, 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, Fisheries Group (Danaher 1995a) which has been recognised (Ward et al. 1998) as an appropriate model for a national approach to coastal wetlands mapping. For the Queensland coast, this coastal wetland resource mapping is an ongoing process, underway since the mid-1980s. To date, approximately 75% of the coastal wetlands have been mapped using this technique (Danaher 1995b; Danaher and Stevens 1995; Danaher personal communication 1999; and Bruinsma et al. 1999).

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

Transferability
It has been demonstrated, in this and previous studies, that the technique developed for coastal wetlands mapping is transferable to similar coastal wetland systems. Landsat TM data is widely available. However, limitations to the technique apply. The minimum mapping unit is a 30 x 30m 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 Round Hill Head to Tin Can Inlet with information suitable for use in GIS systems. Additionally, information has been collated regarding the levels of existing disturbance to and protection of the wetlands and existing recreational and commercial fisheries in the region. As a result of this project numerous environments have been identified in the study area, which have a high conservation value. Actions to protect these environments through FHA declaration have been recommended.

Demonstration/Communication Activities Undertaken
The results of the study have been communicated to DPI Fisheries Marine Habitat Unit, Southern Fisheries Centre and other regional DPI Fisheries staff. Copies of the report will be available through the QDPI Library.

APPENDIX 11: DISTRIBUTION OF INTERTIDAL FLATS AND FRESHWATER SWAMPS FROM ROUND HILL HEAD TO TIN CAN INLET

Sheet 1: Round Hill Head
Sheet 2: Hervey Bay
Sheet 3: Fraser Island
Sheet 4: Tin Can Inlet

APPENDIX 12: SPECIES RECORDED DURING FIELDWORK FEBRUARY TO MAY, 1999

LOCATION	SPECIES RECORDED	LOCATION	SPECIES RECORDED
Poona	Av, R	**Moon Creek**	Ae, Av, Ce, O, R
Boonooroo	Ae, Av, Ce, R	**Tin Can Inlet**	Ae, B, L, O, R
Maaroom	Av, Ce, L	**Carlo Point**	Ac, Ae, Av, B, Ce, E, L, O, R
Beaver Point	Ae, Av, B, E, X	**Bullock Point**	Ae, Av, R
Mary River	Ae, Av, B, Ce, E	**Point Vernon**	Ae, Ag, Av, Ce, R
Bookar Island	Av, R	**South-east Toogoom**	Ae, Av
Little Woody Island	Ae, Ag, Av, R	**Burrum Heads**	Ae, Av, Ce, E, L, R
Power Island	Av, R	**Baffle Creek**	Ae, Ag, Av, Ce, E, L, O, R
Rocky Creek	Ae, Ag, Av, B, Ce, Cr, E, L, O, R, X	**Kolan River**	Ae, Av
Walsh Island	Ae, Av, R	**Elliott River**	Ag, Av, Ce, R
Turkey Island	Ae, Ag, Av, Ce, L, O, R	**Coonarr Creek**	Av, Ce,
Mosquito Creek	Ac, Ae, Av, B, Ce, E, R	**Theodolite Creek**	Av, Ce, R
Poyungan Creek	Aeg, Av, B, E, R, X		

Abbreviations:

Ac – *Acrostichum speciosum*
Ae – *Aegiceras corniculatum*
Ag – *Aegialitis annulata*
Av – *Avicennia marina*
B – *Bruguiera gymnorrhiza*
Ce – *Ceriops tagal*
Cr – *Crinum pedunculatum*
E – *Excoecaria agallocha*
L – *Lumnitzera racemosa*
O – *Osbornia octodonta*
R – *Rhizophora stylosa*
X – *Xylocarpus granatum*

NOTE – This list is not to be used as a comprehensive list of the species occurring at each location. Rather, it is an indication of the change in dominant species within the study area, as observed during fieldwork.