COASTAL WETLANDS RESOURCES INVESTIGATION

OF THE BURDEKIN DELTA FOR

DECLARATION AS FISHERIES RESERVES

REPORT TO OCEAN RESCUE 2000

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SUMMARY

Importance of the coastal wetlands resources of the Burdekin Delta

Protection of fisheries habitat is an important prerequisite to effective fisheries management. Mangroves and seagrasses directly support local and offshore fisheries through the provision of food, shelter, breeding and nursery areas. Previous departmental 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 in Queensland during some phase of their life cycle (e.g. prawns, mud and sand crabs, barramundi, whiting, flathead, bream and mullet).

A project to investigate the coastal wetland resources of the Burdekin Delta, north Queensland, was undertaken as part of the longterm assessment of the coastal fisheries resources of Queensland. Funding was provided by the Ocean Rescue 2000 Program and the Fisheries Division of the Queensland Department of Primary Industries. Extending from November 1993 to May 1995, fieldwork was undertaken in November 1993 and August 1994.

The Burdekin River delta region provides an important fishery, both commercially and recreationally. The region is currently undergoing radical changes in land management practices as a result of the expansion of the Burdekin River Irrigation Area (Sinclair Knight 1993*a*). The scope of the coastal wetlands resources investigation of the Burdekin Delta for declaration as a Fish Habitat Area was:

1. To document and map the marine wetland vegetation communities in the Burdekin River delta.
2. To document levels of existing disturbance to wetlands, existing recreational and commercial fisheries resources, and existing fishing activities.
3. To evaluate the conservation values of the areas investigated from the viewpoint of fisheries productivity and as habitat for important/threatened species.
4. To initiate Fish Habitat Area declaration under Section 120 of the *Queensland Fisheries Act 1994* with formal consultation to all stakeholders.

The Fish Habitat Area declaration process is currently under way, based on all four Points. This report concentrates on Points 1 and 3, the documentation of the marine wetland vegetation communities and the evaluation of conservation values from a fisheries viewpoint.

Methods

The distribution of mangrove communities was mapped on a computer using digital imagery from the Landsat Thematic Mapper satellite. These maps were validated with colour aerial photography and from field work. The seagrass distribution maps were produced from dive and boat surveys conducted by the Department of Primary Industries Northern Fisheries Centre, during October and November 1987. The mangrove and seagrass maps have been combined and now reside digitally on a geographic information system (GIS). Colour hardcopy maps have also been produced at 1:100 000 scale.

Results

The mangrove communities in the Burdekin delta region tend to establish in the shelter of bays, coastal inlets and creeks. The general trend of the mangrove communities is for closed *Rhizophora* dominated communities lining the foreshore and watercourses, with closed mixed communities containing *Rhizophora* spp., *Avicennia marina*, *Bruguiera* spp., *Excoecaria agallocha*, *Xylocarpus mekongensis*, *Ceriops* spp. and *Osbornia octodonta* landward of these. Most of the closed communities are less than 12 metres tall. Extensive saltpans occur between the mangroves and non tidal land, with the less saline areas supporting samphires, grasses such as *Sporobolus virginicus* and brackish sedges such as *Scirpus littoralis*.

From Bowling Green Bay to Cape Bowling Green *Ceriops* communitites predominate with extensive saltpans landward. Around the Burdekin River delta, this dominance is taken over by mixed communities containing a strong presence of *Xylocarpus mekongensis*, with saltpans rarely present. South of the Burdekin River to Cape Upstart, *Rhizophora* communitites predominate and extensive saltpans occur landward.

In the Burdekin delta region, seagrasses occur in bays sheltered from the south-east trade winds and in some of the coastal inlets and creeks from depths below mean sea level to 20 metres (Coles *et al.* 1992).

Mangroves	**Area (hectares)**
Rhizophora (closed)	4990
Ceriops (closed)	1390
Avicennia (closed)	820
Avicennia (open)	460
Mixed (closed)	5560
Saltpan	11290
Exposed banks	2060
Total	26570
Seagrass	**Area (hectares)**
Sparse	400
Medium	740
Dense	1110
Total	2250

Table 1 Marine vegetation community areas for the whole of the Burdekin Region

Comparison of the marine vegetation communities to other areas

The Burdekin delta region contains approximately 20 mangrove species compared to 36 in Cape York Peninsula (Duke 1992) and 9 species in south-east Queensland (Duke 1992). Eight species of seagrass have been recorded from the inshore waters of the region, compared to 13 species found in Torres Strait (Poiner *et al*. 1989) and 5 species in south-east Queensland (Coles *et al*. 1989).

Within the mangrove communities, zonation patterns in the Burdekin delta are not as strong, as tall, or species rich, as compared to the wetter tropical areas such as the Innisfail to Cooktown region (Le Cussan 1991) and Cape York Peninsula (Danaher 1995). Mixed communities are abundant in the region and while containing the common *Rhizophora*, *Avicennia* and *Ceriops* species, also have a strong presence of *Xylocarpus mekongensis*. In comparison to south-east Queensland, the zonation of the Burdekin region mangrove communities is stronger (Danaher and Luck 1991) and more species rich.

Disturbances to the marine vegetation

The topographic maps produced during the 1970s and the satellite image of 1992 show that the watercourses and coastline in the Burdekin delta region have moved considerably during this time. This is most likely due to natural events such as floods and cyclones. The map of mangrove communities produced for this project reflects the changes by showing the pioneering *Avicennia marina* on younger islands and accretion banks.

Extensive bunding and sand dams occur in the Burdekin delta area. The expansion of irrigated agriculture during the 1960s caused a decline in groundwater which resulted in the intrusion of seawater. Recharge areas were set up to overcome this. Some of the bund walls were erected in mangrove areas as mature *Excoecaria* plants were observed growing healthily upstream of bunded areas despite not receiving tidal inundation for more than 20 years. The implications of this are that most of the freshwater habitats adjacent to the tidal areas have been substantially modified by human activity. The two systems are now only linked by underground water flow and during flooding. Such limited interconnection must have an impact on fisheries habitat and productivity.

The noxious weed, rubbervine (*Cryptostegia grandiflora*) is a major problem in the terrestrial areas of the Burdekin delta region. It has also invaded the upper areas of the intertidal zone and was observed growing quite densely in some areas of the closed mixed mangrove communities, choking the marine plants.

The current expansion of the Burdekin River Irrigation Area is likely to alter water quality and water quantity in the region and may have adverse impacts on fisheries habitat conservation. It is important to have in place in the near future, an effective habitat management regime to ensure that any such impacts are minimised.

Identification of conservation areas

The Burdekin delta region is being investigated for declaration as a Fish Habitat Area. The fisheries habitat study outlined in this report has been used to draft an 'Area of Interest' Plan. This Plan is circulated to all relevant management agencies, local authorities, fishing industry sectors and specific interest groups or individuals for consideration and provision of comments on draft boundaries. This step includes direct consultation to outline the implications of Fish Habitat Area status and management in relation to specific interests or interaction with other management rationales. On receipt of comments, draft boundaries are reviewed and final boundaries are advised to all parties prior to submission for Ministerial and Cabinet consideration. The selection, investigation and declaration process normally extends over a two year or longer period. The process has commenced with the preparation and release of an 'Area of Interest' Plan for the Fish Habitat Area.

The proposed Fish Habitat Area covers the tidal land and waters, and where possible a terrestrial buffer, between Cape Bowling Green and Cape Upstart, and the rivers, creeks and tributaries.

Recommendations of this report

1. a Fish Habitat Area is declared for all significant tidal habitats eastwards from Cape Bowling Green to Cape Upstart;

2. the tidal wetlands of Cape Bowling Green and Bowling Green Bay are included in the existing Bowling Green Bay Fish Habitat Area; and

3. support be offered to faciliating the monitoring of effects of bunding in the delta.

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1.0 INTRODUCTION

1.1 The Burdekin River delta region

The Burdekin River flows through a coastal plain approximately 70 kilometres south of Townsville. The township of Ayr is situated north of the Burdekin River, and Home Hill is south of the River. Supported by irrigation, most of the area is under crop production. The principal crops are sugar cane, rice, seed beans and several small crops. Some land is presently devoted to fruit and vegetable production. The remaining area is grazed by cattle and consists of cleared pasture, tracts of woodland and wetlands. The Burdekin River Irrigation project is currently expanding the areas of irrigated land available in the lower Burdekin region (Sinclair Knight 1993*a*).

The Burdekin River delta is the largest delta and floodplain in tropical north-east Australia. The delta is a flat to gently undulating coastal plain of sedimentary deposits up to about 100 metres thick resting and consolidating on an irregular buried erosion surface of basement rock. The present course of the Burdekin River is incised some twenty metres into the coastal plain and its levies result in the surface drainage of the delta being mainly away from the river rather than towards it. The floodplain and delta are bordered to seaward by extensive, predominantly unvegetated saltpans. Further seaward, the estuarine areas consist of a succession of mangrove communities established on the many channels which enter the sea (Sinclair Knight 1993*a*).

The tidal communities are dominated by *Rhizophora stylosa, Ceriops tagal* and *Avicennia marina*. On the extensive plains adjacent to the tidal communities and in bunded areas occur freshwater marshes, dominated by the sedge *Eleocharis dulcis*. Coastal dune-swale systems also occur adjacent to the tidal areas. These are predominantly *Casuarina equisetifolia* on the foredunes with *Eucalypt* and *Melaleuca* open forest and woodland on the older dunes behind. Species include *Eucalyptus tesselaris*, *E. tereticornis*, *E. alba*, *Lophostemon suaeveolens*, *Melaleuca leucadendron* and *M. quinquenervia*. Submerged and emergent aquatics, grasses, sedges, palms and a complex of littoral forest, often dominated by *Melaleuca* species, occur in the swales. Open forest and woodland communities containing *Eucalyptus crebra*, *E. platyphylla* and *E. papuana* occur in the hills (Blackman 1978).

Situated in the dry tropics, the Burdekin River delta region has a relatively low rainfall. Approximately 75% of annual rainfall is concentrated in the summer months with a high degree of variability. Ayr, with an average annual rainfall of 1101 mm, will experience more than 25% either above or below average in over half the years. The average annual maximum and minimum temperatures in Ayr are 29.1°C and 17.9°C respectively (Sinclair Knight 1993*a*). The area is subject to cyclonic activity and flooding, usually in the wet season between January and March. Major recent flood events have occurred in the years 1954, 1958, 1968, 1972, 1974 and 1991 (source: Queensland Department of Primary Industries, Water Resources Division).

The tidal range for the area is similar to that for Townsville. The mean range, low to high water spring, is 2.3 metres, and the maximum range, lowest to highest astronomical tide, is 4.0 metres (Queensland Transport 1994).

1.2 The fisheries of the region

The value of the Burdekin River delta region for commercial and recreational fisheries is high (Coles *et al*. 1992, Russell 1988). The region provides employment for 36 commercial operators together with their assistant fishers. The main species of fish caught in the area are barramundi, grunter, flathead, mullet, salmon, mackerel, and shark, whilst whiting, mangrove jack, queenfish, bream, dart, trevally and jewfish are also caught on a commercial basis. Banana and tiger prawns are caught in areas along the coast. Mud crabs are caught frequently in all tidal areas (source: Queensland Commercial Fishermen's Organisation).

Because of the wide range of habitats in the region, freshwater, beach, estuary, inshore, blue water and reef fishing are popular recreational activities. Traditional fishing has included the hunting of dugong and sea turtle (M. Small, Queensland Lands Department, *pers. comm.* 1995).

1.3 Marine vegetation

Mangroves and seagrasses directly support local and offshore fisheries through the provision of food, shelter, breeding and nursery areas. Previous departmental 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 phase of their life cycle (e.g. prawns, mud and sand crabs, barramundi, whiting, flathead, bream and mullet).

Mangroves are a diverse group of predominantly tropical shrubs and trees growing in the marine intertidal zone (Duke 1992). Mangroves also provide physical protection of the coastal fringe from erosion and provide a habitat for wildlife such as birds and crocodiles (Claridge and Burnett 1993). Seagrasses are flowering marine plants which grow in subtidal and intertidal areas. Seagrasses stabilise the substrate, provide shelter and a nursery habitat for many marine species (e.g. fish and prawns) and are the main food source for other marine fauna (e.g. protected species such as dugong and turtles).

Intertidal areas are subjected to an extreme range of environmental parameters including salinity, soil type, frequency of inundation (both tidal and fresh) and wave action etc. As mangrove species are variable in their tolerance of these factors a pattern of species distribution known as zonation occurs for these plants (Lovelock 1993). Mangrove zones 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 amount of tidal inundation, and hence the direct utilisation by marine fauna. For example *Rhizophora* zones (or communities) which occur on the water's edge generally receive inundation with every high tide (twice a day for the Burdekin delta region), while *Ceriops* communities, more towards the landward mangrove edge, are generally inundated only on the spring tides which occur several times per month. Indirect information can also be derived on the amount of food production for marine fauna through leaf litter. Production varies between communities.

Mangroves proliferate in areas protected from high energy waves. Thus in the Burdekin delta region these marine plants tend to be abundant in sheltered bays, and in coastal inlets and creeks. The Burdekin delta region contains approximately 20 mangrove species compared to 36 in Cape York Peninsula, nine in south-east Queensland and one in Victoria (Duke 1992).

Seagrasses tolerate minimal exposure to air, require shelter from high energy waves, light penetration sufficient for photosynthesis and marine salinities. Coastal and surface topography, water depth and turbidity, and freshwater runoff therefore affect seagrass distribution and abundance patterns. In the Burdekin delta region, seagrasses can occur in bays sheltered from the south-east trade winds and in some of the coastal inlets and creeks. There are 8 species of seagrass found in the inshore waters of the Burdekin delta region (Coles *et al*. 1992), compared to 13 species found in Torres Strait (Poiner *et al*. 1989) and 5 species in south-east Queensland (Coles *et al*. 1989).

1.4 The project scope

Several environmental studies have been undertaken in the Burdekin delta region with particular emphasis on the impacts of irrigation (e.g. Paijmans 1981, Sinclair Knight 1993*a*). However, no detailed mapping of communities has been available for the marine vegetation of the region and until recently for much of the coast of Queensland. General descriptions of mangrove communities have been made (e.g. Macnae 1967, Bunt *et al.* 1982, Dowling and McDonald 1982, and Wells 1982) and broad scale assessments of the total areas of intertidal vegetation have been made by Galloway (1982) and Bucher and Saenger (1989). Fisheries habitat mapping by the Queensland Department of Primary Industries is ongoing with detailed mapping of seagrass vegetation completed for most of the coast (Hyland *et al*. 1989, Lee Long *et al*. 1993), and mapping of intertidal vegetation completed for Cape York Peninsula (Danaher 1995), south-western Cape York Peninsula (Danaher and Stevens 1995), south-east Queensland (Hyland and Butler 1988, Lennon and Luck 1990, Danaher and Luck 1991), Trinity Inlet (Olsen 1983), and other areas of central Queensland (Olsen *et al*. 1980).

Protection of fisheries habitat is an important prerequisite to effective fisheries management. The Burdekin River delta region provides an important fishery, both commercially and recreationally. The region is currently undergoing radical changes in land management practices as a result of the expansion of the Burdekin River Irrigation Area (Sinclair Knight 1993*a*). Coles *et al.* (1992) recognised the importance of mapping seagrass for the management and conservation of the habitat. Russell (1988) stated that there is a need to identify and protect important nursery habitats, particularly for barramundi.

The scope of the coastal wetlands resources investigation of the Burdekin Delta for declaration as a Fish Habitat Area is:

1. To document and map the marine wetland vegetation communities in the Burdekin River delta.
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3. To evaluate the conservation values of the areas investigated from the viewpoint of fisheries productivity and as habitat for important/threatened species.
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The freshwater/marine interface in the Burdekin River delta region has been much modified for the purposes of agriculture. With this in mind, this project has concentrated on the marine coastal wetlands. Several studies have been made on the freshwater wetlands (e. g. Blackman and Spain 1991, Congdon 1991, Finlayson and Mitchell 1981, and Thomas and Pearson 1993) and Bowling Green Bay has been listed as a RAMSAR site (an international convention on wetlands of international importance especially as waterfowl habitat, but allowing multiple use of the area, subject to appropriate management mechanisms). For information on the extent and location of freshwater areas of the region contact the Water Resources Division of the Queensland Department of Primary Industries, Ayr, phone (077) 830 555.

2.0 METHODS

2.1 Mangroves

Digital image processing of remotely sensed data (e.g. satellite imagery) has sucessfully mapped mangrove communities in Queensland, e.g. Moreton Bay (Danaher and Luck 1991), Cape York Peninsula (Danaher 1995, Danaher 1994), Weipa (Long *et al.* 1992), eastern Gulf of Carpentaria (Danaher and Stevens 1995) and Bowling Green Bay (Gay *et al*. 1990). Appendix 5 contains explanatory information on satellite remote sensing.

The maps were produced from Landsat Thematic Mapper satellite imagery captured on 25 August 1991 at high tide. Cloud cover and a deterioration in satellite image quality during 1992/93 meant that a later image could not be purchased. The pixel resolution of the satellite imagery was 30 metres by 30 metres. In addition to the satellite imagery, colour aerial photography at 1:50 000 from the Beach Protection Authority - St Lawrence to Townsville - Runs 16 to 19 captured in June 1993 was used.

The satellite image was processed using MIPS^{TM} (Map and Image Processing System) on a Sun SPARC2 workstation. Thematic Mapper band 6 (the thermal band) was discarded and a linear function stretch highlighting the intertidal zone was applied to all other bands. All water bodies were spectrally masked out using TM band 4 (near infrared). The upper limit of the intertidal zone cannot be spectrally separated readily so a mask was made by manually interpreting the boundary from a false colour composite of TM bands 1, 4, and 5 (blue, green and red respectively) in conjunction with colour 1:50 000 aerial photography. This false colour composite is the best combination for identifying the intertidal zone and uses the most decorrelated bands (Sheffield 1985).

The remaining imagery, which included the intertidal zone and adjacent coastal land, was processed with unsupervised rather than supervised classification (Danaher and Luck 1991). That is, no training sites were selected by the operator, but the software groups spectrally similar pixels into classes. The classification used the Isoclass algorithm (Skrdla 1992) which uses iterative processes to determine the final classes. Aided by the aerial photography, individual classes were labelled according to their dominant cover type. Sharing the same spectral signature, the saltpan and exposed banks classes were separated by manual interpretation. The data was rectified to the Australian Map Grid with pixels resampled to 30 metres by 30 metres.

The computer-based community classification was validated on field trips with access by boat and vehicle. At selected sites information was collected on the mangrove community floristics and structure. Sites were selected that represented each of the computer derived classes. At each site data recorded included the species composition of mangroves, dominant genus, height and density (foliage projective cover) of each vegetation layer, composition and hardness of substrate, and presence/absence of seedlings, samphires, grasses, algae, leaf litter, roots, ferns, epiphytes, sedges and ponds. The field trips were during November 1993 and August 1994.

The classification of mangroves was community based using the dominate genus present and relative densities. Generic level was selected as species within some genera could only be identified during the flowering and fruiting seasons. The communities identified are listed in Table 2.1. The densities were determined by the Foliage Projective Cover (FPC) of the canopy layer - more than 50% is closed, less than 50% is open.

The height of communities cannot be easily derived from satellite imagery so the Specht (1978) categories such as “forest” and “scrub” have not been included in the description. However, from field observations, the mangrove communities of the Burdekin region rarely grow above 10 metres tall, thus tend to be “scrub” rather than “forest”.

The classes included were those which receive tidal inundation, hence appropriate habitat of mangroves. Excluded classes were permanent pools of water (both fresh and salt), and elevated land containing terrestrial vegetation such as trees, shrubs and grass. As these classes were derived spectrally from the Landsat imagery, including permanent water pools would mean including the ocean. Addition of terrestrial vegetation islands would mean including all terrestrial vegetation, which would result in more than the intertidal zone being represented.

Marine Vegetation Unit	Density
Mangrove Units	
Rhizophora	closed
Ceriops	closed
Avicennia	closed
Avicennia	open
Mixed	closed
Saltpan	-
Exposed banks	-
Seagrass Units	
Sparse	0-10%
Medium	10-50%
Dense	50-100%

Table 2.1 The marine vegetation units

The type of mangrove habitat was classified according to the terminology of Bunt (1978) as:

1. island sites
2. open coastal fronts
3. coastal flats with complex but not extensive creek drainage
4. small to large meandering rivers without extensive estuaries
5. relatively directly flowing rivers within confined valleys, character of freshwater discharge variable
6. rivers discharging to the sea via extensive estuaries, fresh water influence variable within the estuary and with season

2.2 Seagrasses

The Department of Primary Industries mapped inshore seagrass beds in conjunction with sampling juvenile prawn populations and dependent habitat along the Burdekin coastline in 1987 (Coles *et al*. 1992). At selected sites, divers investigated bottom type and vegetation over an area of at least five square metres. The area observed was greater than five square metres when underwater visibility was good. On each dive sediment type and estimates of seagrass cover were recorded and samples of seagrass were kept for later identification. The sea bottom type was recorded at 370 metre intervals on transects and at intervals of at least every one nautical mile between transects. Transects continued seaward until no seagrass was found. Seagrass beds were mapped by extrapolating from the records of bottom vegetation and sediment at each dive site. Sequential sites with seagrass were mapped as a continuous zone of seagrass habitat. The seagrass communities were classified according to density of vegetation cover with 3 classes (see Table 2.1) - sparse (0 to 10%), medium (10 to 50%) and dense (50 to 100%).

Seagrasses have been successfully mapped using Landsat imagery where the water was very clear above submerged beds or where the scene was captured at a low tide sufficiently exposing the intertidal beds (Lennon and Luck 1990). Due to the Landsat image being captured at high tide and no resources for collecting additional field data in this project, no attempt was made to map the seagrasses from the satellite imagery.

2.3 Conversion for input into GIS

The combined mangrove and seagrass maps were converted from raster format to vector polygons. This was done using ARC/INFO GIS software. To improve cartographic presentation of the data the jagged raster boundaries were splined and generalised and polygons with areas under 10 000 square metres (one hectare) were eliminated.

Hardcopy maps were produced at 1:100 000 (see Appendix 1). Four A3 sheets cover the study area. The coloured marine vegetation polygons were overlayed on a black and white background of Landsat TM band 3 (visible red) imagery.

As part of the Fish Habitat Area declaration process (see Section 6), the marine vegetation communities were overlayed with land tenure from the digital cadastral database to help in determining the boundary of the area. Appendix 2 contains these maps. Note the difference in coastline between the recent satellite image (1991) and the digital cadastral database, particularly in the Burdekin River delta.

2.4 Data accuracy

Through comparison to aerial photography and field data, the satellite imagery derived maps had an accuracy greater than 80%. There are some typical mangrove zones (or communities) which have been identified by many authors, e.g. Macnae (1967), Davie (1982) and Bunt (1978), which do not fall within the classification used in this study. Some examples of these are the seaward *Sonneratia* fringe and *Bruguiera* communities. While these communities do occur within the Burdekin Region they are generally linear and not large enough to be mappable units (30 metres wide) using the remote sensing techniques as applied in this study. Due to similar foliage, *Bruguiera* communities cannot be easily separated from *Rhizophora* communities, either from satellite imagery or aerial photography. The littoral grass communities (containing species such as the salt couch, *Sporobolus virginicus*) that receive some tidal inundation on the spring tides could not be separated from terrestrial grass communities and so have been excluded from the tidal vegetation classification for this study.

The seagrass distribution on the maps are based on historic, broad-scale surveys; they may not include all seagrass habitats and should be interpreted with care. The seagrass surveys used in this project did not always precisely define the seaward limit, and as a general rule, did not investigate areas at depths greater than 20 metres. It is possible that seagrass occurs at very low densities in deep water beyond the survey areas. In large bays such as Bowling Green Bay and Upstart Bay, diver observations revealed very patchy but extensive distributions of very low density seagrass (less than 1% cover). At such low densities the seagrass is difficult to find in turbid water, thus may be underestimated in the maps (Coles *et al.* 1992). Studies have found large seasonal (Mellors *et al.* 1993) and year-to-year (Poiner *et al.* 1989) changes in seagrass distribution and abundance in the northern Australia region. Similar changes are likely to occur in the Burdekin region.

3.0 DESCRIPTION OF THE MAPPING UNITS

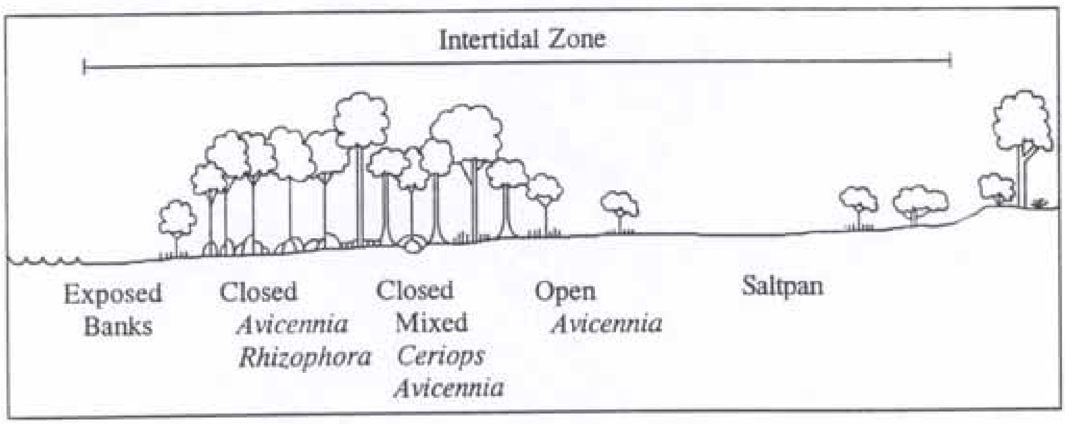

Figure 3.1 The position of the mangrove communities across the tide profile

Rhizophora (closed)

Habitat	occurs fringing waterways low in intertidal zone with roots submerged during high tides.
Canopy	usually dominated by *Rhizophora* spp. with occasional *Xylocarpus mekongensis* and *Avicennia marina*. Foliage projective cover is more than 50%. Height varies from 4 metres to more than 12 metres.
Shrub layer	generally absent.
Ground cover	*Rhizophora* stilt roots with a sparse cover of *Rhizophora* seedlings.

Ceriops (closed)

Habitat	generally occurs on creek edges upstream towards the upper intertidal limit on land more elevated than *Rhizophora* communities and landward of *Rhizophora* communities, only inundated by the spring tides.
Canopy	*Ceriops* spp. and occasionally *Rhizophora* spp., *Bruguiera* spp., *Sonneratia* spp. and *Avicennia marina*. Foliage projective is cover more than 50%. Height varies from 1.5 metres to more than 10 metres.
Shrub layer	generally absent.
Ground cover	consists of sparse seedlings of genera present.

Avicennia (closed)

Habitat	a very diverse community which can be found in all intertidal environments from pioneering the seaward edge of mangroves, fringing water ways on accretion banks, to the landward edge.
Canopy	*Avicennia marina* with occasional *Ceriops* spp., *Excoecaria agallocha, Rhizophora* spp., *Bruguiera* spp., and *Sonneratia* spp. The foliage projective cover is more than 50%. Height varies from 2 metres to more than 10 metres.
Shrub layer	occasional presence of *Aegialitis annulata* and *Aegiceras corniculatum* to 2 metres in height.
Ground cover	consists of seedlings of species present among the pneumatophores (peg roots) of *Avicennia marina*.

Avicennia (open)

Habitat	a very diverse community which can be found in all intertidal environments from pioneering the seaward edge of mangroves, fringing water ways on accretion banks, to the hyper saline claypans at the landward edge.
Canopy	*Avicennia marina* with the occasional presence of *Ceriops* spp., *Excoecaria agallocha* and *Lumnitzera* spp. The foliage projective cover is less than 50%. Height varies from 0.5 metres in hyper saline areas to more than 10 metres.
Shrub layer	occasional presence of *Aegialitis annulata* and *Aegiceras corniculatum* to 2 metres in height.
Ground cover	may consist of seedlings of species present among the pneumatophores (peg roots) of *Avicennia marina* as well as sparse samphires (e.g. *Suaeda arbusculoides*, *Tecticornia australasica* and *Sarcocornia quinqueflora*) and grasses such as salt couch (*Sporobolus virginicus*).

Mixed (closed)	
Habitat	a diverse community which can be found in many intertidal environments from fringing water ways on accretion banks as well as behind *Rhizophora* communities towards the landward edge.
Canopy	a mix which may consist of *Rhizophora* spp., *Avicennia marina*, *Bruguiera* spp., *Excoecaria agallocha*, *Xylocarpus mekongensis*, *Ceriops* spp. and *Osbornia octodonta*. The foliage projective cover is more than 50%. Height may vary from 5 metres to more than 12 metres.
Shrub layer	in the lower communities may be absent. In the taller communities the shrub layer may consist of juvenile canopy species with *Aegialitis annulata* and *Aegiceras corniculatum* to 4 metres in height. *Acanthus ilicifolius* may occur.
Ground cover	may consist of seedlings of species present.
Saltpan	
Habitat	occurs toward the landward edge of the intertidal zone, and are hyper saline being only inundated during the highest spring tides.
Canopy	sparse, stunted plants of *Avicennia marina*, *Ceriops* spp. and *Aegialitis annulata* may occur.
Shrub layer	absent.
Ground cover	sparse samphires (e.g. *Suaeda arbusculoides*, *Tecticornia australasica* and *Sarcocornia quinqueflora*) and grasses such as salt couch (*Sporobolus virginicus*).
Exposed banks	
Habitat	occurs at the seaward edge of the intertidal zone, and is inundated during every high tide.
Canopy	Absent
Shrub layer	absent.
Ground cover	generally sand or river sediment. May contain sparse samphires (e.g. *Suaeda arbusculoides*, *Tecticornia australasica* and *Sarcocornia quinqueflora*) and grasses such as salt couch (*Sporobolus virginicus*).

<u>Sparse Seagrass</u>

The percentage of vegetation cover on substrate is less than 10%. The seagrass species present may be *Cymodocea serrulata, Halodule uninervis, H. pinifolia, Halophila spinulosa, H. ovalis, H. decipiens, H. tricostata* and *Zostera capricorni*.

<u>Medium Seagrass</u>

The percentage of vegetation cover on substrate is between 10% and 50%. The seagrass species present may be *Cymodocea serrulata, Halodule uninervis, H. pinifolia, Halophila spinulosa, H. ovalis, H. decipiens, H. tricostata* and *Zostera capricorni*.

<u>Dense Seagrass</u>

The percentage of vegetation cover on substrate is between 50% and 100%. The seagrass species present may be *Cymodocea serrulata, Halodule uninervis, H. pinifolia, Halophila spinulosa, H. ovalis, H. decipiens, H. tricostata* and *Zostera capricorni*.

Figure 3.2 A closed *Rhizophora* community along Groper Creek

Figure 3.3 A closed *Avicennia* community along Groper Creek

Figure 3.4 A closed Ceriops community on Cape Bowling Green

Figure 3.5 A closed mixed community in Little Sugarloaf Creek

Figure 3.6	A saltpan with a terrestrial island on Bowling Green Bay

Figure 3.7	A dense seagrass community near Green Island

4.0 DISTRIBUTION OF THE MARINE VEGETATION

4.1 General distribution of the marine vegetation

The mangrove communities in the Burdekin delta region tend to establish in the shelter of bays, coastal inlets and creeks. The general trend of the mangrove communities is for closed *Rhizophora* dominated communities lining the foreshore and watercourses, with closed mixed communities containing *Rhizophora* spp., *Avicennia marina*, *Bruguiera* spp., *Excoecaria agallocha*, *Xylocarpus mekongensis*, *Ceriops* spp. and *Osbornia octodonta* landward of these. Most of the closed communities are less than 12 metres tall. Extensive saltpans occur between the mangroves and non tidal land, with the less saline areas supporting samphires, grasses such as *Sporobolus virginicus* and brackish sedges such as *Scirpus littoralis*.

In the Burdekin delta region, seagrasses occur in bays sheltered from the south-east trade winds and in some of the coastal inlets and creeks from depths below mean sea level to 20 metres (Coles *et al.* 1992).

Mangroves	**Area (hectares)**
Rhizophora (closed)	4990
Ceriops (closed)	1390
Avicennia (closed)	820
Avicennia (open)	460
Mixed (closed)	5560
Saltpan	11290
Exposed banks	2060
Total	26570
Seagrass	**Area (hectares)**
Sparse	400
Medium	740
Dense	1110
Total	2250

Table 4.1 Marine vegetation community areas for the whole of the Burdekin Region

Appendix 1 contains four mapsheets of the region at 1:100 000 with the marine vegetation communities overlayed on Landsat Thematic Mapper band 3 (visible red light).

4.2 Barratta Creek to Cape Bowling Green

Mangroves	**Area (hectares)**
Rhizophora (closed)	850
Ceriops (closed)	1050
Avicennia (closed)	210
Avicennia (open)	240
Mixed (closed)	970
Saltpan	5410
Exposed banks	310
Total	9040
Seagrass	**Area (hectares)**
Sparse	80
Total	80

Table 4.2 Marine vegetation community areas for Barratta Creek to Cape Bowling Green

The terrain in this area is very flat. Cape Bowling Green, lying south-east/north-east, is a sand spit created by the prevailing south-easterly winds. A dune ridge runs along the eastern side of the Cape preventing tidal water from reaching the extensive mangrove systems which occur west of the dune ridge. The northern half of Cape Bowling Green is predominantly closed *Ceriops* and closed *Rhizophora* communities. The more sheltered southern half has stronger zonation patterns - closed *Avicennia* communities pioneering on the prograding foreshore with closed *Rhizophora* communities landward. Several tidal creeks dissect the area and are lined with closed *Rhizophora* communities with closed *Ceriops* communities towards land and then saltpans.

The mangroves provide evidence that Cape Bowling Green is moving westwards. Remnants of mature *Ceriops* stands occur in the surf zone on the eastern side of the Cape (see Figure 4.1). It is highly unlikely that these plants, which generally occur towards the landward edge of the intertidal zone could ever have established in such exposed conditions.

Barratta Creek and its mouth are fringed by communities of closed *Rhizophora* and closed *Avicennia* with closed *Ceriops* and mixed communities towards land and then extensive saltpans. Eastwards towards Cape Bowling Green, saltpans predominate with mangrove communities restricted to a thin fringe along the foreshore and creeks.

Along the landward edge from Barratta Creek to Cape Bowling Green extensive saltpans occur. The boundary between the tidal saltpans and adjacent pastures has been very modified in recent years due to building of bund walls, creating barriers to the flow of tidal water inland.

In the shelter of Bowling Green Bay small patches of sparse seagrass occur.

4.3 Alva Beach to the Burdekin River

Mangroves	**Area (hectares)**
Rhizophora (closed)	1120
Ceriops (closed)	200
Avicennia (closed)	170
Avicennia (open)	50
Mixed (closed)	1630
Saltpan	180
Exposed banks	500
Total	3850

Table 4.3 Marine vegetation community areas for Alva Beach to the Burdekin River

This coastline is very exposed to the prevailing south-easterly winds. A series of sandbanks and bars have developed along the coastline with shallow estuarine areas building up in their protection. Alva Creek, Plantation Creek and the anabranch of the Burdekin River are the major water courses of the area. Zonation of mangrove communities is not strong with mixed communities dominating. Closed *Rhizophora* communities fringe the waterways at the mouth of Plantation Creek. Closed *Avicennia* communities pioneer on the shifting banks within some of the waterways.

The terrain is very level and the intertidal area has sugar cane farms and pastures adjacent. As found in the Barratta Creek to Cape Bowling Green area, the boundary between the tidal saltpans and adjacent pastures has been very modified in recent years. A large number of bund walls have been erected across most of the waterways to create recharge areas for the aquifers, but historical aerial photography suggests that many hectares of mangroves have been lost upstream of these barriers (see Figure 4.2).

No seagrass beds have been mapped in these exposed waters.

4.4 Burdekin River to Molongle Creek

This area also has very level terrain with one headland (Beach Hill) at the mouth of Yellow Gin Creek. The delta at the mouth of the Burdekin River is changing, as a result of flooding which occurs from time to time. Thus the mangrove communities are not well zoned but tend to be mixed. A relatively young island which has changed shape over recent years contains pioneering *Avicennia* communities. Some of the sand banks in the river bed contain samphire species as well as small *Avicennia* plants. The noxious weed rubbervine (*Cryptostegia grandiflora*) is present on both sides of Groper Creek (Peters Island and the mainland) and regularly invades the upper intertidal zone, choking the mangrove plants (see Figure 4.3).

Mangroves	Area (hectares)
Rhizophora (closed)	1370
Ceriops (closed)	60
Avicennia (closed)	410
Avicennia (open)	90
Mixed (closed)	2430
Saltpan	1380
Exposed banks	1000
Total	6740
Seagrass	**Area (hectares)**
Sparse	80
Medium	440
Total	520

Table 4.4 Marine vegetation community areas for the Burdekin River to Molongle Creek

The mangrove communities along R. M. Creek have slightly stronger zonation with closed *Rhizophora* and mixed communities along the waterways and closed *Ceriops* and mixed communities behind, suggesting that this creek system is more long lived.

South of the Burdekin River, between the Yellow Gin Creek and R. M. Creek systems, large saltpans occur landward of the mangroves. Charlies Creek broke through during Cyclone Charlie (1988) causing tidal water to flood hectares of low lying land. This creek has since had a dam wall built near its mouth. Mature *Avicennia* and *Excoecaria* plants were observed along freshwater holes approximately 8 kilometres inland, not far from the highway, suggesting that in previous times this very low lying area had been tidal (see Figure 4.4).

Beds of medium and sparse seagrass occur just offshore in the sheltered waters of Upstart Bay.

4.5 Molongle Creek to Saltwater Creek

The flat terrain is broken by the mountainous Cape Upstart. Nobbies Inlet supports a large estuarine area with closed *Rhizophora* communities fringing the waterways, and closed mixed and *Ceriops* communities landward. Extensive saltpans lie between the mangrove communities and the upper tidal limit. Adjacent land is mainly open woodland.

Mangroves	**Area (hectares)**
Rhizophora (closed)	1650
Ceriops (closed)	80
Avicennia (closed)	30
Avicennia (open)	80
Mixed (closed)	530
Saltpan	4320
Exposed banks	250
Total	6940
Seagrass	**Area (hectares)**
Sparse	240
Medium	300
Dense	1110
Total	1650

Table 4.5 Marine vegetation community areas for Molongle Creek to Saltwater Creek

Isolated individual mangrove plants do occur on the beaches on the western side of rocky Cape Upstart. The Elliot River/Saltwater Creek system contains closed *Rhizophora* and mixed communities with large saltpans. This area, east of Cape Upstart, was not field checked as part of this study.

Extensive seagrass beds of all densities occur just offshore in sheltered Upstart Bay, with dense beds at the mouth of Nobbies Inlet of *Halophila spinulosa*, *Zostera capricorni* and *Halodule uninervis*. Seagrass beds also occur just off the eastern side of Cape Upstart in more exposed waters.

4.6 Classification of the mangrove habitats

Selected tidal wetlands of the Burdekin delta region have been categorised according to the classification of mangrove habitat by Bunt (1978).

Habitat (Bunt 1978)	**Locality**	**Major marine vegetation communities**
Island sites	None	
Open coastal fronts		
	Cape Bowling Green	*Ceriops*, *Rhizophora*, mixed, *Avicennia*
Coastal flats with complex but not extensive creek drainage		
	Bowling Green Bay	saltpan, mixed, *Ceriops*
	Rita Island	mixed
Small to large meandering rivers without extensive estuaries		
	Burdekin River Anabranch	mixed
	Kalamia Creek	mixed, *Avicennia*
Relatively directly flowing rivers within confined valleys, character of freshwater discharge variable		
	Molongle Creek	*Avicennia*, mixed
Rivers discharging to the sea via extensive estuaries, fresh water influence variable within the estuary and with season		
	Plantation Creek	*Rhizophora*, mixed
	Burdekin River	mixed, *Rhizophora*, *Avicennia*
	Groper Creek	mixed, *Rhizophora*
	Wallace Creek	saltpan, mixed, *Rhizophora*
	R. M. Creek	*Rhizophora*, mixed
	Nobbies Inlet	saltpan, *Rhizophora*, mixed

Table 4.6 Selected tidal wetlands categorised according to the classification of mangrove habitat by Bunt (1978).

Figure 4.1 Evidence of previous *Ceriops* communities now on the eastern side of Cape Bowling Green

Figure 4.2 A bund wall against an *Avicennia* community on Plantation Creek

Figure 4.3 A *Bruguiera* plant smothered by the noxious weed rubbervine (*Cryptostegia grandiflora*) on Groper Creek

Figure 4.4 Mature *Avicennia* and *Excoecaria* plants isolated from tidal waters for several years, near the Highway at the Wunjunga turnoff

5.0 DISCUSSION

5.1 Comparison of the marine vegetation communities to other areas

Within the mangrove communities, zonation patterns in the Burdekin delta are not as strong, as tall, or species rich, as compared to the wetter tropical areas such as the Innisfail to Cooktown region (Le Cussan 1991) and Cape York Peninsula (Danaher 1995). Although tropical, the region from Townsville to Bowen falls in a rain shadow, with annual precipitation rates much less than those areas immediately north (Innisfail/Cairns) and south (Proserpine/Mackay). The Burdekin delta region contains approximately 20 mangrove species compared to 36 in Cape York Peninsula (Duke 1992).

On Cape York Peninsula, Princess Charlotte Bay on the east coast and the intertidal areas on the south-western coast, also contain large proportions of mixed communities without clear zonation, with extensive saltpans landward (Danaher 1995). These two areas also have very level terrains (both terrestrially and tidally) and less rainfall and higher evaporation rates than adjacent areas. The mangrove communities on the south-western side of Cape York Peninsula were not as tall (less than 15 metres) as those in the eastern and northern areas, but in Princess Charlotte Bay some closed communities (mixed and *Rhizophora*) grew in excess of 20 metres.

In comparison to south-east Queensland, the zonation of the Burdekin region mangrove communities is stronger (Danaher and Luck 1991) and more species rich, with nine species in south-east Queensland (Duke 1992). Of note is that the mangrove communities observed further south of the Burdekin region in Repulse Bay (with a higher average annual rainfall) were not significantly taller than those in the Burdekin region, nor do they have a higher species diversity. This supports the premise that species richness is due to a latitudinal effect, since most species are found in more equatorial latitudes with a progressive reduction in species diversity to the south (Duke 1992).

Closed mixed and *Rhizophora* communities dominate the mangroves of the Burdekin region. Along the eastern coast of Queensland, *Rhizophora* communities dominate in the north (Danaher 1995) and *Avicennia* communities dominate in the south (Danaher and Luck 1991). This pattern also occurs on the western coast (along the Gulf of Carpentaria) with the switch from *Rhizophora* to *Avicennia* dominance occurring at approximately 14°S (Danaher and Stevens 1995) and at approximately 25°S on the eastern coast.

Mixed communities were unexpectedly abundant in the region and contained a strong presence of *Xylocarpus mekongensis*. Paijmans (1981) noted that the lower Burdekin valley intertidal areas were relatively high in elevation, mainly above mean high water mark, with deep incisions by the tidal creeks. The habitat between normal high and spring tides appears to suit most mangrove species, thus the forming of mixed communities. The flatter terrain of the Burdekin delta region (both terrestrially and tidally), could limit the variation of tidal inundation within the intertidal zone, thus favouring the establishment of more mixed communities. At the upper tidal level and above, conditions become more extreme due to less frequent tidal flooding and increasing salinity. *Ceriops* and *Avicennia* persist the longest in these conditions.

Both this study and Paijmans (1981) found that *Ceriops tagal* was the predominant species in the Bowling Green Bay/Cape Bowling Green area but was less so in the Burdekin delta area. In fact, the 'typical' *Ceriops* zone which occurs between the saltpans and seaward *Rhizophora* zone (Macnae 1967) is not common in the Burdekin delta region, in contrast to the areas around Townsville (Macnae 1967, Spenceley 1983), Cape York Peninsula (Danaher 1995) and Gladstone (Olsen *et al*. 1980). Possible reasons for this may be that:

- the Bowling Green Bay/Cape Bowling Green area may be more elevated, receiving less tidal inundation than further south in the Burdekin River delta,
- the Burdekin River delta may receive more fresh water input, creating conditions favourable to a mix of species rather than the more salt tolerant *Ceriops*,
- tidal creek levees causing ponding may drown the *Ceriops*, and
- the *Ceriops* zone is occurring in bands too narrow to be mapped (less than 30 metres) and is absorbed within the highly abundant mixed zone.

Eight species of seagrass have been recorded from the inshore waters of the Burdekin delta region, compared to 13 species found in Torres Strait (Poiner *et al*. 1989) and 5 species in south-east Queensland (Coles *et al*. 1989). *Zostera capricorni* in Upstart Bay had higher densities than in other areas between Cairns and Bowen (Coles *et al.* 1992).

5.2 Relationship of mangroves and seagrasses to marine fauna

The importance of mangroves and seagrasses to marine fauna 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 plankton or epibenthos. The work by Coles *et al*. (1993) in Cairns Harbour confirms that some juvenile fish and prawns are dependent on inshore seagrass habitats for shelter and survival during the early part of their life cycle. Both inshore and deepwater seagrass habitats provide food for dugong and sea turtle, and thus are important to their survival (Marsh 1989).

Table 5. 1 is a comparison of fish density and standing crop (weight) for studies of fish within mangrove communities along the east coast of Australia. The study of tropical mangrove communities undertaken in Townsville (Robertson and Duke 1990) recorded a higher density of fish than those from subtropical areas but the fish were of little direct economic importance in Australia. However they contribute to production of economic fish species in adjacent open waters. The lower direct use of subtropical *Rhizophora* communities than subtropical *Avicennia* communities may be due to forest structure and the differential leaf litter decomposition within these communities. Fish may be reluctant or unable to enter the *Rhizophora* communities due to the complex root structure. *Avicennia* communities are more open (I. Halliday, Queensland Department of Primary Industries, *pers. comm.* 1995).

Mangrove community	Density (No. m^{-2}) (% economic)	Standing Crop (g m^{-2}) (% economic)	Location	Source
Avicennia (temperate)	~0.94 (38)	~6.4 (32)	Botany Bay	Bell *et al.* (1984)
Avicennia (subtropical)	0.27 ± 0.14 (75)	25.3 ± 20.4 (94)	Moreton Bay	Morton (1990)
Rhizophora (subtropical)	0.05 ± 0.01 (61)	2.01 ± 0.30 (80)	Tin Can Bay	I. Halliday, QDPI (*pers.comm.* 1995)
Rhizophora, Ceriops, Avicennia (tropical)	3.5 ± 2.4 (<6)	10.9 ± 4.5 (<36)	Towns-ville	Robertson and Duke (1990)

Table 5.1 Comparison of fish density and standing crop for studies of fish within mangrove communities along the east coast of Australia

Mangrove species	Primary production g m^{-2} yr^{-1}	Source
Rhizophora stylosa (tropical)	556	Robertson (1986)
Avicennia marina (tropical)	519	Robertson and Daniel (1989)
Ceriops tagal (tropical)	822	Robertson and Daniel (1989)
Avicennia marina (subtropical)	580	Goulter and Allaway (1979)

Table 5.2 Comparison of studies determining the primary production of mangroves as leaf litter

Table 5.2 compares studies determining the primary production of mangroves as leaf litter. Robertson and Daniel (1989) found that in *Ceriops* forests much of the leaf litter is removed by crabs (71%) with microbial turnover being very low (<1% yr-1). Less *Avicennia* leaf litter is consumed by crabs (33%) with microbial turnover being much higher (32%) and tides exporting about 21% of the annual production. The leaves of *Rhizophora* and *Ceriops* have low initial nitrogen concentrations, high C:N ratios and very high tannin concentrations. This results in decay rates slower than that of *Avicennia* leaves which have high initial nitrogen concentrations, low C:N ratio and low tannin content (Robertson 1988). Although leaf litter production of *Rhizophora* mangroves is similar to that of *Avicennia* the greater export of its leaves and their relatively slower release of carbon and nitrogen suggests that *Rhizophora* may be of less importance for primary production within communities, than are *Avicennia* mangroves (I. Halliday, QDPI, *pers. comm.* 1995). However, *Rhizophora* and mixed communities containing *Rhizophora* are the dominant communities for the Burdekin region, so it would be exporting a greater volume of leaf litter for fisheries production in adjacent waters than *Avicennia* in this location.

At this stage there is still not enough quantitative information to rate the value to fisheries of different communities (or habitats) in importance against one another. Considerable variation has occurred in measuring mangrove leaf litter (Hutchings and Saenger 1987), and the temporal nature of seagrass beds (Mellors *et al.* 1993, Poiner *et al*. 1989) make quantification of the relative values of different species/densities difficult. The assumption that dense communities (both mangroves and seagrass) are more important than less dense communities does not always hold true. Ridd *et al.* (1988), studying the outwelling from tropical tidal saltpans in the Gulf of Carpentaria, suggests that the input of salt and nutrients from these saltpans is important to the survival of juvenile prawns in the Gulf. Dugong in the Cape York Peninsula region graze in areas of patchy seagrass in preference to dense beds (Marsh 1989). Coles *et al*. (1993) found in Cairns Harbour that the abundance of juvenile commercial penaeid prawns was significantly greater on vegetated substrate than on nonvegetated substrate.

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, rocky rubble, could significantly effect the potential abundance of the crustacean fauna, thus the nutrient cycling process itself.

Both Coles *et al.* (1992) and Russell (1988) stress the need to identify and map fisheries habitat for the management and conservation of the resource, as well as conducting further research into the interactions between the fauna and habitat.

5.3 Disturbances to the marine vegetation

The topographic maps produced during the 1970s and the satellite image of 1992 show that the watercourses and coastline in the Burdekin delta region have moved considerably during this time. This is most likely due to natural events such as floods and cyclones. Hopley (1970) suggested that the Cape Bowling Green land mass was extending seaward an average of 5.5 metres per year. The Burdekin-Haughton river catchment contributes the largest amount of sediment to the marine environment in Queensland, and there has been a three- to five-fold increase in sediment and nutrient exports since European settlement (Moss *et al.* 1992). The sediment load in the Burdekin River does not seem to have been affected significantly by the Burdekin Falls Dam, which was completed in 1987 (Sinclair Knight 1993*a*). The map of mangrove communities produced for this project reflects changes in sediment distribution in the delta by identifying the pioneering *Avicennia marina* on younger islands and accretion banks. As a result of the movement, significant amounts of what is now tidal land (even creek beds) are included in private tenure. Land holders on Groper Creek are trying to reinforce their banks to stop erosion.

Extensive bunding and sand dams occur in the Burdekin delta area and are clearly identifiable on the aerial photography. According to DPI Water Resources officers in Ayr, the expansion of irrigated agriculture during the 1960s caused a decline in groundwater which resulted in the intrusion of seawater. Recharge areas were set up to overcome this. The recharge scheme is controlled by the North and South Burdekin Water Boards, on which DPI Water Resources is represented. Some of the bund walls were erected in mangrove areas as mature *Excoecaria* plants were observed growing healthily upstream of bunded areas despite not receiving tidal inundation for more than 20 years. The implications of this are that most of the freshwater habitats adjacent to the tidal areas have been substantially modified by human activity. The two systems are now only linked by underground water flow and during flooding. Such limited interconnection must have an impact on fisheries habitat and productivity. The agriculture and fishing industries appear to be in conflict in relation to preservation of tidal inshore habitats in the delta.

The noxious weed rubbervine (*Cryptostegia grandiflora*) is a major problem in the terrestrial areas of the Burdekin delta region. It has also invaded the upper areas of the intertidal zone and was observed growing quite densely in some areas of the closed mixed mangrove communities, choking the marine plants. Unfortunately rubbervine is not detectable on the 1:50 000 aerial photography. This could be in part due to that rubbervine is almost leafless during the dry season when aerial photography is flown.

The proposed expansion of the Burdekin River Irrigation Area is likely to alter water quality and water quantity in the region. Sinclair Knight (1993*a*) has summarised the potential impacts on the marine environment as:

- Decreased salinity in estuarine and near-shore regions due to increased discharge leading to mangrove die-back and death or emigration of aquatic life.
- Increased turbidity in near-shore areas leading to decreased submarine light levels and reduced seagrass and algal growth, and the consequent loss of important prawn and fish nursery areas. Filter feeding organisms and sessile/sedentary benthic organisms are also affected by increased turbidity and sediment deposition.
- Toxic effects to marine flora and fauna from increased heavy metal, insecticide, herbicide and fungicide concentrations in the water.
- Increased productivity and eutrophication resulting from increased nutrient concentrations in the water, particularly phosphorous and nitrogen.
- Modification of upper estuarine intertidal zonation resulting from changed stream discharge regimes leading to habitat alteration.
- Disruption of faunal life cycles (e.g. spawning, metamorphosis, catadromous and anadromous migrations) resulting from altered temporal stream discharge patterns.

6.0 IDENTIFICATION OF CONSERVATION AREAS

6.1 Habitats for important/threatened species

Marine plants, including mangroves, saltcouch and seagrasses, are specifically protected under the *Fisheries Act* 1994 in Queensland. Disturbance of these plants may only be undertaken with specific approval. To provide additional habitat protection for fisheries purposes, Fish Habitat Areas are declared under Section 120 of the *Fisheries Act*. Fish Habitat Areas were known as Fish Habitat Reserves and Wetland Reserves in previous fisheries legislation. The *Fisheries Act* now allows for Fish Habitat Areas to be declared over freshwater as well as estuarine/marine wetlands. These declared Areas are part of the ongoing management of fisheries habitat resources within Queensland and are declared with the specific intent to ensure continuation of productive recreational and commercial fisheries in a region. Declaration proclaims the value of the area from a fisheries viewpoint, and increases the level of protection and management of the wetlands and/or fishing grounds for community benefits.

The Burdekin delta region is being investigated for declaration as a Fish Habitat Area. The fisheries habitat study outlined in this report has been used to draft an 'Area of Interest' Plan. This Plan is circulated to all relevant management agencies, local authorities, fishing industry sectors and specific interest groups or individuals for consideration and provision of comments on draft boundaries. This step includes direct consultation to outline the implications of Fish Habitat Area status and management in relation to specific interests or interaction with other management rationales. On receipt of comments, draft boundaries are reviewed and final boundaries are advised to all parties prior to submission for Ministerial and Cabinet consideration. The selection, investigation and declaration process normally extends over a two year or longer period. The process has commenced with the preparation and release of an 'Area of Interest' Plan for the Fish Habitat Area. Appendix 3 contains the Plan of the proposed Fish Habitat Area outer boundary which has been circulated for comment.

6.2 Criteria for Fish Habitat Areas

The purpose of Fish Habitat Areas is to ensure that productive or representative marine vegetation communities and other fish habitats receive long-term protection to ensure sustainability of dependent fisheries. The following criteria are currently used for the selection of Fish Habitat Areas:

1. size;
2. diversity of or specific habitat features;
3. diversity of or specific marine fauna and flora;
4. existing or potential fishing grounds;
5. level of existing and likely future disturbances;
6. unique features; and
7. protected species.

Marine vegetation communities are a major component of fish habitats. This report concentrates on the identification of conservation areas from a marine vegetation perspective. Information on the fisheries conservation value of the non-vegetated habitats (e.g. sand banks and mud flats) will be determined as part of the consultation phase of the Fish Habitat Area declaration process.

6.3 Existing Fish Habitat Areas (Reserves) between Townsville and Proserpine

<u>Bowling Green Bay Fish Habitat Area.</u> This area covers the waters from Cape Cleveland to Cape Bowling Green. The mangrove areas from Haughton River to Cape Bowling Green are not covered by the Fish Habitat Area. Sparse seagrass beds have been recorded in the Fish Habitat Area. Bunt (1978) habitat environment classification 3 - coastal flats with complex but not extensive creek drainage. The extensive tidal communities of Cape Bowling Green and

Bowling Green are not currently protected within a Fish Habitat Area. The land tenure over these is National Park. The boundary of the existing Bowling Green Bay Fish Habitat Area should be extended to high water mark, to include the mangrove communities of Cape Bowling Green and Bowling Green Bay.

Repulse Bay Fish Habitat Area. Closed *Rhizophora* communities dominate this Fish Habitat Area. Sparse seagrass beds have been recorded in the Area. Bunt (1978) habitat environment classification 3 - coastal flats with complex but not extensive creek drainage.

See Appendix 2 for Plans of the Fish Habitat Areas (Reserves).

6.4 The Burdekin Delta Fish Habitat Area

The proposed Fish Habitat Area covers the tidal land and waters, and where possible a terrestrial buffer, between Cape Bowling Green and Cape Upstart, and the rivers, creeks and tributaries. Table 6.1 shows the criteria mentioned in Section 6.2 met for the localities in the proposed Fish Habitat Area.

Potential Fish Habitat Area	1	2	3	4	5	6	7
Bowling Green Bay	x	X	x	x	x	x	X
Cape Bowling Green	x	X	x	x	x	x	X
Kalamia Creek		X		x	x		X
Plantation Creek	x	X	x	x	x		X
Burdekin River Anabranch		X		x	x		X
Rita Island		X		x	x		X
Burdekin River	x	X	x	x	x	x	X
Groper Creek				x	x	x	X
Wallace Creek	x	X	x	x	x		X
R. M. Creek				x	x		X
Molongle Creek		X		x	x		X
Nobbies Inlet	x	X	x	x	x	x	X

Table 6.1 Application of criteria to the localities within the potential Fish Habitat Area

7.0 CONCLUSIONS

7.1 Importance of the marine vegetation of the Burdekin River region

The Burdekin River region is unique in Queensland. With its relatively dry climate in a tropical area, it may provide different habitats to the wetter coastal areas both to the north and south. Although flooding of the Burdekin River is infrequent, the extent of flooding on the sedimentary coastal plain makes this coastline more dynamic than most parts of Queensland.

The region includes diverse marine vegetation and supports some of the densest seagrass beds on the north Queensland coast. The terrestrial landscape adjacent to the tidal areas has undergone substantial modification in recent years to support agriculture. The proposed expansion of the Burdekin River irrigation area will increase the pressure on the region's natural resources, especially fisheries habitat. Thus it is important that the marine vegetation is protected to sustain fisheries for future generations.

This report recommends that:

1. a Fish Habitat Area is declared for all significant tidal habitats eastwards from Cape Bowling Green to Cape Upstart;

2. the tidal wetlands of Cape Bowling Green and Bowling Green Bay are included in the existing Bowling Green Bay Fish Habitat Area; and that

3. support be offered to facilitating the monitoring of effects of bunding in the delta.

7.2 Satellite remote sensing and GIS technology

The use of GIS technology and satellite remote sensing has revolutionised natural resources mapping. This project mapped all of the mangrove communities in the Burdekin region to detail greater than 1:100 000 in less than one month. The accuracy was greater than 80 percent. Using traditional cartographic methods, production of the 1:100 000 map sheets would have taken approximately six months to complete. Digital data allows efficient storage and low cost distribution. It is also easier to update than conventional mapping and allows numerical natural resource modelling. The digital marine vegetation classes were integrated with digital cadastral information (land tenure), providing an excellent base on which to delineate the boundaries of the proposed Fish Habitat Area.

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APPENDICIES

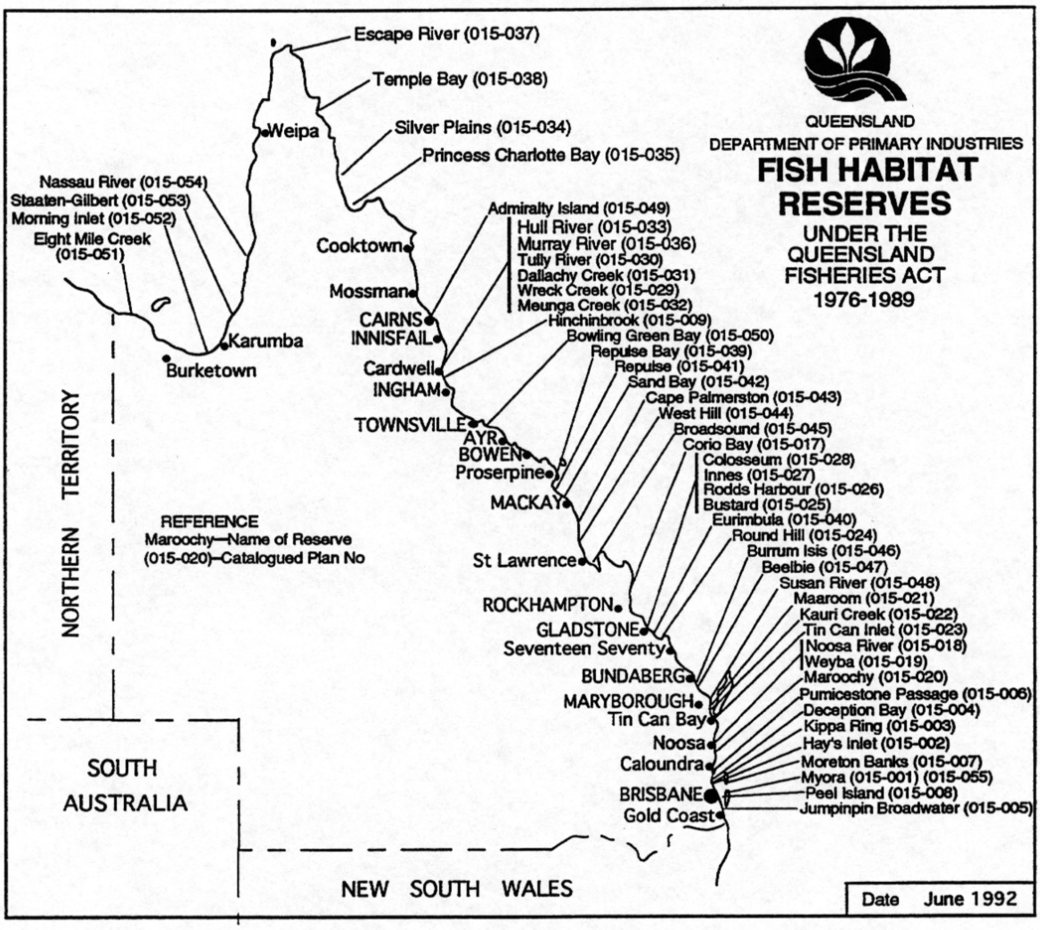
A.1 Marine vegetation maps

A.2 Tidal land and tenure maps

A.3 Proposed Fish Habitat Area outer boundary

A.4 Existing Fish Habitat Area plans

A.5 Remote sensing


QUEENSLAND
DEPARTMENT OF PRIMARY INDUSTRIES
FISH HABITAT
RESERVES
UNDER THE
QUEENSLAND
FISHERIES ACT
1976-1989
Escape River (015-037)
Temple Bay (015-038)
Weipa
Silver Plains (015-034)
Princess Charlotte Bay (015-035)
Nassau River (015-054)
Staaten-Gilbert (015-053)
Morning Inlet (015-052)
Eight Mile Creek
(015-051)
Karumba
Burketown
Cooktown
Mossman
CAIRNS
INNISFAIL
Cardwell
INGHAM
TOWNSVILLE
AYR
BOWEN
Proserpine
MACKAY
St Lawrence
ROCKHAMPTON
GLADSTONE
Seventeen Seventy
BUNDABERG
MARYBOROUGH
Tin Can Bay
Noosa
Caloundra
BRISBANE
Gold Coast
Admiralty Island (015-049)
Hull River (015-033)
Murray River (015-036)
Tully River (015-030)
Dallachy Creek (015-031)
Wreck Creek (015-029)
Meunga Creek (015-032)
Hinchinbrook (015-009)
Bowling Green Bay (015-050)
Repulse Bay (015-039)
Repulse (015-041)
Sand Bay (015-042)
Cape Palmerston (015-043)
West Hill (015-044)
Broadsound (015-045)
Corio Bay (015-017)
Colosseum (015-028)
Innes (015-027)
Rodds Harbour (015-026)
Bustard (015-025)
Eurimbula (015-040)
Round Hill (015-024)
Burrum Isis (015-046)
Beelbie (015-047)
Susan River (015-048)
Maaroom (015-021)
Kauri Creek (015-022)
Tin Can Inlet (015-023)
Noosa River (015-018)
Weyba (015-019)
Maroochy (015-020)
Pumicestone Passage (015-006)
Deception Bay (015-004)
Kippa Ring (015-003)
Hay's Inlet (015-002)
Moreton Banks (015-007)
Myora (015-001) (015-055)
Peel Island (015-008)
Jumpinpin Broadwater (015-005)
REFERENCE
Maroochy—Name of Reserve
(015-020)—Catalogued Plan No
NORTHERN TERRITORY
SOUTH
AUSTRALIA
NEW SOUTH WALES
Date June 1992

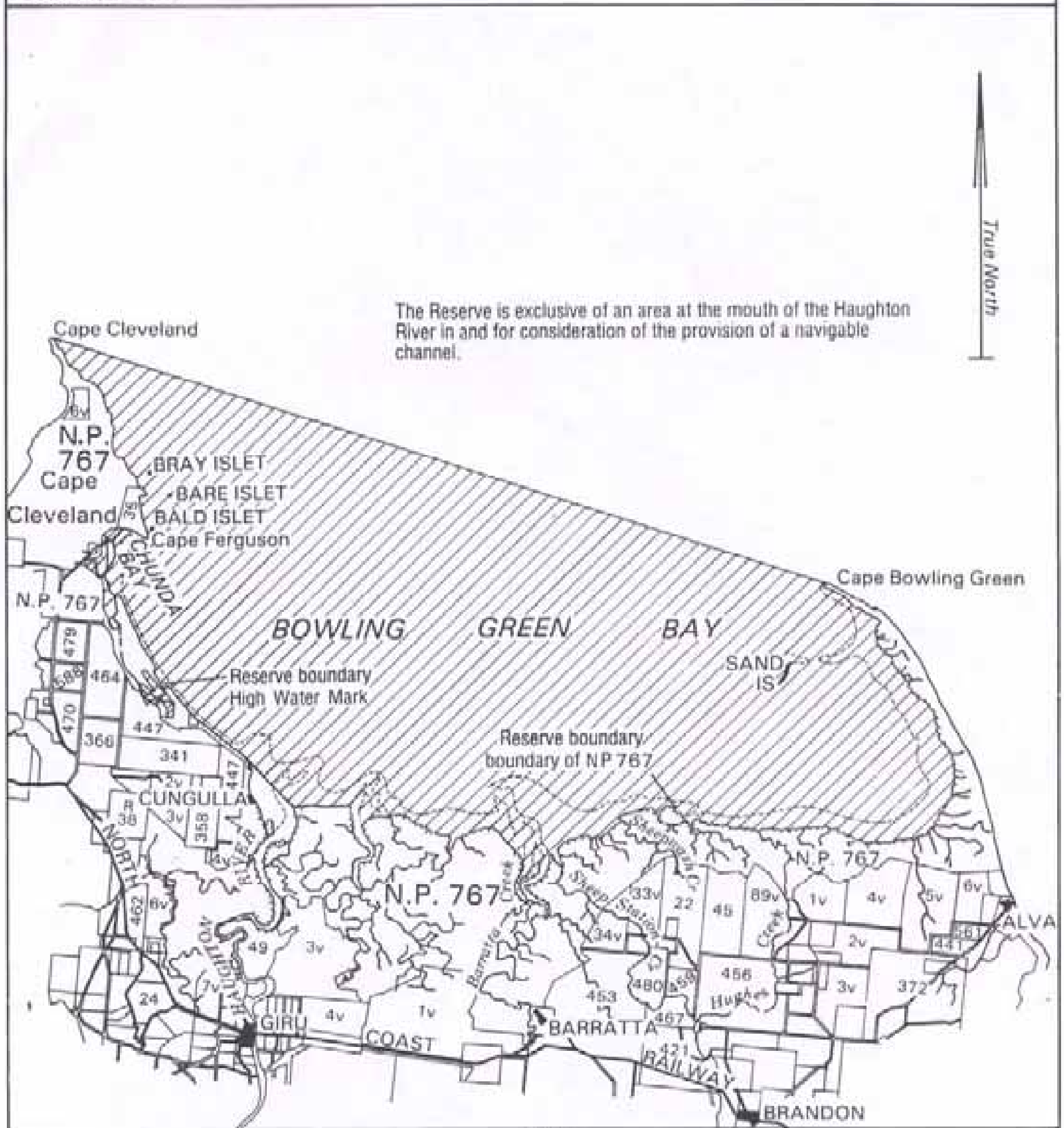
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT RESERVE

Name: **BOWLING GREEN BAY**

Locality: **AYR**

015-050



NOTE

The Reserve is exclusive of
Any land below high water mark alienated or licenced from the Crown under any Act prior to the date of declaration of the Reserve.
Any navigable channels defined by navigation markers placed pursuant to the Queensland Marine Act

NOTE

The Bowling Green Bay Fish Habitat Reserve covers the land below high water mark and the waters covering the land of that part of Bowling Green Bay indicated.

Kilometres 2 0 2 4 6 8 10 12 14 Kilometres

Co-ordinates of approx midpoint: 19°20'00"S. 147°15'00"E.
1 : 100 000 Map Reference Number **8359**
Gazettal Date: 25 November 1989 Signature.

Plan Number **015-050**

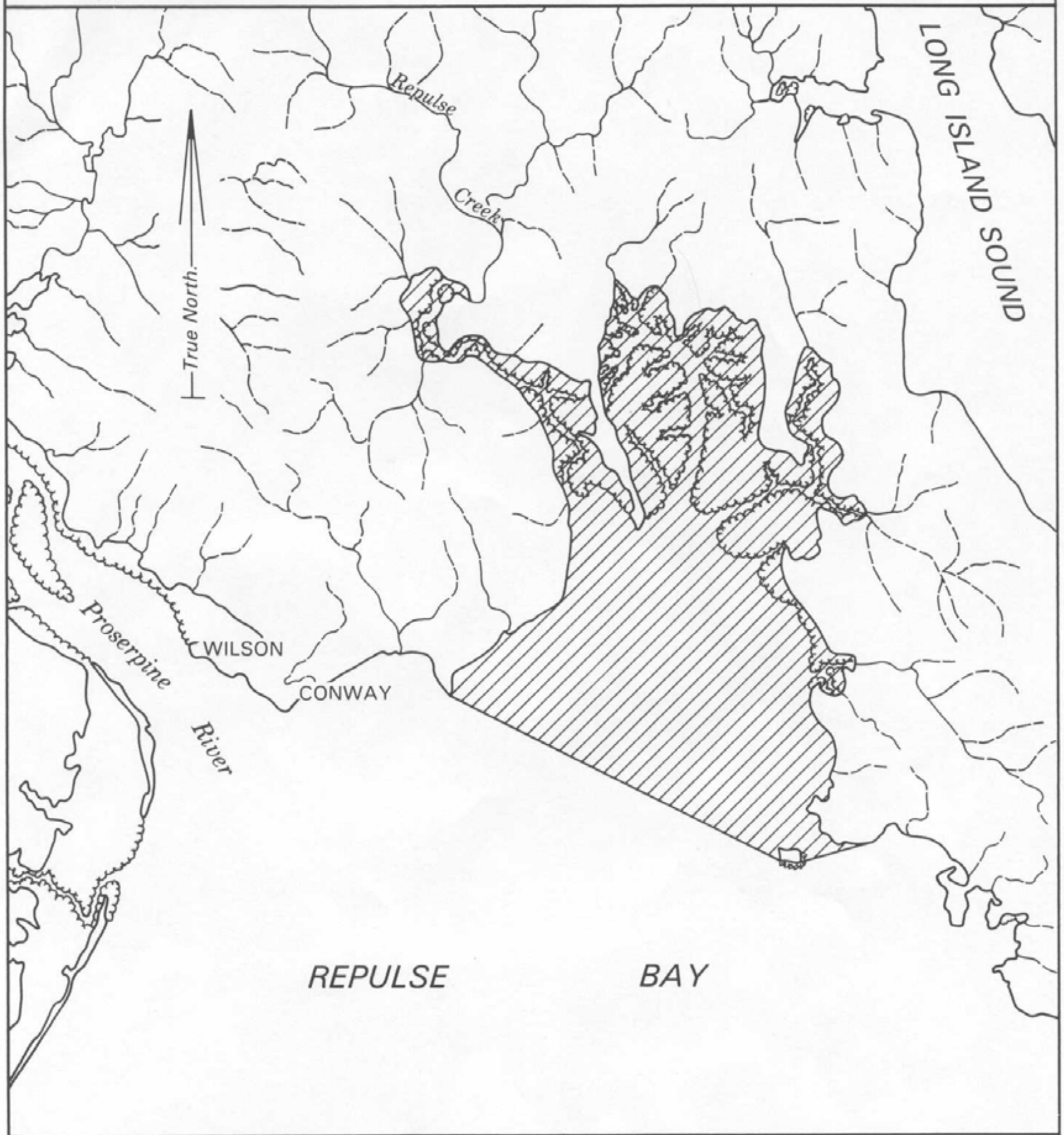
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT RESERVE

Name: **REPULSE BAY**

Locality: **PROSERPINE**

015-039



NOTE:
The Reserve is exclusive of:
Any land below high water mark alienated or licenced from the Crown under any Act prior to the date of declaration of the Reserve.
Any navigable channels defined by navigation markers placed pursuant to the Queensland Marine Act.

NOTE:
The Repulse Bay Fish Habitat Reserve covers the land below high water mark and the waters covering the land of that part of Repulse Bay indicated and its rivers, creeks and tributaries.

2 1 0 Kilometres. 2 4 6

Co-ordinates of approx midpoint: 20° 18′ 00″ S 148° 33′ 00″ E
1 : 100 000 Map Reference Number: 8657
Gazettal Date: 19th November 1983 Signature:

Plan Number:
015-039

APPENDIX 5 Remote sensing

Many natural resource mapping programs now use data collected remotely by sensors - thus the term “remote sensing”. Aerial photography and satellite imagery are perhaps the best known examples. This project used imagery collected by a Landsat satellite, which was launched by the government of the USA. Landsat orbits at 705 kilometres above the earth’s surface and takes 16 days to cover the whole surface of the earth. Its instrument, the Thematic Mapper (TM), digitally scans “scenes” 185 kilometres by 185 kilometres. The scanned scenes are made up of digital values recorded from the amount of reflected light from “pixels”. The TM pixels are areas representing 30 metres by 30 metres on the ground. This 30 metre by 30 metre pixel resolution means that an object must be at least this size to be detected by Landsat TM. While it is over Australia, Landsat beams this information to a receiving station in Alice Springs. For every pixel Landsat TM measures light in seven different wavelengths or “bands”. Table 1.1 describes the bands of Landsat Thematic Mapper instrument.

Band	Light Region	Generalised Applications
1	visible blue	coastal water mapping, soil/vegetation differentiation
2	visible green	green reflectance by healthy vegetation
3	visible red	chlorophyll absorption for plant species differentiation
4	near infrared	biomass surveys, water body delineation
5	middle infrared	vegetation moisture measurement
6	thermal infrared	plant heat stress mapping, sea surface temperatures
7	middle infrared	hydrothermal mapping

Table 1.1 Characteristics of the Landsat Thematic Mapper bands (from ACRES 1989)

The advantages of Landsat imagery are that it records infrared light as well as visible light; it is digital; it can be processed by computers; and a new scene can be collected for an area every 16 days. Unfortunately it cannot penetrate through cloud which is an important constraint for wet tropical areas like North Queensland.

The Fisheries Division of the Department of Primary Industries has already effectively used Landsat imagery to map mangrove communities in Cape York Peninsula (Danaher 1994), Moreton Bay (Danaher and Luck 1991) and to map seagrass communities in Great Sandy Strait (Lennon and Luck 1990).

The collection of aerial photography is very flexible, usually project driven, and thus can be at any resolution (e.g. from 1:5 000 to 1:100 000) depending on the height at which it is flown. It can also be captured in black and white, colour or on colour infrared film. Its ease of interpretation, detail of information and handy size for taking into the field have made aerial photography part of most natural resource mapping programs. However it takes a lot of aerial photography to cover the same area as Landsat imagery and thus is more expensive per square kilometre. Aerial photography may not always exist for some locations and if it does it may be out dated.