NATURAL RESOURCES ANALYSIS PROGRAM
(NRAP)

MARINE VEGETATION OF CAPE YORK PENINSULA

Karen F. Danaher
Queensland Department of Primary Industries

1995

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QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
LAND USE AND FISHERIES

CAPE YORK PENINSULA LAND USE STRATEGY
(CYPLUS)

Natural Resources Analysis Program

MARINE VEGETATION OF CAPE YORK PENINSULA

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Queensland Department of Primary Industries

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Due to the timing of publication, reports on other CYPLUS projects may not be fully cited in the REFERENCES section. However, they should be able to be located by author, agency or subject.

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CAPE YORK PENINSULA LAND USE STRATEGY
STAGE I

PREFACE TO PROJECT REPORTS

Cape York Peninsula Land Use Strategy (CYPLUS) is an initiative to provide a basis for public participation in planning for the ecologically sustainable development of Cape York Peninsula. It is jointly funded by the Queensland and Commonwealth Governments and is being carried out in three stages:

- Stage I - information gathering;
- Stage II - development of principles, policies and processes; and
- Stage III - implementation and review.

The project dealt with in this report is a part of Stage I of CYPLUS. The main components of Stage I of CYPLUS consist of two data collection programs, the development of a Geographic Information System (GIS) and the establishment of processes for public participation.

The data collection and collation work was conducted within two broad programs, the Natural Resources Analysis Program (NRAP) and the Land Use Program (LUP). The project reported on here forms part of one of these programs.

The objectives of NRAP were to collect and interpret base data on the natural resources of Cape York Peninsula to provide input to:

- evaluation of the potential of those resources for a range of activities related to the use and management of land in line with economic, environmental and social values; and
- formulation of the land use policies, principles and processes of CYPLUS.

Projects examining both physical and biological resources were included in NRAP together with Geographic Information System (GIS) projects. NRAP projects are listed in the following Table.

Physical Resource/GIS Projects	Biological Resource Projects
Bedrock geological data - digitising and integration (NR05)	Vegetation mapping (NR01)
Airborne geophysical survey (NR15)	Marine plant (seagrass/mangrove) distribution (NR06)
Coastal environment geoscience survey (NR14)	Insect fauna survey (NR17)
Mineral resource inventory (NR04)	Fish fauna survey (NR10)
Water resource investigation (groundwater) (NR16)	Terrestrial vertebrate fauna survey (NR03)
Regolith terrain mapping (NR12)	Wetland fauna survey (NR09)

Physical Resource/GIS Projects	Biological Resource Projects
Land resource inventory (NR02)	Flora data and modelling (NR18)
Environmental region analysis (NR11)	Fauna distribution modelling (NR19)
CYPLUS data into NRIC database FINDAR (NR20)	Golden-shouldered parrot conservation management (NR21)
Queensland GIS development and maintenance (NR08)*	
GIS creation/maintenance (NR07)*	

* These projects are accumulating and storing all Stage I data that is submitted in GIS compatible formats.

Research priorities for the LUP were set through the public participation process with the objectives of:

- collecting information on a wide range of social, cultural, economic and environmental issues relevant to Cape York Peninsula; and
- highlighting interactions between people, land (resource use) and nature sectors.

Projects were undertaken within these sector areas and are listed in the following Table.

People Projects	Land Projects	Nature Projects
Population	Current land use	Surface water resources
Transport services and infrastructure	Land tenure	Fire
Values, needs and aspirations	Indigenous management of land and sea	Feral and pest animals
Services and infrastructure	Pastoral industry	Weeds
Economic assessment	Primary industries (non-pastoral, non-forestry)	Land degradation and soil erosion
Secondary and tertiary industries	Forest resources	Conservation and natural heritage assessment
Traditional activities	Commercial and non commercial fisheries	Conservation and National Park management
Current administrative structures	Mineral resource potential and mining industry	
	Tourism industry	

SUMMARY

CYPLUS

The Cape York Peninsula Land Use Strategy (CYPLUS) is a joint Queensland/Commonwealth initiative to provide a framework for making decisions about how to use and manage the natural resources of Cape York Peninsula in ways that will be ecologically sustainable. As part of the Natural Resources Analysis Program (NRAP) of CYPLUS, the Fisheries Division of the Queensland Department of Primary Industries has mapped the marine vegetation (mangroves and seagrasses) for Cape York Peninsula. The project ran from July 1992 to June 1994. Field work was undertaken in November 1992, May 1993, and April 1994.

Importance of mangroves and seagrasses of the Cape York Peninsula region

Mangroves and seagrasses are of ecological importance, directly supporting 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).

Cape York Peninsula has one of the highest species diversities of marine vegetation in the world. It contains 36 mangrove species compared to nine in south-east Queensland and one in Victoria (Duke 1992). There are 13 species of seagrass found in the inshore waters of the Cape York region including Torres Strait, (Poiner *et al*. 1989) compared to 5 species found in south-east Queensland (Coles *et al*. 1989).

The aim of this project was to obtain baseline information on the distribution of marine vegetation within Cape York Peninsula for the purpose of developing an appropriate strategy for management of fisheries resources. A system of Reserves is in place but the boundaries of current Reserves and the need for additional Reserves in areas of high habitat value are the subject of ongoing review.

Methods

The mangrove communities were mapped on a computer using digital imagery from the Landsat Thematic Mapper satellite. These maps were validated with colour aerial photography and field work using a helicopter for access. The seagrass maps were produced from dive and boat surveys conducted by the Department of Primary Industries Northern Fisheries Centre, from 1984 to 1989 supplemented also by colour aerial photography. The mangrove and seagrass maps have been combined and now reside digitally on the CYPLUS Geographic Information System (GIS). Colour hardcopy products have also been produced at 1:100 000 scale.

Results

Mangroves	Area for eastern side (hectares)	Area for western side (hectares)	Total Area (hectares)
Rhizophora (closed)	23 590	21 570	45 160
Ceriops (closed)	3 860	6 770	10 630
Ceriops (open)	2 870	2 340	5 210
Avicennia (closed)	1 140	13 710	14 850
Avicennia (open)	320	3 070	3 390
Rhizophora/Ceriops (closed)	640	1 770	2 410
Avicennia/Ceriops (closed)	1 160	260	1 420
Avicennia/Ceriops (open)	5 660	900	6 560
Landward Rim (open)	370	320	690
Mixed (closed)	3 700	9 300	13 000
Saltpan	39 770	61 490	101 260
Total	**83 080**	**121 500**	**204 580**
Seagrass	**Area for eastern side (hectares)**	**Area for western side (hectares)**	**Total Area (hectares)**
Sparse	74 170	6 370	80 540
Medium	74 890	2 040	76 930
Dense	61 100	8 040	69 140
Total	**210 160**	**16 450**	**226 610**

Table 1: Marine vegetation community areas for the whole CYPLUS region, and the eastern and western sides divided by the longitude 142°30’E

Distribution of the marine vegetation

The general pattern for mangroves on the eastern side of Cape York was strong zonation with closed *Rhizophora* communities fringing the waterways and protected foreshores, closed *Ceriops* communities immediately landward, open *Ceriops* and *Avicennia/Ceriops* communities behind, and a narrow saltpan between the mangroves and the terrestrial vegetation. Due to the generally hilly terrain, there was often only a narrow saltpan between the mangroves and the terrestrial vegetation. An exception to this is Princess Charlotte Bay where the saltpans were extensive, and dotted with slightly elevated areas covered with grass and the occasional palm (*Corypha elata*).

Major mangrove communities occurred in the Endeavour River, the Starke region, Princess Charlotte Bay, Lockhart River, Temple Bay, Shelburne Bay and Newcastle Bay. Extensive seagrass beds occurred in the shallow waters off the Starke region, and in Bathurst, Princess Charlotte and Shelburne Bays.

The hilly Torres Strait islands were generally fringed with *Rhizophora* communities with *Avicennia* and *Ceriops* communities landward. This study did not map the seagrass beds in the Torres Strait north of 10°40'S as these have been mapped by CSIRO. The seagrass beds were distributed around the coasts of the islands, on reef flats and in the lagoons of atolls and reefs, as well as in the shallow open waters of the north-western Torres Strait (Williams 1994).

On the western side of Cape York Peninsula the mangrove zonation pattern was similar except that *Avicennia* started to invade all communities. On the north-western side, mangroves rarely occurred on the foreshore of the Gulf of Carpentaria but in rivers and estuaries that run almost parallel to the coast. Extensive mangrove communities occurred in Port Musgrave, Albatross Bay (Weipa) and Archer Bay (Aurukun). These Bays also supported seagrass beds.

South of Aurukun the communities were either *Avicennia* dominated or mixed. *Rhizophora* communities diminished in depth, and as far south as the Nassau River were restricted to fringing the waterways in bands only several plants deep, thus not mappable units in this study. The Mitchell and Nassau Rivers contained large areas of *Avicennia* and mixed communities. Just to the north of the Mitchell River pure *Avicennia* communities started to line the foreshore. With the flat terrain on the south-western side of Cape York Peninsula saltpans mixed with grasslands and extended for kilometres inland. No seagrass beds were identified in this area.

The general seagrass zonation for the Cape York region consisted of a shallow zone less than 6 metres deep with all species present. Between 6 and 11 metres, the pioneering *Halophila* and *Halodule* species were the most frequently sampled seagrasses. Deeper than 11 metres, only *Halophila* species were common (Lee Long *et al.* 1993).

Reasons for the distribution differences

The differences in marine vegetation on the two sides of Cape York Peninsula are a result of the many environmental factors which also differ. The flatter the terrain, the greater occurrence of saltpans (e.g. Princess Charlotte Bay, south-western side of Cape). The dominance of *Rhizophora* communities on the eastern side, and its almost absence on the south-western side with *Avicennia* dominating is explained by Wells (1983). He believes that the prevailing south-east trade winds blow across hot dry land towards the south-western side of the Peninsula during the dry season causing seasonal aridity and thus limit the establishment of the mangrove species with more humid climatic requirements (i.e. *Rhizophora*).

Another difference observed between the eastern and western sides of the Peninsula is that on the eastern side mangroves are common on the foreshore. On the western side (excluding the major bays of Port Musgrave, Albatross Bay and Archer Bay) this does not occur north of approximately 15°S near Malaman Creek. The heavily embayed eastern coastline offers more protection from high energy waves as well as the greater protection offered by the Great Barrier Reef.

The zonation patterns of seagrass habitat were mostly related to depth zonations (Lee Long *et al.* 1993). Depth zonation patterns were influenced by the tidal range and levels of exposure, turbidity and salinity (Coles *et al.* 1987). Lee Long *et al.* (1993) found that seagrass beds dominated by *Enhalus acoroides*, which were common in shallow, sheltered sites in the Gulf of Carpentaria (Poiner *et al.* 1987) and in the Torres Strait (Bridges *et al.* 1982), were not common on the eastern coast. Open-coastline communities typical of the western Gulf of Carpentaria, where *Halophila ovalis* and *Halodule uninervis* dominate intertidally and *Cymodocea serrulata* and *Syringodium isoetifolium* dominate subtidally (Poiner *et al.* 1987), were mostly found on parts of the eastern coast where there was less freshwater runoff from coastal rivers.

Relationship of marine vegetation 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. 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).

The literature reviewed suggests that 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 leaf litter (Hutchings and Saenger 1987), and the temporal nature of seagrass beds (Mellors *et al.* 1993, Poiner *et al.* 1989) make quantification 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.

Fisheries Reserves planning

The data set was applied to Fisheries Reserves planning. The purpose of Fisheries Reserves are to ensure that representative marine vegetation communities (hence representative fish habitats) receive long-term protection to ensure sustainability of dependent fisheries. A preliminary assessment was made of the marine vegetation communities within current Reserves, as well as identifying those communities which are not currently represented in Reserves.

Project Recommendations

Resulting from the project are the following recommendations:

1. That the boundaries of the existing Fisheries Reserves be reassessed, to include where possible submerged seagrass habitat, freshwater habitat, and provide protection for adjacent terrestrial land.

2. That the regions of Starke, Lockhart River delta, Margaret Bay, Jardine River, Doughboy River, MacDonald River, Jackson River, Wenlock River and Kendall River be investigated as to their potential as Fisheries Reserves.

3. That satellite remote sensing and GIS technology continue to be used as a cost effective tool for mapping and monitoring intertidal vegetation such as mangrove communities on Queensland's coast.

4. That for large projects cooperation continue to be sought with other agencies for the sharing of data.

5. That during the land-use planning process, areas of marine vegetation are recognised as wetland habitat of importance to fisheries.

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1.0 INTRODUCTION

1.1 Cape York Peninsula

The Cape York Peninsula region lies between Latitudes 10° and 16°S and is biologically one of the most diverse areas in Australia (Stanton 1976). Its immense area, roughly the size of the State of Victoria (Midgley 1988), gives rise to a range in environmental conditions.

Cape York Peninsula is generally of low relief and flat to undulating landscape with a range of low mountains and hills in the eastern and southern areas to 800 metres in elevation. The several large river systems are subject to extensive seasonal and annual flow variations, can carry large volumes of water and are dominant landscape features. Eucalypt woodland/open forest dominates the Cape with areas of paperbark woodland. Vine forests occur in the southeastern, eastern and northern areas.

The eastern and northern coastal areas of the region, including the southern Torres Strait and Coral Sea, contain many islands, islets, coral reefs and cays. Islands and coral reefs are absent along the western coast into the Gulf of Carpentaria. For most of the region the tides are semidiurnal but towards the south-eastern Gulf of Carpentaria they become diurnal.

The climate is distinctively tropical, with the wet season concentrated in a five month period over summer, followed by an almost rainless seven month dry season. Temperatures grade from warm to hot throughout the year with high humidity during the wet season. Winds persist throughout the year.

Cape York Peninsula is sparsely settled but supports several indigenous communities. The major land use of the area is cattle grazing, with mining activities and commercial fishing also occurring. The large distances from major population centres, poor infrastructure, low population and climate have limited its economic development (Connell Wagner 1989).

1.2 Cape York Peninsula Land Use Strategy (CYPLUS)

The Cape York Peninsula Land Use Strategy (CYPLUS) is a joint Queensland/Commonwealth initiative to provide a framework for making decisions about how to use and manage the natural resources of Cape York Peninsula in ways that will be ecologically sustainable. CYPLUS has three stages:

Stage 1 - getting people involved and collecting information
Stage 2 - using the information to make policies about sustainable land use
Stage 3 - implementing and reviewing the decisions about land use.

The Natural Resources Analysis Program (NRAP) is part of Stage 1 and was set up to collate existing information for the natural resources and to collect new information for a complete baseline. CYPLUS is storing all the information in a Geographical Information System (GIS) which will aid the major stake holders (e.g. residents of the

Peninsula, government agencies and interest groups) in developing land use management strategies. This project (NR06), as part of NRAP, has mapped the marine vegetation (mangroves and seagrasses) for Cape York Peninsula.

1.3 Marine vegetation

Mangroves and seagrasses are of ecological importance, directly supporting 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 most of Cape York Peninsula), 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. This production varies between communities.

Mangroves proliferate in areas protected from high energy waves. Thus in Cape York Peninsula these plants tend to be abundant in sheltered bays, in coastal inlets and creeks, on the sheltered side of continental islands and can also occur on inner reef platforms. Cape York Peninsula has one of the highest mangrove species diversities in the world with 36 species compared to nine in south-east Queensland and one in Victoria (Duke 1992). Adjacent Papua New Guinean estuaries to the north contain several more species than Cape York Peninsula. This suggests that species richness is due to a latitudinal effect, since most species are found in more equatorial latitudes with a progressive reduction in numbers to the south (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 Cape York, seagrasses are common in sheltered bays, behind continental islands, on platforms of fringing and barrier reefs, and in some of the coastal inlets and creeks. There are 13 species of seagrass found in the inshore waters of the Cape York region including Torres Strait, (Poiner *et al*. 1989) compared to 5 species found in south-east Queensland (Coles *et al*. 1989).

No detailed mapping of communities is available for the marine vegetation of Cape York Peninsula and until recently for much of the coast of Queensland. 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 (Lee Long *et al*. 1993, Hyland *et al*. 1989), and mapping of intertidal vegetation completed for 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).

1.4 Cape York fisheries

The Cape York Peninsula region yields large amounts of seafood for both local consumption and for consumption for domestic markets throughout Australia and for export markets overseas. Seafoods are an important part of the diet of the indigenous inhabitants of the Cape York region. The traditional hunting of dugong and sea turtle still takes place.

The commercial fisheries of the region include prawns, barramundi, king and blue salmon, spanish and grey mackerel, coral trout, red emperor, shark, mud crab, rock lobster, trochus, beche-de-mer, and pearls. Annually these are worth in excess of $65 million at prices to the fisherman (source: Queensland Fish Management Authority). Many of the local people are involved in the fishing industry. The products are for sale throughout Australia and overseas.

Cape York Peninsula is recognised as an important area for recreational fishing. Increasing numbers of tourists are visiting the region each year and are enjoying fishing as a holiday activity.

1.5 The project aim

While the marine plants of Cape York have attracted scientific attention due to species richness, (e.g. Macnae 1967, Bunt 1978, and Dowling and McDonald 1982) the communities as a whole have not been mapped in detail. Nor have the eastern and western sides of the Peninsula which interface with different marine environments been studied and documented simultaneously.

Marine plants, including mangroves and seagrasses, are specifically protected under the *Fisheries Act* 1976-89 in all Queensland waters. Disturbance of these plants may only be undertaken with Ministerial approval. To provide additional habitat protection for fisheries purposes, Fish Habitat Reserves and Wetland Reserves are declared under Section 51 of the *Fisheries Act*. These Reserves (to be known as Fish Habitat Areas in forthcoming fisheries legislation) are part of the ongoing management of fisheries 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. Appendix 1 provides more information on each type of Reserve. A system of Reserves is in place on Cape York Peninsula but the boundaries of current Reserves and the need for additional Reserves in areas of high habitat value are the subject of ongoing review of which this study forms a major part.

The aim of this project was to obtain baseline information on the distribution of marine plants of Cape York Peninsula and to identify representative marine vegetation communities (hence representative fish habitats). This information will supplement broader strategies for management of fisheries resources in this region.

1.6 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. It 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" - 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. While it is over Australia, Landsat beams this information to a receiving station in Alice Springs. For every pixel the Landsat Thematic Mapper instrument measures light in seven different wavelengths or "bands". Table 1.1 describes these bands.

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 indentifying and interpreting satellite imagery for Cape York Peninsula.

The Fisheries Division of the Department of Primary Industries has already effectively used Landsat imagery to map mangrove communities in 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.

2.0 METHODS

2.1 Mangroves

Digital imagery from the Landsat satellite's Thematic Mapper (TM) sensor was processed to map the mangroves. Each Landsat scene covered an area 185 kilometres by 185 kilometres and the pixel resolution was 30 metres by 30 metres. The 12 Landsat TM scenes covering Cape York were captured between 1986 and 1991 and were not all captured in the same climatic season or at the same tidal phase (see Figure 5.1 for the coverage of the 12 scenes). The TM data received was already rectified to the Australian Map Grid with pixels resampled to 30 metres by 30 metres by the Australian Geological Survey Organisation.

Path/Row	Date	Season	Tide Phase
99/67	16 June 1988	early dry	mid
99/68	16 June 1988	early dry	mid
99/69	16 June 1988	early dry	mid
99/70	21 March 1991	late wet	high
98/68	6 April 1988	late wet	high
98/69	23 March 1991	late wet	high
98/70	6 April 1988	late wet	high
98/71	21 May 1987	early dry	mid
97/69	21 October 1987	late dry	high
97/70	3 November 1986	late dry	high
96/70	24 August 1986	mid dry	mid
96/71	17 September 1986	mid dry	high

Table 2.1 The Landsat TM scenes used

All 12 scenes were processed separately using MIPS^{TM} (Map and Image Processing System) on a personal computer and 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 and unpublished vegetation maps at 1:250 000 from the CYPLUS Vegetation Mapping Team (Neldner *pers. comm.*). This false colour composite is the best combination for identifying the intertidal zone and uses the most decorrelated bands (Sheffield 1985). A one kilometre buffer above the intertidal zone was retained for processing, as this boundary with above-tidal lands can be very difficult to interpret, even from colour 1:50 000 aerial photography.

The colour aerial photography at 1:50 000 from the Beach Protection Authority used were - Cooktown to Crab Island - Runs 1 to 26 captured during 1991 and 1992, and Crab Island to NT Border - Runs 26 to 37 captured during 1989.

The remaining imagery, which included the intertidal zone, was processed with unsupervised classification rather than supervised classification (Danaher and Luck 1991) which means 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.

The computer-based community classification was validated on field trips by helicopter flights along the coastline. Landings were made at selected sites to document information 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 specific 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. In addition random trees were selected and the genus, height, girth at breast height and distance was measured for the nearest neighbour in every quarter (point quarter method). The field trips were:

Cooktown to Shelburne Bay	November 1992
Shelburne Bay to Aurukun	May 1993
Pormpuraaw to Nassau River	April 1994

Scheduled ground truthing of the whole area could not be undertaken because of the refusal of traditional owners to grant access.

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 2.2. 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 experience Closed *Rhizophora*, Closed *Rhizophora/Ceriops*, Closed Mixed and Closed *Avicennia* are generally more than 10 metres tall, thus "forest" *sensu* Specht; while the remaining classes (except saltpans) generally are less than 10 metres thus Specht's "scrub".

The classes included were those which receive tidal inundation, hence appropriate habitat of mangroves. Excluded classes were permanent pools of water, elevated land containing terrestrial vegetation such as trees, shrubs and grass, and tidally exposed bare mud and sand banks. 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 shown. Tidally exposed bare mud and sand banks were excluded as these have the same spectral signature as saltpans.

Marine Vegetation Unit	**Density**
Mangrove Units	
Rhizophora	closed
Ceriops	closed
Ceriops	open
Avicennia	closed
Avicennia	open
Rhizophora/Ceriops	closed
Avicennia/Ceriops	closed
Avicennia/Ceriops	open
Landward Rim	open
Mixed	closed
Saltpan	open
Seagrass Units	
Sparse	0-10%
Medium	10-50%
Dense	50-100%

Table 2.2 The marine vegetation units

2.2 Seagrasses

The Department of Primary Industries mapped seagrass beds in conjunction with sampling juvenile prawn populations and dependent habitat along the coastline of Cape York Peninsula between 1984 and 1989. The inshore waters between Cape York and Cairns were surveyed in November 1984 (Coles *et al*. 1985). The area between Lookout Point and Barrow Point was revisited in September 1989 (Lee Long *et al*. 1989). The inshore waters of the western side of Cape York Peninsula was surveyed in July 1985 (Lee Long *et al*. unpublished data).

Visual assessment of the seabed was made by diving along transects out from the coastline at intervals of about four kilometres. Extra dive checks were made between transects for continuity, particularly where coastal topography was varied, such as bays. Where seagrass was present, four 0.25m^2 samples of the bottom vegetation were collected for laboratory analysis. The height of each species of seagrass and a percentage cover of the bottom were also estimated. Maps were produced showing community densities. In addition this CYPLUS project used colour 1:50 000 aerial photography captured between 1988 and 1992 to modify some boundaries. No additional ground truthing was undertaken in the CYPLUS project.

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 cost, the Landsat imagery used was a pre-existing data set selected for cloudlessness rather than particular tide height or water clarity. As a result the available images are a mix of tide heights and water clarity. The inshore waters surrounding Cape York Peninsula are fairly turbid. The high incidence of cloud cover over Cape York Peninsula makes the capture of a low tide, clear water image improbable.

The seagrass communities were classified according to density of vegetation cover with 3 classes (see Table 2.2) - sparse (0 to 10%), medium (10 to 50%) and dense (50 to 100)%.

2.3 Conversion for input into GIS

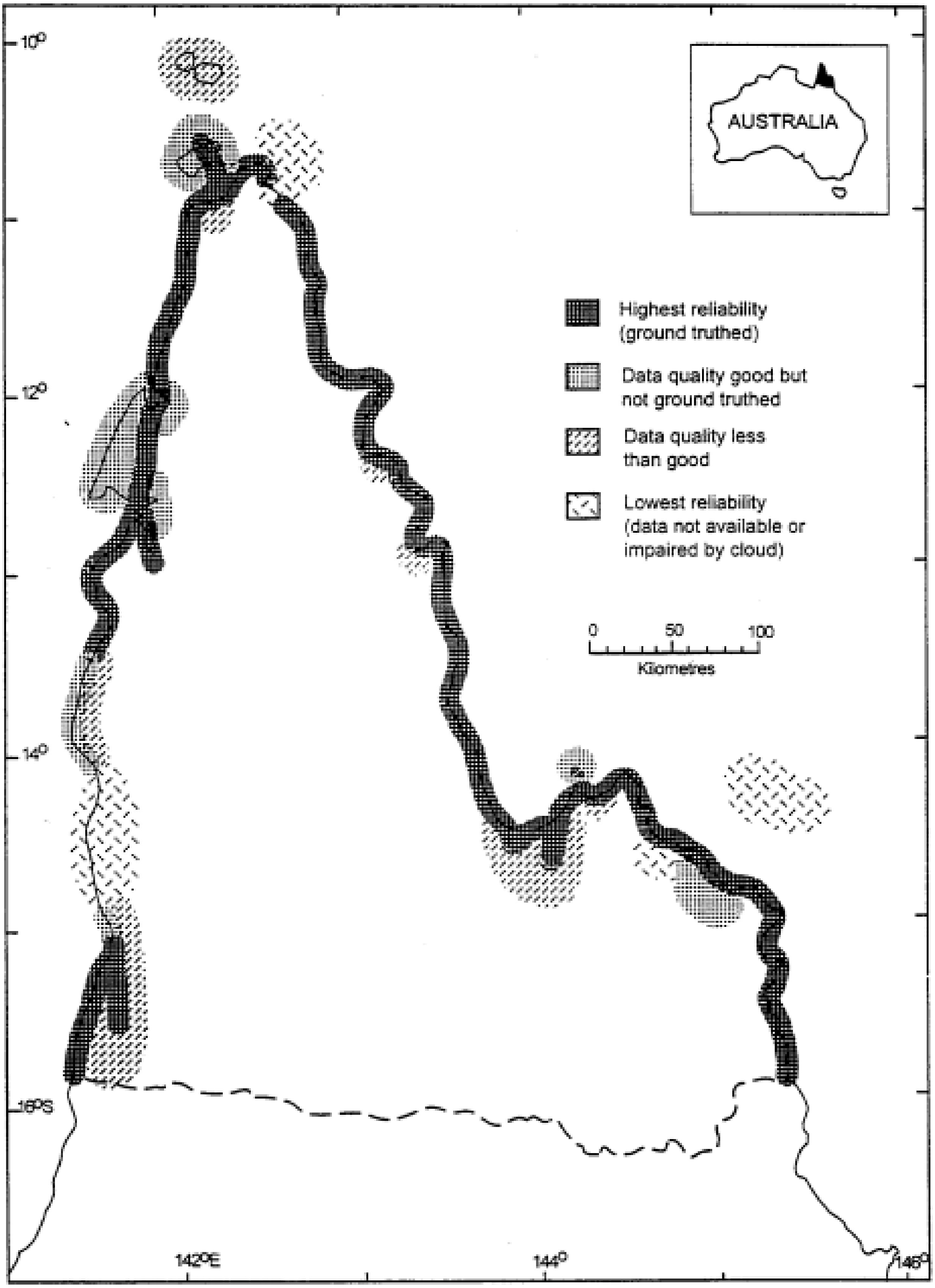
The combined mangrove and seagrass maps were converted from raster format to vector polygons. This was done using ARC/INFO GIS software. To improve cartographic presentation of the data the jagged raster boundaries were smoothed and generalised and polygons with areas under 10 000 square metres were eliminated. The coverages were reprojected to geographical coordinates. Label and node errors were corrected.

2.4 Data accuracy

The overall accuracy for the data was greater than 80%. The accuracy was derived by comparing the computer based community classification to the aerial photography and field data. Using other data sources such as the aerial photography and field data helped to overcome the heterogeneity in the satellite imagery but some inconsistencies in interpretation of vegetation communities may occur. Problems were also created by cloud on the satellite imagery and aerial photography. Gaps in the aerial photography coverage and poor quality pictures also limited interpretation. Only representative estuaries were field checked and were based on accessibility from the helicopter.

Figure 2.1 is a data reliability diagram for the intertidal vegetation (mangroves and saltpan) of the study area. The highest reliability class covers areas which were visited by helicopter for the mangrove survey. The next highest reliability (class 2) is for areas which were not visited but are covered by 1:50 000 colour aerial photography. Of less reliability (class 3) are areas which are covered by satellite imagery but are not covered by the aerial photography, or the available aerial photography is of poor quality. The final class covers areas that were not covered by satellite imagery or where cloud affected the satellite imagery and digital classification.

The horizontal accuracy of the Marine Vegetation product is between 10 and 100 metres. Despite different data sources the satellite imagery based coverages overlay well with the coastline coverage derived from the 1:100 000 topographic maps.


AUSTRALIA
Highest reliability (ground truthed)
Data quality good but not ground truthed
Data quality less than good
Lowest reliability (data not available or impaired by cloud)
0
50
100
Kilometres
10°
12°
14°
16°S
142°E
144°
146°

3.0 DESCRIPTION OF THE MARINE VEGETATION UNITS

3.1 The Mangroves

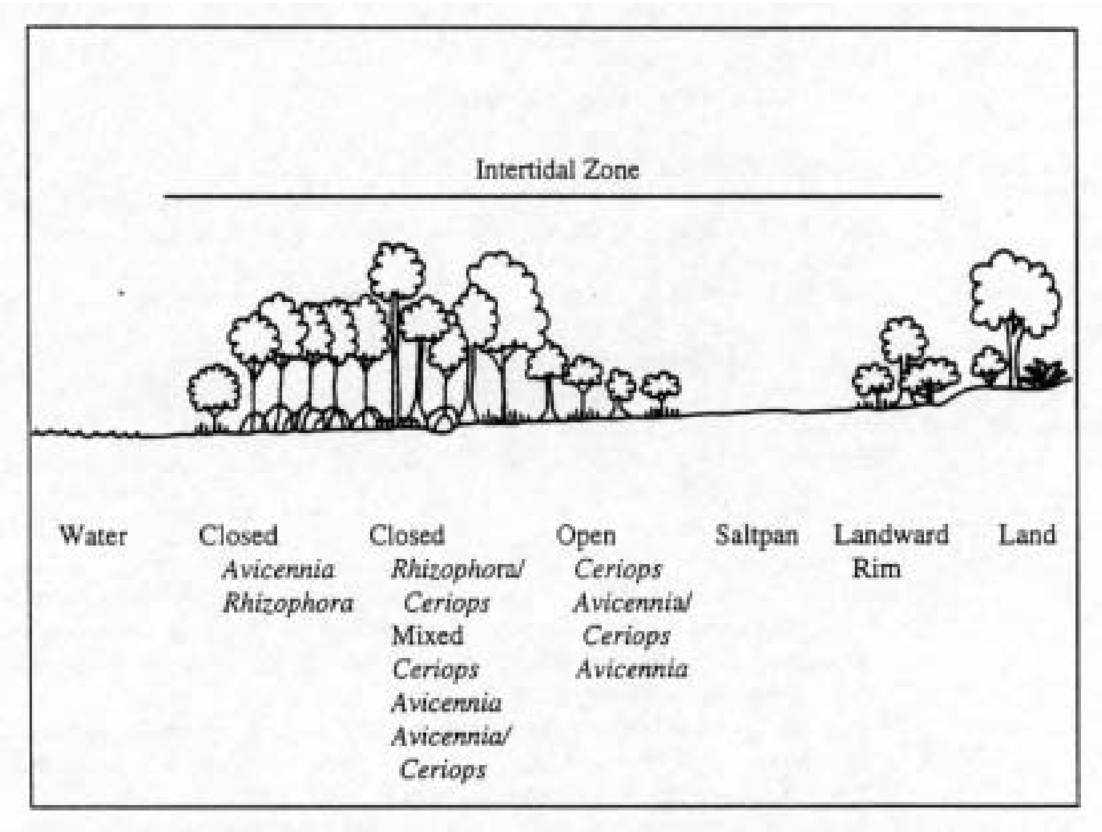


Figure 3.1 The position of the mangrove communities across the tide profile

Rhizophora (closed) (Figure 3.2)

Habitat	occurs fringing waterways low in intertidal zone with roots submerged during high tides. Some species pioneer in the front of the mangroves such as *Rhizophora stylosa* while other species such as *R. apiculata* and *R. lamarckii* prefer perennial freshwater input provided by permanent watercourses.
Canopy	usually dominated by *Rhizophora* spp. with occasional *Bruguiera* spp. and *Avicennia marina*. Foliage projective cover is more than 50%. Height varies from 4 metres to more than 30 metres.
Shrub layer	generally absent.
Ground cover	*Rhizophora* stilt roots with a sparse cover of *Rhizophora* seedlings.

<u>*Ceriops* (closed)</u> (Figure 3.3)

Habitat: generally occurs between *Rhizophora* communities and open *Ceriops* communities on land more elevated than *Rhizophora* communities and not inundated by every tide.

Canopy: *Ceriops* spp. and occasionally *Rhizophora* spp., *Bruguiera* spp. and *Avicennia marina*. Foliage projective is cover more than 50%. Height varies from 1.5 metres to more than 17 metres.

Shrub layer: generally absent.

Ground cover: consists of sparse seedlings of genera present.

<u>*Ceriops* (open)</u> (Figure 3.4)

Habitat: occurs towards the landward edge of the intertidal zone, inundated by only the high spring tides. This community often surrounds saltpans and is rarely on waters edge, except on eroding banks.

Canopy: *Ceriops* spp., and occasionally with emergents of *Avicennia marina*. The foliage projective cover is less than 50%. Height varies from less than 0.5 metre in very saline environments to 5 metres.

Shrub layer: occasional presence of *Aegialitis annulata* to 2 metres in height.

Ground cover: consists of seedlings of species present with occasional presence of samphire species such as *Suaeda arbusculoides*, *Tecticornia australasica* and *Sarcocornia quinqueflora*.

<u>*Avicennia* (closed)</u> (Figure 3.5)

Habitat: a very diverse community which can be found in all intertidal environments from pioneering the seaward edge of mangroves and fringing waterways on accretion banks being inundated on every tide, to the landward edge only being inundated on the highest spring tides.

Canopy: *Avicennia marina* with the occasional presence of *Ceriops* spp., *Excoecaria agallocha* 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*.

<u>*Avicennia* (open)</u> (Figure 3.6)

Habitat	a very diverse community which can be found in all intertidal environments from pioneering the seaward edge of mangroves and fringing waterways on accretion banks being inundated on every tide, to the landward edge only being inundated on the highest spring tides.
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*).

<u>*Rhizophora/Ceriops* (closed)</u> (Figure 3.7)

Habitat	generally occurs between closed *Rhizophora* communities and closed *Ceriops* communities receiving inundation by most high tides.
Canopy	*Ceriops* spp. with emergent *Rhizophora* spp. and occasional *Bruguiera* spp. Foliage projective is cover more than 50%. Height varies from 2 metres to more than 15 metres.
Shrub layer	generally absent.
Ground cover	consists of sparse seedlings of genera present between *Rhizophora* stilt roots and occasional *Ceriops* knee roots.

<u>*Avicennia/Ceriops* (closed)</u> (Figure 3.8)

Habitat	generally occurs towards the landward edge or in the centre of islands on substrate only inundated during spring tides.
Canopy	*Ceriops* spp. with emergents of *Avicennia marina*. Foliage projective is cover more than 50%. Height varies from 2 metres to more than 10 metres.
Shrub layer	generally absent.
Ground cover	consists of sparse seedlings of genera present.

<u>*Avicennia/Ceriops* (open)</u> (Figure 3.9)

Habitat	generally occurs towards the landward edge near hypersaline claypans or in the centre of islands on substrate only inundated during the spring tides.
Canopy	*Ceriops* spp. with emergents of *Avicennia marina*. The foliage projective cover is less than 50%. Height varies from less than 0.5 metre in very saline environments to 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 with occasional presence of samphire species such as *Suaeda arbusculoides*, *Tecticornia australasica* and *Sarcocornia quinqueflora*.

<u>Landward Rim (open)</u> (Figure 3.10)

Habitat: generally occurs on substrates only inundated on the highest spring tides - next to the landward edge or on dune systems dissected by tidal waterways.

Canopy: usually a mix consisting of *Avicennia marina*, *Ceriops* spp., *Excoecaria agallocha*, *Lumnitzera* spp. Terrestrial plants from *Melaleuca* and *Acacia* genera may also occur. The foliage projective cover is less than 50%. Height varies from 2 metres to 10 metres.

Shrub layer: may exist of smaller canopy species as well as the occasional presence of *Aegialitis annulata* and *Aegiceras corniculatum* to 2 metres in height.

Ground cover: may consist of seedlings of species present as well as sparse samphires (e.g. *Suaeda arbusculoides*, *Tecticornia australasica* and *Sarcocornia quinqueflora*) and grasses such as salt couch (*Sporobolus virginicus*).

<u>Mixed (closed)</u> (Figure 3.11)

Habitat: may occur behind closed *Rhizophora* communities, in areas where zonation is less defined, as well as by permanent watercourses. Tidal inundation varies from almost every high tide to only the spring tides where there is more fresh water input.

Canopy: a mix which may consist of *Rhizophora* spp., *Avicennia marina*, *Bruguiera* spp., *Excoecaria agallocha*, *Xylocarpus mekongensis,* and *Ceriops* spp. *Melaleuca* spp. may be present. The foliage projective cover is more than 50%. Height may vary from 5 metres to more than 30 metres depending on the amount of fresh water available.

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* and, in far northern areas, the palm *Nypa fruticans* may occur.

Ground cover: may consist of seedlings of species present as well as the fern *Acrostichum speciosum*.

<u>Saltpan</u> (Figure 3.12)

Habitat: occurs toward the landward edge of the intertidal zone, and are hypersaline 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*).

3.2 The seagrasses

The seagrass species present may be *Cymodocea serrulata, Syringodium isoetifolium, Halodule uninervis, Thallassia hemprichii, Halophila spinulosa, Halophila ovalis, Halophila decipiens* and *Enhalus acaroides*.

<u>Sparse Seagrass</u> (Figure 3.13)
The percentage of vegetation cover on substrate is less than 10%.

<u>Medium Seagrass</u> (Figure 3.14)
The percentage of vegetation cover on substrate is between 10% and 50%.

<u>Dense Seagrass</u> (Figure 3.15)
The percentage of vegetation cover on substrate is between 50% and 100%.

Figure 3.2 A closed *Rhizophora* community near the Normanby River mouth, Princess Charlotte Bay

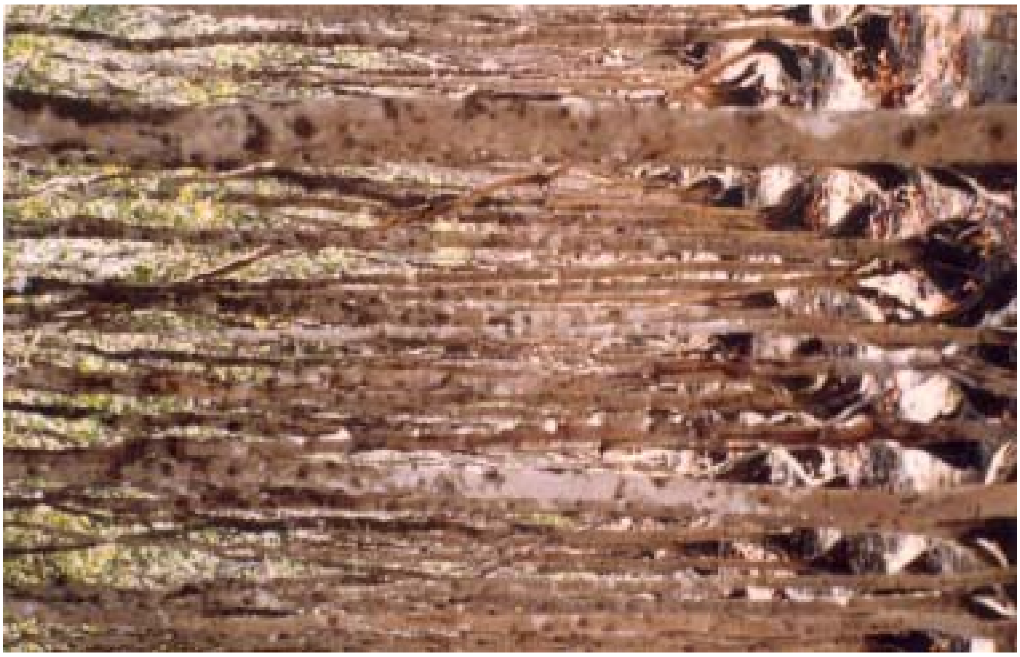


Figure 3.3 A closed *Ceriops* community near the Normanby River mouth, Princess Charlotte Bay

Figure 3.4 An open *Ceriops* community at Temple Bay

Figure 3.5 A closed *Avicennia* community near the South Mitchell River mouth

Figure 3.6 An open Avicennia community near the Claudie River

Figure 3.7 A closed *Rhizophora/Ceriops* community near the Starke River

Figure 3.8 A closed *Avicennia/Ceriops* community in the Lockhart River delta

Figure 3.9 An open *Avicennia/Ceriops* community near the Escape River

Figure 3.10 An open landward rim community near the Jardine River

Figure 3.11 A closed mixed community on the Nassau River

Figure 3.12 A saltpan community on the Nassau River

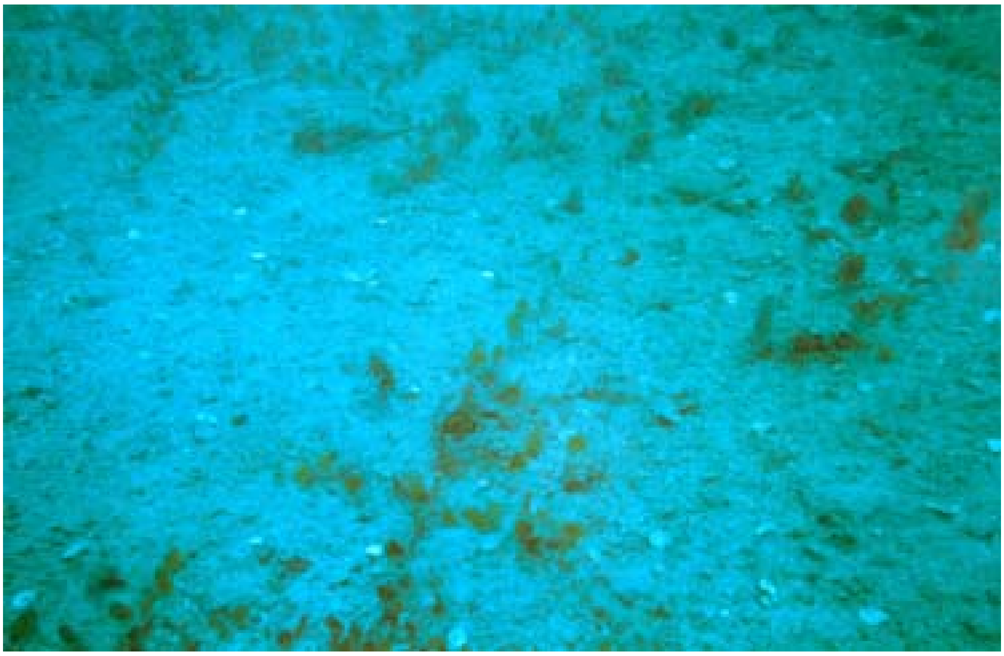


Figure 3.13 A sparse seagrass community near Lizard Island

Figure 3.14 A medium seagrass community in Orford Bay

Figure 3.15 A dense seagrass community near Green Island

4.0 DESCRIPTION OF THE GIS DATA

4.1 Digital data

Appendix 4 contains printouts of the digital files which are attached to the digital GIS data. MARVEG.RME describes the data and how to display it, and MARVEG.CND contains the conditions of use for the data. MARVEG.QAL is the data quality information, and MARVEG.DCT is the data dictionary describing the classes of marine vegetation.

Mapping Region	Coverage (geographicals)	Coverage (A.M.G.)
Bloomfield River to Cape Bedford (Cooktown)	cooktown_geo	cooktown_amg
Cape Bedford to Red Point (Starke, Lizard Island)	lizard_geo	lizard_amg
Red Point to Nesbit River (Princess Charlotte Bay)	pcbeast1_geo pcbeast2_geo pcbeast3_geo pcbwest_geo	pcbeast1_amg pcbeast2_amg pcbeast3_amg pcbwest_amg
Nesbit River to Bobardt Point	east_geo	east_amg
Bobardt Point to Temple Bay (Lockhart River)	lockhart_geo	lockhart_amg
Temple Bay to Cape York (Shelburne Bay, Escape River)	shelburn_geo escape_geo	shelburn_amg escape_amg
Cape York to Doughboy River (Torres Strait, Jardine River)	torres_geo jardine_geo	torres_amg jardine_amg
Doughboy River to Hey River (Port Musgrave, Weipa)	weipa1_geo weipa2_geo weipa3a_geo weipa3b_geo weipa4a_geo weipa4b_geo	weipa1_amg weipa2_amg weipa3a_amg weipa3b_amg weipa4a_amg weipa4b_amg
Hey River to Kendall River (Aurukun)	aurukun1_geo aurukun2_geo	aurukun1_amg aurukun2_amg
Kendall River to Balurga Creek	west_geo	west_amg
Balurga Creek to Malaman Creek	holroyd_geo	holroyd_amg
Malaman Creek to Nassau River (Mitchell River)	nassau1_geo nassau2_geo	nassau1_amg nassau2_amg

Table 4.1 The marine vegetation coverages related to the mapping regions

The directory NR06 contains all the information in ARC/INFO format. The subdirectory MARVEG contains the mangrove and seagrass community polygons in 24 separate coverages. Due to the problem in the raster to vector conversion in ARC/INFO Rev 6 of reaching more than 10 000 arcs per polygon several coverages had to be split. These split coverages bear the same name but their parts are numbered.
All coverages are projected in both geographicals (_geo) and the Australian Map Grid (_amg). The projection files (amg542geo.prj, amg552geo.prj, geo2amg54.prj and geo2toamg55.prj) have been included should one projection be deleted. Forty-five

megabytes of disk space are required for these coverages (see Appendix 5 for individual sizes). Table 4.1 shows which marine vegetation coverages represent the mapping areas described in 5.2 - distribution of the marine vegetation by mapping regions.

For displaying the marine vegetation classes in detail Landsat Thematic Mapper band 3 (visible red) has been provided as a background. The subdirectory TMBAND3 contains segments of Landsat Thematic Mapper band 3 (visible red) imagery in GRID format which have been projected to AMG. One hundred and forty megabytes of disk space are required for these coverages (see Appendix 5 for individual sizes). Table 4.2 displays which marine vegetation coverages overlay on the TM Band 3 imagery.

TM Band 3 Grid Coverage	**Marine Vegetation Coverage**
cooktowngr_a	cooktown_amg
lizardgr_a	lizard_amg
pcbeastgr_a	pcbeast1_amg pcbeast2_amg pcbeast3_amg
pcbwestgr_a	pcbwest_amg
eastgr_a	east_amg
lockhartgr_a	lockhart_amg
shelburngr_a	shelburn_amg
escapegr_a	escape_amg
torresgr_a	torres_amg
jardinegr_a	jardine_amg
weipagr_a	weipa1_amg weipa2_amg weipa3a_amg weipa3b_amg weipa4a_amg weipa4b_amg
aurukungr_a	aurukun1_amg aurukun2_amg
westgr_a	west_amg
holroydgr_a	holroyd_amg
nassaugr_a	nassau1_amg nassau2_amg

Table 4.2 The marine vegetation coverages related to the TM band 3 grid coverages

The subdirectory COAST_GEO is the AUSLIG coastline data projected to geographicals.

4.2 Hard copy products

Maps of the coloured marine vegetation polygons overlayed on a black and white background of Landsat TM band 3 imagery are available produced at 1:100 000 scale from the author. These are plotted on A3 sheets for easy reproduction by colour laser copying.

5.0 DISTRIBUTION OF THE MARINE VEGETATION

5.1 General distribution for Cape York Peninsula

The mangroves and seagrasses of Cape York Peninsula occur in sheltered areas such as bays, estuaries and associated with coral reefs. Table 5.1 displays the area for each marine vegetation community for the whole of the CYPLUS study area, and the eastern and western sides of the Peninsula, divided by the longitude 142°30'E.

Mangroves	Area for eastern side (hectares)	Area for western side (hectares)	Total Area (hectares)
Rhizophora (closed)	23 590	21 570	45 160
Ceriops (closed)	3 860	6 770	10 630
Ceriops (open)	2 870	2 340	5 210
Avicennia (closed)	1 140	13 710	14 850
Avicennia (open)	320	3 070	3 390
Rhizophora/Ceriops (closed)	640	1 770	2 410
Avicennia/Ceriops (closed)	1 160	260	1 420
Avicennia/Ceriops (open)	5 660	900	6 560
Landward Rim (open)	370	320	690
Mixed (closed)	3 700	9 300	13 000
Saltpan	39 770	61 490	101 260
Total	**83 080**	**121 500**	**204 580**
Seagrass	**Area for eastern side (hectares)**	**Area for western side (hectares)**	**Total Area (hectares)**
Sparse	74 170	6 370	80 540
Medium	74 890	2 040	76 930
Dense	61 100	8 040	69 140
Total	**210 160**	**16 450**	**226 610**

Table 5.1: Marine vegetation community areas for the whole CYPLUS region, and the eastern and western sides divided by the longitude 142°30'E

The general pattern for mangroves on the eastern side of Cape York was strong zonation with closed *Rhizophora* communities fringing the waterways and protected foreshores, closed *Ceriops* communities immediately landward, open *Ceriops* and *Avicennia/Ceriops* communities behind, and a narrow saltpan between the mangroves and the terrestrial vegetation. Due to the generally hilly terrain, there was often only a narrow saltpan between the mangroves and the terrestrial vegetation. An exception to this is Princess Charlotte Bay where the saltpans were extensive, and dotted with slightly elevated areas covered with grass and the occasional palm (*Corypha elata*).

Major mangrove communities occurred in the Endeavour River, the Starke region, Princess Charlotte Bay, Lockhart River, Temple Bay, Shelburne Bay and Newcastle Bay. Extensive seagrass beds occurred in the shallow waters off the Starke region, and in Bathurst, Princess Charlotte and Shelburne Bays.

The hilly Torres Strait islands were generally fringed with *Rhizophora* communities with *Avicennia* and *Ceriops* communities behind. This study did not map the seagrass beds in the Torres Strait north of 10°40'S as these have been mapped by CSIRO. The seagrass beds were distributed around the coasts of the islands, on reef flats and in the lagoons of atolls and reefs, as well as in the shallow open waters of the north-western Torres Strait (Williams 1994).

On the western side of Cape York Peninsula the mangrove zonation pattern was similar except that *Avicennia* started to invade all communities. On the north-western side, mangroves rarely occurred on the foreshore of the Gulf of Carpentaria but in rivers and estuaries that run almost parallel to the coast. Extensive mangrove communities occurred in Port Musgrave, Albatross Bay (Weipa) and Archer Bay (Aurukun). These Bays also supported seagrass beds.

South of Aurukun the communities were either *Avicennia* dominated or mixed. *Rhizophora* communities diminished in depth, and as far south as the Nassau River were restricted to fringing the waterways in bands only several plants deep, thus not mappable units in this study. The Mitchell and Nassau Rivers contained large areas of *Avicennia* and mixed communities. Just to the north of the Mitchell River pure *Avicennia* communities started to line the foreshore. With the flat terrain on the south-western side of Cape York Peninsula saltpans mixed with grasslands and extended for kilometres inland. No seagrass beds were identified in this area.

The general seagrass zonation for the Cape York region consisted of a shallow zone less than 6 metres deep with all species present. Between 6 and 11 metres, the pioneering *Halophila* and *Halodule* species were the most frequently sampled seagrasses. Deeper than 11 metres, only *Halophila* species were common (Lee Long *et al.* 1993).

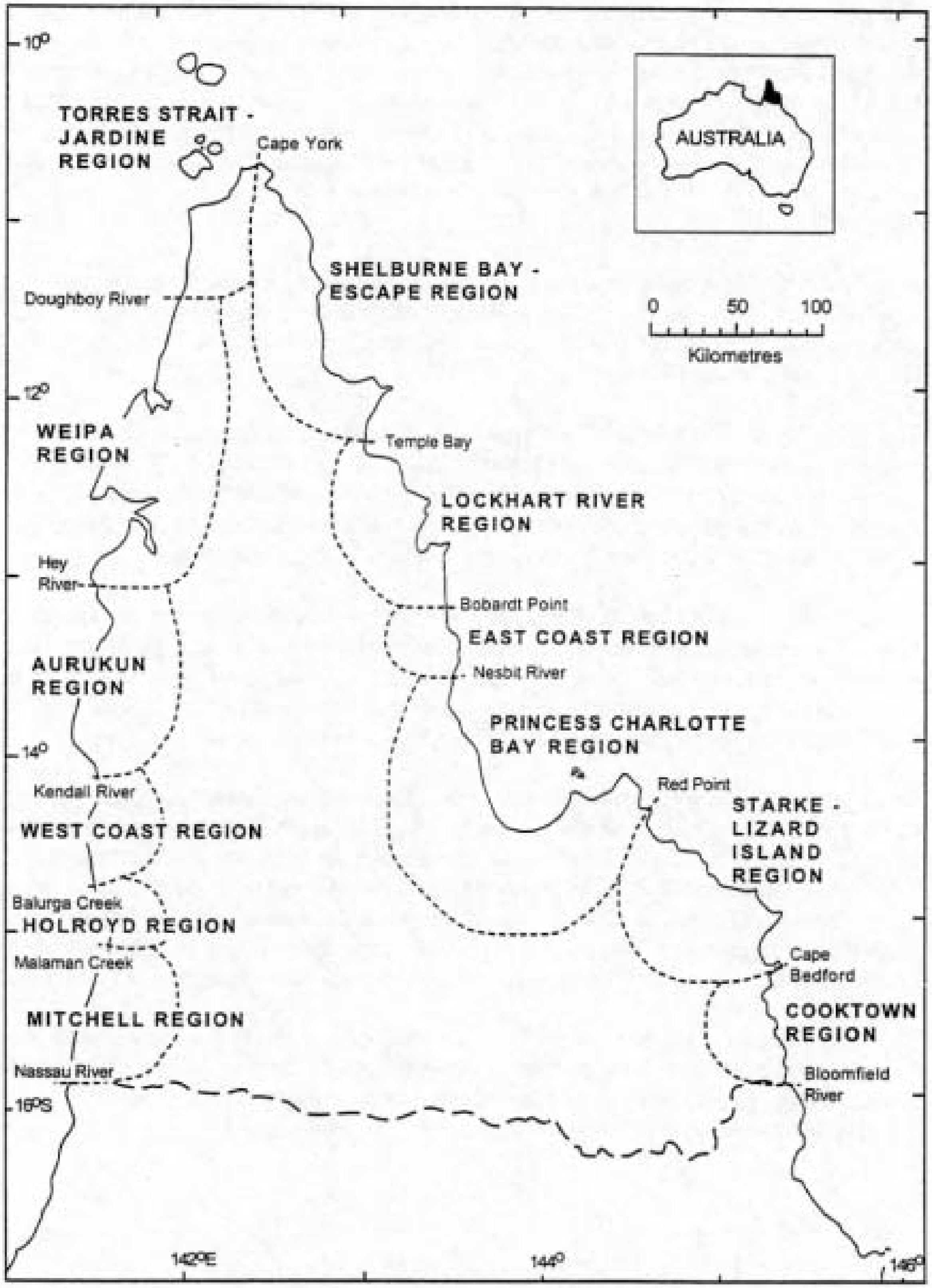


Figure 5.1 The mapping regions of the study

5.2 Distribution of the marine vegetation by mapping regions

Figure 5.1 displays the study area divided into the mapping regions.

5.2.1 Bloomfield River to Cape Bedford - 15°S to 16°S (Cooktown Region)

Community comments. In this region the forested Great Dividing Range lies close to the sea, with coastal plains dominated by the paths of rivers. Thus the main mangrove communities are in the sheltered estuarine areas of the Endeavour River and the Annan River. The Endeavour River communities are very mixed, with significant communities containing less salt tolerant mangroves such as *Bruguiera* spp. and *Heritiera littoralis*. These communities form a continuum with terrestrial vegetation. Surprisingly mangrove communities occur exposed to the south-easterly wind on the foreshore around Thomas Point, only protected by a fringing reef. *Rhizophora* communities occur at the seaward edge with a zone of *Ceriops* dominated communities behind. The Hope Islands, which have a coral cay with a *Rhizophora* dominated community, are the only islands populated by mangroves in this area.

In these exposed waters only small patches of seagrass have been recorded in sheltered bays.

Mangroves	**Area (hectares)**
Rhizophora (closed)	450
Ceriops (closed)	270
Ceriops (open)	320
Avicennia (open)	30
Rhizophora/Ceriops (closed)	400
Avicennia/Ceriops (open)	90
Mixed (closed)	240
Saltpan	620
Total	**2420**
Seagrass	**Area (hectares)**
Medium	90
Dense	140
Total	**230**

Table 5.2 Marine vegetation community areas for Bloomfield River to Cape Bedford

Mapping comments. The Landsat data processed was scene 96/71 captured on 17 September 1986. This was mid dry season and the approximate tide phase was high. No field data was gathered in this area as no access was allowed to land occupied by the Hopevale community. Cloud affected small areas of the Endeavour River estuary.

5.2.2 Cape Bedford to Red Point - 14°30'S to 15°S (Starke, Lizard Island Region)

Mangroves	**Area (hectares)**
Rhizophora (closed)	3 770
Ceriops (closed)	450
Ceriops (open)	480
Avicennia (closed)	20
Avicennia (open)	200
Rhizophora/Ceriops (closed)	240
Avicennia/Ceriops (open)	2 470
Saltpan	4 860
Total	**12 490**
Seagrass	**Area (hectares)**
Sparse	56 530
Medium	68 710
Dense	18 770
Total	**144 010**

Table 5.3 Marine vegetation community areas for Cape Bedford to Red Point

Community comments. North of the heath sand dune country around Cape Flattery, the woodland covered coastal plain is interrupted with a series of headlands. Large mangrove communities occur in bays sheltered from the prevailing south-easterly winds such as in the Starke and Murdoch Point regions. The foreshore and major waterways are generally *Rhizophora* dominated with communities of *Ceriops* and *Avicennia* behind. Extensive saltpans then occur towards the landward edge. The only system with a well developed estuary is the McIvor River. *Rhizophora* dominated communities occur on the numerous continental islands and coral cays that are sheltered from high energy wave action by the outer edge of the Great Barrier Reef.

Sheltered by the Great Barrier Reef, seagrass beds occur across much of the continental shelf between Lookout Point and Barrow Point, even at depths of more than 10 metres. Seagrass also occurs on some of the inner reef platforms.

Mapping comments. The Landsat data processed was scene 96/70 captured on 28 August 1986. This was mid dry season and the approximate tide phase was 2 hours before high. Several intertidal areas and offshore islands were affected by scattered cloud and shadow on the Landsat image such as Lizard Island, Newton Island, between Cape Bowen and Red Point, Murdoch Point, and the Starke region. The Starke region was also affected by cloud on the aerial photography. No access was allowed to land occupied by the Hopevale community to collect field data.

5.2.3 Red Point to Nesbit River - 13°30'S to 14°30'S (Princess Charlotte Bay Region)

Community comments. Around the boulder covered hills of Cape Melville and west past the Bathurst Range lie the extensive plains of Princess Charlotte Bay region. Protected from the prevailing south easterly winds, this one of the largest tidal wetland systems in Cape York Peninsula with meandering rivers cutting through extensive saltpans and grasslands. Here the foreshore is lined by magnificent stands of *Rhizophora* up to 30 metres in height. Closed mixed communities occupy the meanders of the Marrett, Normanby, Bizant, North Kennedy and Annie Rivers. Also in the riverine areas, behind the mixed communities occur grasslands with scattered *Avicennia marina* and *Excoecaria agallocha*, mixed with terrestrial species. The extensive saltpans are dotted with rises containing grass with palms (*Corypha elata*) and sometimes landward mangrove (*Excoecaria*, *Lumnitzera*) communities.

As the coastline turns north again tidal wetlands occur on almost the whole coastal plain to Nesbit River. As elsewhere due to exposure to the south-easterly winds, the mangroves rarely occur on the foreshore but are behind a dune, which may sometimes contain terrestrial vegetation. These tidal communities are generally fed by waterways which run parallel to the coastline. Closed *Rhizophora* communities dominate the most frequently inundated waterways with a mixed *Avicennia/Ceriops* community between them and large areas of saltpan. The two rivers in this area, the Stewart and the Nesbit, have only small estuarine areas. Also along this coastline are numerous wetland areas which would receive fresh water in the wet season as well as infrequent tidal inundation, making these hypersaline during the dry season. Here, waterways dissect slightly elevated land which often contains a rim of mixed *Avicennia marina, Excoecaria agallocha, Lumnitzera* spp. and terrestrial *Melaleuca* and *Acacia* spp.

Rhizophora dominated communities occur on continental islands of the Flinders Group and on numerous coral cays that are sheltered from high energy wave action by the outer edge of the Great Barrier Reef.

Seagrass communities are extensive in the sheltered waters of Ninian Bay and Bathurst Bay, and fringe the shore in the south-east of Princess Charlotte Bay. There are also extensive beds between Frenchmans Reef and Claremont Point, despite exposure to prevailing winds and wave action.

Mangroves	Area (hectares)
Rhizophora (closed)	3 020
Ceriops (closed)	490
Avicennia (closed)	1 030
Avicennia (open)	40
Avicennia/Ceriops (closed)	580
Avicennia/Ceriops (open)	1 750
Landward Rim (open)	370
Mixed (closed)	2 570
Saltpan	32 180
Total	**42 030**
Seagrass	**Area (hectares)**
Sparse	10 330
Medium	3 850
Dense	32 360
Total	**46 540**

Table 5.4 Marine vegetation community areas for Red Point to Nesbit River

Mapping comments. The Landsat data processed was scene 97/70 captured on 21 October 1987. This was late dry season and the approximate tide phase was high tide. The limits of intertidal areas within Princess Charlotte Bay were very difficult to determine. The aerial photography did not cover all the intertidal areas and was of poor quality (very washed out). Field visits showed that it was not uncommon for mangrove species to mix with terrestrial species, particularly towards the landward edge. *Excoecaria agallocha* (deciduous) was observed to be almost leafless at the end of the dry season (November), which was similar to when the satellite image was taken. This would definitely give seasonal variation to the spectral signature of this mangrove.

5.2.4 Nesbit River to Bobardt Point -13°10'S to 13°30'S

Community comments. Forested mountain ranges run close to the coast for all of this region but there is a coastal plain with very few headlands. Due to exposure to the south-easterly winds, the mangroves rarely occur on the foreshore but are behind a dune, which may sometimes contain terrestrial vegetation. These tidal communities are generally fed by waterways which run parallel to the coastline. Closed *Rhizophora* communities dominate the most frequently inundated waterways with mixed *Avicennia/Ceriops* communities landward between them and large areas of saltpans . Also along this coastline are repeated occurrences of wetlands which would receive fresh water in the wet season as well as infrequent tidal inundation, making them hypersaline during the dry season. Here, waterways dissect slightly elevated land which often contains a rim of mixed *Avicennia marina, Excoecaria agallocha, Lumnitzera* spp. and terrestrial *Melaleuca* and *Acacia* species. *Rhizophora* dominated communities occur on several coral cays that are sheltered from high energy wave action by the outer edge of the Great Barrier Reef.

Inshore seagrass beds sheltered by fringing reefs occur for almost this whole coastline.

Mangroves	**Area (hectares)**
Rhizophora (closed)	370
Ceriops (open)	120
Avicennia (closed)	40
Avicennia/Ceriops (closed)	50
Avicennia/Ceriops (open)	10
Saltpan	390
Total	**980**
Seagrass	**Area (hectares)**
Sparse	1 180
Dense	6 180
Total	**7 360**

Table 5.5 Marine vegetation community areas for Nesbit River to Bobardt Point

Mapping comments. The Landsat data processed was scene 97/69 captured on 21 October 1987. This was late dry season and the approximate tide phase was high tide. It was difficult to separate mixed mangrove/terrestrial communities from purely terrestrial communities.

5.2.5 Bobardt Point to Temple Bay - 12°20'S to 13°10'S (Lockhart River Region)

Mangroves	**Area (hectares)**
Rhizophora (closed)	7 150
Ceriops (closed)	2 020
Ceriops (open)	1 010
Avicennia (closed)	10
Avicennia/Ceriops (open)	950
Mixed (closed)	260
Saltpan	1 020
Total	**12 420**
Seagrass	**Area (hectares)**
Sparse	5 430
Medium	840
Dense	680
Total	**6 950**

Table 5.6 Marine vegetation community areas for Bobardt Point to Temple Bay

Community comments. This region is shaped by hills and headlands with the resulting bays offering shelter for large areas of mangroves. The two biggest areas are the mouth of the Lockhart River and Temple Bay. The mangroves in this region have strong zonation. *Rhizophora* dominated communities fringe the foreshore as well as major waterways. Behind them are *Ceriops* dominated communities. The saltpans between the mangrove communities and the landward edge are not as extensive as in areas further south, and sometimes do not exist.
The systems with significant fresh water input, Lockhart River, Claudie River and Pascoe River, support mixed communities containing the less salt tolerant mangroves such as *Bruguiera* spp. and *Heritiera littoralis*. Also noted in field visits to the Claudie and Lockhart River systems were stands of the mangrove palm, *Nypa fruticans*. One continental island, Lloyd Island, contains a *Rhizophora* dominated community. No coral cays had significant mangrove communities.

Isolated patches of seagrass occur in areas sheltered by bays or reefs.

Mapping comments. The Landsat data processed was scene 98/69 captured on 6 April 1988. This was late wet season and the approximate tide phase was high tide. The late wet season and high tide satellite image made freshwater wetlands hard to discriminate from tidal wetlands particularly around Lockhart River delta and then south below Cape Sidmouth. The available aerial photography did not completely cover the Lockhart

River delta or Temple Bay. Some of the runs were very washed out. Unfortunately the *Nypa* communities were too small to be mappable units in this study.

5.2.6 Temple Bay to Cape York - 10°40'S to 12°20'S (Shelburne Bay, Escape River Region)

Mangroves	**Area (hectares)**
Rhizophora (closed)	8 830
Ceriops (closed)	630
Ceriops (open)	940
Avicennia (closed)	40
Avicennia (open)	50
Avicennia/Ceriops (closed)	530
Avicennia/Ceriops (open)	390
Mixed (closed)	630
Saltpan	700
Total	**12 740**
Seagrass	**Area (hectares)**
Sparse	700
Medium	1 400
Dense	2970
Total	**5 070**

Table 5.7 Marine vegetation community areas for Temple Bay to Cape York

Community comments. From Olive River north to Escape River lies sand dune country covered with heath vegetation. Cape Grenville provides protection for Margaret Bay and Shelburne Bay, both supporting large mangrove communities. Like the region further south, the mangrove communities are zoned with *Rhizophora* dominated communities fringing the foreshore as well as major waterways. Similarly, behind them are *Ceriops* dominated communities, and then generally saltpans between the mangrove communities and the landward edge. On the exposed coast the sand dunes are drained by numerous small creeks, often containing a small *Rhizophora* dominated community at their mouths. The continental Home Islands contain *Rhizophora* dominated communities and likewise the coral cay, Bird Island.

Sheltered Newcastle Bay supports an extensive intertidal area. While the mangrove zones are similar to those further south, they contain more mixed communities. *Rhizophora* dominated communities still hug all the waterways but contain other species such as *Avicennia marina* and *Bruguiera* spp. The *Ceriops* zone behind this contains a lot of emergent *Avicennia marina*. Saltpans rarely occur in the transition to terrestrial vegetation but are present in the middle of some of the mangrove islands. Slightly elevated areas within these saltpans contain a mix of *Avicennia marina, Excoecaria agallocha, Lumnitzera* spp. and terrestrial *Melaleuca* and *Acacia* species.

Extensive areas of seagrass occur in the sheltered southern part of Shelburne and Margaret Bays. The exposed coast between Shelburne Bay and Escape River had a bottom of generally clean sand. Shallow banks of seagrass occur in the Escape River.

Mapping comments. The Landsat data processed was scene 98/68 captured on 6 April 1988. This was late wet season and the approximate tide phase was high tide. Cloud severely contaminated the satellite image from the Escape River to Cape York. Although a mangrove classification was performed there are large gaps from the cloud and shadow. Also aerial photography did not cover all of the Newcastle Bay intertidal areas. It was difficult to separate the mangrove communities from terrestrial vegetation, as often the two met with similar density vegetation. The mangrove communities on the creeks in the sand dune country were too small to be mapped.

5.2.7 Cape York to Doughboy River - 10°S to 11°30'S (Torres Strait, Jardine River Region)

Community comments. The Torres Strait Islands are large, hilly continental islands covered with woodland. Many headlands combined with fringing reefs encourage the establishment of mangrove communities. *Rhizophora* dominated communities occupy the foreshore and fringe the waterways with *Ceriops* dominated communities behind. The landward rim community (*Avicennia marina, Excoecaria agallocha, Lumnitzera* spp.) often occurs at the *Ceriops* side of the saltpans as well as at the landward side.

The Jardine River has a large area of mangrove and freshwater swamp near its mouth. In this region the boundary between tidal and non tidal is difficult to determine, with *Melaleuca* spp. observed in mangrove communities and *Rhizophora* spp. observed in *Melaleuca* forests. Isolated *Nypa* palms were observed fringing the Jardine River.

On the west facing coastline with no reefs for protection, mangrove communities do not occur on the foreshore, but in a series of inlets with little fresh water input, which run almost parallel to the coastline. The usual zones are very strong, but *Avicennia marina* plants start to mix in with the *Ceriops* communities.

Seagrass beds occur on the mainland side of the Endeavour Strait, south of Crab Island and at the mouth of the Cotterell River. No seagrass data was collected for Torres Strait during this study.

Mangroves	**Area (hectares)**
Rhizophora (closed)	5 680
Ceriops (closed)	270
Ceriops (open)	2 040
Avicennia (open)	30
Avicennia/Ceriops (closed)	260
Avicennia/Ceriops (open)	60
Landward Rim (open)	220
Mixed (closed)	530
Saltpan	1 180
Total	**10 270**
Seagrass	**Area (hectares)**
Sparse	2 810
Medium	900
Dense	1 670
Total	**5 380**

Table 5.8 Marine vegetation community areas for Cape York to Doughboy River

Mapping comments. The Landsat data processed was scene 99/67 captured on 16 June 1988. This was early dry season and the approximate tide phase was mid tide. No aerial photography was obtained for the outer islands of the Torres Strait (e.g. Moa and Badu Islands). The aerial photography over the Jardine River was very washed out. There was an overlap between tidal and freshwater communities in the Jardine area.

5.2.8 Doughboy River to Hey River - 11°30’S to 13°S (Port Musgrave, Weipa Region)

Community comments. This coastline is bordered by fairly level land covered with open *Eucalyptus* forest. Two large bays, Port Musgrave fed by the Wenlock and Ducie Rivers, and Albatross Bay fed by the Mission and Embley Rivers host large intertidal areas. *Rhizophora* dominated communities hug the foreshore and the major waterways, but the abundance of *Avicennia marina* increases, invading both the *Rhizophora* and *Ceriops* communities, and forming large communities of its own. With significant fresh water input from these river systems very complex mixed mangrove forests have established. At one field site on the Wenlock River *Rhizophora* emergents grew to 35 metres, above a mixed canopy up to 25 metres of *Avicennia marina, Bruguiera* spp., *Ceriops* spp., *Excoecaria agallocha* and *Xylocarpus mekongensis*. The understorey included *Acanthus ilicifolius, Aegiceras corniculatum, Nypa fruticans* and mixed seedlings.

Seagrass beds occur in these sheltered bays along with some coastal inlets such as the Skardon River and Pennefather River.

Mangroves	**Area (hectares)**
Rhizophora (closed)	13 700
Ceriops (closed)	6 170
Ceriops (open)	300
Avicennia (closed)	10 380
Avicennia (open)	1 740
Rhizophora/Ceriops (closed)	860
Avicennia/Ceriops (open)	730
Mixed (closed)	4 330
Saltpan	9 530
Total	**47 740**
Seagrass	**Area (hectares)**
Sparse	3 090
Medium	250
Dense	3 720
Total	**7 060**

Table 5.9 Marine vegetation community areas for Doughboy River to Hey River

Mapping comments. The Landsat data processed was scene 99/68 captured on 16 June 1988. This was early dry season and the approximate tide phase was mid tide. The aerial photography did not cover the full tidal areas of the Ducie and Wenlock Rivers. In some places the boundary between tidal and terrestrial was hard to determine, as the field visit revealed open communities of *Avicennia marina* mixed with *Melaleuca* and *Acacia* species.

5.2.9 Hey River to Kendall River - 13°S to 14°15'S (Aurukun Region)

Mangroves	**Area (hectares)**
Rhizophora (closed)	2 190
Ceriops (closed)	330
Avicennia (closed)	1380
Avicennia (open)	620
Rhizophora/Ceriops (closed)	470
Mixed (closed)	1680
Saltpan	9020
Total	**15 690**
Seagrass	**Area (hectares)**
Sparse	470
Medium	890
Dense	2 650
Total	**4 010**

Table 5.10 Marine vegetation community areas for Hey River to Kendall River

Community comments. The coastline from Albatross Bay to Archer Bay is similar to the region further north - fairly level land covered with open *Eucalyptus* forest. Archer Bay, fed by the Archer and Watson Rivers, supports a large tidal area. While *Rhizophora stylosa* still fringes the foreshore and the waterways, the depth of this zone has become much narrower, with *Ceriops* communities mixing in. Landward of this are *Avicennia* communities, then saltpans. *Avicennia marina* plants often mix in with both the *Rhizophora* and *Ceriops* communities. In riverine conditions, mixed communities occur of *Avicennia marina* and *Excoecaria agollocha* with *Melaleuca* spp. These give way to pure *Melaleuca* communities. In the wide sandy channels of the Archer River, mangrove communities are dominated by *Avicennia marina*.

South of Archer Bay the coastal plain becomes very flat supporting large areas of grass, but with wooded dunes on the foreshore. The Love and Kirke Rivers form large saline lakes with extensive saltpans around. The Love River supports communities of *Rhizophora* and *Avicennia*, but the saline Kirke River only supports small communities of *Avicennia*. The Kendall River has mixed communities of *Avicennia*, *Rhizophora* and *Ceriops*.

Major seagrass beds occur in the sheltered inlets of Archer Bay, Love River and Kirke River.

Mapping comments. The Landsat data processed was scene 99/69 captured on 16 June 1988. This was early dry season and the approximate tide phase was mid tide. The aerial photography did not cover the full tidal areas of the Watson and Archer Rivers. Terrestrial vegetation mixed with mangroves on many river islands. No field data was collected for this region south of the Love River.

5.2.10 Kendall River to Balurga Creek - 14°15'S to 14°45'S

Community comments. The coastal plain is very level supporting grassland and low open *Melaleuca* woodland. There are no major rivers in the area, only a few small creeks with small catchment areas, hence little regular fresh water input during the dry season. The coastal plain would receive freshwater flooding during the wet season. The small creeks are lined narrowly with *Avicennia marina* dominated communities.

No seagrass beds were observed during the dive and boat survey or were visible on the aerial photography.

Mangroves	**Area (hectares)**
Saltpan	1 580
Total	**1 580**

Table 5.11 Marine vegetation community areas for Kendall River to Balurga Creek

Mapping comments. The Landsat data processed was scene 99/70 captured on 21 March 1991. This was late wet season and the approximate tide phase was high tide. This was only a small area which covered a gap between adjacent Landsat scenes. There was substantial fresh water flooding on the coastal plains which contain some saltpans probably inundated during the highest spring tides. The luxurious growth of freshwater grass and reeds in the intertidal areas meant that these areas could not be spectrally separated from terrestrial grass. They have not been mapped as saltpans, the area measurement above being an understatement. There were mangrove fringes on the small creeks (*Avicennia marina* dominated), but most of these have proved not to be "mappable units" and have hence disappeared in the cartographic process. Due to mechanical problems with the helicopter no field data was gathered in this region.

5.2.11 Balurga Creek to Malaman Creek - 14°45’S to 15°S

Community comments. This flat terrain is covered by grassland and low open *Melaleuca* woodland. Along the coast run dune systems which support woodland. These dune systems are dissected with drains that receive fresh water inundation during seasonal flooding and tidal inundation during highest tides. In some places shifting sands may cut off pools from tidal flooding, and in the short term, the landward type mangrove plants such as *Avicennia marina, Excoecaria agallocha* and *Lumnitzera* spp. remain.

Zonation still occurs in the mangrove communities, but on a much smaller scale. *Rhizophora* communities may fringe the waterways but can be only 2 to 3 plants wide. In riverine areas the communities are mixed but tend to be *Avicennia marina* dominated. In this region pure *Avicennia* communities start to line the foreshore but are not continuous.

No seagrass beds were observed during the dive and boat survey or were visible on the aerial photography.

Mangroves	**Area (hectares)**
Avicennia (closed)	630
Avicennia (open)	60
Saltpan	6 990
Total	**7 680**

Table 5.12 Marine vegetation community areas for Balurga Creek to Malaman Creek

Mapping comments. The Landsat data processed was scene 98/70 captured on 6 April 1988. This was late wet season and the approximate tide phase was high tide. The late wet season Landsat image showed freshwater flooding in tidal areas. The image also had scattered cloud that covered some intertidal areas. The aerial photography did not cover the limits of the intertidal areas. No field data was collected north of Pormpuraaw due to mechanical problems with the helicopter.

5.2.12 Malaman Creek to Nassau River - 15°S to 16°S (Mitchell River Region)

Community comments. This region is dominated by grass covered coastal plains. The terrain is so level that tidal saltpans mix with the grasslands and extend for kilometres inland. Zonation occurred to some extent in the mangrove communities but at a much smaller scale. *Rhizophora* communities generally fringe the creeks but are only 1-5 plants wide. In riverine areas very mixed communities occur containing *Rhizophora*, *Bruguiera*, *Ceriops*, *Xylocarpus mekongensis*, *Avicennia*, *Aegialitis*, and *Agiceras* and are generally less than 10 metres tall. The club mangrove *Aegialitis* which is usually only 0.5 to 2 metres in height was observed on several occasions to be growing more than 5 metres tall. Directly landward of these communities, bands of grass (*Sporobolus virginicus*) occur and then saltpans. Pure closed *Avicennia* communities line parts of the foreshore.

The terrestrial land adjacent to the intertidal zone is very infested with the noxious weed, rubbervine (*Cryptostegia grandiflora*). Isolated rubbervine plants, obviously with considerable salt tolerance, are occuring in the landward rim communities.

No seagrass beds were observed during the dive and boat survey or were visible on the aerial photography.

Mangroves	**Area (hectares)**
Avicennia (closed)	1 320
Avicennia (open)	620
Rhizophora/Ceriops (closed)	440
Avicennia/Ceriops (open)	110
Landward Rim (open)	100
Mixed (closed)	2 760
Saltpan	33 190
Total	**38 540**

Table 5.13 Marine vegetation community areas for Malaman Creek to Nassau River

Mapping comments. The Landsat data processed was scene 98/71 captured on 21 May 1987. This was early dry season and the approximate tide phase was mid tide. The available aerial photography did not cover the upper tidal limits. No access was allowed to land occupied by the Kowanyama community which included the whole Mitchell River Delta. Extensive dieback in *Avicennia* communities was observed by helicopter on the Mitchell River Delta which has occurred since the Landsat scene and aerial photography were collected.

6.0 DISCUSSION

6.1 Comparison of the eastern and western sides of Cape York Peninsula

As Cape York Peninsula is such a huge area supporting a range in environmental conditions it is no surprise that it supports a variety of coastal vegetation habitat types. Major intertidal vegetation composition by latitude along the eastern and western coasts is shown in Figure 6.1.

Duke (1992) reports up to 36 mangrove species on the eastern side of Cape York Peninsula and up to 20 on western side. Smith and Duke (1987) found that the following factors impact upon mangrove species richness in north eastern Australia. Increasing temperatures lead to greater species richness. Species richness decreases with increasing tidal amplitude. Estuaries which are long and have large catchments tend to have more species than estuaries which are shorter and have small catchments. High inter-annual rainfall variability and frequency of cyclones tends to decrease species richness.

This study has confirmed that the mangrove communities on the south-western side of the Peninsula were generally not as tall, with lower basal areas but higher stem density than those elsewhere. Rainfall and freshwater runoff appear to be the major determinants of community structure (height, density, and biomass accumulation). Complex communities, characterised by tall canopies, high basal areas, and low stem densities are common in wet, high rainfall areas. The least complex communities are in arid regions with high stem density, but low in species richness, height, and basal areas (Smith 1992).

The number of vertical strata in the mangrove communities was usually only one: the main canopy. This was the case in the majority of field sites. Corlett (1986) states that understoreys do occur, mainly in areas with abundant year-round rainfall and freshwater runoff. This could explain the presence of understoreys at field sites such as the Wenlock River. The competition for resources such as light and the even age of plants explain why the plants in a community are fairly uniform in height.

The results of the mapping show that saltpans tend to be more abundant in areas of level terrain. This is apparent in the Princess Charlotte Bay region on the east coast and also on the south-western side of the Peninsula. Both of these regions support large areas of the mixed mangrove community. The frequency and duration of tidal inundation are the most obvious parameters which vary across the intertidal zone and thus influence zonation. Lower intertidal areas are inundated much more frequently than high intertidal areas and thus vary in soil salinity and degree of soil waterlogging (Smith 1992). In intertidal areas with flat terrain there is little variation in tidal inundation and distinct zones or communities have not established.

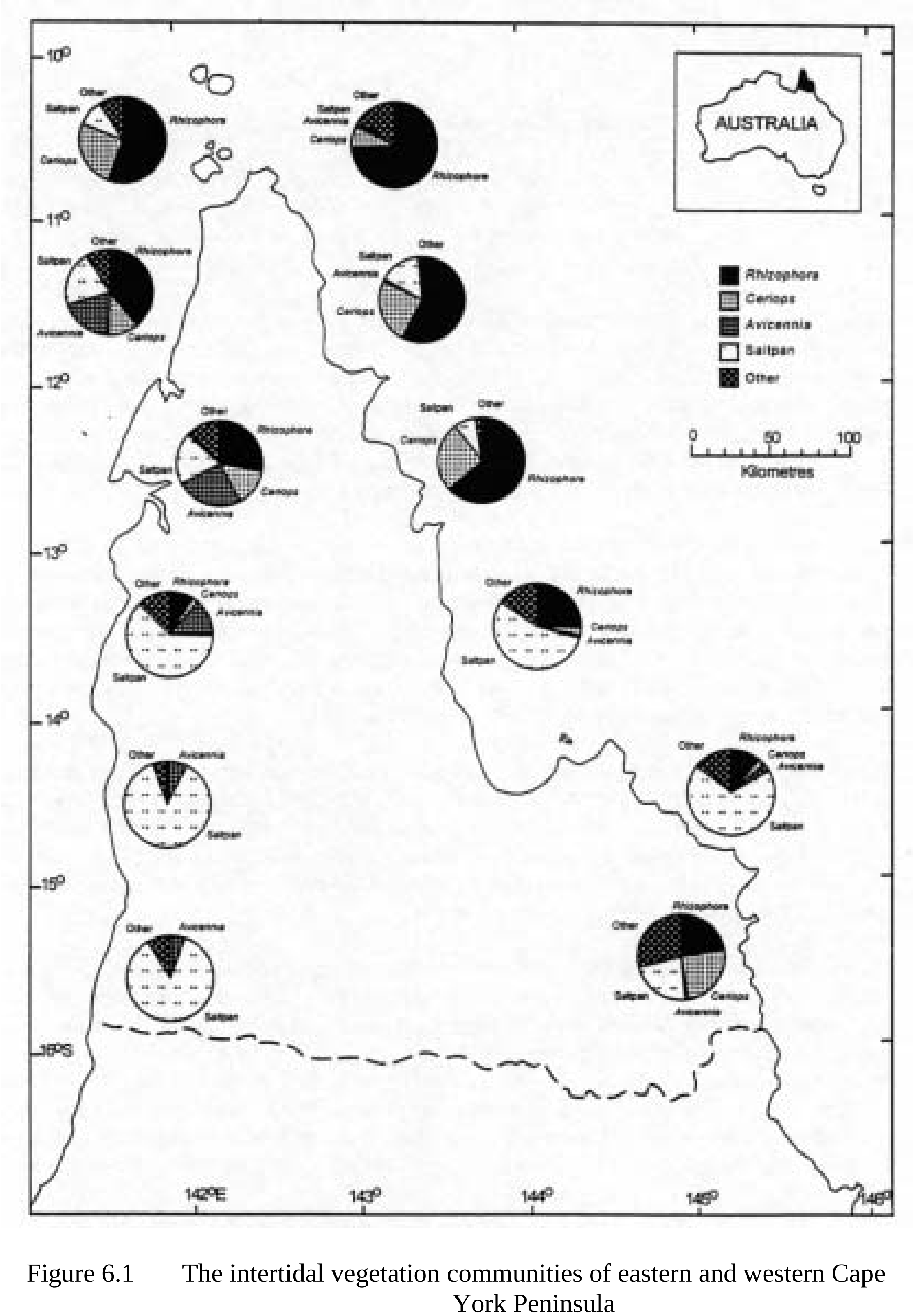


Figure 6.1 The intertidal vegetation communities of eastern and western Cape York Peninsula

One obvious difference between the eastern and western sides of the Peninsula is the dominance of *Rhizophora* communities on the eastern side, and its almost absence on the south-western side with *Avicennia* dominating. *Ceriops* communities are also less common. The south-western side of the Peninsula is subject to quite different environmental conditions from the eastern side. Average rainfall is lower, especially in the dry season, and tidal patterns are influenced by the diurnal tide of the southern Gulf of Carpentaria. Wells (1983), however, believes that the main reason for the variation in mangrove communities is that the prevailing south-east trade winds blow across hot dry land towards the south-western side of the Peninsula during the dry season. These drying winds cause seasonal aridity and thus limit the establishment of the mangrove species with more humid climatic requirements.

Another difference observed between the eastern and western sides of the Peninsula is that on the eastern side mangroves are common on the foreshore. On the western side (excluding the major bays of Port Musgrave, Albatross Bay and Archer Bay) this does not occur north of approximately 15°S near Malaman Creek. The heavily embayed eastern coastline offers more protection from high energy waves as well as the greater protection offered by the Great Barrier Reef.

From field observations it is obvious that the sea and land interface varies enormously for Cape York Peninsula. It would appear that the clearest boundaries are in areas where the gradient of the slope is steeper. In areas of level terrain under certain weather conditions tidal surges can occur allowing mangrove plants to establish above the mean high water spring tide mark.

The zonation patterns of seagrass habitat were mostly related to depth zonations (Lee Long *et al.* 1993). Depth zonation patterns were influenced by the tidal range and levels of exposure, turbidity and salinity (Coles *et al.* 1987). Lee Long *et al.* (1993) found that seagrass beds dominated by *Enhalus acoroides*, which were common in shallow, sheltered sites in the Gulf of Carpentaria (Poiner *et al.* 1987) and in the Torres Strait (Bridges *et al.* 1982), were not common on the eastern coast. Open-coastline communities typical of the western Gulf of Carpentaria, where *Halophila ovalis* and *Halodule uninervis* dominate intertidally and *Cymodocea serrulata* and *Syringodium isoetifolium* dominate subtidally (Poiner *et al.* 1987), were mostly found on parts of the eastern coast where there was less freshwater runoff from coastal rivers.

6.2 Effectiveness of the mapping

The Cape York Peninsula region contains one quarter of Queensland’s coastline. Inaccessible for five months of the year during the wet season by land, and with persistent wind all year round limiting sea access, the collection of ecological information is difficult. Also to overcome is the inhospitable nature of mangrove communities (e.g. tides, crocodiles and wild pigs) and seagrass communities (tides, strong wind, turbidity, crocodiles, sea snakes and sharks).

For the mangrove communities, remotely sensed information (satellite imagery and aerial photography) verified with ground truthing by helicopter proved to be the most cost effective way to collect information. Remote sensing currently has some limitations. Particularly relevant to Cape York Peninsula is its inability to penetrate cloud, but the technology continues to improve. With the Landsat satellite able to revisit every sixteen days there exists a cloud free data set for most of the region. New satellites collecting reflected radar information are able to penetrate cloud and may be of use in the future.

There are some typical mangrove zones (or communities) which have been identified by many authors, e.g. Macnae (1967), Davie (1985) and Bunt (1978), which do not fall within the classification used in this study. Some examples of these are the seaward *Sonneratia* fringe, *Bruguiera* communities and *Nypa* stands. While these communities do occur within Cape York Peninsula 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. Narrow fringes of *Rhizophora* spp. particularly on the western side of the Cape, are not given separate status for this reason. Due to similar foliage, *Bruguiera* communities cannot be easily separated from *Rhizophora* communities, from satellite imagery, aerial photography or even from helicopter.

The grass communities that receive some tidal inundation on the spring tides (containing species such as *Sporobolus virginicus*) could not be separated from terrestrial grass communities and so have been excluded from the tidal vegetation classification for this study. Occasionally towards the landward zone, *Avicennia* communities were confused with adjacent terrestrial vegetation. The field observations revealed that tidal and freshwater communities sometimes overlap with no clear boundary. However if mangrove plants dominate the overlapping community it was included as tidal vegetation.

The seagrass surveys used in this project did not always precisely define the seaward limit, but it is unlikely that dense seagrass beds would be found at depths greater than 30 metres (Lee Long *et al.* 1993). Studies have found that seasonal (Mellors *et al.* 1993) and year-to-year (Poiner *et al.* 1989) changes in seagrass distribution and abundance in the northern Australia region can be large.

It is important to point out that the mapping of the marine vegetation communities is a composite snap shot in time but it does provide baseline information. As remote sensing and GIS technologies improve, successful monitoring of community changes will be possible.

6.3 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. 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).

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 $\pm$ 0.14 (75)	25.3 $\pm$ 20.4 (94)	Moreton Bay	Morton (1990)
Rhizophora (subtropical)	0.05 $\pm$ 0.01 (61)	2.01 $\pm$ 0.30 (80)	Tin Can Bay	Halliday (*pers. comm.*)
Rhizophora, Ceriops, Avicennia (tropical)	3.5 $\pm$ 2.4 (<6)	10.9 $\pm$ 4.5 (<36)	Townsville	Robertson and Duke (1990)

Table 6.1 Comparison of fish density and standing crop for studies of fish within mangrove communities along the east coast of Australia

Table 6. 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 subtropical areas but the fish were currently of little direct economic importance in Australia. However they may 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. Fish may be reluctant or unable to enter the *Rhizophora* communities due to the complex root structure. *Avicennia* communities are more open (Halliday *pers. comm.*).

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 6.2 Comparison of studies determining the primary production of mangroves as leaf litter

Table 6.2 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 (Halliday *pers. comm.*). However, as *Rhizophora* is the dominant community for all but the south-western side of the Peninsula, it would be exporting a greater volume of leaf litter for fisheries production in adjacent waters.

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 leaf litter (Hutchings and Saenger 1987), and the temporal nature of seagrass beds (Mellors *et al.* 1993, Poiner *et al*. 1989) make quantification 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.

6.4 Importance of the marine vegetation data set

The collection of this baseline information on marine vegetation is an important first step in managing these habitats and for maintaining the integrity and sustainability of coastal zone systems and fisheries stocks. The first stage is to ensure that representative fisheries habitats are protected.

The mangrove system is not closed, but exports materials to estuaries and is influenced by adjacent marine and terrestrial vegetation communities (Hutchings and Saenger 1987). Seagrass systems too are influenced by adjacent marine and terrestrial communities. With this in mind it is important that this data set and the CYPLUS GIS are used to consider the protection of and land use strategies applied to land adjacent to important fisheries habitat.

Now that the baseline information is collected it will be possible to monitor temporal changes. The extent of temporal and spatial variability of seagrass beds could have far-reaching consequences for juvenile-prawn biology (Lee Long *et al*. 1993) as well as important effects on dugong and turtle biology (Lanyon *et al*. 1989) as adult populations remain under heavy exploitation or in low numbers. Mangrove communities too, can be monitored to determine if they are naturally increasing or decreasing, or changed as a result of human impact within their catchment area.

Baseline knowledge of the mangrove and seagrass community composition and areal extent for Cape York Peninsula gained through this study will enable us to better model the relationship between marine vegetation and fisheries resources in this region.

7.0 APPLICATION OF THE DATA SET TO FISHERIES RESERVES PLANNING

7.1 Criteria for Fisheries Reserves

The purpose of Fisheries Reserves is to ensure that representative marine vegetation communities (hence representative fish habitats) receive long-term protection to ensure sustainability of dependent fisheries. The following criteria are currently used for the selection of these 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 future disturbances
6. unique features
7. protected species

In regards to the diversity of or specific habitat features, Bunt (1978) has classified the mangrove habitat environments for the eastern side of Cape York Peninsula as:

1. Island sites: e.g. the Flinders Group (Princess Charlotte Bay region)
2. Open coastal fronts: e.g. Cape Flattery to Lookout Point (Starke region)
3. Coastal flats with complex but not extensive creek drainage: e.g. Hunter Inlet (Temple Bay)
4. Small to large meandering rivers without extensive estuaries: e.g. Princess Charlotte Bay
5. Relatively directly flowing rivers within confined valleys, character of freshwater discharge variable: e.g. Nesbit (Princess Charlotte Bay region) and Pascoe Rivers (Lockhart region).
6. Rivers discharging to the sea via extensive estuaries, fresh water influence variable within the estuary and with season: e.g. Lockhart River, Jacky Jacky Creek (Escape region).

This classification can also be applied to the western side, and thus can be used to check that all representative communities can be identified.

7.2 Existing Reserves

The eastern side of Cape York Peninsula already has several wetland areas gazetted as Fish Habitat Reserves. These are in Princess Charlotte Bay, Silver Plains, Temple Bay, and Escape River. All of these Fish Habitat Reserves are bounded seaward by low water mark and landward by mean high water springs mark. There is a Fish Sanctuary at German Bar in the Princess Charlotte Bay Region. No Wetland Reserves have been declared. The western side has one Fish Habitat Reserve along the Nassau River. No Fish Sanctuaries or Wetland Reserves have been declared. See Appendix 2 for plans of the Reserves.

7.2.1 Eastern side of Cape York Peninsula

Princess Charlotte Bay Fish Habitat Reserve. The Reserve over Princess Charlotte Bay covers a large area. The mangrove communities included are closed *Rhizophora*, *Ceriops*, *Avicennia*, mixed and *Avicennia/Ceriops*. Spectacular *Rhizophora* communities grow to over 30 metres tall. Open communities such as *Avicennia/Ceriops*, the landward rim and extensive saltpans are also included. There are medium and dense seagrass beds offshore which are currently not in the Reserve. Bunt (1978) habitat environment classification 4 - small to large meandering rivers without extensive estuaries.

Silver Plains Fish Habitat Reserve. Adjoining the Princess Charlotte Bay Fish Habitat Reserve is the Silver Plains Fish Habitat Reserve. It supports closed mangrove communities of *Rhizophora*, mixed and *Avicennia/Ceriops*. It also has open communities of *Avicennia/Ceriops* and saltpans. It too has extensive dense seagrass beds outside its boundary. Bunt (1978) habitat environment classification 4 - small to large meandering rivers without extensive estuaries; and 5 - relatively directly flowing rivers within confined valleys, character of freshwater discharge variable.

Temple Bay Fish Habitat Reserve. This Fish Habitat Reserve extends up to the Olive River. The mangrove communities of the Olive River are dominated by *Rhizophora*. Also present in this Fish Habitat Reserve are less common mangroves such as *Nypa fruticans* and *Dolichandrone spathacea* (Le Cussan 1993). Temple Bay contains predominantly closed *Rhizophora* communities with both open and closed *Ceriops* communities and open *Avicennia/Ceriops* communities. Sparse seagrass beds are located below low water mark. Bunt (1978) habitat environment classification 3 - coastal flats with complex but not extensive creek drainage.

Escape River Fish Habitat Reserve. The Escape River Fish Habitat Reserve is dominated by *Rhizophora* communities with some mixed communities occurring. The area is rich in mangrove species with tall stands rivalling those seen in higher rainfall areas such as between Innisfail and Tully (Bunt 1978). Bunt (1978) habitat environment classification 6 - rivers discharging to the sea via extensive estuaries, fresh water influence variable within the estuary and with season.

7.2.2 Western side of Cape York Peninsula

Nassau River Fish Habitat Reserve. This Fish Habitat Reserve contains extensive saltpans and closed mixed, *Avicennia* and *Rhizophora/Ceriops* communities. No seagrass beds have been recorded in or near the Reserve. Bunt (1978) habitat environment classification 4 - small to large meandering rivers without extensive estuaries.

7.3 Representative habitats not currently incorporated in Fisheries Reserves

An obvious habitat omission from the current Reserves is seagrass beds occurring below the low water mark. Some protection is provided on the eastern side where these occur within the Great Barrier Reef Marine Park.

The habitat environment classification provided by Bunt (1978) highlights that representative mangrove communities such as 1 - island sites and 2 - open coastal fronts are missing from current Reserves on the eastern side of the Peninsula. Again, some protection is provided on the eastern side for islands where these occur within the Great Barrier Reef Marine Park. It is important that habitats of open coastal fronts are protected as these are uncommon in Queensland.

Most mangrove communities are currently represented in Reserves on the eastern side except for *Avicennia* communities.

The western side of Cape York Peninsula, with only the Nassau River Fish Habitat Reserve, lacks the protection of 1 - island sites, 2 - open coastal fronts, 3 - coastal flats with complex but on extensive creek drainage, 5 - relatively directly flowing rivers, and 6 - rivers discharging to the sea via extensive estuaries.

Most of the mangrove communities found on the western side are not currently represented in Reserves, e.g. *Rhizophora, Ceriops, Avicennia/Ceriops*. The north-western Cape is very species rich and includes less common mangroves such as the palm *Nypa fruticans.* The western side also supports a distinct gradation of dominance change within mangrove communities (i.e. *Rhizophora* in the north and *Avicennia* in the south) so it is important that the Reserves include different biogeographic regions.

7.4 Typical areas to be considered for potential Reserves

Reserves for Fisheries Purposes (to be known as Fish Habitat Areas in the *Fisheries Act to 1994*) may be gazetted over tidal and freshwater wetlands habitat of importance to fisheries. Discussions are under way with members of the CYPLUS NRAP Fish Fauna Survey Team (NR10) regarding Reserves for freshwater habitats. A number of tidal wetland areas considered suitable for gazettal are listed below. This list is derived using the baseline information compiled by this project and at this stage is suggestive not conclusive. Boundaries for the potential Reserves will not be determined as part of this project.

7.4.1 Eastern side of Cape York Peninsula

<u>Starke Region.</u> Protected by the Great Barrier Reef, seagrass beds occur across much of the continental shelf between Lookout Point and Barrow Point, even at depths of more than 10 metres. Seagrass also occurs on some of the inner reef platforms. This area is a very important dugong habitat (Marsh 1989). Adjacent to this are extensive mangrove communities, dominated by *Rhizophora*. Their situation is uncommon in Queensland as Bunt (1978) habitat environment classification 2 - open coastal fronts. Also present, but in small areas, are Avicennia communities which, without mixed with Ceriops, were found by this study not to be common on the eastern side of Cape York Peninsula. The land tenure is Pastoral Holdings and National Park.

Lockhart River Delta. This is a large pristine delta supporting many mangrove communities with *Rhizophora, Ceriops* and *Avicennia* communities towards the mouth. The tall stands rival those seen in higher rainfall areas such as between Innisfail and Tully (Bunt 1978). The substantial freshwater input from the Lockhart River has enabled closed mixed mangrove communities to merge with rainforest. The land tenure is Aboriginal Reserve. Bunt (1978) habitat environment classification 6 - rivers discharging to the sea via extensive estuaries, fresh water influence variable within the estuary and with season.

Margaret Bay. Sheltered from the prevailing south easterly winds Margaret Bay supports extensive seagrass beds, which vary from dense to sparse. The land tenure adjacent to this area is Permit to Occupy. Bunt (1978) habitat environment classification to adjacent coast 3 - coastal flats with complex but not extensive creek drainage.

7.4.2 Western side of Cape York Peninsula

Jardine River. The persistent flow of water from this river prevents the penetration of tidal water, thus limiting the mangroves to the mouth of the river. However the ‘Jardine Swamps’ to the south of the river must receive some tidal inundation as mixed mangrove communities occur mixed with terrestrial *Melaleuca* spp. The land tenure is Crown Reserve for Camp and Recreational Purposes. Bunt (1978) habitat environment classification 5 - relatively directly flowing rivers within confined valleys, character of freshwater discharge variable.

Crab Island. Excluding the Torres Strait Islands, this is the only offshore island on the western side of the Cape. It supports a *Rhizophora* community and is partially surrounded by both dense and sparse seagrass beds. The land tenure is Aboriginal Reserve. Bunt (1978) habitat environment classification 1 - island sites.

Doughboy River / MacDonald River / Jackson River. These rivers are well developed estuaries behind coastal dunes protecting them from the open waters of Gulf of Carpentaria. The mangrove communities present are dominated by *Rhizophora, Ceriops* and *Avicennia* spp. It is in this region that *Avicennia marina* starts to increase it presence, as compared to the eastern side. Stands of the uncommon mangrove palm *Nypa fruticans* are also present. The land tenure is Aboriginal Reserve. Bunt (1978) habitat environment classification 3 - coastal flats with complex but not extensive creek drainage.

Wenlock River. This river supports the most impressive mixed communities that I observed on the my (limited) field work in Cape York Peninsula. At one site *Rhizophora* emergents grew to 35 metres, above a mixed canopy at 25 metres of *Avicennia marina, Bruguiera* spp., *Ceriops* spp., *Excoecaria agallocha* and *Xylocarpus mekongensis*. The understorey included *Acanthus ilicifolius, Aegiceras corniculatum,* and *Nypa fruticans*. The land is under mining tenures. Bunt (1978) habitat environment classification 6 - rivers discharging to the sea via extensive estuaries, fresh water influence variable within the estuary and with season.

Kirke River. This area is located in a position of importance but unfortunately was not field checked. According to my mangrove community mapping and supported by

Stevens (1994), the western side of Cape York Peninsula is divided into two biogeographic regions at Cape Keerweer/Kirke River (roughly 14° South). This is where *Avicennia marina* increases its dominance over *Rhizophora* and *Ceriops* spp. The Kirke River includes a large tidal lake several kilometres inland which supports seagrass communities. The land tenure is Aboriginal Reserve. Bunt (1978) habitat environment classification 3 - coastal flats with complex but not extensive creek drainage.

Holroyd/Kendall Rivers. The Holroyd and Kendall Rivers (Holroyd meets the Kendall near its mouth) support a large area of intertidal land in part of the coast where water courses are not common. The area was not field checked. The land tenure is Aboriginal Reserve. Bunt (1978) habitat environment classification 6 - rivers discharging to the sea via extensive estuaries, fresh water influence variable within the estuary and with season.

Edward River. The Edward River is representative of the small rivers and creeks which dissect an almost continuous coastal saltpan in this region. The land tenure is Aboriginal Reserve. Bunt (1978) habitat environment classification 3 - coastal flats with complex but not extensive creek drainage.

Melaman Plain. This is the only open coastal front (Bunt 1978) of the CYPLUS area on the western side, and the only open coastal front to support *Avicennia* communities.

Table 7.1 shows the criteria mentioned in Section 7.1 met for these Reserve suggestions.

Potential Reserve	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Starke Region	x	x	x	x	x	x	x
Lockhart River Delta	x	x	x	x	x	x	
Margaret Bay	x	x	x	x	x	x	x
Jardine River		x	x	x	x	x	
Crab Island		x				x	
Doughboy, MacDonald and Jackson Rivers	x	x	x	x	x	x	
Wenlock River	x	x	x	x	x	x	
Kirke River	x	x	x	x	x	x	x
Holroyd/Kendall Rivers	x	x	x	x	x	x	
Edward River		x	x	x	x		
Melaman Plain		x	x			x	

Table 7.1 Application of Reserve criteria to potential Fisheries Reserves

7.5 Reserve selection and gazettal process

Areas of fisheries habitat considered of value to fisheries are investigated in detail before "Area of Interest" plans are drafted. These plans are then circulated to all relevant management agencies, fishing industry sectors, specific interest groups, local authorities, individuals and communities for consideration and provision of comments on draft boundaries. This step often also includes direct consultation to outline the implications of Reserve status and management.

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 gazettal process normally extends over a two year period.

Of note is the forthcoming fisheries legislation which provides for gazettal of Reserves (to be known as Fish Habitat Areas) over freshwater as well as estuarine/marine wetlands of importance to fisheries. The process outlined above will be used to investigate estuarine/marine wetlands (this study - NR06) and those identified by the Fish Fauna Survey (NR10), undertaken by Fisheries staff at Walkamin, North Queensland.

8.0 CONCLUSIONS

8.1 Importance of the marine vegetation of Cape York Peninsula

The marine vegetation of Cape York Peninsula region is unique and highly diverse. The region is one of the most diverse in the world for both mangroves (Duke 1992) and seagrasses (Lee Long *et al*. 1993). The region supports one of the largest areas of mangrove communities in Australia (Galloway 1982). Due to limited coastal development, the majority of communities are still pristine.

8.2 Reserves for Fisheries Purposes

While some Fish Habitat Reserves do exist on Cape York Peninsula it is clear that they do not represent all fish habitat types. The boundaries of existing reserves need to be reassessed to take into account the protection of submerged seagrass habitat, freshwater habitat, and adjacent terrestrial land.

8.3 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 Cape York Peninsula to detail greater than 1:100 000 in less than 18 months. The accuracy was greater than 80 percent. Using traditional cartographic methods, production of the thirty-five 1:100 000 maps sheets would have taken approximately 3 years to complete. The methodologies employed here saved approximately 18 months salary for one person. Digital data allows efficient storage and low cost distribution. It is also easier to update than conventional mapping and allows numerical natural resource modelling.

8.4 Cooperation through joint projects

CYPLUS set up an excellent framework to facilitate financial efficiency for individual, related projects. Due to data sharing between agencies this program saved approximately $70 000. The coordination of helicopter charter saved this project approximately $10 000.

More benefits were gained from the cooperation between the individual projects in the Natural Resources Analysis Program. This project was particularly aided by the draft vegetation maps produced by NR01 - Vegetation Mapping Project, the rectification of Landsat imagery by NR14 - Coastal Environment Geoscience Survey, and the ARC/INFO coverages produced by the GIS Teams NR07 and NR08.

8.5 Recommendations

1. That the boundaries of the existing Fisheries Reserves be reassessed, to include where possible submerged seagrass habitat, freshwater habitat, and provide protection for adjacent terrestrial land.

2. That the regions of Starke, Lockhart River delta, Margaret Bay, Jardine River, Doughboy River, MacDonald River, Jackson River, Wenlock River and Kendall River be investigated as to their potential as Fisheries Reserves.

3. That satellite remote sensing and GIS technology continue to be used as a cost effective tool for mapping and monitoring intertidal vegetation such as mangrove communities on Queensland's coast.

4. That for large projects cooperation continue to be sought with other agencies for the sharing of data.

5. That during the land-use planning process, areas of marine vegetation are recognised as wetland habitat of importance to fisheries.

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APPENDIX 1 Fisheries Reserves information

Fisheries Information Leaflet

QL92008

Reserves For Fisheries Purposes

Fish Habitat Reserve, Wetland Reserve, Fish Sanctuary

Fish Habitat Reserves, Wetland Reserves and Fish Sanctuaries are declared under Section 51 of the *Fisheries Act* for fisheries purposes.

These Reserves and Sanctuaries are part of the ongoing management of fisheries resources within Queensland. They 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 of fishing grounds for a community benefit.

Fish Habitat Reserves and Wetland Reserves and, on occasion, Fish Sanctuaries, may also be declared jointly within an area to provide integrated resource management.

Reserve and Sanctuary Lands

The Reserves and Sanctuaries include only tidal wetlands and do not include private property without the specific permission of the owner.

Whilst not limited to, these Reserves are normally declared over, bay and estuarine wetlands identified as critical to the fish and/or fisheries of a region. Within Queensland more than 80% of important fish and crustacean species depend upon and use these wetlands entirely or at some stage during their life cycle for food and habitat requirements (e.g. prawns, mud and sand crab, barramundi, whiting, flathead, bream, bass, mullet).

Reserves

Reserves, in general, are tidal crown wetlands which are important nursery and feeding grounds for the fish stocks of a region and usually also contain important recreational and commercial fishing grounds.

Sanctuaries

Sanctuaries are declared over strategic areas of extreme importance to the maintenance of fish stocks and include nursery grounds or areas from which fish stocks will migrate to replace those fished from neighbouring areas. Not normally declared over popular fishing grounds, sanctuaries may be declared near certain tourist attractions such as underwater observatories to provide protection to fish populations.

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EDFISH A Wetlands Education Project

DPI DEPARTMENT OF PRIMARY INDUSTRIES

Management

-	Fish Habitat Reserve	Wetland Reserve	Fish Sanctuary
Protect	Tidal wetlands and fish and marine products	Tidal wetlands	Fish and marine products
Allow	Access, boating, fishing by lawful line or net, crabbing by lawful dilly or pot, yabby pumping, certain public works under Permit, certain maintenance of existing facilities under Permit	Access, boating, all forms of legal fishing and bait gathering , certain public reserve purpose works under Permit, certain private or other purpose works under Permit	Access, boating
Prohibit	Alteration of tidal lands, placement or removal of material, harmful discharges, spearfishing, wormdigging, collecting activities, private benefit works, public reserve purpose and maintenance works without Permit	Alteration of tidal lands, placement or removal of material, harmful discharges,works without Permit	Fishing, crabbing, bait gathering,collecting activities
Fishing	Legal forms allowed but no spearfishing and wormdigging	Legal forms allowed	No fishing or bait gathering allowed

Fish Habitat Reserves

These Reserves offer the highest level of protection for wetlands under the *Fisheries Act* and are declared over tidal wetlands or fishing grounds considered to be core conservation areas.

Designed and managed to generally not impact upon the normal day-to-day uses of the wetlands by the community, the Reserves do not restrict boating or access, or commercial and recreational fishing, except for worm digging and spear fishing. Wetland habitat disturbances are however, severely restricted.

Dredging, filling, alteration of the habitat features and construction of facilities are prohibited except for specific Reserve purposes or certain public purposes performed under Permit. Construction of public facilities (jetties, boat ramps, etc.) and maintenance of existing facilities (public or private) may be permitted subject to conditions. Disturbances associated with the provision of such as private piled jetties or boat ramps and marinas etc. may not be permitted.

Regulations M1 of the *Fisheries Act* details the activities which may not be undertaken in a Fish Habitat Reserve without Permit (Authorisation). Section 52 of the *Fisheries Act* allows for Authorisation of only those works which are for the preservation, proper management or public enjoyment of a Reserve. (Proper management might include maintenance of existing facilities).

Wetland Reserves

These Reserves are similar to Fish Habitat Reserves, but provide a secondary level of management and protection. They are declared over wetlands or fishing grounds still of importance but not meeting the higher criteria for declaration as a Fish Habitat Reserve. Declaration may also be as a buffer zone between a core conservation Fish Habitat Reserve and existing or future disturbances.

All forms of fishing, boating, access and existing day to day uses are not restricted.

Wetland habitat disturbances, if for specific Reserve purposes or certain public purposes (public boat ramp and jetties, etc.) or maintenance of existing facilities (public or private) might be permitted subject to conditions.

It is also the intention of a Wetland Reserve declaration to allow, on circumstances, with Permit, under proper management of the Reserve works of a non-reserve or private purpose with minimal impact upon the Reserve. These works include private boat ramp or jetties from adjoining tenures where dredging or reclamation are not involved.

Regulation M3 of the *Fisheries Act* details the activities which may not be undertaken in a Wetland Reserve without Permit (Authorisation). Section 52 of the *Fisheries Act* allows for Authorisation of only those works which are for the preservation, proper management or public enjoyment of a Reserve.

Fish Sanctuaries

These Sanctuaries are not common within Queensland but are designed to completely protect all fish and marine products within the boundary of the Sanctuary. Boating and access are not restricted. All forms of fishing, bait gathering or collecting of marine organisms may not be undertaken without specific Permit. It is normal that this type of protection is achieved through the more common, possibly less specific, Fishery Closures.Fish Sanctuaries or Fishing Closures may be declared in association with other types of Fisheries Reserves on occasions.

Regulation M2 of the *Fisheries Act* details the activities which may not be undertaken in Fish Sanctuary without Permit (Authorisation). Section 52 of the *Fisheries Act* allows for Authorisation of only those works which are for the preservation, proper management or public enjoyment of the Sanctuary.

This is a summary only and should not be taken as a substitute for the Queensland *Fisheries Act*

For further information contact :

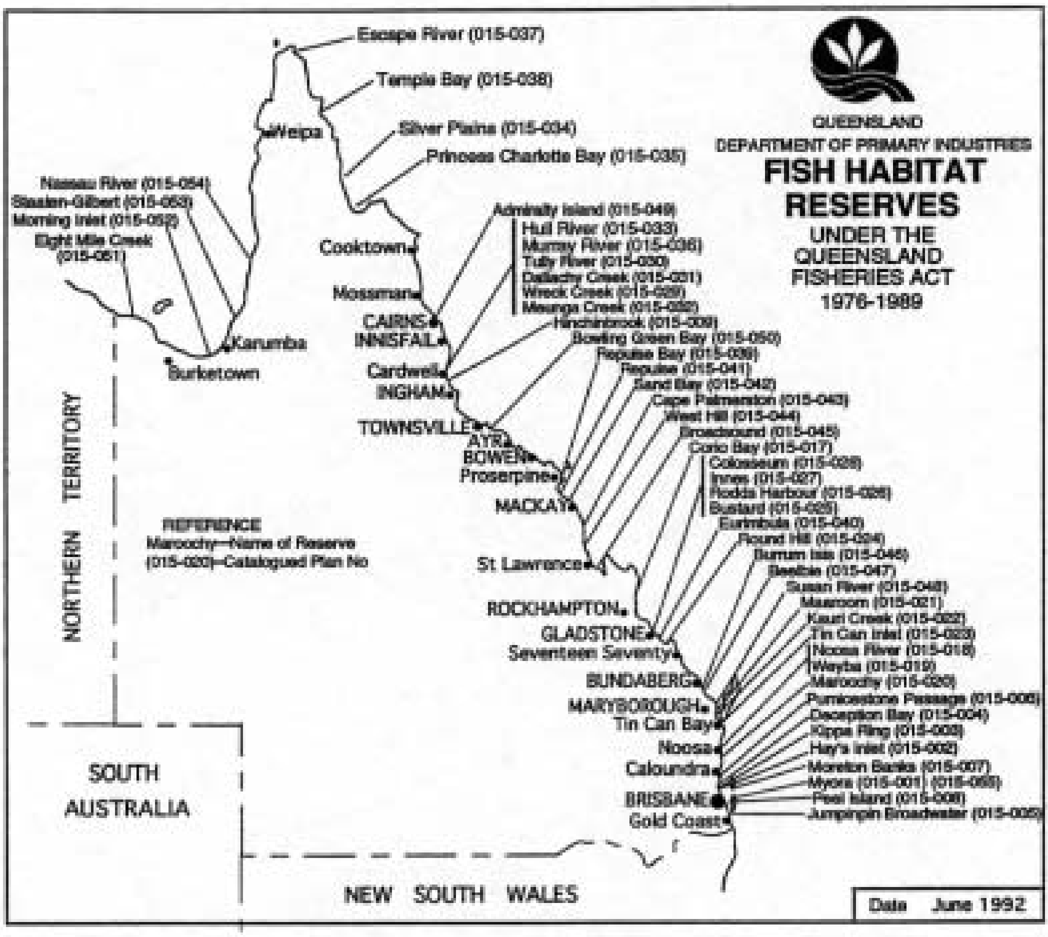
The Land Use and Fisheries Group, or
The Queensland Boating and Fisheries Patrol
at the nearest regional office of the
Queensland Department of Primary Industries.

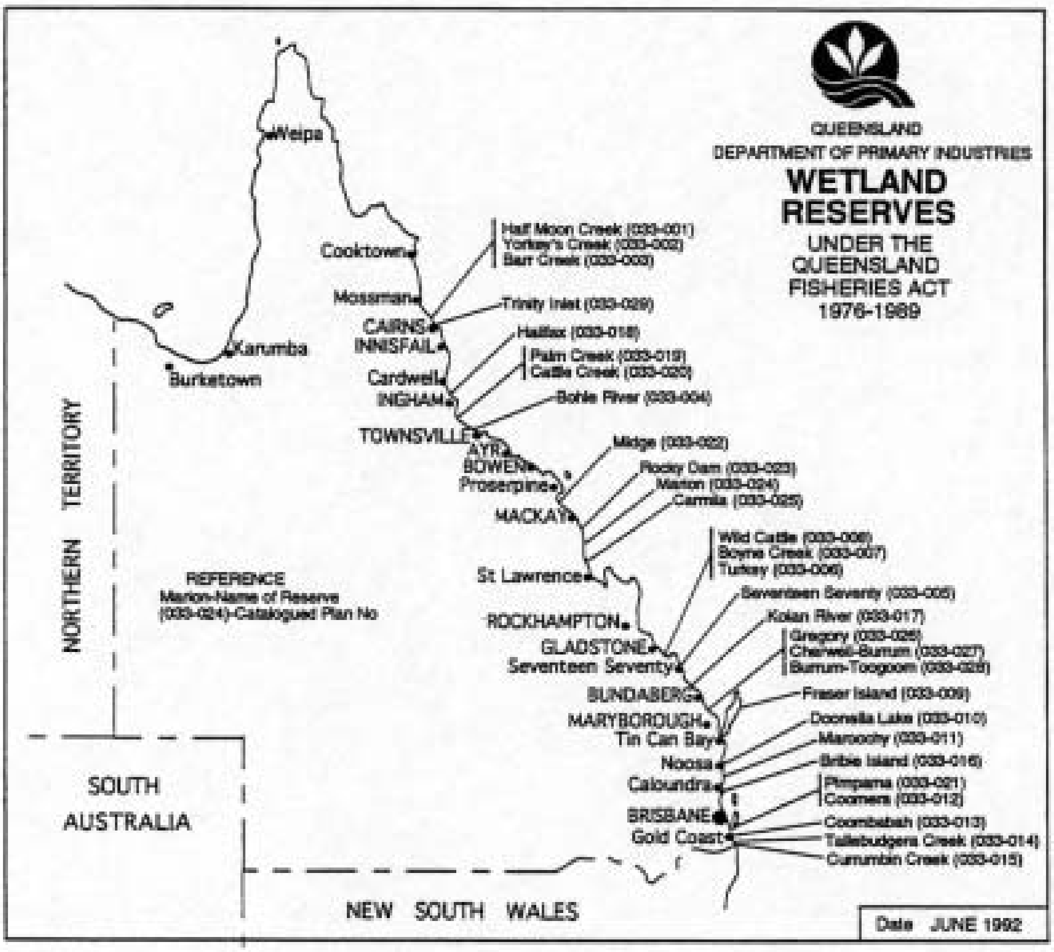
Queensland Department of Primary Industries
Fisheries Division,
G.P.O. Box 46,
Brisbane, QLD, 4001.

Queensland Department of Primary Industries
Queensland Boating and Fisheries Patrol
G.P.O. Box 46,
Brisbane, QLD, 4001.

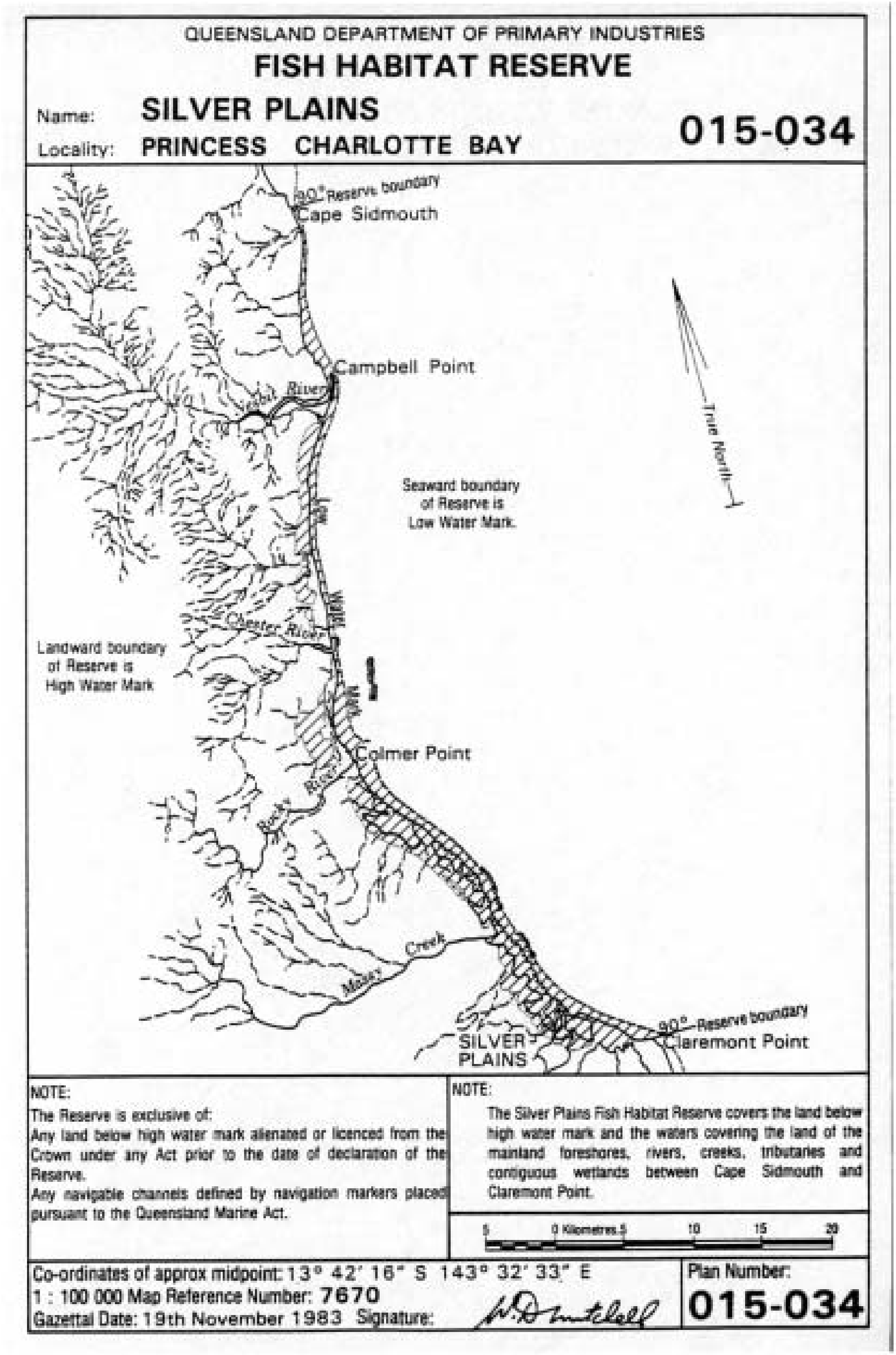
July 1992

APPENDIX 2 Current Fisheries Reserves plans




QUEENSLAND
DEPARTMENT OF PRIMARY INDUSTRIES
WETLAND RESERVES
UNDER THE QUEENSLAND FISHERIES ACT 1976-1989
Weipa
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
Karumba
Burketown
Half Moon Creek (033-001)
Yorkey's Creek (033-002)
Barr Creek (033-003)
Trinity Inlet (033-029)
Halifax (033-018)
Palm Creek (033-019)
Cattle Creek (033-020)
Bohle River (033-004)
Midge (033-022)
Rocky Dam (033-023)
Marion (033-024)
Carmila (033-025)
Wild Cattle (033-008)
Boyne Creek (033-007)
Turkey (033-006)
Seventeen Seventy (033-005)
Kolan River (033-017)
Gregory (033-026)
Cherwell-Burrum (033-027)
Burrum-Toogoom (033-028)
Fraser Island (033-009)
Doonella Lake (033-010)
Maroochy (033-011)
Bribie Island (033-016)
Pimpama (033-021)
Coomera (033-012)
Coombabah (033-013)
Tallebudgera Creek (033-014)
Currumbin Creek (033-015)
REFERENCE
Marion-Name of Reserve
(033-024)-Catalogued Plan No
NORTHERN TERRITORY
SOUTH AUSTRALIA
NEW SOUTH WALES
Date JUNE 1992


QUEENSLAND
DEPARTMENT OF PRIMARY INDUSTRIES
FISH SANCTUARIES
UNDER THE FISHERIES ACT 1976 – 1989
German Bar (023-007)
Centenary Lakes (023-001)
Hook Island (023-004)
Middle Island (023-006)
Swan Bay (023-003)
Coombabah Lake (023-002)
REFERENCE
Swan Bay (023-003) Name of reserve and (catalogued plan no.)
CAIRNS
INNISFAIL
Cardwell
INGHAM
TOWNSVILLE
AYR
BOWEN
Proserpine
MACKAY
ROCKHAMPTON
GLADSTONE
BUNDABERG
MARYBOROUGH
GYMPIE
BRISBANE
Gold Coast
NORTHERN TERRITORY
SOUTH AUSTRALIA
NEW SOUTH WALES
Date: 23 : 11 : 1989


QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
FISH HABITAT RESERVE
Name: SILVER PLAINS
Locality: PRINCESS CHARLOTTE BAY
015-034
90° Reserve boundary
Cape Sidmouth
Campbell Point
River
True North
Seaward boundary of Reserve is Low Water Mark.
Chester River
Landward boundary of Reserve is High Water Mark
Colmer Point
Rocky River
Creek
SILVER PLAINS
90° Reserve boundary
Claremont Point
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 Silver Plains Fish Habitat Reserve covers the land below high water mark and the waters covering the land of the mainland foreshores, rivers, creeks, tributaries and contiguous wetlands between Cape Sidmouth and Claremont Point.
5 0 Kilometres 5 10 15 20
Co-ordinates of approx midpoint: 13° 42' 16" S 143° 32' 33" E
1 : 100 000 Map Reference Number: 7670
Gazettal Date: 19th November 1983 Signature:
Plan Number:
015-034

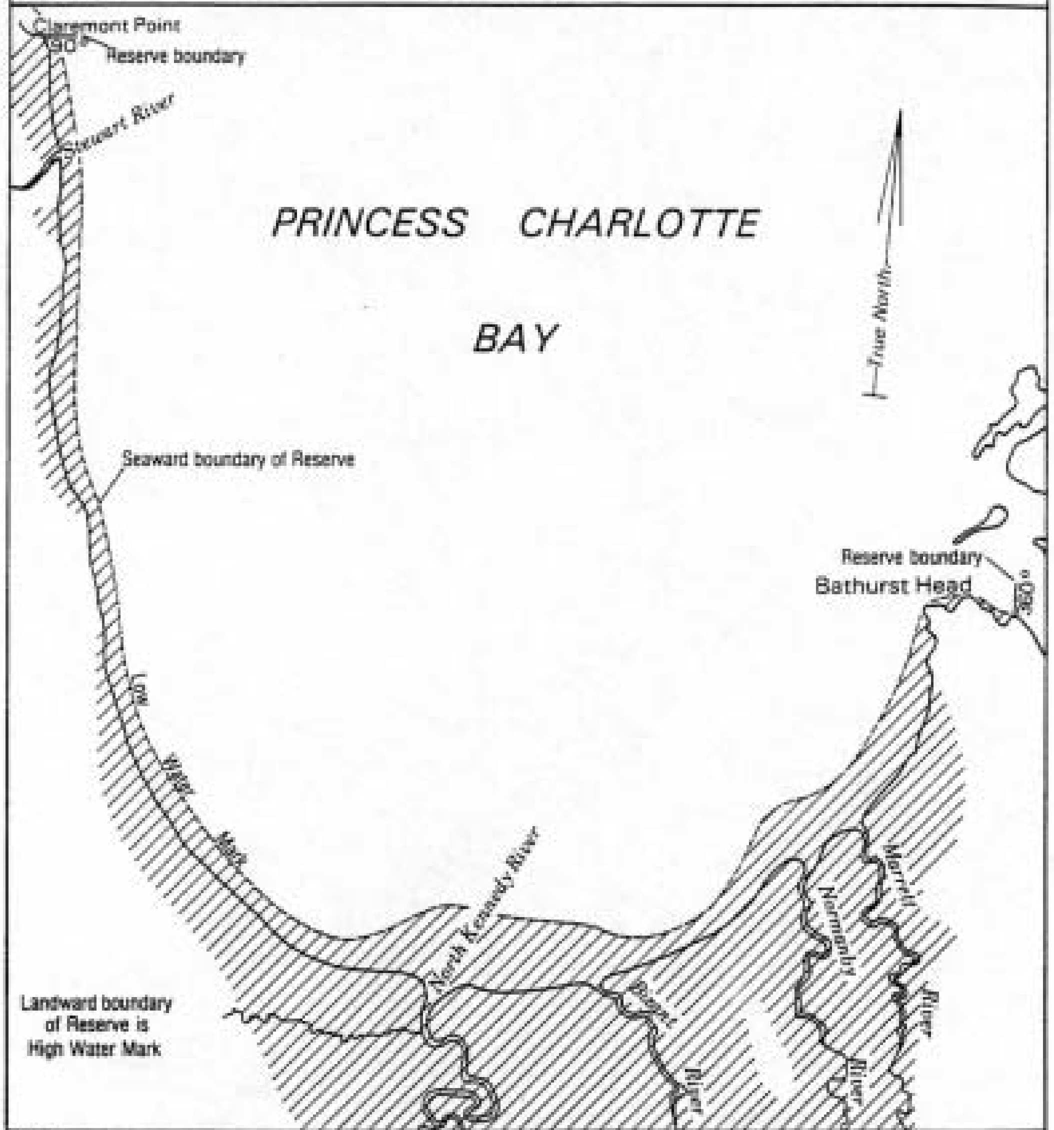
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT RESERVE

Name: **PRINCESS CHARLOTTE BAY**

Locality: **PRINCESS CHARLOTTE BAY**

015-035



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 Princess Charlotte Bay Fish Habitat Reserve covers the land below high water mark and the waters covering that land being the mainland foreshores, rivers, creeks, tributaries and contiguous wetlands between Claremont Point and the eastern headland of Bathurst Head.

5 0 Kilometres 5 10 15 20

Co-ordinates of approx midpoint: 14° 24' 23" S 143° 46' 55" E

1 : 100 000 Map Reference Number: **7769**

Gazettal Date: 19th November 1983 Signature:

Plan Number: **015-035**

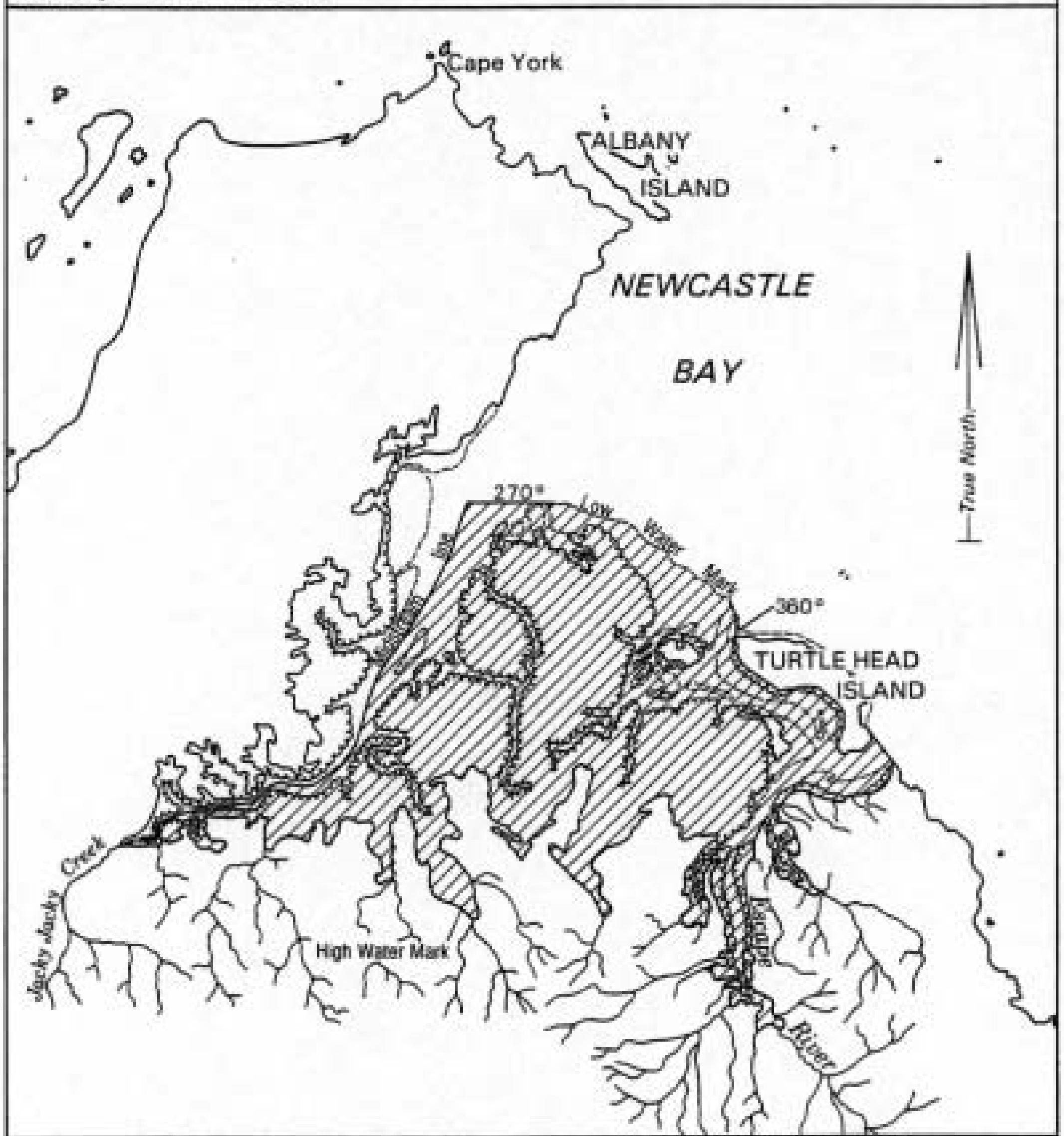
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT RESERVE

Name: **ESCAPE RIVER**

Locality: **CAPE YORK**

015-037



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 Escape River Fish Habitat Reserve covers the land below high water mark and the waters covering the land of Escape River and part of Jacky Jacky Creek as indicated and their tributaries and contiguous wetlands.

10 0 Kilometres 10

Co-ordinates of approx midpoint: 10° 55' 58" S 142° 36' 05" E
1 : 100 000 Map Reference Number: 7476
Gazettal Date: 19th November 1983 Signature:

Plan Number:
015-037

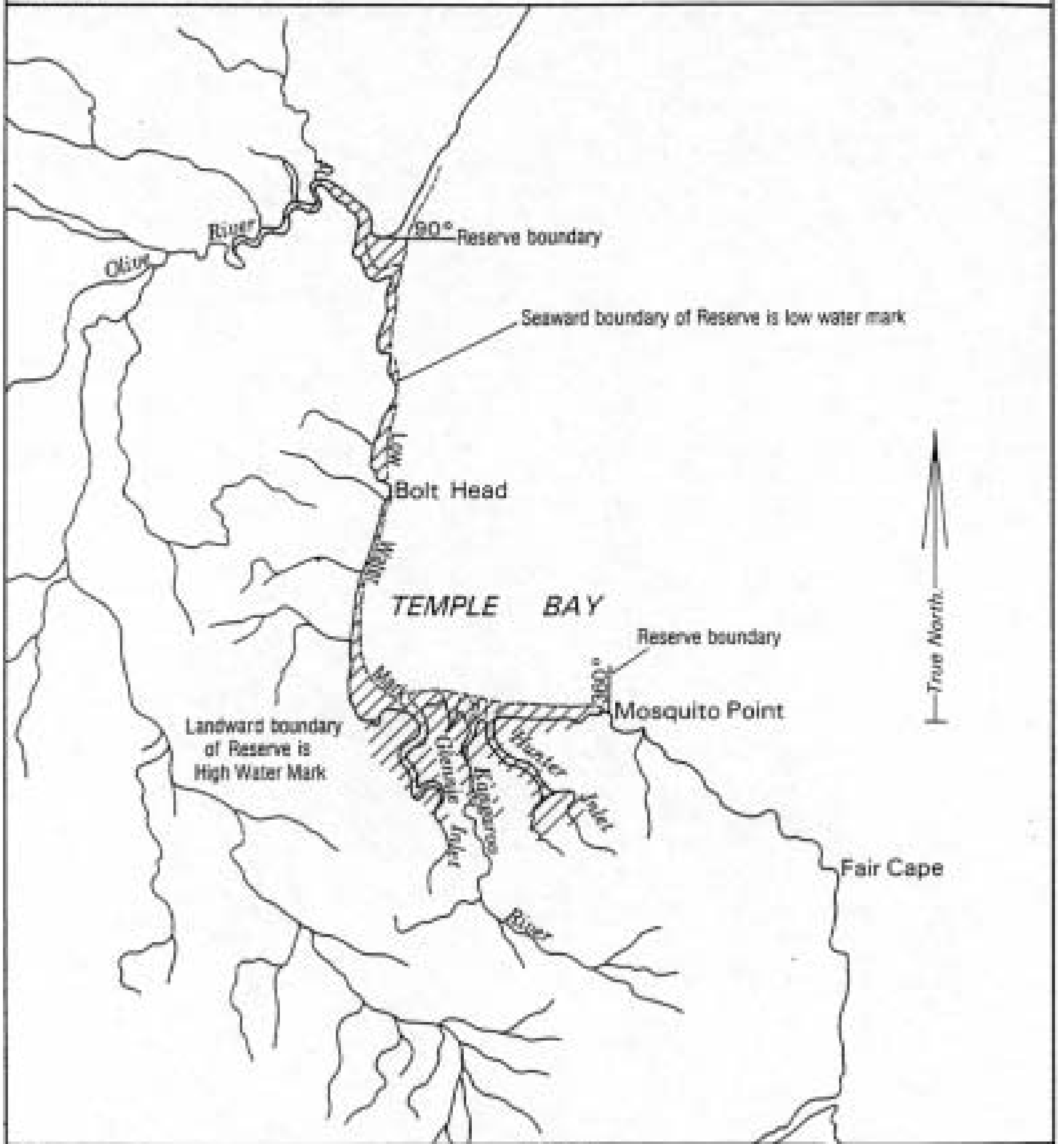
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT RESERVE

Name: **TEMPLE BAY**

Locality: **TEMPLE BAY**

015-038



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 Temple Bay Fish Habitat Reserve covers the land below high water mark and the waters covering the land of the mainland foreshores, inlets, rivers, creeks, tributaries, and contiguous wetlands between Mosquito Point and the north head at Olive River mouth.

10 0 Kilometres 10

Co-ordinates of approx midpoint: 12° 16′ 30″ S 143° 05′ 00″ E
1 : 100 000 Map Reference Number: 7573
Gazettal Date: 19th November 1983 Signature:

Plan Number: **015-038**

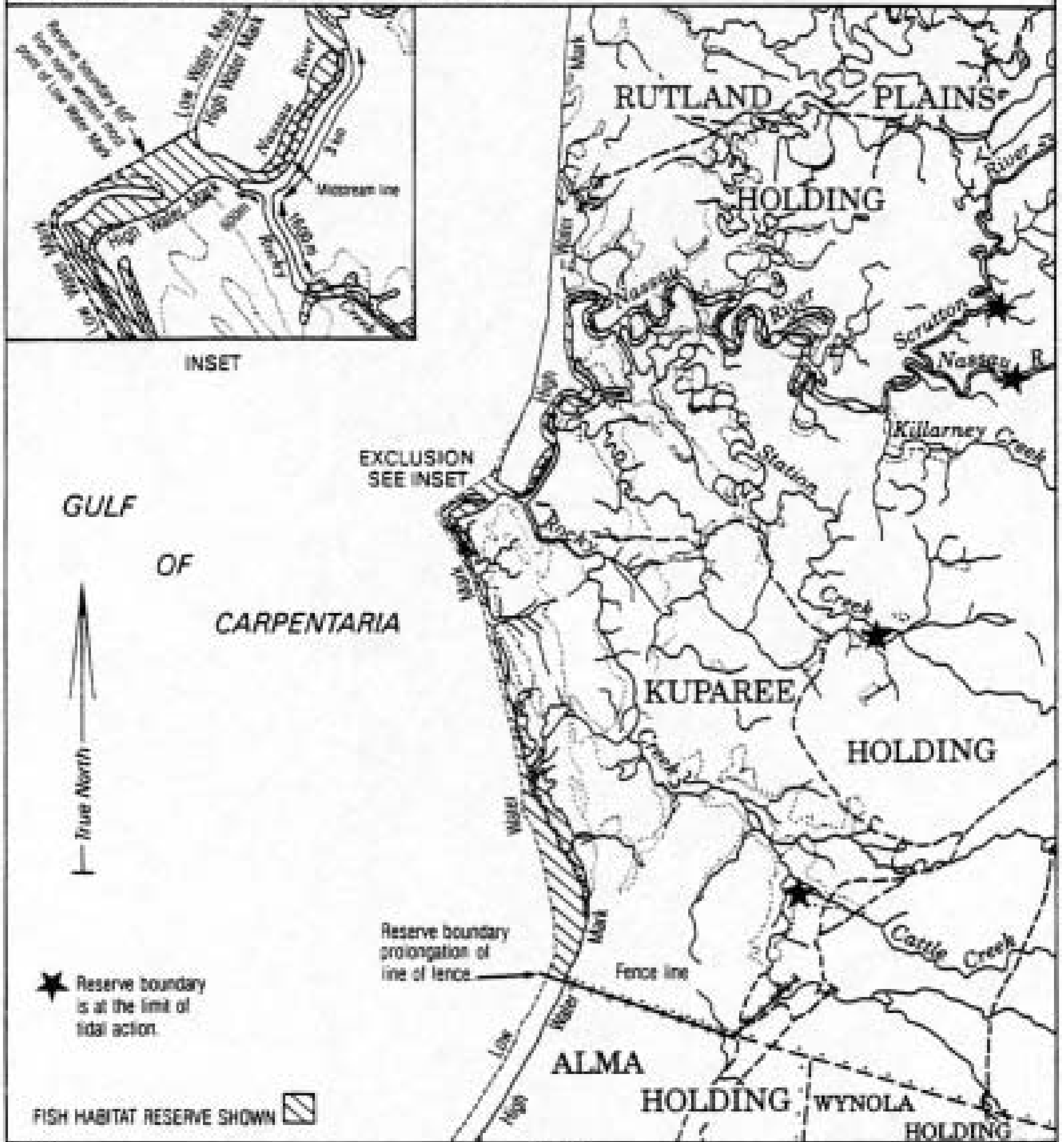
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH HABITAT RESERVE

Name: **NASSAU RIVER**

Locality: **GULF OF CARPENTARIA**

015-054



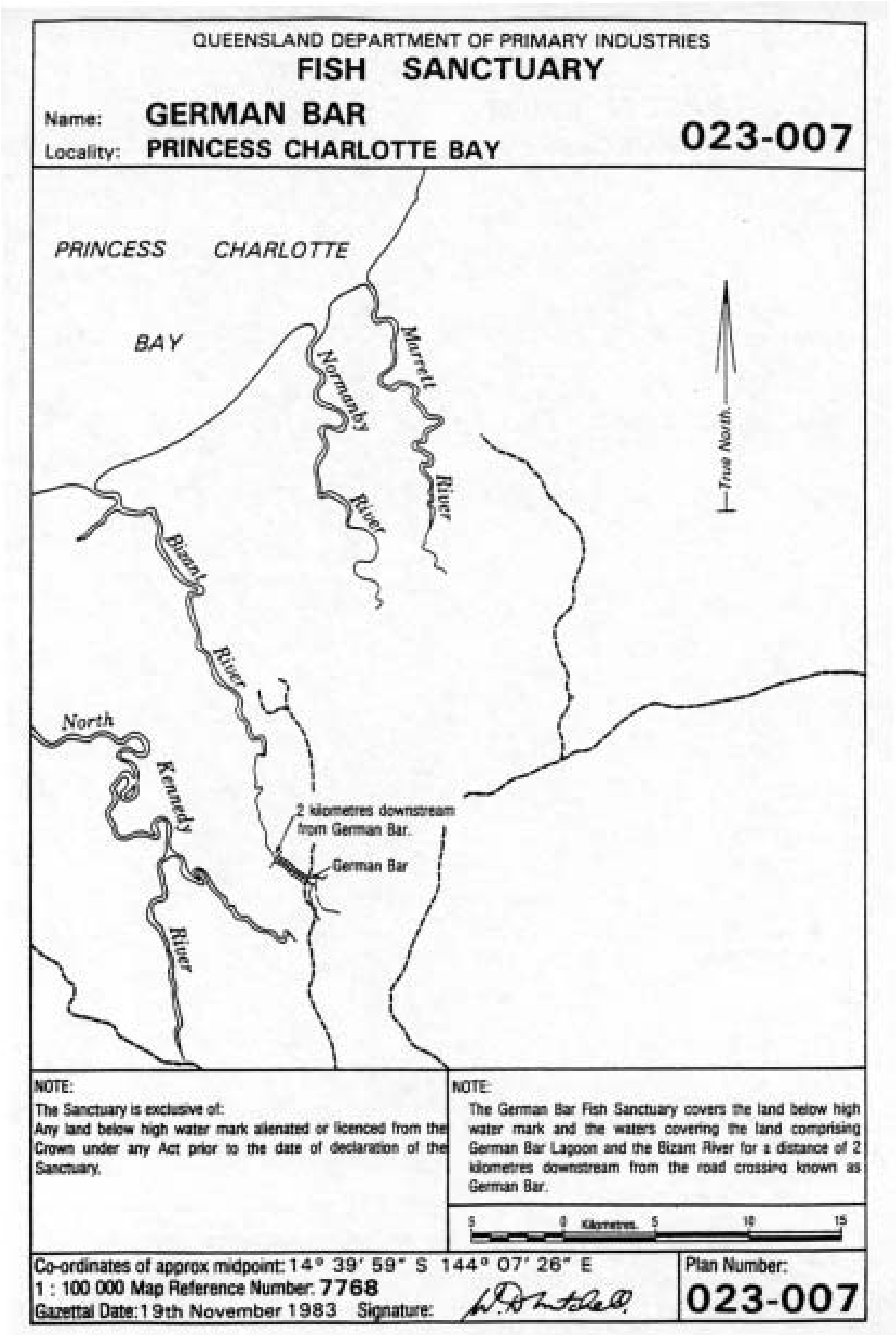
NOTE:
The Reserve is exclusive of:
Any land below high water mark alienated or licenced from the Crown under any Act prior to the date of declaration of the Reserve.
Any navigable channels defined by navigation markers placed pursuant to the Queensland Marine Act.

NOTE:
The Nassau River Fish Habitat Reserve covers the land below High Water Mark and the waters covering the land of the Nassau River and Rocky Creek and that part of the Gulf of Carpentaria as indicated and all rivers, creeks and tributaries thereof to the limit of tidal action.

Kilometres: 5 0 10 15

Co-ordinates of approx midpoint: 15° 56′ 00″ S 141° 23′ 00″ E
1 : 100 000 Map Reference Number: 7166
Gazettal Date: 17th May 1990 Signature:

Plan Number: 015-054


QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

FISH SANCTUARY

Name: **GERMAN BAR**

Locality: **PRINCESS CHARLOTTE BAY**

023-007

NOTE:
The Sanctuary 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 Sanctuary.

NOTE:
The German Bar Fish Sanctuary covers the land below high water mark and the waters covering the land comprising German Bar Lagoon and the Bizant River for a distance of 2 kilometres downstream from the road crossing known as German Bar.

Co-ordinates of approx midpoint: 14° 39′ 59″ S 144° 07′ 26″ E
1 : 100 000 Map Reference Number: 7768
Gazettal Date: 19th November 1983 Signature:

Plan Number: **023-007**

APPENDIX 3 List of mangrove and seagrass species of Cape York Peninsula

Mangroves	**Common Name**
Acanthus ebracteatus Vahl.	
Acanthus ilicifolius L.	Holly Leaf Mangrove
Acrostichum speciosum Willd.	Mangrove Fern
Aegialitis annulata R. Br.	Club Mangrove
Aegiceras corniculatum (L.) Blanco	River Mangrove
Avicennia marina (Forsk.) Vierh.	Grey Mangrove
Bruguiera cylindrica (L.) Bl.	Small-Fruited Orange Mangrove
Bruguiera exaristata Ding Hou.	Rib-Fruited Orange Mangrove
Bruguiera gymnorhiza (L.) Lamk.	Large-Leaved Orange Mangrove
Bruguiera parviflora (Roxb.) W&A ex Griff.	Small-Leaved Orange Mangrove
Bruguiera sexangula (Lour.) Poir.	Northern Large-Leaved Orange Mangrove
Camptostemon schultzii Mas.	Kapok Mangrove
Ceriops australis C.White	Smooth-Fruited Yellow Mangrove
Ceriops decandra (Griff.) Ding Hou.	Rib-Fruited Yellow Mangrove
Ceriops tagal (Perr.) C.B. Rob	Long-Fruited Yellow Mangrove
Cynometra ramiflora L.	
Cynometra ramiflora var. *Bijuga* (Spanoghe) Benth.	Wrinkle-Pod Mangrove
Dolichandrone spathacea (L.f.) K. Sch.	
Excoecaria agallocha L.	Milky Mangrove
Heritiera littoralis (Dryand) Ait.	Looking-Glass Mangrove
Lumnitzera littorea (Jack.) Voigt.	Red-Flowered Black Mangrove
Lumnitzera racemosa Willd.	White-Flowered Black Mangrove
Lumnitzera rosea (Gaud.) Presl.	Pink-Flowered Black Mangrove
Osbornia octodonta F. Muell.	Myrtle Mangrove
Nypa fruticans Wurmb.	Mangrove Palm
Pemphis acidula J. R. & G. Forst	
Rhizophora apiculata Blume	Tall-Stilted Mangrove
Rhizophora lamarckii Montr.	
Rhizophora mucronata Lamk.	Long-Fruited Red Mangrove
Rhizophora stylosa Griff.	Red Mangrove
Scyphiphora hydrophyllacea Gaertn. f.	Yamstick Mangrove
Sonneratia alba J.E. Sm.	White-Flowered Mangrove Apple
Sonneratia caseolaris (L.) Engl.	Red-Flowered Mangrove Apple
Xylocarpus granatum Koen.	Cannonball Mangrove
Xylocarpus mekongensis Pierre	Cedar Mangrove

Seagrasses
Cymodocea rotundata Ehrenb. et Hempr. ex Aschers.
Cymodocea serrulata (R. Br.) Aschers. and Magnus
Enhalus acoroides (L. f.) Royle
Halodule pinifolia (Miki) den Hartog
Halodule uninervis (Forsk.) Aschers.
Halophila decipiens Ostenfeld
Halophila ovalis (R. Br.) Hook f.
Halophila ovata Gaud. in Freycin
Halophila spinulosa (R. Br.) Aschers.
Halophila tricostata Greenway
Syringodium isoetifolium (Aschers.) Dandy
Thalassia hemprichii (Ehrenb.) Aschers.

APPENDIX 4 Information files attached to the digital data

1. MARVEG.RME Digital data description

Data provided The directory NR06 contains all the information in ARC/INFO format. The subdirectory MARVEG contains the mangrove and seagrass community polygons in 24 separate coverages. Due to the problem in the raster to vector conversion in ARC/INFO Rev 6 of reaching more than 10 000 arcs per polygon several coverages had to be split. These split coverages bear the same name but their parts are numbered. All coverages are projected in both geographicals (_geo) and the Australian Map Grid (_amg). The projection files (amg542geo.prj, amg552geo.prj, geo2amg54.prj and geo2toamg55.prj) have been included should one projection be deleted. Forty-five megabytes of disk space are required for these coverages (see Appendix 5 of Report for individual sizes). Table 1 shows which marine vegetation coverages represent the mapping areas described in 5.2 - distribution of the marine vegetation by mapping regions.

Mapping Region	Coverage (geographicals)	Coverage (A.M.G.)
Bloomfield River to Cape Bedford (Cooktown)	cooktown_geo	cooktown_amg
Cape Bedford to Red Point (Starke, Lizard Island)	lizard_geo	lizard_amg
Red Point to Nesbit River (Princess Charlotte Bay)	pcbeast1_geo pcbeast2_geo pcbeast3_geo pcbwest_geo	pcbeast1_amg pcbeast2_amg pcbeast3_amg pcbwest_amg
Nesbit River to Bobardt Point	east_geo	east_amg
Bobardt Point to Temple Bay (Lockhart River)	lockhart_geo	lockhart_amg
Temple Bay to Cape York (Shelburne Bay, Escape River)	shelburn_geo escape_geo	shelburn_amg escape_amg
Cape York to Doughboy River (Torres Strait, Jardine River)	torres_geo jardine_geo	torres_amg jardine_amg
Doughboy River to Hey River (Port Musgrave, Weipa)	weipa1_geo weipa2_geo weipa3a_geo weipa3b_geo weipa4a_geo weipa4b_geo	weipa1_amg weipa2_amg weipa3a_amg weipa3b_amg weipa4a_amg weipa4b_amg
Hey River to Kendall River (Aurukun)	aurukun1_geo aurukun2_geo	aurukun1_amg aurukun2_amg
Kendall River to Balurga Creek	west_geo	west_amg
Balurga Creek to Malaman Creek	holroyd_geo	holroyd_amg
Malaman Creek to Nassau River (Mitchell River)	nassau1_geo nassau2_geo	nassau1_amg nassau2_amg

Table 1 The marine vegetation coverages related to the mapping regions

The subdirectory TMBAND3 contains segments of Landsat Thematic Mapper band 3 (visible red) imagery in GRID format which have been projected to AMG. 140 megabytes of disk space are required for these coverages (see Appendix 5 for individual sizes). Table 2 displays which marine vegetation coverages overlay on the TM Band 3 imagery.

TM Band 3 Grid Coverage	**Marine Vegetation Coverage**
cooktowngr_a	cooktown_amg
lizardgr_a	lizard_amg
pcbeastgr_a	pcbeast1_amg pcbeast2_amg pcbeast3_amg
pcbwestgr_a	pcbwest_amg
eastgr_a	east_amg
lockhartgr_a	lockhart_amg
shelburngr_a	shelburn_amg
escapegr_a	escape_amg
torresgr_a	torres_amg
jardinegr_a	jardine_amg
weipagr_a	weipa1_amg weipa2_amg weipa3a_amg weipa3b_amg weipa4a_amg weipa4b_amg
aurukungr_a	aurukun1_amg aurukun2_amg
westgr_a	west_amg
holroydgr_a	holroyd_amg
nassaugr_a	nassau1_amg nassau2_amg

Table 2 The marine vegetation coverages related to the TM band 3 grid coverages

The subdirectory COAST_GEO is the AUSLIG coastline data projected to geographicals.

The MARVEGWP.* files are the text files in Word Perfect 5.2 Windows format.

<u>Displaying data.</u> Full Display of Cape York Peninsula:
Edit fulldisp.aml for appropriate shadeset
Arc: arcplot
Arcplot: &run fulldisp.aml

Marine Vegetation Polygons on TM band 3:
For large scale (or detailed) display overlay the marine vegetation polygons over the Landsat TM band 3 grid. This can only be done in the AMG projection.

Example for Cooktown:

Edit marveg/marveg.lut for appropriate shadeset.
Arc: w nr06/marveg (change workspace to marveg)
Arc: arcplot
Arcplot: shadeset (allocate appropriate shadeset)
Arcplot: mapextent ../cooktowngr_a (set map extent for the TM band 3 grid)
Arcplot: gridpaint ../cooktowngr_a # # # gray (displays TM band 3 grid in grayscale)
Arcplot: polygonshades cooktown_amg marine-veg marveg.lut (uses the lookup table to paint the marine vegetation classes)

Warning: the TM band 3 coverages contain overlaps but the marine vegetation polygons do not. Marine vegetation areas towards the boundaries of the grid may be shown on the next coverage and not that coverage.

Marine Vegetation Polygons on AUSLIG Coastline:
This is better for small scale display.

Example for Cooktown:

Edit marveg/marveg.lut for appropriate shadeset.
Arc: w nr06/marveg (change workspace to marveg)
Arc: arcplot
Arcplot: shadeset (allocate appropriate shadeset)
Arcplot: mapextent cooktown_geo (set map extent for the marine vegetation polygons)
Arcplot: polygonshades ../coast_geo 18 (shades coast polygon in grey)
Arcplot: polygonshades cooktown_geo marine-veg marveg.lut (uses the lookup table to paint the marine vegetation classes)

2. MARVEG.CND Conditions of use of the Marine Vegetation data

The Department of Primary Industries, Queensland, has agreed to supply the Marine Vegetation Data Base as described hereunder to Cape York Peninsula Land Use Strategy (CYPLUS) Participants for the purposes of the project.

Description of Marine Vegetation Data Base as supplied:

This data is supplied free of charge and according to the principles in the CYPLUS Memorandum of Understanding (MOU).

The Crown in right of the State of Queensland is the owner of the attached Marine Vegetation Data supplied to the Cape York Peninsula Land Use Strategy Participants, hereinafter referred to as the Participant. This data is provided upon the following conditions in addition to those specified in the CYPLUS (MOU):

- The Department of Primary Industries is the agent of the Crown for the purposes of these conditions;

- Ownership of the data has not been transferred;

- Data may be used for the project for which it was supplied;

- The data may be combined with other data, provided it will not derogate from the ownership of the data provided by the Department of Primary Industries;

- The data supplied is for the Participant's internal use only and may not be distributed to any other organisation, in enhanced form or otherwise, without prior written agreement of the Department of Primary Industries;

- Any copies of the data made or hard copy products produced, must acknowledge the source of the Marine Vegetation Data;

- Hard copy products may be derived from the supplied data, for internal use only. These products may not be sold to any other organisation without prior written agreement of the Department of Primary Industries.

3. MARVEG.QAL Data quality information

Lineage. The mangrove polygons were derived from digitally processed satellite imagery together with aerial photography and field data. Table 3 displays the Landsat Thematic Mapper scenes used.

Path/Row	Date	Season	Tide Phase
99/67	16 June 1988	early dry	mid
99/68	16 June 1988	early dry	mid
99/69	16 June 1988	early dry	mid
99/70	21 March 1991	late wet	high
98/68	6 April 1988	late wet	high
98/69	23 March 1991	late wet	high
98/70	6 April 1988	late wet	high
98/71	21 May 1987	early dry	mid
97/69	21 October 1987	late dry	high
97/70	3 November 1986	late dry	high
96/70	24 August 1986	mid dry	mid
96/71	17 September 1986	mid dry	high

Table 3 The Landsat TM scenes used

The colour aerial photography at 1:50 000 from the Beach Protection Authority used was:
Cooktown to Crab Island - Runs 1 to 26 captured during 1991 and 1992
Crab Island to NT Border - Runs 26 to 37 captured during 1989.

The field trips were:

Cooktown to Shelburne Bay	November 1992
Shelburne Bay to Aurukun	May 1993
Pormpuraaw to Nassau River	April 1994

The seagrass polygons were derived from dive and boat surveys and the aerial photography used above. The boat surveys were:

Cape York to Cairns	November 1984
Lookout Point to Barrow Point	September 1989
Western side of the Cape	July 1985

The Landsat TM data was rectified to the Australian Map Grid with pixels resampled to 30 metres by 30 metres by the Australian Geological Survey Organisation using control points from the 1:100 000 topographic maps. The seagrass surveys used the 1:150 000 hydrographic charts for positioning.

See section 2.0 Methods of the Report for details on the processing of the information.

Positional accuracy. The horizontal accuracy of the Marine Vegetation product is between 10 and 100 metres. Despite different data sources the satellite imagery based coverages overlay well with the coastline coverage derived from the 1:100 000 topographic maps.

Attribute accuracy. The overall accuracy for the data was greater than 80%. Using other data sources such as the aerial photography and field data helped to overcome the heterogeneity in the satellite imagery but some uncheckable inconsistencies in interpretation of vegetation communities may occur. Problems were also created by cloud on the satellite imagery and aerial photography. Gaps in the aerial photography coverage and poor quality pictures also limited interpretation. Only representative estuaries were field checked. Ground sites were based on accessibility for the helicopter. Mapping problems overcome for each coverage are mentioned below.

1. Bloomfield River to Cape Bedford (Cooktown)

Landsat scene 96/71 17-09-86 mid dry season high tide

No field data was gathered in this area and no access was allowed to land occupied by the Hopevale community. Cloud affected small areas of the Endeavour River estuary.

2. Cape Bedford to Red Point (Lizard)

Landsat scene 96/70 28-08-86 mid dry season near high tide

Several intertidal areas and offshore islands were affected by scattered cloud and shadow on the Landsat image such as Lizard Island, Newton Island, between Cape Bowen and Red Point, Murdoch Point, and the Starke region. The Starke region was also affected by cloud on the aerial photography. No access was allowed to land occupied by the Hopevale community to collect field data.

3. Red Point to Nesbit River (PCBeast, PCBwest)

Landsat scene 97/70 21-10-87 late dry season high tide

The limits of intertidal areas within Princess Charlotte Bay were very difficult to determine. The aerial photography did not cover all the intertidal areas and was of poor quality (very washed out). Field visits showed that it is not uncommon for mangrove species to mix with terrestrial species, particularly towards the landward edge. *Excoecaria* (deciduous) was observed to be almost leafless at the end of the dry season, which is when the satellite image was taken. This would definitely give seasonal variation to the spectral signature of this mangrove.

4. Nesbit River to Bobardt Point(East)

Landsat scene 97/69 21-10-87 late dry season high tide

It was difficult to separate mixed mangrove/terrestrial communities from purely terrestrial communities.

5. Bobardt Point to Temple Bay (Lockhart)

Landsat scene 98/69 06-04-88 late wet season high tide

The late wet season and high tide satellite image made freshwater wetlands hard to discriminate from tidal wetlands particularly around Lockhart River delta and then south below Cape Sidmouth. Available aerial photography did not completely cover the Lockhart River delta or Temple Bay. Some of the photographic prints were very washed out. Unfortunately the Nypa stands present were too small to be mappable units.

6. Temple Bay to Cape York (Shelburn, Escape)

Landsat scene 98/68 06-04-88 late wet season high tide

Cloud severely contaminated the satellite image from the Escape River to Cape York. Although a mangrove classification was performed there are large gaps from the cloud and shadow. Also aerial photography did not cover all of the Newcastle Bay intertidal areas. It was difficult to separate the mangrove communities from terrestrial vegetation, as often the two met with similar density vegetation. The mangrove communities on the creeks in the sand dune country were too small to be mapped.

7. Cape York to Doughboy River (Torres, Jardine)

Landsat scene 99/67 16-06-88 early dry season mid tide

No aerial photography was obtained for the outer islands of the Torres Strait (e.g. Moa and Badu Islands). The aerial photography over the Jardine River was very washed out. There was an overlap between tidal and freshwater communities in the Jardine area.

8. Doughboy River to Hey River (Weipa)

Landsat scene 99/68 16-06-88 early dry season mid tide

The aerial photography did not cover totally the tidal areas of the Ducie and Wenlock Rivers. In some places the boundary between tidal and terrestrial vegetation was hard to determine, as the field visit revealed open communities of *Avicennia* mixed with terrestrial *Melaleuca* and *Acacia* species.

9. Hey River to Kendall River (Aurukun)

Landsat scene 99/69 16-06-88 early dry season mid tide

The aerial photography did not cover the full tidal areas of the Watson and Archer Rivers. Terrestrial vegetation mixed with mangroves on many river islands. No field data was collected south of the Love River.

10. Kendall River to Balurga Creek (West)

Landsat scene 99/70 21-03-91 late wet season high tide

This was only a small area (size) which covered a gap between adjacent Landsat scenes. There were no major rivers in the area, only a few small creeks with small catchment areas, hence not much regular fresh water input. The late wet season Landsat scene meant that there was substantial fresh water flooding on the coastal plains which contain some saltpans that are probably also inundated during the highest spring tides. The luxurious growth of fresh water grass and reeds in the intertidal areas meant that these areas could not be spectrally separated from terrestrial grass, and thus have not been mapped as saltpans, affecting their areal measurement above. There were mangrove fringes on the small creeks (*Avicennia* dominated), but most of these have proved not to be "mappable units" and have hence disappeared in the cartographic process. Due to mechanical problems with the helicopter no field data was gathered in this region.

11. Balurga Creek to Malaman Creek (Holroyd)

Landsat scene 98/70 06-04-88 late wet season high tide

The late wet season Landsat image showed fresh water flooding in tidal areas. The aerial photography did not cover the limits of the intertidal areas. No field data was collected north of Pormpuraaw due to mechanical problems with the helicopter.

12. Malaman Creek to Nassau River (Nassau)

Landsat scene 98/71 21-05-87 early dry season mid tide

No access was allowed on land occupied by the Kowanyama community which included the whole Mitchell River Delta. The aerial photography did not cover the upper tidal limits.

Figure 2.1 of the Report is a data reliability diagram for the study area. The highest reliability class covers areas which were visited by helicopter for the mangrove survey and by boat for the seagrass survey. The next highest reliability (class 2) is for areas which were not visited but are covered by 1:50 000 colour aerial photography. Of less reliability (class 3) are areas which are covered by satellite imagery but are not covered by the aerial photography, or the aerial photography is of poor quality. The final class covers areas that were not covered by satellite imagery or contained cloud affecting the satellite imagery and digital classification.

Logical consistency. Topology exists for all coverages.

Completeness. The classification of mangroves is based on the dominate genus present and density. Generic level was selected as species within some genera could only be separately identified during the flowering and fruiting seasons. The communities identified are listed in Table 4. The densities are determined by the foliage projective cover (FPC) of the canopy layer - more than 50% is closed, less than 50% is open. The seagrass communities are classified according to density of vegetation cover with 3 classes - 0 to 10%, 10 to 50% and 50 to 100%.

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

Table 4 The marine vegetation units

The height of vegetation cannot be easily derived from satellite imagery so the Specht (1978) labels such as "forest" and "scrub" have not been included in the description. However, from field experience Closed *Rhizophora*, Closed *Rhizophora/Ceriops*, Closed Mixed and Closed *Avicennia* are generally more than 10 metres tall, thus "forest" *sensu* Specht; while the remaining classes (except for saltpans) generally are less than 10 metres conforming to Specht's "scrub".

The classes included are those which receive tidal inundation, hence appropriate habitat of mangroves. Excluded classes are permanent pools of water, elevated land containing terrestrial vegetation such as trees, shrubs and grass, and bare mud and sand banks. As these classes were derived spectrally from the Landsat imagery, including permanent water pools would mean including the ocean, and including terrestrial vegetation islands would mean including all terrestrial vegetation, which would result in more than the intertidal zone being shown. Bare mud and sand banks were excluded as these have the same spectral signature as saltpans.

There are some typical mangrove zones (or communities) which have been identified by many authors, e.g. Macnae (1967), Davie (1985) and Bunt (1978), which do not appear to be mapped. Some examples of these are the seaward *Sonneratia* fringe, *Bruguiera* communities and *Nypa* stands. The reason for this is that while these communities do occur within Cape York Peninsula they are generally linear in shape and not large enough to be mappable units (30 metres wide). Narrow fringes of *Rhizophora* spp. particularly on the western side of the Cape, are missing for this reason. Due to similar foliage, *Bruguiera* communities cannot be easily identified from *Rhizophora* communities, from satellite imagery, aerial photography or even from helicopter.

For detailed description on the classes see MARVEG.DCT (data dictionary).

The minimum size of a polygon is 10 000 metres or one hectare. Areas less than this were eliminated to ease cartographic interpretation.

4. MARVEG.DCT Data dictionary

<u>Data group:</u> Marine Vegetation

<u>Description of data.</u> Mangroves and seagrasses are flowering plants which grow in sheltered bays, estuaries and rivers in coastal areas. Mangroves only occur in the intertidal zone (between high water mark and low water mark) while seagrasses occur below low water mark as well. Mangroves and seagrasses are important in the provision of food and habitat for marine fauna; and in stabilising coastal substrates. The mangrove polygons were determined from satellite imagery, aerial photography and field data, processed during the two years (1993 and 1994) of the CYPLUS Natural Resources Analysis Program. The seagrass polygons were determined from dive and boat surveys in 1984, 1985 and 1989 with additional boundary clarification in some areas using aerial photography during the CYPLUS project.

<u>Content of data.</u>
NUMBER of LAYERS: 1

LAYER NAME	SPATIAL FEATURES	DATA STRUCTURE
Marine-Veg	Marine_Veg Unit	Polygon

Related files. The data for Marine Vegetation Units are structured as polygons with attribute information designed in one related data file:

.PAT - the standard Arc/Info polygon attribute file, and **.PMV** - the marine vegetation information.

Attributes in .PAT file: this file contains the standard Arc/Info COVERAGE attributes with one additional attribute (MARINE_VEG) which is used as a relational key to the **.PMV** file.

ITEM NAME	WIDTH	OUTPUT	TYPE	DEC. PLACES
AREA	4	12	F	3
PERIMETER	4	12	F	3
COVER#	4	5	B	-
COVER-ID	4	5	B	-
MARINE_VEG	4	8	B	-

Attributes in .PMV file: this file contains the standard Arc/Info COVERAGE attributes with one additional attribute (MARINE-VEG) which is used as a relational key to the **.PMV** file.

ITEM NAME	WIDTH	OUTPUT	TYPE	DEC. PLACES
MARINE-VEG	4	8	B	
CLASS	20	20	C	
DENSITY	8	8	C	

List and description of spatial features

The mangroves

Rhizophora (closed) (Figure 3.2)

Habitat	occurs fringing waterways low in intertidal zone with roots submerged during high tides. Some species pioneer in the front of the mangroves such as *Rhizophora stylosa* while other species such as *R. apiculata* and *R. lamarckii* prefer perennial freshwater input provided by permanent watercourses.
Canopy	usually dominated by *Rhizophora* spp. with occasional *Bruguiera* spp. and *Avicennia marina*. Foliage projective cover is more than 50%. Height varies from 4 metres to more than 30 metres.
Shrub layer	Generally absent.
Ground cover	*Rhizophora* stilt roots with a sparse cover of *Rhizophora* seedlings.

Ceriops (closed) (Figure 3.3)

Habitat	Generally occurs between *Rhizophora* communities and open *Ceriops* communities on land more elevated than *Rhizophora* communities and not inundated by every tide.
Canopy	*Ceriops* spp. and occasionally *Rhizophora* spp., *Bruguiera* spp. and *Avicennia marina*. Foliage projective is cover more than 50%. Height varies from 1.5 metres to more than 17 metres.
Shrub layer	Generally absent.
Ground cover	Consists of sparse seedlings of genera present.

Ceriops (open) (Figure 3.4)

Habitat	occurs towards the landward edge of the intertidal zone, inundated by only the high spring tides. This community often surrounds saltpans and is rarely on waters edge, except on eroding banks.
Canopy	*Ceriops* spp., and occasionally with emergents of *Avicennia marina*. The foliage projective cover is less than 50%. Height varies from less than 0.5 metre in very saline environments to 5 metres.
Shrub layer	Occasional presence of *Aegialitis annulata* to 2 metres in height.
Ground cover	Consists of seedlings of species present with occasional presence of samphire species such as *Suaeda arbusculoides, Tecticornia australasica* and *Sarcocornia quinqueflora.*

Avicennia (closed) (Figure 3.5)

Habitat	a very diverse community which can be found in all intertidal environments from pioneering the seaward edge of mangroves and fringing waterways on accretion banks being inundated on every tide, to the landward edge only being inundated on the highest spring tides.
Canopy	*Avicennia marina* with the occasional presence of *Ceriops* spp., *Excoecaria agallocha* 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*.

<u>*Avicennia* (open)</u> (Figure 3.6)

Habitat — a very diverse community which can be found in all intertidal environments from pioneering the seaward edge of mangroves and fringing waterways on accretion banks being inundated on every tide, to the landward edge only being inundated on the highest spring tides.

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*).

<u>*Rhizophora/Ceriops* (closed)</u> (Figure 3.7)

Habitat — Generally occurs between closed *Rhizophora* communities and closed *Ceriops* communities receiving inundation by most high tides.

Canopy — *Ceriops* spp. with emergent *Rhizophora* spp. and occasional *Bruguiera* spp. Foliage projective is cover more than 50%. Height varies from 2 metres to more than 15 metres.

Shrub layer — Generally absent.

Ground cover — Consists of sparse seedlings of genera present between *Rhizophora* stilt roots and occasional *Ceriops* knee roots.

<u>*Avicennia/Ceriops* (closed)</u> (Figure 3.8)

Habitat — Generally occurs towards the landward edge or in the centre of islands on substrate only inundated during spring tides.

Canopy — *Ceriops* spp. with emergents of *Avicennia marina*. Foliage projective is cover more than 50%. Height varies from 2 metres to more than 10 metres.

Shrub layer — Generally absent.

Ground cover — Consists of sparse seedlings of genera present.

<u>*Avicennia/Ceriops* (open)</u> (Figure 3.9)

Habitat — Generally occurs towards the landward edge near hypersaline claypans or in the centre of islands on substrate only inundated during the spring tides.

Canopy — *Ceriops* spp. with emergents of *Avicennia marina*. The foliage projective cover is less than 50%. Height varies from less than 0.5 metre in very saline environments to 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 with occasional presence of samphire species such as *Suaeda arbusculoides, Tecticornia australasica* and *Sarcocornia quinqueflora*.

<u>Landward Rim (open)</u> (Figure 3.10)

Habitat: Generally occurs on substrates only inundated on the highest spring tides - next to the landward edge or on dune systems dissected by tidal waterways.

Canopy: usually a mix consisting of *Avicennia marina*, *Ceriops* spp., *Excoecaria agallocha*, *Lumnitzera* spp. Terrestrial plants from *Melaleuca* and *Acacia* genera may also occur. The foliage projective cover is less than 50%. Height varies from 2 metres to 10 metres.

Shrub layer: may exist of smaller canopy species as well as the occasional presence of *Aegialitis annulata* and *Aegiceras corniculatum* to 2 metres in height.

Ground cover: may consist of seedlings of species present as well as sparse samphires (e.g. *Suaeda arbusculoides*, *Tecticornia australasica* and *Sarcocornia quinqueflora*) and grasses such as salt couch (*Sporobolus virginicus*).

<u>Mixed (closed)</u> (Figure 3.11)

Habitat: may occur behind closed *Rhizophora* communities, in areas where zonation is less defined, as well as by permanent watercourses. Tidal inundation varies from almost every high tide to only the spring tides where there is more fresh water input.

Canopy: a mix which may consist of *Rhizophora* spp., *Avicennia marina*, *Bruguiera* spp., *Excoecaria agallocha*, *Xylocarpus mekongensis*, and *Ceriops* spp. *Melaleuca* spp. may be present. The foliage projective cover is more than 50%. Height may vary from 5 metres to more than 30 metres depending on the amount of fresh water available.

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* and, in far northern areas, the palm *Nypa fruticans* may occur.

Ground cover: may consist of seedlings of species present as well as the fern *Acrostichum speciosum*.

<u>Saltpan</u> (Figure 3.12)

Habitat: occurs toward the landward edge of the intertidal zone, and are hypersaline 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 (e.g. *Sporobolus virginicus*).

The seagrasses

The seagrass species present may be *Cymodocea serrulata, Syringodium isoetifolium, Halodule uninervis, Thallassia hemprichii, Halophila spinulosa, Halophila ovalis, Halophila decipiens* and *Enhalus acaroides*

Sparse Seagrass (Figure 3.13)
The percentage of vegetation cover on substrate is less than 10%.

Medium Seagrass (Figure 3.14)
The percentage of vegetation cover on substrate is between 10% and 50%.

Dense Seagrass (Figure 3.15)
The percentage of vegetation cover on substrate is between 50% and 100%.

APPENDIX 5 Size of the digital coverages

Marine Vegetation Coverage	**Size** (megabytes)	**TM Band 3 Grid Coverage**	**Size** (megabytes)
cooktown_geo/cooktown_amg	0.5	cooktowngr_a	10
lizard_geo/lizard_amg	1.5	lizardgr_a	10
pcbeast1_geo/pcbeast1_amg	2.5	pcbeastgr_a	11
pcbeast2_geo/pcbeast2_amg	1.5		
pcbeast3_geo/pcbeast3_amg	0.5		
pcbwest_geo/pcbwest_amg	1.0	pcbwestgr_a	9
east_geo/east_amg	0.5	eastgr_a	3
lockhart_geo/lockhart_amg	1.5	lockhartgr_a	5
shelburn_geo/shelburn_amg	0.5	shelburngr_a	5
escape_geo/escape_amg	1.5	escapegr_a	8
torres_geo/torres_amg	0.5	torresgr_a	7
jardine_geo/jardine_amg	1.0	jardinegr_a	4
weipa1_geo/weipa1_amg	1.5	weipagr_a	17
weipa2_geo/weipa2_amg	1.5		
weipa3a_geo/weipa3a_amg	1.0		
weipa3b_geo/weipa3b_amg	1.5		
weipa4a_geo/weipa4a_amg	2.5		
weipa4b_geo/weipa4b_amg	2.0		
aurukun1_geo/aurukun1_amg	1.5	aurukungr_a	15
aurukun2_geo/aurukun2_amg	1.0		
west_geo/west_amg	0.5	westgr_a	1
holroyd_geo/holroyd_amg	0.5	holroydgr_a	4
nassau1_geo/nassau1_amg	2.0	nassaugr_a	16
nassau2_geo/nassau2_amg	1.5		